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Promoting teamwork in healthcare

Edited by
Juliane E. Kämmer, Margarete Boos and Julia Carolin Seelandt

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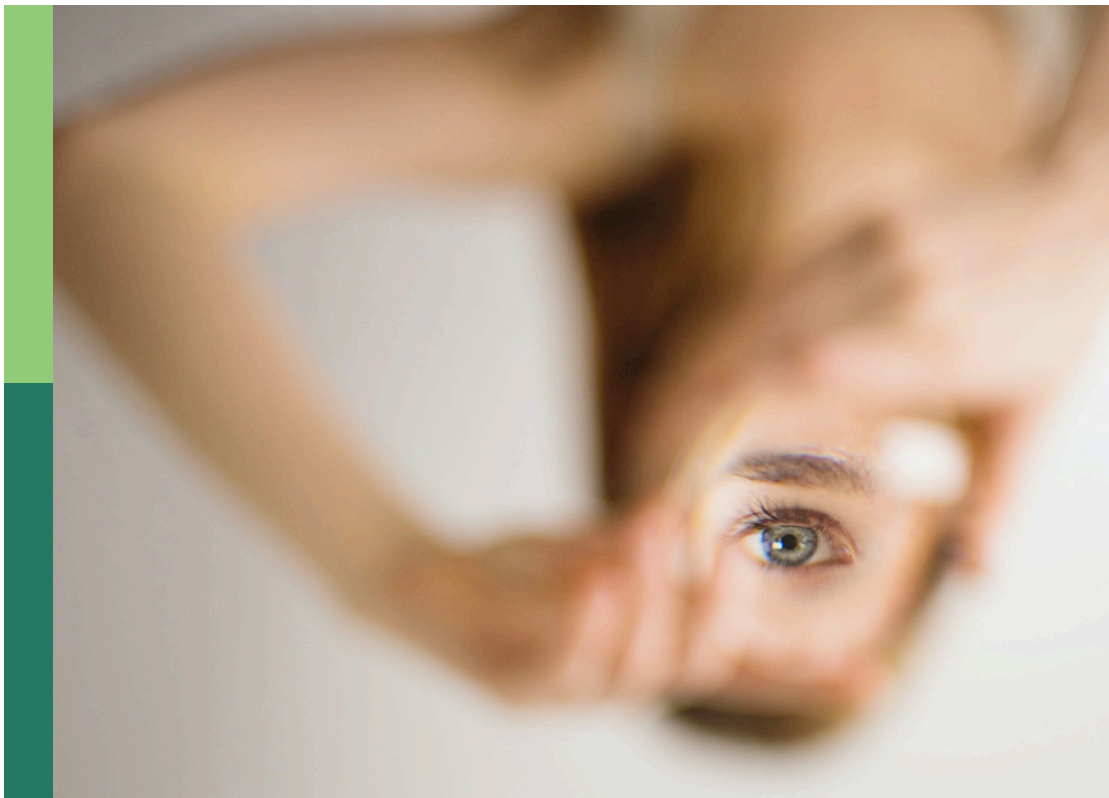

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Promoting teamwork in healthcare

Topic editors
Juliane E. Kämmer — University of Bern, Switzerland
Margarete Boos — University of Göttingen, Germany
Julia Carolin Seelandt — University Hospital Zürich, Switzerland

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EDITED AND REVIEWED BY
Darren C. Treadway,
Niagara University, United States

*CORRESPONDENCE
Juliane E. Kämmer
juliane.kaemmer@unibe.ch

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Editorial: Promoting teamwork in healthcare

Juliane E. Kämmer [1]*, Margarete Boos [2] and Julia C. Seelandt [3]

[1]Department of Emergency Medicine, University of Bern, Bern, Switzerland, [2]Institute for Psychology, Georg August University Göttingen, Göttingen, Germany, [3]Simulation Center, University Hospital Zurich, Zürich, Switzerland

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Editorial on the Research Topic
Promoting teamwork in healthcare

1 Introduction

Delivering healthcare is inherently collaborative, involving diverse teams across various stages of patient care, from *ad-hoc* emergency and anesthesia teams delivering immediate care to surgeries and tumor boards conferring on long-term cancer treatment (Lamb et al., 2011; Tschan et al., 2015; Choi et al., 2023). Thereby, quality of patient care hinges on the successful intra- and interprofessional collaboration among healthcare professionals, and sensitive interaction with patients and their families (World Health Organization, 2010; Committee on Diagnostic Error in Health Care et al., 2015; Graber et al., 2017). In particular, communication and coordination in healthcare teams are pivotal for team performance and patient safety (Tucker and Edmondson, 2003; Lingard, 2004; Salas et al., 2008; Manser, 2009; Künzle et al., 2010; Fernandez Castelao et al., 2013; Kolbe and Grande, 2013; Tschan et al., 2014). However, achieving effective teamwork is challenging, especially in large hospitals where turnover rates are high, and for interdisciplinary and interprofessional *ad-hoc* teams lacking ongoing collaboration experience (Pearce et al., 2006; Nemeth, 2008; St. Pierre et al., 2011; Fortune et al., 2012). Moreover, healthcare teams face intricate tasks, requiring rapid decision making amidst uncertainty and adaptability to evolving conditions (King et al., 2008; Nemeth, 2008; Fortune et al., 2012). Fostering research into promoting effective teamwork in healthcare stands to significantly enhance patient care quality.

To promote effective teamwork in healthcare, a number of important knowledge and practice gaps need to be closed. The 23 articles in this Research Topic contribute to advancing our understanding of determinants and mechanisms of effective teamwork in healthcare, identifying useful methods for studying teams, and enlarging our repertoire of best practices for promoting and training teamwork in healthcare (see Tables 1, 2). These articles are authored by researchers from countries including Germany, Israel, Sweden, Switzerland, the UK, China, and the USA.

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2 Overview on the articles in this Research Topic

One way of grouping the articles relates to the well-known and widespread input-process-outcome model of teamwork (Ilgen et al., 2005; Hackman, 2012), another is to group them along the methodical dimension. Providing a brief overview of variables and topics covered, Table 1 comprises our categorization based on these two taxonomies for the 13 articles that report primary empirical studies. Input variables considered in the studies range from member and team characteristics, diverse professional knowledge, skills and stereotypes, and task-based cognitive and emotional demands, to the experimental induction of communication training, simulation and E-learning. The articles focus on multiple process variables including e.g., learning activities, coordinative behavior, interaction with human and AI agents, speaking up behavior, and coping with stress. Output variables considered include e.g., team effectiveness and team skills, psychological safety, patient safety, as well as team wellbeing. The Research Topic comprises articles based on various kinds of data, ranging from questionnaire and interview data to observational data, and performance measures. Besides medical students, a large range of healthcare professionals participated in the studies, individually and as teams.

Table 2 contains the 10 contributions that focus on new methods and concepts. Topics range from presenting new measures for assessing interprofessional teamwork, to proposing conceptual frameworks aimed at improving interprofessional collaboration and education in healthcare, and advocating for diverse perspectives in researching healthcare team dynamics.

3 Discussion

As we move forward, three crucial next steps emerge, each essential for advancing our understanding and practice in this critical area.

Firstly, given the rapidly evolving nature of the healthcare domain, encompassing technological advancements, clinical research, and evolving work environments, research continually faces emerging research questions. To tackle these, leveraging insights from existing research in tandem with innovative methodologies is particularly promising. For example, the utilization of advanced technologies such as eye tracking, as delineated by Weiss K. E. et al., in the examination of human-AI teams (Bienefeld et al.), presents a novel approach to understanding attention dynamics within these teams. Additionally, integrating biophysiological process measures (Wespi et al.) with traditional observer ratings (e.g., Morian et al.) and self-reports (e.g., Kämmer et al., Schulz and Wirtz) offers potential for enriching our understanding of the multifaceted nature of teamwork across various levels. Furthermore, exploring alternative viewpoints such as the temporal or conflict-power-status perspectives, as advocated by Seelandt et al., is likely to yield valuable new insights.

Secondly, research and curriculum development must prioritize the provision of practically relevant insights and methods

TABLE 1 Overview of articles reporting primarily empirical studies.

Authors	3 keywords	Input variables	Process variables	Output variables	Study participants	Study design	Data type	Purpose	Results
Anselmann et al.	Team learning, knowledge sharing, psychological empowerment	Team member characteristics, team characteristics	Individual learning activities, team learning activities	Team effectiveness	Gerontological nurses in teams	Survey study	Questionnaire data	Investigated how individual learning activities influence knowledge sharing and nursing team effectiveness.	Individual learning activities enhance knowledge sharing, leading to improved team effectiveness.

(Continued)

TABLE 1 (Continued)

Authors	3 keywords	Input variables	Process variables	Output variables	Study participants	Study design	Data type	Purpose	Results
Bienefeld et al.	Human-AI teams, transactive memory, speaking up	Human vs. AI team member knowledge	Interaction with human vs. AI agents	Transactive memory, speaking up, team performance	Intensive care (ICU) human-AI-teams	Field study during simulation training	Observational and performance data	Examined the impact of transactive memory and speaking up in human-AI teams in simulated clinical scenarios.	Interaction with AI positively affects novel hypothesis generation and speaking up, but only in higher-performing teams. Conversely, reliance on human team members negatively affects novel hypothesis generation and speaking up, regardless of team performance.
Dietl et al.	Interprofessional intervention, psychological safety, interpersonal communication	Communication training, perceived psychological safety	Interpersonal communication	Perceived psychological safety, perceived team performance, perceived patient safety risks	Interprofessional teams from obstetric units	Intervention study	Questionnaire data	Examined the psychological mechanisms of a 4-hour communication intervention for healthcare teams aimed at enhancing patient safety and team performance perception by fostering psychologically safe environments and improving communication.	Perceived patient safety risks post-intervention were significantly decreased, whereas no significant changes in interpersonal communication or team performance perception were shown. Mediation analyses revealed interpersonal communication as a mediator between psychological safety and safety performances.
Gerbeth and Mulder	Work engagement, team learning behaviors, dealing with emotions	Amount of work, work pace, cognitive demands, emotional demands	Team learning behaviors, dealing with emotions in the team	Team members' work engagement	Members of interdisciplinary health and social care organizations	Survey study	Questionnaire data	Investigated how team behaviors, such as reflective activities, mediate the impact of work demands on engagement, considering cognitive and emotional dimensions.	Positive associations between work engagement, team learning behaviors, and dealing with emotions in the team were shown. Cognitive demands positively and emotional demands negatively influence work engagement, with team behaviors mediating these relationships.

(Continued)

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TABLE 1 (Continued)

Authors	3 keywords	Input variables	Process variables	Output variables	Study participants	Study design	Data type	Purpose	Results
Kämmer et al.	Teamwork quality, medical teams, team-based diagnosis	Different patient, physician and context factors		Perceived teamwork quality	Emergency physicians	Field study	Questionnaire data	Examined factors affecting perceived teamwork quality in a medical diagnosis setting, where a senior and junior physician team collaborate to diagnose a patient.	Patient case clarity and urgency positively affect perceived teamwork quality, while the level of experience the supervisor has negatively affects both supervisor and trainee perceptions, though to varying extents.
Kolbe et al.	Simulation, education, TeamSIM	Simulation training		Psychological safety, headline reflections, teamwork skills, reaction to TeamSIM	Third-year medical students	Intervention study	Observational and survey data	Developed and evaluated the feasibility of TeamSIM, a simulation-based teamwork training for medical students.	Positive student reactions and increased psychological safety were shown. Students' reflections highlight the effectiveness of the course content, and faculty members rated students' teamwork skills higher after the last compared to the first debriefing.
Körner et al.	Patient safety, error management, training	Blended learning vs. eLearning		Safety-related behaviors in the fields of teamwork, error management, patient involvement, and subjectively perceived patient safety	Interprofessional teams (mainly nurses and physicians) of different wards	Intervention study	Survey data and interview data	Introduced an Interprofessional Training Program (IPTP) employing eLearning and blended learning to enhance patient safety through innovative adult learning methods.	No consistent differences between groups or a clear pattern in safety-related behaviors in the fields of teamwork, error management, patient involvement, and subjectively perceived patient safety were found. Feasibility checks indicate barriers to eLearning participation but highlight increased awareness of patient safety with in-person training.

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TABLE 1 (Continued)

Authors	3 keywords	Input variables	Process variables	Output variables	Study participants	Study design	Data type	Purpose	Results
Schilling et al.	COVID-19, inter-professional teams, mental health	Social support, group identity, professional skills	Personnel's ability to work together and cope with pandemic stress	Delivery of care and staff wellbeing	Health care workers from ICU and those deployed to ICU/COVID wards	Field study	Interview data	Explored the COVID pandemic's impact on teamwork, social dynamics, and mental health among permanent and deployed healthcare workers.	The significance of social factors in teamwork and mental wellbeing, with deployed staff facing increased workload and diminished social support is revealed.
Sheffer Hilel et al.	Professional stereotypes, faultlines, leadership style	Professional stereotypes, team's faultlines	Leadership style	Team's quality of care	Interprofessional teams from geriatric long-term-care facilities	Survey study	Questionnaire data, EHR data on performance	Investigated the impact of professional stereotypes and leadership style on interprofessional team performance and care quality in geriatric long-term-care facilities.	Faultlines are not directly harmful but influence care quality when professional stereotypes emerge. High stereotype teams benefit from person-oriented championship leadership, while low stereotype teams are harmed by it.
Soukup et al.	Cancer multidisciplinary teams, multidisciplinary tumor boards, teamwork among the medical professions		Initiation and interactivity of interaction sequences		Members of MDT meetings in cancer care	Field study	Observational data	Examined MDT meeting dynamics in hospitals.	High interactivity with increased verbal dysfluencies in the latter half of MDT meetings was identified. Findings stress teamwork's critical role in meeting planning, addressing cognitive load, hierarchy, and integration of patient perspectives.

(Continued)

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TABLE 1 (Continued)

Authors	3 keywords	Input variables	Process variables	Output variables	Study participants	Study design	Data type	Purpose	Results
Timm-Holzer et al.	Teamwork in surgery, surgical checklist, intraoperative briefing		Timeout quality		Surgical teams	Intervention study	Observational data	Evaluated team timeout (TTO) quality pre and post StOP?-protocol implementation.	Post-intervention, team timeouts demonstrated higher completeness and engagement, better social atmosphere, and reduced noise, and were less rushed. Contrary to concerns, StOP?-protocols enhance TTO quality without inducing checklist fatigue, highlighting their positive impact on surgical team communication.
Wang et al.	Team functioning, multidisciplinary team, county-level hospitals		Retaining talent, task design, leadership	Team functioning	Hospital presidents, health care team leaders	Field study	Interview data	Examined critical factors shaping team performance from the perspective of leaders in healthcare organizations.	Factors comprise being "stuck in the middle", local dynamics, talent recruitment hurdles, task focus, and leadership styles. Interventions target talent retention, restructuring of teams, and enhancing collaboration through training.
Weiss M. et al.	Voice/speaking up, psychological safety, team perception	Psycholgical safety	Voice/speaking up	Evaluation of voice as helpful vs. not	Emergency medicine nurses and physicians	Experimental study	Questionnaire data	Examined the impact of nurses voicing work-related concerns on team perception, considering the role of psychological safety.	When psychological safety is high, nurses' input is valued more for team decision-making compared to situations with lower psychological safety.

EHR, electronic health record; ICU, intensive care unit; MDT, multi-disciplinary team.

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TABLE 2 Overview of articles reporting method and concept developments.

Authors	3 keywords	Development of method or concept	Target readers	Purpose	Results
Fernández Castillo	Team science, team communication, team coaching	Concept	Healthcare professionals, educators, trainers, team researchers	Build upon ten observations in healthcare team science, emphasizing communication's significance and addressing challenges like accountability and conflict management.	The authors underscore thriving research in interprofessional collaboration, highlighting its evolving understanding and how it boosts teamwork across practitioners' careers.
Kauff et al.	Medical education, intergroup contact, social identity	Concept	Educators, trainers, curriculum developers	Advocate integrating interprofessional education into health-related study programs to address healthcare complexity.	The perspective article emphasizes competency cultivation and fostering diversity appreciation in interprofessional education.
Lia et al.	Intraoperative teamwork, tone, team dynamics	Concept	Team researchers	Propose "tone" as a key factor for understanding team dynamics, linking it to culture, shared mental models, and psychological safety.	The paper provides insights into intraoperative teamwork by elucidating the interplay among culture, shared mental models, and psychological safety.
Morian et al.	Distributed team, team performance, instrument	Method	Distributed emergency teams, team researchers	Investigate the validity, reliability and applicability of the Team Emergency Assessment Measure (TEAM) in distributed healthcare teams.	Report good reliability and validity of the TEAM in distributed acute-care team settings.
Paquette et al.	Perioperative handoffs, teamwork training, patient safety, care coordination, implementation challenges	Method	Educators, trainers	Highlight the risks associated with perioperative handoffs, stressing the importance of teamwork to mitigate miscommunications and ensure patient safety.	Their perspective article underscores the need to address challenges in implementing effective teamwork training programs, emphasizing evidence-based practices.
Schulz and Wirtz	Woman-centered care, interprofessional collaboration, midwifery care	Method	Interprofessional teams, team researchers	Analyzed midwives' perspectives on interprofessional care during pregnancy, birth, and postnatal periods, adapting the Interprofessional Collaboration Scale (ICS).	Report good construct validity in the revised ICS-R.
Seelandt et al.	Research perspectives, team dynamics, interdisciplinary perspectives	Concept	Team researchers	Advocate for diverse perspectives in researching healthcare team dynamics, analyzing a heart surgery team interaction through five lenses.	The paper concludes by suggesting further research avenues and emphasizing the advantages of diverse approaches in healthcare analysis.
Weiss K. E. et al.	Eye tracking, pose estimation, feedback	Method	Medical simulation trainers, team researchers	Utilized minimally invasive video-based technologies like eye tracking and pose estimation to measure teamwork in healthcare simulation training with medical students.	The authors emphasize the potential of these objective metrics in creating visualizations of team interactions, stressing the need for further research.

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TABLE 2 (Continued)

Authors	3 keywords	Development of method or concept	Target readers	Purpose	Results
Wespi et al.	Objective process measures, medical simulation training, team performance assessment	Concept, method	Medical simulation trainers, team researchers	Explore the potential of the use of objective measures for evaluating team performance for research and training purposes by conducting expert interviews.	Identify various potential objective measures including acoustical, visual, physiological, and endocrinological measures. Highlight the opportunities and challenges (e.g., feasibility, complexity, cost, and privacy concerns) of assessing healthcare team performance using objective process measures.
Witti et al.	Conceptual framework, healthcare education, interprofessional collaboration	Concept	Team researchers, educators, trainers, curriculum developers	Present FINCA, a conceptual framework aimed at improving interprofessional collaboration in healthcare education and practice with key variables and activities essential for problem-solving competency among healthcare professionals.	The framework aims to support curriculum development, assessment of outcomes, and foster interprofessional problem-solving skills across healthcare settings.

to prepare practitioners for one of the biggest challenges in healthcare: interprofessional collaboration. The Team FIRST framework identifies 10 essential teamwork competencies for healthcare providers (Greilich et al., 2023) that could guide further research in real-world settings. Another approach toward this goal involves tailoring research designs and samples to reflect the interprofessional reality, for instance by involving diverse members of surgical teams with different backgrounds (e.g., Timm-Holzer et al.). Additionally, conducting more field and observational studies, as demonstrated by Schilling et al.'s field study during the COVID-19 pandemic or Soukup et al.'s investigation of real-life cancer multidisciplinary team meetings, proves essential. It is also imperative to validate findings from the laboratory in practical settings, exploring the boundary conditions of existing findings and methodologies in diverse environments and adopting a condition-focused approach (Hackman, 2012). For instance, Fernández Castillo et al. emphasized that more communication may not invariably lead to improved outcomes; instead, contextual factors influence the value of communication, which need to be scrutinized in further research.

Lastly, ensuring the accessibility of research findings and knowledge for interprofessional education is essential for preparing the next generation of healthcare professionals. While this Research Topic showcases innovative developments in interprofessional education (e.g., Körner et al., Kolbe et al., Witti et al.), the focus should now shift toward increasing the accessibility of educational materials and resources. This could range from publishing open-access materials alongside research articles, as done by Körner et al., to establishing platforms dedicated to sharing interprofessional training materials and curricula (e.g., https://www.did-act.eu, https://did-act.instruct.eu/course/view.php?id=3), such as virtual patient case collections (e.g., https://icovip.eu/) and the initiative Behavioral Science Applied to Healthcare (BSAH; Keller et al., 2024). By making such resources readily available, we can empower healthcare professionals with the necessary skills and knowledge to effectively collaborate across disciplines, ultimately enhancing teamwork and patient outcomes.

By embracing these challenges and opportunities, we can further enhance our understanding and practice of effective collaboration in healthcare settings, ultimately leading to improved patient care quality and outcomes.

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JK: Conceptualization, Writing – original draft, Writing – review & editing. MB: Conceptualization, Writing – original draft, Writing – review & editing. JS: Conceptualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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EDITED BY
Nicola Mucci,
University of Florence,
Italy

REVIEWED BY
Lauren E. Benishek,
Johns Hopkins Medicine,
United States
Jayoung Park,
Seoul National University,
Republic of Korea

*CORRESPONDENCE
Simone Ehrhard
✉ Simone.Ehrhard@insel.ch

†These authors have contributed equally to this work and share first authorship

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What factors affect team members' evaluation of collaboration in medical teams?

Juliane E. Kämmer[1†], Simone Ehrhard[1*†], Olga Kunina-Habenicht[2], Sabine Weber-Schuh[1], Stefanie C. Hautz[1], Tanja Birrenbach[1], Thomas C. Sauter[1] and Wolf E. Hautz[1]

[1]Department of Emergency Medicine, Inselspital, University Hospital Bern, University of Bern, Bern, Switzerland, [2]Psychological Assessment, TU Dortmund University, Dortmund, Germany

Introduction: Perceived teamwork quality is associated with numerous work-related outcomes, ranging from team effectiveness to job satisfaction. This study explored what situational and stable factors affect the perceived quality of teamwork during a specific team task: when a medical team comprising a senior (supervisor) and a junior (trainee) physician diagnoses a patient.

Methods: During a field study in an emergency department, multisource data describing the patients, the diagnosing physicians, and the context were collected, including physicians' ratings of their teamwork. The relationships between perceived teamwork quality and situational (e.g., workload) and stable (e.g., seniority) factors were estimated in a latent regression model using the structural equation modeling (SEM) approach.

Results: Across the N = 495 patients included, SEM analyses revealed that the patient-specific case clarity and urgency influenced the perceived teamwork quality positively, whereas the work experience of the supervisor influenced the perceived teamwork quality of both supervisor and trainee negatively, albeit to different degrees.

Discussion: Our findings shed light on the complex underpinnings of perceived teamwork quality, a performance-relevant factor that may influence work and organizational effectiveness in healthcare settings.

KEYWORDS

collaborative decision making, perceived teamwork quality, healthcare teams, structural equation modeling, supervisor–trainee relationships

1. Introduction

Teamwork has been repeatedly identified as the number one global workforce trend, spanning domains such as law, health care, engineering, and science (Edmondson, 2012; Deloitte Insights, 2019). In companies, for example, multidisciplinary or cross-functional teams often collaborate during product development and innovation projects (Hoegl and Praven Parboteeah, 2003; Dayan and Di Benedetto, 2009). In health care, teamwork occurs across the continuum of medical care, such as when a team of health-care professionals together with the patient and their family engage in finding the correct diagnosis or

deciding on a treatment (Committee on Diagnostic Error in Health Care et al., 2015). Reasons for this trend include increased specialization, constant changes in work environments, and increasingly complex problems that cannot be solved by single experts alone but instead demand cross-disciplinary and interprofessional collaboration. It is therefore not surprising that team performance is linked to organizational success (Hoegl and Gemuenden, 2001; Dayan and Di Benedetto, 2009; Manser, 2009; Kozlowski and Bell, 2013; Schmutz and Manser, 2013). Yet, where collaboration and coordination are crucial, failures in teamwork can have detrimental consequences. For example, communication breakdown is one of the most common causes of adverse events in medicine, including diagnostic errors (Risser et al., 1999; Manser, 2009). Diagnostic error is a particularly common, enormously harmful, and extremely costly type of medical error, constituting not only an individual but also a societal burden (Hautz et al., 2019; Hautz, W. E. et al., 2020).

Research on the determinants of successful teamwork has flourished over the last decades (Mathieu et al., 2017) and has proven its relevance to organizational performance by, for example, informing the development of theory-based team trainings (Salas et al., 2008) or identifying successful coordination behaviors (Schmutz et al., 2015). Following established taxonomies (e.g., Hoegl and Gemuenden, 2001; Salas et al., 2005), we define teamwork as a higher order construct encompassing a number of different facets such as coordination, communication, and leadership. *Objective* team performance can be distinguished from *subjective* teamwork quality, but these aspects are correlated such as when better perceived teamwork quality is related to better quality of care (Manser, 2009; Berry et al., 2020). Whereas objective team performance can be assessed by trained raters who observe team behaviors (e.g., Kolbe and Boos, 2019); subjective/perceived teamwork quality can be assessed by asking team members about their perceptions or evaluations (Hoegl and Gemuenden, 2001). In this study, we focused on *perceived* teamwork quality for two reasons. First, eliciting team perceptions is an efficient means of gaining insight into teamwork when the assessment of teamwork through observations is impractical or impossible; second, team perceptions are also a team outcome in their own right, which may in turn influence more distal variables (Mathieu et al., 2008). For example, favorable perceptions of teamwork have been shown to be positively related to job satisfaction and well-being, as well as reduced staff turnover (Dechairo-Marino et al., 2001).

An important finding of research into perceived teamwork quality is that perceptions of teamwork vary with position in the organizational hierarchy (Hautz, S. C. et al., 2020), seniority (Fleming et al., 2006), discipline (Ummenhofer et al., 2001), and professional group (Temkin-Greener et al., 2004). For example, studies in health care have found that physicians consistently rate the quality of teamwork higher than nurses do (Flin et al., 2006; Makary et al., 2006; Wauben et al., 2011; Tang et al., 2013; Müller et al., 2018). Yet, despite the empirical evidence of divergent teamwork perceptions, only a few studies have examined the underlying reasons for the observed differences. Possible reasons that have been discussed include that expectations (Frasier et al., 2017), communication styles (Jones and Durbridge, 2016), and stereotypes (Lingard et al., 2005; Kämmer and Ewers, 2021) vary with roles and profession—and hence shape perceptions. In addition, even though teams have a shared team goal, subtasks likely vary by role and profession and may thus influence the perceived strain (Keller et al., 2021) and perspective on the overall teamwork quality. For example, in a study of team performance in the emergency room, residents (i.e., junior doctors) were found to feel particularly stressed (Ummenhofer et al., 2001); similarly, trainee surgeons were particularly affected by tension in their team's communication (Lingard et al., 2002).

Most of these reasons pertain to rather stable person-specific factors (e.g., position in the organizational hierarchy, seniority; Müller et al., 2018); less is known about situational factors that affect the perception of teamwork during a specific team event. Previous research suggests that perceptions of teamwork quality in general may be influenced by factors other than perceptions of teamwork quality in a specific team event, resulting in differences between general survey studies and studies of single team events (Müller et al., 2018). Also, from an organizational perspective, situational factors are particularly interesting because they are partially modifiable and can be changed if necessary.

The purpose of this study was thus to explore what situational and stable factors affect the perceived quality of teamwork during a specific team task, that is, when diagnosing and treating a single patient. One reason for investigating situational factors is the practical implication: Whereas stable factors such as hierarchy and seniority cannot be influenced, situational factors such as noise are (partially) modifiable and can be changed if they turned out to have a detrimental effect on teamwork or performance. Another reason is that there is an imbalance in the evidence base concerning which factors impact teamwork perceptions, lacking the variety of possible influencing factors such as situation-specific ones. Therefore, we conducted an exploratory analysis of data collected during a field study in an emergency department (ED), where we obtained ratings of teamwork quality from the medical team members for each patient they diagnosed and treated (Hoegl and Gemuenden, 2001). The ED is a task-oriented environment, in which team members share a common goal (i.e., treating a patient) and work highly interdependently in *ad-hoc* teams.

We focus on the core-team of senior/attending physician and junior/resident physician who work together in an apprenticeship model as supervisor (i.e., senior physician) and trainee (i.e., junior physician), a constellation that is common in many educational settings in the workplace. The trainee usually attends to a patient first, takes the patient's history, conducts a physical exam and orders initial diagnostic tests before reporting to the supervising fully licensed physician. Together, they then analyze available diagnostic test results and decide on additional tests before ultimately settling on a diagnosis and initiating treatment. Of course, this general procedure varies in accordance with numerous factors including the urgency of the patient's condition and the trainee's skills.

In sum, we had two research questions: (1) Do supervisors and trainees differ in their perceptions of teamwork quality? (2) What factors influence team members' perceptions of teamwork quality? To obtain a comprehensive picture of factors that might impact the individual team member's perceptions, we collected data on various variables that count as "input" factors in classic input–process–output models of team effectiveness (McGrath, 1964; Ilgen et al., 2005; Mathieu et al., 2008), including patient, physician, and context factors (Durning et al., 2012).

2. Materials and methods

2.1. Study design

This study is an exploratory secondary analysis of a data set obtained in the cDx (change in diagnosis) study, a prospective, observational cohort study of diagnostic decision making in the ED of a university-affiliated tertiary care hospital in Switzerland (Hautz et al., 2016a, 2019). In this study, data on patients, physicians, and context factors were prospectively collected for all non-vitally threatened ED patients aged 18 or older who were hospitalized from the ED to any internal medicine ward in a 4-month period.

The ED where the study took place is a self-contained interdisciplinary unit and sees more than 45,000 patients each year (Exadaktylos and Hautz, 2015). This study setting was chosen for three reasons: (1) We aimed at including healthcare teams with a diverse level of acquaintance (from well-known to completely new), which is more likely to occur in larger hospitals; (2) we wanted to make sure that collaboration happened face-to-face, which effectively requires larger settings where senior physicians are physically present around the clock; and (3) we expected to achieve a larger participation rate because both physicians and patients in a university-affiliated hospital are more used to taking part in research projects and would thus be more willing to participate in the study.

2.2. Data collection

Prior to patient recruitment, all ED physicians were invited to participate in the study and asked to provide demographic and professional data including on age, gender, extent of work experience (i.e., years of work experience since graduation and in emergency medicine in particular), professional background (specialization, e.g., internal medicine), and current position (i.e., junior or senior physician). After admission of each patient to a medical ward, the treating ED junior and senior physician were asked to individually fill in a questionnaire that enquired about physician factors (i.e., confidence in diagnosis, familiarity with similar cases, ease of the diagnostic process), patient factors (atypical/typical presentation), and our dependent variable, teamwork quality (frequency of collaboration in the past and quality of collaboration with the other physician during this case). All items fit on a single page to help in obtaining a high response rate (see Table 1; Hautz et al., 2016b for original questionnaires). We employed a code-generation instruction on every questionnaire that ensured that all questionnaires could be associated with the person who filled it in while at the same time protecting the respondents' anonymity. Participating physicians received compensation of 10 Swiss francs (approximately $10.05 at the time of data collection) for each completed questionnaire.

Patients' medical data (e.g., triage, treatment in resuscitation bay) were extracted from the ED's electronic health record. The latent factor for the objective workload was measured by indicators for noise and the National Emergency Department Overcrowding Scale (NEDOCS; Weiss et al., 2004). The level of noise was measured by continuously logging noise levels in decibels at the physicians' workplace in the ED with a sound meter (HD600, Extech Instruments, Nashua, New Hampshire). The objective workload was measured with the NEDOCS in intervals of 15 min (for details see Weiss et al., 2004, 2006). Across each patient's length of stay in the ED, the respective average and peak noise and NEDOCS levels were calculated.

2.3. Statistical analyzes

Descriptive analyzes were conducted with R software for statistical computing (Version 4.1.1) and IBM SPSS (Version 21). Structural equation modeling (SEM) analyzes were conducted with the statistical software Mplus 8.0 (Muthén and Muthén, 1998, 2010) using the weighted least square mean and variance adjusted (WLSMV) estimator, which was developed for categorical and ordinal indicator variables. As model fit indices, we report the comparative fit index (CFI) and root-mean-square error of approximation (RMSEA) in addition to the χ^2 value. These measures of fit were included because the χ^2 value depends on sample size, where even small amounts of misfit can lead to significant χ^2 values when sample sizes are moderate to large (Chen, 2007). As a rule of thumb, a ratio of the χ^2 value to the number of degrees of freedom smaller than 2 indicates a good model fit. For RMSEA, values smaller than 0.05 reflect a good fit and values between 0.05 and 0.08 an adequate fit. For CFI, values of 0.90 or higher are considered a satisfactory fit, and values above 0.95 are considered an excellent fit (Hu and Bentler, 1999). Missing data were considered during the model estimation as a default option in Mplus by using the WLSMV estimator that uses pairwise present data (Asparouhov and Muthen, 2010).

In SEM, we postulated a latent regression model with several latent factors (Table 1): *physician professional experience*, *case clarity*, *case urgency*, *workload*, and *perceived teamwork quality*. Age and postgraduate experience overall and in emergency medicine specifically were used to generate the latent factor *professional experience*. The latent factor *case clarity* was modeled using the indicators diagnostic confidence, familiarity with symptoms, perceived ease of the diagnostic process, and whether the patient presentation was perceived as typical or atypical. The latent factor *case urgency* was modeled using the indicators triage category, treatment in a resuscitation bay, and mortality of the

TABLE 1 Overview of collected data and how they were summarized into latent factors.

Factor	Measure	Values	Latent factor in the SEM
Physician factor	Age	Number of years	Physician professional experience
	Work experience (total)	Number of years	
	Work experience in ED	Number of years	
	Confidence in diagnosis	1 *unconfident* – 5 *confident*	Case clarity
	Familiarity with similar cases	1 *never encountered* – 5 *familiar*	
	Ease of the diagnostic process	1 *difficult* – 5 *easy*	
	Perceived presentation of patient	0 *atypical*, 1 *typical*	
Patient factor	Triage category	1 *treated immediately by a physician*	Case urgency
		2 *treated within 20 min by a physician*	
		3 *treated within 120 min by a physician*	
		4 *not an urgent treatment situation*	
		5 *follow-up check*	
	Treated in resuscitation bay	0 *not in resuscitation bay*, 1 *in resuscitation bay*	
	Mortality	0 *alive*, 1 *dead*	
Context factor	Noise (SD)	Standard deviation of noise in intervals of 15 min, averaged across the time the patient spent in the ED	Objective workload
	Noise (max)	Peak noise in intervals of 15 min, averaged across the time the patient spent in the ED	
	Objective workload during diagnostic process (SD)	Standard deviation of NEDOCS in intervals of 15 min, averaged across the time the patient spent in the ED	
	Objective workload during diagnostic process (max)	Maximum value of NEDOCS in intervals of 15 min, averaged across the time the patient spent in the ED	
Team factor	Perceived quality of collaboration with the other physician	1 *was alone* – 5 *very good*	Quality of teamwork (dependent variable)
	Frequency of collaboration with the other physician in the past	1 *rarely* – 5 *very often*	

ED, emergency department; NEDOCS, National Emergency Department Overcrowding Scale (Weiss et al., 2004); SEM, structural equation modeling.

patient. *Objective workload* was captured in a separate latent factor by considering the standard deviation and maximum values of the NEDOCS and noise level at the physician's workstation. We included both measures because it is unclear whether it is the peak load that most impairs performance or whether it is the load variation. To account for both options, both variables were included as indicators into the model. The latent factor *perceived teamwork quality* was modeled by the indicators quality of interaction and quantity of collaboration (Table 1). Because familiarity fosters teamwork (Hayes, 2014), frequency of collaboration may also contribute to perceived teamwork quality and was therefore included in the latent factor. The latent factors physician professional experience, case clarity, and perceived teamwork quality were modeled separately for junior and senior physicians because they may differ between team members. In the latent regression model, we postulated that the perceived teamwork quality can be explained by the following latent predictors: *physician professional experience*, *case clarity*, *case urgency*, and *workload*. We allowed for correlations between all these predictors.

2.4. Ethics statement

Patient data were collected during usual care in the ED and internal medicine ward. No additional patient data were collected for this study. Physicians participated on a voluntary basis. Anonymity of participants, both patients and physicians, was maintained at all times by pseudonymizing physician and patient data. The local ethics committee of the Canton of Bern registered the study as a quality assessment study under KEK No. 197/15 and waived the need for informed consent. The study protocol was previously published (Hautz et al., 2016a).

3. Results

In total, 55 physicians took part in the study and provided 644 questionnaires for 495 patients (65.6% of the total study population of the cDx study; for detailed patient demographics see Supplementary Table S1). For 149 patients, two questionnaires were available, filled in by the junior and senior physician; for 346

patients, only one questionnaire from either the junior or the senior physician was available.

3.1. Descriptive results

Of the 50 participating physicians in the final sample, 35 were junior physicians (M_{age} = 31.1 years, 60.0% female, mean postgraduate work experience 3.88 years) and 15 were senior physicians (M_{age} = 40.7 years, 53.3% female, mean postgraduate work experience 11.07 years). Descriptive characteristics for participating physicians are shown in Table 2.

3.2. Questionnaire analyzes

Junior physicians provided questionnaires for 414 patients and senior physicians for 230 patients, with an overlap of 149 patients. As shown in Table 3, junior and senior physicians provided on average intermediate to high ratings concerning their confidence in their diagnoses, familiarity with similar cases, and the ease of the diagnostic process. In more than 70% of cases, junior and senior physicians rated their patients' presentation as typical for the diagnosis made. With regard to teamwork, both junior and senior physicians rated their teamwork as of high quality (M_{junior} = 4.35, SD = 0.88, M_{senior} = 4.43, SD = 0.69) and the frequency of their collaboration as high (M_{junior} = 4.05, SD = 0.98, M_{senior} = 4.12, SD = 0.91). No significant differences between junior and senior physicians in any of these ratings were revealed (Table 3).

TABLE 2 Descriptive statistics for participating physicians (N=50).

Physician characteristic	Junior physicians	Senior physicians
N (%)	35 (70.0)	15 (30.0)
Age (years), mean (SD)	31.1 (2.67) (37% missing)	40.7 (3.73) (75% missing)
Gender, *n* (%)		
Male	13 (37.1)	6 (40.0)
Female	21 (60.0)	8 (53.3)
Unknown	1 (2.8)	1 (6.7)
Work experience total (years), mean (SD)	3.88 (1.63) (22.9% missing)	11.07 (2.86) (53.3% missing)
Work experience in ED (years), mean (SD)	1.33 (1.12) (22.8% missing)	4.93 (2.95) (53.3% missing)

ED, emergency department.

3.3. Latent regression model

The final SEM (Figure 1) revealed a very good model fit (N = 495; χ^2 = 387.787; df = 244; p < 0.001; CFI = 0.953; RMSEA = 0.035). Whereas in the measurement models, all regression loadings were significant (p < 0.011), in the structural part of the model, only some of the latent predictors significantly contributed to the prediction of perceived teamwork quality. For the sake of clarity, only the significant correlations between predictors are shown in Figure 1.

The results showed that junior and senior physicians largely agreed in their ratings of case clarity (r = 0.62). For senior physicians, among the predictors, only their own work experience and case urgency significantly contributed to the prediction of their perceived teamwork quality (R^2 = 44.5%). Whereas case urgency was positively related to the perceived teamwork quality (r = 0.22), we found a negative regression coefficient (r = −0.62) for the experience of the senior physician, meaning that higher experience of the senior physician negatively affected the teamwork quality perceived by him or her.

For junior physicians, their perceived teamwork quality could be explained by the experience of the collaborating attending physician and their own perceived case clarity, whereas all other predictors were not significant (R^2 = 16.5%). Specifically, the experience of senior physicians was also negatively associated with the teamwork quality perceived by the junior physicians (r = −0.23), but this relation was less pronounced than it was for senior physicians. Moreover, for junior physicians, we found a significant positive regression coefficient for case clarity (r = 0.25),

TABLE 3 Descriptive statistics of questionnaire data.

Measure	Questionnaires of junior physicians	Questionnaires of senior physicians	*t*-test results
	M (SD)	*M* (SD)	
Confidence in diagnostic accuracy	3.88 (1.18)	3.82 (0.95)	$t(560) = -0.644$, $p = 0.520$
Ease of the diagnostic process	3.48 (1.22)	3.43 (1.02)	$t(548) = -0.585$, $p = 0.559$
Familiarity with a case	3.94 (1.07)	4.03 (0.93)	$t(528) = 1.099$, $p = 0.272$
Case is typical	0.70 (0.46)	0.72 (0.45)	$t(480) = 0.507$, $p = 0.613$
Quality of teamwork	4.35 (0.88)	4.43 (0.69)	$t(571) = 1.35$, $p = 0.178$
Frequency of collaboration	4.05 (0.98)	4.12 (0.91)	$t(501) = 0.891$, $p = 0.373$

N = 414 junior physician questionnaires; N = 230 senior physician questionnaires. No missing data.

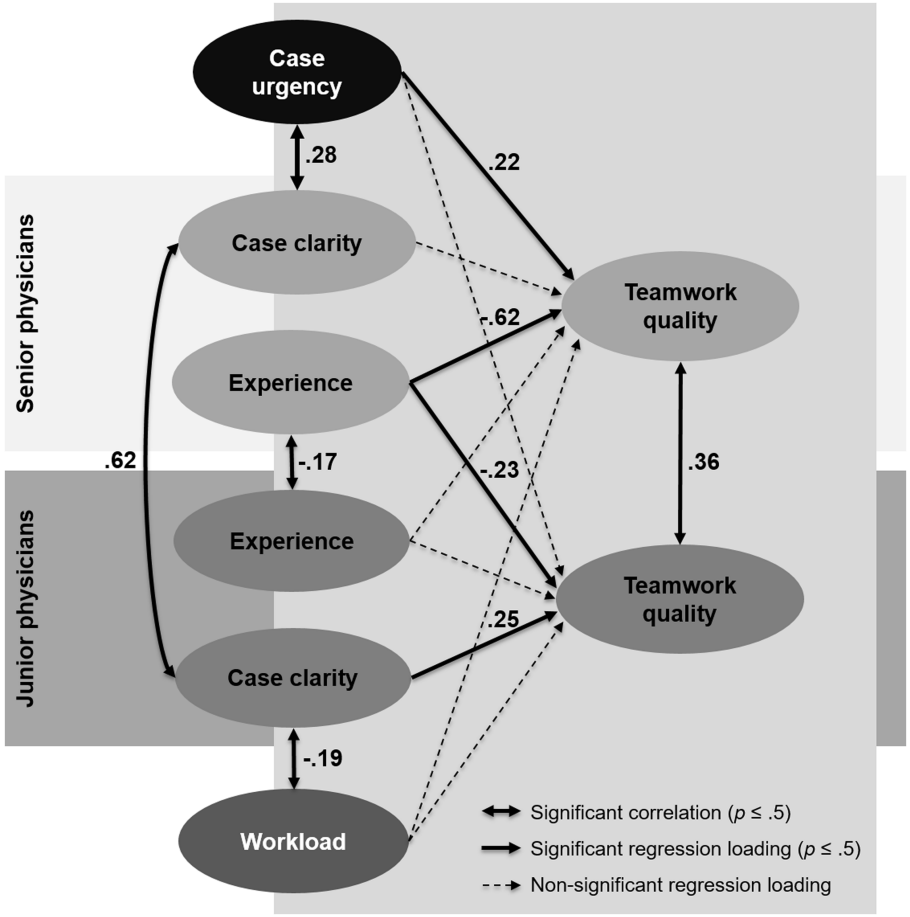

FIGURE 1
Relations of patient, physician, and context factors, as analyzed with a structural equation model.

meaning that higher case clarity was related to higher perceived teamwork quality.

After the latent regression, a positive residual correlation still remained between the latent factors perceived teamwork of senior physicians and the perceived teamwork of junior physicians ($r = 0.36$), meaning that these two factors still had some variance in common that was not covered by the predictors included in the model. Another interesting result was that for the senior physicians, case urgency was positively related to perceived case clarity ($r = 0.28$), whereas for junior physicians, the perceived case clarity was negatively correlated with objective workload ($r = -0.19$). Complete results can be seen in the Mplus output file in our OSF repository (Kämmer et al., 2022).

4. Discussion

"Teamwork [is] in the eye of the beholder" (Makary et al., 2006, p. 746)–a number of studies have revealed, and these teamwork perceptions are an important factor that may influence individual, team, and organizational effectiveness (Dechairo-Marino et al., 2001; Manser, 2009; Kristensen et al., 2015; Berry et al., 2020). We have extended previous research by not only exploring perceptions of teamwork quality in a team setting that is common in many educational settings, namely, the team of trainee (i.e., junior physician) and supervisor (i.e., senior physician) diagnosing and treating patients in the ED, but also using SEM analyzes to investigate the role of situational and stable factors underlying these perceptions to generate new hypotheses. Also, we provide insights based on field data, thus addressing the demand for more studies of teams "in the wild" (Salas, 2008).

Our explorative analyzes of survey field data revealed highly positive evaluations of teamwork by supervisors *and* trainees. Additional SEM analyzes showed that these perceptions were mainly driven by the case-specific clarity and urgency, and the supervisor's work experience.

The situational factors that determined perceived teamwork quality were case clarity and case urgency: the clearer the diagnosis (for trainees) and the more urgent the treatment (for supervisors), the better was perceived teamwork. We suspect that both these

aspects helped the team know what to do and thus facilitated coordination between members and hence (perceived) teamwork quality. For case urgency, the rationale is that patients who arrive in critical condition and require urgent treatment often have more pronounced symptoms and are treated according to specific medical algorithms, such as when resuscitation is required. Also, at least in the ED under investigation, critically ill patients are always initially examined and treated jointly by the junior and senior physician together. In these situations, the junior is closely supervised and decisions regarding patient management are made directly at the bedside by the team. This may result in less cognitive load and a clearer coordination process compared to treating less urgent patients with, for example, nonspecific symptoms. The positive correlation between case clarity and case urgency (for senior physicians) supports this explanation. In contrast, less critically ill patients are—for educational reasons—usually initially assessed by the junior physician alone, who then discusses the case with the senior physician (who is always responsible for the final decisions). This often requires a more complex clinical reasoning process on behalf of the trainee and the supervisor. More generally, we would suggest that these observations indicate a moderating effect of task type and complexity on *perceived* teamwork quality. Follow-up research on this notion would extend prior theoretical and empirical work on the impact of the task type on *objective* team performance and behavior (Antoni and Hertel, 2009; Tschan et al., 2011; Schmutz et al., 2015).

Interestingly, although supervisors and trainees largely agreed in their judgment of case clarity, trainees' judgments were negatively impacted by workload, but not supervisors' judgments. In other words, trainees judged a case to be less clear, the louder and more crowded it was around them. We would thus hypothesize that everything that helps render the case clearer and reduces the cognitive load, such as clear instructions, reduced noise, structured communication with the supervisor, or feedback, may facilitate teamwork for trainees.

The stable factor that determined perceived teamwork quality (negatively) was the supervisor's work experience: the more experienced the supervisor was, the less positive was perceived teamwork quality, for both trainees and (to a larger extent) supervisors. One explanation for this could be a greater professional disparity as a consequence of more work experience. With more experience, senior physicians may develop higher expectations of their trainees concerning what the trainees should know and do, and more nuanced conceptualizations of teamwork. If these expectations are then not met (from the perspective of the senior physician) or are perceived as too high (from the perspective of the junior physician), this could have a negative impact on the assessment of the quality of collaboration of both parties. Also, it is known from studies with interprofessional teams that different rationalities and priorities of team members may result in communication and coordination problems (Kvarnström, 2008; Rydenfält et al., 2012). To explore this question further, future research should investigate supervisors' and trainees' expectations of each other and their conceptualizations of teamwork, their respective roles, and tasks (Sebok-Syer et al., 2018; Rydenfält et al., 2019). If these turn out to be very different, informing both parties about each other's expectations may help decrease misunderstandings and increase mutual empathy (Ebert et al., 2014) and ultimately enhance individual and team effectiveness.

Taken together, our findings have methodological, theoretical, and practical implications. On theoretical grounds, our findings shed light on the complex structure underlying perceptions of teamwork quality, which, at the same time, call for further research. Methodologically, the finding that the same factors may affect supervisors' and trainees' ratings of teamwork to different degrees suggests caution when attempting to compare or aggregate team members' ratings of teamwork quality, even when ratings of teamwork do not differ in their numerical value (Tscholl et al., 2015; Sebok-Syer et al., 2018). Practically, the same finding is informative for educators and practitioners who need to decide on the necessity of organizing a debriefing or after-action review (Jarrett et al., 2016; Weiss et al., 2017) after a team event or on ways to (re)design workplace-based settings and processes; given our findings, it seems indicated to collect ratings of all participating members and not just those of the seniors or leaders (see also Hautz, S. C. et al., 2020).

4.1. Limitations

This study has several limitations. First, our results are based on cross-sectional data and therefore do not allow for causal interpretations. Second, because the ratings of teamwork quality were in general very positive, it is likely that there is a ceiling effect and thus the variance of those ratings is shrunk. This, in turn, may have led to an underestimation of the parameters in the regression analysis. Third, additional contextual and relationship factors such as psychological safety, team cohesiveness (Bravo et al., 2019), trust (Wang et al., 2019), autonomy (van Mierlo et al., 2006), cognitive load (Durning et al., 2012), and leadership style may also affect perceptions of teamwork and should be measured in future studies (Olson et al., 2020). Fourth, a limitation can be seen in our use of a two-item measure to capture teamwork quality. Despite its advantage of being short and despite evidence of the general suitability of single-item measures to capture overall concepts (Postmes et al., 2013; Müller et al., 2018), our measure may have captured only the collaboration dimension of teamwork, excluding other processes such as coordination or communication (Hoegl and Gemuenden, 2001; Rousseau et al., 2006; Reeves et al., 2018). In other contexts where time is less scarce than in an ED, it might be feasible to use longer measurement tools of teamwork quality (e.g., Shortell et al., 1991; Hoegl and Gemuenden, 2001; Temkin-Greener et al., 2004; Keebler et al., 2014) to understand how the method used to measure teamwork quality impacts results. It seems unlikely, however, that the interpretation of what a certain item is intended to measure varies systematically between supervisors and trainees. We would thus argue that this limitation can hardly cause the effects observed here.

4.2. Conclusion

To improve workplace culture and team effectiveness, research into the attitudes, perceptions and evaluations of personnel is relevant (c.f. Ummenhofer et al., 2001). For understanding the dynamics of work environments, it is important to take into account the organizational, physical and social context factors under which teams work (Reason, 2000). Here, we examined stable and situational factors that may influence team members' assessments of teamwork quality when collaborating in a high-risk setting. Three factors turned out to have a major impact on teamwork perceptions, though to different degrees, depending on the role of the member as either supervisor or trainee: case clarity, case urgency, and supervisor's work experience. Our insights into the complex underpinnings of teamwork perceptions may be informative for organizational, educational, and research endeavors targeting improved teamwork.

Data availability statement

Original questionnaires are available under https://doi.org/10.17605/OSF.IO/JTUQ7. Complete results can be retrieved from our OSF repository https://doi.org/10.17605/OSF.IO/PYQ48. Data are available upon request from the corresponding author to researchers eligible to work with codified personal health care data under Swiss legislation. Eligibility will be determined by Kantonale Ethikkomission Bern when needed.

Ethics statement

The ethics committee of the Canton of Berne registered the study as a quality evaluation study under No. 197/15 and waived the requirement for informed patient consent. All patients provided a general consent for the use of their data according to Swiss law.

Author contributions

JEK, SE, OK-H, and WEH conceived and designed the study. WEH, SW-S, SCH, TB, and TCS collected the data. JEK and OK-H performed the statistical analyzes. JEK, SE, and WEH drafted and revised the manuscript. All authors reviewed and approved the final manuscript and have agreed to be accountable for all aspects of the work.

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Conflict of interest

WEH has received research funding from the European Union, the Swiss National Science foundation, the Zoll Foundation, Dräger Medical Germany, Mundipharma Research United Kingdom, MDI International Australia, and Roche Diagnostics Germany, all outside the submitted work. WEH has provided paid consultations to the AO Foundation Switzerland and MDI International Australia, all outside the submitted work. WH has received financial support for a conference he chaired from EBSCO Germany, Isabel Healthcare United Kingdom, Mundipharma Medical Switzerland, and VisualDx United States, all outside the submitted work.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

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Juliane E. Kämmer,
University of Bern,
Switzerland

REVIEWED BY
Keri L. Heitner,
Saybrook University,
United States
Chester S. Spell,
Rutgers,
The State University of New Jersey,
United States

*CORRESPONDENCE
Galia Sheffer Hilel
galia@telhai.ac.il

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The paradoxical effects of professional stereotypes on the quality of care by interprofessional teams: The contingent effects of team faultlines, team stereotypes, and championship behaviors

Galia Sheffer Hilel[1]*, Anat Drach-Zahavy[2] and Ronit Endevelt[3]

[1]Nutrition Sciences Department, Faculty of Sciences at Tel-Hai College, Kiryat Shmona, Israel, [2]Nursing Department, Faculty of Social Welfare and Health Sciences at Haifa University, Haifa, Israel, [3]School of Public Health, Faculty of Social Welfare and Health Sciences at Haifa University, Haifa, Israel

Background: Despite calls for interprofessional teamwork to ensure quality care in healthcare settings, interprofessional teams do not always perform effectively. There is evidence that professional stereotypes inhibit effective interprofessional teamwork, but they haven't been explored as a phenomenon that impacts team's performance and quality of care.

Objectives: To focus on professional stereotypes emerging in interprofessional teams and examine the contingency effects of interprofessional team's faultlines, professional stereotypes, and leader's championship behaviors on team's quality of care.

Methods: A cross-sectional nested sample of 59 interprofessional teams and 284 professionals, working in geriatric long-term-care facilities in Israel. Additionally, five to seven of the residents of each facility were randomly sampled to obtain the outcome variable. Data collection employed a multisource (interprofessional team members), multimethod (validated questionnaires and data from residents' health records) strategy.

Results: The results indicated that faultlines are not directly harmful to team's quality of care; instead, they are likely to impact quality of care only when team stereotypes emerge. Furthermore, whereas teams typified by high professional stereotypes require person-oriented championship leadership, for teams typified by low team stereotypes, championship leadership harms the quality of care they provide.

Conclusion: These findings have implications for handling interprofessional teams. Practically, leaders must be well-educated to better analyze team members' needs and maintain the appropriate leadership style.

KEYWORDS

Interprofessional teams, stereotypes, leadership, championship behaviors, faultlines

Introduction

As healthcare settings pursue new reforms to ensure patients' safe, high-quality care, the need to collaborate *via* interprofessional teamwork grows substantially (Freund and Drach-Zahavy, 2007; Winstein et al., 2016). Scholars view the interdisciplinary team as a "proxy for

cognitive heterogeneity, representing innovativeness, problem-solving abilities, creativity, diversity of information sources and perspectives, openness to change, and willingness to challenge and be challenged" (Finkelstein et al., 2009, p. 125). Concomitantly, the World Health Organization (2010) called for adopting "a different paradigm in the management of health personnel through evidence-based policies and practices that promote collaborative interprofessional teamwork." Advocates of employing healthcare interprofessional teams argue that, in combination, they contain a more comprehensive information base, equipping the team to develop innovative solutions to complex patient- and service-related challenges (Dias and Escoval, 2013; Mitchell and Boyle, 2015).

Despite these repeated calls for administrators, policymakers, and scholars to advance interprofessional care, research findings so far have been inconclusive, suggesting that interprofessional teams do not necessarily fulfill their potential to perform effectively, as they may experience friction, hostility, and poor performance (Mitchell and Boyle, 2015, 2019; Homan et al., 2020). Apparently, the obvious professional diversity of the interprofessional team members, coupled with additional potential diversity for other attributes (e.g., race, age, educational background), can sometimes hamper team performance and quality of care (Sarma et al., 2012).

A key cause of interprofessional teamwork failure is the emergence of professional stereotypes–cognitive structures that provide knowledge, beliefs, and expectations about individuals, based on their belongingness to a profession (Quadflieg and Macrae, 2011). Stereotypes may be positive (e.g., all social workers are compassionate) or negative (e.g., physicians are poor team leaders), but in most cases harm the effectiveness of the interprofessional team, particularly in cases where there is a need for in-depth information elaboration on novel tasks (Meyer et al., 2022). In most cases, stereotypes trigger negative intrateam interactions, conflict, distrust, disliking, and limited communication among interprofessional team members, thereby perhaps challenging the foundation for creating the interprofessional team in the first place, and harming team effectiveness (van Dijk et al., 2017; Conroy, 2019).

This study focuses on professional stereotypes emerging in interprofessional teams and aims to explore the circumstances where stereotypes impede teamwork and the means to buffer those harmful effects. Embedded within the categorization-elaboration model (CEM; van Knippenberg et al., 2004) combined with the leadership diversity model LeaD (Homan et al., 2020), we suggest that team diversity (in terms of team faultlines), team's professional stereotypes, and the leader's championship behaviors interact in their impact on the team's quality of care (Figure 1).

CEM proposes that interprofessional teamwork might be characterized by two alternative potentially complementary pathways (van Knippenberg et al., 2004). According to the first—*the elaboration of information pathway,* in the absence of professional stereotypes, interprofessional team diversity can increase the effectiveness of team quality of care. LeaD similarly suggests that under these circumstances, person-related leadership (championship behaviors) may be redundant and can even harm the team's quality of care (Homan et al., 2020).

Alternatively, in line with the second pathway—*the team categorization pathway*—when professional stereotypes emerge within a team, the team leader is required to intervene actively to attenuate any interpersonal conflicts and/or inadequate communication among the interprofessional team members. Here is where the LeaD model (Homan et al., 2020) can contribute by suggesting that leadership style is contingent on the interprofessional team's needs and thus should differ substantially between interdisciplinary teams that face intergroup bias and those that engage with information elaboration. Accordingly, person-related leadership may be required to attenuate the deteriorating effects of team professional stereotypes on team effectiveness. Thus, the leader's championship behaviors, as a form of person-related leadership, encompassing expressions of enthusiasm for team success and perseverance under adversity, in tandem with individualized attention to each member's contribution and involving the appropriate people, might lessen the negative impact of emerging stereotypes. We test this model (Figure 1) with interdisciplinary team members working in 59 geriatric long-term-care facilities (LTCFs) that implement reforms to improve residents' quality of care.

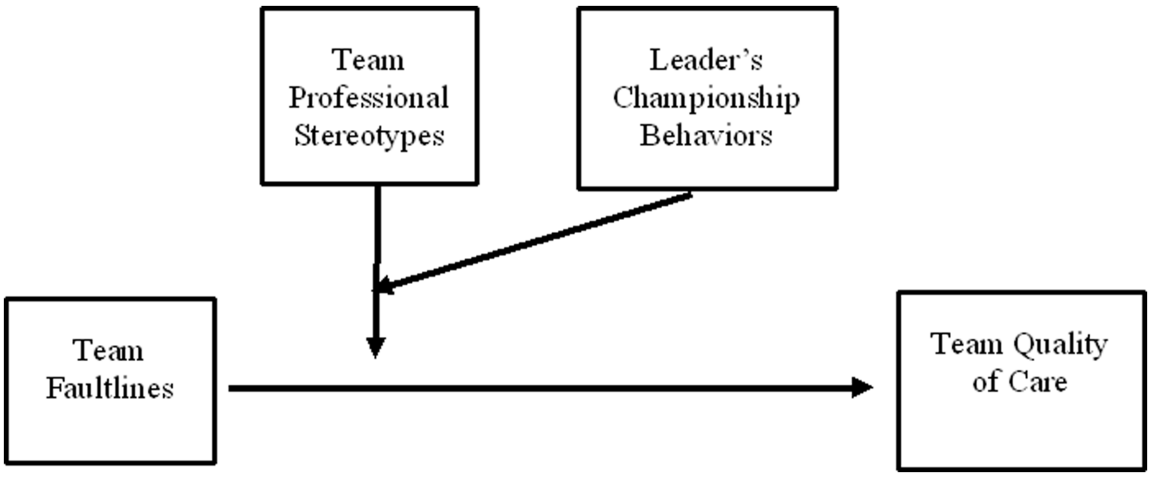

FIGURE 1
The study model.

Background and hypotheses testing

Professional stereotypes

Practitioners on an interprofessional team are acculturated into professional groups; thus, they may often develop professional stereotypes, thereby creating barriers to collaboration (Hall, 2005). Embedded within the social identity framework (van Knippenberg and Schippers, 2007; van Dick et al., 2008) and its extension, professional identity theory (Schein, 1978), scholars argue that the professionally diverse composition of the interprofessional team reinforces the salience of professional identity by increasing the cognitive accessibility of profession as a social category (Mitchell and Boyle, 2015). Consequently, categorization processes among professional groups might create stereotypes about other professional groups (Hean et al., 2006; Mitchell et al., 2011).

Professional stereotypes are overgeneralized representations of a group of people based on their profession (Conroy, 2019). Through professional stereotyping, one infers characteristics from a single professional, such as a nurse or a social worker, assuming that all members of the profession also possess these traits. No matter how positive or negative stereotypes are, they most frequently lead to prejudice against the professional group (Conroy, 2019). In healthcare, professional stereotypes are reinforced through institutionalized mechanisms (e.g., the medical hierarchy; Thylefors, 2012), which leads to distrust and conflict among professions, thus hindering communication between them (McNeil et al., 2013). Early research on professional stereotypes of healthcare professionals has been mainly descriptive. Studies depicted hetero-stereotypes (stereotypes of other professions against one's profession) or auto-stereotypes (stereotypes of one's own profession against one's profession) among practitioners (Barnes et al., 2000; Kämmer and Ewers, 2022) and students (Foster and Macleod Clark, 2015). Previous studies also evaluated the impact of interprofessional education (IPE) interventions of various types and durations on the reduction of professional stereotypes, with mixed results (Barnes et al., 2000; Michalec et al., 2013). More recently, Conroy (2019) argued that professional stereotypes might represent a barrier to interprofessional team outcomes, as stereotyping increases the risk of breakdowns in communication and coordination. This is unfortunate because the main rationale for using interprofessional teams is to increase the communication and coordination among professionals who care for patients (Zwarenstein et al., 2009; Gittell et al., 2013). A theoretical model, delineating the boundary conditions that determine whether and how interpersonal stereotypes create long-term consequences in team functioning has recently been introduced (van Dijk et al., 2017). Still, this question has gained limited empirical attention so far.

Further, professional stereotypes have been typically addressed as individually manifested states, cognitions, and acts that may have a direct bearing on interpersonal relationships. However, part of the professional-stereotypes phenomenon may be further understood by investigating how it is embedded in different contexts, such as the interprofessional team. The input-process-output–input (IPOI) framework that dominates current team research (Ilgen et al., 2005; Mathieu et al., 2014) provides solid theoretical ground for considering professional stereotypes as a relatively shared property of the team. Accordingly, team members are exposed to similar inputs in their work environment, such as organizational structures that separate professional groups, or how leaders, colleagues, and patients react to different types of professionals. The team members then share their interpretations of the inputs with each other, creating emergent states or team processes based on the shared interpretations. This leads to similar reactions and behaviors among team members (Weick, 1993; Lindell and Brandt, 2000; Mathieu et al., 2014). Here, we examine professional stereotypes as overgeneralized representations of a group of people based on their profession and their moderating effect on team effectiveness.

The joint effects of team diversity and team's professional stereotypes

Obviously, the interprofessional team is by definition diverse in terms of professions. Yet, faultline theory (Lau and Murnighan, 1998; Chrobot-Mason et al., 2009) argues that in considering the impact of team diversity, other dimensions of diversity (e.g., tenure, gender) should also be considered. Apparently, the impact of diversity is stronger when members differ from each other in the same way on more than one attribute Van Dijk (e.g., when dietitians in the interprofessional team are also women and younger than physicians, who are also men, and older; Meyer et al., 2014; van Dijk et al., 2017). In line with van Knippenberg et al.'s (2004) CEM model, team faultlines are not fundamentally "good" or "bad"; instead, they can enact two distinct, yet not mutually exclusive, pathways: team categorization processes and information elaboration.

As for the former, as an extension of the classic self-categorization model (Tajfel et al., 1986), CEM (van Knippenberg et al., 2004) contends that team diversity may be linked to harmful outcomes only when (a) team diversity attributes serve as a basis for categorization processes (i.e., the perception of subgroups) and (b) categorization further creates intergroup bias, namely favoring one's own subgroup while out-group members are subject to projected biases and prejudices, and tend to be excluded from formal and informal interaction. These joint circumstances may create professional stereotypes, hindering the care provided to patients.

Alternatively, if information elaboration is prominent, intergroup bias and stereotypes are less likely to surface, thus improving team effectiveness, and the quality of care provided to patients. Information elaboration refers to "the degree to which information, ideas, or cognitive processes are shared, and are being shared, among the group members" (Hinsz et al., 1997, p. 43) and involves "feeding back the results of […] individual-level processing into the group, and discussion and integration of their implications" (Homan et al., 2007, p. 1,189). Yet, as our model suggests, this link may be moderated by team's championship behaviors.

Championship behaviors, team faultlines, and team's professional stereotypes

The notion that the impact of team faultlines could be mitigated by the leader's behavior is not new and has attracted ample research (Meyer et al., 2015; Homan et al., 2020). In the context of healthcare, champions of innovation play increasingly important roles in leading the quality of care of interprofessional teams (Howell et al., 2005; Byers, 2017). They are exceptional frontline practitioners who are

formally or informally nominated to lead their teams and who are passionate and dedicated to working on improving the quality of care in the teams (Schon, 1963; Howell and Higgins, 1990). Champions are characterized by three main person-focused behaviors: expressing optimism and confidence about the team's success, building networks by assembling the right interprofessional-team members, and persisting despite the difficulties (Howell et al., 2005; Luz et al., 2019b). These behaviors are aimed at facilitating the social interactions among team members and their motivational attitudes such that effective teamwork is enabled (Homan et al., 2020).

Yet, preliminary empirical evidence may suggest that championship behaviors do not always benefit team success and that sometimes the champion may even disrupt team effectiveness (Markham et al., 1991; Pinto and Patanakul, 2015). For example, in a recent study of 94 medical wards, Luz et al. (2019a) concluded that championship behaviors facilitated the novelty of team projects only when team members' engagement and enthusiasm were required. In contrast, championship behaviors did not improve and even hampered novelty when projects required tighter supervision and leader's monitoring (Luz et al., 2019a). Under these circumstances, championship behaviors might have been redundant and even harmful (Walter et al., 2011). A recent research review, summarizing findings on a broad variety of leadership styles (e.g., inclusive leadership, transformational leadership, inspirational leadership; Homan et al., 2020), reached similar conclusions, serving as the impetus for the development of the LeaD model (Homan et al., 2020). Briefly, the model proposes that leadership style is contingent on the interdisciplinary team's needs and thus should differ substantially between interprofessional teams that face intergroup bias and those that engage with information elaboration. Whereas the former teams require the leader's person-focused behaviors that establish the social interactions and motivations, necessary to enable effective teamwork, the latter teams demand the leader's task-oriented behaviors that facilitate the understanding of task requirements, procedures, and the acquisition of task-relevant information (Homan et al., 2020). Similarly, the substitute-for-leadership theory argues that certain individual, task, and organizational variables act as "substitutes for leadership," thereby negating the leader's ability to influence team members' effectiveness (Kerr and Jermier, 1978).

Accordingly, we propose that interprofessional teams facing professional stereotypes require people-oriented leadership behaviors (e.g., championship behaviors), aimed at proactively preventing or retroactively suppressing stereotypes. Apparently, by expressing confidence in the team's success, the champion conveys that the team's achievements are a mutual goal that is attainable regardless of professional belongingness; thus, input from all members, especially those who may not usually participate in discussions, is welcomed. Moreover, by building networks and assigning the right people to the right tasks without prejudice, the champion expresses the value in diverse, even conflicting, opinions from different professions and signals that all are perceived as equally important members of the team. Champions who incorporate higher levels of these behaviors are likely to engender an atmosphere of mutual respect across the different professions, in which the specialized expertise held by each professional is perceived as valuable to the team's shared task (Mitchell et al., 2015; Mitchell and Boyle, 2019).

Conversely, when the interprofessional teamwork is not accompanied with professional stereotypes, and thus is likely to engage in information elaboration, person-focused behaviors are redundant or even harmful. Under these circumstances, the team requires more task-structuring behaviors such as establishing and monitoring task deadlines and goals for the different stages of a project, as well as hands-on provision of task information and training to achieve those deadlines and goals (Luz et al., 2019a; Homan et al., 2020).

To conclude, we propose that the three-way interaction of team's faultlines, professional stereotypes, and championship behaviors will have a significant relationship to team's quality of care. The rationale behind this suggestion is that team faultlines do not necessarily deteriorate team quality, but only when team stereotypes emerge (van Knippenberg et al., 2004). Likewise, team stereotypes do not necessarily harm the quality of care provided by the team. For teams typified by high team professional stereotypes—championship behaviors, exhibited by the team leader, may be helpful in easing the harmful impacts of the stereotypes, whereas in teams with low team stereotypes, the championship behaviors exhibited by the team leader may be redundant and even harmful (Homan et al., 2020).

Accordingly, we propose the following:

The three-way interaction of championship behaviors, faultlines, and professional stereotypes will have a significant relationship to team's quality of care, such that

(a) when the team's professional stereotypes are high, team quality of care will be associated with championship behaviors regardless of the level of faultlines;

(b) when the team's professional stereotypes are low, team quality of care is contingent upon championship behaviors such that.

(b1) when championship behaviors are low, the stronger the team faultlines the higher the team's quality of care;

(b2) when championship behaviors are high, the stronger the team faultlines the lower the team's quality of care.

Methods

Setting

The Ministry of Health's nutrition division launched a program aimed at improving the quality of care of LTCF residents in Israel. The program trained dietitians to lead residents' oral health reform by conducting a Nutrition-Focused Physical Examination (NFPE) with all residents of LTCFs, developing an interprofessional care plan, and engaging the interprofessional team members at the facility to improve residents' quality of care. The main assumptions underlying the program were that (a) preserving and improving residents' quality of life and nutrition status requires interdisciplinary teamwork that addresses oral health and swallowing problems and (b) the dietitian as a champion of innovation should lead the program in the various LTCFs (Weening-Verbree et al., 2013). Accordingly, the dietitian, who is the champion of innovation, would conduct the NFPE and, based on the results, prepare a nutritional intervention that brings together all interprofessional team members. The physician would treat abnormal cases and adjust the drug treatment if xerostomia or a taste/smell change was found. The nurse, as responsible to the nonprofessional care workers, would be responsible for residents' oral hygiene and would instruct the staff on food-serving modes. The speech therapist would diagnose and determine the texture of food

and fluids. The occupational therapist would provide tools to improve eating abilities. The social worker would seek funding options for dental treatments. The physiotherapist would address sitting and head positions while eating. Hence, there is a connection between the dietitian's examination results for oral health and the interprofessional team's approach. Protocols were developed for integrating the program into routine work, and infrastructure was formed to document the information in residents' electronic health records (EHRs).

Design

The study employed a cross-sectional nested design, where 284 professionals were nested within 59 LTCFs.

Sample and study procedure

All LTCFs in rural and urban areas throughout Israel were invited to participate in the study. The inclusion criteria included an LTCF where the dietitian was exposed to the new program. Exclusion criterion was institutional tenure of at least 1 year for each team member. Eleven wards declined. Thus, the final sample included 59 LTCFs (participation rate: 84%). Of these, most were medium-size LTCFs ($n = 25$; 44.8%), followed by small institutions ($n = 17$; 28.8%) and large institutions ($n = 17$; 28.1%). Most LTCFs (79.6%) were for-profit and the rest were nonprofit (20.4%).

In total, 284 interdisciplinary professionals working in 59 LTCFs completed the questionnaires (response rate = 70%), including 57 physicians, 59 nurses, 36 physiotherapists, 33 social workers, 28 occupational therapists, 12 speech therapists, and 59 dietitians (between 4 and 7 different professionals in a LCTF). Their ages ranged from 24 to 78 years ($M = 44.65$, $SD = 13.65$). The sample included 76.4% females; their institutional tenure ranged from 1 to 25 years ($M = 6.21$, $SD = 5.54$); and 62.9% held a bachelor's degree, 17.3% a master's degree, and the rest held a doctoral degree. Estimation of the required sample size was made using alpha = 0.05 and group sizes of 4–7 participants; It indicated the need for a sample size of $n = 230$ for level 1 and $n = 55$ for level 2 to ensure a power of at least 0.80 and effect size of at least 0.4 for all our hypotheses.

LTCF managers received a letter explaining the study and its objectives. After obtaining their consent, the researcher met with the interdisciplinary teams at their institutions to complete the questionnaires. Two weeks later, residents' information was collected from EHRs.

Data collection

Data were collected during 2019. To decrease bias, we employed a multisource (interprofessional team members and residents), multimethod (validated questionnaires, EHRs) strategy for data collection (Podsakoff et al., 2003).

Team's quality of care, the dependent variable, was assessed using data gathered from EHRs of the 5–7 randomly selected residents for whom the team cared ($n = 292$ residents). Only new residents (hospitalized for 1 to 8 months) were included, as the protocol requires each to undergo dietitian assessment. Terminal patients or patients receiving enteral-tube feeding were excluded. Data were gathered *via* a checklist, developed, and validated specifically for the present study. The checklist was designed to assess the extent to which the dietitian, as project champion, succeeded in engaging the interprofessional team in the project. Observing residents' information in the EHRs, the researcher assessed on a 4-point Likert-type scale (0 = *not performed at all*; 1 = *low partial performance*; 2 = *high partial performance*; 3 = *fully performed*) whether there was a record of the dietitian's recommendations to the interdisciplinary team members in accordance with the findings, whether the interprofessional team members performed the recommendation, and whether there was a record of monitoring the performance of the recommendations by the interdisciplinary team members and evaluation of their work. Quality of care was calculated as the mean score across residents in a particular LTCF.

To validate a team's quality of care, we conducted a pilot study with 20 experts of NFPE, serving as managers in LTCFs, as supervisors at the Ministry of Health, or in academia. All were women; their ages ranged from 32 to 65 years (mean [M] = 47.2, standard deviation [SD] = 11), and their seniority ranged from 5 to 40 years ($M = 21.75$, $SD = 10$). To examine the face validity of the success score, capturing the extent to which the scale's questions reflected our intended measures, we asked the experts to assess their clarity: "Are all the questionnaire items clear?;" "Should items be added or removed to cover the subject?" These served as criteria for modifying items. Consequently, we clarified that the items refer to health situations in which the patient would need care from other members of the interprofessional team.

To establish content validity, we asked the 20 experts to rate, on a 5-point Likert-type scale, the relevance of each indicator to quality-of-care implementation (1 = *not relevant*; 5 = *very relevant*). We calculated the content validity index (CVI), defined as the proportion of items rated as quite/very relevant by each expert. The CVI score was 0.90, indicating good validity (Polit et al., 2007). Then, to test interrater reliability, three dietitians separately evaluated the success measure with a sample of 20 residents. There was full agreement between their evaluations. Finally, to test the criterion validity, we calculated the association between our new measure and a well-established questionnaire of team effectiveness by the ward manager and found a significant positive correlation ($r = 0.0.368$, $p < 0.001$).

Team diversity was assessed in line with faultline theory using the average silhouette width (ASW) method (Meyer and Glenz, 2013). To determine the strength of the team faultlines, we calculated the ASW across the three most commonly discussed attributes in the faultlines literature: gender, academic degree, and team tenure (e.g., Carton and Cummings, 2012). We did not include team members' age because of its high correlation with team tenure ($r = 0.42$, $p < 0.01$). The literature (e.g., Meyer and Glenz, 2013; Meyer et al., 2014) indicates that the alignment of attributes that are highly correlated should be avoided because the redundant information will bias the estimate. ASW was calculated using R with the ASW cluster package for faultline calculation (Meyer and Glenz, 2013). Faultline strength ranges from 0 to 1, where values closer to 1 represents maximum alignment of multiple attributes, resulting in maximum separation of a group into homogeneous subgroups.

Team's professional stereotypes were measured using the Student Stereotype Rating Questionnaire (SSRQ; Hean et al., 2006). The

questionnaire addresses nine characteristics: academic ability, professional competence, interpersonal skills (i.e., warmth, sympathy, communication), leadership abilities, ability to work independently, ability to be a team player, ability to make decisions, practical skills, and confidence. Members of the interprofessional team were asked to assess on a 7-point Likert-type scale (1 = *very low*; 7 = *very high*) the extent to which they believed each profession (nurses, physicians, dietitians, social workers, occupational therapists, and speech therapists) is characterized by the attribute. To obtain the individual professional stereotypes score, we first calculated the mean score that each individual provided for the seven professions. Next, in line with the definition of professional stereotypes as "cognitive structures that provide knowledge, beliefs, and expectations about individuals based on their belongingness to a profession" (Quadflieg & Macrae, 2011, p. 216–217), we calculated the individual member's level of stereotypes as the *SD* of the mean ratings across professions. A high *SD* indicates high stereotypes, as the individual assigned attributes to professionals according to their profession. In comparison, a low *SD* indicates low stereotypes, and that the profession does not serve as a criterion for assessing attributes. To calculate team-level professional stereotypes, we averaged individual professional stereotypes across team members. To assess professional stereotypes, we averaged the interprofessional team members' evaluations, ensuring the appropriateness of our aggregations with ICC scores (James, 1982). The findings indicated that ICC(1) = 0.12 and ICC(2) = 0.56, showing satisfactory results.

Championship behavior was assessed with Howell et al.'s (2005) 15-item questionnaire, comprising three subscales. Interprofessional team members were asked to rate the dietitian's championship behaviors on a 7-point frequency scale (1 = *never*; 7 = *always*). Six items measure expressing enthusiasm for and confidence in the innovation's success: for example, "[the dietitian] expresses confidence in what the innovation can do" (α = 0.961); six items measure persistence under adversity: for example, "[the dietitian] persists in the face of adversity" (α = 0.961); and three items measure network-building by involving the right people: for example, "[the dietitian] gets key decision-makers involved" (α = 0.941). Total alpha reliability across the three subscales was 0.97. To assess dietitian's championship behavior, we averaged the interprofessional team members' evaluations, ensuring the appropriateness of our aggregations with ICC scores (James, 1982). The findings indicated that ICC (1) = 0.34 and ICC (2) = 0.76, showing satisfactory results.

Control variables

We also collected interprofessional team members' sociodemographic characteristics: academic degree (bachelor's/master's/doctorate), gender, and team's tenure, and organizational characteristics: institution type (nonprofit/for-profit) and size (number of beds: small [>36], medium [36–180], and large [<180]).

Data analysis

Data analysis was conducted in three steps using SPSS, version 23.0 (IBM Corp., Armonk, NY, United States). First, descriptive analyses were presented, including means and SDs for continuous variables, and percentages for nominal variables. Next, we conducted univariate analyses: Pearson's correlations for continuous variables and t-tests and ANOVA for ordinal variables to provide preliminary support for our hypotheses. Third, prior to the hypotheses testing, we employed the Kolmogorov–Smirnov test and Monte Carlo calculations. These tests were non-significant, supporting the adequacy of Mixed linear model analyzed to analyze our data. We employed a mixed linear model analysis because of the nested sample: residents were nested in naturally occurring hierarchies (Singer, 1998). We followed the procedure recommended (Baron and Kenny, 1986) for testing moderating models. Accordingly, the control and the interdependent variables were entered into the first step, all two-way interactions were entered into the second step, and three-way interactions into the third step.

Ethical considerations

Participants signed informed consent forms, and data confidentiality was ensured. Because of the need to link the dietitians', interdisciplinary team members', and residents' data, the study was not anonymous. Each interdisciplinary team member received an identifying code and was assured that the findings would be kept confidential.

Results

Preliminary analyzes

Univariate analyzes were conducted to select the appropriate control variables. Of these, only team's tenure was negatively and significantly associated with team's quality of care (see Table 1). In addition, *t*-test analysis revealed no significant differences in quality of care between for-profit and nonprofit institutions [$t_{(57)} = -0.08$; $p > 0.05$], and ANOVA analysis revealed that institute size was not significantly associated with team's quality of care [$F(2,55) = 2.07$; $p > 0.05$]. However, in line with a previous study (Sheffer-Hilel et al., 2022), we decided to control for team's tenure and team size, as these variables were associated with quality of care.

Hypotheses testing

Table 1 presents the correlations between the study variables. Championship behaviors were significantly associated with team's quality of care ($r = 0.38$, $p = 0.01$). However, it was not significantly associated with professional stereotypes and faultlines. Table 2 shows the results of the linear mixed-model analysis for predicting team's quality of care from the controls, independent variables, and their interactions. Step 1 included the controls (institute size and team's tenure) and the independent variables of professional stereotypes, faultlines, and championship behaviors. Of these, only championship behaviors had a significant main effect on team's quality of care (β = 0.22; $p = 0.00$).

In Step 2, only the two-way interaction effect of faultlines and championship behaviors on quality of care was significant (β = −1.68; $p = 0.01$). Figure 2 plots the two-way interaction effect on team's quality of care. We followed the recommendations with values of 1 *SD* serving as weak faultlines and strong faultlines, respectively, (Dawson, 2014). As seen in Figure 2, when interprofessional teams have stronger faultlines, they will perform better when the leader engages in a low

TABLE 1 Descriptive statistics and correlations between team's quality of care and independent and control variables.

Characteristics		*M*	*SD*	1	2	3	4	5
1.	Team's tenure	6.21	3.39	1				
2.	Professional stereotypes	0.56	0.25	−0.23*	1			
3.	Faultline	0.54	0.11	0.15*	−0.25**	1		
4.	Championship behavior	5.16	1.58	0.07	−0.60	−0.13*	1	
5.	Team's quality of care	1.13	0.74	−0.02	0.11	−0.10	0.38**	1

M, mean; *SD*, Standard deviation. *$p < 0.05$, **$p < 0.01$.

TABLE 2 Results of the linear mixed-model analysis for predicting team's quality of care from independent variables.

Characteristics	Step 1		Step 2		Step 3	
	B	(SE)	*B*	(SE)	*B*	(SE)
Institute size	0.01	0.11	0.05	0.11	0.07	0.10
Team's tenure	0.00	0.02	0.01	0.03	0.00	0.02
Professional stereotypes	0.43	0.38	−0.59	2.58	16.96	10.75
Faultline	−0.18	0.81	9.33	3.89	27.38	11.40
Championship behavior	0.22*	0.07	1.00	0.44	2.97	1.25
Faultline × professional stereotypes			−0.189	3.56	−31.56	19.00
Faultline × championship behavior			−1.68*	0.62	−5.14	2.15
Professional stereotypes × championship behavior			0.28	0.34	−3.15	2.03
Faultline × professional stereotypes × championship behavior					6.09*	3.58
Δ-2Restricted Log Likelihood			13.65[a].**		7.18[b].*	
Institute-level variance	0.23	0.00	0.21	0.00	0.22	0.00
Residual	0.23**	0.09	0.21*	0.08	0.25*	0.01

SE, standard error. *$p < 0.05$, **$p < 0.005$.
[a]The difference between Step 2 and Step 1 with 3 degrees of freedom.
[b]The difference between Step 3 and Step 2 with 1 degree of freedom.

degree of championship behaviors, whereas when interprofessional teams have weak faultlines, they will perform better when the leader engages in a high degree of championship behaviors.

The effect of the three-way interaction effect of faultlines, professional stereotypes, and championship behavior on team's quality of care was significant ($\beta = 6.09$; $p = 0.04$). Figure 3 plots the three-way interaction on team's quality of care. As demonstrated in the figure, when team's professional stereotypes were high, team's quality of care was positively associated with championship behaviors regardless of the level of faultlines. In comparison, when team's professional stereotypes were low, team quality of care was contingent on championship behaviors such that when championship behaviors were low, the stronger the team faultlines, the higher the team's quality of care, whereas when championship behaviors were high, the stronger the team faultlines, the lower the team's quality of care, lending support to our hypotheses.

Discussion

In healthcare, interprofessional teams represent an important strategy for boosting the quality of care, but in practice, teams often fail to benefit from their diversity (Homan et al., 2007; Mitchell and Boyle, 2019). Addressing this concern, we proposed that interprofessional teams will be less capable of gaining from their diversity when team stereotypes surface at the team level. By integrating leadership theory (Homan et al., 2020) and the CEM (van Knippenberg et al., 2004), we demonstrated that, in line with the CEM, when team stereotypes were high, social categorization processes were activated, and thus quality of care was critically dependent on the leader's championship behaviors. When stereotypes were low, on the other hand, information elaboration processes were activated, and thus team faultlines were positively related to team's quality of care. Moreover, under the latter condition, the leader's championship behaviors could even harm the team's quality of care. These novel findings contribute to the literature in several respects.

In line with recent recommendations in the field, we assessed team diversity in terms of team faultlines (Antino et al., 2019). The finding indicated that faultlines did not exert a significant direct effect on team quality of care. This finding supports recent developments in faultline theory, which argue that faultlines are not inherently "good" or "bad" (Bezrukova et al., 2010; Carton and Cummings, 2012; Meyer et al., 2015), and is in line with recent empirical findings that found no direct effect of faultlines on interprofessional team innovation (e.g., Mitchell and Boyle, 2020a).

This study also contributes to the interprofessional team literature by broadening the understanding of teams' professional stereotypes. As we suggested, team members' aggregated differences in the kinds of virtues attributed to colleagues based on their profession may

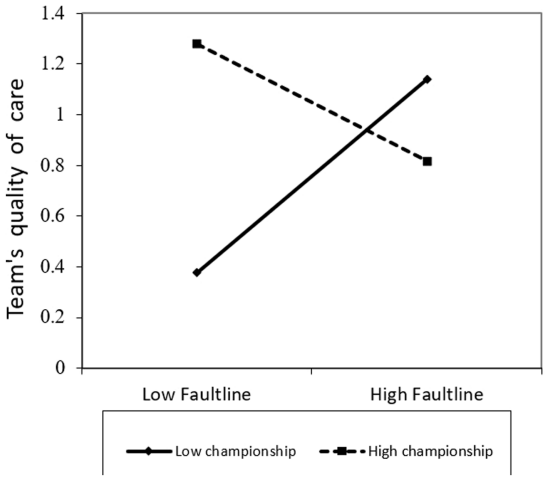

FIGURE 2
Team's quality of care, by faultlines and championship behaviors.

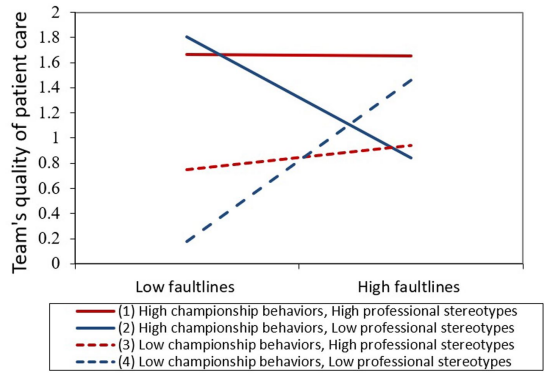

FIGURE 3
Team's quality of care, by faultlines, and championship behaviors, and professional stereotypes.

represent this phenomenon as the property of the team. Our findings made it possible to examine professional stereotypes as a team-level phenomenon, thereby addressing recent calls to explore the impact of stereotypes on team performance (van Dijk et al., 2017). As Van Dijk et al. (2017) recommended, "More research that explicitly investigates the consequences of stereotypes in diverse teams is needed. To date, most research on the consequences of stereotyping has focused on the consequences for the target, and generally has not taken place in a team context" (p. 58). Conceptualizing team stereotypes at the team level may pave the way for further research on this issue.

Perhaps, our most intriguing finding is the significant three-way interaction effect of team faultline, team stereotypes, and championship behavior on team's quality of care. As we found, team faultlines do not necessarily create team stereotypes (van Knippenberg et al., 2004). Further, when faultlines and team professional stereotypes were high, quality of care was not necessarily harmed. Instead, it was critically dependent on the leader's championship behaviors. This finding supports the LeaD model (Homan et al., 2020), claiming that teams require different types of leadership in different circumstances. Apparently, when team stereotypes are high, leadership behaviors that are relationship-oriented are required for the team to run effectively. In this sense, championship behaviors that signal confidence in team success, encourage intergroup networking, and assign work to individual professionals without prejudice signal that all members of the team are regarded as equally important (Nembhard and Edmondson, 2006; Homan et al., 2020). Furthermore, the leader's championship behaviors represent concomitant use of recategorization and decategorization strategies. Through recategorization, the leader creates an overarching, common, inclusive social identity through their demonstration of confidence in the group as a whole; through decategorization, the leader acknowledges and takes into account each individual's contributions to the team by assigning the correct individual to the correct task without prejudice. In the end, these strategies enable leaders to sustain both their professional identity and their subordinate members' team identity, thus overcoming the risk of threat to professional identity (Homan et al., 2020).

However, as our findings also revealed, when team faultlines are strong and professional stereotypes are low, the leader's championship behavior can harm the relationship between faultlines and the team's quality of care. Apparently, the team's communication and coordination are unimpaired, so that the team may benefit from the elaboration of information stemming from the diverse perspectives each employee brings to the discussion. Under these circumstances, our findings showed, high championship behaviors are not only redundant but even harmful. This finding supports Homan's LeaD and Kerr's substitute-for-leadership theories, in that leadership style should fit a team's needs (Kerr and Jermier, 1978; Homan et al., 2020). Preliminary empirical support for this argument was provided by studies on championship behaviors as well as the research on team's professional diversity. As for the former, Walter et al. (2011) demonstrated that the leader's championship behaviors could be too persistent in the face of adversity or take too much responsibility for an innovative undertaking, thus raising team members' resistance to change. Similarly, Mitchell and Boyle's (2020b) studies of interprofessional teams demonstrated that a relationship-oriented leadership style (e.g., inclusive leadership) had a negative effect on team outcomes when professional differentiation was low. Together, these findings highlight that a relationship-oriented leadership style is not productive for promoting quality of care for teams who do not face team bias or stereotypes.

Limitations and recommendations for future research

This study has several limitations. First, as with similar research, there is merit in future research adopting longitudinal designs investigation of causal pathways. Second, despite our efforts to design a study embedded within a theoretical model, our study focused on person-related leadership (championship behaviors) and demonstrated that it fosters quality of care when stereotypes are high but hampers quality of care when stereotypes are low. Future research should explore whether task-related leadership can foster the interprofessional team's quality of care when team stereotypes are low. Third, the nature of our healthcare sample LTCFs for elderly people was chosen precisely because of the importance of interprofessional teamwork in such facilities. Yet, the sample may

be perceived as potentially limiting the generalizability of the findings. Although there is some evidence that healthcare teams face similar pressures across settings (Jeffcott and Mackenzie, 2008), future studies in different settings are warranted. Finally, we measured team quality of care as a process variable but made sure to use a different method–different source strategy, employing archival data. The study was conducted in LTCFs, where most residents had a complex medical condition and were in a poor cognitive state, and therefore unable to respond to questionnaires. Furthermore, the nutrition literature is equivocal in recommending clinical outcome measures to evaluate nutritional care in LTCFs (Moick et al., 2020). However, as improving quality of life is the primary objective of caring for the elderly, and as oral health and nutrition play a significant role in this, future research should consider developing measures of quality of care linked to older adults' psychosocial outcomes (Rasheed and Woods, 2013; Porter et al., 2015; Joling et al., 2018).

Practical implications

Our findings have important practical implications for managers and policymakers seeking to promote quality of care for patients *via* interprofessional teamwork. First, as our findings indicated, interprofessional team faultlines in themselves neither impeded nor improved a team's quality of care, nor did team professional stereotypes. Our finding suggests that leaders should not try to create an inclusive team identity by any means, as previously recommended (Mitchell and Boyle, 2020a). Instead, they should help interprofessional team members develop a "dual team identity," as members of both specific healthcare professions and interprofessional teams (Hill et al., 2019).

To this end, leaders should be well trained in analyzing team members' needs: are team members currently struggling with stereotypes and prejudices hampering their performance? Or, alternatively, are they currently benefiting from the diverse opinions of each member? An assessment will subsequently identify the style of leadership that will foster the interprofessional team's level of care. If the team tends to expend more energy on reinforcing existing stereotypes, the leader should assume a champion role by assigning the right specialists to assignments without bias, by signaling to coworkers that all are perceived as significant members of the group together, and by expressing confidence in the team's success (Mitchell and Boyle, 2020b). Alternatively, if members of the interprofessional team communicate effectively without relying on stereotypes, another style of leadership may be required to ensure high-quality care.

It also logically follows that healthcare educators must already nurture dual identities in the early stages of students' professional identity formation by providing both nonprofessional and interprofessional education throughout their programs. This may enable learners to understand their professional boundaries, and their contributions to an interprofessional team, without those boundaries developing into barriers, as they will not perceive their territories as being threatened. This may also ease the acceptance of those in new professions and discredit negative professional stereotypes (Hammick et al., 2007). Finally, these recommendations are of special importance for informal, low-status leaders of interprofessional teams, such as dietitians (Mak et al., 2019; Sheffer-Hilel et al., 2022). It is important to develop programs to teach those informal leaders how to become effective team leaders; such skills should be included in their academic training and continually reinforced during on-the-job training.

Conclusion

Our findings make an important contribution to the understanding of team stereotypes as a property of the team and of the capacity of championship behaviors to mitigate the adverse impact of stereotypes on team's quality of care. They highlight that team faultlines are not intrinsically harmful to team quality of care; instead, they can mitigate team quality of care only when team stereotypes emerge. Furthermore, the emergence of team stereotypes determines the type of leadership needed to promote quality of care. Whereas teams typified by high team stereotypes require a personal-relationship-oriented type of championship leadership, teams typified by low team stereotypes should apparently be treated with another type leadership style; otherwise, it can harm team's quality of care. Taken together, the capacity of the team's professional stereotypes to account for inconsistencies in the impact of interdisciplinary teams on quality of care, and the subsequent leadership style required, provide a direction for future research.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the Ministry of Health's Ethical Review Boards (24\2017) and the University's Institutional Review Board approved the study (365/17). The patients/participants provided their written informed consent to participate in this study.

Author contributions

GS, RE, and AD-Z developed the concept and study design. GS collected the data that was analyzed by GS, RE, and AD-Z. GS wrote the first draft with contributions from AD-Z. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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EDITED BY
Julia Carolin Seelandt,
University Hospital Zürich,
Switzerland

REVIEWED BY
Anna T. Mayo,
Carnegie Mellon University,
United States
Lauren E. Benishek,
School of Medicine,
Johns Hopkins University,
United States

*CORRESPONDENCE
Mona Weiss
✉ mona.weiss@fu-berlin.de

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I like what you are saying, but only if i feel safe: Psychological safety moderates the relationship between voice and perceived contribution to healthcare team effectiveness

Mona Weiss[1]*, Elizabeth W. Morrison[2] and Demian Szyld[3]

[1]School of Business and Economics, Department of Management, Freie Universität Berlin, Berlin, Germany, [2]Stern School of Business and Economics, Department of Management, New York University, New York, NY, United States, [3]School of Medicine, Boston University, Boston, MA, United States

Introduction: Are nurses who voice work-related concerns viewed as positive contributors to a team? We propose that the extent to which healthcare professionals consider voice by nurses as helpful for the team depends on how psychologically safe they feel. Specifically, we hypothesized that psychological safety moderates the relationship between voice of a lower ranking team member (i.e., a nurse) and perceived contribution by others, such that voice is more likely to be seen as valuable for team decision-making when psychological safety is high but not when it is low.

Methods: We tested our hypotheses with a randomized between-subjects experiment using a sample of emergency medicine nurses and physicians. Participants evaluated a nurse who either did or did not speak up with alternative suggestions during emergency patient treatment.

Results: Results confirmed our hypotheses: At higher levels of psychological safety the nurse's voice was considered as more helpful than withholding of voice for team decision-making. This was not the case at lower levels of psychological safety. This effect was stable when including important control variables (i.e., hierarchical position, work experience, gender).

Discussion: Our results shed light on how evaluations of voice are contingent on perceptions of a psychologically safe team context.

KEYWORDS

psychological safety, voice, teamwork, healthcare, nurses, hierarchy

Introduction

Successful teamwork depends on effective and efficient sharing of information among individuals (Mesmer-Magnus and DeChurch, 2009). Healthcare teams in particular need to discuss treatment options and potential hazards to ensure patient safety (e.g., Castelao et al., 2013; Hautz et al., 2015). Yet, research suggests that individuals are often reluctant to speak up with alternative suggestions or concerns that challenge the status quo (i.e., voice) because they fear backlash from co-workers and superiors (Morrison and Milliken, 2000). In healthcare, these fears are especially prevalent as nurse's report that they are often hesitant to voice suggestions or concerns to physicians (Russo et al., 2015).

Existing research on consequences of voice has shown that speaking up has the potential to result in positive evaluations from superiors but that these are contingent on factors such as demographic characteristics (e.g., gender, ethnicity) of the voicer (Howell et al., 2015), or on how, what, and when they voice (Whiting et al., 2012; Maynes and Podsakoff, 2014; Chamberlin et al., 2017). Further, a qualitative study by Burris et al. (2017) suggested that in healthcare contexts, the content of the voiced message and the ease of enacting the recommended change affected the extent to which manager's value voice behavior. At this point, however, we know relatively little about how voice is evaluated in healthcare teams that come together on the spot to engage in rapid decision-making and that are characterized by an entrenched professional hierarchy (e.g., Cott, 1997; Nembhard and Edmondson, 2006; Uitdewilligen and Waller, 2018). Thus, to advance current knowledge on receptivity to voice, it is crucial to better understand the conditions under which the voicing of suggestions and concerns by a lower ranking team member (i.e., a nurse) is viewed as helpful by other team members.

In this research, we build on previous findings that show that constructive voice can get individuals more recognition and appreciation from others, as they are seen as contributing positively to a team (e.g., Weiss and Morrison, 2019). We argue that healthcare team members consider it as more helpful for the team when a lower-ranking team member speaks up than remains silent with his/her concerns. Yet, we posit that this effect is contingent on team members' psychological safety. Drawing from a social-cognitive perspective, we argue that when people perceive and evaluate other people's behavior, they are strongly influenced by their experiences of and resulting beliefs about the social context (e.g., Fiske, 1993). Psychological safety refers to the perception of whether the organizational or team context is safe for interpersonal risk-taking (Edmondson, 1999; Edmondson and Lei, 2014) and is also a crucial antecedent of engaging in voice (Detert and Burris, 2007). Feeling psychologically safe (i.e., being able to bring up problems and tough issues) is especially important in healthcare settings where individuals are strongly attuned to hierarchical norms within the team and expectations of superiors (Nembhard and Edmondson, 2006).

We argue that psychological safety not only determines whether people voice themselves, but also affects the extent to which they perceive voice by others as helpful for the team. We argue that only when people *themselves* feel safe to ask questions and point out problems, will they also appreciate it when *others*—especially those who hold a lower formal rank and are usually expected to agree with the suggestions of higher-ranking individuals—take a risk and voice their opinion. We tested this prediction in a medical emergency team context, where speaking up with alternative suggestions or concerns regarding patient treatment is crucial for team decision-making but is particularly risky for team members from a subordinate profession (i.e., nurses) who hold relatively lower status and power (Cott, 1997; Magee and Galinsky, 2008).

With this study, we contribute to and extend the growing body of work that focuses on the consequences of voice for the individual employee (e.g., Burris, 2012; Whiting et al., 2012; Weiss and Morrison, 2019, see also Morrison, 2023 for an overview). We point to psychological safety as an important social-contextual factor affecting evaluations of voice in functionally and hierarchically diverse *ad-hoc* teams that operate in a high-risk context. Thus, psychological safety is not only a crucial antecedent of voice (Detert and Burris, 2007) but also poses a boundary conditions to evaluations of voice.

We also contribute to and extend the literature on healthcare team functioning by pointing out conditions under which healthcare team members appreciate voice behavior by nurses which can have important implications for the performance of these teams (e.g., Schmutz and Manser, 2013; Uitdewilligen and Waller, 2018). More broadly, our work complements research on functionally diverse teams that has suggested psychological safety as a moderator in the relationship between minority dissent or conflict and team performance (e.g., Bradley et al., 2012; Nijstad et al., 2014; see also Jetten and Hornsey, 2014). Over and above that, our findings suggest that psychological safety also affects whether individuals are able to value dissenting and challenging views of team members who have a lower professional rank and lower status on the team.

Employee voice and perceived contribution to the team

In line with Morrison (2014), we define voice as "discretionary communication by an employee of ideas, suggestions, concerns, information about problems, or opinions about work-related issues […] with the intent to bring about improvement or change" (p. 174). There is evidence across several different industries that employee voice can have direct effects on organizational, unit, and team performance (Detert et al., 2013) and is particularly relevant for healthcare team effectiveness (Weiss et al., 2014). Yet, at this point, no research has systematically investigated how individuals who speak up in healthcare teams are evaluated by others. In this research, we are especially interested in how nurses' voice is judged, because nurses are formally subordinate to physicians and as a result of this hierarchical difference, they may be less expected to challenge their decisions (e.g., Cott, 1997; Magee and Galinsky, 2008). Specifically, we aim to examine how voice relates to perceived contribution to team effectiveness, defined as the extent to which a behavior is considered as helpful for the team's performance (Waller et al., 2011; Steinmetz et al., 2016). Such evaluations are particularly important during team decision-making and affect how team members elaborate and process divergent information (Jetten and Hornsey, 2014).

Two recent studies showed that voice can earn individuals higher status in the eyes of others (McClean et al., 2018; Weiss and Morrison, 2019). For example, Weiss and Morrison (2019) showed that constructive voice can lead to evaluations of higher agency, communion, and status as compared to silence within product development teams. These positive effects also appeared when the voiced suggestions came from a team member with a relatively lower rank. Relatedly, McClean et al. (2018) showed that team members who voiced promotively (i.e., voicing suggestions for improvement) were seen as higher status and were consequently more likely to be selected as leaders.

Based on these previous findings, we submit that voice should generally be considered as positive within healthcare teams as well. When team members with a lower occupational rank (i.e., nurses) provide alternative viewpoints and make suggestions regarding treatment options, this should signal to others that they are motivated to contribute to the team and that they have the patient's best interest in mind (Weiss and Morrison, 2019). By voicing their concerns, they

stimulate divergent thinking in teams by contributing their expertise and judgments (Jetten and Hornsey, 2014). As a result, they are likely to be seen as more competent and helpful team members than those who do not voice their concerns and suggestions. Thus, we hypothesize:

> Hypothesis 1: Nurses' voice is more likely to be seen as a positive contribution to team effectiveness than nurses' withholding of voice.

The moderating role of psychological safety in healthcare teams

Even though the literature has shown that voice has the potential to result in positive consequences for the voicing employee, studies point to a number of contingencies. For example, research by Burris (2012) showed that managers feel more threatened and perceive employees as more disloyal when they engage in challenging rather than supportive voice. Further specifying these effects, a study by Whiting et al. (2012) found that voicers who are perceived as more trustworthy, who speak up early rather than late during a discussion, and who frame their message constructively are seen as better performers. Moreover, Lam et al. (2019) found that individuals who spoke up in a direct rather than an indirect manner were more likely to be endorsed by their managers such that managers perceived their comments as valuable and helpful. Another study showed that employees get more credit for voicing when they have higher ascribed status, such as being from the majority ethnicity or working full-time (Howell et al., 2015). In sum, the existing research suggests that factors pertaining to the person who is voicing, or to the nature of the voiced message, affect how others react.

The current study points to an additional contingency factor, rooted in the social context. Our theoretical reasoning is informed by a social-cognitive perspective, which argues that individuals make sense of their social context based on processing social cues in the environment (Fiske, 1993). In other words, employees socially construe their beliefs, perceptions, and attitudes about the "right" way to think, feel, and behave within their organization. We argue that such social-cognitive processing should be especially relevant in healthcare teams because this context places emphasis on norms and codes of conduct defined by occupational function and hierarchical ordering (Cott, 1997).

One important social cue within work contexts is psychological safety, defined as the extent to which employees perceive their team or work unit as safe for interpersonal risk-taking (Edmondson, 1999). Psychological safety builds on the notion that employees hold tacit beliefs about interpersonal interactions at work, which can affect whether employees seek feedback, talk about errors or work-related concerns, and share information vertically and horizontally (Argyris, 1993). When employees feel that they can talk about ideas without being judged or disrespected, when they are given autonomy and freedom to engage with their work and develop new approaches, they feel psychologically safe at work. Kahn (1990) concluded that "psychological safety was experienced as feeling safe to show and employ one's self without fear of negative consequences to self-image, status, and career" (Kahn, 1990, p. 708). Psychological safety has been shown to affect outcomes at multiple levels including employee engagement, team learning and performance, organizational performance, and organizational change processes (Edmondson, 1999; Baer and Frese, 2003; Cataldo et al., 2009; Edmondson et al., 2001). In the voice literature, psychological safety has often been conceived of as an important antecedent of speaking up (e.g., Detert and Burris, 2007).

Research has also demonstrated that psychological safety is of particular importance in healthcare settings. Studying an intensive care unit, Nembhard and Edmondson (2006) showed that unit-level psychological safety mediated the relationship between inclusive leadership and engagement in quality improvement efforts (i.e., being actively involved in efforts to improve work processes) suggesting psychological safety as a key mechanism for speaking up. One reason is that healthcare teams are hierarchically structured with clear professional boundaries and authority gradients between nurses and physicians (e.g., Cott, 1997). This creates not only a functional differentiation between nurses and physicians but also certain role expectations regarding power, status, and conformity (Apker et al., 2005). For example, it is commonly expected that physicians make important treatment decisions and that nurse's take on an assisting function (Cott, 1997).

Another reason that psychological safety is particularly important in healthcare teams is the fact that they are *ad-hoc* teams and required to "team up" for a specific shift or a sudden unexpected emergency (e.g., Sundstrom et al., 1990). As such, they have also been described as "fluid teams" as they are constantly reconstituted and often have little shared history (Avgerinos et al., 2020). For example, in emergency care, teams are composed for a specific shift only and may even be recomposed during a specific teamwork episode (e.g., more nurses or physicians joining an EM team for a resuscitation; Hunziker et al., 2011). These circumstances place particular demands on healthcare teams, and, thus, previous research has emphasized the importance of socio-contextual factors such as familiarity or leadership (Avgerinos et al., 2020; Krenz et al., 2020; Akşin et al., 2021).

Psychological safety was originally proposed as a climate factor—or a shared perception—within teams or units (Edmondson, 1999). More recently, however, researchers have suggested that psychological safety should be conceptualized as a multi-level construct that can exist at the interpersonal, team, and unit level (Roussin et al., 2016). A recent study also reveals that within healthcare teams, psychological safety is shaped by multiple, accumulated teamwork episodes (e.g., O'Donovan et al., 2021). Thus, given the fluid nature of teams in healthcare and emergency care specifically, we conceptualize psychological safety at the level of the unit or department in which individuals are situated and work together in various and constantly changing team compositions. Even though we do not expect that perceptions of psychological safety will necessarily be shared within the context of *ad-hoc* teams, we believe that it will significantly impact the link between voice and perceived contribution to team effectiveness.

In more stable teams (i.e., those that remain intact over a longer period of time), psychological safety has been shown to be an important moderator in the context of team conflict and performance. For example, Bradley et al. (2012) investigated student project teams and found that team conflict was positively associated with team performance when teams perceived their psychological safety to be high, but not when they perceived it to

be low. Moreover, conducting a study with top management teams, Nijstad et al. (2014) showed that psychological safety moderated the impact of minority dissent on team innovation such that dissent could only be transformed into innovative team outcomes when team members felt psychologically safe. This line of research shows that psychological safety can affect important team processes and outcomes and that it is especially important for teams dealing with dissent and conflict (Jetten and Hornsey, 2014).

Taken together, previous research suggests that psychological safety is often a prerequisite for engaging in voice and is especially important within teams and healthcare settings. Yet, it is unclear how psychological safety may affect interpersonal evaluations of voice—specifically when these evaluations are situated in healthcare teams that are marked by an entrenched social hierarchy.

Based on a social-cognitive approach (Fiske, 1993), we argue that individuals draw on their socially-informed cognitive schemas and belief systems to evaluate others' voice behavior and one such schema is their psychological safety. We argue that when healthcare professionals feel psychologically safe, they will see more value in others who speak up in comparison to those who do not. Individuals who feel psychologically safe generally interpret their work context as a safe place for sharing alternative opinions and concerns (Edmondson and Lei, 2014). They feel that they can bring up tough issues at work and stand out from the group without being negatively judged (Edmondson, 1999). As a result of these perceptions and experiences, they have formed a positive schema about their work context in general (Fiske, 1993) which entails that they and others can freely voice opinions or concerns. Thus, these perceptions are likely to influence subsequent team interactions (O'Donovan et al., 2021) such that they will be more likely to perceive team members who speak up with suggestions as contributing positively to team decision-making, regardless of the person's function or status. This is because they interpret their voice behavior as compatible with the perception that their work context allows for interpersonal risk-taking and as stimulating reflection and fostering team decision-making (Carmeli and Gittell, 2009; Edmondson, 1999; Bradley et al., 2012).

In contrast, when people feel psychologically unsafe at work, they should be less likely to view others' voice as helpful for the team. Because they themselves feel unable to raise alternative suggestions or concerns, they may also use this schema to evaluate others' behavior. When individuals feel psychologically unsafe, they should be less supportive of lower-ranking team members who propose alternative actions. This is because they hold the belief that alternative viewpoints are negatively judged, and that individuals who make mistakes will be punished (Edmondson, 1999). Individuals who feel psychologically unsafe may feel that it is not advisable to be different from others and stand out with one's opinion, as they are highly concerned that such behavior results in negative interpersonal consequences (Edmondson, 1999; Bradley et al., 2012). Particularly if the person who voices has a lower hierarchical rank, they may see such behavior as a threat to the hierarchy and as crossing a line that they personally would not dare to cross (Nembhard and Edmondson, 2006). Consequently, they are less likely to view a lower-ranking team member who speaks up with concerns as helpful for the team. We thus hypothesize that the relationship between nurses' voice and perceived contribution to the team is moderated by psychological safety:

> Hypothesis 2: There is an interaction between nurses' voice and psychological safety on perceived contribution to the team: At higher (but not at lower) levels of psychological safety, nurses are more likely to be judged as helpful for the team when they voice than when they do not voice their concerns.

Materials and methods

Participants

Participants were recruited from the Emergency Medicine (EM) department of a large hospital in the United States (Institutional Review Board approval number: i16-01193). We used the department's email list to contact all of their physician and nursing staff ($N = 250$). Of these 250, 101 healthcare professionals participated in the study (overall response rate: 40.4%). Seventy-five participants were EM physicians and 26 were EM nurses. Fifty-three participants were female, and the average clinical work experience was 7.18 years ($SD = 9.50$). In comparison to the full population in this particular hospital department, our sample entailed more physicians (74 vs. 57) and fewer nurses (26 vs. 43%) and slightly fewer women (53 vs. 65%).

No incentive was given for participation, and all participants provided their informed consent to the use of their data.

Materials

To systematically examine receptivity to nurses' voice, we designed four clinical vignettes. Clinical vignettes are widely used in medical education and have also been used in previous studies on voice behavior in healthcare (Kobayashi et al., 2006). Our goal in developing these vignettes was to present a common but complex situation occurring during a patient assessment, where voicing an alternative suggestion can contribute to a more effective team decision in terms of higher quality of care and lowered risk for the patient.

All vignettes were identical with respect to the clinical case they described but differed with respect to whether a nurse spoke up with treatment-related concerns or remained silent with those concerns. Specifically, it was described that a 25-year old male patient was admitted to the Emergency Room (ER) with multiple injuries following a severe car accident. The case posed ambiguity as to how to proceed with the treatment (i.e., transferring patient immediately to radiology vs. applying further measures to stabilize the patient). The Glasgow Comma Scale (GCS) for this patient is 12 indicating mild to moderate traumatic brain injury. The Oxygen saturation is 90%, which in the context of rib injuries with suspected rib fractures could be due to lung contusions, pneumothorax (punctured lung), splinting/hypoventilation (when the lung is not well expanded due to pain), or from a combination of factors. Application of oxygen to raise the oxygen saturation to greater 92–94% would be standard. British Thoracic Society Guidelines recommend nasal cannula supplementation in this case (O'Driscoll et al., 2017). Intubation (placing a breathing tube) to ventilate and oxygenate would be indicated if the patient was declining in mental status, blood pressure or if oxygen saturation was not improving with supplemental oxygen. One often discussed reason for intubation is anticipating clinical course. One concern may be that traveling to the CT scanner and having to lie flat for a prolonged period of time would be safer if an intubation was performed in advance.

Participants were asked to adopt their regular professional role (nurse or physician) during the comprehension of the presented medical case. It was stated that a nurse on the team was concerned about the relatively low oxygen saturation of the patient and felt that it was necessary to intubate him immediately. This information was held constant across conditions, but we manipulated the nurse's communication behavior. In the voice condition ($n = 48$), she spoke up with her concerns to the physicians and suggested intubating the patient before transferring him to the radiology department. In the no-voice condition ($n = 53$), she did not bring up her concerns or offer this alternative suggestion. We slightly adapted the wording of the vignette for nurses to match their perspective of evaluating a fellow nurse speaking up to a physician. Thus, for each of the two professional groups (nurses and physicians), we designed two versions of the clinical vignette (voice, no voice). Appendix A presents the full vignettes we used in the study.

Procedure

The study was implemented as an online experiment, and EM nurses and EM physicians working in the study hospital were invited *via* email. We employed a randomized between-subjects design, such that each participant was assigned to one experimental condition only. After providing their informed consent, participants first provided information on their demographics including their gender, their age (assessed categorically to further ensure anonymity), and their professional function (nurse or physician). Next, participants were asked to report their perceived psychological safety in their department. After that, participants were randomly assigned to either the voice or the no-voice condition that matched their professional role on the team (i.e., either nurse or physician). After reading the vignette, participants completed a manipulation check question and were then asked to evaluate the nurse's behavior in terms of its contribution to the team's decision-making effectiveness. At the end of the study, participants received a comprehensive debriefing on the study purpose and the two different experimental conditions.

Measures

Manipulation check

To ensure that our manipulation *via* the vignettes was effective, we used a manipulation check question (*Please indicate the extent to which you feel the nurse spoke up with alternative suggestions during the assessment*) with responses made on a scale from 1 (not at all) to 7 (very much).

Perceived contribution to team effectiveness

Based on established measures assessing perceived contribution in teams (e.g., Waller et al., 2011; Steinmetz et al., 2016), we asked participants to indicate the extent to which they agreed with the following item "This person's behavior helped us make the right decision" using a scale from 1 (do not agree) to 7 (completely agree). Notably, this assessment presented a subjective perception of whether the respective behavior of the nurse contributed positively to the optimal team decision. Thus, either behavior, remaining silent or voicing an alternative treatment suggestion, could have been perceived as contributing positively to the team. Remaining silent with the suggestion to intubate could be seen as contributing to a more efficient team decision-making process as it allows for a faster further treatment (transferring to radiology without the need to intubate beforehand). Based on medical guidelines, however, oxygen levels below 90% are considered beginning desaturation which represents a major risk factor in ongoing emergency treatment and thus provide an indication for intubation (Dunford et al., 2003). Moreover, one major reason for intubation is anticipating clinical course. Considering the patient's clinical status, one might worry that traveling to the CT scanner and having to lie flat for a prolonged period of time would be safer if an intubation was performed in advance. Thus, the decision on how to further treat the patient is not clearly apparent, but intubating the patient can be considered as the safer option and should certainly be openly discussed within the team to ensure the best possible outcome for the patient.

Psychological safety

We assessed psychological safety by using seven-item team psychological safety scale of Edmondson (1999) (Cronbach's Alpha = 0.77). It is important to point out that we asked participants to report on their perceptions of psychological safety in their actual work department and not within the hypothetical scenario. Sample items were: "People in this department sometimes reject others for being different" or "If you make a mistake it is often held against you" using a scale from 1 (do not agree) to 7 (completely agree). We note that the intraclass correlation indicated poor agreement among the staff members from this particular EM department [$ICC(1) = 0.28$, $p < 0.001$], thus suggesting that there is variance in perceptions (Koo and Li, 2016).

Control variables

We assessed participants' professional role (0 = nurse, 1 = physician) as a control variable, as it might affect evaluations of a member from one's own or a different function. Moreover, in healthcare teams specifically, professional role and hierarchical level are intertwined such that physicians hold a higher hierarchical level than nurses which may further affect evaluations of voice. In addition, we controlled for participants' gender (1 = male, 2 = female) and work experience (in years) as these have been noted as important in the context of voice (e.g., Howell et al., 2015).

Results

Table 1 presents the means, standard deviations, and intercorrelations between all variables. Before testing our hypotheses, we examined the responses to our manipulation check question. The results confirmed that our manipulation of voice was successful, as participants in the voice condition reported a significantly higher extent of the nurse speaking up with alternative suggestions during the scenario ($M = 5.79$, $SD = 1.20$) than participants in the no-voice condition ($M = 2.47$, $SD = 2.03$), $t(93) = -9.73$, $p < 0.001$. We excluded eight participants who failed the manipulation check from further analyses[1].

To test hypothesis 1, which predicted that nurses who voice are more likely to be perceived as helpful for the team than those who do

1 We note that the reported results are consistent when including participants who failed the manipulation check.

TABLE 1 Descriptive statistics and correlations.

Variable	*M*	*SD*	1	2	3	4	5
1. Professional role	0.76	0.43	—				
2. Work experience	7.10	9.52	0.00	—			
3. Gender	1.53	0.50	−0.33**	−0.25*	—		
4. Experimental condition	0.52	0.50	0.17	0.26*	−0.27**	—	
5. Psychological safety	4.66	1.05	0.19	−0.02	0.16	0.02	—
6. PCT	5.20	1.78	−0.01	0.23*	−0.14	0.25*	−0.04

$N = 101$. PCT, perceived contribution to team effectiveness.
[a]0 = Nurses, 1 = Physicians. [b]0 = No voice, 1 = Voice. *$p < 0.05$, **$p < 0.01$.

TABLE 2 Moderated multiple regression results predicting perceived contribution to team effectiveness (PCT; including control variables).

Variable	PCT		
	B	*SE*	*t*
Control variables			
Professional role[a]	−0.35	0.48	−0.73
Work experience	0.02	0.02	1.12
Gender	−0.19	0.43	−0.45
Predictors			
Experimental condition[b]	0.87*	0.39	2.2
Psychological safety	−0.57	0.3	−1.86
Interaction effect			
Exp. cond. × Psych. safety	0.86*	0.38	2.27

$N = 93$.
[a]0 = Nurses, 1 = Physicians.
[b]0 = No voice, 1 = Voice.
*$p < 0.05$.

not voice, we computed an independent samples *t*-test. In line with prediction, findings revealed that nurses in the voice condition ($M = 5.60$, $SD = 1.30$) were seen as contributing more strongly to team effectiveness than nurses in the no-voice condition ($M = 4.72$, $SD = 2.14$), $t(91) = -2.37$, $p = 0.020$.

To test hypothesis 2, that is, the moderating role of psychological safety in the relationship between voice and endorsement, we computed a multiple regression analysis using the PROCESS tool for SPSS (Hayes, 2017). Note that we centered psychological safety to ease interpretation of the results. In line with best-practice recommendations (Bernerth and Aguinis, 2016), we tested our proposed interaction hypothesis with and without the inclusion of relevant control variables. Supporting our hypothesis, we found a significant interaction between the experimental condition and psychological safety on perceived contribution to team effectiveness in our model using covariates (Table 2; $B = 0.86$, $SE = 0.38$, $t = 2.27$, $p = 0.026$; $\Delta R^2 = 0.05$). We also found a significant interaction between psychological safety and condition in our model without covariates (Table 3; $B = 1.00$, $SE = 0.36$, $t = 2.77$, $p = 0.007$; $\Delta R^2 = 0.08$).

Figure 1 depicts the interaction effect and visualizes the slopes for voice versus no voice under different levels of psychological safety. Simple slope analyses indicated a significant effect at higher levels of psychological safety, showing that when psychological safety was perceived to be high (i.e., 1 SD above the mean), participants evaluated the nurse who voiced concerns with the treatment and spoke up with an alternative suggestion as more valuable for team decision-making than the nurse who did not voice concerns or offer alternative suggestions ($B = 0.95$, $SE = 1.88$, $t = 3.76$, $p < 0.001$). In contrast, when psychological safety was perceived to be low (i.e., 1 SD below the mean), there was no significant relationship between voice and perceived contribution to team effectiveness ($B = -0.98$, $SE = -0.04$, $t = -0.07$, *ns*).

As an additional analysis, we also analyzed our data using the subsample of physicians ($n = 64$) to better understand how physicians as higher-ranking individuals evaluate nurses who voice or remain silent with suggestions. Computing a moderated regression analysis, we also found a significant interaction between psychological safety and experimental condition on endorsement in this group ($n = 64$; $B = 1.31$, $SE = 0.44$, $t = 2.98$, $p = 0.004$). Simple slopes analyses revealed the same direction of effects as in our overall sample with physicians evaluating voicing nurses more positively at high (i.e., 1 SD above the mean; $B = 2.48$, $SE = 0.59$, $t = 4.20$, $p < 0.001$) but not at low (i.e., 1 SD below the mean) levels of psychological safety ($B = 0.01$, $SE = 0.58$, $t = 0.03$, $p = 0.974$). Consistent with our findings from the overall sample, nurses who voiced concerns were generally considered as more helpful for the team by physicians, but this effect tended to increase and decrease with increasing and decreasing levels of psychological safety. Finally, we also computed a three-way interaction between professional role, experimental condition, and psychological safety on perceived contribution to team effectiveness but found no

TABLE 3 Moderated multiple regression results predicting perceived contribution to team effectiveness (PCT; without control variables).

	PCT		
	B	*SE*	*t*
Main effects			
Experimental condition[a]	0.94*	0.37	2.57
Psychological safety	−0.70*	0.29	−2.48
Interaction effect			
Exp. cond. × Psych. safety	1.00**	0.36	2.77

$N = 93$.
[a]0 = No voice, 1 = Voice.
*$p < 0.05$; **$p < 0.01$.

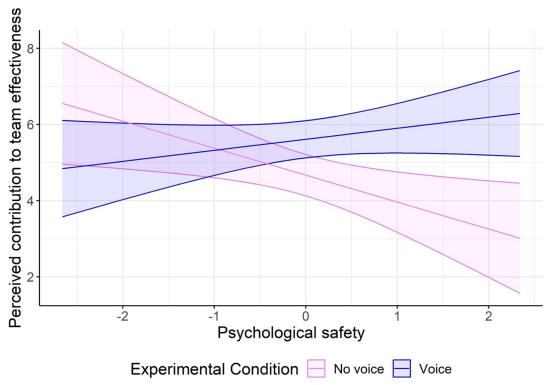

FIGURE 1
Interaction effect between experimental condition (no voice vs. voice) at different levels of psychological safety on perceived contribution to team effectiveness.

significant three-way interaction effect ($B = 0.54$, $SE = 0.98$, $p = 0.59$). Overall, this suggests that participants' function (i.e., being a nurse or a physician) did not significantly affect their judgment of the nurse.

Discussion

This study shows that when healthcare team members feel psychologically safe, they evaluate nurses who speak up as contributing more positively to the team than those who do not voice their concerns. Recent research indicates that voice can have positive interpersonal consequences, including higher recognition by superiors, higher perceived social status or better leadership abilities (Howell et al., 2015; McClean et al., 2018; Weiss et al., 2018).

Theoretical implications

Our study complements and extends research on consequences of voice by showing that psychological safety poses a boundary condition for evaluations of voice in functionally and status-diverse teams such as healthcare teams. In line with a social-cognitive perspective, people seem to "read the wind," that is, they look for cues in their immediate work context to determine whether another person's voice behavior may or may not be beneficial for the group (Fiske, 1993; Dutton et al., 1997). This seems particularly relevant when individuals assess the value of voice from a lower-ranking team member as such voice may challenge hierarchical boundaries and authority gradients (Magee and Galinsky, 2008).

We also complement research that has shown that group-or climate-related factors in teams such as psychological safety or group-voice climate are antecedents of voice (Detert and Trevino, 2010; Morrison et al., 2011). Our findings show that perceptions of psychological safety are also relevant for *evaluations of* voice. Nurses and physicians who feel psychologically safe consider nurses' voice, versus withholding of voice, as more helpful to team decision-making. Even though we did not find perceptions of low psychological safety to significantly diminish the evaluation of voicers, we found that under this condition people do not seem to recognize the added value of voice coming from a nurse to potentially improve team outcomes. This resonates with the notion of psychological safety as an enabler for organizational learning and change (Schein, 1985; Edmondson and Lei, 2014). Because we consider reactions toward voicing, this naturally has implications for individuals' further attempts to induce change at work. When leaders and coworkers believe that speaking up is helpful for the team (which this work shows is contingent on their own psychological safety), individuals who voice may continue to speak up versus learn that it is not advisable to do so.

As noted by Schein (1993), psychological safety reduces learning anxiety which is often prevalent when people are confronted with novel or contradictory information. When people feel that divergent opinions create ambiguity and uncertainty rather than an opportunity for reflection and adaptation, they do not perceive others who voice as helpful contributors to decision-making, and consequently, an opportunity for team reflection and learning is neglected. The fact that we found no differences between nurses and physicians in evaluating voice vs. withholding of voice from a nurse further underlines that psychological safety has implications regardless of employees' formal role or status within an organization. Physicians were just as likely as nurses to be guided by their perceptions of psychological safety when evaluating a nurse who speaks up or remains silent. While most previous work has conceptualized psychological safety as a shared team-or organizational-level concept (e.g., Edmondson and Lei, 2014; Roussin et al., 2016), we highlight psychological safety as a social-cognitive variable that differs across individuals within the same work context. This extends our theoretical understanding of psychological safety, as the same organizational context may be perceived as a psychologically safe vs. unsafe context by different

individuals. The variance in psychological safety that was evident in our sample (composed of individuals from the same work unit) suggests that individual experiences and sense-making processes likely shape different perceptions across individuals within the same organization, unit, or team.

Our results also have implications within the broader context of teamwork. Although functionally diverse teams may have more information available due to team members' divergent expertise, they are often unable to reap those benefits. Due to social categorization processes and "us" vs. "them" distinctions, stereotyping, discrimination, and disparaging treatment of out-group members are often prevalent in diverse teams, with negative implications for team processes and outcomes (Hogg and Terry, 2000). Studies have shown that psychological safety moderates the extent to which diverse teams can leverage the benefits of their diverse demographic, functional, or cognitive backgrounds or when they have diverging viewpoints (e.g., Bradley et al., 2012; Kirkman et al., 2013; Martins et al., 2013; Jetten and Hornsey, 2014). For example, Martins et al. (2013) showed that high levels of psychological safety can buffer the negative effect of expertise diversity on team performance. The authors suggested that psychological safety fosters a more inclusive team climate in which the capabilities of different team members can be best utilized. We add to this line of research by showing that a high level of psychological safety is positively associated with an appreciation of those who constructively challenge the status quo to the benefit of the team.

Limitations and future research

There are some limitations of our study that are worth noting. Although we were able to conduct a randomized between-subjects experiment with working healthcare professionals and systematically investigate responses to voice, participants were not actually immersed in the situation. This may raise concerns about participants responding in a socially desirable manner and evaluating the nurse's voice behavior in a way that was overly positive. In actual teamwork or interpersonal episodes, factors beyond the content of the message such as timing or tone (Whiting et al., 2012) as well as liking and other interpersonal factors may also affect evaluations of voice. Thus, we encourage the use of laboratory studies (e.g., using medical or other teamwork simulations) where voice behavior can be manipulated *via* a confederate and subsequent evaluations can be observed and assessed more validly.

Second, our sample was slightly skewed, as we had more physicians participating in the study than nurses. However, we actually consider this a plus, as we thus had more individuals from the higher-ranking profession evaluating an individual from a lower-ranking profession. Studies investigating voice behavior in healthcare settings have shown that nurses are particularly hesitant to voice concerns to physicians because they feel that it is not their place to speak up and that they would bypass the hierarchy when doing so (Edmondson, 1996). Although our findings suggest that evaluations of voice may be more determined by perceptions of psychological safety rather than one's professional role and hierarchical rank, future research should assess the impact of professional role on voice endorsement using larger samples from different team contexts.

Relatedly, our sample was drawn from a single department in a hospital, which may limit the generalizability to other organizational contexts. Because perceptions of psychological safety likely differ across occupational contexts and organizational levels, future research should examine other team and organizational contexts. It would also be valuable to adopt a multi-level approach to investigate how within-and between team differences in psychological safety affect evaluations of voice.

Practical implications

One important practical implication that can be derived from our findings is that team leaders, which, in healthcare teams are represented by senior physicians, need to be mindful of the importance of psychological safety in affecting interpersonal evaluations and team processes. One way in which leaders may increase psychological safety is through communication with their subordinates. For example, a study investigating the effects of inclusive leader language within professionally diverse teams showed that leader attempts to foster voice behavior need to be adapted to different team members: team members from a lower status profession (i.e., nurses) required more affirmation that their voice is appreciated than team members from a higher status profession (i.e., physicians; Weiss et al., 2018). Thus, using collective language and explicitly inviting nurses to speak up can help build psychological safety in the team which not only increases voice but may also foster positive responses to it. Apart from inviting subordinates to speak up, leaders should also foster positive responses to voice within a team. Recent research shows that team leaders who openly seek and discuss feedback can build a climate of trust and psychological safety (Coutifaris and Grant, 2022). This signals to employees that their input is welcome and may result in sustained efforts to contribute to the team.

A further practical implication is that healthcare teams may also reflect their perceptions of psychological safety in the context of after-event reviews, that is, short debriefings that happen after a specific teamwork episode and that are frequently adopted in high-risk contexts (e.g., Ellis and Davidi, 2005). Such after event-reviews have been shown to decrease the perception of hierarchical barriers and increase voice behavior in teams (Weiss et al., 2017).

Conclusion

Emerging research focuses on understanding how individuals who voice suggestions or work-related concerns are evaluated by others. We highlight psychological safety as an important moderator in healthcare teams that affects whether nurses who voice critical input are seen as more valuable contributors for team decision-making than those who withhold their concerns. Our findings underline that individuals rely on cues from the environment when determining the value of voice.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors upon request, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Institutional Review Board NYU Langone. The patients/participants provided their written informed consent to participate in this study.

Author contributions

MW developed the research question, designed the study, performed the statistical analyses, and drafted the manuscript. EM supported the theoretical development of the manuscript. DS provided access to the sample and helped with the design of the experimental manipulations. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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EDITED BY
Juliane E. Kämmer,
University of Bern, Switzerland

REVIEWED BY
Lauren Kennedy-Metz,
Roanoke College, United States
Margarete Boos,
University of Göttingen, Germany

*CORRESPONDENCE
Hanna Morian
✉ hanna.morian@umu.se

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Reliability and validity testing of team emergency assessment measure in a distributed team context

Hanna Morian[1]*, Maria Härgestam[1], Magnus Hultin[2], Håkan Jonsson[3], Karin Jonsson[1], Torben Nordahl Amorøe[4,5] and Johan Creutzfeldt[6,7]

[1]Department of Nursing, Umeå University, Umeå, Sweden, [2]Department of Surgical and Perioperative Sciences, Anesthesia and Critical Care Medicine, Umeå University, Umeå, Sweden, [3]Department of Epidemiology and Global Health, Umeå University, Umeå, Sweden, [4]Department of Molecular and Clinical Medicine, Institute of Medicine, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden, [5]Simulation Center West, Department of Research, Education, and Development, Region Västra Götaland, Sahlgrenska University Hospital, Gothenburg, Sweden, [6]Department of Clinical Science, Intervention, and Technology, Karolinska Institute, Stockholm, Sweden, [7]Center for Advanced Medical Simulation and Training, Karolinska University Hospital, Stockholm, Sweden

Medical multi-professional teams are increasingly collaborating *via* telemedicine. In distributed team settings, members are geographically separated and collaborate through technology. Developing improved training strategies for distributed teams and finding appropriate instruments to assess team performance is necessary. The Team Emergency Assessment Measure (TEAM), an instrument validated in traditional collocated acute-care settings, was tested for validity and reliability in this study when used for distributed teams. Three raters assessed video recordings of simulated team training scenarios (n=18) among teams with varying levels of proficiency working with a remotely located physician *via* telemedicine. Inter-rater reliability, determined by intraclass correlation, was 0.74–0.92 on the TEAM instrument's three domains of leadership, teamwork, and task management. Internal consistency (Cronbach's alpha) ranged between 0.89–0.97 for the various domains. Predictive validity was established by comparing scores with proficiency levels. Finally, concurrent validity was established by high correlations, >0.92, between scores in the three TEAM domains and the teams' overall performance. Our results indicate that TEAM can be used in distributed acute-care team settings and consequently applied in future-directed learning and research on distributed healthcare teams.

KEYWORDS

interprofessional teams, team performance, teamwork, distributed team, telemedicine, instrument, validation, assessments

1. Introduction

With the increasing use of telemedicine, alternative team structures have emerged in healthcare (Butler et al., 2019). Telemedicine uses electronic information and communications technologies to provide and support healthcare when distance separates the participants (Field, 1996). The COVID-19 pandemic has brought telemedicine to the forefront of healthcare systems; today, telemedicine is widely used and highly relevant (Bains et al., 2020; Vilendrer

et al., 2020; Garattini et al., 2021). By enabling local medical staff to be connected to specialists *via* a video link, telemedicine can assist in bringing first-rate healthcare to remote areas (Craig and Patterson, 2005).

A considerable amount of research has focused on understanding how teams work effectively (Salas et al., 2016). Teamwork is generally seen as more challenging in distributed team settings (Bolle et al., 2009); however, the added complexity needs to be defined. Distributed teams can be distinguished from traditionally collocated teams in terms of collaboration through communication technologies and their geographical dispersion (Bell and Kozlowski, 2002). Typically, they include knowledge workers with unique skills (Bell and Kozlowski, 2002). In addition, they can vary in structure, from entirely distributed teams when all team members are distributed to different locations to partially distributed teams, where the number and size of isolated and collocated subgroups differ (O'Leary and Cummings, 2007). Today, it is still being determined how technology and the lack of the physical presence of team members impact teamwork in healthcare teams.

Across healthcare, high-performing team functions are critical in providing safe patient care (Shapiro et al., 2008; Valentine et al., 2015). Analyses of human errors in medicine have revealed that poor teamwork skills are often at the heart of mistakes and failures (Kohn et al., 2000). Insufficient leadership, communication, decision-making, and collaboration (i.e., teamwork skills or non-technical skills) are associated with many adverse events, leading to patient injury, permanent disability, and even death (Boet et al., 2019). Team research has proven that education and training can improve team processes and patient safety outcomes (Weaver et al., 2014). In particular, increased training in non-technical skills enhances team performance (American College of Surgeons Committee on Trauma, 2013) and patient safety (Manser, 2009).

Instruments to evaluate team performance are essential to determine the effectiveness of team training, and instruments addressing crucial teamwork skills help foster clinicians' understanding and guide training (Boet et al., 2019). Furthermore, a vital aspect of training effective teamwork is to include the team's specific challenges and environment (Manser, 2009) when planning the training program since clinical context greatly affects how team members work together (Schmutz et al., 2019). Several instruments for performance evaluation have been developed and validated for teams working in traditional co-located settings, either in clinical or simulation-based environments (Valentine et al., 2015; Boet et al., 2019; Bhangu et al., 2022). Available instruments range in focus from assessing general teamwork skills (e.g., Healthy Teams Model; Mickan and Rodger, 2005) to more context-specific skills such as Non-Technical Skills for Surgeons (NOTSS; Yule et al., 2008). The increased use of telemedicine makes it necessary to validate instruments for assessing team performance in distributed teams, considering their profoundly different working conditions.

The Team Emergency Assessment Measure (TEAM) was developed by Cooper and colleagues as an instrument focusing on team performance specific to the cardiac resuscitation context (Cooper et al., 2010). The instrument was subsequently recognized as valid and reliable in several studies for emergency teams (Cant et al., 2016) in simulated and clinical settings with students (Hultin et al., 2019) and medical staff (Cooper et al., 2016). TEAM has also been translated into and validated for languages other than English (Maignan et al., 2016; Karlgren et al., 2021).

Even though TEAM is an established measurement of teamwork with good psychometric properties for emergencies (Valentine et al., 2015; Boet et al., 2019; Bhangu et al., 2022), to the best of our knowledge, its validity and reliability have not been established for the distributed team context. To address this gap, we report on the reliability and validity of TEAM for distributed teams managing acute medical conditions when the physician participates from a remote location *via* telemedicine.

2. Methods

2.1. Ethics

The Swedish Ethical Review Authority reviewed our application (registration number 2021-01027, date of decision: 2021-03-22). Since no intervention in a manner specified in Swedish legislation on ethics was planned, they concluded that this study was exempt from formal ethics approval. Nevertheless, the review authority presented no ethical objections to the study during the vetting process. Written informed consent was obtained, and the participants were informed that they were free to withdraw their consent without further explanation.

2.2. Data collection

Data collection consists of two stages, presented in chronological order: stage 1: simulation-based team training, and Stage 2: rating procedure.

2.2.1. Stage 1: simulation-based team training

Data were collected in the autumn of 2021 at the Clinical Training Center at Umeå University in Northern Sweden during video-recorded simulation-based team training in which the physician participated remotely.

2.2.1.1. Participants

A total of 27 participants were recruited: nine students (nursing and medical) at Umeå University and 18 medical staff (assistant nurses, registered nurses (RNs), and physicians) from the emergency department (ED) at Umeå University Hospital. Students referred to as *beginners* were invited during their final year of education through e-mail and classroom announcements and during digital seminars. ED managers, who were blinded to the study aim, invited medical staff with limited work experience in their field and/or ongoing specialist training, referred to as *intermediates*, and medical staff with extensive work experience in their field and/or specialists, referred to as *experts*. The participants were organized into nine three-person teams based on their proficiency level (Table 1): beginners (Teams 1–3), intermediates (Teams 4–6), and experts (Teams 7–9). At the beginner level, each team consisted of two student nurses (in the 5th or 6th semester) and one medical student (in the 10th or 11th semester). At the intermediate and expert levels, each team consisted of one assistant nurse, one RN, and one physician, according to standard practice in small emergency teams. In contrast to the other participants, the nursing and medical students had never worked together. In all teams, except one, both genders were represented. The characteristics of the

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TABLE 1 Study population characteristics.

	Participants	Teams 1–3	Teams 4–6	Teams 7–9
	All	Beginner	Intermediate	Expert
	N=27	*N*=9	*N*=9	*N*=9
Age median (Q1–Q3)	30 (25–43)	25 (24–27.5)	38 (29–46)	42 (28.5–52)
Female *n* (%)	17 (63)	6 (67)	5 (56)	6 (67)
Male *n* (%)	10 (37)	3 (33)	4 (44)	3 (33)
Nursing student *n* (%)	6 (22)	6 (67)	0 (0)	0 (0)
Medical student *n* (%)	3 (11)	3 (33)	0 (0)	0 (0)
Assistant nurse *n* (%)	6 (22)	0 (0)	3 (33)	3 (33)
Registered nurse *n* (%)	6 (22)	0 (0)	3 (33)	3 (33)
Physician *n* (%)	6 (22)	0 (0)	3 (33)	3 (33)
Work experience: year median (Q1–Q3)	4 (1.8–10.5)	1 (1–3)	5 (4–11)	11 (4.3–19.5)
No previous experience in team training, *n* (%)	1(4)*	0 (0)	1 (11)	0 (0)*
Previous experience in team training < 5 events, *n* (%)	11 (42)*	7 (78)	2 (22)	2 (25)*
Previous experience in team training ≥ 5 events, *n* (%)	14 (54)*	2 (22)	6 (67)	6 (75)*
Previous experience working in a distributed team, *n* (%)	4 (15)*	4 (44)	0 (0)	0 (0)*

*One missing value.

study population are presented in Table 1. All participants completed the study.

2.2.1.2. Scenarios for team training

Each team participated in two scripted scenarios in which they were instructed to assess and treat a patient with deteriorating vital signs in the emergency room. For all teams, the patient suffered a urosepsis in the first scenario, whereas in the second scenario; the patient experienced a myocardial infarction. A standardized patient setup was used to support standardization and encourage interaction—more specifically, an individual was trained to follow a script to portray the patient (Felix and Simon, 2020). Each scenario was designed to last for about 20 min and displayed a medical emergency requiring immediate action. Furthermore, the scenarios were designed so that the patient's condition would deteriorate at given times. The complexity and difficulty of the two scenarios were established beforehand by an expert group of experienced physicians and nurses in the area to make them comparable.

2.2.1.3. Setting

To emphasize the location of the participants during the simulation-based team training, the student nurses, assistant nurses, and RNs are referred to herein as *proximal staff*, since they were located in the emergency room with the patient. The medical students and physicians are referred to as *remote physicians*, since they participated in a separate room. A setup with the common locations of the participants during the simulation-based team training is illustrated in Figure 1. In both locations (i.e., the emergency room and the remote room), there were laptops equipped with Zoom™ video conferencing software—that is, a synchronous audiovisual communication platform—for connectivity. When the proximal staff needed to consult a remote physician, they initiated contact through the platform. An external loudspeaker amplified the sound of the connection in the emergency room. The laptop in the emergency room was placed on a portable table, facilitating direct interaction with the patient. A vital sign monitor—which is typically used during patient care—displaying the patient's heart rate, blood pressure, and peripheral oxygen saturation was present and facilitator-controlled for further simulation authenticity. The facilitator was present in the room's periphery while the scenario was running to provide information on clinical tests that the standardized patient could not display. To allow for the later assessment of team performance, the proximal staff were audio- and video-recorded from different angles, and the remote physician was recorded through the live-video feed. The setup, including camera views, is presented in Figure 2.

2.2.1.4. Implementation of simulation-based team training

Before the simulated team training scenarios started, the participants viewed a 10-min video describing patient safety and teamwork according to the Crew Resource Management (CRM) concept (Helmreich et al., 1999) and initial assessment and treatment based on the Advanced Trauma Life Support (ATLS) program (American College of Surgeons Committee on Trauma, 2013). The research group made the introduction video.

Then, the participants were informed about the training structure, available resources and equipment, and function of the educational staff. The participants reported their basic demographics through a questionnaire regarding their age, gender, medical education, and work experience. In addition, questions were asked about previous experience in team training and prior experience working in distributed medical teams relying on synchronized communication technology (Table 1).

The team training sessions started with a facilitator-led briefing on the primary goal of the training sessions. The participants were encouraged to use all available resources in the team and to use a systematic approach to treat the patient. The scenarios then started with a handover from the facilitator, who gave brief background information on the patient. Team members were instructed to follow

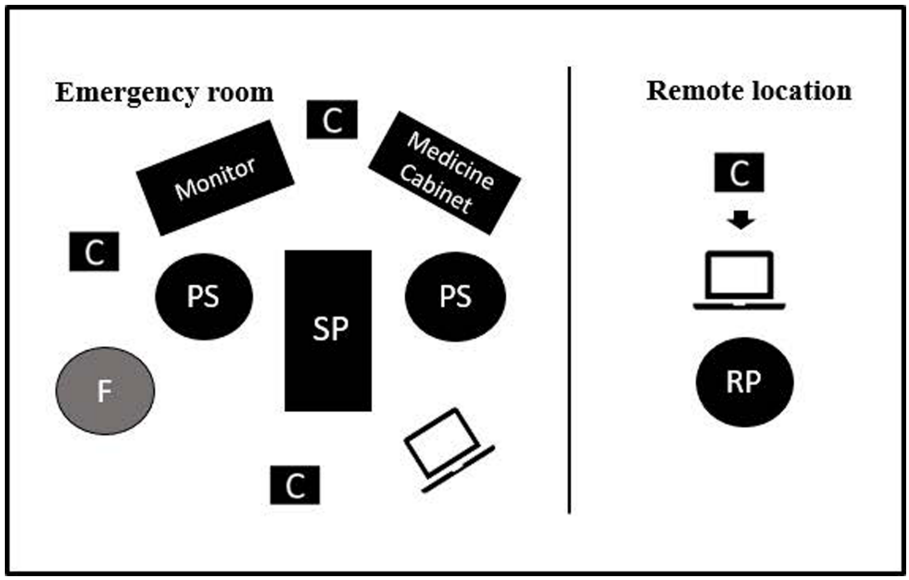

FIGURE 1
Setup for simulation team training. SP, Standardized patient; PS, Proximal staff (assistant nurse, registered nurse, or student nurses); RP, Remote physician or remote medical student; F, Facilitator; C, Camera. In the remote location, the camera was integrated into the laptop. The laptop in the emergency room was on a portable table, so the figure demonstrates a typical but not fixed location. Monitor for patient vital signs. Medicine cabinet contained emergency medical equipment.

FIGURE 2
Different camera views. **(A)** Standardized patient and proximal staff; laptop screen displays the remote physician, encircled in red. **(B)** Remote physician. **(C)** Proximal staff and standardized patient. **(D)** Remote physician's camera view: facilitator, proximal staff, and standardized patient.

standardized operating procedures and medical guidelines to identify the medical condition and start necessary treatments. The facilitator ended the scenario when the team stabilized the patient's vital signs and communicated a diagnosis and continued care plan. The facilitator initiated and led a debriefing that focused on medical treatment (task performance) and teamwork skills, which lasted for about 15 min, immediately after completing each scenario. Figure 3 provides a flowchart of the simulation-based team training in Stage 1.

2.2.2. Stage 2: rating procedure

Data was collected in spring of 2022. Three raters assessed video-recorded simulation-based team training.

2.2.2.1. Participants

We recruited three raters with a convenience sample for rating procedures with the TEAM instrument. Rater 1 was a critical care registered nurse and PhD in nursing. Rater 2 was a consultant physician in anesthesia and intensive care and PhD student. Rater 3 was a resident physician in anesthesia and intensive care medicine. Raters 1 and 2 had more than 12 years of experience as simulation facilitators and raters, while Rater 3 was a novice. Both genders were represented.

2.2.2.2. Rating procedure

The raters were introduced to the TEAM instrument in its original version and an additional guide (Cooper et al., 2010). As a preparation, the raters independently practiced assessments on two video-recorded team training simulations (2 × 20 min) equivalent to those included in the study. Then, the raters discussed their scores to establish a common understanding of the instrument and reach a consensus (calibration) for the rating procedure. The video-recorded scenarios ($n = 18$) were coded, and the assessments were assigned randomly. Figure 4 provides a flowchart of the rating process in Stage 2.

2.2.2.3. The instrument

TEAM is an item-based instrument for assessing teamwork developed by Cooper et al. and composed of three domains: *leadership* (items 1–2), *teamwork* (items 3–9), and *task management* (items 10–11; Cooper et al., 2010; Cooper, 2022). Each item is rated on a five-point Likert scale, ranging from 0 = Never/hardly ever to 4 = Always/nearly always, based on the frequency of occurrence of defined behaviors. In total, the maximum score is 44. According to Cooper et al., scores of 33 or less, 34–39, and 40–44 indicate poor, good, and excellent team performance, respectively. In addition, a twelfth item, *overall performance,* is rated on a scale of 1–10, based on the rater's overall "gut reaction" to the global team performance. Global rating scores below 7 indicate poor performance, while 9–10 are considered excellent.

2.3. Data analysis

Based on previous work (Hultin et al., 2019), a sample size of nine teams was suggested. For inter-rater reliability calculations, Koo et al. recommend three raters (Koo and Li, 2016). In this study, all three raters assessed all video-recorded scenarios ($n = 54$). No rating data was missing. SPSS Statistics for Windows version 28 (IBM, 2021) was used to compute descriptive statistics and the validity and reliability outcomes.

This study was methodologically guided in reliability and validity, based on the definitions of these terms by Streiner et al. (2015). *Reliability* assesses that the instrument measures something in a reproducible fashion; in other words, it is the extent to which a research instrument consistently has the same results if used in the same situation repeatedly. However, reliability says nothing about what is being measured; valid evidence is required to determine that. *Validation* is a process of determining what concept is being accurately measured with the instrument (Streiner et al., 2015).

Inter-rater reliability using intraclass correlation (ICC) explores the variation between raters when assessing the same group of subjects. With guidance from Koo et al., we calculated the ICC based on the model: two-way random effect; type: average measure; and definition: consistency and absolute agreement (Koo and Li, 2016). Calculations were made on TEAM domains using the mean score of each rater and on each item using each rater's scoring results. The two-way random effect regards the raters as randomly selected from a larger population with similar characteristics. Average measures were chosen, since the data were based on the mean of multiple raters. Analyses of both consistency and absolute agreement were made, because we intended to measure whether the raters' scores for the same group of subjects were correlated in an additive manner (consistency) and whether different raters assigned the same score to the same subject (absolute agreement) *Internal consistency*, which explores the extent to which all items measure the same concept (Tavakol and Dennick, 2011), was calculated using Cronbach's alpha on the mean value of the raters for the items in each of the three TEAM domains. Cronbach's alpha was also measured on all TEAM items except item 12. *Predictive validity* is the extent to which the instrument's results predict the outcome (Streiner et al., 2015). To reflect the variation in TEAM scores across the teams' experience levels and between scenarios, a one-way analysis of variance, the Kruskal Wallis test, was calculated with an exact p value. The mean value for the respective rater scores in each TEAM domain was compared with the proficiency levels (beginner, intermediate, and expert) and scenarios (urosepsis and myocardial infarction). Finally, *concurrent validity* shows the extent of the agreement between two measures or assessments taken at the same time (Streiner et al., 2015). Using Pearson's method, correlations were calculated between the

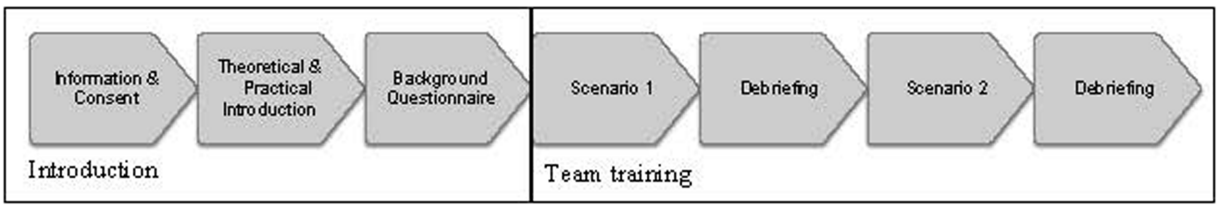

FIGURE 3
Flowchart for Stage 1: simulation-based team training. The time required for information and consent, theoretical and practical introduction, and background questionnaire was 1 h. Each scenario was designed to last for about 20 min, and debriefing was carried out for 15 min.

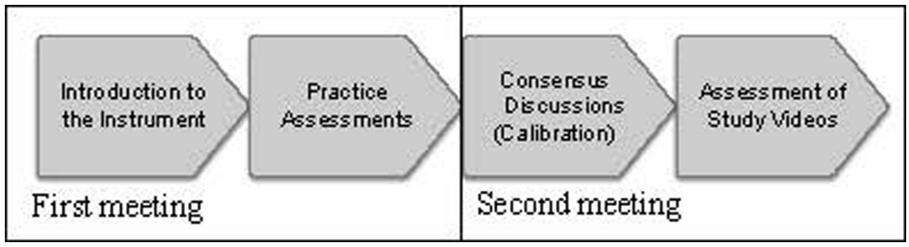

FIGURE 4
Flowchart for Stage 2: rating procedure. At the first meeting, the instrument was introduced for 2 h. Then, during 2 weeks, the raters assessed two scenarios of 20 min each. In the second meeting, a consensus discussion took place for 2 h. Within 2 months, all raters individually assessed 18 video-recorded simulation-based team training sessions.

overall performance scores and the three TEAM domains. A statistical significance was considered with a p value <0.05.

3. Results

3.1. Reliability

The ICC values for the domains and item levels are presented in Table 2. For consistency, the ICC (95% confidence interval) calculated for the TEAM domains of leadership, teamwork, and task management were 0.74 (0.42–0.89), 0.92 (0.81–0.97), and 0.85 (0.67–0.94), respectively. According to Koo et al., these values correspond to moderate, excellent, and good inter-rater reliability in the respective domains (Koo and Li, 2016). For absolute agreement, the corresponding values for leadership, teamwork, and task management were 0.59 (0.10–0.83), 0.82 (0.36–0.94), and 0.78 (0.46–0.92), respectively, indicating good reliability. Moreover, the ICCs for item 12 were 0.91 (0.81–0.97) and 0.80 (0.30–0.94), regarding consistency and absolute agreement, indicating excellent and good inter-rater reliability, respectively, as the overall rating. The item rating correlation between raters was fitted by linear regression, as shown in Figure 5.

3.2. Internal consistency

The internal consistency measured with Cronbach's alpha for the three TEAM domains (leadership, teamwork, and task management) were 0.94, 0.97, and 0.89, respectively, indicating excellent internal consistency. For the total scores of items 1–11, Cronbach's alpha was 0.97.

3.3. Predictive validity

In all three TEAM domains, as well as in the overall performance, significant differences were found between the beginner, intermediate, and expert groups in terms of the performances scores ($p < 0.001$). The boxplots in Figure 6 illustrate the main differences between the beginners and the other two team categories (intermediates and experts). A comparison of the three TEAM domains for the two scenarios (urosepsis vs. myocardial infarction) showed no significant difference.

3.4. Concurrent validity

Finally, there was a positive correlation between the scores in the three TEAM domains and the 12th item (overall), all of which were above 0.92. This indicates a strong connection between the concept's leadership, teamwork, task management, and overall team performance.

4. Discussion

This study aimed to test the validity and reliability of TEAM in distributed healthcare teams working in an acute simulated setting. Overall, we found strong inter-rater reliability and internal consistency, suggesting that TEAM can be used to assess team performance with a remote physician. New demands from a continuously changing workplace emphasize the importance of development in team research. Today, there is a need to investigate alternative team structures and to understand better what it means to connect short-lasting *ad hoc* emergency teams and technology (White et al., 2018). Since non-technical skills contribute to providing safe patient care and positively influencing the quality of teamwork (Cooper et al., 2016), developing team training adapted to distributed team settings and their different working conditions is essential.

Good psychometric properties have previously been reported for the TEAM instrument in terms of validity and reliability in various settings for co-located teams (Cooper et al., 2010, 2016; Maignan et al., 2016; Hultin et al., 2019). However, physically separating the team profoundly affects the prerequisites for teamwork (Butler et al., 2019). Therefore, the reliability and validity of the instrument could not be taken for granted in this alternate setting.

According to Shoukri et al., the estimated ICC value depends on the sampled subjects' heterogeneity; in other words, the more heterogeneity, the higher the ICC value (Shoukri et al., 2004). Low values may reflect a lack of variability in subjects, a small number of issues, or a small number of raters. Freytag et al. compared novice and expert raters using TEAM in simulated emergencies and found a similar distribution of the ratings, even though the novices were slightly more forgiving in rating behavior (Freytag et al., 2019). In this study, the ICC values of the three raters with somewhat different backgrounds and experiences were consistent.

The values for Cronbach's alpha were between 0.89–0.97. An alpha value greater than 0.7 is considered acceptable, even though values

TABLE 2 Intraclass correlation.

Items in TEAM	ICC (CI 95%)	ICC (CI 95%)
	Consistency	Absolute agreement
Leadership	0.74 (0.42–0.89)	0.59 (0.10–0.83)
1. The team leader let the team know what was expected of them through direction and command.	0.65 (0.24–0.86)	0.55 (0.09–0.81)
2. The team leader maintained a global perspective.	0.70 (0.34–0.88)	0.54 (0.05–0.81)
Teamwork	0.92 (0.81–0.97)	0.82 (0.36–0.94)
3. The team communicated effectively.	0.64 (0.20–0.85)	0.64 (0.21–0.85)
4. The team worked together to complete the tasks in a timely manner.	0.93 (0.84–0.97)	0.89 (0.71–0.96)
5. The team acted with composure and control.	0.47 (0–0.78)	0.36 (0–0.71)
6. The team morale was positive.	0.80 (0.56–0.92)	0.72 (0.35–0.89)
7. The team adapted to changing situations.	0.87 (0.71–0.95)	0.73 (0.22–0.91)
8. The team monitored and reassessed the situation.	0.83 (0.62–0.93)	0.72 (0.30–0.89)
9. The team anticipated potential actions.	0.78 (0.51–0.91)	0.73 (0.42–0.89)
Task management	0.85 (0.67–0.94)	0.78 (0.46–0.92)
10. The team prioritized tasks.	0.79 (0.54–0.92)	0.78 (0.53–0.91)
11. The team followed approved standards/guidelines.	0.76 (0.46–0.90)	0.62 (0.14–0.85)
Overall		
12. On a scale of 1–10, give your global rating of the team's performance.	0.91 (0.81–0.97)	0.80 (0.30–0.94)

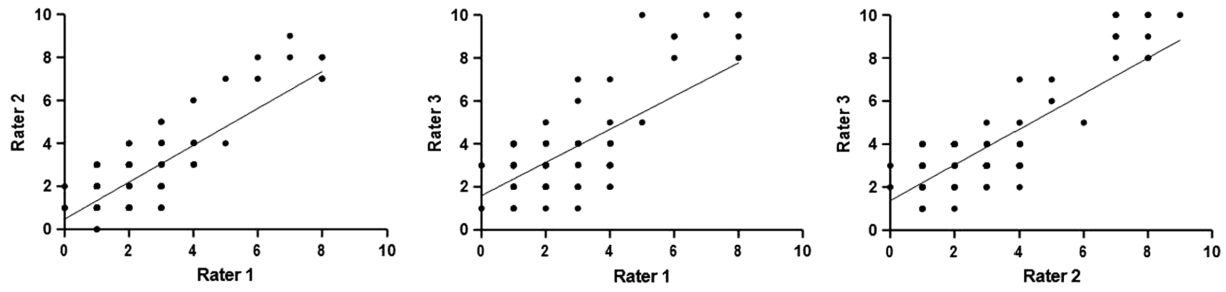

FIGURE 5
Item rating correlation between the raters, as fitted by linear regression. Rater 1 vs. Rater 2: $Y=0.8572*X+0.4800$, $p<0.0001$. Rater 1 vs. Rater 3: $Y=0.7714*X+1.595$, $p<0.0001$. Rater 2 vs. Rater 3: $Y=0.8284*X+1.376$, $p<0.0001$. The p-value is the significance for the slope being non-zero; i.e., a correlation between x and y.

above 0.8 are preferable. Nevertheless, values >0.90 might not be desirable unless in high-stakes examinations, as may indicate item redundancy (Tavakol and Dennick, 2011). The original version of TEAM was validated for a cardiac resuscitation context (Cooper et al., 2010). The values for Cronbach's alpha in that context were 0.89, and a validation of a Swedish translation of TEAM yielded alpha values of 0.96 (Karlgren et al., 2021). Our findings on internal consistency are similarly high, indicating that some items might be redundant. As instrument development was not the topic of this study, we only conclude that the instrument has excellent internal consistency in this setting.

Having teams with different proficiency levels allowed us to test the scale for predictive validity. We found that the beginner groups' scores differed from those of the intermediate and expert groups. There were minor differences between the intermediates and experts, reflecting the difficulty in assessing the experience and knowledge of the already-established staff. Furthermore, younger and less clinically experienced staff may have more experience in electronically mediated communication. In this study, some of the participants at the beginner level had previous experience in distributed settings. The medical staff at the expert levels were experts in clinical expertise but not necessarily in teamwork *via* video communication. Moreover, it is well known that familiarity among team members positively affects communication and performance (Marlow et al., 2018). In our study, in contrast to participants at the beginner level, intermediates and experts were familiar with each other, which could contribute to the results on predictive validity. Hence these results should be interpreted with caution. No significant differences were found between the TEAM domains and the scenarios. This could result from the work done beforehand to make the scenarios equally complex.

According to von Wendt et al., the most crucial factor in a scientific investigation is deciding on an instrument suited for the research and field of study (von Wendt and Niemi-Murola, 2018). Also, Schmutz et al. claim that there is no "one-size-fits-all training

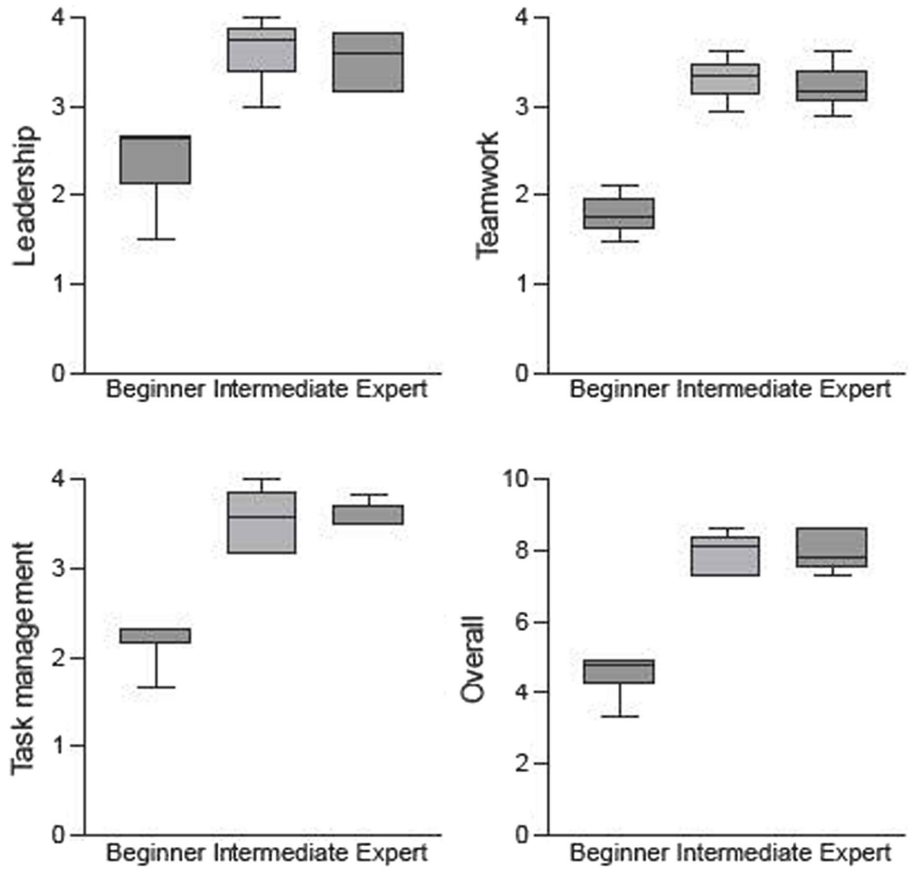

FIGURE 6
Boxplots showing the distribution of the ratings for TEAM domains and overall performance depending on proficiency levels. In all TEAM domains, the scores significantly correlated with the proficiency level (p-value < 0.001 for all dimensions).

method" and that factors such as norms and collaboration influence teamwork and clinical performance (Schmutz et al., 2019). Although they had varying backgrounds and levels of experience, the raters in this study perceived the TEAM instrument as user-friendly with a clear design. The raters in this study used the original version of the instrument, since they had used it before; moreover, by validating the English version, access to a larger community of users is provided. Karlgren et al. translated and validated the TEAM instrument in Swedish and struggled with the first leadership item, since "through command" was considered to be culturally inappropriate in Swedish healthcare (Karlgren et al., 2021). The wording was negatively perceived as being authoritarian. In our preparatory work, when the raters were gaining a shared sense of the instrument, we reasoned along the same lines as Karlgren et al. "that team leaders should convey a plan to the team" rather than give command (Karlgren et al., 2021).

5. Limitations

We acknowledge that this study has some limitations. When conducting a reliability study, Koo et al. suggest at least 30 heterogeneous samples and a minimum of three raters (Koo and Li, 2016). The ICC values we obtained for the TEAM instrument aligned with those reported by previous researchers (Cooper et al., 2010; Carpini et al., 2021; Karlgren et al., 2021). However, due to the small sample size ($n = 9$) in this study, some caution is warranted regarding our findings on reliability. For this type of study, three raters may be regarded as acceptable, and using video recordings allows for double-checked observations and access to the same camera views (Karlgren et al., 2021). Due to the recruitment strategy, the sample of participants for the team training was not controlled for. It is possible that some of the groups contained particularly motivated and high-performing individuals; however, this situation is likely to have been similar for all the groups, independent of the proficiency level. Another limitation of this study is its simulated environment, which may not fully represent the complexity of the real-world setting. However, the scenarios were scripted with commonly occurring emergencies within the setting of a rural primary care healthcare center that relies on a distributed team. Future research could add to our findings with ratings from actual emergencies in distributed settings, thereby strengthening transferability.

6. Conclusion

In conclusion, when tested in a distributed team setting, TEAM was found to be a valid and reliable instrument for assessing emergency medical teamwork. This finding indicates that the instrument is feasible for use when assessing non-technical skills for

providing safe care in distributed teams. To the best of our knowledge, the instrument had not been previously validated in this context. Our findings can help focus future-directed learning in healthcare and assist future research on distributed healthcare teams.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by the Swedish Ethical Review Authority. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

JC obtained funding for the study. The study was conceived by JC, MHä, and MHu. HM, MHä, KJ, and TN participated in data collection. HJ, HM, JC, MHä, and MHu planned the statistical analysis and interpreted the data. HM carried out the formal analysis and the first draft preparation. HM, MHä, MHu, HJ, KJ, TN, and JC edited the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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EDITED BY
Margarete Boos,
University of Göttingen, Germany

REVIEWED BY
Consuelo Morgado-Valle,
Universidad Veracruzana, Mexico
Francesca Loia,
University of Naples Federico II, Italy

*CORRESPONDENCE
Veronika Anselmann
✉ veronika.anselmann@ph-gmuend.de

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The relationships between perceived individual and team characteristics, individual and team learning activities with effectiveness in nursing teams

Veronika Anselmann[1]*, Jasperina Brouwer[2] and Regina H. Mulder[3]

[1]Institute of Nursing Science, University of Education Schwäbisch Gmünd, Schwäbisch Gmünd, Germany, [2]Educational Sciences, Faculty of Behavioural and Social Sciences, University of Groningen, Groningen, Netherlands, [3]Faculty of Human Sciences, University of Regensburg, Regensburg, Bavaria, Germany

Introduction: Team learning plays a crucial role in addressing the shortage of nurses and ensuring that there are enough trained and capable nurses available during times of crisis. This study investigates the extent to which individual learning activities (1) contribute to knowledge sharing in teams and (2) impact the effectiveness of nursing teams. Furthermore, we want to obtain more insight into whether (3) the antecedents of individual psychological empowerment, teamwork preference, and team boundedness contribute to individual learning activities and knowledge sharing in nursing teams.

Method: We conducted a cross-sectional questionnaire study of 149 gerontological nurses working in 30 teams in Germany. They completed a survey measuring knowledge sharing, teamwork preference, team boundedness, individual learning activities, psychological empowerment, and team effectiveness (as an indicator of performance).

Results: The results from structural equation modeling revealed that individual learning activities contribute to knowledge sharing in teams and, as a result, enhance team effectiveness. In particular, psychological empowerment was found to be associated with individual learning activities, while teamwork preference and team boundedness were related to knowledge sharing.

Discussion: The results indicated that the accomplishment of individual learning activities plays an important role in nursing teams, as it is linked to knowledge sharing and, as a result, contributes to team effectiveness.

KEYWORDS

team learning, learning activities, knowledge sharing, psychological empowerment, nursing

1. Introduction

The current shortage of nurses worldwide (World Health Organization [WHO], 2020) highlights the importance of individual learning activities and their impact on team effectiveness. In light of this shortage, it is imperative for experienced nurses to educate

their novice colleagues rapidly. Nurses are often assigned to various work environments and are required to collaborate with teams that are not their usual colleagues. Nurses effectively navigate such situations by incorporating diverse learning opportunities and gaining hands-on experience from their other colleagues. Both of these approaches may contribute to team effectiveness (VanDevanter et al., 2014). King et al. (2022) claimed that many nurses deployed during the COVID-19 pandemic reported that they could meet standards; however, some expressed concerns about the quality of health care. The availability of diverse resources for knowledge sharing and support can help individuals manage their responsibilities and overcome the challenges posed by various deployments (VanDevanter et al., 2014).

Nursing means working in teams (Anselmann and Disque, 2022). A nursing team is defined as "two or more nursing staff who work together to provide care and administrative tasks for a group of patients" (Kalisch et al., 2009, p. 3803). Team boundedness and teamwork preference reflect an individual's sense of belonging to a team and their willingness to work in a team. Broetje et al. (2020) found that working in teams and having interpersonal relationships are important resources for nurses to handle the demands of their jobs. Therefore, for nurses, having a supportive and trustworthy team is a key factor in fostering effective teamwork (McInnes et al., 2015).

Teamwork is an important facilitator of performance in nursing teams (Schmutz et al., 2019). Defining nursing performance is challenging because nursing is a complex area with several co-occurring factors that impact performance (McCance et al., 2012). Nevertheless, nursing performance can be measured in terms of organizational factors involved in nursing healthcare provision (Dubois et al., 2013). Efficiency is one of the most important performance indicators because it "requires the formation of therapeutic relationships between professionals, patients, and others significant to them in their lives." (McCance et al., 2012, p. 1149). Therefore, in line with Wageman et al. (2005), we focused on the concept of effectiveness as an indicator of performance in terms of nursing teams' attainment of goals and attainments with regard to cost and time.

Although Tanyaovalaksna and Li (2013) observed that individual learning, team learning, and organizational learning are strongly interconnected, many studies have focused solely on team learning and team activities and have not specified the impact of individual learning activities on team learning and effectiveness (e.g., Timmermans et al., 2012). Rashkovits and Drach-Zahavy (2017), for example, showed that team accountability is positively associated with team learning and, hence, team effectiveness. Previous research, however, did not fully overlook the role of an individual in team learning and showed that individual characteristics (i.e., gender, education, and empowerment) and positive beliefs about teamwork preference, team learning, and improvement are important for team learning (Timmermans et al., 2012). Little is known about how accomplishments are derived from individuals' learning activities within teams and how individual and team-related factors influence team learning activities (Timmermans et al., 2012).

Furthermore, research has shown that different conditions can influence team learning in various ways (Wiese and Burke, 2019). Therefore, in addition to individual learning activities and knowledge sharing, we also included the antecedents of psychological empowerment, teamwork preference, and team boundedness while investigating how knowledge sharing contributes to team effectiveness (see **Figure 1**). To sum up, there is a dearth of information on how individual learning is related to team learning activities and how these learning activities can be influenced.

Therefore, the following research questions were answered in this study:

(1) To what extent is psychological empowerment related to nurses' individual learning activities?
(2) To what extent are team boundedness and teamwork preferences related to the team learning activity of knowledge sharing?
(3) To what extent does knowledge sharing relate to effectiveness?

We hypothesized that individual and team learning characteristics are related to individual and team learning activities as well as team effectiveness. We were interested in nurses' perceptions of their individual and team conditions for their engagement in individual and team learning activities and their self-reported effectiveness.

Nurses are the largest group of professionals in healthcare systems worldwide (Labrague et al., 2022). Nurses are of great importance for obtaining more insights into how teamwork can be promoted in healthcare. Nurses work in teams to handle their complex work tasks.

In the second section, the theoretical framework will describe definitions of learning and individual and team learning activities. All components of the empirical study, such as the sample and instrument, are described in methodology in the third section, followed by an overview of the results in the final sections.

2. Theoretical framework

2.1. Informal learning

Simons and Ruijters (2004, p. 210) described learning as "implicit or explicit mental/or overt activities and processes leading to changes in knowledge, skills, or attitudes or the ability to learn from individuals, groups, or organizations." Eraut (2004) described a continuum of informal and formal learning and defined informal learning as implicit, unintended, and unstructured learning. Because these learning processes are unstructured and experiential, they are often influenced by the learner's intentions and preferences (Marsick and Volpe, 1999). Vygotsky's (1978) sociocultural theory defines learning as a socially mediated process. Social interactions with team members can lead to cognitive development. The context in which social practices can be embedded is important for learning (Vygotsky, 1978).

Informal learning "includes the relations and dynamics among individual learners and learning collectives and is often embedded in everyday practice" (Lundgren et al., 2017, p. 317). This idea is in accordance with Dechant et al.'s (1993) definition of learning as an interaction between individuals, team beliefs, values, norms, and knowledge sharing. Informal learning activities can be socially shared or performed individually, independent of the context in

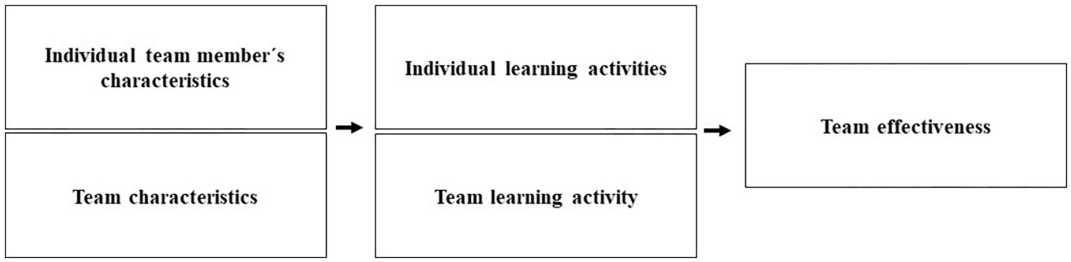

FIGURE 1
Research model.

which they are accomplished. Individuals can have ideas and gain knowledge and information for their own edification or share them with others. Informal learning activities occur in individual cognitive processes but can be shared and, through this sharing, become social learning activities (Russ-Eft et al., 2014). Participating in team learning activities is one way that nurses can handle the demands of their job.

Individual and team learning activities can be influenced by factors at the individual and team levels. Research has shown that psychological empowerment, as someone's estimation of the importance of work (Seibert et al., 2011), is an "important internal incentive factor" for nurses' motivation (Li et al., 2018, p. 1265).

2.2. Team learning

Decuyper et al. (2010, p. 116) developed a "systemic, cyclical and integrative team learning model that organizes and combines team learning processes, outputs, inputs, catalyst emergent states, and time-related variables into a coherent whole." Team learning is a dynamic process (Edmondson, 1999; Decuyper et al., 2010) in which team members engage in group learning activities. Knowledge sharing is a fundamental team learning activity and can be described as "communicating knowledge, competencies, opinions, or creative thoughts from one team member to the other team member" (Decuyper et al., 2010, p. 116). Sharing knowledge in teams is required to develop strategies and determine productive and innovative solutions for work tasks (Timmermans et al., 2012).

2.3. Individual learning activities in the team context

The "multi-level" model by Decuyper et al. (2010, p. 117) shows that team learning activities, such as knowledge sharing, can be influenced by team members' behaviors and characteristics. Individuals engage in informal learning activities, particularly when they encounter critical situations that require problem-solving or finding solutions to work-related problems (Marsick and Watkins, 2001; Manuti et al., 2015). As such, informal learning activities are not necessarily planned (Eraut, 2004) but can arise as a "by-product of work activities" (Joeng et al., 2018, p. 130) that are "self-directed, intentional, and field-based" (Cerasoli et al., 2018, p. 2). They can be differentiated from individual and social learning activities (Mulder, 2013). Individual learning activities are carried out by an individual and may result in individual learning outcomes, which might then be shared as knowledge among team members. Social learning activities, such as knowledge sharing, are carried out in interaction with others and lead to output within a social setting. Learning activities can be mental and covert or physical and overt (Simons and Ruijters, 2004). All of these characteristics need to be considered when investigating learning activities.

2.4. Conditions for nurses' engagement in individual and team learning activities

The characteristics of team members can serve as preconditions for learning activities (Decuyper et al., 2010, p. 122). One individual characteristic that is particularly important is psychological empowerment (Jha, 2019). Psychological empowerment is defined as someone's estimation of the importance of work and his or her motivation to take the initiative and handle work situations (Seibert et al., 2011). According to Spreitzer's (1995) multidimensional instrument, psychological empowerment consists of four components: meaning, self-determination, belief in one's own competencies, and belief in impact. Meaning refers to one's beliefs and values and how they align with the work environment. Self-determination refers to having control over one's work tasks and actions in the workplace. Competence concerns one's belief in their ability to successfully handle work tasks. The fourth component, belief in impact, is one's conviction that they have an influence on work actions and performance (Kraimer et al., 1999; Seibert et al., 2011). A condition that is especially relevant to work teams is team members' preference for working in teams. Teamwork preference is considered an individual's orientation toward a group and an individual's attitude toward the work within the context of their team (Kiffin-Petersen and Cordery, 2003).

In addition, emergent states of a team—such as one's feeling of belonging to the team—are an influential factor in team learning activities (Decuyper et al., 2010). Team boundedness contributes to team cohesion, which can enhance members' willingness to share knowledge since they will not consider it "too costly" (Dey and Ganesh, 2020). Conversely, when the boundaries of a team are blurred, trust and cohesion may decrease (Mortensen and Haas, 2018), leading to less willingness to share knowledge.

2.5. Team effectiveness

These conditions and consequential team learning activities determine a team's performance (Decuyper et al., 2010). Assessment of nursing performance is often based on a patient's estimation of their received quality of care and the achievement of organizational goals (Germain and Cummings, 2010). In contemporary society, the healthcare system is strongly affected by technical and organizational changes, financial difficulties (Germain and Cummings, 2010), and a lack of qualified nursing staff (DeLucia-Waack, 1997). The assessment of nursing performance can be based on the measurement of a nurse's competencies, patient outcomes, or the nurse's behavior or competencies in specific situations or with regard to specific tasks such as triage decisions (DeLucia-Waack, 1997). In the present study, the focus was on the effectiveness of nursing teams. Wageman et al. (2005) defined the effectiveness of a team as the attainment of goals and expectations with regard to cost and time. Team effectiveness describes the productive outcome of a team and the output that meets its intended purpose (Hoegl and Gemuenden, 2001; Wageman et al., 2005). Sharing information with team members can contribute to team effectiveness (Anselmann and Mulder, 2020).

Figure 1 visualizes the assumed relationships between individuals and team characteristics as conditions for individual and team learning activities and their relationship to team effectiveness.

The following hypotheses will be tested:

> H1: Psychological empowerment positively relates to individuals' engagement in individual learning activities.

> H2: Teamwork is positively preference related to knowledge sharing.

> H3: Team boundedness is positively related to knowledge sharing.

> H4: Engagement in individual learning activities is positively related to knowledge sharing.

> H5: Knowledge sharing is positively related to team effectiveness.

3. Materials and methods

3.1. Sample and procedure

We conducted a cross-sectional questionnaire study. The participants in our study included 149 gerontological nurses (91% female) with a mean age of 42 years (M = 42.07; SD = 12.97). On average, the respondents had more than 4 years of experience as gerontological nurses (M = 4.88; SD = 1.29 years). They worked in 30 different gerontological nursing teams (N = 30, n = 149) at 17 retirement homes in Bavaria, Germany. The sizes of the retirement communities varied from small (more than 65 clients) to large (more than 100 clients). The size of the nursing teams varied from 3 to 12 nurses. The survey data were collected with paper and pencil, and the survey items were written in German. Participants were informed about the aims of the research project and its measurements, and their participation was voluntary. We started this research project in 2016. With respect to the work of nurses, the German healthcare system has many similarities with other healthcare systems in other European countries. For instance, nurses in hospitals and retirement homes have to work together in teams, which makes this study valuable for other countries.

3.2. Measures

In addition to background variables (i.e., gender, age, years of experience, etc.), the present study used validated scales to measure the other variables. All variables showed satisfactory Cronbach's alpha, ranging from 0.74 to 0.88, indicating good internal consistency (see **Table 1**).

Spreitzer (1995) developed a 12-item multidimensional assessment of psychological empowerment in the work environment, which was used in this study. Four subscales measure meaning, competence, impact, and self-determination. Example items include the following: "My work is really important for me," "I am confident that I have the skills to perform my job," "I can determine to a large extent how I can perform my job," and "I can control what happens in my job." The answering format was a 5-point Likert scale ranging from 1 = "absolute agreement" to 5 = "disagreement."

Individual learning activities were measured with a list of 24 learning activities. Out of 24 learning activities, 12 were individual and 12 were social. This approach for measuring individual learning activities was developed by Mulder (2013). The participants were asked to estimate how often they fulfilled the listed learning activities with an answer format in the form of a 5-point Likert scale that ranged from 1 = "never" to 5 = "very often." The list of learning activities is a list of possible activities, indicating that individuals engage in different learning activities. We counted the number of learning activities participants were assigned to indicate their engagement in learning activities. For instance, an individual mental learning activity is "thinking about specialized literature," whereas an individual physical learning activity is "searching on the Internet." An example of a mental, social learning activity is "thinking together with a colleague about the support received." For instance, physical and social activity is "getting information from a person outside of the team" (see Messmann and Mulder, 2015).

Knowledge sharing was measured using Staples and Webster's (2008) instrument, with a 5-point Likert scale answering format ranging from 1 = "absolute agreement" to 5 = "no agreement." This measures a nurse's perception of their knowledge of a colleague. Example items are "People in this team are willing to share knowledge/ideas with others" and "People in this team share their ideas openly" (Staples and Webster, 2008, p. 639).

Teamwork preference referred to an individual's attitude toward working together with others in teams (Kiffin-Petersen and Cordery, 2003) and was measured with three items and a 5-point Likert scale ranging from 1 = "absolutely" to 5 = "not at all." An example item is, "I appreciate working in a team."

Team boundedness was measured with Wageman et al.'s (2005) three items. Nurses responded in the answer format of a 5-point Likert scale ranging from 1 = "absolutely" to 5 = "not at all." One example item is: "The team is stable; there is no cast change."

Team effectiveness, which is an individual's perception of the extent to which a team achieves its objectives, was measured with five items designed by Van Woerkom and Croon (2009), with a 7-point Likert scale answer format ranging from 1 = "strongly agree" to 7 = "strongly disagree." An example item is: "As a team, we achieve our goals." In this study, we were interested in the individual team members' perceptions of their teams' effectiveness, which required self-reports. Following Ajzen (1991), we were interested in nurses' estimation of their team's performance because it can be assumed that these perceptions can influence behavior.

3.3. Data analyses

Descriptive statistics and correlation analyses were conducted using SPSS 25.0. Furthermore, we used structural equation modeling to test the assumed hypotheses. We used Mplus 6 (Muthén and Muthén, 2012). Different characteristics needed to be considered in the analyses. First, knowledge sharing was estimated using the individual participants' views of knowledge sharing in their teams. This enabled knowledge sharing to describe team learning activities. Second, because the participants were members of teams that were included in the data collection, the data were nested.

To meet these characteristics, we used an approach capable of considering complex data (cf. Marcoulides and Schumacker, 2009). By using this approach [i.e., Maximum Likelihood Robust (MLR) estimation and type complex], data at the individual level could be analyzed, and the clustering and nestedness of the data were considered. The study used fit indices described by Kline (2010). An acceptable fit was indicated by SRMR $\leq$ 0.10, CFI $\geq$ 0.90, and RMSEA $\leq$ 0.08. For psychological empowerment and individual learning activities, we had factors measuring different components of the variables so that we estimated both as second-order variables (Wickrama et al., 2021).

4. Results

In **Table 1**, the bivariate correlations among individual learning activities and knowledge sharing, teamwork preference, team boundedness, psychological empowerment, and team effectiveness are listed. Individual learning activities were significantly related to knowledge sharing (r = 0.42, p < 0.001). Psychological empowerment and individual learning activities were also significantly related (r = 0.46, p < 0.001). A relationship exists between team boundedness and teamwork preference (r = 0.27, p < 0.001). Effectiveness moderately correlates with knowledge sharing (r = 0.33, p < 0.001). Based on these results, we specified the structural equation model.

The structural equation model (**Figure 2**) shows an acceptable fit to the data (SRMR = 0.08, CFI = 0.92, RMSEA = 0.04). The results of the modeling indicate that psychological empowerment was related to individual learning activities (β = 0.61, p < 0.001). This result supports Hypothesis 1. We also found support for Hypotheses 2 and 3 since team boundedness (β = 0.38, p < 0.001) and teamwork preference (β = 0.33, p < 0.05) were related to knowledge sharing. The accomplishment of individual learning activities was positively related to the team learning activity of knowledge sharing (β = 0.48, p < 0.001), which supports Hypothesis 4. In addition, Hypothesis 5 was supported by the finding that knowledge sharing is positively related to team effectiveness (β = 0.59, p < 0.001).

5. Discussion

The present study contributes to the literature on team learning in the nursing field by testing a research model in which different conditions play an important role in team performance. The results highlight the importance of individual and team conditions for informal learning at the workplace. Although knowledge sharing has been investigated in organizations (Noe et al., 2014), the understanding of the role of individual learning activities and knowledge sharing in nursing teams is rather limited. Our results indicate that engagement in individual learning activities plays an important role in nursing teams because it links to knowledge sharing and, hence, to team effectiveness.

The results of this study show that knowledge sharing in teams is an important activity that is related to team effectiveness. This relation could be found in different other studies. Ahmad and Karim (2019) showed in their systematic review that knowledge sharing can influence outcomes such as performance at the individual, team, and organizational levels. The accomplishment of an individual learning activity is not directly related to the effectiveness of nursing teams. When knowledge is shared within the nursing team, it relates to the perceived team's effectiveness. Our results are in line with a meta-analysis from Wiese et al. (2022). They found that "intrateam learning behaviors uniquely predict performance" (Wiese et al., 2022; p. 571). Intrateam learning behaviors can be defined as "internal behavioral processes that teams engage in that build shared meaning from existing information." (Wiese and Burke, 2019, p. 4).

Wiese et al. (2022) showed that conditions such as a team's familiarity or task complexity are unrelated to a team's performance. The results of this study show that individual characteristics, such as team characteristics, are related to learning activities but not directly to team performance. When nurses prefer working in teams and perceive a close connection with their colleagues, this contributes to knowledge sharing among nurses, allowing an organization to use the existing knowledge of the individual nurses. These findings are consistent with Cabera and Cabera's (2002) proposition to increase group identity and commitment to enhancing knowledge sharing. Dey and Ganesh (2020) found that team boundedness can have an impact on dynamics in teams. While studies in other domains revealed that flexible belonging to teams can positively affect a team's performance (Dibble and Gibson, 2018), nurses need a feeling of belonging to a team to share their knowledge (Longacre et al., 2019).

TABLE 1 Mean, standard deviation, Cronbach's alpha, and bivariate correlations.

Scales	M	SD	α	1	2	3	4	5
1. Individual learning activities				–				
2. Knowledge sharing	3.97	0.65	0.88	0.42**	–			
3. Psychological empowerment	4.15	0.65	0.86	0.46**	0.14	–		
4. Teamwork preference	4.16	0.77	0.87	0.29**	0.16	0.27*	–	
5. Team boundedness	4.08	0.90	0.74	0.29**	0.13	0.27**	0.36**	–
6. Effectiveness	3.86	0.62	0.84	0.26**	0.33**	0.27**	0.26**	0.33**

*$p < 0.05$, **$p < 0.001$.

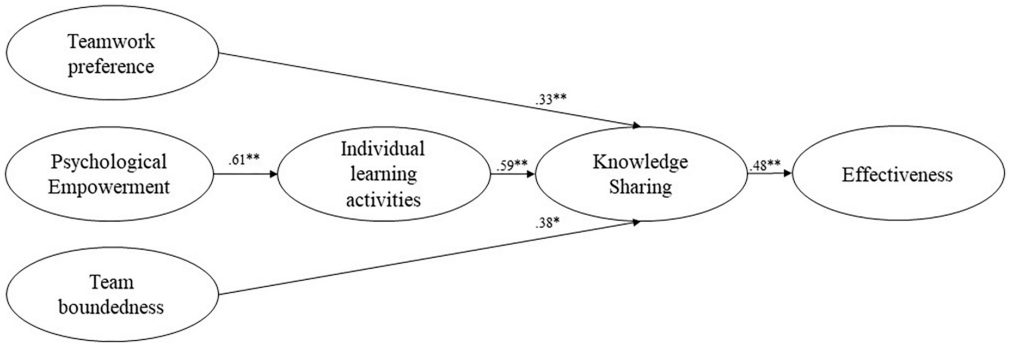

FIGURE 2
Structural equation model of psychological empowerment, individual learning activities, knowledge sharing, team boundedness, team work preference, and team effectiveness. *$p < 0.05$, **$p < 0.001$.

Psychological empowerment is an individual resource and an antecedent for engaging in individual cognitive and physical learning activities. This is in line with the results of a study from Jha (2019), who found that psychological empowerment is related to a learning orientation. This can have an effect on team performance. Studies in nursing showed that nurses who felt high psychological empowerment had a lower intention to leave their job (Shapira-Lishchinsky and Benoliel, 2019).

5.1. Implications of this research

The current study's findings provide insights into how individual and team learning activities are related and what conditions can have an influence on them. In this study, we were interested in team effectiveness as estimated by nurses. Their individual perception of meaning, competence, self-determination, and impact is not perceived as a condition for their team's performance. It leads to their engagement in individual learning activities, which leads to knowledge sharing in teams. By doing so, they perceive that their teams' performance can be increased.

While our study results show that individual characteristics are related to individual learning and team characteristics to team learning, we agree with Wiese et al. (2022) that there is a need for subsequent theory development and research.

The current study's findings provide insights into how individual and team learning activities are related and the conditions involved. While our study results indicate that individual characteristics are related to individual learning and team conditions to team learning, we agree with Wiese et al. (2022) that there is a need for subsequent theory development and research on the relationship between conditions and learning activities.

Regarding psychological empowerment, Friend and Sieloff (2018) proposed a theory for nursing in which group empowerment is included. Our study results showed that empowerment can affect individual learning activities. Empowerment is considered an individual's positive perception of having control over one's work. This could increase collaboration and, by extension, team effectiveness. Contributing to this line of reasoning and based on our results, empowerment (in particular confidence in meaning, competence, self-determination, and impact) is an important resource and antecedent, and individual learning activities and knowledge sharing are crucial for team effectiveness in addition to team preferences and perceptions of team boundedness. Nurses seem to engage in individual learning activities when they feel capable of making work-related choices on their own that impact their work. Further research focuses on the team's perception of empowerment and finds out how relations between team members can strengthen their performance.

Importantly, in addition to empowerment, work structures can impact nurses' engagement in individual learning activities (Kalisch et al., 2009). Further research is required to increase insight into what kinds of work structures enhance individual learning activities.

Furthermore, research should work to gain further insight into the quality of shared knowledge and find out how team members' knowledge is shared, for instance, in a network (cf. Brouwer and Jansen, 2019; Brouwer and Froehlich, 2020). Social network research can help investigate and inform us about with whom nurses exchange their knowledge or accomplish their social learning activities among their colleagues. It may prove interesting to gain more information about the types of knowledge that team members share by capturing them using a team mental model.

5.2. Implications for practice

The results are informative for nursing team leaders and managers, as they indicate that fostering individual learning activities and team learning activities are related to a team's effectiveness. Results of our study showed that psychological empowerment, team boundedness, and teamwork preference are related to individual and to team learning activities. To improve team performance, team leaders and managers in nursing need to foster the engagement of individual and team learning activities by providing opportunities for these activities (through, for instance, fitting work structures and time for reflection, as well as fostering psychological empowerment and team boundedness).

Nurses need time to accomplish learning activities, meet with each other, and discuss relevant issues. For this reason, it is crucial to empower nurses, consider their preferences for working in a team, and enhance team boundedness. Team leaders should be aware of the importance of these factors, take these aspects into account, and foster them. This might require rethinking management styles (Nevalainen et al., 2018). In addition to creating possibilities for knowledge sharing, team leaders should pay attention to team members' work preferences, psychological empowerment, and the team's overall boundedness because these foster knowledge sharing in nursing teams.

5.3. Limitations

One limitation concerns the relatively small sample size within a cross-sectional design. Nevertheless, the model fit was acceptable. We recommend future studies investigate team learning with longitudinal designs to make temporal inferences and to obtain a better understanding of the changes over time in the accomplishment of the learning activities, knowledge sharing, and the effect on team effectiveness.

The study was performed on 30 teams in one specific sector within healthcare (gerontological nursing). Therefore, the study should be repeated in other healthcare sectors (for example, acute care) to improve the generalizability of the results.

In addition, the study focused on one performance indicator to measure nursing teams' performance (i.e., team effectiveness). Other forms of team performance indicators could be used in further research, such as absenteeism, wellbeing, patient safety indicators, and reports of incidents (see Devasahay et al., 2021).

Finally, the data were collected through self-reports. With other instruments, such as interviews, focus groups (Merriam and Tisdell, 2016), or observations, more insight can be gained into (1) what exactly happens, (2) how and what kind of knowledge has been shared among team members, and (3) the meaning of the relationships between individual and team characteristics with learning activities, sharing knowledge, and team effectiveness; this might require a mixed-methods design. Our results showed that learning activities are related and can be assumed to be understood as a learning process. Therefore, more insights into learning as a process should be gained instead of investigating single activities. This could be realized using process approaches, such as time-series techniques (Poole and Van de Ven, 2004).

6. Conclusion

In nursing, learning is critical for coping with challenging, unexpected, and new situations. Informal learning involves both individual learning activities and knowledge sharing among nursing team members. Nurses' individual empowerment is positively related to the accomplishment of individual learning activities. Engagement in individual learning activities does not seem to foster team effectiveness directly. More important for team effectiveness, it seems, is that the team members share their knowledge.

Data availability statement

The datasets presented in this article are not readily available because data could not be made applicable because this was not part of participants written informed consent. Requests to access the datasets should be directed to VA, veronika.anselmann@ph-gmuend.de.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

Author contributions

VA and RM contributed to the conception and design of the study. VA collected the data and performed the statistical analysis. VA and JB wrote the first draft of the manuscript. RM wrote sections of the manuscript and gave feedback. All authors contributed to manuscript revision, read, and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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University of Göttingen, Germany

REVIEWED BY
Jürgen Dönitz,
University of Göttingen, Germany
Kia Homayounfar,
Klinikum Kassel, Germany

*CORRESPONDENCE
Tayana Soukup
✉ t.soukup@imperial.ac.uk

†These authors have contributed equally to this work

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Analysis of communication styles underpinning clinical decision-making in cancer multidisciplinary team meetings

Tayana Soukup[1,2,3,4]*, Benjamin W. Lamb[5,6], James S. A. Green[5†], Nick Sevdalis[1†] and Ged Murtagh[2]

[1]Health Service and Population Research Department, Centre for Implementation Science, King's College London, London, United Kingdom, [2]Department of Surgery and Cancer, Imperial College London, London, United Kingdom, [3]Department of Epidemiology and Environmental Health, University of Buffalo, Buffalo, NY, United States, [4]School of Health and Sport Sciences, University of Suffolk, Suffolk, United Kingdom, [5]Whipps Cross University Hospital, Barts Health NHS Trust, London, United Kingdom, [6]Barts Cancer Institute, Queen Mary University of London, London, United Kingdom

Introduction: In cancer care, multidisciplinary team (MDT) meetings are the gold standard. While they are trying to maximize productivity on the back of the steadily increasing workload, growing cancer incidence, financial constraints, and staff shortages, concerns have been raised with regards to the quality of team output, as reported by Cancer Research UK in 2017: "*Sometimes we discuss up to 70 patients. This is after a whole day of clinics, and we do not finish until after 19.00. Would you want to be number 70?*". This study aimed to explore systematically some of the dynamics of group interaction and teamwork in MDT meetings.

Materials and methods: This was a prospective observational study conducted across three MDTs/university hospitals in the United Kingdom. We video-recorded 30 weekly meetings where 822 patient cases were reviewed. A cross-section of the recordings was transcribed using the Jefferson notation system and analyzed using frequency counts (quantitative) and some principles of conversation analysis (qualitative).

Results: We found that, across teams, surgeons were the most frequent initiators and responders of interactional sequences, speaking on average 47% of the time during case discussions. Cancer nurse specialists and coordinators were the least frequent initiators, with the former speaking 4% of the time and the latter speaking 1% of the time. We also found that the meetings had high levels of interactivity, with an initiator–responder ratio of 1:1.63, meaning that for every sequence of interactions initiated, the initiator received more than a single response. Lastly, we found that verbal dysfluencies (laughter, interruptions, and incomplete sentences) were more common in the second half of meetings, where a 45% increase in their frequency was observed.

Discussion: Our findings highlight the importance of teamwork in planning MDT meetings, particularly with regard to Cancer Research UK in 2017 cognitive load/fatigue and decision-making, the hierarchy of clinical expertise, and the increased integration of patients' psychosocial information into MDT discussion and their perspectives. Utilizing a micro-level methodology, we highlight identifiable patterns of interaction among participants in MDT meetings and how these can be used to inform the optimization of teamwork.

KEYWORDS

cancer multidisciplinary teams, multidisciplinary tumor boards, teamwork, communication, interaction, teamwork among the medical professions, clinical decision-making, multidisciplinary team meetings

1. Introduction

In the United Kingdom (UK), multidisciplinary teams (MDTs or tumor boards) routinely plan care management for people with cancer. This generally consists of histopathologists, radiologists, surgeons, specialist cancer nurses (CNSs), and oncologists. They typically meet weekly or bi-weekly, and they discuss large numbers of cancer cases for several hours at a time (Department of Health, 2004; Raine et al., 2014; Cancer Research UK, 2017; Soukup et al., 2018, 2019a; National Institute for Health Care Excellence, 2020; Guirado et al., 2022).

While the MDT model is considered the gold standard (Raine et al., 2014; National Institute for Health Care Excellence, 2020), evidence indicates that MDTs are often subject to a variety of internal and external factors that may influence their functioning and, more specifically, the communication process between the team members (Lamb et al., 2011, 2013; Raine et al., 2014; Soukup et al., 2016a,b, 2020a,b, 2021c). For example, factors external to the team (see Figure 1) may include things such as time and workload pressures. A recent large-scale study into MDT communication and decision-making (Soukup et al., 2020a) found a reduction in the frequency of task-oriented communication (e.g., asking questions and giving answers to those questions) in the second half of meetings, possibly because of the experience of fatigue later in the meeting. This is in addition to such effects found with the quality of decision-making with cases discussed at the beginning of meetings generally receiving more discussion (Lamb et al., 2013; Soukup et al., 2019a,b, 2020a). As cancer MDTs try to maximize productivity in the face of ever-increasing workload (Cancer Research UK, 2017), growing cancer incidence (NHS England, 2014; World Health Organization, 2014), and complexities around repeated recurrence of cancer, for which treatment options are not necessarily standardized by the (inter)national guidelines (in contrast to treatment options for first occurrence), in addition to financial constraints (Mistry et al., 2011; NHS England, 2014), and the pressures brought by staff shortages (NHS Improvement, 2016), concerns have been raised that the quantity of workload of MDT meetings negatively impacts on the quality of output (Cancer Research UK, 2017). In the Cancer Research report published in 2017 (Cancer Research UK, 2017), one MDT member was quoted as saying: "*Sometimes we discuss up to 70 patients. This is after a whole day of clinics, and we do not finish until after 19.00. Would you want to be number 70?*" (Cancer Research UK, 2017).

Factors internal to the team (Figure 1) may involve further possible impediments to team communication. For example, MDT meetings can be fast-paced, particularly for the uninitiated. This means that securing one's turn to contribute may be challenging, potentially reducing levels of participation by team members (Soukup et al., 2021c), leading to unequal contributions and suboptimal sharing of information (Lamb et al., 2013; Raine et al., 2014; Soukup et al., 2020a,b, 2021c). While the reasons behind the underutilization of expertise in meetings are not fully understood (Valcea et al., 2019), the significance of it cannot be overlooked. For instance, a recent study of MDT meetings (Soukup et al., 2020a) found that higher levels of interactive responsiveness among team members significantly predicted better quality decision-making for patients. Indeed, communication is the channel through which the team progresses through the stages of decision-making: from problem identification, information sharing, and critical evaluation to formulating the decision and implementing it (Orlitzky and Hirokawa, 2001; Hollingshead et al., 2005; Kugler et al., 2012; Soukup, 2017; Soukup et al., 2020b, 2021a). There is then a need to build an understanding of the communication practices team members employ during their meetings and how this can be improved.

This study aimed to systematically explore some of the dynamics of group interaction in MDT meetings. To do this, the study employed a linguistic analysis previously used in cancer MDTs (Soukup et al., 2021a,c), which includes a combination of quantitative frequency counts, and a qualitative approach based on the principles of conversation analysis (CA), which details characteristics of speech exchange (e.g., questions and answers, pauses, pace, and intonation; 25–26). We used this forensic approach for the analysis of speech and interaction to gain an understanding of how decision-making is shaped interactionally and how the levels of participation are shaped during case discussions. More specifically, we attempted to address the following issues:

Q1: Is there an identifiable pattern for who leads or initiates talk in these meetings?
Q2: How responsive are team members to one another during case discussions?
Q3: Is there a difference in communication in the first vs. the second half of the meeting?

2. Materials and methods

2.1. Study design

This was a prospective, cross-sectional, observational study.

2.2. Study setting

We recruited three cancer MDTs (breast, colorectal, and gynecologic) from three university hospitals in the Greater London and Derbyshire areas of the UK. Their meetings were video recorded for 3 months each. The study took place between September 2015 and July 2016. The study was granted ethical and regulatory approvals from the Northwest London Research Ethics Committee (JRCO REF. 157441) and the R&D departments of the participating NHS Trusts. Informed consent was obtained from the MDT members. Patient consent was not required because patient-identifiable information was retained during the study. This study was part of a larger MDT study (Soukup, 2017) that adopted by the the National Institute for Health Research Clinical Research Network Portfolio.

2.3. Participants and sample size

Availability sampling was used to identify the MDTs. The criterion for the study was a cancer MDT from the UK National Health Service (NHS) that represents the most common type

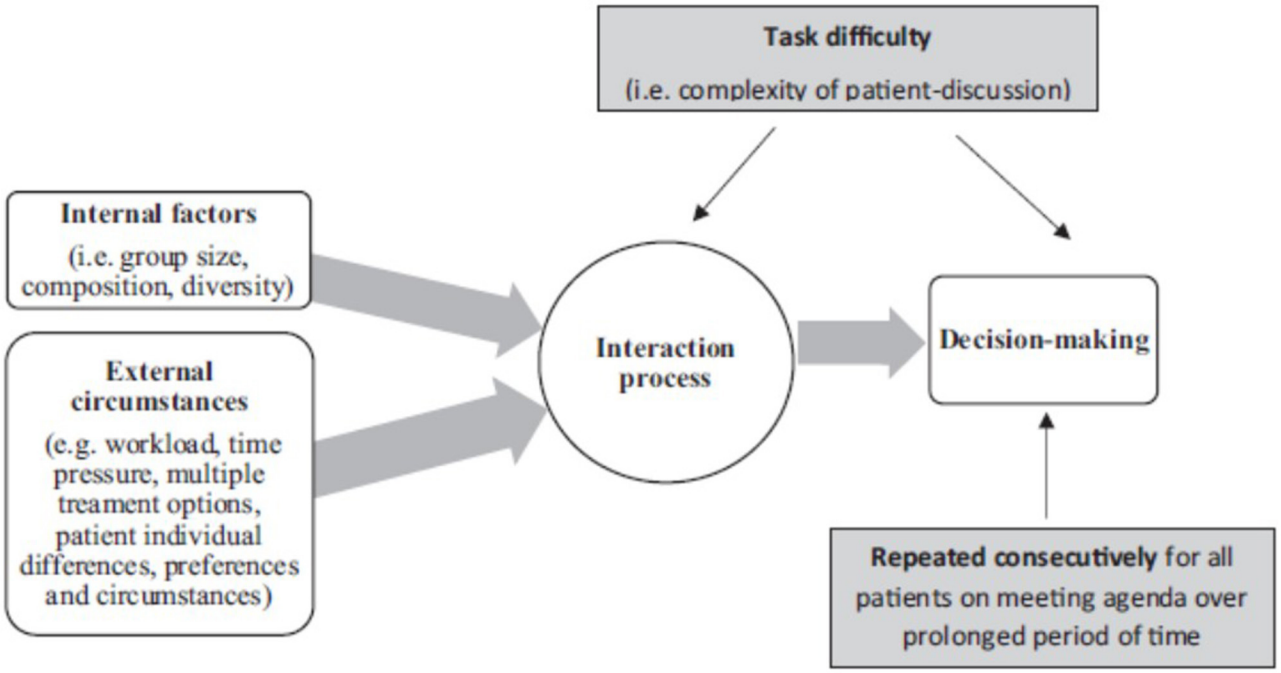

FIGURE 1
Graphic representation of the factors affecting cancer team functioning and communication in line with the functional perspective of group decision-making. This diagram demonstrates the functional perspective of group decision-making graphically with the interaction process and communication at the center of the process. Reprinted with permission from the following two sources: (Soukup, 2017) "Socio-cognitive factors that affect decision-making in cancer multidisciplinary team meetings [Doctoral thesis, Imperial College London]" Spiral Repository, https://doi.org/10.25560/79603 by Soukup (2017); and (Soukup et al., 2020a) "A multicenter observational cross-sectional observational study of cancer multi-disciplinary teams: analysis of team decision-making" by Soukup et al. (2021c), Cancer Medicine, https://doi.org/10.1002/cam4.3366.CCBY-NC-ND.

of cancer. The recruited participants were 44 MDT members from across three cancers: breast, colorectal, and gynecologic. The teams consisted of surgeons, oncologists, CNSs, radiologists, histopathologists, and coordinators (medical students sometimes attended on an educational basis). At least one team member from each professional group was present during the MDT meetings, with an average attendance presented in Table 1. However, all participating MDTs organized their cases on the meeting agenda in line with whether the case required radiologists' input only, histopathologists' input only, or both radiologists' and histopathologists' inputs—this influenced at what point during the meeting the radiologists and histopathologists came into the room. Further details on team composition and meeting characteristics are found in Table 1.

A total of 822 case discussions were video recorded. These consisted of all the cases listed on the meeting agenda (including suspected or confirmed cancers and, in breast and gynecologic cancer teams, benign cases) discussed in 30 meetings (or 55 h of meeting time). A selection of 24 malignant discussions is presented in this article (or 72 min of meeting footage). The selection criteria for the 24 case discussions have been described in some detail previously (Soukup, 2017; Soukup et al., 2021a,c), and they included the following: quality and clarity of the audio, feasibility, equal distribution between the first and second half of the meetings, duration of the case discussion, malignancy, and saturation (Soukup, 2017; Soukup et al., 2021a,c).

The long-term approach that we use in filming MDT meetings is something that we have described in some detail previously (Soukup, 2017; Soukup et al., 2021a,c). Such an approach entails the following: (a) filming the team for at least 3 months (12 consecutive weekly meetings); (b) excluding the first two meetings from analysis as these were used to allow the team to get used to being observed/filmed and for the assessor to learn about who is who in the team (for example, although we collected the data over 30 meetings, we recorded 36 meetings, allowing us to exclude six meetings or the first two meetings for each team); (c) filming was conducted discreetly with a small camera (all sound off, operated remotely) and out of the immediate view of the team (placed with other meeting room equipment). Such strategies help to induce habituation, allowing the teams to "forget" about the camera and continue their practice as usual, therefore, minimizing the Hawthorne effect (Soukup, 2017; Soukup et al., 2021a,c).

The layout of the meeting rooms each MDT used did not change during the study. Each room had two large screens: one for patient proforma and the other for radiology/histopathology slides. All attendees were seated in a U-shape facing the large screens, making the behavior of all attendees straightforward to capture with a single camera. The breast and gynecologic MDT meetings were conducted in a face-to-face format, with all core disciplines physically present during case discussions. This was in contrast to the colorectal MDT meetings, which were hybrid, with the histopathologist and

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TABLE 1 Team composition and meeting characteristics of participating cancer multidisciplinary teams.

Variable	Cancer multidisciplinary team							
	Breast		Colorectal		Gynecologic		Full sample	
	N	*n* of women	*N*	*n* of women	*N*	*n* of women	*N*	*n* of women
Team composition								
Surgeons	4	2	4	1	4	0	12	3
Oncologists	2	2	2	1	2	2	6	5
Radiologists	2	1	2	0	2	2	6	3
Pathologists	1	1	1	0	3	2	5	3
Specialist cancer nurses	5	5	5	4	2	2	12	12
Team coordinator	1	1	1	1	1	1	3	3
Total	15	12	15	7	14	10	44	30
Meeting characteristics								
Average number of members present	11	7	11	6	7	2	9	5
Average number of cases discussed per meeting	26		20		43		33	
Average time per patient (HH:MM:SS)	00:02:25		00:03:20		00:02:30		00:02:58	
Average meeting duration (HH:MM:SS)	01:06:00		01:00:00		02:52:00		01:53:00	
Study characteristics								
Number of hours recorded (HH:MM:SS)	09:57:00		13:40:00		31:30:00		55:07:00	
Number of cases discussed	241		185		396		822	
Number of meetings observed	10		10		10		30	

n = subsample size of female members within each cancer multidisciplinary team. *N* = sample size within each team. Reprinted with permission from the following two sources: (Soukup, 2017) "Socio-cognitive factors that affect decision-making in cancer multidisciplinary team meetings [Doctoral thesis, Imperial College London]." Spiral Repository, https://doi.org/10.25560/79603 by Soukup, 2017; and (Soukup et al., 2021c) "Gaps and overlaps in multidisciplinary team meetings: analysis of speech" by Soukup et al. (2021c), Small Groups Research, https://doi.org/10.1177/1046496420948498.CC~BY-NC-ND.

oncologist having to dial into the meeting virtually from another hospital site.

2.4. Materials

We examined communication in the MDT meetings by capturing not only what was said but also how it was said. We used the Jefferson notation system, commonly used in CA (Psathas, 1994; Ten Haves, 2007), to identify and analyze different aspects of communication and interaction during case discussions. We combined qualitative and quantitative approaches in our analyses. While the former is traditionally used in the CA, the latter approach uses frequency counts and has been used on the individual case discussions in previous research utilizing CA (Stivers, 2001, 2002; Soukup, 2017; Soukup et al., 2021a,c), and more frequently in linguistics (Ten Bosch et al., 2004; Kurtić et al., 2013; Levinson and Torreira, 2015).

For quality control and as a vital part of CA (Ten Haves, 2007), our data have been discussed in multiple data sessions ($N = 4$) with leading international CA scholars, who provided their critical input and insight into the analysis presented in this study. This included watching videos of MDT meetings and discussing the interaction while formulating points of interest in the data and how best to analyze such complex multiparty interactions.

2.5. Analyses

2.5.1. Q1: Is there an identifiable pattern of who leads or initiates talk in the meetings?

Here, we aimed to determine several things using CA. First, how the interaction was initiated in these meetings; second, whether some groups initiate interaction more frequently than others; and lastly, levels of responsiveness, i.e., did some groups respond more often than others, and how did they respond? We have identified grammatical constructs (21, 25–26, 32–33; shown in Table 2), which we grouped against individual disciplines comprising an MDT (i.e., surgery, radiology, histopathology, nursing, and oncology). For each discipline and team, the usage frequency of these actions was calculated using counts and percentages.

2.5.2. Q2: How responsive are team members to one another during case discussions?

We calculated the degree of responsiveness (to the initiator's utterance, question, or request) during case discussions using the originator–responder ratio (Soukup, 2017). Here, the total number of responses was divided by the total number of sequences prompted by the initiator of the interaction (Soukup, 2017).

TABLE 2 Overview of terms used in the analysis of communication among participating cancer multidisciplinary teams (MDTs).

Discourse and dimension	Example quote
Declarative form	
• 1.a Giving information to others.	**PAT:** "It is an invasive high-grade serous adenocarcinoma."
Interrogative form	
• 2.a Seeking information from others.	**ONC**: "Has she got some other malignancy going on?"
Imperative form	
• 3.a Giving instructions to others.	**ONC:** "Write it on the MDT outcome sheet."
Adjacency pair	
• 4.a A basic unit of interaction that is typically paired, e.g., a question is typically followed by an answer	[e.g. question-answer pair]
	ONC: "Has she got some other malignancy going on?"
	RAD: "Well, there is something in the lung."
	[e.g. request-compliance]
	ONC: "Write it on the MDT outcome sheet."
	NUR: "Okay."
Originator/initiator	
• 5.a The person that initiates the interactional sequence.	**ONC: "**Has she got some other malignancy going on?"
Responder	
• 6.a The person that responds to the originator's interactional sequence.	**RAD: "**Well, there is something in the lung."

SUR, surgeon; PAT, pathologist; NUR, nurse; ONC, oncologist; RAD, radiologist; MDT, multidisciplinary team. Reprinted with permission from Soukup (2017) "Socio-cognitive factors that affect decision-making in cancer multidisciplinary team meetings [Doctoral thesis, Imperial College London]." Spiral Repository, https://doi.org/10.25560/79603 by Soukup (2017).

2.5.3. Q3: Is there a difference in communication in the first vs. the second half of the meeting?

Here, we explored cognitive load as linguistically evident through verbal fragmentations and dysfluencies, such as incomplete sentences and interruptions, pauses, pitch peaks, repetitions, vocalizations, interruptions, laughter, and chatter (Bortfeld et al., 2001; Arnold et al., 2003; Adda-Decker et al., 2008; Corley and Stewart, 2008; Soukup, 2017). An association between high levels of such verbal behaviors and higher levels of cognitive load and fatigue was previously found (Arnold et al., 2003; Heldner and Edlund, 2010; Nicholson et al., 2010; Womack et al., 2012). In addition, we determined the frequency of the identified verbal fragmentations in the transcripts across the first and second halves of the meetings. Table 3 shows a list of fragmentations with the corresponding definitions, symbols, and data examples that were examined across all three MDTs. Frequencies were converted to a percentage change from the first to the second half of the meetings.

3. Results

3.1. Q1: Is there an identifiable pattern of who leads or initiates conversation in the meeting?

Table 4 shows that the higher levels of verbal contribution in breast cancer MDT meetings were made by surgeons and oncologists. These two professional groups were also frequent initiators, i.e., they typically started the discussion and answered the questions about the case (e.g., Case 16, Surgeon: "This is a 26 year-old presenting with intermittent spontaneous discharge." and Case 12, Oncologist: "We will need to keep an eye out for HER2."). The most frequent initial questions come from the oncologists (e.g., Case 2, Oncologist: "Why did she start on Letrizole?"; Case 12, Surgeon: "Has she had a CT?"). Radiologists were also frequent contributors to the discussion together with, but to a lesser extent, pathologists (e.g., Case 10, Oncologist: "What was the biopsy result?", Pathologist: "It was benign."; Case 8, Surgeon: "Are you happy [with the images], Mark [the radiologist]?", Radiologist: "Yeah", Surgeon: "Yeah fine okay … R&D").

In contrast, the least frequent speakers in the breast cancer MDT meetings were CNSs and coordinators. Their contributions typically took the form of a response to something the surgeon had raised, "Those scans?", i.e., providing information and facts (e.g., Case 12, Oncologist: "Has she had a lung MDT discussion?", Nurse: "No"; Oncologist: "Can you get them?", Coordinator: "Those scans" Oncologist: "Yes, please yeah"). However, the data showed that the CNSs sometimes initiated an interaction (for example in Case 8, "Does anyone want to see the abscess?") which appeared to lead to a change from the original decision of "Reassure and discharge" to "Clinical review".

In the colorectal cancer MDT meetings, the surgeons were also the most frequent contributors to the meetings. They typically used questions to initiate interaction (e.g., Case 4, "Do you you have this, Paul [pathologist]?", "Okay, is it suspicious for cancer?"; Case 11, "Did you see anything on the PET?"), but also declarative statements (e.g., Case 13, "This is his first request"). They were the only professional group to request actions (e.g., Case 4, "Will you

TABLE 3 List of verbal fragmentations, and corresponding definitions, Jefferson notation symbols, and data examples.

Discourse and dimensions	Example quotes
Incomplete sentence • A sentence, phrase, or word that is too incomplete to be understood. • A forward slash (/).	**ON: so I am not/** and I think we need to review everything for this lady. ———————— **ON: Could/** does it say why?
Interruption (overlaps and cut-offs) • "A successful speaker switch in which there is some simultaneous talk, but the first speaker's utterance is not completed and the incoming speaker has successfully gained the floor" (Hutchby and Wooffitt, 2008, p. 110). Cooperative recognition of the first speaker's overlapping point was not counted. • Overlap is indicated by square brackets [], and cut off by a dash (-).	**PAT:** no, the only[thing is the-] **ONC:** [so you just] have a chest x-ray? ———————— **RAD:** so [this is-] **SUR:** [they have] all been interesting today, every single one of them
Laughter and chatter (break in communication flow) • Temporary break in communication flow (normally related to the formulation of a treatment plan) that needs to then be reestablished later. Includes laughter and chatter about an unrelated topic. • Double brackets.	**SUR:** she was worried hmm:: **((laughter from many in the room))** **ONC:** yes but I can not believe there were five appointments
Pauses • Continuous pause segment of more than 100 milliseconds/ 0.1 seconds between words, or sentences was counted. • Number in brackets.	**ONC:** ye::s but I can not believe there were five **(0.4)** appointments that she was **(0.4)** DNA as a result ———————— **NUR:** someone needs to call **(2.4)**
Pitch peaks • Shifts to a particularly high-pitch, or loud speech relative to the surrounding speech. • Up-facing arrow (↑), upper case.	**ONC: so ↑you ↑just ↑have a ↑chest x-ray?** ———————— **SUR: uh I PRESUME YOU DO NOT HAVE ANY HISTOLOGY,↑right?**
Repetitions • Repetition of words or groups of words incorporated in a sentence. • Repetition.	**PAT: we/ we** looked at it ———————— **NUR: shall we/ shall we** look at
Vocalizations • In the struggle to find a word, the speaker is compelled to insert a sound to repair the break in the flow of communication (also known as vocal insertions). • ah, eh, er, aw, uh, um, hm, mm	**ONC:** a::nd **um** only had radiotherapy at that poi:nt as was appropriate **um** and the::n, she was followed up for a number of years, but **um** ———————— **SUR:** this is the chap that had an adenocarcinoma **er**

m, man; f, woman; SUR, surgeon; PAT, pathologist; NUR, nurse; ONC, oncologist; RAD, radiologist. Reprinted with permission from Soukup (2017) "Socio-cognitive factors that affect decision-making in cancer multidisciplinary team meetings [Doctoral thesis, Imperial College London]." Spiral Repository, https://doi.org/10.25560/79603 by Soukup (2017).

document a reasonable request?"; Case 11, "For UA and excision"; Case 12, "So first refer to HPB for discussion, secondly refer to Dr. Sheppard to consider palliative chemotherapy"). In the colorectal cancer MDT meeting, those who most frequently responded to contributions by the surgeon were the radiologists and CNSs, who used largely declarative statements to provide information (e.g., Case 11, Surgeon: "Did you see anything on the PET?" Radiologist: "Well, there are two things..."; Case 14, Surgeon: "We do not need to do a colonoscopy, do we?" Nurse: "It is already booked."), and to a lesser extent, they asked questions (e.g., Case 15, Nurse: "So who is going to follow her up?"; Case 14, Radiologist: "Did she have a colonoscopy?"). In these meetings, pathologists and coordinators contributed the least. When they did contribute, it was largely in response to a question or request from the surgeon. For example, in Case 12, Surgeon: "Do you have any histology report?", Pathologist: "Very necrotic cause… which would be consistent with a colorectal primary"; or Case 3, Surgeon: "Hold on a second, Anna [the coordinator] is checking?", Coordinator: "We have him scheduled for the 24th".

In the gynecologic cancer MDT meetings, once again, surgeons were the ones who contributed the most, followed by histopathologists and, to a lesser extent, radiologists, oncologists, and CNSs. Surgeons spoke the most, using predominantly declarative statements to initiate interaction (e.g., Surgeon: "This is a lady who probably had stage 3 ovarian cancer, she has had an ultrasound-guided biopsy." Pathologist: "Yeah, it is an invasive high-grade."), but also interrogative (e.g., Case 27, "Is that the fairly simple cyst?"), and imperative (e.g., Case 27, "for THO and BSN"; Case 1, "So, discuss surgery vs. chemo"). In the gynecologic cancer MDT meetings, coordinators were also the least frequent speakers,

TABLE 4 Communication style by professional group across participating cancer multidisciplinary teams (MDTs).

Professional group	*n*	SPEAKING %	Originator %	Responder %	Originator			Responder		
					Declarative %	Interrogative %	Imperative %	Declarative %	Interrogative %	Imperative %
Breast cancer MDT										
Surgeon	4	39	11	28	14	11	3	37	4	4
Oncologist	2	28	16	12	23	17	3	17	0.4	2
Radiologist	2	16	2	14	4	2	–	20	0.4	0.4
Pathologist	1	13	8	5	13	4	3	8	0.4	0.4
Cancer nurse specialist	5	4	1	3	–	3	–	6	–	–
Coordinator	1	0.3	–	0.3	–	–	–	0.4	–	–
Overall	15	100	38	62	54	37	9	88	5	6
Colorectal cancer MDT										
Surgeon	4	63	43	20	32	43	15	35	–	4
Oncologist	2	1	–	1	–	–	–	1	–	–
Radiologist	2	15	2	13	1	1	–	26	–	–
Pathologist	1	5	–	5	–	–	–	10	–	–
Cancer nurse specialist	5	15	3	12	2	6	–	22	–	–
Coordinator	1	1	–	1	–	–	–	2	–	–
Overall	15	100	48	52	35	50	15	94		4
Gynecologic cancer MDT										
Surgeon	4	40	30	10	41	10	5	20	–	–
Oncologist	2	14	6	8	9	2	2	16	–	–
Pathologist	2	21	11	10	18	–	1	22	1	–
Radiologist	3	14	3	11	5	–	1	23	1	–
Cancer nurse specialist	2	10	3	7	6	–	–	12	3	–
Coordinator	1	1	–	1	–	–	–	2	–	–
Overall	14	100	53	47	79	12	9	95	5	–

N, 24 case discussions; MDT, multidisciplinary team. The originator–responder ratio in the gynecologic cancer team it was 1:1.13, in the breast cancer team it was 1:1.63, and in the colorectal cancer team it was 1:1.1.

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TABLE 5 Overview of similarities and differences in communication among participating cancer multidisciplinary teams (MDTs).

Variable	Cancer multidisciplinary team		
	Breast	Colorectal	Gynecologic
Most frequent speaker	**Surgeons**, oncologists	**Surgeons**	**Surgeons,** pathologists, radiologists, oncologists, CNSs
Least frequent speaker	**Coordinator**, CNSs	**Coordinator,** pathologists, oncologists	**Coordinator**
Most frequent originator	**Surgeons**, oncologists, pathologists	**Surgeons**	**Surgeons**, pathologists
Least frequent originator	**Coordinator,** radiologists, CNSs	**Coordinator,** oncologist, pathologist	**Coordinator,** oncologists, radiologists, CNSs
Most frequent responder	**Surgeons, radiologists,** oncologists	**Surgeons, radiologists**, CNSs	**Surgeons, radiologists**, pathologists, oncologists, CNSs
Least frequent responder	**Coordinator,** pathologists, CNSs	**Coordinator,** pathologists, oncologists	**Coordinator**
Originator-responder ratio	1:1.63	1:1.1	1:1.13
Common communication style	Declarative	Interrogative	Declarative

CNS, cancer nurse specialist. Similarities between teams are shown in bold. Reprinted with permission from Soukup (2017) "Socio-cognitive factors that affect decision-making in cancer multidisciplinary team meetings [Doctoral thesis, Imperial College London]." Spiral Repository, https://doi.org/10.25560/79603 by Soukup (2017).

responding largely in a declarative form (e.g., Case 37, Surgeon: "What is her CA 125?", Coordinator: "123").

3.2. Q2: How responsive are team members to each other during case discussions?

Breast cancer MDT members appeared highly responsive, with an initiator–responder ratio of 1:1.63, i.e., for every initiated sequence of interaction, the initiator received more than a single response. Colorectal and gynecologic cancer MDTs were also relatively responsive, with an initiator–responder ratio of 1:1.11 and 1:1.13, respectively, i.e., for every initiated sequence of interaction, the originator received a single response.

3.2.1. Similarities between cancer teams

The coordinators' contributions appeared to be minimal at 1%, and they were in a declarative form, i.e., giving information. Across the participating teams, the CNSs did not appear to be making requests. Instead, the CNSs' inputs to the discussion were in the form of statements and questions, typically in response to others. One notable contribution (mentioned earlier) from the CNSs led to an amendment to the original recommendation for the patient. In this particular case, the patient is reported (by the pathologist and radiologist) to have a benign abscess. Asking for the team's opinion, the surgeon is met with a question from the CNS, which leads to a 3-min discussion and then the decision to review the case (line 73).

12 **Surgeon 2:** Are you happy?
13 **Radiologist:** Yeah.
14 **Surgeon 1:** Yeah, fine, okay.
15 **Surgeon 3:** Mh.
16 **Surgeon 2:** R&D?
17 **Surgeon 1:** Yeah.
18 **Nurse:** Does anyone want to see the abscess?

[3-min long exchange surgeons, radiologist, pathologist, and nurse regarding a plan of care]

72 **Surgeon 2:** Why not do a review?
73 **Surgeon 3:** Clinical review.

The teams also had in common the discipline that tended to formulate treatment recommendations for patients, which were most frequently surgeon-led and to a lesser extent oncologist-led. Moreover, another similarity across the participating teams was that the new information/knowledge about the patient and their circumstances were brought into the discussion by a wider range of disciplines, including surgeons, radiologists, pathologists, and to a lesser extent oncologists and CNSs. The type of information/knowledge that each discipline brought to the discussion corresponded to their area of expertise and how well they knew the patient. For instance:

Clinical picture
Surgeon 3: This is an 89-year-old woman who presented with a large mass in her right breast, graded T4, who had a mammogram and an ultrasound scan, and a core biopsy.
Pathologist: Okay, so she has an invasive ductal grade 2 carcinoma ER+ PR+ malignant invasive.
Radiologist: Yeah, in terms of imaging, it looks as if she has a primary… lesion in the cecum.
Oncologist: I brought her in, she is on adjuvant chemotherapy for stage 1 submucous cancer this year.
Wider patient context
Nurse: You have no follow-up.
Nurse: They [the patient and their family] are not happy about the wait, and they want to go and see Mr. Brown.

Table 5 summarizes the similarities and differences in multidisciplinary communication between the participating teams.

3.3. Q3: Is there a difference in communication in the first half of the meeting vs. the second half?

The frequency and percentage change for each feature of communicative dysfluency between the first and the second halves

TABLE 6 Frequency and percentage increase in verbal fragmentation in the first vs. the second half of meetings across the participating cancer multidisciplinary teams (MDTs).

	Multidisciplinary cancer team											
	Breast			Colorectal			Gynecologic			Full sample		
Verbal fragmentation	1st half *n*	2nd half *n*	% increase	1st half *n*	2nd half *n*	% increase	1st half *N*	2nd half *n*	% increase	1st half *N*	2nd half *n*	% increase
Incomplete sentences	*22*	*74*	237	*10*	*22*	120	*18*	*22*	22	*50*	*118*	136
Pauses	76	152	100	90	109	21	80	92	15	246	353	44
Pitch peaks	268	506	87	212	210	−0.9	209	222	6	689	938	36
Repetition	12	20	67	16	20	25	15	20	33	43	60	40
Vocalization	37	43	16	42	58	38	27	41	52	106	142	34
Interruption	7	19	171	4	6	50	2	6	200	13	31	138
Chatter and laughter	5	21	320	0	0	–	0	11	1,000	5	32	540
Overall	427	835	96	374	425	14	351	414	18	1,152	1,674	45

Analysis was conducted on 24 case discussions. The average *duration of the meeting* was 60 min for the breast cancer team, 45 min for the colorectal cancer team, and 160 min for the gynecologic cancer team (Soukup, 2017). Reprinted with permission from Soukup (2017) "Socio-cognitive factors that affect decision-making in cancer multidisciplinary team meetings [Doctoral thesis, Imperial College London]." Spiral Repository, https://doi.org/10.25560/79603 by Soukup (2017).

of meetings are presented in Table 6. An overall increase in verbal fragmentations of 52% in the second half of the meeting can be seen, with some variation between teams. For example, the colorectal cancer MDT showed the highest percentage increase in incomplete sentences, while the breast and gynecologic cancer MDTs showed an increase in interruptions, chatter, and laughter. In contrast, the breast cancer MDT showed the least increase in vocalizations, the gynecologic cancer MDT in raised pitch, and the colorectal cancer MDT in pauses. Moreover, the colorectal MDT was the only participating team where both the pathologist and oncologist used a videoconferencing system and were not physically present at the meeting. Here, there were frequent connection and sound issues, and raised pitch may have been used for clarity, resulting in a similar number of counts between the first and the second halves of the meeting with a small percentage change (−0.9).

For the three teams combined, the chatter and laughter, interruptions, and incomplete sentences showed the greatest increase. Approximately a 1-fold increase was evident in incomplete sentences, a 1.5-fold increase in interruptions, and nearly a 4-fold increase in chatter and laughter in the second half of the meeting. This was closely followed by pauses, repetitions, vocalizations, and pitch peaks with the smallest increases.

4. Discussion

Guided by some of the analytical principles of linguistics and CA, our study explored the communication patterns that underpin patient decision-making in cancer MDT meetings.

4.1. Q1: Is there an identifiable pattern of who leads or initiates conversation in the meeting?

We found that across teams, surgeons were the most frequent initiators and responders of interaction sequences, while CNSs and coordinators were the least frequent. Oncologists were also high-frequency contributors in breast MDT meetings, whereas, in colorectal and gynecologic meetings, communication was driven solely by surgeons. This finding is consistent with previous studies showing that surgeons, and to a lesser extent oncologists, are the most frequent contributors to case discussions in the meetings, while CNSs and coordinators do not contribute to the same extent (Lamb et al., 2011, 2013; Raine et al., 2014; Soukup et al., 2016a, 2021a; Soukup, 2017). However, while coordinators have an administrative role and their input into case discussions is not expected, the input of CNSs is required and is often critical to decisions around care planning. Moreover, in the breast and gynecologic team meetings, communication was driven by declarative statements, with statements/giving information appearing to be the most common way of initiating sequences of interaction by both initiators and responders. In the colorectal meetings, communication was more dominated by question–answer pairs. Here, the initiators would largely use an interrogative form of communication, and the responders a declarative one.

4.2. Q2: How responsive are team members to each other during case discussions?

We found that for every sequence of interactions initiated, a member received a response from the team. In breast cancer meetings, in particular, the responsiveness appeared to be even higher, with the initiator receiving an average of one and a half responses for each initiated sequence of interactions. This points to MDT meetings exhibiting high levels of interactivity, which is in line with previous findings in this setting (Soukup et al., 2021a,c).

4.3. Q3: Is there a difference in communication in the first half of the meeting vs. the second half?

A trend of increase in verbal fragmentations in the second half of meetings across participating teams was observed, with only

slight variations. For instance, pitch peaks in the colorectal team meeting did not differ between the two time points, which could be due to the way these meetings are set up, with the oncologist and pathologist having to dial into the meeting, with Internet/sound issues a common occurrence. In the combined sample, however, the chatter and laughter, in addition to interruptions and incomplete sentences, seemed to be the most common across teams. These were closely followed by pauses, repetitions, and vocalizations, indicating less focused discussion in the second half of the meetings, pointing to a possible link to increased cognitive load and fatigue (Adda-Decker et al., 2008; Heldner and Edlund, 2010; Nicholson et al., 2010; Womack et al., 2012), and time-on-task effects on communication and decision-making in MDT meetings (Lamb et al., 2013; Soukup et al., 2019a,b, 2020a). It is possible that such effects also impacted the quality of decisions made—while the current study did not investigate this aspect, this is something that future research should further unpack to ascertain the correlation between the quality of the decision-making process and decisions made in relation to these effects. Further research should also examine the verbal fragmentations in more detail and their impact on team communication and decision-making in a larger sample and across more teams to understand the extent to which some of the patterns identified in our study apply to them.

4.4. Implications and further research

4.4.1. Cognitive fatigue and quality of communication and decision-making in MDT meetings

The possible link between higher frequencies of verbal fragmentations, and increased cognitive load and fatigue, may also be a factor shaping team interaction (Adda-Decker et al., 2008; Heldner and Edlund, 2010; Nicholson et al., 2010; Womack et al., 2012). Verbal fragmentation can impact the listener's understanding of what the speaker wants to communicate to the group (Bailey and Ferreira, 2003; Barr and Seyfiddinipur, 2010; Womack et al., 2012; Soukup, 2017). Information that is not clearly communicated/understood can have an impact on clinical decision-making (Leonard et al., 2004; Soukup et al., 2016a,b, 2020a; Soukup, 2017). To optimize safety and quality, it is therefore important to maintain an acceptable level of cognitive load in MDTs during their weekly meetings by adapting appropriate cognitive strategies (Soukup, 2017; Soukup et al., 2019b). For instance, a short break in the middle of the meeting (Soukup, 2017; Soukup et al., 2019b), streamlining the workload according to clinical complexity using validated tools and clinical protocols (NHS England NHS Improvement, 2020; Soukup et al., 2020c,d), and a trained, non-contributing chair to facilitate communication and helping the team stay on task by minimizing the chatter, interruptions, and incomplete sentences (Soukup, 2017; Soukup et al., 2019b).

4.4.2. Task complexity and cognitive load in MDT meetings

Another related point to consider is that in task-orientated interactions (such as those occurring in the context of MDT meetings where the task is to formulate treatment recommendations), speakers and listeners spend considerable time on task-relevant activities (e.g., going through patients' paper notes in the meeting, looking for radiology/pathology slides to upload, and taking notes/populating patient proformas) than on other speakers/team members. This is in contrast to spontaneous non-task-oriented interactions, where the focus is more on other speakers; hence, gaze/token responses are common (Nicholson et al., 2010). It is arguable, therefore, that fragmentations and disfluencies during case discussions may occur due to task or case complexity (Bard et al., 2001; Nicholson et al., 2010; Soukup, 2017). However, at the time of this study, psychometrically sound tools for gauging case complexity in MDT meetings were lacking. Instead, we matched the cases on, for example, malignancy and duration of case discussion. However, the cases will differ on finer clinical aspects and complexity (Soukup, 2017; Soukup et al., 2020c). Further studies are, therefore, needed to begin to build the knowledge base on this issue and to create a cohort of case discussions that are closely matched on clinical complexity—something that can now be measured, for example, using the MeDiC tool (Soukup et al., 2020c). For instance, some of the questions that future studies could address are:—how do disfluencies differ in complex vs. simpler cases?—how do these change in the second half of the meetings? This would certainly begin to shed light on the relationships between verbal disfluencies and cognitive load/fatigue, and how they are elicited in the context of cancer MDT meetings (Soukup, 2017).

4.4.3. Role and contributions of cancer nurse specialists in MDT decision-making

Hierarchy may shape interaction in these meetings in ways that indicate how participants orient to status, role, and responsibility. This needs to be evaluated further, for example through a direct assessment of levels of real and perceived hierarchy in cancer MDTs and how this may correlate with patterns of team communication as assessed in the present study. Further CA research may help to clarify this, by shedding light on how the hierarchy of clinical expertise may shape the form and content of interactions in MDT meetings. CNSs, for example, occupy a lower professional status within this hierarchy, which appears to reflect their level of direct contribution. However, as discussed, their role is often critical, and one example from our data shows a direct contribution from a CNS that resulted in a change in the original decision (e.g., from discharging the patient to a clinical review). Communication in MDT meetings is influenced by many factors, including hierarchy, status, and power relationships. Our data appear to indicate that the hierarchy of expertise within the MDT does not determine action, but may systematically shape how communication between team members is conducted. Further analysis of this would shed light on the relationship between hierarchy and perceptions of role and responsibility.

4.4.4. Integration of patient perspectives into MDT decision-making

Further understanding is needed of how patients' perspectives are incorporated into MDT decision-making across different

teams and how this could be optimized (during and post-MDT meetings; Soukup et al., 2021b). This is particularly important in light of the current study, and previous research, demonstrating their underrepresentation (Lamb et al., 2011, 2013; Raine et al., 2014; Stairmands et al., 2015; Soukup et al., 2016a,b, 2020a,b, 2021c). It is understood that patients are experts in their health and lived experience and that they should be considered equal partners in clinical decision-making (Department of Health, 2004; Landmark et al., 2015; Soukup, 2017). This is reflected in the recommendations for MDTs suggesting a patient-centered approach (Department of Health, 2004), so that their views are included in the MDT discussion as part of the minimum information required about the patient (National Cancer Action Team, 2010), and shared decision-making as a healthcare norm (Department of Health, 2012).

4.5. Limitations and generalizability

Our study has limitations, some of which have been reported previously (Soukup, 2017; e.g., Soukup et al., 2019a, 2020a,c, 2021a). The first is the Hawthorne effect. We minimized its effect by (a) using a long-term approach to filming, (b) excluding the first two meetings from the analysis, and (c) filming discreetly (Soukup, 2017; Soukup et al., 2021a). Second, there were instances of inaudible speech in the meetings of all participating teams. This is a natural limitation of such complex multiparty interactions, where people do not speak in neatly organized rounds (Soukup, 2017; Soukup et al., 2021a).

However, by using real-time, unstructured observations of cancer teams, we were able to capture the flow of behavior in its setting, thus achieving greater ecological validity, while generating new avenues of inquiry that may provide new insights for improving MDT meetings and a better understanding of teams in general (Soukup, 2017). Our study also shows that a hybrid approach, encompassing qualitative data and quantitative frequency counts, is a feasible method for studying MDT communication and complex team dynamics. Future studies could apply our method to a larger sample to help build knowledge and generalizability in the context of cancer MDT meetings, as well as across other chronic conditions that use MDT meetings (Soukup, 2017).

Finally, we did not examine the effect of individual team members in the meetings. We acknowledge that although this is important to explore, it also carries a certain risk in potentially and unintentionally creating a culture of blame. We have, therefore, focused on disciplinary/professional groups, which is helpful when studying relatively small teams, such as the MDTs, because it ensures team safety by minimizing the risk of defensive routines and blaming a particular member for performance difficulties, which could distract from addressing the issues constructively (West, 2012; Soukup et al., 2019a). Similarly, and consequently, we did not collect information on the individual members' qualifications or years of experience in their current role, except that the members' studied as part of the analysis presented in the current study were at the consultant level, as they were more formally considered to be the core members who actively participated in and led the discussion. We know, however, that there are professional hierarchies and that more junior doctors may be present at MDT meetings but are not empowered to speak (West, 2012). Future studies should explore this aspect in more detail, with MDT research incorporating the hierarchies into the study design, which would allow for a more granular assessment of how different hierarchical positions impact team decision-making. In a similar vein, understanding the role of preparation time for MDT meetings and how this might impact the level of verbal contribution of team members to the discussion should also be further investigated, as this cannot be concluded from the current study and should be taken into consideration when interpreting the participation of different professional groups.

5. Conclusion

Factors such as (a) team cognitive load and fatigue, and (b) CNSs' input should be considered when planning MDT meetings because of their potential impact on the quality of team communication and decision-making. Our methodological approach could be further applied to other healthcare teams to build a knowledge base on team communication in this and other settings, and to provide guidance to teams to optimize teamwork.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: https://zenodo.org/record/582272#.XntHvoj7Q2w.

Ethics statement

The studies involving human participants were reviewed and approved by Northwest London Research Ethics Committee (JRCO REF. 157441). The patients/participants provided their written informed consent to participate in this study.

Author contributions

TS and GM have made substantial contributions to the conception and design of the study. All authors have made a substantial contribution to data acquisition, analysis, and interpretation of data, have been involved in drafting the manuscript and revising it critically for important intellectual content, have given final approval of the version to be published, and have agreed to take responsibility for all aspects of the article to ensure that questions relating to the accuracy or integrity of any part of the article are appropriately investigated and resolved.

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Conflict of interest

BL and TS received funding from Cancer Alliance and Health Education England for training MDTs in assessment and quality improvement methods in the United Kingdom. TS received consultancy fees from Roche Diagnostics. NS is the Director of London Safety & Training Solutions Ltd., which provides patient safety and quality improvement training and advisory services on a consultancy basis to hospitals and training programs in the UK and internationally. JG is the Director of Green Cross Medical Ltd. that developed MDT FIT for use by National Health Service Cancer Teams in the UK.

The remaining author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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EDITED BY
Julia Carolin Seelandt,
University Hospital Zürich, Switzerland

REVIEWED BY
Keri L. Heitner,
Saybrook University, United States
York Hagmayer,
University of Göttingen, Germany

*CORRESPONDENCE
Anja Alexandra Schulz
✉ anja.schulz@ph-freiburg.de

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Assessment of interprofessional obstetric and midwifery care from the midwives' perspective using the Interprofessional Collaboration Scale (ICS)

Anja Alexandra Schulz* and Markus Antonius Wirtz

Research Methods in the Health Sciences, University of Education Freiburg, Freiburg, Germany

Introduction: Interprofessional collaboration of physicians and midwives is essential for appropriate and safe care of pregnant and parturient women as well as their newborns. The complexity of woman-centered care settings requires the continuous exchange of information and the coordinated implementation of multi-and interprofessional care concepts. To analyze the midwives' perspective on the multi-and interprofessional care process during pregnancy, birth and postpartum period, we aimed to adapt and psychometrically evaluate the Interprofessional Collaboration Scale (ICS).

Methods: The ICS (13 items) was answered by 299 midwives for (i) prenatal and postpartum care as well as (ii) perinatal care. Three items on equitable communication (EC) identified in qualitative interviews with $N=6$ midwives were added as further aspects of quality in collaborative midwifery care. Confirmatory factor analysis was used to test competing theoretically hypothesized factorial model structures, including both care settings simultaneously, i.e., birth and prenatal/postpartum.

Results: A two-dimensional structure assuming the 13 original ICS items and the 3 items on EC as psychometric distinct item groups accounts for the data best. After deleting 5 ICS items with insufficient indicator reliability, a very good-fitting model structure was obtained for both prenatal/postpartum as well as perinatal care: $\chi^2_{df=192}=226.35$, $p=0.045$, CFI=0.991, RMSEA=0.025 (90%CI: [0.004; 0.037]). Both the reduced ICS-R and the EC scale (standardized response mean=0.579/1.401) indicate significantly higher interprofessional collaboration in the birth setting. Responsibility in consulting, attitudes toward obstetric care and frequency of collaboration with other professional groups proved to be associated with the ICS-R and EC scale as expected.

Discussion: For the adapted ICS-R and the EC scale a good construct validity could be confirmed. Thus, the scales can be recommended as a promising assessment for recording the collaboration of midwives with physicians working in obstetric care from the perspective of midwives. The instrument provides a validated assessment basis in midwifery and obstetric care to identify potentially divergent perspectives within interprofessional care teams in woman's centered care.

KEYWORDS

interprofessional collaboration, midwifery care, woman-centered care, psychometric evaluation, confirmatory factor analysis

1. Introduction

The care of pregnant women, women in labor, women who have recently given birth, and newborns takes place in a multidisciplinary care context (International Confederation of Midwives, 2014; Hansson et al., 2019). All professions involved in maternal and child care share the common goal of providing high-quality, safe, and efficient health care (Angelini et al., 2012; Tunçalp et al., 2015). Additionally, health care professionals in (non-)clinical obstetrics face the challenge of fulfilling the demands of modern obstetrics and the increasingly complex care processes with sometimes limited care capacity and maximally utilized (human) resources (Shamian, 2014; WHO, 2016).

The purposeful linking of profession-specific knowledge and skills in the sense of integrated care practice or interprofessional care may contribute to ensure the required status quo of quality of care (Shamian, 2014; WHO Regional Office for Europe, 2015; Freytsis et al., 2017). Interprofessional collaboration (IC) of midwives and physicians is defined as "a process in which midwives and physicians work together toward a common purpose: to provide safe, effective, patient-centered care for women and their families, guided by shared rules and structures, both formal and informal, which govern a mutually beneficial relationship, a relationship which seeks to optimize the context in which the collaboration is convened" (Smith, 2015). Successful IC supports the development of a common understanding in terms of a continuum of care in which competing or conflicting ways of working are avoided (McFarland et al., 2020; Stahl and Agricola, 2021). Insufficient cooperation within the obstetric staff is be perceived by mothers as a negative experience during the care process (Cornthwaite et al., 2013).

1.1. Midwives' and physicians' perspective on interprofessional collaboration

Professional groups involved in obstetric care generally consider that the benefits of IC predominate (Aquino et al., 2016). Both midwives and physicians perceive a positive effect in the case of successful IC with regard to woman-centered care outcomes (Cornthwaite et al., 2013; Aquino et al., 2016). The professional group affiliation is of particular importance when assessing the individual evaluation of IC. Especially, in the clinical setting physicians' perceptions of IC in everyday care with midwives and nurses proved to be more positive than vice versa (Warmelink et al., 2017; Romijn et al., 2018). In contrast, non-medical health care professionals generally have a more positive attitude toward IC than physician staff (Sollami et al., 2015).

Because professions understand the IC differently, the practice of IC is perceived differently by these and the respective expectations may differ (Lingard et al., 2012; Sollami et al., 2015). Accordingly, endpoints of the assessment must be defined and operationalized clearly and unambiguously (IC attitude or IC perception) to allow for a valid comparison between professional groups (Lingard et al., 2012; Sollami et al., 2015).

Challenges in implementing IC in the clinical obstetric care setting are well documented and stringently reported regardless of professional group perspective. In general, pronounced hierarchical structures, fragmentation of care, lack of respect and trust, and unclear areas of responsibility and authority are key barriers to implement IC (Smith, 2015; Aquino et al., 2016). Midwives perceive their work environment as tense with a high risk of conflict (McFarland et al., 2020). Professional dissonance, caused by discrepancies in professional ethics or expectations of, e.g., communication structures and coordination mechanisms, is considered a central cause (Smith, 2015; Hansson et al., 2022). The overall heterogeneous professional basic understanding (physiological vs. pathological) as well as competing birth concepts (home birth vs. clinical birth) and traditionally determined concepts of care (trust in the normality of birth vs. birth as a high-risk event) between midwives and physicians may also be influential. These aspects may enhance feelings of demarcation between professional groups and impede a shared vision or philosophy of care (Reiger, 2008; Reiger and Lane, 2009; Behruzi et al., 2017; McFarland et al., 2020).

In addition to the demanding and complex care setting, high fluctuation, inadequate professional resources, and poor work climate, conflicting ideologies within the team and role conflicts may additionally negatively influence the experience of emotional demands, increase job-related stress, and negatively affect job satisfaction (Hunter, 2004; Nedvědová et al., 2017; Bloxsome et al., 2019). Fostering IC also improves the organizational and psychosocial work environment of health professionals and is positively associated with job satisfaction (Weller et al., 2014; Dinius et al., 2020).

1.2. Challenges in analyzing effects of interprofessional collaboration in woman-centered maternity and obstetric care

The effectiveness of working in collaborative care teams in obstetrics in terms of woman-related healthcare outcomes proved to be limited (Homer et al., 2001; Sandall et al., 2016; Lee et al., 2021). Care within an interprofessional continuity of care model (midwife-led continuity model) is associated with a reduction in (i) instrumental vaginal births (mean RR = 0.90; 95% CI: [0.83; 0.97]), (ii) local analgesia (mean RR = 0.85; 95% CI: [0.78; 0.92]), (iii) preterm birth (mean RR = 0.76; 95%- CI: [0.64; 0.91]), and (iv) miscarriage before and after 24 weeks of gestation (mean RR = 0.84; 95% CI: [0.71; 0.99]) (Sandall et al., 2016). In addition, the likelihood of spontaneous natural delivery is increased (mean RR = 1.05; 95%CI: [1.03; 1.07]) (Sandall et al., 2016). However, some research results also indicate negative effects of IC, i.a. reducing productivity or enhancing restricted decision-making processes due to the necessity of more complex coordination processes (Mitchell et al., 2011; Kaba et al., 2016).

When considering the reported effects, it is important to take into account that inconsistent foundations for the operationalization of IC make the interpretation and comparability of the effects difficult (Reeves et al., 2011; Langer et al., 2012; Kaba et al., 2016; Reeves et al., 2017). The types and practices of IC vary widely from (i) simple information through (ii) enabling and generating synergies of the professions involved to (iii) joint decision-making and action processes (Gerber et al., 2018). Furthermore, the construct IC is often analyzed as a sub-aspect of a multimodal intervention (e.g., integrated care) or as a facet within the scope of action of occupational psychological processes (Stahl et al., 2019). This fact, combined with the paucity of study results based on experimental studies, makes it

difficult to classify the impact of IC in terms of patient-relevant outcomes, patient safety, efficiency, and improved quality of care in general (Mitchell et al., 2011; Kaba et al., 2016; Reeves et al., 2017).

1.3. Operationalization of interprofessional collaboration of midwives and physicians

IC in the health care sector is primarily assessed using self-rating instruments (Walters et al., 2016). The focus is predominantly on capturing IC between physicians and nurses in different health care settings (Sollami et al., 2015). Most instruments assess attitudes related to IC [e.g., Jefferson Scale of Attitude towards Physician-Nurse Collaboration (JSAPNC) (Hojat et al., 1997)], while a smaller number operationalize perceived IC in interprofessional teams [e.g., Nurse-Physician Collaboration Scale (NPCS) (Ushiro, 2009), Collaboration Practice Scale (CPS) (Weiss and Davis, 1985), Collaboration and Satisfaction About Care Decision Scale (CSACDS) (Baggs, 1994)].

The instruments assess not only the frequency of conferences with other professions, but also sub-facets of collaborative relationship, the organizational climate or information management processes (Ushiro, 2009). Validation steps with samples from allied health staff (e.g., midwives) are missing (Peltonen et al., 2020). Furthermore, a limited examination of psychometric properties of assessment instruments is to be acknowledged (Peltonen et al., 2020).

The Interprofessional Collaboration Scale (ICS) takes a generic approach to capture IC between different health care professions (Kenaszchuk et al., 2010). The multiple-group assessment was developed primarily for three professions in clinical settings: physicians, nurses, and other regulated health care professionals (e.g., speech therapists, dietitians, physical therapists). In successive validation steps, the three-factorial structure of the questionnaire: (i) *Communication*, (ii) *Accommodation*, (iii) *Isolation*, was confirmed also for the German version (Vittadello et al., 2018). However, shortcomings in model fit were found for the group of allied health personnel (occupational and physical therapists, pharmacists, social workers). The authors recommend psychometric testing not for the allied health personnel in general. Instead, the analysis should be specific for each occupational group that belong to the more general population of health care workers (Kenaszchuk et al., 2010). Because of the generic developmental approach, the ICS can be considered a relevant operationalization approach for assessing IC in obstetric care between midwives and physicians.

1.4. Properties of the German midwifery care system

The unique properties of the German midwifery system should be taken into account when investigating IC in the midwifery and obstetric care setting. All insured women in Germany have a statutory entitlement to midwifery care during pregnancy, childbirth, the postpartum period, and during breastfeeding. This includes activities such as preventive examinations, help with pregnancy complaints, care of sutures and birth injuries, postpartum care, and conducting newborn screening. In addition, midwives are responsible for the independent management of physiological births without risk (§ 1 Midwives Law). Furthermore, there are different work structures, whereby midwives work as employees (mainly clinical obstetrics), freelancers (e.g., out-of-hospital obstetrics, prenatal care, retraining) or both. Thus, a variety of midwifery activities are provided in different care settings (prenatal, perinatal, postpartum) in multi-and interdisciplinary care teams (specialists in obstetrics and gynecology, pediatricians, midwives). A differentiated assessment and comparison of midwives' perspectives on IC with physicians in clinical and out-of-hospital care of pregnant women, mothers, and women in childbirth has not yet been conducted (O'Reilly et al., 2017).

1.5. Study aims and research questions

To assess IC of physicians and midwives in clinical and out-of-hospital care settings in Germany, we adapted the existing German version of the ICS (Vittadello et al., 2018) to the context of midwifery care considering further aspects to ensure content-validity. The analysis was divided in two steps: First, psychometric evaluation of the scale properties of the adapted ICS supplemented by additional items on equitable communication (EC) between midwives and physicians; Secondly, evaluation of the IC from the perspective of midwives in clinical and out-of-hospital care settings on scale and item level. The bivariate relationship with other IC-associated characteristics was analyzed exploratorily. Thus, the following research questions were investigated:

1. Are the responses on the 13 ICS items and the 3 EC items determined by a four-factor structure 4-DIM model (accommodation, isolation, communication, equitable communication)?
2. Do midwives' views of IC with physicians differ between care settings (prenatal/postpartum vs. perinatal) on item and scale level?
3. Are the ICS scores associated with

a. midwives' job satisfaction?
b. perceptions and attitudes toward the obstetric care process and professional responsibilities?
c. the frequency of collaboration with other professional groups?

2. Materials and methods

The present study is a follow-up study of the research project "Structural analysis of midwifery care in the rural district of Ortenau (Southwest Germany)" which was approved to be ethically appropriate by the Ethics Committee of the German Psychological Society (DGPs; Ref: MAW 022019). The study was conducted from April to May 2020 as a cross-sectional online survey using the SoSci Survey tool (anonymous online questionnaire). No personal data were collected. Only characteristics of the individual work situation (scope and duration of work, field of activity, federal state) were recorded. Accordingly, the local ethics committee did not require a separate ethics vote for this study arm. All participating midwives were fully informed about study conditions (especially data privacy and protection) and participant rights. Confirmation of informed consent was obtained prior to completion of the questionnaire.

2.1. Sample

Midwives were recruited in a two-stage selection process. Ad hoc samples of independent and employed midwives in clinical and non-clinical care were drawn in all 16 federal states of Germany (primary sampling units). In addition, recruitment was supported by multipliers at the level of regional and national associations.

$N = 468$ midwives could be enrolled. Of these, $N = 325$ (69.4%) completed the online questionnaire. Twenty-six of these cases had to be excluded from the sample due to premature termination of questionnaire processing. Accordingly, $N = 299$ (63.9%) were included in the final data analysis. The questionnaires were completely answered except for single missing data (maximum of missing data on the scale items $N = 8$ or 0.4%).

2.2. Instruments

The ICS (Kenaszchuk et al., 2010) is a self-report tool that was developed to assess core aspects of IC between two or more professional groups in health care (e.g., nurses, doctors, allied health professionals). Each of the 13 scale items (Table 1) is answered on a 4-point rating scales ranging from "1" – "strongly disagree" to "4" – "strongly agree". Factor analysis revealed a three-factor structure of the self-report tool: perceptions of *Communication*, *Isolation*, and *Accommodation* proved to be distinguishable. Nevertheless, the three identified factors were highly correlated (e.g.: nurses rating collaboration with physicians: $r = 0.75–0.86$). Composite reliability proved to be acceptable for *Communication* and *Isolation* ($\rho_c = 0.76$ in each case), and good for *Accommodation* ($\rho_c = 0.85$). In the present study, according to the basic conception of the instrument, the professional groups *physicians* and *midwives* were placed in the item templates. The assessment of IC of these two professional groups in the care of pregnant and childbearing women was made from the perspective of midwives. The content validity of the ICS for IC in prenatal and obstetric woman-centered care could be substantiated by preceding qualitative interviews with $N = 6$ midwives. The content of each item corresponded with statements made by the midwives interviewed. However, in the interviews, midwives placed emphasis on the importance of equitable interprofessional communication and team spirit. In order to take these aspects into account, three additional items were formulated which were intended to ensure the completeness of the content spectrum of IC in obstetrics (Table 1; EC-01 to EC-03). These items were answered on 6-point Likert scales. According to the response range of the ICS items, response categories were coded from "1" – "strongly disagree" to "4" – "strongly agree" (intermediate levels: "1.6" – "mostly disagree", "2.20" – "rather disagree", "2.80" – "rather agree", "3.40" – "mostly agree").

Convergent and discriminant validity of the supplemented ICS scale were examined by incorporating established assessment scales as well as newly developed items based on the content of the preceding qualitative interviews. To assess midwives' *job satisfaction*, the corresponding scale from the Copenhagen Psychosocial Questionnaire (COPSOQ; (Kristensen et al., 2005)) was used. Five aspects of *job satisfaction* (career perspective, people you work with, physical job conditions, organization of work situation, opportunities to contribute skills) are rated on 4-point Likert scales ("1" – "very satisfied" to "5" – "very dissatisfied"). The aggregated scale score proved to be sufficiently internal consistent [Cronbachs $\alpha = 0.78$; (Nübling et al., 2006)].

In the preceding qualitative interviews *perceptions and attitudes toward the obstetric care process and professional responsibilities* could be identified as relevant for IC between physicians and midwives. To record these in a standardized way, corresponding items were developed. Eleven aspects of *attribution of professional responsibilities in consulting and support* (see Table 2) were answered on 5-point bipolar rating scales. The response categories were chosen to indicate whether the physician or the midwife was considered more responsible ("−2" = "physician", "−1" = "rather the physician", "0" = "both equally", "+1" = "rather the midwife", "+2" = "midwife"). Eleven items on *attitudes towards obstetric care* (see Table 2) were answered on 6-point bipolar rating scales ("1" – "does not apply at all" to "4" – "applies completely"). Finally, the frequency of collaboration with (1) pediatricians, (2) gynecologists and (3) other midwives and maternity nurses was surveyed by selecting from the categories "never", "occasionally" and "frequently".

2.3. Data analysis

Before starting the in-depth analysis missing values in the scale items were imputed by the expectation maximization (EM) algorithm implemented in the Software SPSS 26. EM-imputation is generally recommended in case of metric or Likert scale items to avoid biases due to possibly not completely random missing values [MCAR; (Schafer and Graham, 2002; Wirtz, 2004)]. Further analyses were started after reverse coding of negatively worded items.

Using the maximum likelihood method, we performed confirmatory factor analyses (CFA; Little and Kline, 2016) to check which of the assumed structural models (uni-, two-or four-dimensional) allows the best fit of the empirical variance–covariance-matrix. For this purpose, a CFA model was defined in which the data of the two care settings [prenatal/postpartum care (PPC) and birth care (BC)] were analyzed in an integrated manner (design for dependent measurements). The possible dependence of the constructs and the items across the care settings was thus taken into account in the modeling approach.

The appropriateness of the CFA models was assessed by measures of global and local fit (Little and Kline, 2016). The χ^2-value allows to test the significance of deviations of the empirical and model implied information in the variance–covariance matrix. However, this test is overly sensitive to sample size (Schermelleh-Engel et al., 2003). Alternatively, measures of approximate fit allow a more valid testing of the global model fit, as they focus on the empirical relevance of inaccuracies of model predictions. The Root Mean Square Error of Approximation (RMSEA) quantifies the amount of unexplained information in the data set. RMSEA less than 0.05 indicates a good model fit (acceptable fit: RMSEA <0.08), because less than 5% of the empirical information remains unexplained. Incremental fit measures like the Confirmatory Fit Index (CFI) and the Tucker-Lewis Index (TLI) reflect a higher model precision the closer their value is to 1 (good model fit: CFI, TLI > 0.97; acceptable model fit: CFI, TLI > 0.95; Schermelleh-Engel

TABLE 1 Mean values and stability of the items of the original ICS and the EC scale in prenatal and postpartum care (PPC) as well as in birth (BC) care in the total sample of *N*=299 midwives.

	M (PPC)	SD (PPC)	M (BC)	SD (BC)	$r_{PPC, BC}$[2]	SD (DIF)[4]	SRM[5]	r_{it}[6] (PPC | BC)	α (PPC | BC)
Interprofessional collaboration scale-R	*2.25*	*0.687*	*2.55*	*0.588*	*0.668***	*0.527*	*0.579****		*0.920 | 0.874*
ICS-01: Midwives have a good understanding with physicians about our respective responsibilities	2.51	0.880	2.90	0.723	0.336***	0.933	0.420***		
ICS-02: Physicians are usually willing to take into account the convenience of midwives when planning their work	2.15	0.810	2.63	0.802	0.311***	0.946	0.513***	0.713 | 0.546	
ICS-03: I feel that woman and newborn care are adequately discussed between midwives and physicians[1]	2.33	0.864	2.62	0.840	0.424***	0.915	0.315***	0.744 | 0.681	
ICS-04: The physicians and midwives have similar ideas about how women and newborn should be treated	2.40	0.815	2.51	0.813	0.492***	0.820	(0.130*)[3]	0.651 | 0.641	
ICS-05: Physicians are willing to discuss midwives' issues	2.34	0.903	2.65	0.836	0.560***	0.818	0.372***	0.799| 0.695	
ICS-06: Physicians cooperate with the way we organize midwifery	2.40	0.835	2.71	0.726	0.418***	0.848	0.367***	0.755 | 0.647	
ICS-07: Physicians would be willing to cooperate with midwifery practices	2.15	0.782	2.38	0.757	0.514***	0.759	0.309***	0.779 | 0.672	
ICS-08: Physicians usually asks or midwife's opinion	2.01	0.945	2.54	0.852	0.519***	0.885	0.495***	0.723 | 0.648	
ICS-09: Physicians anticipate when midwives need their help	2.19	0.815	2.59	0.800	0.518***	0.793	0.500***		
ICS-10: Important information is always passed on between midwives and physicians	3.48	0.647	3.65	0.636	0.433***	0.683	0.240***		
ICS-11: Disagreements with physicians are usually clarified	2.31	0.812	2.64	0.743	0.454***	0.815	0.402***		
ICS-12: Physicians think their work is more important than the work of midwives[1]	1.86	0.900	2.04	0.910	0.519***	0.888	(0.196**)[3]		
ICS-13: Physicians are willing to discuss their new practices with us	2.12	0.893	2.39	0.818	0.440***	0.908	0.302***	0.719 | 0.538	
Equitable communication (EC)	*1.80*	*0.435*	*2.59*	*0.624*	*0.481****	*0.563*	*1.405****		*0.920 | 0.864*
EC-01: Physicians and midwives nurses consider themselves as a team	1.90	0.528	2.87	0.679	0.388***	0.679	1.436***	0.838 | 0.733	
EC-02: Physicians and midwives nurses encounter at eye level	1.68	0.486	2.51	0.778	0.391***	0.739	1.111***	0.875 | 0.825	
EC-03: Professionals try to place themselves in the perspective of the other professional group	1.80	0.519	2.38	0.647	0.354***	0.671	0.862***	0.809 | 0.685	

Scale properties for the reduced ICS and the EC scale. [1]Inversely poled item. [2]Pearson correlation. [3]not significant after Bonferroni correction (adjusted α = 0.003 for $n = 18$ tests). [4]Standard deviation of differences between PPC and BC. [5]Standardized response mean of differences between PPC and BC. [6]Item-total-correlation of the items of the reduced ICS and the EC scale; *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$; PPC = prenatal/postpartum care; BC = birth care.

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TABLE 2 Correlation of the reduced ICS and the EC scale with satisfaction with work, responsibility consulting/support, attitudes toward obstetric care as well as frequency of collaboration with other professional groups.

	PPC		BC	
	ICS-R	EC	ICS-R	EC
Perceptions and attitudes toward the obstetric care process and professional responsibilities				
Attitudes toward obstetric care				
A01 - A clinical birth is usually preferable to a home birth	0.420***.a	0.413***.a	0.343***.a	0.385***.a
A02 - Joint supervision of all professional groups involved is essential for good quality in obstetric care	−0.085	−0.038	−0.059	0.127*
A03 - Midwives should work more in midwife-led birth centers.	−0.242***.a	−0.203***.a	−0.300***.a	−0.123*
A04 - If I know that the physicians have already performed an examination, I prefer to perform it again myself	−0.086	−0.158**	−0.145*	−0.074
A05 - I think the communication path between the physicians and the midwives *via* the maternity passport/preventive care booklet is sufficient	0.291***.a	0.277***.a	0.264***.a	0.214***.a
A06 - Midwives should be allowed to take on more diagnostic tasks (e.g., ultrasound) in the care process	−0.121*	−0.139*	−0.109	−0.093
A07 - Current financing in obstetrics creates competition between midwives and physicians	−0.325***.a	−0.320***.a	−0.348***.a	−0.223***.a
A08 - Midwives are the first point of contact for parents in case of uncertainty, providing referrals to other professionals or facilities	−0.018	0.028	−0.089	−0.001
A09 - Integration of midwifery care in general practices is an important step in ensuring quality of care	0.216***.a	0.207***.a	0.335***.a	0.328***.a
Responsibility consulting/support				
R01 - Parturient with gestational diabetes	−0.063	−0.083	−0.131*	−0.008
R02 - Physiological birth	−0.170**	−0.103	−0.181**	0.031
R03 - Information about possible complications during birth	−0.215***.a	−0.273***.a	−0.277***.a	−0.225***.a
R04 - Breastfeeding counseling	0.025	0.061	−0.061	0.139*
R05 - Counseling for pregnant women's fears and anxieties about childbirth	−0.052	−0.066	−0.091	−0.040
R06 - Treatment of mastitis	0.033	0.062	−0.114*	0.000
R07 - Control of the infant heart actions	−0.093	−0.105	−0.200***.a	−0.125*
R08 - Information about physical changes during pregnancy	−0.086	−0.101	−0.137*	−0.047
R09 - Vaccination counseling	0.020	0.019	−0.036	−0.094
R10 - Postpartum courses	−0.037	0.015	−0.071	0.088
R11 - Nutritional counseling	−0.074	−0.084	−0.158**	−0.051
Frequency collaboration professional groups				
Pediatricians	0.238***.a	0.215***.a	0.191**	0.131*
Gynecologists	0.340***.a	0.294***.a	0.361***.a	0.315***.a
Other midwives and maternity nurses	0.120*	0.072	0.141*	0.161**
COPSOQ – Satisfaction with work (scale)	0.011	0.051	0.101	0.041
C01 - Career perspectives	0.126*	0.120*	0.176**	0.137*
C02 - People you work with	0.164**	0.163**	0.226***.a	0.166**
C03 - Physical job conditions	−0.088	−0.027	−0.110	−0.097
C04 - Organization of work situation	0.019	0.008	0.007	−0.008
C05 - Opportunities to contribute skills	0.113	0.076	0.136*	0.101
C06 - Salary	0.051	0.043	0.103	0.060

PPC = prenatal/postpartum care, BC = birth care; *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. [a]Still significant after Bonferroni correction (adjusted $\alpha = 0.0005$ for $n = 88$ tests).

et al., 2003). A value of 1 indicates that the tested model can fully explain all the variance–covariance information in the data set. The Bayesian Information Criterion (BIC) makes it possible to compare models of different complexity, since it takes into account the models 'degrees of freedom (df). Additional df are rewarded by this information-theoretic measure. If the number of analysis variables remains the same, the model with the lowest BIC value provides the best data fit according to the respective df (Schermelleh-Engel et al., 2003; Little and Kline, 2016).

Additionally, at the local item level it must be ensured that each item is sufficiently closely associated with the factor to which it is assigned: factor loadings >0.632 or indicator reliabilities >0.400 indicate an acceptable item-construct association (Little and Kline, 2016).

For the identified scales Cronbach's α was determined as a measure of internal consistency. According to Classical Test Theory, α is an estimate of the correlation of the aggregated scale value and the underlying latent true score (Lord and Novick, 2008). $\alpha > 0.7$ indicates acceptable internal consistency. Values above 0.8 indicate good internal consistency.

Paired t-tests were calculated to analyze differences between care settings of IC at scale level (ICS-R and EC scale) and item level [research question 2; (Tabachnick and Fidell, 2014)]. The stability of the scale items across care settings was tested by calculating Pearson product–moment correlations (Tabachnick and Fidell, 2014). The association of the ICS-R and EC-scale with further (care-) characteristics was determined by calculating Pearson product–moment correlations (research question 3). To account for the problem of multiple testing regarding research question 2 and 3, Bonferroni-corrected significance limits are reported (Tabachnick and Fidell, 2014).

All statistical analyses were performed using the statistic software SPSS 26.0 and MPlus 8.3 (Muthén and Muthén, 2017).

3. Results

3.1. Sample characteristics and descriptive statistics

325 midwives completed the online questionnaire. Of those, 26 respondents (0.8%) were excluded because of limited data quality (proportion of missing values >10% in scale items). Table 3 shows the distribution of key characteristics in midwifery activity and employment. Mostly, participating midwives work as independent midwives (88.8%) in urban areas (66.2%). On average, midwives have 18.64 years of professional experience (median = 18.00, SD = 11.96).

Table 1 shows the mean values for the individual items of the original ICS and the supplemented EC items separately for the assessed care settings prenatal/postpartum (PPC) and birth (BC). For 13 of the 16 items, the assessment of IC quality was significantly higher for birth after correcting for multiple testing. The standardized response mean for the original ICS items proved to be small to medium (SRM = 0.240–0.513). The three items on EC indicated very high differences between settings (SRM = 0.862–1.436). Thus, in the birth setting, IC was higher in all assessed aspects. Furthermore, the single items were significantly correlated between PPC and BC setting within the range of medium to high effect sizes ($r = 0.311$–0.560).

3.2. Confirmatory factor analysis of competing structural model definitions

Table 4 shows the results of the CFAs for the assumed integrated model structures of the items of IC at BC and in PPC. The one-dimensional model (1 DIM) did not fit the data information adequately (χ^2 ($df = 447$) = 1177.79; $p < 0.001$; RMSEA = 0.075 (90%CI: [0.069; 0.080]); CFI = 0.866). The two-dimensional model (2 DIM; ICS, EC) and the four-dimensional model (4 DIM; *Communication*, *Accommodation*, *Isolation*, *EC*) provided a considerably better model fit. For these two models, a similar global data fit could be determined. The fit indicators $RMSEA_{2DIM/4DIM} = 0.051/0.052$ and $CFI_{2DIM/4DIM} = 0.937/0.939$ proved to be acceptable.

However, the four-dimensional model was not factorial valid due to the exceptionally high correlations of the three subfactors of ICS. *Communication* correlated with *Accommodation* and *Isolation* in the care settings PPC and BC to. 973/0.988 and 0.988/0.996, respectively. The correlation of *Accommodation* and *Isolation* in the care settings PPC and BC was 0.936/0.927. Hence, the separability of these three components proved to be not possible due to the high information redundancy. Overall, the three-factor structure found in the original version of the ICS proved not to be appropriate in the sample of midwives. A second distinct construct, in addition to the ICS component, resulted only from the newly added EC items.

In all models tested, some of the ICS items exhibited insufficient factor loadings and thus insufficient factor reliabilities. In particular item ICS-10 ("*Important information always passed on*") (max. loading = 0.303) falled substantially below the critical threshold of 0.642. The loadings of items ICS-01 ("*Good understanding with physicians about our respective responsibilities*"), ICS-09 ("*Anticipate when midwives need their help*"), ICS-11 ("*Disagreements with physicians are often resolved*"), and ICS-12 ("*Consider their work more important*") were below 0.624. After removing these items from the model, the reduced model definition 2-DIM-R yielded an excellent global model fit: $\chi^2_{(df=192)} = 226.35$, $p = 0.045$; RMSEA = 0.025 (90%CI: [0.004; 0.037]); CFI = 0.991. At the local fit level, especially for the BC setting, the item-construct associations proved to be good (min. loading: 0.674). The item-specific residual correlations across the two care settings, as indicators of the information stability that cannot be explained by the latent constructs, are low or at most moderate ($r_e = 0.046$–0.326; Table 4). This substantiates the adequacy of the assumed structural model, as setting-relevant information was adequately represented by the ICS-R and EC constructs (stability across care settings: $r_{ICS\text{-}R} = 0.724$, $r_{EC} = 0.579$).

Within the care settings the intercorrelation of ICS-R and EC was 0.801 and 0.774, respectively.

3.3. Scale properties of the ICS-R and EC scales regarding care settings

Sufficient corrected item-total correlations and internal consistencies were obtained for both scales (Table 1). For PPC scores were slightly higher ($r_{it} = 0.651$–0.799 and 0.809–0.875, respectively; $\alpha = 0.920/0.920$, respectively) than for BC ($r_{it} = 0.546$–0.695 and 0.685–0.825, respectively; $\alpha = 0.874/0.864$). The ICS-R-and EC-scale proved to be highly correlated within in both settings: $r_{PPC} = 0.873$, $r_{BC} = 0.698$ (Figure 1). Stability between the two care settings was more

TABLE 3 Descriptive sample statistics.

	N (%) Total: 299
Scope of activity	
Prenatal/pregnancy care	213 (71.2%)
Birth	174 (58.2%)
Postpartum	275 (92.0%)
Employment	
Independent	265 (88.6%)
Private medical practice	34 (11.4%)
Private midwife practice	76 (25.4%%)
Clinic	143 (47.8%)
Obstetric clinic	76 (25.4%)
Perinatal focus	16 (5.4%)
Perinatal center level 1	60 (20.1%)
Perinatal center level 2	17 (5.7%)
Attending midwife	42 (14.0%)
Other	31 (20.4%)
Volume of work	
Full-time	152 (50.8%)
Part-time up to 50%	102 (34.1%)
Part-time at least 50%	28 (9.4%)
Work location	
Urban area	198 (66.2%)
Rural area	95 (31.8%)
Professional experience (years) [min, 1., 2., 3., quartile, max]	[1.0, 8.0, 18.0, 29.0, 52.0] M = 18.64; SD = 11.96.

pronounced for the ICS-R scale ($r = 0.668$) than for the EC scale ($r = 0.481$). These scale intercorrelations thus correspond very well with those at the latent construct level (Table 4).

Both scales reflected a higher degree of IC between midwives and physicians in BC than in PPC (see Table 1). The ICS-R scale showed a medium effect size of SRM = 0.579 between the two care settings. The fact that the difference on the EC scale was even more pronounced with SRM = 1.405 is due to the considerably lower scale mean in PPC ($M_{PPC} = 1.80$ vs. $M_{BC} = 2.25$).

3.4. Correlation of the final scales (2-DIM-R) with other work characteristics and assessments of the midwives

When midwives are more likely to prefer clinical birth (A01, $r = 0.343–0.420$) and when they are more likely to communicate with physicians indirectly (maternity passport, A05, $r = 0.214–0.291$), satisfaction with IC tends to be higher on both scales in both settings (Table 2). This is also consistent with midwives who are more satisfied with IC having a desire to integrate midwifery care into general practices (A09, $r = 0.207–0.335$) and being more critical of midwife-led birth centers (A03, $r = -0.203$ to -0.300). The more frequently midwives work together especially with gynecologists ($r_{ICS-R} = 0.340/0.361$; $r_{EC} = 0.294/0.315$) but also with paediatricians in PPC, the more positive is their view on IC as well as EC ($r_{ICS-R} = 0.238$; $r_{EC} = 0.215$). The *COPSOQ - Satisfaction with work scale* was not correlated with both scales in both settings (Table 2). One exception was item C02: the more satisfied midwives are with their cooperation with other people during birth, the higher they rate the ICS-R ($r = 0.226$). Also with regard to the area of *Responsibility Consulting/Support*, only one item (R03) showed a significant correlation after Bonferroni correction in both settings ($r = -0.215$ to -0.277). When midwives see themselves as primarily responsible for passing on information about complications during birth, they are less satisfied with IC on both scales.

4. Discussion

In this study, the ICS was used to assess IC between midwives and physicians for the first time (Kenaszchuk et al., 2010; Vittadello et al., 2018). The ICS was expanded to include Equitable Communication (EC) in order to validly represent IC in midwifery and obstetric care. Our results suggest that the adapted ICS-R/EC assessment allows to capture perceived IC in a psychometrically sound manner. The setting-specific operationalization supports the recommendation of Vittadello et al. (2018) that different "allied health professional" disciplines and their action settings should be considered separately. This takes into account that IC between physicians and individual subgroups of allied health professionals may take different forms and qualities based on the particular profession-specific concept of care and intensity in terms of patient contacts.

4.1. Research question 1: structural properties of the ICS from the midwives' perspective

The a priori tested three-dimensional structure of the original ICS (Kenaszchuk et al., 2010; Vittadello et al., 2018) could not be confirmed in the sample of midwives. In both examined care settings PPC and BC the two-dimensional structure proved to be superior, after considering insufficient item-construct association of 5 ICS items. In contrast to existing research findings on IC between physicians and nursing, midwives seem to perceive the ICS-facets *Communication*, *Accommodation*, and *Isolation* less differentiated and more in terms of general IC. However, it must also be taken into account that in previous studies using the ICS in primary health care (cooperation physicians, nursing, allied health personnel), the theoretically postulated subconstructs proved to be poorly separable: E.g., high scale intercorrelations of the *Communication* facet with the *Isolation* and *Accommodation* facets ($|r| = 0.78–0.86$) were found (Kenaszchuk et al., 2010). Accordingly, the Fornell-Larcker discriminant factorial validity criterion proved to be violated, because the item-construct associations fell below the according scale intercorrelations substantially (Fornell and Larcker, 1981). In addition, a confirmatory test of model fit differentiated by rater-target group combinations (nurse vs. physician; allied professional vs. physician; physician vs. nurse; allied professional vs. nurse; nurse vs. allied professional; physician vs. allied professional) also indicated an insufficient to weak

TABLE 4 Factor loadings and model fit indices for the tested confirmatory model structures for prenatal/postpartum care and birth care.

	1 DIM	4 DIM[2]	2 DIM	2 DIM-R		
	Standardized item loadings (PPC | BC)				Intercept	r_e[3]
Communication (ICS-C)						
ICS-01	0.594 | 0.615[1]	0.616 | 0.630	0.608 | 0.632	–	–	–
ICS-03	0.707 | 0.756	0.718 | 0.772	0.725 | 0.774	0.727 | 0.776	3.10 | 2.70	0.084
ICS-09	0.524 | 0.639	0.530 | 0.643	0.531 | 0.643	–	–	–
ICS-10	0.294 | 0.306	0.268 | 0.299	0.285 | 0.303	–	–	–
ICS-11	0.568 | 0.616	0.574 | 0.547	0.577 | 0.633	–	–	–
Accomodation (ICS-A)						
ICS-02	0.578 | 0.747	0.610 | 0.754	0.602 | 0.753	0.572 | 0.745	3.27 | 2.65	0.090
ICS-04	0.691 | 0.663	0.703 | 0.685	0.697 | 0.673	0.702 | 0.674	3.11 | 2.92	0.223
ICS-05	0.739 | 0.801	0.754 | 0.823	0.748 | 0.816	0.772 | 0.827	3.15 | 2.58	0.280
ICS-06	0.652 | 0.753	0.683 | 0.786	0.670 | 0.776	0.682 | 0.784	3,65 | 2.87	0.079
ICS-07	0.706 | 0.794	0.713 | 0.813	0.714 | 0.805	0.725 | 0.818	3.17 | 2.77	0.184
Isolation (ICS-I)						
ICS-08	0.706 | 0.748	0.726 | 0.778	0.712 | 0.756	0.700 | 0.743	2.98 | 2.23	0.326
ICS-12	−0.501 | −0.328	−0.528 | −0.343	−0.501 | −0.318	–	–	–
ICS-13	0.551 | 0.704	0.592 | 0.728	0.561 | 0.705	0.537 | 0.689	2.85 | 2.34	0.191
Equitable communication (EC)						
EC-01	0.726 | 0.778	0.814 | 0.875	0.814 | 0.875	0.813 | 0.874	3.49 | 2.34	0.110
EC-02	0.775 | 0.826	0.918 | 0.940	0.916 | 0.941	0.916 | 0.941	2.77 | 2.35	0.046
EC-03	0.637 | 0.750	0.736 | 0.857	0.738 | 0.856	0.741 | 0.858	3.06 | 2.57	0.229
Correlation of the ICS construct between care settings (PPC and BC)	$r_{1DIM} = 0.728$	$r_{ICS\text{-}C} = 0.635$ $r_{ICS\text{-}A} = 0.727$ $r_{ICS\text{-}I} = 0.753$ $r_{EC} = 0.578$	$r_{ICS} = 0.705$ $r_{EC} = 0.578$	$r_{ICS} = 0.724$ $r_{EC} = 0.579$		
Correlation of the constructs within the care setting PPC	–	$r_{ICS\text{-}C,\ ICS\text{-}A} = 0.973$ $r_{ICS\text{-}C,\ ICS\text{-}I} = 0.988$ $r_{ICS\text{-}A,\ ICS\text{-}I} = 0.936$ $r_{ICS\text{-}C,\ EC} = 0.774$ $r_{ICS\text{-}A,\ EC} = 0.795$ $r_{ICS\text{-}I,\ EC} = 0.810$	$r_{ICS,EC} = 0.802$	$r_{ICS,EC} = 0.801$		
Correlation of the constructs within the care setting BC	–	$r_{ICS\text{-}C,\ ICS\text{-}A} = 0.988$ $r_{ICS\text{-}C,\ ICS\text{-}I} = 0.996$ $r_{ICS\text{-}A,\ ICS\text{-}I} = 0.927$ $r_{ICS\text{-}C,\ EC} = 0.761$ $r_{ICS\text{-}A,\ EC} = 0.770$ $r_{ICS\text{-}I,\ EC} = 0.775$	$r_{ICS,EC} = 0.779$	$r_{ICS,EC} = 0.774$		
Global fit measures						
χ	1177.79	751.98	785.73	226.35		
df	447	420	442	192		
p	<0.001	<0.001	<0.001	0.045		
TLI	0.851	0.928	0.929	0.990		
CFI	0.866	0.939	0.937	0.991		
RMSEA [90%CI]	0.075 [0.069; 0.080]	0.052 [0.046; 0.058]	0.051 [0.046; 0.057]	0.025 [0.004; 0.037]		
SRMR	0.055	0.047	0.050	0.032		
AIC	19708.53	19336.72	19326.47	–[4]		
BIC	20124.77	19852.43	19761.13	–[4]		

[1]Factor loadings. [2]Not positive definite. [3]Residual correlation PPC, BC. [4]Not suitable for model comparison due to reduced number of items.

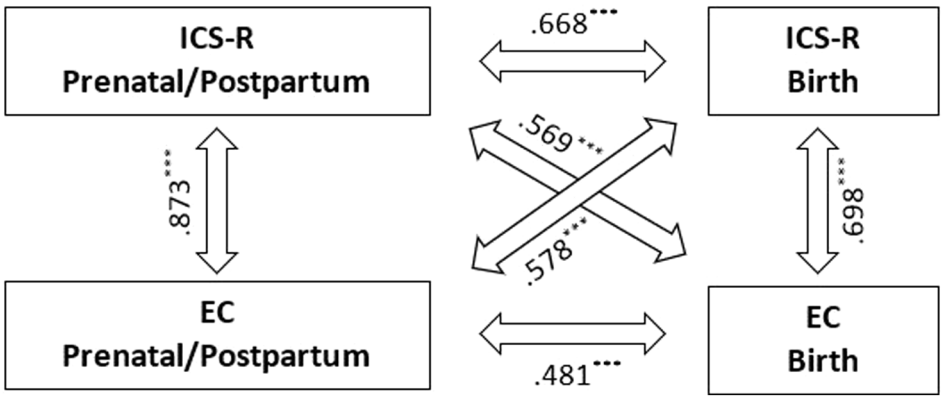

FIGURE 1
Correlation of the reduced ICS and the EC scale for both prenatal/postpartum and birth care (***p<0.001).

model fit for the assumed three-dimensional structure (CFI = 0.823–0.948; TLI = 0.904–976) (Kenaszchuk et al., 2010).

Due to insufficient indicator reliabilities, 5 ICS items were eliminated. Item ICS-12 ("*Consider their work is more important than ours*") represents the only negatively worded item in the entire ICS, which may contribute to the poor item fit in the overall model. The remaining 4 eliminated ICS items (ICS-01, ICS-09, ICS-10, ICS-11) indicate the original ICS subfacet *Communication* according to Kenaszchuk et al. (2010). The study of Vittadello et al. (2018) also showed a considerably weaker loading for the 10th item ("*Important information is always passed on from us to the other profession*") in the German translated version than in the original English version (Kenaszchuk et al., 2010). The insufficient item-construct association of this item may be caused from a semantic shift occurred during the translation process of the German version by Vittadello et al. (2018). In the German version respondents rate the extent to which their own profession transmits information to the other profession ("*Important information is always passed on **from** us **to** the other profession*" [ICS-10 German translation] (Vittadello et al., 2018)). In the original version the responsibility for the transmission of information is not attributed to one of the interacting professional groups: "*Important information is always passed on **between** us **and** them*" (ICS-10 original). In general, the ICS is designed to evaluate primarily the behavior of the respective other professional group with regard to IC with one's own professional group (external evaluation). The focus is less on the assessment of the extent to which one's own professional group practices interprofessional behavior (self-assessment). This minimal linguistic shift may lead to (i) weaker indicator reliability and (ii) a bias due to socially desirable response behavior, self-serving bias, being more pronounced in the German version than in the original form (Dufner et al., 2018).

Item ICS-09 ("*Anticipate when midwives need their help*") addresses less strongly active verbal communication behaviors. This item relates more to aspects of work organization in terms of supportive collective action or the concept of *Collective Intelligence* (Jean et al., 2020). *Collective Intelligence* is positively related to IC in healthcare but should be considered as an independent information component (Awal and Bharadwaj, 2014). In contrast, Item ICS-11 ("*disagreements with physicians are often resolved*") primarily addresses the conflict culture within the team to overcome the described professional dissonance in midwife-physician teams, rather than specific communication skills (McFarland et al., 2020). Item ICS-01 ("*Good understanding with physicians about our respective responsibilities*") deals with the aspect of perspective adoption. The adaptation of the perspectives and concepts of other reference disciplines as well as an active reflection of one's own actions characterizes the highest level of collaboration (transdisciplinary). This allows the creation of a common understanding, which would not have been possible without the formation of synergies (WHO, 2010).

Due to the item selection, the aspect of *Communication* is thus significantly weaker represented in the ICS-R compared to the original ICS. Instead, the aspect of *Equitable Communication* (EC) has proven to be a clearly separable alternative communication facet. EC addresses in particular interactional factors, i.e., communication behavior that promotes group esteem and internal cohesion (D'Amour et al., 2008; Behruzi et al., 2017). Perceived boundaries or inequalities among members in an interprofessionally designed care team represent a key barrier to the implementation of IC in practice (Aquino et al., 2016). Interpersonal appreciation within a team represents a facilitating factor, as it implies the individual's need for recognition, consideration, and acceptance (Warschburger, 2009; Behruzi et al., 2017). Thus, conflictual IC processes in the obstetric setting have been attributed partly to the lack of appreciation (Behruzi et al., 2017).

In summary, the ICS-R/EC-assessment allows for a comprehensive and psychometric sound examination of the IC domain in woman-centered midwifery and obstetric care.

4.2. Research question 2: differences between care settings from the midwives' perspective

Overall, midwives rated IC and EC with physicians in PPC as rather unsatisfactory (M_{PPC} = 1.68–2.40). Considerably better values are obtained for BC (M_{BC} = 2.38–2.87). This is in line with existing findings from previous studies that perceived IC with physicians is rated as more critical by midwives (Warmelink et al., 2017; Romijn et al., 2018).

An analysis at the individual item level reveals that the differences are reflected to different degrees (item-stetting interaction). While

weak to moderate differences appeared for the 8 ICS items, large effects were found for the EC items (SRM = 0.862–1.436). The overall EC within the midwife-physician care dyad turned out to be more pronounced in BC than in PPC (SRM = 1.405) (WHO, 2010).

Furthermore, discrepancies between care settings may result from specific characteristics of the health care system in general and the according model of care (Scheerhagen et al., 2015). While in BC care is usually provided by an interprofessional team at one location, PPC is organized multiprofessionally, autonomously in the sense of parallel care (Careau et al., 2015). Because the fields of action and communication situations are separated in the latter setting, less direct coordination is feasible and necessary, so that perspectives and concepts of the reference disciplines may be reflected to a lesser extent (WHO, 2010).

Furthermore, the results provide evidence that IC is mainly judged as satisfactory when midwives have similar birth and care related concepts and attitudes as physicians (O'Reilly et al., 2017). This is characterized by a more clinically oriented view, preferring clinical births to home births, accepting light forms of IC (information and communication via the maternity passport), and considering collaboration with physicians in private practice. Satisfactory IC may be supported if midwives work primarily in the clinical setting and experience a socialization process similar to that of the medical profession (O'Reilly et al., 2017).

4.3. Research question 3: association of the ICS with further care and IC characteristics

In contrast to existing study results, no or only weak correlations between the IC with the COPSOQ-items (Kristensen et al., 2005) on job satisfaction could be identified (Hansson et al., 2022). It should be regarded that existing studies on midwives' job satisfaction analyze only IC sub-facets [e.g., role conflict (Stahl et al., 2019); lack of appreciation (Weller et al., 2014); recognition (Papoutsis et al., 2014)]. Primarily workload, salary, work-life balance, and autonomy proved to be significantly associated with midwifes' job satisfaction and early career exits (Kirkham et al., 2006; Jarosova et al., 2016; Nedvědová et al., 2017; Hansson et al., 2022). The quality of IC should thus be assumed to be primarily a moderator rather than a central predictor of job satisfaction in midwifery care.

In addition to a good organizational structure and sufficient available resources, experience with IC represents an important determinant of successful IC (Downe et al., 2010). The present results confirm these findings. The higher the frequency of collaboration with other professional groups, the better the overall assessment of IC and EC in all care settings studied ($r = 0.215$ to 0.361). The associations with IC with pediatricians proved to be weaker compared to IC with gynecologists. This is reasonable because of the job-related responsibilities, especially in the obstetric setting (pediatricians are not involved in obstetrics). This is in line with the call to establish IC processes early in the respective training programs of all disciplines involved (e.g., midwives, physicians, nursing) (Stahl and Agricola, 2021).

External framework conditions and professional positions determine which responsibilities for midwifes and physicians exist, and which instance is accountable for them (Auhagen, 2002). In Germany, this is not always clearly defined, especially due to legal regulations. For example, insured women with no risk are allowed to receive services during pregnancy (exception: sonography) from a physician, a midwife, or both (§134a social code V). Furthermore, women without abnormal (pathological) progress are able to choose between a clinical or a non-clinical (home birth, birth center, midwife's office) delivery. Accordingly, some areas of responsibility cannot be clearly assigned to a single professional group. Thus, emerging role conflicts or unclear areas of responsibility represent a central challenge for the implementation of successful IC in German midwifery care (Aquino et al., 2016; Stahl, 2016). The results indicate that IC is rated as satisfactory especially when midwives tend to assign responsibility to physicians in highly midwifery-specific areas of activity related to direct birth care (e.g., information about possible complications during birth, control of infant heart action; Table 2). This is in line with existing evidence, suggesting a need for action to reduce role conflict between midwives and physicians in order to improve existing IC processes (Hansson et al., 2020).

4.4. Limitations

In this study, self-rating data were analyzed, which reduces the validity due to methodological limitations. Subjective judgments may be specifically influenced by response sets (e.g., self-serving bias, social desirability, consistency effects, halo effects due to positive care experiences during birth) (Dufner et al., 2018). Furthermore, the ad-hoc study sample may distort the distribution of relevant midwifery-specific characteristics in health care practice (e.g., skewed urban/rural ratio) (Higgins et al., 2020). Because the present study was designed as a cross-sectional survey to collect retrospective judgments, considerations about possible causal effects have only limited empirical evidence and should be interpreted with caution (Dufner et al., 2018). The accuracy and validity of the judgment depends not only on the competence of the participating midwives and the quality of the IC, but also by the extent of experience that could be acquired in the IC with the other profession (Neyer, 2006). Due to fewer communication needs and opportunities within the multiprofessional collaboration in PPC setting, external judgments may therefore be biased to a greater extent, e.g., by tendency to extreme values or halo-effects (Dufner et al., 2018). To reduce potential individual judgment biases, there is a need for greater aggregation of external judgments of midwives who work predominantly in the PPC setting.

4.5. Research perspectives and conclusion

In general, further validation steps of the ICS-R and EC scale seem necessary. In addition to the data for midwives, the physicians' perspective should be analyzed in an integrated way (Neyer, 2006). Simultaneously analyzing and comparing the perspectives of both professional groups is an essential prerequisite for obtaining a more complete view on everyday care-related IC processes. Assessing the perspective of physicians (gynecology, obstetrics, and pediatrics) is important since they significantly regulate the involvement of others in teamwork and take responsibility with regard to an effective allocation of work resources (O'Reilly et al., 2017). The comparative and integrated consideration of different perspectives of professions involved in care creates the basis for being able to differentiate coordination behavior as well as interaction patterns in the team. This

may help to identify in which environment and in which conditions IC processes can be established appropriately. Particularly, future surveys should examine (i) whether the two-dimensional structure of the assessment instrument is also valid in the physicians' population, and (ii) to what extent the identified setting-specific differences (prenatal, perinatal, postpartum) represent a specific feature of midwifery work or rather a generally valid feature in the interprofessional care of (expectant) mothers. Regarding the construct IC in general, it should be investigated which aspects of the IC construct can be considered generic and overarching and with regard to which aspects adjustments are necessary depending on the investigated collaborating professional dyads. Adopting analysis procedures based on generalizability theory (Brennan, 2001) provides the opportunity to systematically differentiate overlapping information components of assessment data in order to (i) identify their importance for midwives' and physicians' IC assessment and (ii) understand which information components should be considered for an appropriate interpretation of IC assessment data in future surveys (e.g., assessment perspective, setting, item content) (Brennan, 2001).

The present study expands the focus of IC to include a broader network of health professionals in maternal and neonatal health care. Professions contribute different skills and knowledge to care with the goal of providing the best possible patient care and safety (O'Reilly et al., 2017). The findings provide evidence to improve IC. Early experience of IC processes seems useful to (i) increase the frequency of collaboration, (ii) establish similar socialization processes on an early stage, and (iii) avoid potential conflict in the long term due to varying attitudes towards obstetric care and responsibility in consulting (Romijn et al., 2018). Especially in PPC, the development of appreciative communication and internal team cohesion seems to be particularly challenging. The psychometrically tested two-dimensional ICS-R/EC-instrument provides a validated assessment basis to analyze IC practice in the complex everyday care of midwifery and obstetric care from multiple perspectives, to characterize IC processes between midwives and physicians, and to identify challenges (practice gaps). Understanding how physicians and midwives conceive IC and how it is implemented in daily care is a key prerequisite for identifying problems, exploring approaches to optimize IC processes, implementing them in evaluation processes, and examining the overall effects of successful IC on woman-centered care outcomes (O'Reilly et al., 2017).

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors upon request (anja.schulz@ph-freiburg.de), without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Ethics Committee of the German Psychological Society (Ref: MAW 022019). The patients/participants provided their written informed consent to participate in this study.

Author contributions

AAS and MAW planned and conducted the data collection, analyzed and interpreted the data set using confirmatory factor analysis, and were primarily involved in all steps of the study and in editing the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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EDITED BY
Juliane E. Kämmer,
University of Bern, Switzerland

REVIEWED BY
Keri L. Heitner,
Saybrook University, United States

*CORRESPONDENCE
Mathias Kauff
✉ mathias.kauff@medicalschool-hamburg.de

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Teaching interprofessional collaboration among future healthcare professionals

Mathias Kauff[1]*, Thorsten Bührmann[1], Friederike Gölz[1], Liane Simon[1], Georg Lüers[1], Simone van Kampen[1], Olaf Kraus de Camargo[2], Stefanus Snyman[3] and Britta Wulfhorst[1]

[1]Medical School Hamburg, Hamburg, Germany, [2]CanChild Centre for Childhood Disability Research, McMaster University, Hamilton, ON, Canada, [3]Centre for Community Technologies, Nelson Mandela University, Gqeberha, South Africa

Healthcare has become more complex in recent years. Such complexity can best be addressed by interprofessional teams. We argue that to ensure successful communication and cooperation in interprofessional teams, it is important to establish interprofessional education in health-related study programs. More precisely, we argue that students in health-related programs need to develop interprofessional competencies and a common language, experience interprofessional contact, build inclusive identities and establish beliefs in the benefit of interprofessional diversity. We give examples how these goals can be implemented in interprofessional education. We also discuss challenges and future avenues for respective research healthcare professionals.

KEYWORDS

interprofessional education, interprofessional competencies, healthcare professionals, medical education, intergroup contact, social identity

1. Introduction

Effective communication and cooperation among healthcare professionals (HCPs) is a requirement for modern and well-functioning health services (World Health Organization, 2010). We argue that interprofessional education of future HCPs can pave the way for successful interprofessional collaboration in healthcare practice.[1] Interprofessional education (IPE) is characterized by "occasions when members or students of two or more professions learn about, with and from each other, to improve collaboration, and the quality of care and services" (Centre for the Advancement of Interprofessional Education (CAIPE), 2019).

In this article, we focus on preconditions that need to be addressed in the education of HCPs. We believe that IPE should be theory-driven and evidence-based (Michalec and Lamb, 2020). We, hence, attend to theories that call for basic measures. Building on those, we then

1 We define interprofessional collaboration as a co-operation that is characterized by interdependence, shared responsibilities within a team with common goals, joint commitment, and mutual respect (World Health Organization, 2010; Khalili et al., 2019). basic preconditions for interprofessional collaboration that needs to be addressed in health-care education.

broadly introduce practical examples of IPE. Finally, we summarize our position and discuss future challenges.[2]

2. Basic preconditions for interprofessional collaboration

In this section, we discuss basic conditions that relate to future HPEs' openness for and ability to cope with interprofessional collaboration. We focus on broad measures that should be considered in study programs and that mainly build on social-psychological theories.

2.1. Interprofessional competencies and a common language

One obvious measure to prepare students to collaborate in interprofessional teams is fostering individual competencies relevant for managing interprofessional intergroup contexts (Frenk et al., 2022). Many scholars have identified core competencies for interprofessional practice (Thistlethwaite et al., 2014). A detailed discussion of these competencies is beyond the scope of this article. Nevertheless, we stress that besides broad and subject-specific competencies it is important to include competencies such as interprofessional values and ethics, handling of professional roles and responsibilities, interprofessional communication, abilities to work in a team and conflict behavior (World Health Organization, 2013; Claus and Wiese, 2019).

Furthermore, a prerequisite for successful cooperation among HCPs from different disciplines is the use of a common language. IPE needs to help students to develop such a language. One model that helps to prevent misunderstandings caused by unsystematic use of terms and concepts is the biopsychosocial model and the categories of the International Classification of Functioning, Disability and Health (World Health Organization, 2001; Kraus de Camargo et al., 2019; Ronen et al., 2020). This classification serves as cross-disciplinary framework and helps to describe in a standardized way an individuals' functioning – and the impact of contextual factors on functioning – from a biopsychosocial perspective (World Health Organization, 2001).

2.2. Overcoming stereotypes through intergroup contact

Besides the evident fostering of interprofessional competencies and a common language, there are more basic challenges that need to be addressed. One important aspect of IPE in this regard is to provide future health professionals with opportunities to learn from each other and to overcome stereotypes.

Michalec et al. (2013) surveyed 638 students from six different health professions. The results revealed that stereotypes about the different professions varied and that perceptions of the own profession were more positive than perceptions of other professions. Moreover, Lewitt et al. (2010) showed that stereotypes between medical doctors and biomedical scientists are prevalent among undergraduate students. Likewise, Hean et al. (2006) demonstrated that students from different health and social care disciplines hold stereotypical beliefs about other health and social care professions (Cook and Stoecker, 2014). Regarding the content of the stereotypes, Hean et al. study revealed that, for example, medical doctors and midwives were perceived as more competent than podiatrists and social workers, while physiotherapists and nurses were ascribed higher practical skills than occupational therapists, doctors, audiologists, pharmacists and social workers. Focusing on the content of stereotypes in the German healthcare system, Kämmer and Ewers (2022) revealed that experienced therapists (i.e., physical, occupational or speech and language), as well as midwives and nurses perceived doctors higher on academic abilities than their own group. They also perceived doctors less practical, with poorer interpersonal and teamwork skills. Needless to say, that negative stereotypes about and devaluation of other professional groups can impair communication and collaboration in interprofessional teams (World Health Organization, 2010; Ateah et al., 2011; Darmayani et al., 2020). Hence, it is of crucial importance to overcome stereotyping and devaluation.

Intergroup contact, that is encounters with members of other social groups (outgroups), has been shown to be among the most effective measures to reduce devaluation (Allport, 1954; Pettigrew and Tropp, 2011). Getting to know outgroup members reduces anxiety, increases perspective taking and enhances knowledge about the outgroup while overcoming negative stereotypes and prejudice (Pettigrew and Tropp, 2008). Therefore, it is imperative to provide students with opportunities for intergroup contact with students from other professions, enabling mutual learning and invalidation of negative attitudes (Hean and Dickinson, 2005; Carpenter and Dickinson, 2016). In fact, a plethora of studies shows that intergroup contact between students of different health professions can increase favorable attitudes towards other professions (Carpenter, 1995; Rudd et al., 2016; Mette and Hänze, 2020). White et al. (2019), for example, demonstrated that public health education students held more positive attitudes about the academic skills of nursing students after completion of a semester-long IPE program than students in a control group that did not complete this program.

Some aspects need to be considered when using contact to reduce stereotypes and prejudice between different professions. First, intergroup contact has been shown to be especially effective when groups share similar status, work co-operatively on a task and have common goals in the contact situation (Pettigrew and Tropp, 2006). Therefore, interactions between students of different health professions should be designed to enable interprofessional collaboration, leading to the accomplishment of shared goals. Given the status-differences between different professions, as well as the strict hierarchy in many healthcare systems (Ewers and Schaeffer, 2019), it is of special importance to create interprofessional encounters in which members of different groups meet each other on eye-level.

Second, intergroup contact is also more effective when supported by persons with authority (Pettigrew and Tropp, 2006). Accordingly, educators and other individuals responsible for study programs

2 We would like to direct the readers' attention to the fact that the present article itself is a result of an interprofessional collaboration. The contributing authors' scholarly background encompasses a variety of disciplines such as pedagogics, medicine, psychology, arts, and social work.

should emphasize that intergroup contact between different professions is an important part of their agenda.

Third, support by authorities could also help dealing with a recently identified shortcoming in the intergroup contact literature. Until lately, researchers have overlooked that contact opportunities are not necessarily exploited and that some individuals actively avoid contact with members of other groups (Al Ramiah et al., 2015; McKeown and Dixon, 2017). IPE could implement programs that purposefully bring students from different professions together. Another option, however, would be to build on an individual's contact motives and clarify that participation in programs fostering contact have a benefit for students: Students should be made aware that contact with other professional groups can satisfy their self-expansion motives, willingness to gain knowledge and aim to advance their own professional career (Paolini et al., 2016; Stürmer and Benbow, 2018).

2.3. Building an inclusive social identity

Intergroup contact does not only enable mutual learning and the facilitation of favorable perceptions of outgroup members, it can also help to build a shared social identity between members of different social groups (Pettigrew and Tropp, 2011). Social identity theory (Tajfel and Turner, 1979) claims that individuals' membership in social groups are an important part of their self-concept. Belonging to social groups provides individuals with a social identity (for a recent discussion of the role of professional identities, see Greco et al., 2022). Moreover, the theory posits that individuals are motivated to achieve and maintain a positive social identity. Accordingly, groups to which individuals belong (ingroups) are evaluated more positively than outgroups. Given that the positivity of one's social identity is always dependent on the superiority of ingroups over outgroups, it is not surprising that HCPs and students in health-related study programs tend to favor their professional group over others.

One way to overcome biases in the evaluation of the in- vs. the outgroup is to change the understanding of the structural relationship between groups. For example, by establishing a new group that includes former in- and outgroup members (Gaertner et al., 1989). Brown and Hewstone (2005) propose that animosity between groups can best be reduced by creating a joint superordinate group that includes the in- as well as outgroups. In the context of IPE that can be done by building work groups (or courses) that include various subgroups of students from different professions. In the context of these groups, students' social identity is shaped by their identification with their profession's group as well as the interprofessional work group (Michalec et al., 2021). On a more abstract level, universities can also be a common superordinate group. Universities should convey that they not only equip students to work in their respective healthcare professions, but that they constitute an overarching "health professions family" that is committed to educate health-professionals-in-general. Students should, hence, not only be regarded as students of psychology, medicine, nursing, or social work but – in addition – as (future) HCPs (Khalili et al., 2013; Joynes, 2018).

However, a hierarchical structure in which different professions are nested in a joint superordinate profession, may also lead to a devaluation of certain professions. This may be due to a lack of prototypicality of these groups for the superordinate group (Mummendey and Wenzel, 1999; Reese et al., 2016). When two groups are part of a superordinate group, it may be the case that members of one group perceive their ingroup but not the outgroup as prototypical for the overarching group. This may lead to a devaluation of the outgroup (Wenzel et al., 2007). It could, for example, be that medical students believe that they are part of a larger group that also includes nursing students. However, the medical students perceive themselves as more prototypical for the larger group "health experts" and, consequently, devalue nursing students (for a similar effect among primary-school teachers vs. high-school teachers, see Waldzus et al., 2004). One antidote for this process can be found in the characterization of the superordinate group. Waldzus et al. (2003) showed that a definition of the superordinate as diverse can reduce perceptions of higher relative and decrease devaluation of subordinate outgroups. Hence, it is not only important to introduce a superordinate group as outlined above, but to also establish a self-image within this group which is determined by the group's diversity. Universities should enable students to identify with a larger encompassing "health-professions-in-general" group at the respective institution. In addition, universities need to construct this larger group in a way that it is defined by its diversity. Accordingly, interprofessionalism should be an important part of a university's mission statement.

2.4. Believing in diversity

"Diversity refers to differences between individuals on any attribute that may lead to the perception that another person is different from self" (Van Knippenberg et al., 2004, p. 1008), Individuals' professional background constitutes one dimension of diversity. A plethora of research tackled the question whether diverse groups outperform homogenous groups when it comes to group functioning and productivity (Meyer, 2017). We now know that the relationship between diversity and outcomes of workgroups is dependent on a number of moderating variables (Van Knippenberg et al., 2004) – among them diversity-beliefs (van Knippenberg and Haslam, 2003; Homan et al., 2019). Diversity beliefs can be defined as "beliefs individuals hold about how group composition affects group functioning, i.e., whether individuals perceive diversity as beneficial, detrimental or neutral for the group functioning" (van Dick et al., 2008, p. 1467). Studies have demonstrated that within diverse groups it is crucial that group members hold pro-diversity beliefs (i.e., beliefs that diversity is an asset to the group). Van Dick et al. (2008), for example, showed that members holding pro-diversity beliefs were more strongly identified with diverse groups than those that held a critical stance on diversity. Furthermore, Homan et al. (2008) demonstrated that diverse groups were more productive than homogenous groups when group members held beliefs in the instrumentality of diversity (for an overview, see Leslie and Flynn, 2022).

To summarize, diverse groups (among them groups that consist of members with different educational/professional backgrounds) can outperform homogenous groups when members believe in the benefit of diversity for group functioning. Accordingly, health professions educators should not only stress the existence of diversity as a value of a superordinate group, but emphasize that diversity makes the group more productive and better placed to solve complex health problems. As a consequence, identification with, information elaboration within and performance of the group should increase. In the context of IPE, the benfit of diversity can be stressed by the application of the biopsychosocial model, which implies that illness and health are the

result of an interaction between biological, psychological and social factors (World Health Organization, 2001). Health-related issues can best be addressed by practitioners from different professions collaborating interprofessionally.

Pro-diversity beliefs can also be used to reduce prejudice and mutual discrimination (Kauff et al., 2021). Conflict between professions often results from different forms of intergroup threat (Stephan et al., 2016). Nursing students, for example, might feel threatened by medical students because they fear that medical students are allocated more resources. Students of social work might feel threatened by the idea that psychology students are perceived as more competent in counseling work in clinical settings. Kauff and Wagner (2012) could show that pro-diversity beliefs can reduce such perceptions of threat and, consequently, reduce conflict between groups.

3. Teaching interprofessionalism in action

Successful implementation of IPE requires measures on various levels, such as institutional commitment, social interactions between students and the integration of IPE in all health professions curricula, including a uniform way of assessing interprofessional competencies (AIPHE, 2014). As example, we will elaborate on problem-based learning (PBL) as general approach to foster interprofessional competencies. We also provide a short overview of a concrete example of an interprofessional module.

3.1. Problem-based learning

From an action-theoretical perspective, the acquisition of interprofessional competencies cannot be taught directly. However, learning environments and opportunities can promote the acquisition of such competencies. PBL meets these criteria and is often used in the context of IPE (Aldriwesh et al., 2022). PBL can be conceived as a higher-level learning approach (Servant-Miklos, 2020) characterized by consistent case orientation and interactive group-learning. PBL build on clearly defined procedures and division of roles (Barrows, 1996; Moust et al., 2005). PBL can be combined with interprofessional learning in a low-threshold way, either as a curriculum-integrated format or in a cross-curricular event format.

We have experience with the latter format. Once a semester, students from up to eight different study programs are invited to work for one day on complex case examples in interprofessional groups. The cases focus on patient problems (e.g., a neglected child with multiple diagnoses, fails at school), group topics (e.g., dealing with shame in an interprofessional team), or institutional concerns (e.g., designing a dementia-sensitive hospital). The students are accompanied by trained tutors and present their interprofessional solutions in short presentations to a large plenum.

PBL fosters interaction between members of different professions. This interaction includes an expression of views from different health professions during the negotiation of phenomena and problems, the joint construction of knowledge, fostering a common identity and individuals' the metacognitive act as well as group reflection. It has been shown that PBL interventions promote communication-related competencies and improve mutual attitudes of members of different professions (Goelen et al., 2006; Dahlgreen, 2009; Lin et al., 2013; Braßler and Dettmers, 2016).

3.2. Module "digital health"

We also implemented an interprofessional elective module in which students are faced with real problems from healthcare practice that often require digital solutions (e.g., a smartphone application for health behavior). Students are brought together to collaborate interprofessionally face-to-face. The interaction is supported by an interprofessional team of lecturers. The enrolment in the module presents a benefit for the students as it deals with a timely and relevant topic that are not encountered in other courses. Ideally, students become aware of differences between professions and how collaboration can lead to better person-centered solutions. They also learn that solution-oriented interprofessional project work can be transferred directly into practice. This module fosters interprofessional contact between students, helping them to build an overarching superordinate identity that embraces diversity. Moreover, students experience the benefit of interprofessional diversity.

4. Discussion

Challenges within health care systems have drastically changed over the last decades as patient care became more complex (Frenk et al., 2022). Likewise, the distribution of tasks between HCPs has changed (Hahn, 2011). To ensure successful communication and cooperation in health teams, future HCPs need to be prepared for interprofessional collaborative practice. In this article, we argue that IPE in health professions education needs to (a) convey interprofessional competencies and a common language, (b) provide opportunities for intergroup contact, (c) develop a common identity and (d) facilitate beliefs in the benefit of diversity. This can be achieved through problem-based learning and in modules that bring together students from different professions to collaborate on relevant societal issues.

From our own experience, we know that implementing IPE can be difficult (Helms and Held, 2020). Often students are caught up in their profession's identity, in professional tribalism and in established hierarchies between professions. Moreover, guidelines for examinations, strict regulations for study courses and a lack of resources make it difficult to implement IPE (Ghebrehiwet et al., 2016; Tong et al., 2016; Busari et al., 2017; Hämel and Vössing, 2017; Findyartini et al., 2019). Frenk et al. (2022) discuss new challenges regarding the implementation of IPE in more detail (see also Wetzlmair et al., 2021; for examples of implementation of IPE during the pandemic, see Alrasheed et al., 2021; Engelmann et al., 2021). Many of these are direct consequences of the COVID-19 pandemic. For example, face-to-face learning in classrooms has declined, which complicates collaborative learning even more. At the same time, the pandemic increased demand for complex health services and, consequently, interprofessional collaboration.

Studies investigating the effectiveness of IPE address different outcomes related to performance (Langlois, 2016; Champagne-Langabeer et al., 2019; Au, 2022). Future work needs to address how we can best evaluate the success of IPE (Kahaleh et al., 2015; Anderson et al., 2016). Robust evidence how IPE contributes to successful cooperation and communication and how it reflects on the

aforementioned broader prerequisites is scarce. We trust this article helps to stimulate respective work.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Author contributions

MK wrote the first draft of the manuscript. SK and BW wrote sections of the manuscript. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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EDITED BY
Margarete Boos,
University of Göttingen, Germany

REVIEWED BY
Eleonora Orena,
IRCCS Carlo Besta Neurological Institute Foundation, Italy
Keri L. Heitner,
Saybrook University, United States
Tayana Soukup,
King's College London, United Kingdom

*CORRESPONDENCE
Kerrin Elisabeth Weiss
✉ weisske@ethz.ch

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Measuring teamwork for training in healthcare using eye tracking and pose estimation

Kerrin Elisabeth Weiss[1]*, Michaela Kolbe[2], Quentin Lohmeyer[1] and Mirko Meboldt[1]

[1]Product Development Group Zurich, ETH Zurich, Zurich, Switzerland, [2]Simulation Center, University Hospital Zurich, Zurich, Switzerland

Teamwork is critical for safe patient care. Healthcare teams typically train teamwork in simulated clinical situations, which require the ability to measure teamwork via behavior observation. However, the required observations are prone to human biases and include significant cognitive load even for trained instructors. In this observational study we explored how eye tracking and pose estimation as two minimal invasive video-based technologies may measure teamwork during simulation-based teamwork training in healthcare. Mobile eye tracking, measuring where participants look, and multi-person pose estimation, measuring 3D human body and joint position, were used to record 64 third-year medical students who completed a simulated handover case in teams of four. On one hand, we processed the recorded data into the eye contact metric, based on eye tracking and relevant for situational awareness and communication patterns. On the other hand, the distance to patient metric was processed, based on multi-person pose estimation and relevant for team positioning and coordination. After successful data recording, we successfully processed the raw videos to specific teamwork metrics. The average eye contact time was 6.46s [min 0s – max 28.01s], while the average distance to the patient resulted in 1.01m [min 0.32m – max 1.6m]. Both metrics varied significantly between teams and simulated roles of participants ($p<0.001$). With the objective, continuous, and reliable metrics we created visualizations illustrating the teams' interactions. Future research is necessary to generalize our findings and how they may complement existing methods, support instructors, and contribute to the quality of teamwork training in healthcare.

KEYWORDS

teamwork, training, eye tracking, pose estimation, simulation, feedback, technology, behavior measurement

1. Introduction

Teamwork is critical for safe patient care. Professionals from different "tribes" must team up — oftentimes on the spot — and work together to achieve excellent patient care (Rosen et al., 2018). Poor teamwork is a considerable risk for patient safety; great teamwork is an enormous asset, particularly for highly specialized care and precision medicine (Pronovost, 2013). Teaming up across professions, specialties, and across the authority gradient does not come naturally (Edmondson, 2012). Healthcare providers, universities, and training institutions include teamwork and the ability to collaborate in any healthcare team in their learning objectives. In particular, simulation-based teamwork training allows both students and professionals to

practice and reflect on teamwork skills in meaningful settings without putting patients at risk (Weaver et al., 2014; Hughes et al., 2016). To be effective, training should be guided, and teamwork performance should be measured (Salas et al., 2009). Without measuring teamwork, feedback and debriefing conversations—and ultimately learning—will be limited (Rosen et al., 2008; Rudolph et al., 2008; Fey et al., 2022). However, identifying relevant teamwork behaviors and tracking them in complex, dynamic, and fast-paced simulated clinical situations is challenging (Halgas et al., 2022). Observing and measuring teamwork in action is prone to bias and constitutes a significant cognitive load even for trained instructors (Caverni et al., 1990; Greig et al., 2014; Uher and Visalberghi, 2016; Fraser et al., 2018). Additionally, simulation educators vary in individual expertise, and feedback might differ between them (Shrivastava et al., 2010; Bosse et al., 2015). We aim to support educators by contributing to the sophisticated collection of dynamic teamwork data (Petrosoniak et al., 2019; Marcelino et al., 2020; Shuffler et al., 2020; Wiltshire et al., 2020; Abegglen et al., 2022).

The choice of how to measure teamwork impacts the possibilities of further data use. For example, while using behavioral anchored rating scales (BARS) is relatively easy, it rarely provides enough variance in the acquired data and only limited information on temporal matters (Kolbe et al., 2013; Dietz et al., 2014; Brauner et al., 2018). On the other hand, timed, event-based behavior coding of teamwork behavior provides more information on the time and duration of behaviors but is complex and time-consuming (Brauner et al., 2018). Although event-based behavior coding allows for reliably capturing many explicit and verbal teamwork behavior (e.g., giving instructions or providing information on request) and allows for capturing more implicit teamwork behavior as well (e.g., team member monitoring), it usually suffers low interrater reliability (Kolbe et al., 2013; Uher and Visalberghi, 2016; Brauner et al., 2018). Low-quality data on team performance impair correct conclusions about team processes and performance, enhance the risk of negative learning, and limit training capacities (Salas et al., 2009).

We propose that using technology to objectively, continuously, and reliably measure teamwork dynamics will improve the quality of teamwork performance data in simulation-based training in healthcare. Technology-based measurement is a promising and fast-developing field of team science that can offer many opportunities for quantitative, scalable, objective, repeatable, new ways of recording data and resulting feedback conversations based on video data (Kozlowski, 2015; Klonek et al., 2019; Kolbe and Boos, 2019; Halgas et al., 2022). Teamwork metrics derived from technology can measure multiple behaviors simultaneously and allow for continuous observation of all team members over the duration of the simulation. They could be especially helpful for observing more implicit behaviors and team interactions that are not detectable via observation by humans (Uher and Visalberghi, 2016). Once established, technology-based metrics are reproducible and could be used for measuring teamwork dynamics during training and research.

Sensor-based measurement and wearable technologies have the ability to capture team dynamics (Rosen et al., 2014; Halgas et al., 2022). For example, Radio-Frequency Identification Devices (RFID) have been successfully used to measure the proximity between team members (Isella et al., 2011) and distance traveled during nursing shifts (Hendrich et al., 2008). In another study heart rate sensors allowed assumptions regarding the physiological synchronization of surgical teams (Dias et al., 2019). In this observational study, we explored the use of video-based technologies for continuously measuring teamwork behavior during simulation-based training in healthcare. We investigated two minimally invasive, video-based technologies: eye tracking and pose estimation.

Mobile eye tracking, an established wearable and minimally invasive technology in the field of healthcare devices and training (Henneman et al., 2017; Weiss et al., 2021), measures what a team member wearing the glasses is looking at (Figure 1A). We used eye tracking and its resulting data to precisely calculate the occurrence and length of eye contact between team members. Eye contact occurs naturally in conversation and is especially relevant during listening communication patterns (Ruth, 1992; Bohannon et al., 2013). Therefore, we considered eye contact a valuable metric for teamwork (Vertegaal et al., 2001; Fasold et al., 2021).

The second video-based technology we investigated was multi-person pose estimation as newer, non-wearable technology (Cao et al., 2021; Weiss et al., 2023). It measures human pose by calculating the exact position of human joints (Figure 1B). Combining two simultaneously recorded video data sets of each team allows for calculating the 3D position of all team members and, thus, their positioning to each other. We calculated each individual's distance to the patient and the team members. The distance to patient influences the healthcare providers' relationship with them (Schnittker, 2004) and is relevant during the workflows of teams (Petrosoniak et al., 2019) and movement coordination (Alderisio et al., 2017). Distance and movement may allow educators to make assumptions regarding the quality of team coordination (Petrosoniak et al., 2019; Marcelino et al., 2020; Shuffler et al., 2020; Tolg and Lorenz, 2020; Wiltshire et al., 2020), therefore being a relevant measure for teamwork. In summary, the ability to precisely measure and visualize eye contact and team member pose over time is highly relevant for simulation-based training providers. It allows an automated and dynamic capturing of visual attention, eye contact, team member positioning, and distance. Being aware of our own and team's attention and positioning enables learning.

This study aims to explore the use of mobile eye tracking and multi-person pose estimation to continuously collect data and measure teamwork during simulation-based training in healthcare. This is an essential step that will enable further studies validating eye tracking and multi-person pose estimation metrics. These technology-based metrics intend to complement existing methods of teamwork assessment, support simulation faculty, improve the quality of simulation-based training and build examples for new methods of measuring teamwork based on technology.

2. Methods

2.1. Study design

We conducted this observational study during a week-long, simulation-based training in March 2022 with a convenience sample.

Abbreviations: A, Simulated Anesthesia Resident; IC, Simulated Intensive Care Resident; ICU, Intensive Care Unit; MI, Simulated Medical Intern; P, Patient; AOI, Area of Interest.

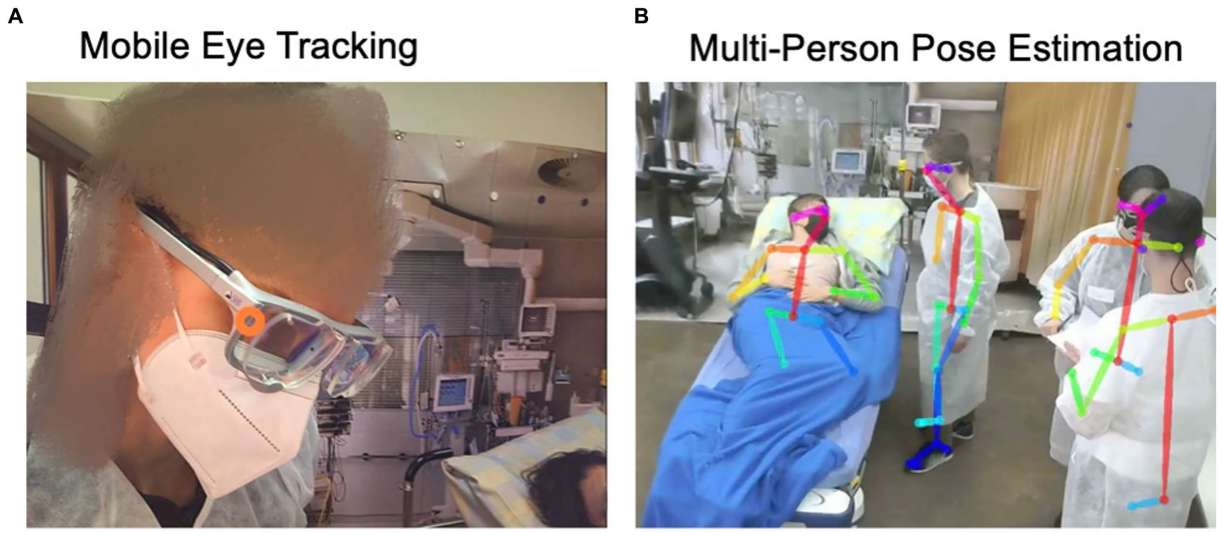

FIGURE 1
Illustration of mobile eye tracking **(A)** and multi-person pose estimation **(B)**.

Third-year medical students of ETH Zurich (Zurich, Switzerland) participated in this training conducted at the simulation center of the University Hospital Zurich (Zurich, Switzerland). The training included eight four-hour simulation exercises on clinical teamwork situations. The overall 88 eligible students rotated in teams of 10–12 students through the course. We conducted this study in one of the eight clinical teamwork simulations, with the topic patient handover. The inclusion criteria were third-year medical students, trackable eyes, and participants' consent. Of the eligible 88 students, 64 actively participated in the simulation scenarios, while the remaining 24 students observed the scenarios and participated in the subsequent debriefings (Figure 2).

2.2. Study ethics

This study was granted exemption from the ethics committee of canton Zurich, Switzerland (BASEC number: Req-2020-00200). No patients were involved, study participation was voluntary, and participants' written informed consent was obtained.

2.3. Simulation-based training and handover case

We used a handover simulation scenario for data collection to explore the applicability of eye tracking and multi-person pose estimation. During patient handover, healthcare providers communicate information and responsibility about patients to ensure their continued, safe care during transfers among units or shift changes (Foster and Manser, 2012). Teamwork is critical during handover (Bogenstätter et al., 2009; Desmedt et al., 2021). The training's learning objectives included the ability to describe pitfalls and risk management strategies such as iSBAR, a communication rubric to standardize team communication during handover (Müller et al., 2018). Two formally trained, experienced simulation educators with a nursing background in intensive care led the handover training. They introduced students to the course, aimed to establish and maintain a psychologically safe learning space, allowed students to familiarize themselves with the particular setting, and oriented them toward the learning objectives (Rudolph et al., 2014; Kolbe et al., 2020). After the introduction, a member of the study team and two master students explained the study goals and recording technologies, invited students to participate, and asked for informed, written consent.

The simulated case included a patient who had undergone trauma surgery after a bicycle accident to be handed over from surgery to the intensive care unit. A room in the simulation center was prepared with a bed and pictures of intensive care unit (ICU) settings. One member of the student team presumed the role of the patient (P) lying in bed. The other three students assumed the roles of anesthesia resident physician (A), intensive care resident (IC), and medical intern (MI). The scenario started with A & IC distancing themselves from P while MI took care of P. The patient was instructed to feel nauseous and in pain, challenging the team members to continue a structured handover. Team members had to take care of the patient while engaging in a structured handover. After the scenario, the two simulation instructors led debriefings based on the Debriefing with Good Judgment approach (Rudolph et al., 2007), which lasted approximately 45 min.

2.4. Data recording

For mobile eye tracking, we used three SMI ETG 2 Wireless mobile eye tracking glasses (Figure 3, Senso Motoric Instruments, Teltow, Germany). We calibrated the eye tracking glasses for every participant with a three-point calibration technique. The glasses recorded the eyes of the participants and their point of view, including audio, therefore allowing us to calculate the gaze point. After each use, we disinfected the glasses.

For multi-person pose estimation, we used two Logitech C270 webcams (Logitech, Lausanne, Switzerland) to record videos of the

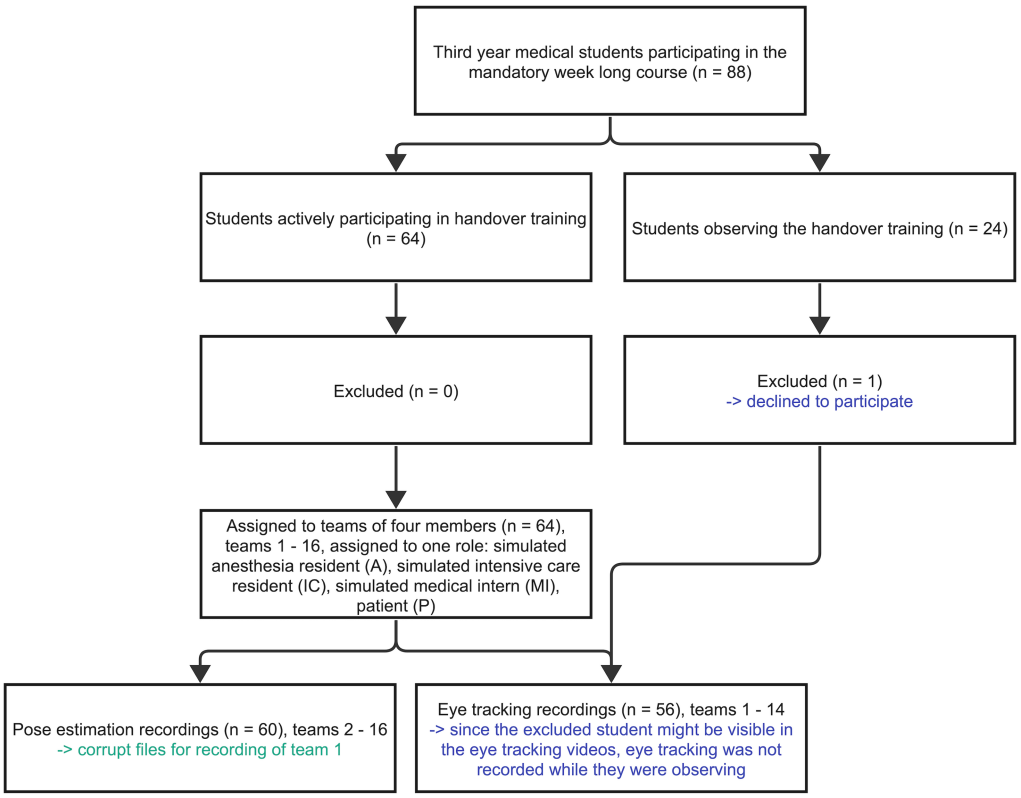

FIGURE 2
Participant's flow diagram visualizes the participants, including their enrollment, consent, distribution, and data sets. The excluded participant is highlighted blue and the corrupt file green.

simulated cases (Figure 3). The cameras were neither invasive nor wearable, therefore not limiting the immersion of the participants or taking time to mount on their bodies. We mounted two pose estimation cameras on the ceiling and calibrated them once using a checkerboard.

2.5. Data processing

We used SMI BeGaze 3.6 (Senso Motoric Instruments, Teltow, Germany) to process the mobile eye tracking data (Figure 3). This software calculated the gaze point, the data of in what millisecond which person is focusing on, in each individual frame. Afterward, we defined the areas of interest (AOIs), relevant and visible objects, people, backgrounds we want to base our analysis on. The AOIs were: face MI, body (excluding the face) MI, face A, body A, face IC, body IC, face P, body P, room, and patient sheet. We manually mapped the gaze point to the AOIs for each frame, for example if the gaze point focused on the patient face we mapped it to the face P AOI. Finally, we exported the mapped AOI data and further processed it using MATLAB (MathWorks, Natick, Massachusetts, USA): we calculated the eye contact time between the team members and visualized using the face AOIs. Additionally, we visualized the complete visual attention of the team members by plotting on which AOI each team member was focusing over time.

We used the open-source software OpenPose (Cao et al., 2021) to process the recorded pose estimation videos (Figure 3). OpenPose allows for detecting 2D human body skeleton points, e.g., chest, shoulder, and hand, for all team members. No body markers were needed, which makes this method completely non-invasive and, despite its limitations, the accuracy of this methodology is sufficiently high to warrant its use. We exported the resulting two 2D pose estimation data sets — one for each camera — and used MATLAB (MathWorks, Natick, Massachusetts, USA) for triangulation, resulting in 3D human body skeletal points. With the 3D representation of the team members and the patient, using their chest points, we calculated the distances between each team member to the patient, as well as the distance between the team members for every frame. Subsequently, we obtained and visualized the average distances. For both technologies, we calculated the statistics (Kruskal-Wallis tests) using SPSS Statistics 28 (IBM, Armonk, New York, USA).

3. Results

3.1. Recorded data and participants

Sixty four students organized in 16 teams of four assumed an active role during the simulated cases of this study. The simulated roles were anesthesia resident physician (A), intensive care resident (IC), medical intern (MI), and patient (P). The student's demographics are shown in Table 1. Since one student observing teams 15 and 16 chose not to participate in the study, no eye tracking was recorded since the particular student might have been visible. Therefore, we collected eye tracking data from 14 teams (teams 1–14), with three mobile eye

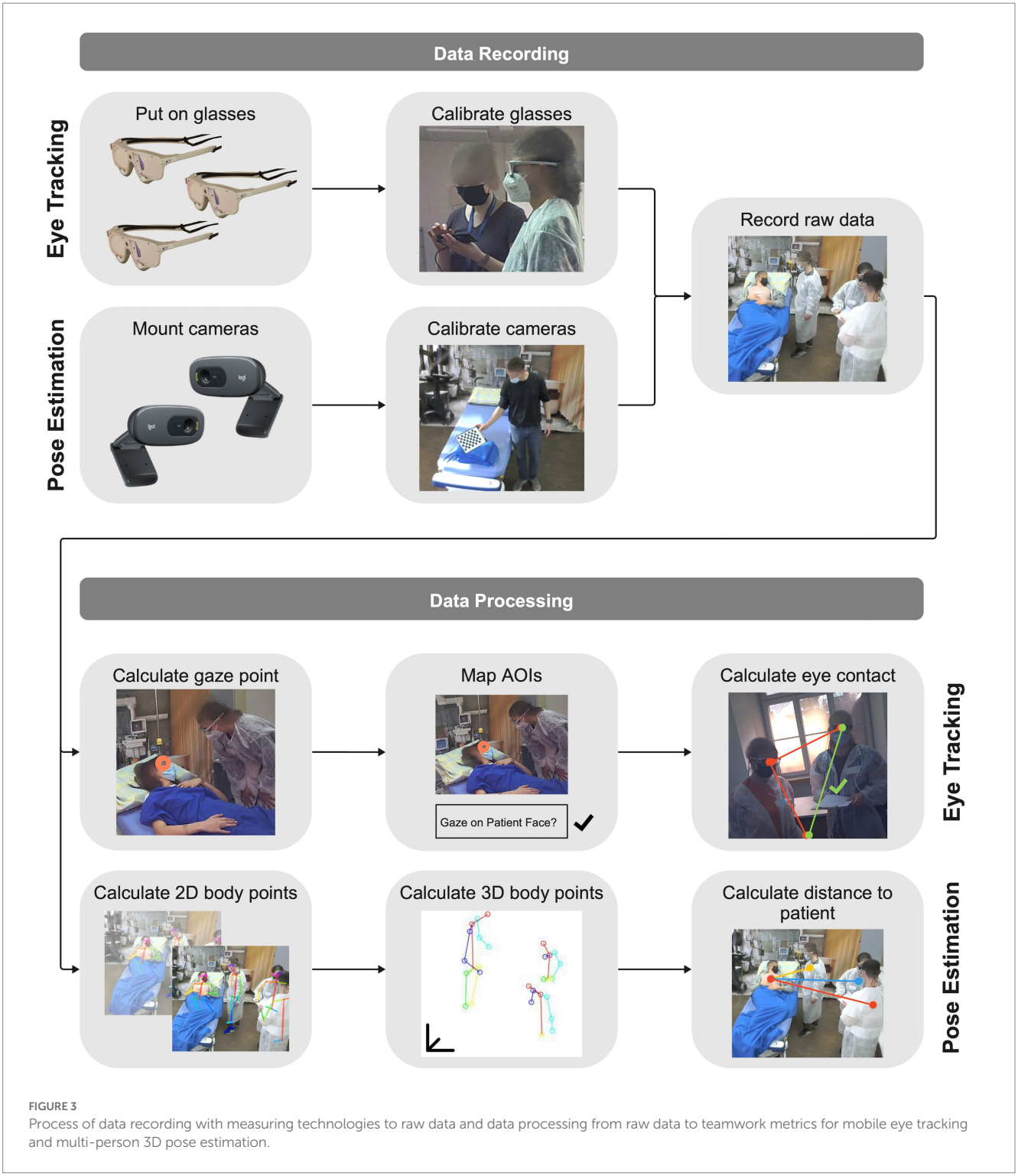

FIGURE 3
Process of data recording with measuring technologies to raw data and data processing from raw data to teamwork metrics for mobile eye tracking and multi-person 3D pose estimation.

tracking glasses per team resulting in 42 eye tracking data sets. Since the pose estimation cameras were fixed and only recorded the team itself, we did not have to exclude the videos of teams 15 and 16. Thus, we recorded all 16 teams with pose estimation. The data set of team 1 was not usable, resulting in overall usable 15 pose estimation team data sets, which allowed us to calculate 60 individual human pose estimation data sets (see Figure 2). The average simulation case length was 6.72 min [min 4.08 min – max 9.57 min], with a combined length of all cases resulting in 107.57 min.

3.2. Eye tracking—eye contact

The measured eye contact times, i.e., when team members looked each other in the eye, for all teams and their members are visible in Table 2; Figure 4. The average eye contact times for all teams were 14 s for A & IC, 3.38 s for A & MI, and 1.99 s for IC & MI ($H(2) = 19.029$, $p < 0.001$) with an average eye contact time of 6.46 s for all teams and roles. Eye contact times varied extensively between teams.

TABLE 1 Participant characteristics (n=64), including average age in years (± SD), the female and male sex ratio in percent, and the percent of participants having completed their obligatory nursing internship.

Participant characteristics	
Age (years)	22.45 ± 1.85
Female sex (%)	57.81
Male sex (%)	42.19
Nursing internship completed (%)	65.63

TABLE 2 Eye contact in seconds for all teams, including the average of all teams, between the different team members depending on their roles (A, Simulated Anesthesia Resident; IC, Simulated Intensive Care Resident; MI, Simulated Medical Intern), high eye contact times (over 20s) are highlighted bold while low eye contact times (below 2s) are highlighted *cursive*.

Eye contact between team members [s]			
Team number	Team member roles		
	A & IC	A & MI	IC & MI
Team 1	**27.94**	4.88	*0.02*
Team 2	16.21	*1.15*	5.47
Team 3	11.38	2.71	*1.44*
Team 4	**28.01**	*0.00*	*0.00*
Team 5	2.36	3.93	*0.00*
Team 6	4.82	7.24	*1.29*
Team 7	13.45	*0.23*	*0.00*
Team 8	14.09	*1.89*	*0.00*
Team 9	**25.50**	7.39	12.74
Team 10	9.62	*1.75*	*0.00*
Team 11	11.29	*1.87*	6.97
Team 12	**20.26**	*0.38*	*0.00*
Team 13	5.23	5.29	*0.00*
Team 14	5.92	8.69	*0.00*
Average of all teams	14.00	3.38	*1.99*

An additional measure based on the eye tracking data, is the visualization of all team member's gaze points over the whole time of the simulation. On which AOI each team member focuses on during the simulation is visualized for two example teams in Figure 5.

3.3. Multi-person pose estimation—distance to patient

The calculated distance to the patient from team members A, IC, and MI is visualized in Figure 6 over the time of the simulated case. The average values for each team are presented in Table 3. The average distance over all teams results in 1.15 m for A, 1.11 m for IC, and 0.78 m for MI ($H(2) = 16.642$, value of $p < 0.001$), with an average distance of 1.01 m to the patient for all teams and roles. The average distance between team members based on calculated 3D pose estimation data is visualized for two teams as an example in Figure 7.

4. Discussion

This study explored the use of video-based, minimally invasive technologies to collect data to measure teamwork in simulation-based training in healthcare. We found that both technologies reliably recorded and analyzed data, only one pose estimation data set was unusable. In what follows, we discuss the feasibility, contribution, and limitations of this study.

4.1. Feasibility of data collection and processing

Mobile eye tracking allowed for precise measurement of visual attention while being minimally invasive. Some participants reported casually and by themselves that they had forgotten that they were wearing the glasses while removing the mobile eye tracking glasses. However, completely non-invasive eye tracking would be beneficial. Although remote eye tracking is common, it currently cannot be used for moving participants (Ferhat and Vilariño, 2016). Handling the mobile eye tracking glasses was time-intensive during the recording since the glasses needed to be calibrated for every team member. However, the collected data yielded valuable, complex details on teamwork. We were able to track three team members simultaneously while not losing a single data set. During data processing, we had to manually map the AOIs, which was time-consuming. Automation of this processing step is being developed (Wolf et al., 2018).

The recording of multi-person pose estimation was more effortless. The one-time calibration for all recordings took little time. The method was entirely non-invasive, neither distracting participants nor hindering their immersion in the simulation. Unfortunately, one data set was unusable. We assume that the video files were corrupted during the process of being saved to the hard drive. During data processing, having multiple participants in the same camera frame was challenging. If occlusions occurred, no data could be extracted about a person if their body was not visible. We manually checked the indexes of the team members to ensure that the algorithm did not mix up the team members. A promising solution to this problem might be using depth cameras or more webcams to record data from multiple points of view.

4.2. Contribution of results for measuring teamwork in healthcare

The teamwork metrics that were calculated and visualized in this paper show the applicability of eye tracking and pose estimation to measure teamwork. Both mobile eye tracking and multi-person pose estimation allowed for collecting numerous, continuous data. The challenge—as with any technology-driven teamwork measure—is to identify parameters that matter and serve to discriminate among teams (Klonek et al., 2019). In our view, using both eye tracking and pose estimation allowed not only for precisely measuring and visualizing eye contact (Figure 4) and distance among patient and team members (Figure 6). It also allowed for discrimination between teams: eye contact among team members and distance to patient (and among team members) varied extensively from team to team. For example, all members of Team 9 had eye contact among each other numerous times (Figure 4). In contrast, members of Team 5, only A

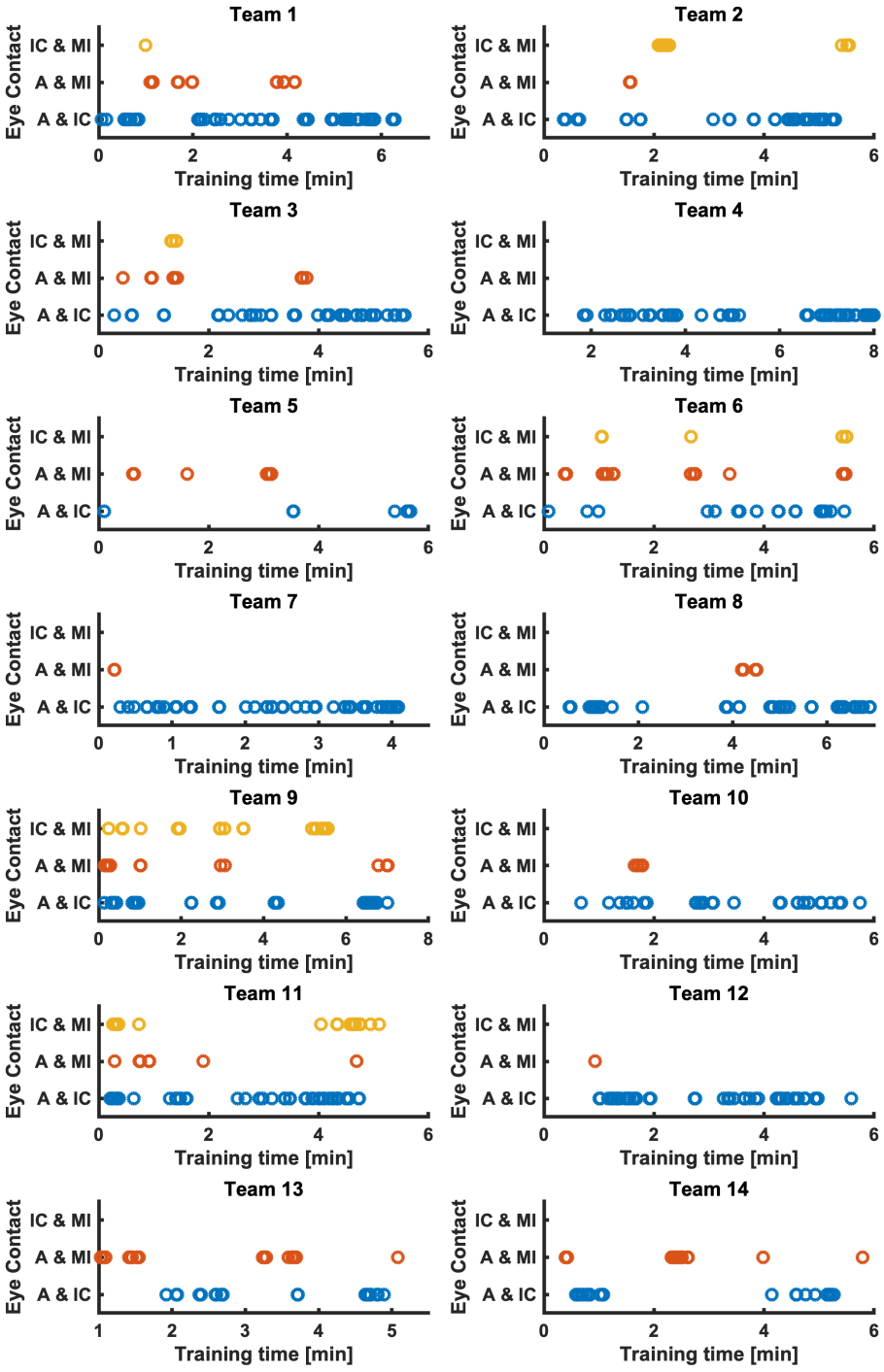

FIGURE 4
Eye contact between A & IC (blue), A & MI (red), and IC & MI (yellow) of all teams over training time in minutes. A, Simulated Anesthesia Resident; IC, Simulated Intensive Care Resident; MI, Simulated Medical Intern.

made eye contact with MI and IC a few times, while MI and IC had no eye contact at all. In Team 4, A and IC had exclusively much eye contact among each other, while A and MI and IC and MI did not look at each other (Figure 4). The visualization of every team member's visual attention during the whole scenario duration (Figure 5) might be very interesting to investigate teamwork.

Regarding distance to patient, all members of Team 15 and 16 had little distance to the patient and slight variance in the distance over time (Figure 6). In contrast, members of Team 13 heavily varied their distance to the patient among each other and over time (Figure 6). That is, both metrics indicate sensitivity to differences in team processes. Neither eye contact nor pose tracking are possible with the naked eye. Yet, for teamwork in healthcare, certain interaction patterns may make all the difference for patient care (Kolbe et al., 2014; Su et al., 2017; Schmutz et al., 2019). The ability to precisely measure and visualize eye contact and team member pose over time is highly relevant for

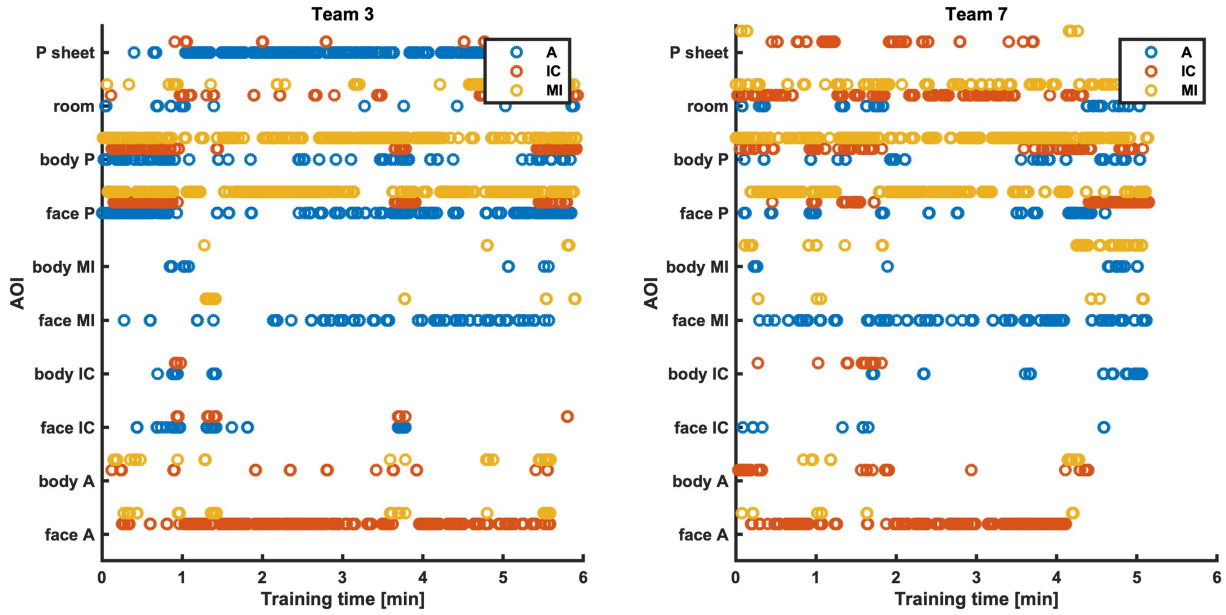

FIGURE 5
AOIs the team members (A blue, IC red, MI yellow) focused on during the training time, for example teams 3 and 7. A, Simulated Anesthesia Resident; IC, Simulated Intensive Care Resident; MI, Simulated Medical Intern.

simulation-based training providers: it allows for more automated and dynamic capturing of visual attention, eye contact, team member positioning, and distance. Simulation educators can access this data and use it for discussing matches and mismatches in desired team performance during debriefing. For example, visual attention and eye contact data can serve discussions of situation awareness, power, and speaking up (Dovidio and Ellyson, 1982). Distance measures may provide essential details in discussing team coordination and task management. For example, in our simulated handover case, A and IC were instructed to distance themselves from P and MI to discuss the patient information, while MI should stay close to P to take care of them. If metrics depending on the teams' position and movement are developed and validated, pose estimation allows continuous measuring of them, allowing for testing hypotheses and performance matches.

These technology-based metrics may complement behavior observation without replacing traditional methods. Medical competence assessment, especially of teamwork, needs both analytic and holistic approaches (Rotthoff et al., 2021), and mobile eye tracking and multi-person pose estimation allow to draw analytical conclusions in a more complex setting than before. An example of combining multiple methods could include self-reports of participants, supporting reflective practice (Liaw et al., 2012), technology-based metrics providing analytical observations for specific behaviors, and expert assessors observing the general behavior based on their extensive knowledge. The vision of using technology to measure teamwork is a static and fully automated recording set-up based in a simulation center. With this set-up new teamwork metrics can be easily co-created and validated with experts and subsequently used to support training. When experts find a new competence metric based on visual attention or body position, we can analyze it with our recorded data set if the participant's consent allows it. The practical applications today are to provide educators with visualizations of existing metrics after the simulated case to use during debriefing. For example, learners may watch their parts of the recorded simulation, including the metrics, which may increase learning (Farooq et al., 2017; Gordon et al., 2017). Recording expert teams performing challenging teamwork tasks may be used in teamwork training to set masterly learning goals and provide specific guidance during rapid cycle deliberate practice (Barsuk et al., 2016; Salvetti et al., 2019; Ng et al., 2021). Our study focuses on teams of three simulated healthcare professionals and one patient to not rely solely on research with dyads to conclude the use of wearable technology in team contexts (Kazi et al., 2021; Halgas et al., 2022). Although the metrics are developed and visualized for a handover scenario, they can easily be transferred to other training scenarios.

4.3. Limitations and further research needs

Our study has limitations. First, although eye tracking and multi-person pose estimation showed promising opportunities and relevance, they require more validation research. In particular, indicators for criterion validity were not included in our study and are highly needed. That is, we cannot conclude if teams with a certain degree of eye contact or distance to patient performed better or worse. This is important, though, and should be studied with experienced healthcare teams rather than with a student sample.

Second, although the AOIs provided a rich set of dynamic details, their information density is high: they provided details about what each team member is looking at and how that changes over time (Figure 5). This level of detail and complexity might be too overwhelming to support simulation educators during debriefings. Simpler indices and/or visualizations will be needed to enhance the applicability of results. However, researchers might find it interesting to discover teamwork patterns in visual behavior. For example, seeing patients enhances the learning (Larsen et al., 2013), which can be measured by focusing on the two patient-related AOIs.

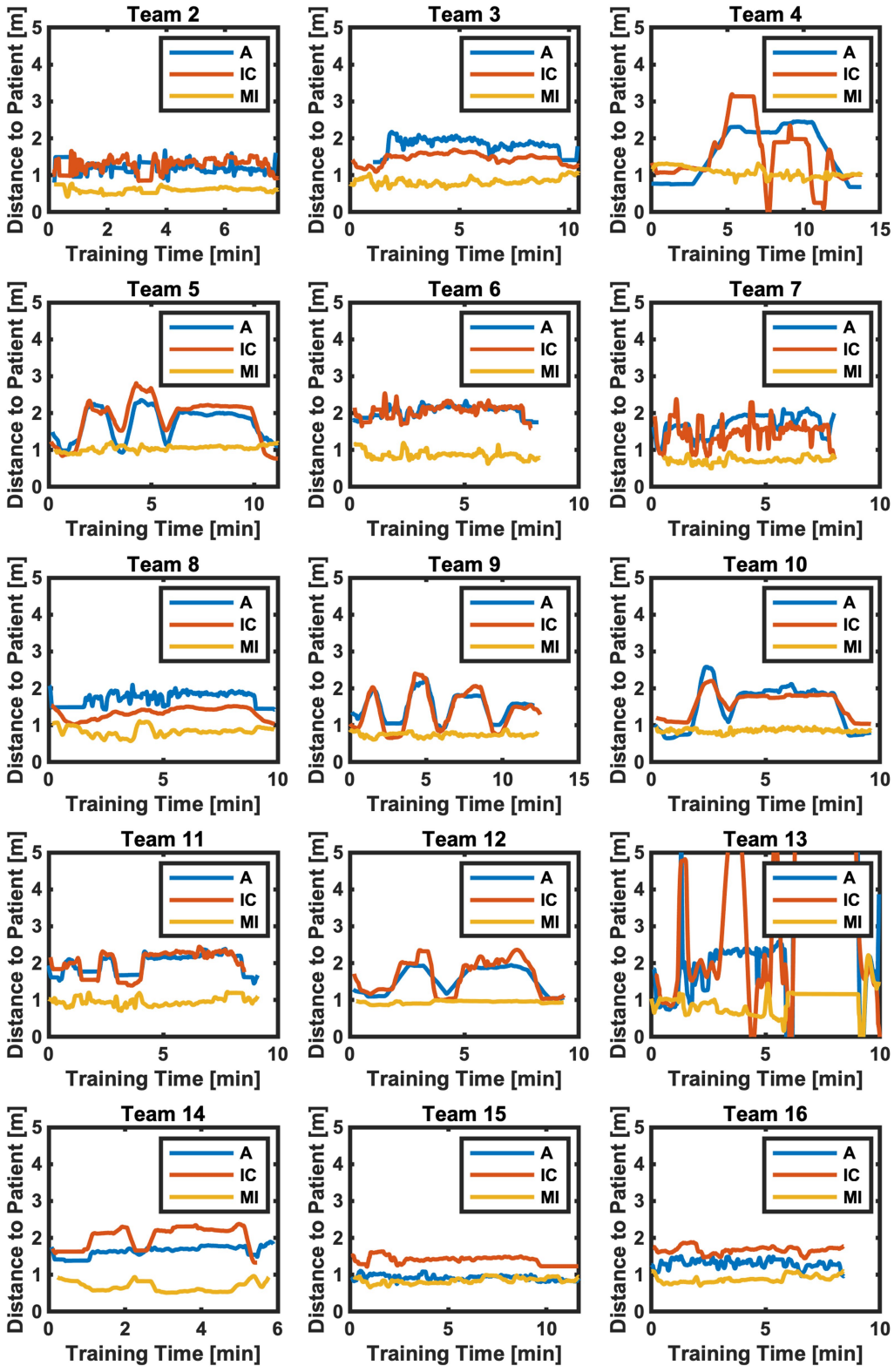

FIGURE 6
Distance to patient for all teams and team members (A blue, IC red, MI yellow) over the training time. A, Simulated Anesthesia Resident; IC, Simulated Intensive Care Resident; MI, Simulated Medical Intern.

Third, the pose estimation teamwork metric of the team's distance to the patient and between the team members may have been influenced by the COVID-19 situation. During data collection in March 2022 people were required to observe the social distance (Jarvis et al., 2020).

Fourth, the process of calculating the first metric for both measures was complicated and time intensive. Fortunately, every iteration and further metric was faster because the data processing framework was already established. Therefore, processing newly

recorded data using existing metrics or developing new metrics and analyzing existing data takes lower effort and is faster. Additionally, the recorded and calculated data sets can be analyzed using other methods even years later, such as behavior coding or emerging machine learning techniques.

Fifth, we only studied one particular simulated case; the resulting metrics reflect only the interaction during simulated handover. Sixth, future studies may include the investigation of simulation educators' cognitive load and overall training quality when using technology-based teamwork metrics (Fraser et al., 2018). Furthermore, the degree of acceptance of the methodologies by the participants may be quantified in future studies.

Finally, conducting this study required an interdisciplinary research team consisting of mechanical engineers and a team of healthcare simulation scientists. Currently, for using technology-based metrics to measure teamwork, interdisciplinary skills are essential: Technical knowledge is needed to program metrics and automate the process, while healthcare and teamwork knowledge is required to define relevant behaviors and metrics. However, once the technology is set up for data collection and the metrics are implemented, they will reduce the cognitive load of researchers and educators because complex team dynamics can be feasibly assessed during simulation-based teamwork training.

TABLE 3 Distance to patient in meters for all teams and team members, including the average of all teams (A, Simulated Anesthesia Resident; IC, Simulated Intensive Care Resident; MI, Simulated Medical Intern), high distances to patient (over 1.5m) are highlighted bold while low distances (below 0.5m) are highlighted *cursive*.

Distance to Patient [m]			
Team number	Team member		
	A	IC	MI
Team 2	*0.44*	0.94	*0.43*
Team 3	**1.53**	1.35	0.72
Team 4	1.04	0.52	1.07
Team 5	**1.53**	1.15	1.01
Team 6	**1.56**	**1.56**	0.78
Team 7	1.05	0.65	0.71
Team 8	1.16	1.23	0.78
Team 9	1.16	1.14	0.75
Team 10	0.68	1.34	0.86
Team 11	1.28	1.31	0.89
Team 12	**1.53**	0.65	0.93
Team 13	0.84	*0.32*	*0.42*
Team 14	**1.53**	**1.55**	0.70
Team 15	0.84	1.32	0.81
Team 16	1.11	**1.60**	0.85
Average all teams	1.15	1.11	0.78

5. Conclusion

In this study, two minimally invasive video-based technologies, mobile eye tracking and multi-person pose estimation, were integrated into simulation-based healthcare training to measure teamwork. Both allowed the recording of objective, continuous, and reliable data that could be processed to multiple teamwork metrics. Future research in necessary to generalize our findings and how they may complement existing methods, support instructors, and contribute to the quality of teamwork training in healthcare.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Ethics Committee of Canton Zurich, Switzerland.

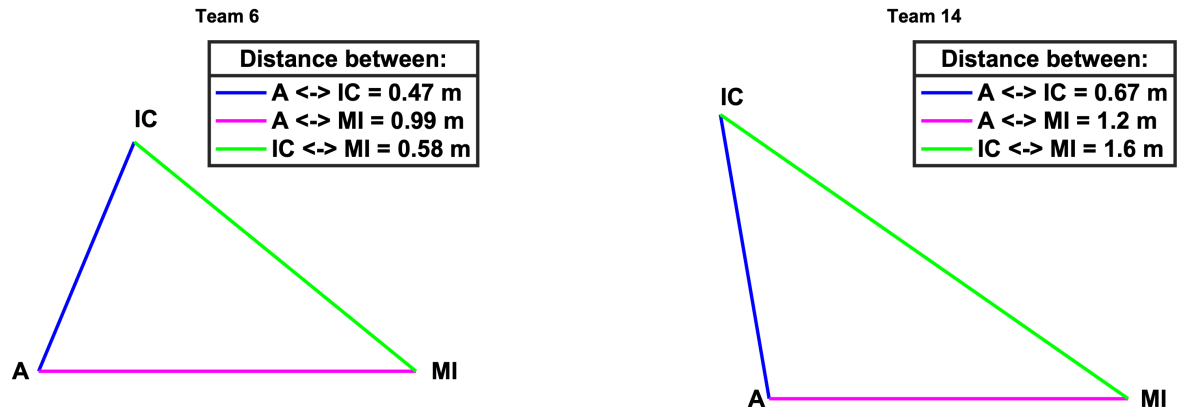

FIGURE 7
Average distance between team members (A & IC blue, A & MI magenta, IC & MI green) for example teams 6 and 14. A, Simulated Anesthesia Resident; IC, Simulated Intensive Care Resident; MI, Simulated Medical Intern.

The patients/participants provided their written informed consent to participate in this study.

Author contributions

KW collected and analyzed the data and wrote the first draft of the manuscript. MK wrote sections of the manuscript. All authors contributed to the conception and design of the study, manuscript revision, read, and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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EDITED BY
Juliane E. Kämmer,
University of Bern, Switzerland

REVIEWED BY
Shannon Leah Marlow,
The University of Texas at San Antonio, United States
Mona Weiss,
Freie Universität Berlin, Germany

*CORRESPONDENCE
Carol-anne Moulton
✉ carol-anne.moulton@uhn.ca

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Contextualizing the tone of the operating room in practice: drawing on the literature to connect the dots

Hillary Lia[1,2,3], Melanie Hammond Mobilio[1,4], Frank Rudzicz[2,3,5,6] and Carol-anne Moulton[1,2,7]*

[1]The Wilson Centre, Toronto General Hospital, University Health Network, Toronto, ON, Canada, [2]Temerty Faculty of Medicine, Institute of Medical Science, University of Toronto, Toronto, ON, Canada, [3]Vector Institute for Artificial Intelligence, Toronto, ON, Canada, [4]Temerty Faculty of Medicine, Institute of Health Policy, Management and Evaluation, University of Toronto, Toronto, ON, Canada, [5]Department of Computer Science, University of Toronto, Toronto, ON, Canada, [6]Faculty of Computer Science, Dalhousie University, Halifax, NS, Canada, [7]Division of General Surgery, University Health Network, Toronto, ON, Canada

The study of teamwork in the operating room has made significant strides in uncovering key constructs which shape safe and effective intraoperative care. However, in recent years, there have been calls to understand teamwork in the operating room more fully by embracing the complexity of the intraoperative environment. We propose the construct of tone as a useful lens through which to understand intraoperative teamwork. In this article, we review the literature on culture, shared mental models, and psychological safety, linking each to the construct of tone. By identifying tone as a theoretical orientation to demonstrate the overlap between these concepts, we aim to provide a starting point for new ways to understand intraoperative team dynamics.

KEYWORDS

operating room teamwork, interprofessional teams, emotions as social information (EASI) theory, surgical team performance, operating room tone

1. Introduction

The tone of the operating room is an under-studied construct that may shape team dynamics to affect team performance and patient safety. The concept of operating room tone was first identified in a 1986 Perspectives piece in the Canadian Medical Association Journal where Leighton (1986), an anesthetist, described the tone of the operating room as an atmosphere which ranges from tranquil to tense. The nature of tone was argued to be shaped by the degree of civility and collegiality of the interactions between team members, in particular the surgeon and the anesthetist. Leighton (1986) proposed that basic respect and courtesy in the operating room can shape a positive tone and improve teamwork, describing sharing the anesthetic plan with the surgeon as "the first step in setting the tone in the operating room, which is so important for the success of the surgery, not to mention the pleasure of those participating in it" (p. 444). Although a perspective piece rooted in anecdotal experience rather than data, Leighton (1986) work provided the language to identify a construct that was arguably experienced by many but that was—and remains to an extent—unarticulated academically. Since 1986, the tone of the operating room has emerged as a relevant finding in several studies examining factors shaping team dynamics,

coordination, and leadership (Leach et al., 2011; Nurok et al., 2011; Stone et al., 2017), indicating that the tone may be an important facet of operating room team dynamics. However, the concept of tone itself has not been the subject of study.

1.1. Tone as a peripheral finding

Tone-setting behaviors have been associated with perceived leader effectiveness (Stone et al., 2017), teaching effectiveness (Hauge et al., 2001), and psychological safety (Weller et al., 2018). In a 2017 study, Stone et al. (2017) coded leadership behaviors based on their developed taxonomy and examined the association between the frequency and valence of those behaviors and ratings of perceived leadership effectiveness. Surgeons who enacted positive tone-setting behaviors (i.e., constructive humor, compliments, and reassurance) more often than negative tone-setting behaviors were perceived by other operating room staff members as more effective leaders. Hauge et al. (2001) similarly developed a coding scheme to categorize teaching behaviors. Tone-setting was one of four categories of key teaching behaviors and included both positive and negative behaviors. While this study did not connect to learning outcomes, based on observations, the study suggests that the tone set by the attending surgeon facilitated an environment for learning. Further, in a study of the effective use of the Surgical Safety Checklist, authors reported that senior members in the operating room set the tone for how the checklist is used which can either promote or deter from a sense of psychological safety (Weller et al., 2018). When senior members demonstrated commitment to using the checklist, other team members described increased engagement. Dependent on how the tone is set staff members may be more or less willing to speak up with questions and patient concerns during the administration of the Checklist. The perceived ability, or inability, to speak up during the Checklist may persist throughout the case. The above studies illustrate how leadership behaviors can set the tone for team performance. Since tone is rooted in team interaction, we may, in future, benefit from drawing upon studies of leader communication to inform tone in the operating room. For example, the use of inclusive language by the leader to increase team member voice (Weiss et al., 2018). However, while the above studies described tone-setting behaviors and linked tone to leadership, teaching, and psychological safety, each lacked a clear definition of tone, an explanation of how tone emerges and the mechanism by which it shapes team factors. If we are to understand the effect of tone and begin to draw from the extant literature, we require a deepened understanding of this phenomenon.

While their study did not interrogate the concept of tone specifically, Leach et al. (2011) described tone and its effect in their study of factors associated with professional role affecting teamwork in the operating room. The authors found that the operating room has an enacted environment, the tone, that changes in response to team interactions and events of the operation. The attending surgeon was primarily responsible for setting the tone though other team members, notably the circulating nurse prior to surgeon entry to the operating room, had a role in shaping the tone of the operating room. The study revealed that some teams made a deliberate effort to create a calm tone to maintain control, specifically in response to complication. Dependent on the tone of the operating room, the teams' ability to adapt and exhibit coordination changed, particularly in response to stressful and unexpected events. Though the tone was not the focus of this study, its identification within the results provides insight into this team construct which we can build upon.

Based on the existing literature, the tone of the operating room may influence how teams dynamically come together and fall apart throughout an operation. However, all studies reviewed lack a clear definition of tone and understanding of how it emerges and shapes teamwork in the naturalistic operating room environment. In this review, we integrate the findings in the literature to define the tone as a dynamic construct which describes the affective atmosphere among team members, rooted in shared understanding of procedural requirements and team norms.

1.2. Tone as an emergent state

We conceptualize tone as a team emergent state. Team emergent states (TES) are constructs that describe team properties or characteristics in a dynamic fashion. TES emerge from team context and processes through interactions among team members resulting in phenomena or effects that are greater than the sum of its parts (Cronin et al., 2011; Waller et al., 2016). Fundamental to TES, lower-level interactions and phenomena converge and, in some cases, there is mutual causality, where the lower-level interactions and constructs that the TES emerged from are then influenced by the TES (Waller et al., 2016). Emergent phenomena have four properties: they are *global*, emerging from lower- or micro-level components, *coherent*, enduring over time, *ostensive*, they are experienced and recognized by team members, and of *radical novelty*, as their features cannot be fully reduced into lower-level components (Waller et al., 2016). TES as a framing allows for the interrogation of complex phenomena that are rooted in social interaction.

We propose that tone is a TES, emerging from team interaction, enduring over time with changes based on interaction, highly influenced by context, experienced by team members in the work environment and irreducible into its lower-level counterparts. Thus far, the tone of the operating room has not been studied formally as an emergent state. We propose that this framing will aid researchers in understanding and formalizing the construct of tone by providing a language for the way in which tone can be seen as a complex interaction of context factors and constructs, rooted in team interactions.

Using the lens of TES, we formalize the construct of tone in this review, demonstrating how known team constructs inform the study of tone while they themselves are influenced by the tone. To do so, we use Emotions as Social Information (EASI) theory as lens for understanding the team interactions that lead to tone emergence. Using this framework, we review three team constructs that influence and are influenced by tone: culture, shared mental model, and psychological safety. We use EASI to demonstrate how team constructs can influence how social interactions are perceived and enacted leading to tone emergence. Though there are many constructs that may inform and be informed by tone, the EASI framework allows us to focus our analysis on the mutually causal relationship between tone, culture, shared mental models, and psychological safety.

2. Tone and Emotions as Social Information (EASI) theory

Emotions as Social Information (EASI) theory is a framework which describes and predicts how outward emotional expressions are processed and understood to affect behavior at the interpersonal level (Van Kleef, 2009). EASI has been used to understand interpersonal interaction in a variety of contexts (Homan et al., 2016; Wang et al., 2018; van Kleef et al., 2019). The premise of EASI theory is that emotional expressions provide information to the observer which can influence subsequent behaviors, attitudes, and cognitions. The processing of information is moderated by contextual factors that affect affective reactions and inferential processes which ultimately lead to the response of the observer.

We have previously augmented the EASI framework with contextual factors in the operating room to propose a mechanism through which we can understand tone emergence (Lia et al., 2022). Using the framework of EASI we demonstrated how key team constructs (shared mental model, culture, and psychological safety) shape how interpersonal behaviors are processed and understood to affect subsequent behavior. We argued that by studying tone through this theoretical framework, we may begin to more precisely understand what the tone is, how it is emerges and what effect is might have on teams (Lia et al., 2022). In our previous work, we suggested that the study of tone may demonstrate how EASI as an individual-level framework may be extended to understand the group. Here, we will expand our work by exploring in depth the three related constructs that have been identified within the EASI framework as critical to team performance (culture, shared mental models, and psychological safety) and their relationship to tone. While there exist many team constructs which may be related to tone, we select this subset of three constructs to demonstrate how tone is situated in the broader context and how it can be studied in relation to the existing literature.

We use the EASI framework to understand how team interactions are influenced, processed and understood in the operative environment to produce tone. Our understanding is facilitated by the incorporation of known team constructs, culture, shared mental model, and psychological safety. First, we study culture and its' relationship to tone. According to EASI, team interactions are processed and understood by the observer to produce an output behavior, cognition and/or attitude. Culture shapes the perceived acceptability and meaning of social interaction (Hofstede et al., 2010), thus we propose that culture is essential to understanding team interactions and the manner in which they are processed to shape team interactions, and, ultimately, tone. Next, we examine shared mental model and its relationship to tone. The essence of EASI is that emotional displays convey information about the task or social expectations (McComb and Simpson, 2014), suggesting that the shared understanding of the situation, or shared mental model, is upheld by interpersonal interaction. We study shared mental model with tone to understand how these constructs are inter-related and how they may emerge through interpersonal interaction. Finally, we review psychological safety and how this construct is shaped by and shapes the tone. As described, the EASI framework conveys information about social expectations and team norms. Thus, the degree of psychological safety experienced, or perceived ability to speak up, share ideas and ask questions (Edmondson and Lei, 2014), may be modified by emotional expressions of team members. In this review, we explore how tone may influence and be influenced by the degree of psychological safety experienced.

The purpose of this review is to situate the construct of tone in the literature by outlining the mutual causality between tone and other key team constructs to integrate the literature on teams. We will expand our work by exploring in depth the three related constructs that have been identified within the EASI framework as critical to team performance (culture, shared mental models, and psychological safety) and their relationship to tone to demonstrate how the literature informs tone and how the study of tone contributes to the literature. Finally, we suggest that a fulsome understanding of tone can in fact connect individual team constructs to contribute an integrated understanding of team dynamics in the operating room.

3. Culture

Culture captures the shared patterns of thinking, feeling, and acting in societies, organizations, and groups (Hofstede et al., 2010). Culture can be described using six dimensions: power distance, uncertainty avoidance, individualism vs. collectivism, masculinity vs. femininity, long term orientation, and indulgence vs. restraint (Hofstede et al., 2010). In work groups, culture is an important social force that shapes group membership and provides a framework for individuals to understand social interactions and group expectations (Hofstede et al., 2010). In the workplace, culture includes routines and norms that guide appropriate or expected behavior (Hemmelgarn et al., 2006). These six dimensions may be examined within the operating room context to understand how covert values and norms shape team interaction and, ultimately, the tone. We propose that the Hofstede model may be used in future empirical study to characterize the unique operating room culture and provide contextual information that explains the tone.

The current literature on operating room culture describes a unique environment shaped by hierarchy (high power distance), rigid expectations for adherence to standards and guidelines of practice (high levels of uncertainty avoidance), and the high stakes, interdisciplinary nature of surgery. In the operating room, an emphasis on knowledge and competence defines culture and social structures (Gillespie et al., 2008). The surgeon is viewed at the top of hierarchy, followed by anesthetists, then nursing staff and other professions; however, the social order may shift depending on the expertise required in the context of the situation at hand (Gillespie et al., 2008). Moreover, there exist hierarchies within the non-surgical professions where individuals who demonstrate specialized knowledge are rewarded with opportunities to participate in more challenging operations and, over time, build relationships with surgeons (Gillespie et al., 2008). These relationships have the potential to push certain staff members up the hierarchy as their expertise and knowledge extends to predicting surgeon needs in various scenarios. This increased knowledge is further valued as it facilitates smooth and efficient conduct of the operating room. An understanding of how demonstrated knowledge and competence define culture to shape the social order and team interaction may contextualize the interactions which set the tone: how meaning is

made in social interaction, whose social behavior exhibits the most influence, and why key members are influential in shaping the tone.

We may use the Hofstede et al. (2010) dimensions of culture to formally integrate the described literature as a means of understanding the norms and values of operating rooms in general, as well as in specific institutions. This deepened understanding of culture in the operating room can provide a lens through which we understand how team members interact and, emerging from their interaction, the tone. Culture and tone similarly underpin the unwritten rules governing social conduct in the operating room, however, they are distinct in their dynamicity. Culture is long-standing and generally resistant to change (Hofstede et al., 2010) while tone changes from moment to moment in the operating room. We propose that as culture governs generally accepted behaviors and ways of being, the culture may shape the range of tones which are set in the operating room and may help us understand how and why tones change, how behaviors change the tone and how the tone changes subsequent behaviors.

While we may better understand the tone using the lens of culture, developing an in-depth understanding of tone may in fact contribute to the literature on culture. The tone, being dynamic and distinct though shaped by culture, may be described as the *enactment* of culture. We may better understand how culture is navigated in real time by understanding social interaction in the operating room using the dynamic lens of tone. While culture is typically measured using cross-sectional surveys or qualitative methods, the lens of tone may provide a tool to better understand those results in the real environment.

4. Shared mental model

Shared mental models are knowledge structures among team members that represent a shared understanding of the task, expectations for the task and explanations for events and behaviors related to the task (Cannon-Bowers et al., 1993). Shared mental models allow for coordination among team members as they work toward their goal (Cannon-Bowers et al., 1993). The perceived leader of the team has a critical role in the development of a shared mental model and it has been suggested that training team leaders' skills for fostering shared mental model could strengthen team performance (Cannon-Bowers et al., 1993).

A concept analysis of shared mental models in healthcare collaboration by McComb and Simpson (2014) describes the defining attributes, antecedents and consequences of shared mental models in healthcare teams. For shared mental model to emerge, two or more individuals must be working on a shared task, there must be communication among these individuals, and the individuals must possess knowledge of the context, including roles of each member, relevant protocols, and task requirements. Shared mental models have four defining attributes: content, similarity, accuracy, and dynamics (McComb and Simpson, 2014). The content of a shared mental model has two domains: the teamwork domain represents an understanding of who the team members are, their capabilities, team expectations and norms while the taskwork domain represents an understanding of the shared goal, progress toward the goal, understanding of next steps and potential for error and complication. The similarity attribute represents the degree to which the mental model aligns among the individuals of the team while the accuracy attribute describes the degree to which the shared mental model reflects the reality of the situation at hand. Finally, the dynamics attribute describes the response of the team to changes in the team environment requiring updates to existing mental models. When an effective shared mental model is in place, it can increase motivation, facilitate task-related processes and improve performance. However, mental models may not align among team members, often related to poor communication, and can undermine team processes and performance (McComb and Simpson, 2014; Wilson, 2019; Gjeraa et al., 2022).

The tone of the operating room may be understood using shared mental model as a construct. For instance, McComb's framing of shared mental model includes team expectations and team norms under the teamwork domain. A "tense" tone in the operating room may indicate that social chatter is not accepted at that moment whereas it may be invited when other tones are present. Moreover, the taskwork domain of shared mental model includes a shared understanding of progress toward a shared goal. A sudden switch to a more focused tone may indicate that an unexpected obstacle or challenge has occurred and may prompt team members without a view of the operative field to seek information about what has occurred and initiate procedures to support the surgical sub-team. We may better understand and contextualize tone by honing in on the shared mental model to understand how the events of the case shape what tone is set. Moreover, we may examine instances where mental models among team members are in fact mismatched and observe how this phenomenon shapes the tone in the operating room. By drawing upon McComb's framing of shared mental model, we may begin to understand tone in greater context. The tone may bridge the procedural aspects of the case to the affective and social components of work in teams.

Additionally, the tone of the operating room may contribute to the literature on shared mental model. The dynamic nature of the tone may provide a window with which we can understand how shared mental models are maintained and how teams negotiate deviations in shared mental model. The tone may shift in response to events of the operation and may prompt team members to update their mental model. For instance, if the attending surgeon suddenly engages in external behavior that changes the tone, other staff may infer that there was a change in procedural requirements and begin to seek information to update their shared mental model. By understanding how tone shifts with events of the operation, we may understand how individual team members interact, gather information, and initiate work processes to support collective efforts.

5. Psychological safety

Psychological safety is a construct that describes the perceived consequence of an individual taking interpersonal risks in a given context (Edmondson and Lei, 2014). This is typically studied in terms of sharing ideas, speaking up, asking questions, and learning. Psychological safety has been studied in a variety of organizations across industries and has been found to be a key factor for facilitating team coordination and performance (Edmondson and Lei, 2014). In the healthcare setting, the degree of psychological safety experienced at work can affect job performance, job satisfaction and rates of turnover (Grailey et al., 2021).

In the healthcare environment, teams are influenced by pre-existing hierarchies which can prevent the sharing of knowledge and open communication from team members occupying lower positions in the hierarchical structure (Nembhard and Edmondson, 2006). Low psychological safety among these team members can be responsible for medical error, reduce opportunities for team learning, and negatively impact patient safety (Nembhard and Edmondson, 2006). Team leaders have a crucial role in facilitating a sense of psychological safety (Nembhard and Edmondson, 2006; Edmondson and Lei, 2014; Grailey et al., 2021). Leaders who are perceived as more inclusive moderate the relationship between lower status and psychological safety by creating an environment conducive and receptive to speaking up behaviors (Nembhard and Edmondson, 2006). Grailey et al. (2021) suggest that leaders in the healthcare context can learn to understand situations which lead to sense of low psychological safety and modify their own behavior to facilitate speaking up behaviors and invite open discussion.

We may understand tone emergence and changes in the operating room by examining psychological safety in the operating room. We may understand why particular tones arise in certain environments and not in others based on the psychological safety experienced in those environments. We may additionally better understand how team members interact, navigating power structures in their work environment, to affect the tone. By incorporating psychological safety into the study of tone, we may better understand how and why some voices are heard and others are not.

As with culture and shared mental model, the dynamic nature of tone can inform the study of psychological safety. While psychological safety is typically studied as a dynamic construct using cross-sectional surveys, Amy Edmondson, who coined the term, calls for the study of psychological safety as a dynamic construct, emphasizing that the construct evolves over time (Edmondson and Lei, 2014). The tone of the operating room changes over time, perhaps in response to the psychological safety and perhaps affecting psychological safety. We propose that the study of tone may answer calls to understand the dynamic nature of psychological safety using tone as a lens.

6. Discussion

In this review, we demonstrate how key team factors can be used to understand tone: what it is, how it may be interpreted, and how it influences team performance. Though the tone of the operating room has been discussed in the literature, in-depth exploration of tone itself has not been the focus of research to date. A rich understanding of intraoperative tone as a theoretical construct has the potential to scaffold our understanding of OR culture. By better understanding the moment-to-moment tone of the OR, we may gain greater appreciation for how the underlying construct shapes and is shaped by teamwork in response to unexpected challenges, changes in staffing, and nuances in the relationships between staff members.

We describe how the shared mental model of the operating room may shape and be shaped by tone. Unlike culture, which is persistent and pervasive, tone can change depending on factors such as the phase of the case and situational characteristics. These "moments" of change in tone may afford the opportunity for researchers to glimpse the impact of culture on teamwork in new ways. For example, while tone may shift during a case, the particular ways in which the shift occurs is likely to remain within the boundaries of what is culturally appropriate. A deepened understanding of tone might allow researchers the opportunity to access the intersection of these moments of cultural influence on OR interactions through the use of qualitative methodologies. Better understanding the emergence and impact of tone may also help to provide an orientation for researchers interested in OR culture to ask questions related to Lingard (2016) collective competence, and the limits of individual expertise on teamwork in the operating room.

Similarly, understanding psychological safety as a dynamic construct shaped by tone can contextualize team interaction and outcomes to help researchers better understand this construct and how it can be modified to improve patient safety. For example, although the surgeon has been identified as the leader in the operating room (Gillespie et al., 2008), their voice is rarely heard in discussions around psychological safety. While it is critical to recognize the impact of hierarchy in psychological safety, the cascading impacts of preexisting OR hierarchies (Gillespie et al., 2008) are rarely appreciated in the context of the responsibilities of the surgeon in practice. Tone may help us understand how surgeons, as leaders, actively balance the expectation to provide an environment conducive to psychological safety for team members alongside other responsibilities, such as patient safety and institutional expectations. Given that the tone of the operating room may convey information about who can speak up, when they speak up and what they speak up about, tone may provide a lens with which to understand how psychological safety evolves dynamically in team interaction. The study of tone may respond to calls in the literature to move from the study of psychological safety as a static construct to the study of psychological safety as a dynamic construct to capture nuances such as shifts in time (Edmondson and Lei, 2014).

Team constructs can be integrated with the EASI framework, as demonstrated in our earlier work (Lia et al., 2022), to provide theoretical insight into how interpersonal interactions are understood and shape team behaviors. An augmented EASI framework can provide insight into how individual team constructs interact in the real work environment to shape teamwork. This builds upon the existing literature by providing a means to study teams in a manner that examines the team as whole rather than positioning the team as the sum of its parts. This approach to the study of team constructs additionally contributes to our understanding of team constructs that were previously difficult to capture and conceptualize as dynamic constructs. By studying tone, we draw from key team constructs, inform each construct and connect them to develop an integrated understanding of team performance. We argue that the study of tone can draw together team constructs in the operating room, bringing them from individual facets of understanding toward a holistic interpretation of team performance in the operating room. Tone may be the mortar describing how the "bricks in the wall" of teamwork (i.e., known team constructs) are connected. By connecting these bodies of literature, we propose that tone may be understood and studied in a manner which emphasizes and appreciates the complexity of the operating room environment. The study of tone

in this manner can elucidate the qualities and characteristics of high-quality teamwork so that we may train operating room staff members to maximize productive team interaction and minimize those that deter from safe and efficient intraoperative care.

We propose that to provide this robust understanding of tone, a mixed methods approach is essential. As a first step, a detailed theoretical understanding of tone needs to be developed to define the tone. This framework may be augmented with an exploration of how tone is experienced by staff members in the naturalistic environment to provide greater insight. We may move from theoretical to practical by using a theoretical basis for tone to understand team interactions *in vivo* to study how tone emerges, changes, and is sustained in the workplace. This study may quantitatively explore team interaction and changes in tone, perhaps using the lens of affect. By understanding tone as a phenomenon both theoretically and practically, we might uncover how the collective comes together and falls apart at critical moments (Lingard, 2016). This knowledge may, in future, allow for new facets for team skills training to ensure heightened and sustained safety and efficiency in the operating room; as well as provide important insight into the literature around psychological safety and team affect.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work, and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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EDITED BY
Juliane E. Kämmer,
University of Bern, Switzerland

REVIEWED BY
Jennifer Weller,
The University of Auckland, New Zealand
Keri L. Heitner,
Saybrook University, United States

*CORRESPONDENCE
Shannon Paquette
✉ shanpaqu@gmail.com
Philip E. Greilich
✉ Philip.Greilich@UTSouthwestern.edu

†These authors have contributed equally to this work and share senior authorship

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Handoffs and the challenges to implementing teamwork training in the perioperative environment

Shannon Paquette[1]*, Molly Kilcullen[2], Olivia Hoffman[3], Jessica Hernandez[4], Ankeeta Mehta[5], Eduardo Salas[2†] and Philip E. Greilich[6*†]

[1]Office of Undergraduate Medical Education, UT Southwestern Medical Center, Dallas, TX, United States, [2]Department of Psychological Sciences, Rice University, Houston, TX, United States, [3]Division of Critical Care Medicine, Department of Pediatrics, UT Southwestern Medical Center, Dallas, TX, United States, [4]Department of Emergency Medicine, UT Southwestern Medical Center, Dallas, TX, United States, [5]Department of Surgery, UT Southwestern Medical Center, Dallas, TX, United States, [6]Department of Anesthesiology and Pain Management, Health System Chief Quality Office, Office of Undergraduate Medical Education, UT Southwestern Medical Center, Dallas, TX, United States

Perioperative handoffs are high-risk events for miscommunications and poor care coordination, which cause patient harm. Extensive research and several interventions have sought to overcome the challenges to perioperative handoff quality and safety, but few efforts have focused on teamwork training. Evidence shows that team training decreases surgical morbidity and mortality, and there remains a significant opportunity to implement teamwork training in the perioperative environment. Current perioperative handoff interventions face significant difficulty with adherence which raises concerns about the sustainability of their impact. In this perspective article, we explain why teamwork is critical to safe and reliable perioperative handoffs and discuss implementation challenges to the five core components of teamwork training programs in the perioperative environment. We outline evidence-based best practices imperative for training success and acknowledge the obstacles to implementing those best practices. Explicitly identifying and discussing these obstacles is critical to designing and implementing teamwork training programs fit for the perioperative environment. Teamwork training will equip providers with the foundational teamwork competencies needed to effectively participate in handoffs and utilize handoff interventions. This will improve team effectiveness, adherence to current perioperative handoff interventions, and ultimately, patient safety.

KEYWORDS

teamwork, team training, interprofessional, handoffs, perioperative, healthcare education, implemenation, patient safety

Introduction

Patient handoffs are "real-time processes of passing patient-specific information from one caregiver to another or from one team of caregivers to another for the purpose of ensuring the continuity of the patient's care" (The Joint Commission, 2017). Regulating bodies that oversee medical education recognize the importance of handoffs; the Accreditation Council for Graduate Medical Education (ACGME) outlines requirements for transitions-in-care training during residency, and the Association of American Medical Colleges identifies patient handovers as an

Entrustable Professional Activity that all medical students should be able to perform before residency (Obeso et al., 2017; ACGME, 2020). Hospital and patient safety organizations consider handoffs high-risk events for communication errors, contributing to sentinel events and significant malpractice costs (The Joint Commission, 2017; Humphrey et al., 2022). The perioperative environment is particularly vulnerable: a single operation requires at least two interprofessional handoffs—preoperative and postoperative—and many surgeries also require several intraoperative handoffs (Frasier et al., 2020; Meersch et al., 2022).

Teamwork skills are essential to addressing perioperative handoff quality and safety issues and delivering safe patient care. Evidence shows that teamwork improves patient, staff, and healthcare organizational outcomes (Rosen et al., 2018). Furthermore, meta-analytic evidence indicates that teamwork significantly impacts healthcare team performance (Schmutz et al., 2019). Recent conceptual models have illustrated that teamwork competencies are imperative to handoff effectiveness (Webster et al., 2022), and meta-analytic evidence shows that teamwork training significantly impacts reactions, learning, transfer, and results across healthcare contexts (i.e., organizational and patient outcomes; Hughes et al., 2016). In the perioperative environment, less frequent application of teamwork skills, such as sharing unique information and briefing, has been associated with increased complications and mortality (Segall et al., 2012). Additional meta-analytic evidence indicates that communication tools (e.g., checklists) improve teamwork and reduce mortality and morbidity in surgical contexts (Lyons and Popejoy, 2014). To improve organizational and patient outcomes in the perioperative realm, where teams are dynamic and patients experience frequent interprofessional handoffs during a high-risk, high-acuity, and high-pressure period, providers must demonstrate adaptability and excellence in teamwork competencies (Segall et al., 2012; Webster et al., 2022). Team science experts recommend teamwork training for medical teams to increase their adaptability to non-routine events (Bedwell et al., 2012), and this advice is particularly relevant for dynamic perioperative teams.

This perspective article discusses the importance of teamwork in perioperative handoffs and challenges to implementing teamwork training in this environment. We propose that teamwork training will improve team effectiveness, adherence to perioperative handoff interventions, and, ultimately, patient safety. Our article provides a foundation for improving teamwork training in perioperative contexts by outlining evidence-based best practices imperative for training success, while acknowledging obstacles to implementing those best practices. We assert that explicitly identifying and discussing these obstacles will provide a critical resource for designing and delivering teamwork training programs fit for the perioperative environment.

Importance of teamwork in interprofessional perioperative handoffs

Perioperative handoffs are particularly challenging due to this setting's unique interdependence of interprofessional roles, acuity and complexity of care, handoff frequency, time constraints, and environmental distractions (Etherington et al., 2019; Abraham et al., 2021b; Michael et al., 2021). Previous interventions have improved perioperative handoff quality; however, high-quality studies demonstrating improved patient outcomes are still needed (Lyons and Popejoy, 2014; Abraham et al., 2021c,d; Stenquist et al., 2022). Furthermore, providers have difficulty adhering to perioperative handoff interventions due to time constraints, competing priorities, and the low perceived utility of these tools, which raises concerns about their sustainability (Abraham et al., 2021a; Burden et al., 2021). Providers need to be trained to effectively utilize such tools and appreciate their importance. For example, providers must learn to effectively employ skills such as structured and closed-loop communication, and asking clarifying questions to get the most out of a mnemonic handoff tool (Greilich et al., 2023). Perioperative team training has been associated with improved teamwork behaviors as well as decreased surgical morbidity and mortality (Neily et al., 2010; Weaver et al., 2010; Rhee et al., 2017). Despite this evidence, there remains a widespread lack of sustained team training in the perioperative space. A review by Raveendran et al. (2023) noted that most current interventions address only a few teamwork constructs and called for perioperative training programs that comprehensively address teamwork competencies and measure interprofessional outcomes. In response to The Joint Commission's (2017) sentinel event alert, the Anesthesia Patient Safety Foundation created guidelines for the execution and research of perioperative handoffs, concluding that teamwork training and attitude/behavior changes are essential for successful perioperative handoff interventions (Agarwala et al., 2019). Teaching teamwork competencies will foster the attitudes and behaviors needed to improve provider adherence to these interventions.

The perioperative space has a unique amalgamation of interprofessional roles working together to deliver care. The variety of professional identities, communication styles, educational backgrounds, competing priorities, and perceived hierarchies strain interprofessional teamwork (Etherington et al., 2019). Interprofessional team members contribute information disproportionately, and miscommunications occur more frequently during exchanges between *different* professions (Cumin et al., 2017; Keller et al., 2019). Perceived hierarchies contribute to this unequal information sharing by impacting psychological safety and team trust, which discourages certain members from speaking up (Cumin et al., 2017; Etherington et al., 2019; Keller et al., 2019). Poor uptake of perioperative handoff interventions may also result from limited team member engagement for the entirety of a handoff (Abraham et al., 2021b). Teamwork training will help overcome some of these obstacles by strengthening team members' foundational teamwork competencies, such as recognizing the criticality of teamwork, creating a psychologically safe environment, establishing mutual trust, and optimizing team mental models to improve engagement (King et al., 2008; Greilich et al., 2023).

The perioperative environment requires many handoffs including pre-, intra-, and postoperative handoffs as well as intra- and interprofessional handoffs. Preoperative intraprofessional handoffs occur between the preoperative nurse and operating room circulating nurse, for example, while preoperative interprofessional handoffs may occur between the preoperative anesthesia team and the operative team. Some postoperative interprofessional examples include the operative team to the anesthesia provider and nurse in the post-anesthesia care unit or surgeon to the advanced practice

provider in the intensive care unit (Frasier et al., 2020; Burden et al., 2021; Meersch et al., 2022). These handoffs provide multiple opportunities for poor care coordination which is exacerbated by the detailed information exchange required for perioperative patients. These patients are acutely vulnerable due to the inherent risks of undergoing anesthesia and invasive procedures and the severity of pathologies that merit surgical intervention (Devereaux and Sessler, 2015; Fernandez-Bustamante et al., 2017; Aminian et al., 2022; Talmasov and Klein, 2022). The performance requirements for surgical patient care result in time pressure within an individual patient's care continuum and interpatient care, as multiple patients require high-level care simultaneously (Etherington et al., 2019; Göras et al., 2019). This time pressure often results in multitasking, which correlates with performance degradation and occurs almost 50% of the time during operative care (Göras et al., 2019; Modi et al., 2020). The high workload conditions created by time pressure causes team members to prioritize their own tasks, decrease attention to other team members' needs, and disengage from activities that benefit the team and overall patient care (e.g., handoffs) if a direct correlation with their individual responsibilities is not clear (Shaw et al., 2010; Etherington et al., 2019). Furthermore, different interprofessional operative team members experience varying workloads and stress levels at different time points in care (Aouicha et al., 2020). Training providers in requisite teamwork competencies, such as the criticality of teamwork, mutual performance monitoring, debriefing, and mutual trust, will help address issues created by time pressure and care complexity (Greilich et al., 2023).

The aforementioned interprofessional nature, time pressure, and care demands of the perioperative environment produce many opportunities for interruptions and distractions that harm handoffs. Interruptions can range from technical tasks, such as managing equipment, to interpersonal, such as other providers initiating conversations about tasks unrelated to the patient at hand (Etherington et al., 2019; Göras et al., 2019; Aouicha et al., 2020; Frasier et al., 2020; Modi et al., 2020). Previous studies demonstrated that disruptions during perioperative handoffs occur frequently (~45% of the time; Frasier et al., 2020) and sometimes result in team members leaving the handoff, further impeding handoff intervention adherence (Abraham et al., 2021b). Providers equipped with the appropriate teamwork skills, such as closed-loop communication, optimizing team mental models, and reflection/debriefing, are more likely to reduce the frequency and impact of such interruptions, ensuring team effectiveness (Salas et al., 2008; Zajac et al., 2021; Greilich et al., 2023).

Challenges to implementing impactful teamwork training programs in the perioperative environment

While there is abundant evidence of the effectiveness of teamwork training and interventions in healthcare (Hughes et al., 2016), evidence in the perioperative environment is mixed (Turcotte et al., 2022), indicating potential issues with program implementation. A review by Teunissen et al. (2020) found that perioperative teamwork is not widely understood. Additionally, a systematic review by Turcotte et al. (2022) showed that current interprofessional perioperative interventions have not yet demonstrated improved provider satisfaction. To optimize the impact of team training in the perioperative environment, programs must meaningfully incorporate science-based learning and training best practices. Training transfer literature emphasizes the importance of what happens before, during, and after training. Healthcare organizations frequently focus on factors that occur during training. However, training science tells us that the most important aspects of training are those done *before* and *after* training (Salas et al., 2018). Program developers must consider five critical components that affect training outcomes: facilitator education, trainee composition, training timing, training evaluation, and supportive conditions (see Table 1). These components are resource-intensive and present major obstacles to successful training. Though they generally apply to all environments in need of team training, they are particularly critical in the perioperative realm. Below, we discuss these five components, the challenges to incorporating them, and the unique aspects of these challenges within the perioperative environment.

Challenge 1: Providing facilitator-led education

Successful training programs must include facilitators who are knowledgeable in training content and delivery. Existing best practices advise a train-the-trainer approach to ensure that facilitators successfully deliver the necessary knowledge and skills to trainees. Compared with self-study approaches, train-the-trainer strategies significantly improve provider adherence and competence (e.g., TeamSTEPPS™; King et al., 2008; Martino et al., 2011). Facilitators should represent all roles within the team (ex. anesthesiologists, intensivists, nurses, surgeons). However, facilitator-led training

TABLE 1 Challenges to implementing teamwork training programs in the perioperative environment.

Challenge	Description
1. Providing facilitator-led education	Utilizing a facilitated training method in conjunction with a train-the-trainer approach
2. Coordinating interprofessional training	Training students and practicing professionals together to improve interdisciplinary (e.g., anesthesiologists, intensivists, surgeons) and interprofessional (e.g., nurses, nurse practitioners, physicians, physician assistants, respiratory therapists, surgical technicians) teamwork coordination and communication
3. Training preclinically and longitudinally	Training preclinically with continual refresher trainings to ensure that effective behaviors are learned from the beginning and sustained over time
4. Comprehensively evaluating training impact	Meaningfully evaluating the reactions, learning, transfer, and results of training preclinically, clinically, and post-graduation
5. Creating supportive conditions to sustain behaviors	Establishing institutional and supervisory support (e.g., resources, policies, behavioral modeling) for teamwork training, behaviors, and initiatives

demands considerable resources: external facilitators require funding and lack contextual knowledge of the perioperative environment's intricacies, whereas training internal facilitators delays training onset. Moreover, obtaining protected non-clinical time for perioperative providers to act as internal facilitators is particularly challenging. Teams of interprofessional providers must dedicate time to facilitator training and delivering the curriculum that would otherwise typically be spent teaching technical skills for the operative environment or providing operative services, which are high-value activities for hospitals (Best et al., 2020).

Challenge 2: Coordinating interprofessional training

Whenever possible, individuals in different yet interdependent interprofessional roles must train together. Interprofessional training increases program fidelity, i.e., the extent to which the simulation (e.g., training) and knowledge and skills learned match the simulated system (e.g., the perioperative environment; Farmer et al., 1999; Maran and Glavin, 2003). Interprofessional team training shows significant improvements in team knowledge, skills, and communication (Nelson et al., 2017). However, incorporating interprofessional training into the perioperative environment requires extensive coordination to balance the competing responsibilities of various roles and ensure that training activities do not disrupt operative services (Etherington et al., 2019; Abraham et al., 2021a). Training content must optimize relevance to all professions without limiting on-the-job context for each role. If the training content does not align with functional tasks, it can devastate transfer of trained behavior to the job, ultimately nullifying the effectiveness and significance of training (Hamstra et al., 2014).

Challenge 3: Training preclinically and longitudinally

Training best practices indicate it is imperative to consider training timing, specifically regarding career stages (e.g., undergraduate vs. graduate medical education) and the duration of training (e.g., a single workshop vs. progressive or recurring context-specific sessions). Despite the increasing prevalence of teamwork training initiatives in healthcare, standardized implementation of these efforts in healthcare education lags (Weaver et al., 2014; Buljac-Samardzic et al., 2020). Recent reviews substantiate that preclinical teamwork training is limited and call for health education programs to incorporate more teamwork training (Fox et al., 2018; Gordon et al., 2018; Vuurberg et al., 2019).

Individuals should learn teamwork competencies preclinically to establish a common language and appreciation for teamwork before they adopt ineffective team behavioral norms. Training efforts are less effective for established providers because existing knowledge and norms make learning and incorporating new material in practice more difficult (Anderson and Neely, 1996). Providers find unlearning ineffective team behaviors difficult for a multitude of reasons: they may struggle to break existing habits and routines and unlearn mental shortcuts (e.g., mindsets about how teamwork should be conducted), fear the unknown of new norms and their effect on patient safety, and lack awareness about the benefits of unlearning (Rushmer and Davies, 2004). These obstacles are exacerbated by the time pressure of the perioperative environment. However, it can be difficult to incorporate teamwork training into preclinical student course schedules and develop team training curricula applicable to all professions while maintaining training fidelity. Again, the acuity of care and time pressure in the perioperative environment impede the incorporation of critical training activities, like practice and debriefing, into students' perioperative rotations. Additionally, while training preclinically is essential to improve teamwork capabilities for future providers, it does not address the gap in teamwork skills of practicing professionals. Introducing teamwork education and training at the preclinical level can address this issue by equipping learners with prerequisite skills to engage in on-the-job perioperative team training like NetworkZ and adapted version of TeamSTEPPS for the perioperative environment (Weaver et al., 2010; Rhee et al., 2017; Jowsey et al., 2019).

The intended duration of training is also important. Although few studies have sought the optimal interval for refresher teamwork training (Weaver et al., 2014), the existing literature does indicate that refresher training is needed to sustain teamwork skills in healthcare (Steinemann et al., 2011). A systematic review of teamwork training studies by Marlow et al. (2017) indicated that distributed training sessions can reinforce the importance of teamwork over time. While not focused on teamwork training, a systematic review of training in emergency care by Ameh et al. (2019) revealed that longer training programs were associated with greater skills improvement and asserted that knowledge and skills can be retained for up to a year, but repeat training and opportunities to practice improve retention (Ameh et al., 2019). Other clinical work research shows that knowledge and skills deteriorate as quickly as 3 to 6 months following training, implying that refresher training may be necessary after this duration (Mancini et al., 2010). Longitudinal teamwork training with refresher intervals requires dedicated resources (e.g., time away from practice, funding for facilitators) and coordination between practicing institutions and educational programs to ensure that content aligns with previous coursework. Previous reviews indicate that teamwork training typically occurs in single sessions, indicative of these resource challenges, which have amplified impact in perioperative spaces (Husebø and Akerjordet, 2016; Fox et al., 2018).

Challenge 4: Comprehensively evaluating training impact

Existing best practices urge incorporation of rigorous evaluation methods to track the effectiveness of training programs. A training program's fidelity and impact on meaningful behavior changes and relevant outcomes cannot be determined without comprehensive evaluation. Currently, training program evaluations are mostly self-reported with some observational ratings (Fox et al., 2018; Li et al., 2018). These methods have varying degrees of reliability and validity (Li et al., 2018) and fail to capture the true outcomes of teamwork training. A review by Chakraborti et al. (2008) showed that most teamwork training programs failed to track teamwork or outcomes beyond the end of the program. A later systematic review found that only 40% of programs tracked

outcomes, although several studies did track the transfer of teamwork skills up to 12 months post-training (Costar and Hall, 2020). Notably, this review included only 20 studies and excluded articles that included medical or nursing students.

The Kirkpatrick evaluation model considers four levels of evaluating training program effectiveness: reactions (trainee satisfaction and perceived utility of the training), learning (the knowledge and skills that trainees gain), transfer (the transfer of learned knowledge and skills to the work environment), and results (the training's impact on individual, team, and organizational outcomes; Kirkpatrick, 1998). Training programs must be rigorously evaluated on all four levels to claim effectiveness. If data can support positive impacts on all levels, this presents a convincing argument for organizations to expend resources to support the training program. However, effective evaluation of each Kirkpatrick level can be time- and resource-intensive and require dedicated personnel. For example, handoff processes frequently involve electronic medical records, but using them to measure outcomes and skills transfer in the perioperative environment would require significant institutional investment in clinical informatics specialists for development (Abraham et al., 2023). The frequency of perioperative handoffs also obscures each dynamic team's influence on patient outcomes. If some teams undergo team training but others do not, it is challenging to delineate the training's impact on outcomes. Therefore, comprehensive training of all interprofessional providers involved in perioperative care is critical for accurate program evaluation.

Challenge 5: Creating supportive conditions to sustain behaviors

Improving perioperative handoff safety requires an environment conducive to teamwork. Local interventions at the unit level are often insufficient without institutional support, and previous perioperative teamwork interventions and systematic reviews of this work have consistently identified this as a crucial obstacle to program success (Jowsey et al., 2019; Teunissen et al., 2020; Keebler et al., 2022; Turcotte et al., 2022; Raveendran et al., 2023). Team members will continue to encounter challenges that increase errors if institutional structures do not allocate time and resources to conducting safe team-based handoffs. Meta-analytic findings substantiate that a supportive work environment is a critical predictor of learning transfer (Blume et al., 2010).

However, establishing conditions to sustain trained behaviors presents several challenges. Changing work culture is difficult and requires time and resources. Recent literature indicates that healthcare organizations must implement a multi-level approach, incorporating both top-down and bottom-up cultural change initiatives (Rosenbluth et al., 2018; Keebler et al., 2022). Leadership must provide support to ensure transfer of training (Grossman and Salas, 2011), consistently message teamwork as a priority, and provide infrastructure for teaming events to take place, such as resources for handoff tool integration into electronic medical records (Abraham et al., 2021a, 2023; Michael et al., 2021). Resources and existing policies must be in place to provide trainees with opportunities to perform and reinforce newly trained skills (Tracey and Tews, 2005; Grossman and Salas, 2011). Additionally, there must be appraisal, recognition, and reward systems to incentivize trainees, faculty, and staff to use their acquired knowledge and skills (Tracey and Tews, 2005).

If training is delivered preclinically, learners transitioning to practice will disperse to different perioperative teams and units or different healthcare systems entirely, where policies and norms affecting culture vary greatly. Institutions that deliver teamwork training can implement initiatives to improve their own culture to support trained behaviors, but widespread dissemination of such initiatives is needed to support learners in external organizations. Therefore, until programs are appropriately scaled, the measurement of longitudinal impact will be limited to preclinical learners that transition to practice within the same institution.

Discussion

Perioperative handoff interventions have become significantly more common in recent years; however, obstacles that limit provider adherence to these interventions threaten their sustainability and scalability. High-quality studies with sustainable interventions that demonstrate improved patient and provider outcomes remain elusive (Shahian et al., 2017; Abraham et al., 2021c; Burden et al., 2021; Riesenberg et al., 2022). Teamwork training is needed to enhance the sustainability of perioperative handoff interventions, and recent systematic reviews of perioperative teamwork training efforts call for robust, interprofessional programs that address the obstacles described above (Teunissen et al., 2020; Turcotte et al., 2022; Raveendran et al., 2023).

Many challenges in the perioperative environment affect patient handoffs, including interprofessional interdependence, handoff frequency, care acuity, time pressure, and environmental distractions (Etherington et al., 2019; Abraham et al., 2021b; Michael et al., 2021; Lazzara et al., 2022). Foundational teamwork training for all providers in perioperative handoffs will improve their ability to manage and overcome these challenges and, therefore, improve handoffs (Salas et al., 2008; Greilich et al., 2023). However, there are significant obstacles to delivering effective teamwork training, including barriers to facilitator-led education, appropriate timing and frequency of training delivery, delivery to an interprofessional audience, providing meaningful evaluation, and fostering conditions to sustain learned teamwork behaviors.

Addressing the complexities of teamwork in the perioperative environment poses an exciting opportunity to improve handoffs and meaningfully impact patient and provider outcomes. For example, though frequent handoffs create a challenge for teamwork, they also allow for repetitive practice and reflection on trained behaviors. This unique, high-need environment offers the ability to implement truly interprofessional interventions where miscommunications and poor coordination can cause life- and limb-threatening errors (The Joint Commission, 2017; Humphrey et al., 2022). The competencies acquired through effective teamwork training can be applied to handoffs as well as other critical teaming events in the perioperative environment, such as huddles, debriefs, and multidisciplinary rounds. Although the components discussed above present considerable obstacles to implementation, acknowledging their importance and discussing their associated challenges is the first step to building more meaningful, sustainable, and impactful teamwork training programs in the perioperative environment.

Conclusion

Teamwork is critical to providing effective and reliable perioperative handoffs. Perioperative providers must be equipped with foundational teamwork competencies to improve team effectiveness, adherence to handoff interventions, and, ultimately, patient safety. To achieve sustained impact, user-centered training interventions must address the identified challenges of teamwork training in the perioperative environment.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

Author contributions

SP and MK made significant contributions to the literature review, manuscript drafting, and revision. OH, JH, and AM provided critical reviews and revision guidance. PG and ES provided conceptual guidance and critical reviews of the manuscript. All authors have made substantial contributions to the conception, drafting, and revision of the manuscript and approved the final version for submission.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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EDITED BY
Juliane E. Kämmer,
University of Bern, Switzerland

REVIEWED BY
Stefano Abbate,
University of Naples Federico II, Italy
Daisung Jang,
The University of Queensland, Australia
Mona Weiss,
Freie Universität Berlin, Germany

*CORRESPONDENCE
Johanna Elisa Dietl
✉ jdietl@constructor.university

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Interdisciplinary and interprofessional communication intervention: How psychological safety fosters communication and increases patient safety

Johanna Elisa Dietl[1]*, Christina Derksen[1], Franziska Maria Keller[1,2] and Sonia Lippke[1]

[1]Health Psychology and Behavioral Medicine, School of Business, Social and Decision Science, Constructor University, Bremen, Germany, [2]Klinikum Bremerhaven Reinkenheide gGmbH, Treatment Center for Psychiatry, Psychotherapy and Psychosomatic, Bremerhaven, Germany

Background: Effective teamwork and communication are imperative for patient safety and quality care. Communication errors and human failures are considered the main source of patient harm. Thus, team trainings focusing on communication and creating psychologically safe environments are required. This can facilitate challenging communication and teamwork scenarios, prevent patient safety risks, and increase team performance perception. The sparse research concerning communication interventions calls for an understanding of psychological mechanisms. Therefore, this study investigated mechanisms of an interpersonal team intervention targeting communication and the relation of psychological safety to patient safety and team performance perception based on the applied input–process–output model of team effectiveness.

Methods: Before and after a 4-h communication intervention for multidisciplinary teams, a paper–pencil survey with $N = 137$ healthcare workers from obstetric units of two university hospitals was conducted. Changes after the intervention in perceived communication, patient safety risks, and team performance perception were analyzed *via* *t*-tests. To examine psychological mechanisms regarding psychological safety and communication behavior, mediation analyses were conducted.

Results: On average, perceived patient safety risks were lower after the intervention than before the intervention ($M_{T1} = 3.220$, $SD_{T1} = 0.735$; $M_{T2} = 2.887$, $SD_{T2} = 0.902$). This change was statistically significant (t (67) $= 2.760$, $p = .007$). However, no such effect was found for interpersonal communication and team performance perception. The results illustrate the mediating role of interpersonal communication between psychological safety and safety performances operationalized as perceived patient safety risks ($\alpha_1^* \beta_1 = -0.163$, 95% CI [−0.310, −0.046]) and team performance perception ($\alpha_1^* \beta_1 = 0.189$, 95% CI [0.044, 0.370]).

Discussion: This study demonstrates the psychological mechanisms of communication team training to foster safety performances and psychological safety as an important predecessor for interpersonal communication. Our results highlight the importance of teamwork for patient safety. Interpersonal and interprofessional team training represents a novel approach as it empirically brings

together interpersonal communication and collaboration in the context of patient safety. Future research should work on follow-up measures in randomized-controlled trials to broaden an understanding of changes over time.

KEYWORDS

healthcare, communication intervention, interdisciplinary teams, psychological safety, patient safety

1. Introduction

Progressive complexity and high demands prevent high-*quality care and patient safety* in various healthcare contexts. To meet these demands, effective teamwork and communication are key values to deliver high-quality care (Knox and Simpson, 2011; Weller et al., 2014; Rosen et al., 2018). While functioning teamwork is associated with quality of care and patient safety, communication and teamwork failures in interdisciplinary teams lead to deficient patient care and thus pose safety risks (Weller et al., 2014; Rosen et al., 2018; Parker et al., 2019).

According to the literature, patient safety is defined as the absence of *preventable adverse events* (PAEs) that are caused by care below existing standards rather than a patient's condition itself (Griffin and Resar, 2009). This definition illustrates the duties of healthcare organizations and healthcare workers (HCWs), which are responsible for the prevention, reduction, and learning of failure and adverse events to improve safety and care delivery. PAEs are defined as unintentional harm which arises from deficits in the collaboration of healthcare providers (Mitchell, 2008). Hence, patient safety and high-quality care depend on interdisciplinary *teamwork* (Manser, 2009). HCWs must adapt to complex environments such as rapidly changing circumstances, patient conditions, fast knowledge, technology development, and team compositions (Rosen et al., 2018). Furthermore, team learning is especially important in healthcare because it is highly interdependent; hence, HCWs must rely on other interdisciplinary and interprofessional team members to combine and apply specific job-related knowledge and skills for better patient care (Derickson et al., 2015). Therefore, to *collaborate and communicate* is crucial to provide patient care and patient safety (Manser, 2009).

The detection and communication of adverse events in healthcare are essential for patient safety. A thorough application of incident reporting systems is driving failure learning behavior since they provide information, progress safety, and hold HCWs responsible for their performance. Error reporting benefits suggestions for decreasing and eliminating errors (Kohn et al., 2000). Nevertheless, adverse events are often underreported in healthcare settings due to a variety of factors, including fear of retribution, blame, job loss, lack of knowledge or awareness, concerns about legal liability, reputation harm, feelings of guilt, inadequate training, or different understanding of error detection (Evans et al., 2006; Stewart et al., 2018). Furthermore, there are data collection challenges on adverse events as it is time-consuming and resource-intensive or may not capture all types of errors (Evans et al., 2006; Kaldjian et al., 2008; Unal and Seren, 2016). The information majority on the frequency of PAEs derives from case studies, retrospective reviews, patient records, or formal incident reporting. While these documentations and analyses of PAEs indicate the occurred PAE or adverse consequences, they rarely focus on their potential processes or triggers (Forster et al., 2006; Keller et al., 2021). Therefore, the existing error tools are not always suitable for drawing conclusions about errors or error experiences. Moreover, assessments of teamwork factors can be impractical or difficult to implement; thus, (team) perceptions are a capable resource to achieve teamwork insights (Mathieu et al., 2008; Kämmer et al., 2023), which applies especially to stressful obstetric processes. Therefore, assessing perceived patient safety risk triggers or perceived team performance perception from a HCWs' perspective is an appropriate approach.

Interpersonal communication in healthcare is described as an interactive exchange process, to achieve a common understanding between HCWs within the team as well as between patients and providers (Echterhoff et al., 2009). Communication is shown to be the primary root cause of serious patient harm as it is a significant contributor to healthcare errors. Risk factors of communication deficits, which contribute to poor patient experience and thus impact patient safety, are the lack of effective handovers, inaccurate diagnosis, treatment errors, and inefficient patient–provider and team interaction. Thus, poor interpersonal communication may lead to weak performance, patient injury, or even death (Gluyas, 2015; Foronda et al., 2016; Burgener, 2017; Bekkink et al., 2018). Furthermore, flawed safety cultures in hierarchically structured hospitals hinder communication by inhibiting speaking up behavior (Nembhard and Edmondson, 2011), showing how closely effective communication is interrelated with teamwork and safety performance.

Previous evidence has identified *psychological safety* as an important factor supporting communication and teamwork in healthcare. It describes team members' level of feeling safe to take interpersonal risks (Derickson et al., 2015). Psychological safety is associated with patient safety, collaboration, involvement in quality improvement work, learning from mistakes, and adverse events (Hirak et al., 2012; Arnetz et al., 2019), which indicates the connection between communication, safety performance, and environments that are perceived as safe (similar as psychological safety). Consequently, fostering a culture of openness around error reporting is essential to increase patient safety (WHO, 2019). This can be achieved through training regarding communication and teamwork (Ito et al., 2022). These factors are promoted by creating an atmosphere of psychological safety in healthcare settings, which in turn leads to more interpersonal communication and knowledge sharing (Leroy et al., 2012; Newman et al., 2017). Previous research has found that psychological safety is linked to

several communication outcomes, such as speaking up behavior or reduction in silence behavior (Newman et al., 2017). Moreover, psychological safety can be regarded as a team attribute or process promoting input by feeling safe for engaging in risk interaction with colleagues (Haviland et al., 2022). Thus, psychological safety could be a crucial prerequisite for interpersonal communication or fostering communication processes in difficult circumstances (O'Leary, 2016).

Especially in *obstetric care*, difficult situations that require interpersonal risk-taking and good communication are common. In this interdisciplinary and interprofessional work environment, HCWs' diverse work philosophies and backgrounds lead to different labor, processes, and teamwork concepts. Hence, communication is indispensable to bridge differences and generating a common understanding of work (Lyndon et al., 2011). Furthermore, HCWs' capacity to communicate, listen, and empathize can profoundly impact care quality and patient satisfaction (Burgener, 2017). Obstetric care is considered "safe" as patient safety incidents are less common than in other fields. Nevertheless, communication breakdowns have severe consequences, e.g., contributing to up to 72% of all perinatal deaths (Forster et al., 2006; Lippke et al., 2021). Teamwork and communication failures between obstetric HCWs could harm both the (expectant) mother and the fetus or newborn and cause high strain for HCWs and high litigation costs (Forster et al., 2006). This indicates the imperative of enhancing teamwork and communication, particularly in obstetrics as an interdisciplinary and interprofessional care unit.

Many studies have investigated the impact of *team training interventions in healthcare*. There are a variety of training programs (e.g., TeamSTEPPS, MedTeams project, Veterans Health Administration Medical Team Training program, and TeamGAINS), which enable team members and teams to improve performance and patient safety (Kolbe et al., 2013; Raemer et al., 2016). The large literature depicts that healthcare team trainings are related to improve effectiveness specifically in terms of learning, reactions, transfer, and results (e.g., organizational and patient outcomes), which demonstrated that team interventions are associated with improving safety performances (Hughes et al., 2016). For example, the well-established team training program TeamSTEPPS is related to error rate reduction and increases teamwork and communication (Parker et al., 2019). TeamSTEPPS (mainly in an emergency context) uses communication methods and tools to foster team communication, focusing on technical communication aspects (Derksen et al., 2022). Further team interventions such as TeamGAINS (Kolbe et al., 2013) were aiming to focus on a technical viewpoint and mostly investigated one single technical strategy of communication such as debriefings (Kolbe et al., 2013), speaking up (Kolbe et al., 2012; Raemer et al., 2016), or after-event reviews (and voice behavior; Weiss et al., 2017) to increase team performance perception and patient safety. Selected high-quality intervention studies in diverse health contexts that systematically examined effects on communication, coordination, or situational awareness can be found (e.g., Kolbe et al., 2013; Hughes et al., 2016; Raemer et al., 2016; Milton et al., 2023). Nevertheless, the literature shows that communication has been trained and evaluated mainly combined with other teamwork dimensions or singular technical communication skills in numerous healthcare trainings.

Looking into communication interventions specifically in obstetrics, previous studies have mixed results. The sparse research concerning interventions focusing on communication lacks clear evidence regarding underlying *psychological mechanisms* and high-quality investigations (Merién et al., 2011; Lippke et al., 2021). Moreover, most failures are based on systems rather than individuals (Derickson et al., 2015). Therefore, team interventions are suitable for reducing errors and improving team performance perception (Merién et al., 2011).

In obstetric care, team compositions and requirements in teaching hospitals alter depending on the specific context, birth situation (e.g., spontaneous birth in the delivery room, cesarean section, and emergencies), and the level of care which is prerequired. Nevertheless, there are some general insights:

The size of obstetrics teams varies, but they typically consist of several healthcare professionals, including obstetricians, midwives, nurses, anesthesiologists, and pediatricians. The peculiarity of the university hospital leads to the fact that there are continuously midwives and nurses under training and residents. Depending on the capacity of the delivery room, the staff is responsible for several births. In addition, to the care by midwives and doctors, nurses predominantly care in the ward. Obstetric teams are based on constantly adapting team structures with continuous elements of intensive and stable cooperation.

In two German university hospitals, the TeamBaby project aimed to implement communication intervention to train interdisciplinary and interprofessional team members together.

There is evidence that after a debriefing intervention (TeamGAINS), psychological safety (and leader inclusiveness) significantly increased (Kolbe et al., 2020), which could indicate that psychological safety is a crucial prerequisite for communication interventions. Against this theoretical background, the *current study* aims to draw attention to psychological safety as a crucial factor in interpersonal communication and baseline for team training. To improve psychological safety and interpersonal communication, a team intervention is developed and tested in obstetrics.

To systematize the evaluation approach, the *input–process–output model* of team effectiveness (IPO) is applied to communication, psychological safety, and perceived safety performances. The IPO is used to systematically analyze the communication team intervention to gain a comprehensive understanding of aspects which might affect individual team member's perceptions in relation to patient safety and communication. Consequently, we adapt the IPO to an individual level to investigate individual perceptions of HCWs in the context of a team intervention. The IPO is a system theory that describes how specific factors interact with each other to result in output (performance; Stewart and Barrick, 2000).

Obstetric teams are characterized as complex and by frequently changing team members due to multiple and different responsibilities, different levels of experience, and unplannable birth processes or complications. Complex and rapidly changing team characteristics are common in teaching hospitals since they must deal with all levels of risks, therefore high-risk patients,

training conditions, and specializations (e.g., pelvic position birth). The IPO represents a framework that shows which important inputs are necessary to achieve outputs (Stewart and Barrick, 2000). Applied to our context, the specific obstetric team characteristics and psychological safety represent important inputs in the IPO framework that are necessary to achieve outcomes such as patient safety and team performance perception improvement.

Therefore, the research objective was to examine how psychological safety (as IPO input) fosters communication (IPO process), which leads to higher safety performance (IPO output, operationalized as perceived patient safety risks and team performance perception; Stewart and Barrick, 2000) in the context of an interdisciplinary team training (as IPO input).

In doing so, we contribute to the inconsistent teamwork and communication literature to shed new clear evidence on how and under which conditions communication interventions foster safety performance by interpreting the IPO on an individual level. The individual level of psychological safety research emphasizes the level of team members experiencing interpersonal safety or non-threat (Edmondson, 1999; Frazier et al., 2017).

Team members' perceptions and attitudes concerning teamwork are linked to patient safety and quality care (Manser, 2009; Müller et al., 2018; Kämmer et al., 2023), summarizing that the perceived teamwork quality differs depending on the profession, status, experience, or hierarchical position (Kämmer et al., 2023). Therefore, the subjective, self-perception analysis furnishes insights into social teamwork interactions, training activities, and outputs (such as patient safety risks and team performance perception) of it.

In more detail, we hypothesize the following:

H1: The interpersonal communication intervention increases perceived communication (H1a), perceived psychological safety (H1b), and perceived team performance perception (H1c) and decreases perceived patient safety risks (H1d).

H2: Perceived psychological safety at baseline is associated with less perceived patient safety risks (H2a) and higher perceived team performance perception (H2b) after the communication training.

H3: The association between perceived psychological safety and perceived patient safety risks (H3a), as well as perceived team performance perception (H3b) are both mediated by perceived communication.

2. Materials and methods

The study was conducted as part of the research project "TeamBaby – Safe, digitally supported communication in obstetrics and gynecology" (ClinicalTrials.gov Identifier: NCT03855735). The project is funded by the German Innovation Fund of the Federal Joint Committee (GBA). Lippke et al. (2019) published more specifics about the research project. The project and the used intervention were described and partially evaluated before (Derksen et al., 2022; Hüner et al., 2023). However, the aspects relating to perceived safety performances (and the psychological mechanisms) were not analyzed or published before and are unique to this manuscript.

2.1. Participants and procedure

Participants of the study were interprofessional team members from two German obstetric university hospitals (both perinatal center level 1[1]). The hospitals have ~2,800–3,200 deliveries per year. The sample consisted of team members who were over 18 years and who had worked at least part-time in any obstetric unit, or a gynecological unit affiliated with the delivery rooms. Physicians, midwives, nurses, healthcare workers in training, and psychologists were included in the study. Participants received information about the research project personally from on-site researchers. They obtained contact details, written information, and consent forms. The on-site researchers served as contact persons for open questions and feedback.

From January 2020 to October 2020, the HCWs were asked to answer baseline and follow-up questionnaires after the intervention, including questions regarding their communication within the team and with patients, team performance perception, perceived patient safety, and psychological safety. After that, all HCWs working in the delivery rooms were required to participate in the communication intervention described below. From March to June 2020, the training sessions were paused because of the regulations regarding the COVID-19 pandemic before the training sessions and post-intervention data collection could be resumed. Thus, the time between t1 and t2 was longer than anticipated with approximately 4 to 5 months, depending on the date of the training. The study contained only the intervention group due to both ethical concerns (providing interventions to improve patient outcomes as quickly as possible) and practical reasons (to avoid spill-over effects and to compare patient outcomes in a separate study; Hüner et al., 2023).

In total, $N = 141$ HCWs participated in the communication training. $N = 137$ voluntarily filled out a baseline (t1) and $N = 87$ the post-intervention (t2) questionnaire. Finally, t1 and t2

1 The participating HCWs of the hospitals were part of numerous obstetric teams with a very dynamic, always changing composition. These obstetric teams were composed based on individual care structure and indications. Birth processes in the participating hospitals (high risk and high complication rates) are often unpredictable; thus, the obstetric teams need to adapt to individual birth conditions. On a daily basis in the delivery room, approximately four to five team members (midwives, physicians, and pediatricians) are assigned to one patient/expected mother. In other contexts, such as emergencies or cesarean operations, the teams consist of an operating nurse, a pediatrician, physician, a midwife, and an anesthetist. In the ward, primarily nurses, midwives, and ward physicians are with the patients.

Team members hand over their patients several times a day within the occupational groups; here, the respective occupational groups meet for patient handover and discuss the processes and cases. In general, midwives and obstetricians have very intensive and stable cooperation over time, and pediatricians and anesthesiologists are temporarily and partially integrated into the care process as needed. As depicted, the participating HCWs are part of constantly adapting team structures with continuum elements.

All employees at the participating obstetric clinic feel as one big team. They have common team meetings, scientific workshops, trainings, debriefings, and feedback rounds, as well as joint further education, simulation practices and shared breaks, break rooms, shared goals, or shared activities.

questionnaires from $N = 69$ individuals could be matched based on study codes. For all variables, the percentage of missing data was under 13.04%, while the baseline measurements had an average of 11.59%. As a result of the high drop-out rate and unmatchable questionnaires, 49.64% of the post-intervention scales had missing data that could not be imputed.

HCWs received a 4-h team training, focusing on interpersonal communication. Exemplary training modules were learning units regarding speaking up, closed-loop communication, perspective change, and mental models. A detailed overview of socio-demographics is provided in Table 1.

2.2. The interpersonal communication intervention

The intervention was described and partially evaluated before (Derksen et al., 2022; Hüner et al., 2023). Hughes et al. (2016) meta-analysis of healthcare team trainings indicates that healthcare team trainings must deal with specific team requirements and team characteristics such as less stability in terms of time, short team life durability, functional roles, highly different fields of competence, shared leadership, interdependence, and authority gradients. These team structures and characteristics underline the important role of communication abilities, to manage teamwork and provide safe patient care (Hughes et al., 2016). Thus, the current training is derived from the previous findings of team training research by aiming to address central interpersonal communication challenges and tools.

The interpersonal communication training was cooperatively developed by the interdisciplinary research project team (psychologists, public health experts, and obstetric HCWs) and two external communication trainers in the field of patient safety. The intervention was designed as a 4-h team training, to ensure adaptation to the stressful and time-consuming daily care routine. The trainings were conducted with the external professional trainers. Participants of the training were interprofessional and interdisciplinary team members of the obstetric units. Thus, physicians, residents, nurses, midwives, midwives and nurses under training, and psychologists were simultaneously trained in person as a group. Anesthesiologists and pediatricians were also invited to the training but did not participate. Finally, only HCWs who were directly employed in the obstetric departments participated in the intervention.

A total of 13 training sessions were performed at the two hospitals of the study, and $N = 141$ HCWs were finally trained. In the 4-h team training session, between 8 and 16 participants from all professional groups and all levels of experience participated. The intervention aimed to convey an understanding of the important role of communication in relation to patient safety and teamwork. The team training focused on combining knowledge transfer, interactive exercises, role plays, and debriefings.

Following Kolbe et al. (2020), the intervention setting and the trainer behavior guidelines were designed to establish psychological safety. The intervention sessions were placed in quiet rooms, separated from the daily work settings, and a circle of chairs was the main setup to foster interaction and discussion. The trainers were part of the circle of chairs to demonstrate being on a par. The trainers varied their positions in different exercises, e.g., they were close to participants in difficult speaking up simulations to support and reduce feelings of stress or threat. In other exercises, they were more in observational perspectives and physically further away from the participants to capture important observations or non-verbal behaviors, if necessary, and to provide feedback (Kolbe et al., 2020).

Debriefings of exercises were a central element of the training to clearly work through processes and mistakes to increase teamwork and communication, again in accordance with research showing how psychological safety can be established in healthcare debriefings (Kolbe et al., 2020). The trainers were required to create an environment that was as psychologically safe as possible so that HCWs were able to talk adequately about mistakes and improvements in the exercises. To establish psychological safety (especially at the beginning of each debriefing), the trainers explained the process and the roles of all parties involved in the debriefings (trainers and participating HCWs). All training participants were explicitly invited for participating and conducting self-reflective and discovering behavior. The trainers proactively positively marked and frequently appreciated the proactive behavior of the participants to support psychological safe actions and behavior. The trainers fostered an agreement of respectful interaction and understanding of different perspectives and opinions.

In the following, important insights into the core elements of the training are provided. The training started with an introduction to clarify expectations. "Zurich resource model"-picture postcards were used to teach an understanding of different mental models (of an optimal birth). The "Zurich resource model"-picture postcards are part of the Zurich Resource Model training, which is a proven method for the targeted motives elaboration and development for scope of action. Thus, an extraordinary feature of the Zurich Resource Model is, that in addition to conscious motives, less conscious or unconscious needs are also addressed. For this purpose, participants were invited to select images (picture postcards) that represented associations with an optimal birth, which were discussed and elaborated further on in a subsequent step in a group discussion. These individual card selection tasks and birth associations in the group discussion showed that all participants had a different idea (equated with mental models) of an optimal birth (Krause and Storch, 2006).

To introduce the importance of patient safety, communication, and teamwork (deficits), the patient safety film "Just a routine operation" was integrated in the training. The film was used to critically discuss and analyze crew resource management (CRM). The participants discussed in a group session their impressions and associations and analyzed the presented erroneous routine operation regarding CRM including centering on the role of communication, support, leadership, workload, re-evaluation of the situation for patient safety, and better teamwork. The film demonstrated an exemplary way to learn from failure (Carne et al., 2012; Mcclelland and Smith, 2016).

Furthermore, challenges of team communication, speaking up, and handovers were interactively demonstrated and trained with appropriate strategies and exercises such as Tangram, closed-loop communication, speaking up, and structured handovers (ISBAR).

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TABLE 1 Overview of socio-demographic data and experience among obstetric HCWs.

	$N = 137$	Physicians ($n = 44$, 32%)	Midwives ($n = 43$, 31%)	Nurses ($n = 23$, 17%)	Others (e.g., Trainees, Psychologist) ($n = 22$, 16%)
Sex	Women ($n = 122$, 89%)	39 (91%)	42 (98%)	21 (91%)	19 (86%)
	Men ($n = 10$, 7%)	4 (9%)	1 (2%)	2 (9%)	3 (14%)
	Missing ($n = 5$, 4%)				
Age	<26 years ($n = 28$, 20%)	1 (2%)	12 (29%)	3 (13%)	12 (57%)
	26–40 years ($n = 73$, 53%)	35 (85%)	20 (48%)	14 (61%)	4 (19%)
	41–55 years ($n = 21$, 15%)	4 (10%)	9 (21%)	3 (13%)	4 (19%)
	>55 years ($n = 6$, 4%)	1 (2%)	1 (2%)	3 (13%)	1 (5%)
	Missing ($n = 9$, 7%)				
Experience	<1 year ($n = 21$, 15%)	4 (9%)	7 (17%)	5 (23%)	5 (24%)
	1–5 years ($n = 54$, 39%)	20 (47%)	19 (45%)	5 (23%)	10 (48%)
	>5 years ($n = 54$, 39%)	19 (44%)	16 (38%)	12 (55%)	6 (29%)
	Missing ($n = 8$, 6%)				

Frequencies and percentages are shown for each occupational group; percentages are in parentheses. Up to nine participants did not provide information on sex, age, and/or level of experience, and/or profession.

ISBAR is a communication framework for patient handovers by standardizing the transmission of patient information. The framework structures the communication process by giving information about introduction, situation, background, assessment, and recommendation. Therefore, ISBAR was introduced as a handover tool, to reduce communication errors.

Using Tangram exercises, interpersonal communication competencies of accuracy and clarity were trained. The Tangram exercise required one team member (the director) to verbally communicate descriptions of abstract figures to another team member (the assigner), who had to puzzle the abstract figure by not knowing the appearance of the figure (Arbuckle et al., 2000). The exercise varied successively in difficulty (e.g., at the beginning no questions are allowed, no visual support, and questions are allowed). The team tasks addressed communication challenges in clarity and accuracy and were used as an introduction to the closed-loop communication strategy to communicate more efficiently in critical task situations (Härgestam et al., 2013; Abd El-Shafy et al., 2018).

"Bad handovers" with unstructured, unimportant, insufficient information were simulated in a role play. Participants had the task of finding out the most important information about the handover. In a moderated group discussion, handover errors of the bad example were identified and discussed. Furthermore, error references to everyday handovers were used. The goal of the task was to reflect on the insufficiency of interpersonal communication as well as to address the importance of structured handovers following the ISBAR strategy (Moi et al., 2019).

The concept of speaking up was already introduced with the patient safety film "Just a routine operation," where participants have seen and discussed a blame-free and exemplary error case showing that HCWs are frequently inhibited to speak up due to hierarchies (Pattni et al., 2019). The training offered predefined case studies of speaking up situations, to provide HCW practice under simulated conditions (role plays).

Finally, an interpersonal adaptation task based on empathy maps was part of the training to practice perspective taking (perspectives of patients, team members, and supervisors) to facilitate coping with stressful and highly complex situations. The empathy maps were applied so that different professionals systemically explored the perspective of another professional group (e.g., midwives analyzed residents, residents analyzed care, senior physicians, and mothers-to-be). The results were presented in plenary sessions across all occupational groups, and similarities and differences between the other professional groups were discussed (Cairns et al., 2021). To ensure the training modules' sustainability, a learning portfolio, reminding pocket cards, and online biweekly microteachings were provided. An overview of all training modules can be found in a study by Derksen et al. (2022).

2.3. Measures

We assessed self-reported data at two time points, namely the baseline (t1) and post-intervention (t2), concerning perceived psychological safety, perceived interpersonal communication within the team and patients, socio-demographic data, and safety performance indicators, which were operationalized as perceived patient safety risk and perceived team performance perception. All items were measured with a six-point Likert scale with the answer options ranging from "1" (*not at all*) to "6" (*absolutely*). All items for each construct were aggregated as mean scores.

2.3.1. Psychological safety

Perceived psychological safety was measured with Edmondson's (1999) adapted four-item measure. A sample item is "Working with members of this team, my unique skills and talents are valued and utilized" (Cronbach's alpha at t1 = 0.71

and McDonald's ω at t1 = 0.73; Cronbach's alpha at t2 = 0.69 and McDonald's ω at t2 = 0.70).

2.3.2. Interpersonal communication within the team and patients

Interpersonal communication was measured with Rider and Keefer's (2006) interpersonal communication competencies. HCWs of the research project discussed an initial item pool, from which a seven-item scale was developed with the sample item "We as a team take the amount of prior knowledge of the patient and how much they can understand into account." Cronbach's alpha was at t1 = 0.85 (McDonald's ω = 0.86) and at t2 = 0.88 (McDonald's ω = 0.89).

2.3.3. Patient safety risks

Safety performance indicators in terms of perceived patient safety risks were assessed as an adapted 15-item preventable adverse trigger scale. The template of the risk scale was from Keller et al. (2021), a patient-centric trigger for adverse events scale, which was adapted to HCWs. We assessed how often team members perceive patient safety risks. A sample item is "Colleagues or I had insufficient knowledge of technical equipment." Cronbach's alpha was at t1 = 0.77 and at t2 = 0.87. McDonald's ω was reported to be 0.78 at t1 and 0.88 at t2.

2.3.4. Team performance perception

We assessed safety performance indicators as perceived team performance perception. We used an adapted 3-item scale from Schaubroeck et al. (2007) with the sample items "This team gets its work done very effectively" and "My team provides quality patient care" (Cronbach's alpha at t1 = 0.78 and t2 = 0.90; McDonald's ω at t1 = 0.78 and at t2 = 0.89).

We implemented strict socio-demographic safeguards to guarantee greater anonymity and a higher response rate. Consequently, sex, age, and profession were assessed as categorical data, with the reply option "I'd rather not say" for participants who considered the provision of socio-demographic information as sensitive. Age and profession were divided in four categories correspondingly (profession: "physician," "midwife," "nurse," "other"; age: "younger than or 25 years," "26–40 years," "41–55 years," and "56 years or above"). Sex was measured in three groups ("men," "women," and "diverse").

2.4. Ethics approval

Ethics approval for the data collection and training at the obstetric hospitals was granted as part of the research project's ethics approval from the two Hospital Ethics Committees. Written informed consent to participate in the study was given by all participants. HCWs voluntarily participated in the baseline and post-intervention questionnaire. Attendance at the training was mandatory.

2.5. Data analysis

All data analyses were conducted using IBM SPSS Version 29. Pre- and post-intervention comparisons were conducted *via* *t*-tests for dependent samples. In detail, *t*-tests for equality of means were used to analyze differences in pre- and post-intervention scores for perceived interpersonal communication, psychological safety, patient safety risks, and team performance perception. Associations of perceived psychological safety (t1) with perceived patient safety risks (t2) and perceived team performance perception (t2) were tested *via* multiple regression analysis. Two mediation analyses were conducted to examine the association between self-reported psychological safety (t1) and patient safety risks (t2) as well as psychological safety (t1) and team performance perception (t2) with the mediator interpersonal communication (t2). The Baron and Kenny approach was applied along with a direct test for the indirect effect *via* bootstrap analyses using 5,000 resamples by applying the Process macro model 4 for SPSS version 3.4 (Hayes, 2013).

Obstetrics is a highly diverse environment; consequently, team members have different work approaches, language use or responsibilities, and hierarchical positions (Forster et al., 2006; Okuyama et al., 2014; Schmiedhofer et al., 2021). Thus, we controlled for professional experience, age, and gender that may be associated with the HCWs' perception and communication, which were added as dummy-coded covariates. For profession, "physicians" was used as the reference group. Concerning age, "younger than or 25 years" was chosen as the reference group. Sex was included as a binary variable as no participants indicated being diverse.

As part of the retrospective Type S and M error analyses, we calculated the average of all the Type M and S errors from the observed estimates. With a statistical power of almost 81%, an average Type M error of 2.256 with a range between 1.344 and 5.042 and an average Type S error of 0.116 with a range between 0.019 and 0.260 were obtained, which means statistically significant results are on average an overestimation of 23% of the hypothesized population effect (Gelman and Carlin, 2014; Altoè et al., 2020).

3. Results

3.1. Pre-post comparison

Descriptive statistics and difference scores among variables are reported in Table 2. The changes from t1 to t2 were analyzed *via* *t*-tests, but there were no significant differences between the pre- and post-intervention in communication (not matching H1a), psychological safety (not supporting H1b), nor in team performance perception (not matching H1c). There was a significant difference in perceived patient safety risks (supporting H1d). On average, perceived patient safety risks were higher before (M_{T1} = 3.220, SD_{T1} = 0.735) than after the intervention (M_{T2} = 2.887, SD_{T2} = 0.902). This change with a difference score = 0.333, 95% CI [0.092, 0.573] was statistically significant ($t(67) = 2.760$, $p = 0.007$) (Table 2).

Multiple regression analysis revealed no significant association between perceived psychological safety at t1 and less perceived

TABLE 2 Sample descriptive using *t*-test for preintervention and post-intervention equality of means.

Variable scores	Timepoint 1			Timepoint 2			*t(df)*	*p*	Effect size (*d*)
	n	*M*	*SD*	*n*	*M*	*SD*			
Communication behavior	68	4.64	0.68	68	4.56	0.71	0.89(67)	0.377	0.108
Psychological safety	67	4.45	0.94	67	4.51	0.83	−0.50(66)	0.617	−0.061
Patient safety risk	68	3.22	0.73	68	2.89	0.90	2.76(67)	0.007	0.335
Team performance perception	67	4.90	0.63	67	4.90	0.81	0.00(66)	1.000	0.000

t-tests for dependent samples and equality of means to analyze differences in pre- and post-intervention scores.

patient safety risks (not supporting H2a) or higher perceived team performance perception at t2 (not supporting H2b)[2].

Overall, 34.0% of the team performance perception's variance could be explained with psychological safety and communication thereby.

3.2. Mediation analyses

The mediation analysis that was conducted to examine the association between self-reported psychological safety (t1) and patient safety risks (t2) with the mediator interpersonal communication (t2) only partly supported H2 and H3. Psychological safety (t1) was not associated with perceived patient safety risks (t2) directly ($\gamma_1' = .259$, $p = 0.038$), and there was no significant total standardized effect ($\gamma_1 = 0.096$, $p = 0.468$). Psychological safety (t1) was associated with communication (t2; $\alpha_1 = 0.329$, $p = 0.013$). Furthermore, communication (t2) was significantly associated with patient safety risks (t2; $\beta_1 = -0.497$, $p < 0.001$; Figure 1). Lastly, bootstrapping procedures using 5,000 resamples revealed a significant standardized indirect effect of psychological safety (t1) on patient safety risks (t2) mediated by communication (t2; $\alpha_1^*\beta_1 = -0.163$, 95% CI [−0.310, −0.046]). Overall, 31.6% of the risk's variance could be explained with psychological safety and communication thereby.

The mediation analyses examining the association between psychological safety (t1) and team performance perception (t2) with the mediator interpersonal communication (t2) also did not reveal the hypothesized direct effects but again showed a significant indirect effect. Psychological safety (t1) was not associated with team performance perception (t2) directly ($\gamma_2' = 0.010$, $p = 0.931$), and there was no significant total standardized effect ($\gamma_2 = 0.200$, $p = 0.141$). Psychological safety (t1) was associated with communication (t2; $\alpha_2 = 0.329$, $p = 0.012$). Furthermore, communication (t2) was significantly associated with team performance perception (t2; $\beta_2 = .574$, $p < 0.001$; Figure 2). Lastly, bootstrapping procedures using 5,000 resamples revealed a significant standardized indirect effect of psychological safety (t1) on team performance perception (t2) mediated by communication (t2; $\alpha_2^*\beta_2 = 0.189$, 95% CI [0.044, 0.370]).

2 While analyzing the participating obstetric units separately in multiple regression analyses, no differences were seen across the clinics. The results revealed no significant association between perceived psychological safety at t1 and less perceived patient safety risks (not supporting H2a) or higher perceived team performance perception at t2 (not supporting H2b) for both participating obstetric units.

4. Discussion

The current study's aim was to examine psychological mechanisms of a communication team training to increase patient safety and team performance perception, as well as psychological safety as an important antecedent of interpersonal communication. The present research illustrates that communication is crucial for safety performance as a mediating factor in healthcare teams such as obstetrics.

Surprisingly, contrary to our assumptions, there were no significant pre- and post-differences before versus after the training in interpersonal communication, psychological safety, nor team performance perception. This speaks for rather stable, resisting patterns and little change over time. However, as predicted, perceived patient safety risks decreased post-training. Regarding interpersonal communication, psychological safety, and team performance perception, HCW's already high scores at the first time point could be attributed to several biases, such as social desirability (Chung and Monroe, 2003), a ceiling effect (Wang et al., 2009), or the better-than-average-effect that describes the propensity to rate oneself better than others, e.g., in behavior or norms (Alicke et al., 1995; Sedikides et al., 2005). Regarding the ceiling effect, HCWs already considered their perceived interpersonal communication as very high before the training. This could have been a biased assessment, but it also could reflect actual high standards in the university hospitals. Accordingly, no decrease can also be seen as an advantage, especially as the stable pattern can be attributed to the intervention but also just a contextual effect as no control group was used as a comparator. As part of the communication team training, participants learned and dealt with challenges and misassumptions of interpersonal communication embedded in teamwork scenarios, which may lead to a higher reflection of their own and team (communication) competencies (Koole et al., 2011). Hence, it is likely that the assessment of the team and own skills became more critical after the intervention.

The communication intervention was designed as a 4-h training. Steinemann et al. (2011) demonstrated a 4-h concept of team training, which was associated with improved teamwork and clinical performance for multidisciplinary trauma teams. Emerging from this study, we conclude that the brief intervention time is suitable to maintain patient safety and team performance

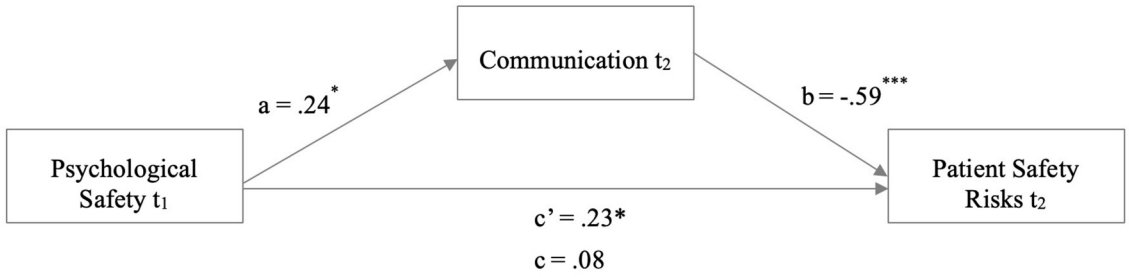

FIGURE 1
Mediation analysis with the outcome variable patient safety risks. Mediation analysis in an obstetric HCW sample. Coefficients are reported as unstandardized regression coefficients for the relationship between psychological safety and patient safety risks mediated by communication. $^{*}p < 0.05$ and $^{***}p < 0.001$.

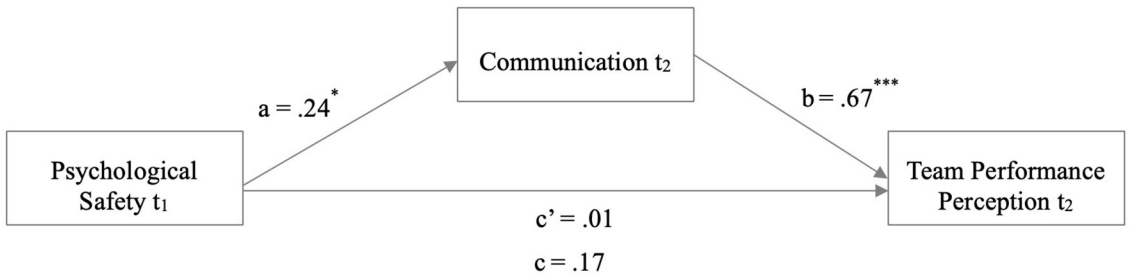

FIGURE 2
Mediation analysis with the outcome variable team performance perception. Mediation analysis in an obstetric HCW sample. Coefficients are reported as unstandardized regression coefficients for the relationship between communication and team performance perception mediated by psychological safety. $^{*}p < 0.05$ and $^{***}p < 0.001$.

perception. To achieve a successful transfer into the daily work routine, HCWs require specific conditions to train under time-critical, stressful, and complex simulations (Hughes et al., 2016); therefore, all training modules and debriefings varied in conditions and difficulty levels.

The training aimed to address central communication challenges. The participants were educated about non-congruence of individuals' thought worlds (mental models), for which intersections can be established through communication. Mental models are mental representations, which capture an individual's understanding of a particular area in their mind. They are an essential concept for organizations and teamwork to improve learning since the understanding of how information is constructed and how individuals behave requires the use of mental models. The training provided the introduction and discussion of mental models in relation to communication (Rook, 2013). Therefore, the training focused on communication processes to create a shared understanding (Verdonik, 2010). The Tangram exercise aimed to practice the quality of interpersonal communication. Clarity is the degree to which interpersonal communication avoids purposeful or unintentional vagueness, ambiguity, and ambiguous language, as opposed to communication accuracy, which relates to the correctness of transmitted message contents (e.g., validity of information; Hannawa et al., 2017). The Tangram exercises depicted communication challenges and aimed to facilitate communication more accurately and sufficiently.

The "Zurich resource model"-picture postcards are in line with psychotherapeutic assumptions that individuals have most of the resources to solve problems within themselves. The postcards contain images that triggered positive feelings (Krause and Storch, 2006). Therefore, the training aimed to induce positive resources (positive associations of birth), which have translated into communication to be shared with other team members and professional groups to gain insights into differences and commonalities. The discussion of the picture postcards, which were associated with an optimal birth, led to the realization that everyone has different ideas of birth. Thus, differences in mental models came into language and hence shared mental models could come into being, which is in line with organizational learning eventually appears through individual members (Rook, 2013).

Furthermore, different from previous expectations, no significant associations between perceived psychological safety (t1) and decreased patient safety risks (t2), as well as increased team performance perception (t2) after the training, could be found. Research depicts the maladaptation of healthcare organizations by suffering from stiff, profession-based hierarchies, hindered open error discussions, and tendencies to blame individuals instead of understanding errors as system-generated (Tucker et al., 2007). To counteract these problematic factors, research has illustrated psychological safety as crucial for such demanding work structures as it ensures high-quality care and patient safety (O'Donovan et al., 2021). Adding to this literature, the

current study empirically demonstrates psychological safety as a fundament of safe communication that, in turn, can improve patient safety and team performance perception. Thus, the study provides further guidance on how to deal with difficult teamwork and structural challenges in the healthcare system.

Moreover, it has been shown that applying the ISBAR strategy in handovers is related to increased patient safety, interprofessional teamwork, awareness of communication (errors), and professional roles (Haddeland et al., 2022). The intervention simulated teamwork and communication challenges by handovers and introduced ISBAR as structured handover tool. Despite existing handover guidelines at both hospitals, the background information about the importance of standardization and structurization of handovers was well-received as fostering patient safety.

Current literature points out that psychological safety supports interpersonal communication, which is required for teamwork and patient safety (Lei, 2014; Jain et al., 2016). Nevertheless, there are inconsistencies in the direction of the association between psychological safety and communication (Siemsen et al., 2009). Studies show that if psychological safety is lacking, patients and healthcare providers interfere with effective care by withholding important information (patients' information, e.g., ambiguity or HCWs knowledge, e.g., research findings; Jain et al., 2016). Moreover, psychologically safe teams tend to discuss more freely with fewer boundaries and risk of being blamed (more voice and speaking up behavior; O'Donovan et al., 2021). Although the advantages of increasing psychological safety within healthcare teams have been demonstrated, interventions are needed to implement these in daily care (O'Donovan and McAuliffe, 2020).

Our study meets O'Donovan and McAuliffe (2020)'s call for interventional needs and practical implementation by implicating that psychological safety predicts communication. Our mediation model revealed that psychological safety as input is only associated with patient safety and team performance perception as output through communication as an intervening mechanism, which is further validated by the IPO model (Stewart and Barrick, 2000).

Effective communication has been broadly found to be positively linked to improved individual, team, and organizational performance. In healthcare, communication is associated with higher patient and HCW's satisfaction, learning, collaboration, and performance outcomes (Jain et al., 2016; O'Donovan and McAuliffe, 2020). Communication errors are primarily discovered in hierarchical conflicts as well as interpersonal conflicts and power issues, thus reflecting poor psychological safety (Yanchus et al., 2014).

Therefore, speaking up was introduced to educate the competence to raise concerns and challenge authority for safety reasons. Speaking up is essential to improve patient safety; nevertheless, it is difficult to speak up due to fear of negative consequences (e.g., career loss and job difficulties), fear of rejection, or disciplinary consequences (Okuyama et al., 2014). Consequently, the training addressed authority gradients and how to deal and communicate errors by practicing speaking up situations in a psychological safe case simulation. In psychologically safe environments, employees described better interpersonal communication and had a higher level of feeling more secure in speaking up, asking questions, and exchanging ideas (Yanchus et al., 2014; O'Donovan and McAuliffe, 2020). Thus, psychological safety fosters an atmosphere that helps team members communicate safer to prevent errors and increase teamwork due to higher team performance perception. To address challenges, our interdisciplinary and interprofessional communication training simulated these difficult interpersonal situations and introduced specific communication strategies such as empathy maps or shared understanding.

As already described before, psychological safety supports patient safety, collaboration, learning from mistakes, and adverse events (Hirak et al., 2012; Arnetz et al., 2019), as well as speaking up behavior or the reduction in silence behavior (Newman et al., 2017). Therefore, in line with Kolbe et al. (2020), psychological safety is an essential requirement for efficient debriefings. We regard the built-in debriefings in the training as fundamental to train and improve communication and handling mistakes in a psychological safe training environment.

The empathy map training element elaborated the other professional and patient perspective about (work) tasks, feelings, thoughts, and fears. Empathy includes the ability to understand other perspective (e.g., of patients or colleagues) and to communicate the individual understanding which could lead to a shared understanding (Cairns et al., 2021). The exercise frequently showed conflict potential between the professional groups by not feeling adequately represented. Nevertheless, empathizing with another professional group, sharing similarities (e.g., common goals and fears), and differences were brought into communication which could support an understanding of another's perspective. The empathy map exercise can be related to establishing psychological safety by training to respect other perspectives.

In sum, challenges of team communication, speaking up, and handovers were interactively demonstrated and trained with appropriate strategies and exercises such as tangram, closed-loop communication, speaking up, structured handovers (ISBAR), and debriefings. Thus, the training aimed to challenge and train effective communication under psychologically safe conditions to address misassumption of communication and how to generate a shared understanding of each other's (team members and patients) thoughts, feelings, and meanings to enhance communication interactions to increase patient safety (Hannawa et al., 2017).

4.1. Limitations of the current research and suggestions for future studies

There are a few limitations that must be considered while interpreting the results. First, no randomized-controlled trial with a control group was implemented to ensure all patients' safety. The reasons for which no control group was realized in this study were two-fold: First, we aimed to provide the intervention to all healthcare workers as quickly as possible so that team communication could be improved, and more birthing persons would benefit (ethical reasons). Other reasons were more practical, including the anticipated rather small sample size and potential spill-over effects compromising the study design, as well as the need to compare clinical routine data before and after the intervention to establish effects on clinical outcomes. The intervention was part of a larger communication project targeting healthcare workers and pregnant women from both psychological and medical perspectives

so that clinical outcomes were investigated in different publications (e.g., Hüner et al., 2023). Nevertheless, changes in communication behavior from t1 and t2 should not be interpreted in terms of intervention effects as alternative explanations could account for improvements and causality cannot be established.

While analyzing HCWs' ratings, it is important to be aware of the limits of self-reported measurements, such as social desirability. The lack of validated scales in prior research led to the necessity to newly develop or modify scales. Therefore, several proposed measures have lower reliability, which must be considered a weakness of the study. Another potential risk of the self-reported scales in this setting is the risk of common source bias, potentially leading to less reliable results than objective indicators. Nevertheless, data were collected at two hospitals from team members with a wide range of characteristics, such as professional occupation, age, and experience, as well as main operational areas (e.g., postpartum units, delivery rooms, and surgical theater) and responsibilities to reduce common source bias.

There is also literature showing that perceptions of performance differ from the actual performance (e.g., Kruger and Dunning, 1999). Observational studies, objective data monitoring, or qualitative interviews, as well as an RCT design, could have helped to understand intervention effects. Over the scope of the research project, clinical routine data were analyzed comparing a time frame after the training with a time frame before the intervention (Hüner et al., 2023). Nevertheless, understanding subjective perceptions is crucial for comprehending shared work reality and mental representations (e.g., regarding psychological safety). Future studies should combine validated measures with more objective and change-sensitive measures such as incident reporting systems, routine data analysis, or patient assessments, introducing a control group and mixed-method approaches. As it was not possible to link perceptions of performance with objective team performance in this study, future research is required.

During the study course, the COVID-19 pandemic influenced the implementation of the intervention. Therefore, the presence and accompanying restrictions of COVID-19 must be considered while interpreting the findings. Our trainings were interrupted; thus, there were longer time lags of 4 to 5 months between the training and surveys. Hence, immediate changes might not have been captured. On the contrary, more long-term training mechanisms might have been uncovered which has been a challenge in previous research. HCWs were confronted with unpredictable threats, fear of infection, psychological stress, and heavy workload (Uzun et al., 2020). For example, face masks and social distancing were important protection activities; however, face masks have greatly impacted communication by muffling noise, reducing facial expressions, and creating distance (Mheidly et al., 2020). These burdens may have affected the assessments and interventions. As an alternative explanation, the intervention and surveys could have offered a reflection and learning platform of interpersonal communication and teamwork, which could have helped HCWs to better cope with the negative consequences of COVID-19. More frequent time points of measurement, including a follow-up and taking team structure into account when conducting analyses, would have been required to capture all changes in communication, but they were not possible to implement.

The high drop-out rate and small sample size could be related to the additional burden of the pandemic and the specifications of the teaching hospitals that may have prevented HCWs from participating in data collection. The results from this study may only be generalizable to interpersonal communication in obstetrics due to the relatively small sample size; other healthcare sectors need to be addressed. Future research designs could work with more follow-up measures in randomized-controlled trials to broaden our understanding of changes over time.

4.2. Implications for practice

According to our findings, it can be concluded that psychological safety is the initial input variable to train HCWs' interpersonal communication skills to foster patient safety and team performance perception. It can be seen that there is a lack of interventions aiming to improve psychological safety in healthcare teams and precise, objective measurements to identify when psychological safety is low and to monitor changes over time (O'Donovan and McAuliffe, 2020). Therefore, our intervention can be used as a template to design further studies on psychological safety and communication in healthcare teams. The length of our training (4 h) guaranteed an integration into the daily routine; nevertheless, longer and more intensive interventions could increase long-term effects. Larger samples should be targeted to counteract higher drop-out rates.

The implementation of health services research into everyday healthcare is associated with great challenges and resembles change processes which are often met with criticism and resistance. Further studies should ensure that internal staff with leadership functions are involved in the implementation process so that the project can be successfully implemented (Kumar, 2013). In addition, the organizational level should be incorporated ideally with a co-creative approach to ensure sustainability of the effects.

The healthcare system has no tolerance for errors; paradoxically, human mistakes are unavoidable. The medical system does not adequately educate HCWs because technical skills and examination techniques are often addressed, but handling errors and teamwork is not trained (enough). For example, physicians are seen as principal decision-makers, which neglects a system approach of a team decision process. Therefore, our communication training in a teamwork setting is indispensable filling the gap to deal with errors adequately (Robertson and Long, 2018). The introduction of systemic trainings for professionals and HCWs under training is important to bring sustainable system transformations aiming at patient safety and teamwork. The creation of expert positions dealing with social skills and system thinking in hospitals could lead to fast and efficient handling of human errors to increase the quality of care and relieve teams. The training manual can be accessed and used for free (German language).

5. Conclusion

Given the difficulty of patient care and different human competence problems, such as frequent communication

breakdowns, can result in unintended patient harm. High-quality care and patient safety require effective teamwork and communication. To meet these requirements, our interpersonal and interprofessional team training represents a novel approach as it brings together interpersonal communication and psychological safety in the context of patient safety although the effects still need to be researched further.

In sum, our study results underscore that psychological safety may have positive effects on perceived team performance perception and inhibiting effects on perceived patient safety risk. These effects appear mediated by interpersonal communication. The reported data are embedded in the IPO model of team effectiveness underlining the psychological mechanism. Our research model displays teamwork and team complexities in healthcare by indicating communication as fruitful intervening mechanism in a psychological safe training environment to promote patient safety and team performance perception.

Data availability statement

The data for this study are not publicly available due to data protection guidelines. The data are available on request from the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by Ethics Committee at Jacobs University Bremen (dated September 17, 2019); University Hospital of Ulm Human Research Ethics Committee (Number 114/19); University Hospital of Frankfurt Medical Research Ethics Committee (Number 19–292). The patients/participants provided their written informed consent to participate in this study.

Author contributions

JED contributed to the conceptualization and study design, data collection, statistical analysis, interpretation of the analyses, and wrote the first draft of the manuscript. CD supervised and managed the data collection, supervised the analyses, and reviewed sections of the manuscript. FMK contributed to the statistical analysis, interpretation of the analyses, and reviewed sections of the manuscript. SL contributed to conception and design of the study, supervised the data collection, analyses, and reviewed the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2023.1164288/full#supplementary-material

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EDITED BY
Margarete Boos,
University of Göttingen, Germany

REVIEWED BY
Eleonora Orena,
IRCCS Carlo Besta Neurological Institute Foundation, Italy
Sven Staender,
Männedorf Hospital, Switzerland

*CORRESPONDENCE
Eliane Timm-Holzer
✉ eliane.timm@unibe.ch
Franziska Tschan
✉ Franziska.tschan@unine.ch
Guido Beldi
✉ guido.beldi@insel.ch

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No signs of check-list fatigue – introducing the StOP? intra-operative briefing enhances the quality of an established pre-operative briefing in a pre-post intervention study

Eliane Timm-Holzer[1]*, Franziska Tschan[1]*, Sandra Keller[1,2], Norbert K. Semmer[3], Jasmin Zimmermann[1], Simon A. Huber[3], Martin Hübner[4], Daniel Candinas[2], Nicolas Demartines[4], Markus Weber[5] and Guido Beldi[2]*

[1]Institute for Work and Organizational Psychology, University of Neuchâtel, Neuchâtel, Switzerland, [2]Department of Visceral Surgery and Medicine, Berne University Hospital, University of Berne, Berne, Switzerland, [3]Department of Psychology, University of Berne, Berne, Switzerland, [4]Department of Visceral Surgery, University Hospital Lausanne (CHUV), Lausanne, Switzerland, [5]Department of Surgery, Triemli Hospital, Zurich, Switzerland

Background: The team timeout (TTO) is a safety checklist to be performed by the surgical team prior to incision. Exchange of critical information is, however, important not only before but also during an operation and members of surgical teams frequently feel insufficiently informed by the operating surgeon about the ongoing procedure. To improve the exchange of critical information during surgery, the StOP?-protocol was developed: At appropriate moments during the procedure, the leading surgeon briefly interrupts the operation and informs the team about the current Status (St) and next steps/objectives (O) of the operation, as well as possible Problems (P), and encourages questions of other team members (?). The StOP?-protocol draws attention to the team. Anticipating the occurrence of StOP?-protocols may support awareness of team processes and quality issues from the beginning and thus support other interventions such as the TTO; however, it also may signal an additional demand and contribute to a phenomenon akin to "checklist fatigue." We investigated if, and how, the introduction of the StOP?-protocol influenced TTO quality.

Methods: This was a prospective intervention study employing a pre-post design. In the visceral surgical departments of two university hospitals and one urban hospital the quality of 356 timeouts (out of 371 included operation) was assessed by external observers before (154) and after (202) the introduction of the StOP?-briefing. Timeout quality was rated in terms of timeout completeness (number of checklist items mentioned) and timeout quality (engagement, pace, social atmosphere, noise).

Results: As compared to the baseline, after the implementation of the StOP?-protocol, observed timeouts had higher completeness ratings (F=8.69, p=0.003) and were rated by observers as higher in engagement (F=13.48, p<0.001), less rushed (F=14.85, p<0.001), in a better social atmosphere (F=5.83, p<0.016) and less noisy (F=5.35, p<0.022).

Conclusion: Aspects of TTO are affected by the anticipation of StOP?-protocols. However, rather than harming the timeout goals by inducing "checklist fatigue," it increases completeness and quality of the team timeout.

KEYWORDS

teamwork in surgery, surgical checklist, intraoperative briefing, patient safety, teamwork in medicine, team intervention

1. Introduction

Besides technical and medical proficiency, teamwork and communication within surgical teams have been identified as crucial factors that impact the surgical process and outcomes (Mazzocco et al., 2009; Sun et al., 2018; Paterson-Brown et al., 2019). In operation rooms (OR), establishing good teamwork is particularly challenging: During surgery, professionals with complementary roles must collaborate. At the operating table, two or more surgeons have to cooperate very closely with each other and with the scrub technician who provides instruments. Anesthesia providers ensure that the patient remains under anesthesia and stable; they often work in parallel with the surgeons, sometimes having to synchronize very closely with them. Circulators are responsible for taking and bringing instruments to the operating table, while also performing administrative duties in parallel with the operation. Because of the different tasks, roles, and perspectives of the team members during an operation, maintaining a shared mental model and high situation awareness may be difficult (Graafland et al., 2015; Afkari et al., 2016). Other challenges to good teamwork in the OR are the notoriously high noise levels which may hamper communication (Keller et al., 2016; Leitsmann et al., 2021), low team familiarity (Kurmann et al., 2014; Stucky et al., 2021) and strong hierarchies, which may hamper psychological safety and diminish speaking up (Appelbaum et al., 2020).

Therefore, interventions have been introduced that aim at fostering better teamwork and communication in the OR (McCulloch et al., 2017; Sun et al., 2018). The best known and nowadays routinely followed intervention is the team-timeout which is part of the WHO surgical safety checklists. The team timeout (TTO) is performed before the operative procedure starts. It has the objective to ensure that OR team members are on the same page about the procedure to be performed and contains checklist items to confirm important information (Haynes et al., 2009). In addition to the team-timeout, other team-related interventions may be employed (McCulloch et al., 2017), such as CRM training, Sun et al. (2018), other checklists (Lyons and Popejoy, 2014), or the StOP?-protocol intraoperative briefing (Tschan et al., 2022) used in the present study.

If multiple interventions are combined or an intervention is added to an existing practice, an important question is whether interventions influence each other. Although there are indications that different team-related interventions may be favorably combined (Buljac-Samardzic et al., 2010; McCulloch et al., 2017) or positively influence one another (Okhuysen and Eisenhardt, 2002), interferences between interventions may also be possible. An example is the tendency to become complacent or even opposed to the use of multiple checklists or interventions, described as "checklist fatigue" (Grigg, 2015).

However, it has rarely been investigated empirically if, and how, interventions influence each other (Buljac-Samardzic et al., 2010). In this prospective observational study using a pre-post design, we evaluate the impact of the introduction of an intraoperative briefing (the StOP?-protocol) on the quality of an already existing briefing (the team-timeout) in surgical departments of three different hospitals.

1.1. The team timeout checklist intervention

In 2008, the World Health Organization (WHO) recommended checklist-based team briefings as a standard for surgical teams worldwide (Haynes et al., 2009). These briefings aim to reduce errors and enhance communication and teamwork. One of the recommended briefings is the team timeout (TTO), conducted at the time the patient is anesthetized and prepared, but just before incision. The minimal standard of the TTO includes presentation of all team members, confirming patient identity, surgical procedure, site of incision, and availability of critical images. Surgeons, anesthesia providers and the nursing team inform about anticipated critical events, and the approximate surgery duration is communicated.

In Switzerland, the TTO is not mandatory by law, but it has been adopted by most hospitals (Mascherek et al., 2013; Fridrich et al., 2022); including in the three hospitals participating in this study. Although the WHO suggests which aspects should be discussed during the TTO, it also recommends that the procedure should be adapted for each hospital, indicating that differences between hospital cultures may be important.

The surgical safety checklist (including the TTO) has been related to improved patient outcomes, Haugen et al. (2019), such as reduced negative events, morbidity, and mortality (Lyons and Popejoy, 2014; Haynes et al., 2017; Abbott et al., 2018), and improved team outcomes, including better coordination and communication (Kearns et al., 2011; Molina et al., 2016). Note that not all studies found positive effects (Urbach et al., 2014; Reames et al., 2015).

However, the effectiveness of the TTO depend on its correct use and quality (van Klei et al., 2012). Studies reported low adherence rate and a reluctant adoption of the procedure, particularly for surgeons (Hurlbert and Garrett, 2009), incomplete TTO execution (van Klei et al., 2012; Fridrich et al., 2022), and inattentiveness during the TTO (Biffl et al., 2015). These are not harmless omissions: If boxes are ticked without paying attention, the risk of error detection failures increases (Cullati et al., 2013), and a false sense of security may develop (Russ S. J. et al., 2015). Thus, active participation and commitment by all team members is crucial (Hicks et al., 2014) and team members should not engage in other tasks during the TTO

(Vogts et al., 2011). Furthermore, the TTO may create a sense of time pressure. Although a typical TTO takes less than two minutes, some feel that it is taking too long, and start to rush. This may result in omitting information (Vats et al., 2010; Conley et al., 2011) and create a sense of urgency that may induce tensions. A tense atmosphere during the TTO has been found to lead to dismissive communication later on (Vats et al., 2010) and to impaired collaboration throughout the surgery (Whyte et al., 2008; Cullati et al., 2013).

The importance of completeness and quality of the TTO points to the need to avoid additional burdens that may threaten the quality of the TTO. It is thus important to consider if the StOP?-protocol as an additional intervention influences the quality of the TTO.

1.2. The StOP?–Intervention

The TTO focuses on exchanging information to prevents omissions and errors, but it cannot cover all necessary information for the whole operation. More specifically, it cannot deal with specific developments that require adapted actions. Indeed, one of the main complaints of surgical team members is feeling under-informed *during* the operation due to the lack of regular updates from surgeons regarding the progress, specific strategic approaches and intraoperative strategy changes (Wauben et al., 2011). Such task-related information exchange during the operation is important, as more information exchange (Mazzocco et al., 2009) and particularly more case-relevant communication have been associated with better patient outcomes (Tschan et al., 2015).

Surgeons are not simply unwilling to share information during the operation with the team. Performing surgery demands high concentration, particularly on manual aspects of the task, and surgeries can be quite stressful for the surgeon (Yamaguchi and Kanemitsu, 2011). Both aspects can impair communication, and high concentration requirements on manual tasks may prevent the surgeon from focusing on the team's information needs, which requires a change in attentional focus. Focusing on the team constitutes a task in its own right (Fernandez et al., 2008). Stress can lead to team members losing the team perspective (Driskell et al., 1999). If surgeons do communicate as they go, but without a clear shift in attention, their communication may not be properly perceived by team members remote from the table.

To facilitate intraoperative information flow and regular updates, particularly from the surgeons to the team, we developed the StOP?-protocol. This protocol, led by the responsible surgeon, is an intraoperative briefing aimed at exchanging task-and cooperation-related information (Keller et al., 2022; Tschan et al., 2022). During the operation, the surgeon informs the team about the progress of the operation (**St** = status of the surgery), upcoming steps and goals (**O** = objectives), anticipated difficulties (**P** = problems), and encourages team members to ask questions and share observations (**?** = Questions or remarks). Information about status, objectives and potential problems aim at updating the team, asking for active participation aims at encouraging equal information exchange and speaking up (Edmondson, 2003). The structure of the StOP?-intervention is similar to other briefing interventions (Marks et al., 2000; Makary et al., 2006), except that it occurs during the operation at natural breakpoints between subtasks. Between subtasks, concentration requirements for specific aspects of the task are temporally reduced, and it is easier to switch attention to the team level. Multiple StOP?-briefings can be conducted during an operation; surgeons announce when they intend conducting a StOP?-briefing for a specific operation at the end of the TTO.

Research has shown that introducing the StOP?-protocol has positive effects on patient outcomes; it is related to a reduced mortality rate, fewer unplanned reoperations and fewer prolonged hospital stays (Tschan et al., 2022).

1.3. Can one team-intervention influence another?

Numerous patient safety interventions have been implemented in surgery over the years, often as a combination of interventions (McCulloch et al., 2017; Storesund et al., 2020).

Both inhibiting and enhancing influences or interferences between different interventions seem possible. For example, adding several checklists may lead to a sense of overregulation (Grigg, 2015) and loss auf of autonomy and even the feeling of infantilization, particularly if checklists are not perceived as well-suited to specific procedures (Grigg, 2015; Dekker, 2018). If checklists multiply, they may be perceived as a hindrance to timely and efficient work (Hales and Pronovost, 2006). If interventions target similar outcomes (as for the TTO and StOP?), people may perceive redundancy (Fourcade et al., 2012). This can create a negative attitude, and medical professionals may develop "checklist fatigue" (Hales and Pronovost, 2006; Grigg, 2015). This may lead to disengagement and reduced adherence (Stock and Sundt, 2015). It is thus possible that anticipating the StoP?-briefing induces aversion and reduces TTO quality.

However, interventions may also positively influence each other. The StOP?-protocol, for instance, builds on and complements the information provided by the TTO during the operation. This may render the information communicated during the TTO more meaningful and useful for the team. Another type of enhancement may be that the introduction of the StOP?-protocol draws attention to team cooperation. In a laboratory setting, Okhuysen and Eisenhardt (2002) explored how simple interventions to foster cooperation improved knowledge integration in groups. One interesting finding of their study was that each of three different interventions not only increased the specifically instructed behavior but spilled over to increase the use of cooperative strategies that were not explicitly instructed. The authors concluded that even simple interventions influence cooperation, as they direct the attention to the team-level and create "windows of opportunity" to switch attention from the task to the team level improving cooperative strategies. Indeed, one study found that teamwork interventions (as compared to system interventions) improved TTO checklist performance (McCulloch et al., 2017). Thus, the introduction of the StOP?-protocol may constitute such a window of opportunity, direct attention to the team process, and thus improve TTO quality. Finally, the introduction of single or combined interventions has been shown to positively influence safety attitudes and the safety climate, which may in turn improve the quality of safety measures (Haynes et al., 2011).

1.4. Research questions

Because both negative and positive effects of the introduction of a new briefing on an existing intervention are plausible, we do not formulate directed research questions.

The first research question thus was to compare the completeness and the quality of the TTO, as assessed by trained observers, before and after the StOP?-protocol was introduced, to assess potential effects of the additional intervention on the TTO.

A secondary research question was to evaluate differences between participating hospitals in completeness and quality of TTO as well as in the effect of the StOP? intervention on the TTO.

2. Methods

2.1. Sample

The study was conducted in the general surgery departments of two large Swiss University Hospitals and in the general and vascular department of a middle-sized urban hospital. These hospitals agreed to participate in a larger study that aimed to investigate the effects of the StOP?-protocol on patient outcomes, using a before-after design and comparing a nine-month baseline with nine-month intervention period (Tschan et al., 2022).

For this smaller observational study, we strove to assess a mix of elective surgeries from the larger study that was typical for each hospital. Criteria to include operations during the nine-month baseline period were elective general or vascular surgeries with an expected duration of more than 1 hour, and observers had to be available. Exclusion criteria were a preexisting surgical site infection (e.g., re-operation after the patient suffered an infection) or another surgery at the same site within the last 30 days. During the intervention period, case-mix and observer availability were once again limiting factors, but we aimed to match the proportion of the different types of surgery observed during the baseline period. In total, 371 operations were observed; and a TTO was performed in 366 of these operations (98.7%). The sample size was determined by the eligibility criteria, and we did not conduct a post-hoc power analysis in accordance with current recommendations (Dziak et al., 2020). The characteristics of the operations are reported in the result section. Due to the typically unstable composition of surgical teams, which can change even within an operation (Stucky and De Jong, 2021); and to assure confidentiality, we did not collect data on specific team members. All analyses are on the team level.

2.2. Measures

2.2.1. Characteristics of operations

Operations performed were coded into 11 different categories as (1) Upper gastrointestinal (GI) tract (e.g., small bowel) (2) Lower GI tract (e.g., hemicolectomy), (3) Liver (e.g., liver resection). (4) Pancreas (e.g., Whipple procedure), (5) Hernia (e.g., inguinal hernia), (6) cholecystectomy, (7) Gastric bypass/sleeve, (8) Kidney transplants, (9) Thoracoscopy (e.g., wedge resection), (10) vascular surgery (e.g., vascular bypass), and (11) other procedures. Data for patient age and gender were collected for each operation.

2.2.2. Intervention, context

It was coded whether the operation took place during the baseline or during the intervention period (0.1). To account for organizational differences, it was coded in which of the three hospitals (A, B, C) the intervention took place, using a dummy code.

2.2.3. Team timeout completeness

The goal of the TTO is to assure that all mandatory checklist items are checked before incision. Team timeout completeness (i.e., discussing each item on the list) therefore is an important quality measure (Cullati et al., 2013; Pickering et al., 2013; Fridrich et al., 2022). TTO completeness indicates whether the items on the checklist are referred to. However, hospitals are encouraged to adapt the TTO checklist to their specific circumstances and needs (Weiser et al., 2010); therefore, the number of items on the checklist, the number of mandatory items to discuss, as well as the specific way of performing the TTO differed across hospitals. In Hospital A, the TTO had eleven items, all of them mandatory. The TTO was initiated and led by the circulating nurse who read out aloud each of the items. Responses were provided by the person responsible for the respective information (e.g., the anesthesiologist for allergies, the surgeon for potential blood loss, the scrub nurse for instruments). In Hospitals B and C, the TTO was initiated by the responsible surgeon and predominantly entailed communication between the surgeon and anesthesiology providers. The TTO checklist of Hospital B had six items, two were mandatory (patient identity and planned procedure); the TTO of Hospital C had six items, three of them mandatory (patient identity, planned procedure, prophylactic antibiotics). In hospital B and C, the non-mandatory items were only mentioned if considered relevant by the surgeon or anesthetists. To assure comparability across hospitals, TTO completeness was calculated as proportion of mandatory items communicated for each hospital. TTO completeness for Hospital A was the proportion of the 11 mandatory items discussed. For Hospital B and C, we calculated two completeness scores; one related to the mandatory items (B: 0, 0.5 or 1; C: 0, 0.33, 0.66 or 1), and one expressed as proportion of all six items on the list (all items). If the communication during the TTO was not audible enough to determine if an item was mentioned or not, the data was coded as missing; scores were only calculated if there was data for every item. None of the hospitals had established a formal sign-out procedure.

2.2.4. Team timeout quality

The TTO quality was assessed by trained observers (work psychologists) using an adapted version of known TTO quality measures (Vogts et al., 2011; Fourcade et al., 2012; Levy et al., 2012; Pickering et al., 2013; Russ S. et al., 2015). In addition to contextual aspects of the TTO (e.g., who was present, who initiated it), which are not reported here, four components of TTO quality were assessed: **Engagement** during TTO was assessed using a 5-point Likert scale ranging from *not committed* (1) to *committed* (5); **Pace** of the TTO was assessed using a 5-point Likert scale ranging from *rushed* (1) to *calm* (5); **Social climate** was assessed using a 5-point Likert scale ranging from *irritated* (1) to *serene* (5); **Noisy conditions** was assessed using a 5-poing Likert scale ranging from *no noise* (1) to *very noisy* (5). The scales provided explicit categories for the extremes, and observers were instructed to indicate the level of agreement based on the numerical values assigned to each option. After reversing the noise item, the quality components were combined into a quality index, which demonstrated good internal consistency (Cronbach's $\alpha = 0.697$). About 9% (N = 33) of the observed TTO were assessed independently by two observers, and intra class correlation (ICC) was calculated to

assess inter-observer agreement, yielding good results (engagement: ICC = 0.741; pace: ICC = 0.818; social climate: ICC = 0.749; noise: ICC = 0.854).

2.3. Study design

This was a prospective intervention study employing a pre-post design. The implementation consisted of the introduction of the StOP?-protocol described in the introduction. During the baseline period, the surgical team did not get any instruction related to their behavior or communication. To prepare the intervention, surgeons were individually trained on how and when to perform the StOP?-protocol. Scrub technicians and circulators as well as anesthesia providers were also informed about the StOP?-protocol.

Observer-based assessment of TTO completeness and quality during the baseline period (9 months) before the implementation of the StOP?-protocol was compared with observations during the intervention period. All TTO were observed *in vivo* by observers present in the OR. Surgical team members were aware of the presence of observers, but neither the members of the surgical team nor the members of the observational team were aware of the specific research question.

The study was conducted in accordance with the principles outlined in the Helsinki protocol for human subject research and was approved by the ethics committees (leading committee #161/2014). Consent from the team members to be observed was based on an opt-out procedure; teams were asked for permission to be observed before the operation, and each member of the team could at any moment before and during the process ask the observers to leave. Patient consent for two hospitals was based on general consent; in one hospital, the local ethical committee also approved inclusion of operations for patients who did not refuse the use of their data.

2.4. Statistics

Descriptive statistics are reported as means and standard deviations, or counts and percentages for categorical variables. To compare TTO quality before and after the intervention across the hospitals, we conducted 2×3 factorial ANOVA's, with the StOP?-intervention (before, after) and the hospital (Hospital A, Hospital B, Hospital C) as fixed factors. Pairwise comparisons (before and after the intervention and between the hospitals) were assessed based on estimated marginal means and were Bonferroni adjusted; differences between hospitals in the rate of change were assessed by an intervention x hospital interaction effect; effect sizes are partial eta squared. Interobserver reliability was assessed by intraclass correlation (ICC). P less than 0.05 was considered statistically significant. We used SPSS 28 for all analyses (IBM, 2021).

3. Results

3.1. Characteristics of operations

A total of 371 operations were observed. Table 1 shows the mix of operations observed during the baseline and intervention period for each hospital. Comparing the proportion of surgery types observed before and after the intervention yielded no significant differences, indicating successful matching.

3.2. Team timeout completeness

In 356 of the 366 operations with observed TTO, completeness of the time-out procedure could be assessed. Descriptive statistics and ANOVA results of TTO completeness are displayed in Table 2. Our analysis focuses on the mandatory items of the checklist; for results concerning all items (which were very similar), see Supplementary Table S1. Analyses showed a positive effect of the StOP? intervention on TTO completeness (Table 2, line "Intervention"). Regarding hospitals, TTO completeness was significantly higher in Hospital A than in Hospitals B and C. Completeness was somewhat higher in Hospital B as compared to Hospital C, but that difference was not significant. These results indicate that the introduction of the StOP?-protocol did have positive effects on the completeness of the TTO. There was no significant interaction effect (intervention × hospital).

3.3. Team timeout quality

Descriptive statistics and ANOVA results for the TTO quality index and for each of the components of the quality index are displayed in Tables 3, 4. Analyses show a significant positive relation between the StOP? intervention and the TTO quality index (Table 3), line "Intervention"), but also for each component separately (Table 4), line "Intervention," indicating that engagement, pace, and social climate during the TTO improved during the StOP? intervention, whereas noise during TTO decreased. Regarding the secondary research question, the analyses showed that TTO quality in Hospital A was significantly higher than in Hospital B before, but also during the intervention, both for the quality index and for the quality components (line "between hospitals" in Tables 3, 4). For Hospital C, the intervention had no significant effects on the quality index nor on the components engagement, pace and noise, and the component social climate in Hospital C was actually significantly lower after the intervention; the interaction hospital x intervention was significant for the quality index and the components engagement, social climate, and noise, but not for pace of the TTO, indicating that the intervention had differential effects in different hospitals.

4. Discussion

The introduction of the StOP?-protocol in surgical wards was associated with the improvement in the quality of the TTO. These improvements encompassed completeness, engagement, pace, social climate, and noise conditions. Thus, the additional briefing did not have a negative effect on the already established briefing; rather, the intervention was related to a better TTO quality. Even in the hospital where the TTO did not improve following the intervention, only one component, social climate, declined significantly; the other components, did not change significantly.

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TABLE 1 Operations observed during baseline and Intervention per hospital.

		Hospital A		Hospital B		Hospital C	
		Baseline	Intervention	Baseline	Intervention	Baseline	Intervention
N		76	75	43	77	46	54
Patient Age		58.41	58.55	56.02	62.32	64.66	61.58
Sex	Male (56.6%)	43	49	25	41	25	27
	Female (43.4%)	33	26	18	36	21	27
Type of surgery							
	Upper GI tract	7	8	4	7	2	2
	Lower GI tract	11	12	9	16	5	11
	Liver	16	13	7	11	1	2
	Pancreas	16	14	7	10	3	3
	Hernia	4	4	1	7	12	11
	Cholecystectomy	4	4	4	12	7	8
	Gastric bypass/ sleeve	6	5	6	6	4	4
	Kidney transplants	8	8		1		
	Thoracoscopic					5	6
	Vascular surgery					4	6
	Other	4	7	5	7	3	1
Chi^2			1.46 (df = 8, p = 0.99)		4.78 (df = 8, p = 0.78)		3.57 (df = 9, p = 0.94)

Chi^2 statistics refer to the difference between surgical type during baseline and intervention period, per hospital.

TABLE 2 Timeout completeness before and after the StOP?–Intervention and between hospitals: mandatory items.

TTO completeness (mandatory items)											
	Total		Baseline		Intervention						
	N	*M* (SD)	*N*	*M* (SD)	*N*	*M* (SD)	Difference** intervention –baseline (SE)	95% CI for difference	*F*	*P*	Partial eta squared
Model									6.75	<0.001	
Intervention	356	0.95 (0.14)	154	0.94 (0.16)	202	0.97 (0.12)	0.05 (0.02)	0.002 to 0.08	8.69	0.003	0.024
Hospital A	149	0.99 (0.04)	76	0.99 (0.51)	73	1.00 (0.10)					
Hospital B	116	0.94 (0.20)	39	0.91 (0.25)	77	0.96 (0.16)					
Hospital C	91	0.90 (0.16)	39	0.86 (0.17)	52	0.94 (0.15)					
							Difference** between Hospitals	95% CI for difference	*F*	*P*	
Between Hospitals									13.62	<0.001	0.072
Hospital A–B							0.06 (0.02)	0.02 to 0.1			
Hospital A–C							0.09 (0.02)	0.05 to 0.14			
Hospital B–C							0.04 (0.02)	−0.01 to 0.08			
Intervention × Hospital									1.47	0.232	0.008

*Completeness scores are shown as proportions. ** Based on estimated marginal means.

These results are consistent with the findings by Okhuysen and Eisenhardt (2002) in a different field, as well as with previous research investigating the effects of team training interventions on TTO quality (McCulloch et al., 2017). One possible explanation for this effect is that an additional briefing opens the opportunity for teams to focus their attention on the team level. This may positively influence cooperative behavior beyond the specific target of the intervention. The effect could be due to momentary effects, whereby the anticipation

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TABLE 3 Quality index TTO before and after the StOP?-intervention and between hospitals.

Quality index TTO*											
	Total		Baseline		Intervention						
	N	*M* (SD)	*N*	*M* (SD)	*N*	*M* (SD)	Difference** intervention −baseline (SE)	95% CI for difference	*F*	*P*	Partial eta squared
Model									31.87	<0.001	
Intervention	366	4.03(0.72)	162	3.90(0.75)	204	4.12(0.68)	0.30 (0.07)	0.17 to 0.43	21.53	<0.001	0.056
Hospital A	149	4.25 (0.59)	76	4.08 (0.59)	73	4.43 (0.54)					
Hospital B	118	3.53 (0.77)	41	3.13 (0.68)	77	3.53 (0.76)					
Hospital C	99	4.28 (0.49)	45	4.31 (0.54)	54	4.26 (0.45)					
							Difference** between Hospitals	95% CI for difference	F	P	
Between Hospitals									71.25	<0.001	0.284
Hospital A–B							0.82 (0.08)	0.64 to 1.01			
Hospital A–C							−0.03 (0.08)	−0.22 to 0.16			
Hospital B–C							−0.85 (0.08)	−1.05 to-0.65			
Intervention × Hospital									7.47	0.001	0.040

*The quality index is the mean of engagement, pace, social atmosphere and (reversed) noise, range from 1 to 5. **Based on estimated marginal means.

of the StOP?-briefing enhances the overall attention of the team. However, it could also be a more general effect, resulting from the information and training provided for the StOP? intervention, as well as the regular refresher training. These activities may have served as reminders to team members about the importance of information exchange and collaboration in the OR.

There were marked differences in TTO quality between the hospitals, as well as some significant interaction effects, indicating differences in the impact of the intervention across hospitals. Notably, although there was an overall positive association between the StOP?-protocol and TTO quality, introducing the StOP?-protocol did not influence the quality of the TTO index or its components engagement, pace, and noise conditions in Hospital C. This lack of impact may be due to a ceiling effect, as the values in Hospital C were already close to the scale maximum before the intervention and were higher compared to the other hospitals, leaving limited room for improvement. However, the social climate during the TTO in Hospital C was significantly lower after the introduction of the StOP?. Again, this outcome may be explained by a ceiling effect or a regression toward the mean effect. Note that the social climate score before intervention was 4.7 (on a scale from 1 to 5) which decreased to 4.44 after the intervention. Social climate was markedly higher in Hospital C than in the other hospitals before the intervention but was similar and still high after the intervention. Nevertheless, alternative explanations cannot be ruled out.

When comparing hospitals, the overall TTO quality in Hospital B was lower than in Hospital A, both before and after the introduction of the StOP?-protocol. In general, hospital effects were larger than the effects of the intervention, as indicated by the partial eta squared measure. This finding confirms the presence of cultural differences between hospitals, a well-established fact (Sexton et al., 2006; Körner et al., 2015).

There was concern regarding the potential of negative effects of the StOP-protocol on the TTO, because it could lead to perceived redundancy and checklist fatigue (Hales and Pronovost, 2006; Grigg, 2015). In healthcare, some level of redundancy is generally favored as it enhances safety by reducing the risk of errors with multiple checks by different persons (Sivathasan et al., 2010). However, too much redundancy can also lead people to skip information checking, as they feel the information was already checked enough (Fourcade et al., 2012; Papaconstantinou et al., 2013). That the StOP?-intervention evidently did not lead to perceived inappropriate redundancy during the TTO and did not negatively impact the TTO quality suggests that the addition of a single briefing was not enough to induce a sense of overload. Moreover, note that the StOP?-protocol addresses other kinds of information than the TTO. Therefore, it may not be perceived as "just another checklist," but rather as the exchange of task-and cooperation-relevant information pertaining to the procedure and to strategic changes. This argument is supported by the positive effects of the StOP?-protocol on patient outcomes (Tschan et al., 2022), and team outcomes, such as perceived collaboration quality, situation awareness, and ease of speaking up (Tschan et al., Submitted). Additionally, the StOP? protocol is not time-consuming to perform and easy to follow, and it facilitates communication among the members of the team.

This study has several limitations. Firstly, the sample size is relatively low, as only surgeries could be included for which observers were available which may also limit the representativeness of the surgeries performed. In addition, all participating surgical departments are located in midsize and large hospitals and predominantly specialize in general (visceral) and vascular surgery, thus limiting the generalizability of the findings to other surgical specialties and smaller settings.

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TABLE 4 Quality of TTO for the quality components engagement, pace, social climate and noise before and after the StOP?–intervention and between Hospitals.

Engagement during TTO											
	Total		Baseline		Intervention						
	N	*M* (SD)	*N*	*M* (SD)	*N*	*M* (SD)	Difference* intervention –baseline (SE)	95% CI for difference	*F*	*p*	Partial eta squared
Model									17.22	<0.001	
Intervention	366	3.93 (0.97)	162	3.78 (1.01)	204	4.04 (0.93)	0.35 (0.10)	0.16–0.54	13.48	<0.001	0.036
Hospital A	149	4.14 (0.74)	76	3.95 (0.73)	73	4.34 (0.63)					
Hospital B	118	3.39 (1.15)	41	3.00 (1.18)	77	3.60 (1.08)					
Hospital C	99	4.25 (0.79)	45	4.22 (0.88)	54	4.28 (0.71)					
							Difference* between Hospitals	95% CI for difference	F	P	
Between hospitals									38.36	<0.001	0.176
Hospital A–B							0.85 (0.11)	0.58 to 1.12			
Hospital A–C							−0.11 (0.12)	−0.38 to 0.17			
Hospital B–C							−0.95 (0.12)	−1.25 to −0.66			
Intervention × Hospital									2.47	0.09	0.014

Pace of TTO											
	Total		Baseline		Intervention						
	N	*M* (SD)	*N*	*M* (SD)	*N*	*M* (SD)	Difference* intervention –baseline (SE)	95% CI for difference	*F*	*p*	Partial eta squared
Model									8.93	<0.001	
Intervention	366	3.84 (1.12)	162	3.64 (1.18)	204	4.00 (1.05)	0.44 (0.12)	0.22 to 0.67	14.85	<0.001	0.040
Hospital A	149	4.07 (1.01)	76	3.87 (1.06)	73	4.29 (0.92)					
Hospital B	118	3.43 (1.14)	41	2.98 (1.17)	77	3.68 (1.15)					
Hospital C	99	3.98 (1.04)	45	3.87 (1.16)	54	4.07(0.93)					
							Difference* between Hospitals	95% CI for difference	*F*	*p*	
Between hospitals									16.97	<0.001	0.086
Hospital A–B							0.75 (0.14)	0.43 to 1.08			
Hospital A–C							0.11 (0.14)	−0.23 to 0.44			
Hospital B–C							−0.65 (0.15)	−1.00 to −0.29			
Intervention × Hospital									1.39	0.25	0.008

Social climate TTO											
	Total		Baseline		Intervention						
	N	*M* (SD)	*N*	*M* (SD)	*N*	*M* (SD)	Difference* intervention –baseline (SE)	95% CI for difference	*F*	*p*	Partial eta squared
Model									9.03	<0.001	
Intervention	366	4.31 (0.80)	162	4.22 (0.82)	204	4.40 (0.77)	0.20 (0.08)	0.04 to 0.36	5.83	0.016	0.016
Hospital A	149	4.35 (0.80)	76	4.21 (0.81)	73	4.49 (0.77)					

(Continued)

TABLE 4 (Continued)

Social climate TTO											
	Total		Baseline		Intervention						
	N	*M* (SD)	*N*	*M* (SD)	*N*	*M* (SD)	Difference* intervention −baseline (SE)	95% CI for difference	*F*	*p*	Partial eta squared
Hospital B	118	4.07 (0.88)	41	4.03 (0.84)	77	4.37 (0.82)					
Hospital C	99	4.60 (0.58)	45	4.70 (0.51)	54	4.44 (0.60)					
							Difference* between Hospitals	95% CI for difference	*F*	*p*	0.081
Between hospitals									15.88	<0.001	
Hospital A– B							0.37 (0.10)	0.14 to 0.60			
Hospital A–C							−0.22 (0.10)	−0.45 to 0.02			
Hospital B–C							−0.58 (0.11)	−0.84 to −0.33			
Intervention × Hospital									7.37	0.001	0.039

Noise** during TTO											
	Total		Baseline		Intervention						
	N	*M* (SD)	*N*	*M* (SD)	*N*	*M* (SD)	Difference * intervention −baseline (SE)	95% CI for difference	*F*	*p*	Partial eta squared
Model									32.47	<0.001	
Intervention	366	1.98 (1.10)	162	2.03 (1.08)	204	1.95 (1.03)	−0.22 (0.10)	−0.41 to −0.03	5.32	0.022	0.015
Hospital A	149	1.56 (0.78)	76	1.71 (0.88)	73	1.40 (0.64)					
Hospital B	118	2.79 (1.11)	41	3.15 (0.99)	77	2.60 (1.13)					
Hospital C	99	1.67 (0.77)	45	1.56 (0.73)	54	1.76 (0.80)					
							Difference*between Hospitals	95% CI for difference	*F*	*p*	
Between Hospitals									78.75	<0.001	0.304
Hospital A–B							−1.32 (0.11)	−1.59 to −1.05			
Hospital A–C							−0.10 (0.12)	−0.38 to 0.17			
Hospital B–C							1.21 (0.12)	0.92 to 1.51			
Intervention × Hospital									4.88	0.008	0.026

*Based on estimated marginal means. **less noise indicates better quality.

Another limitation is that random assignment was not feasible for this intervention, so a pre-post design had to be employed. Furthermore, participants and observers were aware of the intervention, as this could not be blinded. However, neither the surgical teams nor the observers were aware of the specific research question investigated in this paper, mitigating some potential biases.

Also, we cannot entirely exclude the possibility that an item was not registered despite being mentioned in the TTO because the observer simply did not hear (or understand) it. But even if we account for this possibility, the increased TTO completeness remains noteworthy. Furthermore, the TTO should be executed loud enough to be audible for the whole OR, even for someone at the other side of the room. Lastly, like in any observational study, there is the limitation that other unmeasured factors or variables could have influenced the results.

This study has practical implications, demonstrating that the already established TTO procedure benefited from another briefing intervention overall in two out of the three hospitals. In addition, even in the hospital that did not show improvement, results did not indicate an effect akin to "checklist fatigue" or a negative impact on the TTO. While the TTO has been recognized for its positive effects on team collaboration (Lingard et al., 2008), its scope and purpose are limited. This study demonstrates that an additional intervention fostering information exchange during the operation can be beneficial and even improve the quality of an already established briefing. However, it is crucial to note that the effectiveness of each additional intervention cannot be assumed and needs to be investigated individually.

Data availability statement

The datasets presented in this article are not readily available because the raw data are available upon request from the corresponding author to

researchers eligible to work with codified personal health care data under Swiss legislation. Eligibility will be determined by Kantonale Ethikkomission Bern when needed. Requests to access the datasets should be directed to guido.beldi@insel.ch.

Ethics statement

The studies involving human participants were reviewed and approved by Kantonale Ethikkommission Bern (KEK); KEK-Gesuchs_Nr: 161/14. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

ET-H, FT, SK, NS, GB, DC, ND, and MW: study conception. ET-H, JZ, and SH: data collection (including conceptual aspects). ET-H and FT: data analysis. ET-H, FT, SK, NS, JZ, MH, MW, DC, ND, and GB: substantial contributions to manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

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Margarete Boos,
University of Göttingen, Germany

REVIEWED BY
Begoña Urien,
University of Navarra, Spain
Alberto Crescentini,
University of Applied Sciences and Arts of Southern Switzerland, Switzerland

*CORRESPONDENCE
Sebastian Gerbeth
✉ Sebastian.gerbeth@ur.de

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Team behaviors as antecedents for team members' work engagement in interdisciplinary health care teams

Sebastian Gerbeth* and Regina H. Mulder

Faculty of Human Sciences, University of Regensburg, Regensburg, Germany

Introduction: Due to the increasing complexity and diversity of work tasks in teams, teams need team members who are dedicated and energetic, both characteristics attributed to team members' work engagement. Especially in the domain of health care, high demands at work impact professionals' work engagement. Despite teams being the main work unit in this domain, team research on antecedents of work engagement has been neglected. The present study examines the role of team behaviors such as reflection activities in the relationships between demands at work and team members' work engagement. In doing so, the study aims to extend findings on team behaviors by considering cognitive and work-task related team behaviors as well as team behaviors that focus on emotional aspects.

Methods: Data of 298 team members of 52 interdisciplinary teams of health and social care organizations which provide care and assistance were collected in this cross-sectional survey study. Relationships between team demands at work, team learning behaviors, dealing with emotions in the team and team members' work engagement were estimated in a mediation model using structural equation modeling (SEM).

Results: The results indicate that team members' work engagement is positively related to team learning behaviors and dealing with emotions in the team. Cognitive team demands at work such as the complexity of work tasks, were found to relate positively to team members' work engagement, while emotional team demands such as the amount of emotional labor at work had a negative relationship. Team learning behaviors and dealing with emotions in the team were found to mediate the relationship between team demands at work and team members' work engagement.

Discussion: Our results provide insights into the actual behavior of teams in the domain of health care, both on cognitive and emotional aspects, and the capability of team learning behaviors and dealing with emotions in the team to mediate the relationship between team demands at work and team members' work engagement. The findings encourage future researchers and practitioners to address cognitive, emotional and motivational components in team research to provide a better understanding of team conditions, team behavior and team outcomes.

KEYWORDS

work engagement, team learning behaviors, team emotions, work teams, structural equation model

1. Introduction

Interdisciplinary teams have become an essential part of work in the last century and are needed to fulfill diverse tasks with high complexity (Van der Haar et al., 2008; Rosen et al., 2018). Particularly in the field of caring and assistance, teams in health and social care organizations often need to collaborate and cooperate with the patient, the patient's family, physicians, psychologists, and other experts to ensure that the patient's needs and goals are met. Teams are defined as a group of two or more individuals who interact socially to achieve common goals and perform content-related tasks while depending on each other (Kozlowski and Ilgen, 2006). Due to the increasing complexity and diversity of work tasks, teams need team members who are dedicated and energetic, both characteristics attributed to the team members' work engagement. Work engagement is defined as a positive work related affective and cognitive state characterized by vigor, dedication, and absorption (Schaufeli et al., 2006). Engaged team members have a lot of energy and perseverance for their work tasks and are proud and enthusiastic about the team and their work in the team, which is especially important for the work carried out by teams in health care. Work engagement is related to various work outcomes such as performance, commitment, health and turnover intention (Halbesleben, 2010; Mazzetti et al., 2021; Neuber et al., 2022). Work engagement is a predictor of performance at individual level and team level in health and social care organizations (Tims et al., 2013). Engaged employees have higher performance (Halbesleben and Wheeler, 2008; Christian et al., 2011; Reina-Tamayo et al., 2018) and low levels of mental health such as anxiety and depression (Innstrand et al., 2012). Accordingly, work engagement is negatively related to turnover intention (De Simone et al., 2018; Wan et al., 2018).

Antecedents of work engagement are demands at work such as challenging and hindering demands. Challenging demands, which have the potential to contribute to performance and learning, have a positive effect on work engagement. Hindering demands, which create constraints that hinder the achievement of work goals, have a negative effect on work engagement (Cavanaugh et al., 2000; Mauno et al., 2007; Breevaart and Bakker, 2018; Riedl and Thomas, 2019; Uhlig et al., 2023). While at the individual level there is empirical evidence on how work engagement is influenced by antecedents and how it impacts various outcomes, the nested structure of organizations also highlights other levels, such as work teams. For example, employees in full-time residential homes for the disabled have to work in teams due to the full-time care of their patients. There is a lack of studies that consider especially variables at the team level as antecedents to team members' work engagement, and that uses a multilevel perspective considering team members being influenced by the teamwork, their team leader and the team (Bakker and Demerouti, 2017). Therefore, the aim of this present study is to provide insights into the demands of teams and their influence on team members' work engagement. Furthermore, the missing link, being the actual behavior of the team members and its impact on work engagement, needs further investigation. Insights into these relationships are lacking so far.

When teamwork occurs, team members are carrying out team behaviors that constitute team member interaction, such as discussing or reflecting on work. Team learning behaviors (TLBs) are defined as team activities team members are carrying out to effectively accomplish work tasks. Teams that share and exchange knowledge between their members, create common understandings and new knowledge, reach agreement by constructively combining and discussing opinions and reflect on their teamwork are recognized as teams carrying out a high amount of TLBs (Widmann and Mulder, 2020) and therefore, represent teams with high cognitive and work-task related team behaviors. TLBs lead to change and improvement in the team (Decuyper et al., 2010). In addition, TLBs were found to predict team performance (Leicher and Mulder, 2016) and team cognition such as shared mental models (Widmann and Mulder, 2020), and parts of TLBs such as team reflection were also found to affect work engagement (Matsuo, 2020; Gupta et al., 2022). Since the objective of this study is to provide insights into the role of team behaviors on team members' work engagement, we focus on the actual interactions within the team instead of the outcomes of these interactions, such as team cognitions. In teams of health and social care organizations, team behaviors are observed to be not only cognitive and work-task related, but include emotional and social aspects (e.g., in patient care). Dealing with emotions in the team consists of activities such as commonly reflecting about occurring emotions in the team or expressing and influencing positive emotions such as gratitude. Dealing with emotions in the team represents team behaviors focused on emotional aspects and is so far neglected in team research.

Mathieu et al. (2019) highlighted the complexity and multilevel perspective of teamwork by recognizing team characteristics and demands, team behaviors and structural features as mediators of outcomes such as team effectiveness and performance. Employees carry out cognitive and work-task related team behaviors such as TLBs and team behaviors focused on emotional aspects such as the dealing with emotions in the team to cope with the variety of complex tasks and demands present in teamwork. The objective of the present study is to fill the knowledge gap on team behaviors as antecedents of individual's outcomes by increasing insights into the role of team behaviors for the relationships between the demands that teams face in their work and team members' work engagement in the domain of care and assistance. Therefore, the following research question will be answered:

> *Do team learning behaviors and dealing with emotions in the team mediate the relationships between team demands at work and team members' work engagement?*

To answer this research question, we formulated three sub-questions:

> *To what extend do teams that provide care and assistance to the elderly, youth, physically and/or mentally disabled engage in team learning behaviors and dealing with emotions in the team?*
>
> *Do team learning behaviors and dealing with emotions in the team predict team members' work engagement?*
>
> *Do team demands at work predict team learning behaviors and dealing with emotions in the team?*

2. Theoretical background

2.1. Work engagement

The concept of work engagement was first pioneered by Kahn (1990) describing employees' work engagement as the employment and expression of personal energies to emotional, cognitive and physical labor. Engaged employees become physically involved in tasks, emotionally connected to other employees relevant for their work and cognitively vigilant, while disengaged employees withdraw and show passive behavior that is characterized by physical absence, a lack of emotional connections and cognitive inattention. Due to the behavior of disengaged employees, work engagement is also considered the opposite of Burnout (Maslach and Leiter, 2008), but Schaufeli et al. (2002) argue that work engagement is distinct from burnout, which is characterized by vigor, dedication, and absorption. Vigor is defined as an employee's energy, mental resilience while working, and willingness to invest effort. Dedication refers to the degree of enthusiasm, inspiration, pride, and appreciation for an employee's own work, and absorption describes a state of being completely focused and fully involved in one's work.

Based on Vroom's (1964) Expectancy Theory, team members' motivation, which can foster their work engagement, depends on the demands at work and the belief that the team member will successfully cope with them (expectancy), associated with the belief that coping with the demand will lead to an outcome (instrumentality) that is valued or attractive (valence). Accordingly, work engagement can be influenced by behaviors of the team members themselves and the processes that occur in teams through the interactions of team members. These interactions between team members can be related to cognition (e.g., in team learning behaviors) and can be related to emotions (e.g., in dealing with emotions in the team). This is consistent with research that indicates that inputs are transformed into outcomes such as work engagement through cognitive, verbal, emotional, and behavioral processes (Marks et al., 2001). In addition, the degree of interaction is central as fewer opportunities for interaction lead to fewer experience of vigor, dedication, and absorption within the work (Costa et al., 2012).

2.2. Team learning behaviors

According to Vygotsky's (1978) Sociocultural Theory, learning, and especially learning in the workplace occurs in social interactions. Thereby, cognitive and social processes influence individual learning and development embedded in teams and organizations (Van den Bossche et al., 2006). Team learning is defined as interplay of complex and dynamic team level processes that lead to change or improvement for teams and their members (Decuyper et al., 2010) and can directly influence team outcomes such as performance and shared mental models (Leicher and Mulder, 2016; Widmann and Mulder, 2020). These processes consist of TLBs referring to team activities team members are carrying out such as sharing, discussing and developing knowledge, ideas and structures and obtaining feedback and reflecting (Edmondson, 1999; Lehmann-Willenbrock, 2017).

There are three basic team learning behaviors (knowledge sharing, co-construction and constructive conflict) that are crucial for the team's function as "they describe what happens when teams learn" (Decuyper et al., 2010, p. 117). Wiese et al. (2022) argue that knowledge sharing is different from co-construction and constructive conflict because knowledge sharing is an important prerequisite for co-construction and constructive conflict, but is not sufficient for a team to learn. *Knowledge Sharing* refers to the exchange of knowledge and structures between team members and can help teams to reach a common knowledge level (Widmann and Mulder, 2020). *Co-construction* is defined as team activities that lead to the creation of new knowledge, structures or common meanings in the team by refining, building on or modifying knowledge, experiences and information (Van den Bossche et al., 2006). *Constructive conflict* describes the process of reaching agreement in the production of new knowledge, recognizing that different team members may not always coincide and therefore some form of team agreement must be reached (Decuyper et al., 2010; Raes et al., 2015). Constructive conflict addresses the handling of different opinions by open communication, negotiation and verification in form of directly commenting or asking critical questions (Van den Bossche et al., 2011). *Team reflection* is defined as reflection and discussion activities on current teamwork, goals, structures and how to adapt as a team for the achievement of future work goals (Decuyper et al., 2010). Team reflection is a facilitating team learning behavior providing context for the basic team learning behaviors (Raes et al., 2015).

Organizations, teams and team leaders affect team members' work engagement by creating job resources (for example support, autonomy or group cohesion) that could be used to deal with work tasks (Bakker, 2017; Tummers and Bakker, 2021). When carrying out TLBs team members are interacting, reflecting, developing and working together which could foster social relatedness (e.g., promoting dialogue and exchange), the feeling of competence (e.g., promoting the creation of common vision, optimizing team structure and work processes, and the fulfillment of work tasks) and the feeling of autonomy (e.g., creating individual learning opportunities, encouraging to contribute own opinions, experiences, knowledge and ideas). Therefore, TLBs can be considered as an underlying resource mechanism that fosters the basic needs for autonomy, relatedness and the feeling of competence formulated in the Self-Determination Theory (Deci and Ryan, 2000), which postulates that motivation can be increased by satisfying the basic needs. In turn, motivated employees have higher levels of work engagement (Shkoler and Kimura, 2020). Furthermore, satisfaction of basic needs itself yields positive work outcomes such as work engagement, well-being and enhanced work performance (Deci et al., 2017).

Furthermore, referring to Flow Theory (Csikszentmihalyi, 1990) individuals can experience flow during activities, that are characterized by a deep involvement in a task while experiencing feelings of energy, focus and success in the process of task completion. Studies found positive correlations between experiencing flow and outcomes such as job satisfaction, intrinsic motivation, and vigor (Csikszentmihalyi and LeFevre, 1989; Demerouti et al., 2012). There has been an increasing interest in flow in work teams, as teams (through their complex tasks, common goals, and interdependencies) engage in team activities that fulfill the preconditions for flow experiences (Walker, 2010; van den Hout et al., 2018, 2019). We argue that TLBs are potential team activities that could lead to flow experiences in teams or within team members as TLBs are goal-directed, occur in cognitive demanding tasks and are based on mutual commitment, open communication and trust (Decuyper et al., 2010). This is in line with the reciprocal

relationships between TLBs and positive emotions such as pleasure, confidence, solidarity, and contentment during teamwork (Watzek et al., 2022).

Therefore, we formulate:

> *Hypothesis 1*. Team learning behaviors are positively related to work engagement.

2.3. Dealing with emotions in the team

In addition to cognitive processes in the team, processes in relation to emotions in the team can influence work engagement. At the individual level emotional competence and emotional intelligence that consists of the perception of own or others' emotions, the expression, and the management of emotions (Stamouli, 2014; Mayer et al., 2016), were found to influence employee's work engagement (Gong et al., 2020; Tesi, 2021). Mindeguia et al. (2021) found team emotional intelligence to have a positive effect on passion and group cohesion, that as job resource is an antecedent of work engagement (Costa et al., 2014; Tesi, 2021). The concept of team emotional intelligence is examined by differences in "the ability of a group to generate a shared set of norms that manage the emotional process in a way that builds trust, group identity and group efficacy" (Druskat and Wolff, 2001, p. 138). Existing research highlights that emotions have been recognized as crucial factors in teams and organizational dynamics (Kelly and Barsade, 2001; Menges and Kilduff, 2015). There is research on the role of emotions in teams (e.g., Cahour, 2013; Watzek and Mulder, 2019), but studies that investigate what teams actually do when team members are confronted with emotions during teamwork are missing.

Team processes related to emotions in teams are characterized by behaviors of team members to commonly perceive emotions, express and regulate emotions occurring during teamwork. Thereby, team members themselves shape their collective emotional experiences through their interactions and behavior, leading to the emergence of shared norms and expectations within the team (Wolff et al., 2006). Therefore, *dealing with emotions in the team* is defined as team activities, shared by at least two team members, focused on emotions that arise in the team. *Dealing with emotions in the team* consists of team activities such as discussing, reflecting, or exchanging about the emotions in the team, for instance to understand and recognize present emotions and to cope with encountered emotions in the team. In addition, team activities of expressing and reacting to emotions, for instance to be sensitive to the emotions of the team members, to express positive and negative emotions and to actively influence emotions.

Bakker (2022) posits that the social-psychological construct of emotional contagion is as an explanatory approach to the emergence of work engagement in teams. Based on the concept of emotional contagion that refers to processes whereby emotions are transferred among team members (Barsade, 2002) it is argued that dealing with emotions in the team can influence team members' affects and behaviors. Additionally, recognizing work engagement as a positive affect (high levels of activation and pleasure; Bakker and Oerlemans, 2011) which can be observed by other team members could in accordance with the Emotion As Social Information Theory (Van Kleef, 2009) lead to further work engagement of other team members. Following the different theoretical foundations, and in line with results indicating that emotions in teams increases performance (Watzek et al., 2022) the expectation is that team members' work engagement is increased by dealing with emotions in the team, which leads to the second hypothesis:

> *Hypothesis 2*. Dealing with emotions in the team is positively related to work engagement.

2.4. Demands at work

Team members face a variety of job demands that determine their teamwork and the work of each team member separately. Demands at work can be classified as either quantitative or qualitative in nature. Quantitative demands refer to the *amount of work* that needs to be accomplished within a certain amount of time and the *work pace* that refers to the speed and urgency of tasks to be fulfilled (Kristensen et al., 2004). Qualitative demands refer to the content of work such as cognitive demands and emotional demands. *Cognitive demands* refer to the complexity of tasks and the amount of problem-solving and decision-making required for accomplishing tasks, whereas *emotional demands* arise from interactions with clients and colleagues, which can be emotionally stressful (Crawford et al., 2010; Bakker and Demerouti, 2017).

Crawford et al. (2010) identified inconsistencies in the research on the relationships between demands at work and work engagement, that could be explained by the Transactional Theory of Stress (Lazarus and Folkman, 1984). This theory posits that individuals appraise stressful situations as either threatening or promoting for mastery and growth. The challenge and hindrance framework of Cavanaugh et al. (2000) supports this reasoning by differentiating between challenging demands, that are appraised as potential to contribute to achievement and learning by creating positive feelings of fulfillment, and hindering demands, that create constraints that hinder work goal achievement. Combined with the aforementioned Expectancy Theory (Vroom, 1964) challenging demands are positively related to work engagement. In contrary, hindering demands are negatively related to work engagement. Emotional demands in nursing and care, for example, require a high level of emotional labor (e.g., calming down an angry patient) that may be overwhelming and exhausting, and as a result may threaten a team member's motivation to continue working with the patient.

In addition, in practice work pace and cognitive demands were found to be positively related to work engagement, while the amount of work and emotional demands are negatively related to work engagement (Crawford et al., 2010; Breevaart and Bakker, 2018; Riedl and Thomas, 2019; Uhlig et al., 2023). Accordingly, based on this argumentation the amount of challenging and hindering demands influence TLBs and dealing with emotions in the team. While the amount of work in the team and tasks to be done may decrease sharing or collaborative interaction due to splitting of work tasks, we postulate that cognitive demands, which describe the complexity of the work tasks to be done, require increased collaboration and cooperation and lead to more discussion to reach agreement, thereby increasing team activities. Therefore, we assume that demands at work influence TLBs,

dealing with emotions in the team and team members' work engagement.

> *Hypothesis 3a.* The amount of work is negatively related to TLBs, dealing with emotions in the team and team members' work engagement.
>
> *Hypothesis 3b.* Work pace is positively related to TLBs, dealing with emotions in the team and team members' work engagement.
>
> *Hypothesis 3c.* Cognitive demands at work are positively related to TLBs, dealing with emotions in the team and team members' work engagement.
>
> *Hypothesis 3d.* Emotional demands at work are negatively related to TLBs, dealing with emotions in the team and team members' work engagement.
>
> *Hypothesis 4.* TLBs and dealing with emotions in the team mediate the relationship between demands at work and team members' work engagement.

To answer our research question Figure 1 presents our research model.

3. Materials and methods

3.1. Study design and data collection

A cross-sectional survey was carried out with a questionnaire in an online as well as paper version. Teams from eight different organizations, that provide care and assistance to the elderly, youth, or physically and/or mentally disabled, were invited to participate. Data were collected from teams whose work tasks are delivering care (e.g., in full-time residential homes), nursing and assistance of people (e.g., treatment according to medical prescription for disabled). Furthermore, teams were selected that met the previously mentioned definition: (1) the team and their members have a common work goal; (2) team members are interdependent in fulfilling their work tasks for the goal; (3) the team consists of more than 3 team members; (4) team members consider themselves to be permanent members of the team. Informal consent was obtained prior of the study by all participants. Participation in the study was voluntary, and all participants were fully informed about the study prior to the data collection. Anonymity of participants, teams and organizations was maintained at all times by pseudonymizing the teams and organizations. No personal information (e.g., names, email) was gathered from the team members. Ethical approval was granted by the ethics committee of the university of Regensburg (no. 22-3077-101).

3.2. Sample

Team members ($N = 298$) from 52 different teams participated in the study. 78.8% of the participants were female (1 missing) and the average age was M (SD) = 40.23 (12.41; 9 missing). 42.1% of the team members were nurses, 28.3% were social or childcare workers, 2.4% were psychologists, 1% were team leaders and 23.1% were assistants. The average amount of work experience was M (SD) = 13.79 (11.26) years. For 23.5% the last job change was in the last 2 years, while 17% had their last job turnover over 10 years ago.

Teams had an average of M (SD) = 12.49 (6.27) team members and ranged from 4 to 28 team members. Most of the team members (59.9%) entered their team more than 2 years ago, while 23.9% did so in the last year. 5.9% joined their team in the last 3 months prior to the data collection (these were consistent with the participants who changed jobs in the last 3 months). Furthermore, in relation to team stability, it was found that 52.2% of the teams had the last gain of a team member over 3 months ago, and for 52,7% of the teams the last loss. This is consistent with the high employee turnover rate in the organizations in the field of caring. In addition, 71.9% of the participants of the study reported that they joined their team over 1 year ago. In the data there were no *ad hoc* or newly formed teams that were not able to report adequate data for our study.

3.3. Instrument

The questionnaire contained the following variables: *Team members' work engagement* was measured with the short version of the Utrecht Work Engagement Scale (UWES-9; Schaufeli and Bakker,

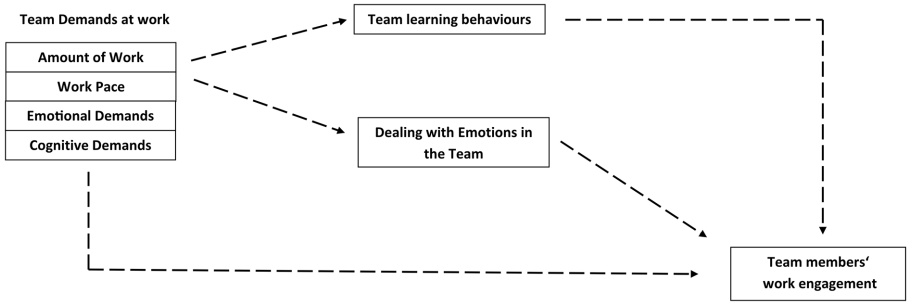

FIGURE 1
Research model.

2004) containing nine items on the extent to which employees identify with, are proud of, and enthusiastic about their work, and have a lot of energy and perseverance for their work tasks. With a 7-point Likert-type response format (1 = never to 7 = daily) the frequency of experiencing the three facets of vigor, dedication and absorption of work engagement was measured. An example item is: "*At my work, I feel bursting with energy*." Cronbach's α was 0.93.

The Copenhagen Psychosocial Questionnaire (COPSOQ II; Pejtersen et al., 2010; COPSOQ III; Lincke et al., 2021) was used to measure *team demands at work*. We adapted items of five scales of the German version of the COPSOQ III including the amount of work (4 items), work pace (3 items), cognitive demands (4 items), emotional demands (3 items). A 5-point Likert-type response format (1 = never to 5 = always) was used with a reference shift to the team level as for example "*does your team get behind with the work*" (amount of work). The Cronbach α's ranged from 0.65 to 0.87.

Team learning behaviors were measured with items covering *knowledge sharing, co-construction, constructive conflict,* and *team reflection*. *Knowledge sharing* was measured with eight items of Neumann (2017) with a Cronbach's α = 0.86. Co-Construction and constructive conflict were measured with ten items each (Widmann et al., submitted) with Cronbach's α ranging from 0.87 to 0.91. *Team reflection* was measured with eight items of Van Dick and West (2005; Cronbach α = 0.87). Example items are: "*we pass on task-relevant know-how in the team*" (knowledge sharing), "*we draw conclusions from the ideas discussed in the team*" (co-construction), "*we try to address disagreements in the team directly*" (constructive-conflict) and "*we regularly discuss whether the team is working together effectively*" (team reflection). The Likert-type response format ranged from 1 = "never" to 5 = "always."

For measuring *dealing with emotions in the team* we developed a scale with 32 items (Gerbeth et al., in preparation) that measure team activities such as discussing, reflecting, or exchanging about emotions (e.g.: *"we ask each other about the reasons for our current emotional state*", "*we reflect on emotional events that have engaged us as a team*") and expressions and reactions to emotions (e.g.: *"in our team we express our gratitude to each other for good work*", "*in our team, we respond sensitively to the emotions of team members*"). For assessing the frequency of engagement of the team in these activities a 5-point Likert-type response format mode ranging from 1 = "never" to 5 = "always" was used. Three items were removed due to poor quality and reliability. An exploratory factor analysis revealed a single-factor solution accounting for 42.06% of the variance. Cronbach's α was 0.95.

Furthermore, the control variables team size, team stability, gender, age and work experience (in years) were included in the questionnaire.

3.4. Analyses

Descriptive statistics and correlation analysis were carried out using IBM's SPSS Statistics 29 software. Because the data of team members in work teams are nested, within-group agreement using the multiple-item estimator ($r_{wg(j)}$) and the intraclass correlation coefficient (ICC) for constructs at team level was calculated. The $r_{wg(j)}$ and ICC values for TLBs, dealing with emotions in the team and team demands at work are presented. For TLBs ($r_{wg(j)}$ = 0.87–0.94), dealing with emotions in the team ($r_{wg(j)}$ = 0.96) and team demands at work ($r_{wg(j)}$ = 0.81–0.96) the $r_{wg(j)}$ values exceeded the proposed cut of value for aggregation of 0.70 (LeBreton and Senter, 2008). For ICC(1) the values of TLBs (ICC(1) = 0.15–0.26), dealing with emotions in the team (ICC(1) = 0.20), and team demands at work (ICC(1) = 0.21–0.44) exceeded the cut-off value of 0.12 (Bliese, 2000) while for ICC(2) the values varied from 0.51 to 0.82.

Structural equation modelling (SEM) was performed using MPLUS 8.2 with robust maximum likelihood estimation and the "type = complex" setting for nested data structure to adjust the standard errors of the regression coefficients (see Muthen and Satorra, 1995). The items were used as indicators of latent variables. For model estimation due to parsimony, item parceling for TLBs and dealing with emotions in the team was conducted by averaging scores of content related and substantially correlated items (Little et al., 2002). In the initial model team size, work experience and team membership were controlled for, but as there were no meaningful significant effects these variables were excluded in the following analyses due to parsimony. Because the χ^2-test is sensitive for moderate to large sample sizes (Chen, 2007), the comparative fix index (CFI), the root mean square error of approximation (RMSEA) and the standardized root mean squared residual (SRMR) are reported next to the χ^2 value for evaluating model fit of the structural equation models tested. We follow the recommendation of Hair (2014) that RMSEA values smaller than 0.08, SRMR values smaller than 0.10 and CFI values higher than 0.90 are satisfactory model fit and RMSEA values smaller than 0.06, SRMR values smaller than 0.08 and CFI values higher than 0.95 are good model fit. Respondents with missing data were removed prior to SEM analysis.

4. Results

4.1. Descriptive statistics and correlations

In Table 1 the means, standard deviations, Cronbach's alphas and zero-order correlations of all variables are listed. Team members reported high levels of work engagement. Based on the dimension scores according to the UWES norm (Schaufeli and Bakker, 2004) vigor is average (M = 4.75, SD = 1.35), dedication is high (M = 5.23, SD = 1.40), and absorption is high (M = 4.89, SD = 1.49). Furthermore, the mean scores indicate that teams and team members strongly engage in knowledge sharing, co-construction, constructive conflict and dealing with emotions in the team. In accordance with our assumption that these teams are particularly engaged in complex cognitive work tasks, team members reported high cognitive demands at work. Female respondents had higher levels of work engagement than males (T-test (df) = 2.71 (286), $p < 0.01$). There were no relevant significant relationships with age. Work experience (in years) relates negatively to work engagement, TLBs and dealing with emotions in the team, while there was a positive relationship with demands at work. Team members who joined their team recently reported higher work engagement while team members who had worked in their team for a few years reported higher amounts of work pace and less knowledge sharing. For team stability no relationships were found. For team size we found correlations with work engagement, cognitive demands and work pace. Correlation coefficients for team size, work experience and joining team are presented in Table 1.

TABLE 1 Descriptive statistics, internal consistency and zero-order correlations.

Variables	*M*	SD	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Work engagement	4.96	1.31	*0.93*												
2. Demands at work	3.28	0.52	0.08	*0.87*											
3. Quantitative demands	2.95	0.50	−0.05	0.66**	*0.75*										
4. Work pace	3.05	0.85	0.07	0.74**	0.34**	*0.84*									
5. Cognitive demands	3.79	0.74	0.22**	0.83**	0.34**	0.49**	*0.81*								
6. Emotional demands	3.26	0.71	−0.05	0.76**	0.43**	0.34**	0.56**	*0.65*							
7. Knowledge sharing	4.05	0.65	0.29**	0.14*	−0.03	0.11	0.28**	−0.01	*0.86*						
8. Co-construction	3.73	0.69	0.30**	0.15**	−0.06	0.15*	0.30**	−0.02	0.86**	*0.91*					
9. Constructive conflict	3.65	0.65	0.27**	0.07	−0.13*	0.09	0.23**	−0.06	0.81**	0.86**	*0.87*				
10. Team reflexion	3.28	0.73	0.29**	0.25**	0.01	0.20**	0.35**	0.12*	0.65**	0.78**	0.67**	*0.87*			
11. Dealing with emotions in the team	3.52	0.61	0.33**	0.19**	−0.01	0.16**	0.29**	0.08	0.75**	0.78**	0.76**	0.67**	*0.95*		
12. Work experience[1]	13.79	11.26	−0.15**	0.15*	0.05	0.15*	0.10	0.13*	−0.19**	−0.19**	−0.12	−0.15*	−0.15*		
13. Joining team[2]	3.78	1.45	−0.26**	0.13*	0.10	0.17**	0.01	0.11	−0.12*	−0.11	−0.08	−0.01	−0.05	0.41**	
14. Team size	12.49	6.27	0.16**	0.13*	0.00	0.13*	0.18*	0.05	0.03	0.02	0.00	0.04	−0.02	0.01	−0.20**

$N = 289$ (Teams > 33% or min. Three team members), Cronbach α (internal consistency) italic on the diagonal. [1]$N = 281$ and [2]$N = 274$ due to missing data. ** = $p < 0.01$, * = $p < 0.05$.

The correlations indicate positive relationships between work engagement and the TLBs knowledge sharing ($r = 0.29$, $p < 0.01$), co-construction ($r = 0.30$, $p < 0.01$), constructive conflict ($r = 0.27$, $p < 0.01$), team reflection ($r = 0.29$, $p < 0.01$) as well as with dealing with emotions in the team ($r = 0.33$, $p < 0.01$). These correlations are in accordance with the research model. Positive relationships were found between cognitive demands and TLBs ($r = 0.23$ to 0.35, $p < 0.01$) as well as dealing with emotions in the team ($r = 0.29$, $p < 0.01$). There were positive correlations between work pace and co-construction, team reflection and dealing with emotions in the team ($r = 0.15$ to 0.20, $p < 0.05$). The correlation analysis (Table 1) found high correlations among variables relating to team demands at work variables and between TLBs and dealing with emotions in the team. For reasons of potential multi-collinearity all predictor variables of team members' work engagement were centered, and the variance inflation factor (VIF) was checked. Demands at work variables did not exceed the VIF value of 2.5 (Johnston et al., 2018). Because the VIF values for TLBs and dealing with emotions in the team exceeded 2.5, separate models for TLBs and dealing with emotions in the team were tested to avoid problems with multicollinearity.

4.2. SEM

The model for TLBs (see Figure 2) achieved a good model fit ($N = 298$ team members, $n = 51$ teams; $\chi^2 = 472.387$, $df = 260$, $p < 0.001$; CFI = 0.951; RMSEA [CI] = 0.053 [0.045–0.061]; SRMR = 0.062). TLBs were related to team members' work engagement ($\beta = 0.19$, $p < 0.01$). The results support H1. Additionally, team members' work engagement was found to be positively related to cognitive demands ($\beta = 0.54$, $p < 0.01$) and negatively related to emotional demands ($\beta = -0.43$, $p < 0.01$). In total, $R^2 = 0.204$ of the variance of team members' work engagement was explained by the model. The results indicate positive relationships between cognitive demands and TLBs ($\beta = 0.67$, $p < 0.01$) and negative ones between emotional demands and TLBs ($\beta = -0.43$, $p < 0.01$). Therefore, H3c and H3d was supported. No relationships between the amount of work, work pace and team members' work engagement were found. So, there was no support for H3a and H3b. TLBs partially mediate the relationships of team members' work engagement with cognitive demands (indirect effect $\beta = 0.12$, $p < 0.01$) and with emotional demands (indirect effect $\beta = -0.07$, $p < 0.05$). These findings in part support hypothesis H4.

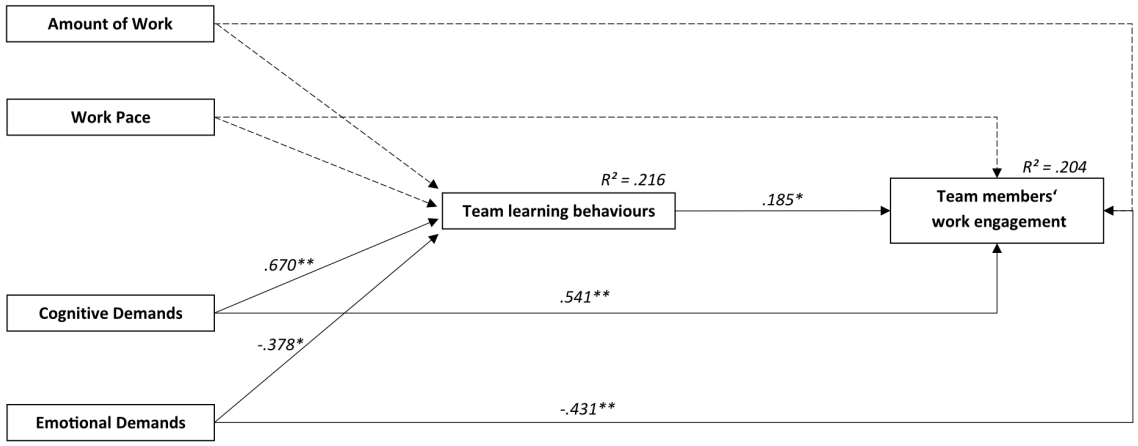

FIGURE 2
Relationships between team demands at work, team learning behaviors and team members' work engagement analyzed with structural equation modelling. Model-fit : X^2=472.387, *df*=260, CFI=0.951, RMSEA [CI]=0.053[0.045–0.061], SRMR=0.062. **p<0.01, *p<0.05.

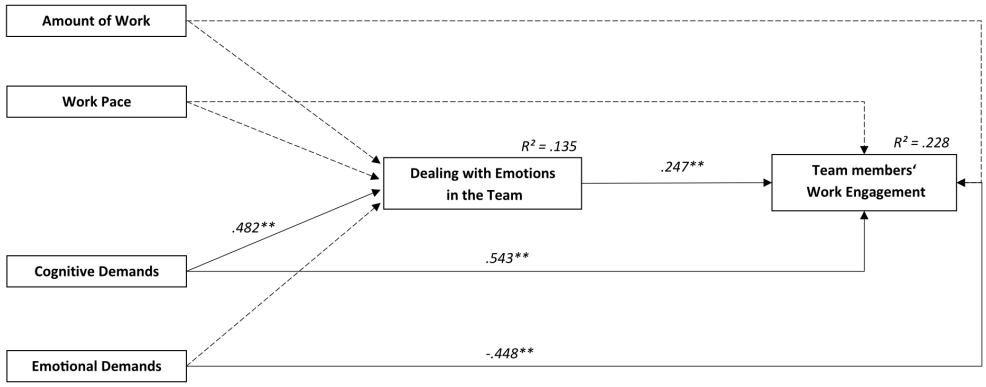

FIGURE 3
Relationships between team demands at work, dealing with emotions in the team and team members' work engagement analyzed with structural equation modelling. Model-fit : X^2=353.249, *df*=194, CFI=0.953, RMSEA [CI]=0.053[0.044–0.062], SRMR=0.054. **p<0.01, *p<0.05.

The model for dealing with emotions in the team (see Figure 3) revealed a good fit ($N = 298$ team members, $n = 51$ teams; $\chi^2 = 353.249$, $df = 194$, $p < 0.001$; CFI = 0.953; RMSEA [CI] = 0.053 [0.044–0.062]; SRMR = 0.054). The results indicate a positive relationship between dealing with emotions in the team and team members' work engagement ($\beta = 0.25$, $p < 0.01$) which supports H2. Furthermore, team members' work engagement was related positively to cognitive demands ($\beta = 0.54$, $p < 0.01$) and negatively to emotional demands ($\beta = -0.45$, $p < 0.01$). In total, $R^2 = 0.228$ of the variance of team members' work engagement was explained by the model. The results indicate a positive relationship between cognitive demands and dealing with emotions in the team ($\beta = 0.48$, $p < 0.01$) and team demands at work explained $R^2 = 0.135$ variance of dealing with emotions in the team. Thus, the prediction of hypothesis H3c that cognitive demands at work positively relates to dealing with emotions in the team and team members' work engagement was supported. H3a, H3b and H3d were not supported as no relationships were found with the amount of work, work pace and emotional demands. Furthermore H4, was partially supported by the indirect effect of team demands at work on team members' work engagement that was mediated by dealing with emotions in the team ($\beta = 0.12$, $p < 0.01$).

5. Discussion

5.1. Antecedents of work engagement

Researchers recognized the complexity and multilevel perspective of team behaviors including cognitive, work-task related, emotional and social aspects (Bell, 2007; Mathieu et al., 2019). The present study increases insights into team antecedents of team members' work engagement but also addresses team behaviors in work teams of health and social care organizations and investigates their role for the relationships between team demands at work and team members' work engagement. Furthermore, insights into the demands at work of teams responsible for providing care and assistance to the elderly, youth, or physically and/or mentally disabled were provided.

The present study investigated team members' work engagement based on the three facets vigor, dedication, and absorption. Results

indicate that team members that provide care and assistance have high dedication and absorption to their work and intermediate vigor, which are slightly higher than findings before and during the COVID-19 pandemic (Riedl and Thomas, 2019; Bartsch et al., 2021). Team members reported that team demands at work such as the amount or pace of work are still high, but our results indicate that these are slightly lower to other studies (Riedl and Thomas, 2019). The findings that cognitive and emotional demands were also reported as high may be due to the fact that teams in these domains deal with many complex cognitive decisions and, therefore, need to take many aspects into account. Since all this happens in the context of social interactions with patients and their relatives, the work has the potential to be emotionally stressful. Therefore, it is particularly important to have team members who devote themselves to these diverse and complex tasks with high concentration, dedication and energy and who do not lose their capacity to work due to excessive emotional burdens.

Teams involved in care and assistance share knowledge, create new knowledge, structures, and plans through co-construction, achieve agreement through constructive conflict and are also characterized by a high level of reflective activities. The team members reported high knowledge sharing, co-construction, and constructive conflict but moderate team reflection activities. One explanation for this might be the working conditions of the teams, as many of them work in shifts which can hinder joint reflection activities. In line with Self-Determination Theory (Deci and Ryan, 2000) and Flow Theory (Csikszentmihalyi, 1990) teams that strongly engage in TLBs show higher work engagement. These results are consistent with studies in other domains and other types of teams investigating parts of TLBs and work engagement (Matsuo, 2020; Gupta et al., 2022; Peeters et al., 2022). Furthermore, our findings indicate that all TLBs (i.e., knowledge sharing, co-construction, constructive conflict, and team reflection) are carried out with similar frequency and positively related to work engagement. One explanation for that finding might be that TLBs are highly interrelated which is in line with Decuyper et al.'s (2010) team learning model and empirical studies (Widmann and Mulder, 2020). In addition, the findings that work experience is negatively related to TLBs may lead to the assumption that team members with long years of work experience fall into routines that result in less knowledge sharing, have less interest in contributing to developing new knowledge or achieving agreement, and reflect less. This also applies to dealing with emotions in the team, which suggests that team members with a lot of work experience participate less in team interactions where emotions are discussed.

The present study successfully measured dealing with emotions in the team and provides new insights into what teams actually do in relation to emotions. Thereby, our study makes a significant contribution to closing the gap that dealing with emotions in teams is detached from individual emotional competence as described by Elfenbein (2006). Our findings provide insights that extend the prior work of Druskat and Wolff (2001) and Aritzeta et al. (2020) on 'team emotional intelligence' while this present study does also take into account team-level emergence and focused on actual behaviors. Teams that discuss and exchange about emotions within the team and express emotions provide individual team members many opportunities for observing and reacting to emotions such as work-related pride and joy or being infected by these emotions. In line with emotion contagion (Barsade, 2002), Emotion As Social Information Theory (Van Kleef, 2009) and empirical studies (Holtz et al., 2020; Mindeguia et al., 2021), our findings support the assumption that team members' work engagement is increased by team activities whose goal is to express, respond to, or discuss or share emotion within the team.

The current evidence also suggests that dealing with emotions in the team is strongly related to TLBs for teams that provide care and assistance, which was surprising at first. TLBs and emotional competence at individual level and at team level are moderately positively related (Gerbeth et al., 2022), suggesting that dealing with emotions in the team, which measures actual observable activities as perceiving, discussing, expressing and reacting to emotions, is also only moderately positively related to TLBs. In the domain of caring and assistance to elderly, youth, physically and/or mentally disabled, work tasks of teams are often linked to emotional aspects (e.g., decisions concerning a patient and his family). TLBs that are work task related could overlap with dealing with emotions in the team for work tasks that are directed to the handling of emotions occurring for example in patient interaction. Nevertheless, our results indicate differences in TLBs and dealing with emotions in the team, as dealing with emotions in the team explained more variance and had a stronger effect on team members' work engagement than TLBs. These results indicate that emotional aspects are crucial in teamwork and that teams should not only focus on cognitive processes, but also recognize the team itself as a social unit and give space to dealing with emotions in the team.

Due to the aforementioned similarities and differences between TLBs and dealing with emotions in the team, it may be suggested that cognitive and emotional aspects are closely related in actual behavior in teams and that these are also related to motivational aspects. The results of this study lead us to strive for team research that extends previous research models by including cognitive, emotional and motivational components, which contributes to the call to consider cognitive, motivational and emotional factors as essential for learning outcomes within teams, such as team performance (Bell, 2007; Mathieu et al., 2019).

5.2. Limitations and future research

This study comes with limitations that should be addressed in future research. First, the cross-sectional design of our study was necessary to identify differences between cognitive work-task related team behaviors and dealing with emotions in the team. Nevertheless, determining changes and team dynamics was not possible. In future studies, longitudinal designs could fill this gap and help to validate the identified relationships over time. Second, we collected data from health and social care organizations and teams in the field of care and assistance to elderly, youth, people with physical and/or mental disabilities. Emotional labor is considered an important part of the teams' field of activity and was decisive in determining the sample. In the context of the study, however, this circumstance could have led to a bias in the demands at work, since cognitive demands (e.g., decisions) and the amount of work can reciprocally influence the emotional demands. Furthermore, we recognize that the classification of a demand as a challenge or as a hindrance demand relies on the appraisal of the team member. This is not captured in the instrument that was used in this study. Replication studies with teams from other domains with less emotional labor in the work

tasks could help to cross-validate the findings. Third, dealing with emotions in the team turned out to be good in covering activities focused on discussing, reflecting about emotions and expressing and reacting to emotions, however this variable needs further validation, also in different domains. Interestingly, although dealing with emotions in the team predicted team members' work engagement, only cognitive demands were found to influence dealing with emotions in the team, and not emotional demands. Even tough teamwork is perceived as emotionally demanding it seems it might only have little influence on dealing with emotions in the team. Team members with high emotional competence have a better understanding of the harmful effects of emotionally demanding situations on their work engagement (Costa et al., 2014; Mayer et al., 2016). Therefore, future studies are needed to investigate relationships between dealing with emotions in the team and team members' emotional competence. Fourth, due to multicollinearity (VIF values), it was not possible to test a model with both TLBs and dealing with emotions in the team at once. Further studies with larger datasets should address TLBs and dealing with emotions in the team and their effects in more detail to provide further insights into the relationships between cognitive behaviors and the teams' dealing with emotions in the team. Therefore, replication studies in different domains and teams using multigroup analysis would be beneficial to cross-validate the findings. In addition, additional job characteristics such as full/part time, virtual versus face-to-face and other contextual variables at individual level (e.g., burnout, performance), at team level (e.g., psychological safety, team cohesiveness), and at organizational level (e.g., organizational commitment, organizational climate) may also be related to team members' work engagement, TLBs and dealing with emotions in the team and should be examined in future studies. Furthermore, we suggest including multilevel analysis to investigate cross-level relationships that take into account the multilevel nature of team members nested in teams nested in organizations.

5.3. Practical implications

For teams and their members our results indicate that in the domain of care and assistance it is for fostering work engagement necessary to not only focus on the individual, but also on the team. Team members need to be aware that work engagement can be fostered by TLBs and dealing with emotions in the team. Moreover, TLBs and dealing with emotions in the team are important because they mediate the effects of team demands at work on work engagement. Teams that frequently carry out team activities of TLBs and dealing with emotions in the team reduce the effects of hindering demands on work engagement, while effects of challenging demands on work engagement are strengthened. These results are also important for other domains that are characterized by a high amount of teamwork.

Furthermore, the implications for practice relate to organizations, leaders, and human resource professionals to provide opportunities for teams and their members to learn and work together more successfully. Leaders and organizations can provide employees with opportunities for sharing their knowledge, creating new knowledge and structures and reflecting on tasks and teamwork. Furthermore, leaders can determine what and how often employees discuss or reflect on and thus trigger, cognitive as well as emotional aspects in teamwork. Especially regarding dealing with emotions in the team, leaders can show their emotions clearly within the team to stimulate team members' perceptions and reactions and specifically address emotions in team meetings to trigger joint reflections and discussions and stimulate emotion regulation strategies. Furthermore, more work experience leads to less TLBs and dealing with emotions in the team. Especially with experienced team members, leaders could increase the required awareness about the importance of TLBs and dealing with emotions by emphasizing this importance in stressing the positive effects of TLBs and dealing with emotions. Furthermore, incentives can be provided for especially more experienced team members to for instance increase sharing and reflecting with the other team members on their knowledge.

There is evidence for several antecedents for TLBs and dealing with emotions in the team such as creating a safe and trustful climate within a team (Leicher and Mulder, 2016). Research indicates that when team members feel safe and work in a trustful environment, they more likely engage in feedback and reflection processes (Edmondson and Lei, 2014). Leaders and organizations can foster a safe and trustful climate by interventions and communication, while team members can foster safe team climate themselves by asking for feedback and initiating feedback processes. Furthermore, leaders could foster team behaviors by their leadership behavior (Koeslag-Kreunen et al., 2018).

In addition, in the process of recruiting new employees in the organization openness and commitment to join TLBs and dealing with emotions could be used as selection criteria. This could help human resource professionals that strive for optimal and effective team composition. Moreover, human resource professionals and team leaders can foster successful onboarding processes of new team members by having an eye for and stimulating the openness and commitment to TLBs and dealing with emotions. This can foster new team members work engagement, as well as their exchange and reflection on their work and the processes in the team which can strengthen the team as a social unit.

Due to the influence of team demands at work on TLBs, dealing with emotions in the team and team members' work engagement organizations have several possibilities to strengthen demands with positive effects such as cognitive demands by for example fostering decision-making within a team. Furthermore, an organization could decrease negative effects of demands at work for instance by reducing hindrance demands for example by lingering the amount of emotional labor or avoiding conflicts that lead to negative emotions within the team.

5.4. Conclusion

Our study provides insights into the actual behavior of teams in the domain of care and assistance to the elderly, youth, or physically and/or mentally disabled, both on cognitive and emotional aspects. Furthermore, insights are provided for the capability of team learning behaviors and dealing with emotions in the team to mediate the

relationship between team demands at work and team members' work engagement as an important precondition for team and individual performance. The findings highlight the relation between cognitive and emotional aspects in the behavior of teams and may encourage future researchers and practitioners to address cognitive, emotional and motivational aspects in team research to provide a better understanding of team conditions, team behavior and team outcomes.

Data availability statement

The data presented in this article are available only upon request due to privacy restrictions. Request to access should be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by the ethics committee of the university of Regensburg. The patients/participants provided their written informed consent to participate in this study.

Author contributions

SG and RM developed the concept and study design, and wrote the manuscript. SG collected the data that was analyzed by SG and RM. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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EDITED BY
Juliane E. Kämmer,
University of Bern, Switzerland

REVIEWED BY
Tayana Soukup,
Imperial College London, United Kingdom
Margarete Boos,
University of Göttingen, Germany

*CORRESPONDENCE
Nadine Bienefeld
✉ n.bienefeld@gmail.com

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Human-AI teaming: leveraging transactive memory and speaking up for enhanced team effectiveness

Nadine Bienefeld[1]*, Michaela Kolbe[2], Giovanni Camen[2], Dominic Huser[2] and Philipp Karl Buehler[2,3]

[1]Work and Organizational Psychology, Department of Management, Technology, and Economics, ETH Zürich, Zurich, Switzerland, [2]Institute of Intensive Care Medicine, University Hospital Zurich, Zurich, Switzerland, [3]Department of Intensive Care Medicine, Cantonal Hospital Winterthur, Winterthur, Switzerland

In this prospective observational study, we investigate the role of transactive memory and speaking up in human-AI teams comprising 180 intensive care (ICU) physicians and nurses working with AI in a simulated clinical environment. Our findings indicate that interactions with AI agents differ significantly from human interactions, as accessing information from AI agents is positively linked to a team's ability to generate novel hypotheses and demonstrate speaking-up behavior, but only in higher-performing teams. Conversely, accessing information from human team members is negatively associated with these aspects, regardless of team performance. This study is a valuable contribution to the expanding field of research on human-AI teams and team science in general, as it emphasizes the necessity of incorporating AI agents as knowledge sources in a team's transactive memory system, as well as highlighting their role as catalysts for speaking up. Practical implications include suggestions for the design of future AI systems and human-AI team training in healthcare and beyond.

KEYWORDS

human-AI teams, transactive memory systems, speaking up, explainable artificial intelligence / XAI, healthcare teams, behavioral observation, interaction analysis, team performance

1. Introduction

The rapid technological advances of recent years and months bring forth increasingly powerful AI agents that are able to assist clinicians in the assessment of critically ill patients and largely reduce the burden on medical staff (Moor et al., 2023). Current evaluations of human-AI collaboration focus predominantly on human-factors-related issues and dyadic interactions between one human and one AI agent (Lai et al., 2021; Knop et al., 2022), thus neglecting the fact that most healthcare work is conducted in larger inter-disciplinary teams (Dinh et al., 2020).

Interactions in human-AI teams, where multiple humans and AI agents interact dynamically and interdependently are bound to be more complex than dyadic ones, yet to date, such interactions have not been sufficiently investigated. This is especially true for real teams collaborating with actual AI agents as past research has mainly used "make-believe" AI agents (i.e., humans pretending to be an AI) in laboratory settings (McNeese et al., 2021; Endsley et al., 2022; O'Neill et al., 2022).

In healthcare, ineffective human-AI teaming could have life-or-death consequences. Consider, for instance, a team's failure to access or misinterpret information from an AI agent that is crucial for diagnosing a critically ill patient. The black-box nature of today's AI agents—which lack explainability because they discern patterns in data without pre-set rules— makes collaboration with AI agents particularly challenging (Lecun et al., 2015; Wiens et al., 2019). To enable effective human-AI team collaboration in healthcare, it is crucial to imbue AI agents with optimal levels of explainability, interpretability, and plausibility, at least regarding the nature of knowledge employed—such as its source, patient cohort, and clinical context (Kundu, 2021; Bienefeld et al., 2023).

A team's transactive memory system (TMS) (Lewis and Herndon, 2011) could help team members remember and retrieve distributed knowledge in the team, including the knowledge held by AI. Building TMS in human-AI teams may be difficult due to the black-box problem outlined above, making it practically impossible to "know what the AI knows" (Durán and Jongsma, 2021). Also, since AI agents cannot (yet) proactively communicate their "view of the world," unless a human team member speaks up on their behalf, communication breakdowns and performance losses are inevitable (Yan et al., 2021).

To help reduce these risks and to close the gap in knowledge about human-AI team interaction in healthcare, we investigate TMS and speaking up behavior in $N = 180$ intensive care unit (ICU) physicians and nurses collaborating with an AI agent in a simulated, yet realistic clinical setting. We draw on the team science literature (see e.g., Kozlowski and Ilgen, 2006 for an overview) to attain this goal and define *human-AI teams* as (a) two or more human team members interacting with one or more AI agents; (b) having interdependencies regarding workflow, goals, and outcomes, and (c) contributing to shared team goals.

1.1. Transactive memory systems in healthcare teams

Transactive memory systems (TMS) are defined as the "group-level knowledge sharing and memory system for encoding, storing, and retrieving information from different knowledge areas in a group" (Yan et al., 2021, p. 52). As shown in Figure 1, "knowing what other team members know" and accessing this knowledge when needed, helps assemble the different pieces of distributed group knowledge into one coherent "group mind." This group mind is associated with team effectiveness (DeChurch and Mesmer-Magnus, 2010). Since AI agents may hold mission-critical information, their knowledge should be included in a team's TMS, which has, however, not yet been researched in human-AI teams.

Tapping into and sharing distributed group knowledge is key for adequate hypothesis-building and decision-making in teams (Palazzolo, 2017), but can be challenging, particularly in diverse and/or hierarchical teams (Ren and Argote, 2011). Furthermore, group members tend to exchange more "shared" (i.e., known by all members) than "unique" (i.e., known only to individual group members) knowledge, which gets further strengthened via confirmation by others in some kind of a vicious circle (Stasser and Titus, 1985; Lewis and Herndon, 2011; Boos et al., 2013). This is problematic and can negatively impact performance because good decisions, e.g., finding the correct diagnosis, depend on a team's ability to choose the most viable option amongst a diverse range of hypotheses (Mesmer-Magnus and DeChurch, 2009; Kämmer et al., 2017). Accessing knowledge from AI agents might provide a way out of this vicious circle because AI agents are not affected by social group dynamics and—based on their immense data storage and analytical capabilities (Moor et al., 2023)—are likely to hold unique knowledge other team members do not possess. Based on these considerations, we propose the following hypotheses:

> *Hypothesis 1a*: In higher-performing teams, "accessing knowledge from the *AI agent*" is more likely followed by "developing new hypotheses" than in lower-performing teams.

> *Hypothesis 1b*: In higher-performing teams, "accessing knowledge from a *human team member*" is more likely followed by "developing new hypotheses" than in lower-performing teams.

1.2. Speaking up in healthcare teams

Speaking up (or voice) is defined as "informal and discretionary communication by an employee of ideas, suggestions, concerns, information about problems […] to persons who might be able to take appropriate action […]" (Morrison, 2014, p. 174). Numerous positive effects such as enhanced decision-making, improved learning, and higher team performance are associated with people's willingness to speak up (Edmondson, 2003; Pfrombeck et al., 2022; Weiss and Zacher, 2022; Morrison, 2023). However, speaking up and respective listening remains challenging because people fear (1) personal embarrassment and doubts about how valid their knowledge is, (2) social repercussions such as creating conflict with other team members or not being a good team player, and because consequently, they suffer from (3) social dynamics impeding positive speaking up experiences (Noort et al., 2019; Long et al., 2020; Sessions et al., 2020).

Because the hurdles to speaking up are predominantly social, team members may find it easier to speak up based on information coming from an AI agent rather than from a human colleague. If people speak up "on behalf of the AI," they may not be as afraid to be personally blamed or lose face. Since speaking up behavior, in general, helps correct faulty decisions or a wrong course of action, in Hypotheses 2 a and b, we assume that speaking up based on knowledge received from the AI and/or other human team members will be associated with higher team performance.

> *Hypothesis 2a*: In higher-performing teams, "accessing knowledge from the *AI agent*" is more likely followed by "speaking up" than in lower-performing teams.

> *Hypothesis 2b*: In higher-performing teams, "accessing knowledge from a *human team member*" is more likely followed by "speaking up" than in lower-performing teams.

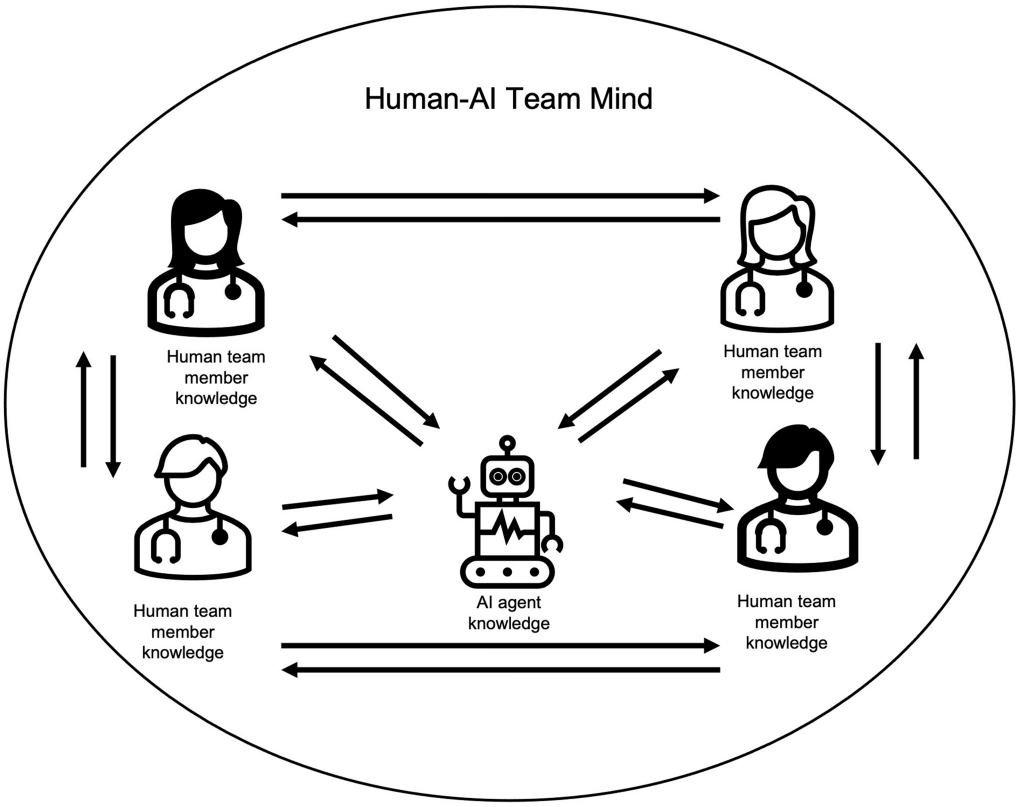

FIGURE 1
Visualization of TMS and speaking up interactions in human-AI teams.

2. Methods

2.1. Participants

Resident and attending physicians and nurses from the Institute of Intensive Care Medicine at a large teaching hospital in Switzerland were invited to participate in this study as they took part in their yearly team-based simulation training. Training took place during work hours and participants received education credits (no other remuneration). Study participation was voluntary and independent of the training. Full anonymity was granted and written consents were given by participants with the possibility to opt out at any time and without any repercussions. $N = 180$ participants chose to participate in the study and were randomly assigned to 45 interdisciplinary 4-person teams. Each physician or nurse acted according to their actual function and, although some participants were acquainted, nobody had previously worked together in the same team.

2.2. Study design and procedure

In this prospective observational study, 180 ICU physicians and nurses collaborated with an AI agent to diagnose and provide medical treatment to a simulated patient suffering from a life-threatening condition. The simulated setting was chosen to create a realistic yet controlled environment without putting real patients at risk (Cheng et al., 2016). For this purpose, a fully equipped, state-of-the-art simulation facility including an advanced simulation training mannequin with interactive patient features (vital signs, pulse, heartbeat, chest movements) was used (SimMan3G®, Laerdal, Stavanger, Norway). Four simulation training medical faculty members (one attending physician and three nurses, all specialized in intensive care medicine) led the simulation training and were blinded to the hypotheses. They provided an introduction to the simulated setting, learning objectives, and procedures to establish a psychologically safe learning environment (Rudolph et al., 2014). Each scenario was audio and video recorded to enable video-based debriefing—a standard practice at the simulation center (Zhang et al., 2019). Participants were familiar with this practice due to prior participation in simulation training, thus minimizing the Hawthorne effect (Wickström and Bendix, 2000; Soukup et al., 2021). To minimize observer bias, significant time (>8 h) and effort was invested into behavioral coding training and specifying each code with specific examples. One major in psychology and health sciences—blinded to the hypotheses—coded the entire data set. To determine interrater reliability, 10% of the data were randomly chosen and coded by a psychology minor, also blinded to the hypotheses and also having undergone behavioral observation training. As displayed in Table 1, Cohen's kappa values represent substantial strength of agreement (Landis and Koch, 1977).

TABLE 1 Behavior codes, descriptive statistics, and independent *t*-tests for study variables for lower- and higher-performing teams.

				Lower performing teams		Higher performing teams				95% CI	
Behavior	Definition	Examples	κ (ICC) [d]	*M*	*SD*	*M*	*SD*	*t*[e]	*p*	*LL*	*UL*
Accessing knowledge from a *human team member*	[a]Searching for information from a human team member when knowing who has it.	Did [the patient] have bradycardia already when you got here?	0.87	17.93	5.48	22.30	9.58	−1.63	0.110	−1.14	0.11
Accessing knowledge from the *AI agent*	[b]Searching for information when knowing that the AI agent has it.	Non-verbal behavior. Searching for specific information stored in the AI agent by opening and closing tabs on the computer screen, analyzing data, and looking for patterns in the data, often combined with adjusting certain ventilation parameters.	0.91	19.13	10.60	16.47	9.69	0.84	0.404	−0.35	0.88
Developing new hypotheses	[a]Articulating ideas about what could be the correct diagnosis based on information received or summarizing all the available information.	Hmm, SpO2 and PetCo2 are getting really low […] Maybe it could be air trapping since [the patient] has COPD [Chronic obstructive pulmonary disorder]?	0.83	11.60	8.59	14.03	8.26	−0.91	0.363	−0.91	0.33
Interacting with non-AI technologies	[b]Reading indicators on a monitor screen (e.g., heart frequency) or gathering information from additional non-AI technologies (e.g., ultrasound or CPR device).	Non-verbal behavior, mostly short glances at a computer screen.	0.69	17.20	7.55	14.83	4.49	1.31	0.194	−0.21	1.04
Speaking up (doubt-focused voice)	[c]Voicing doubts or contradicting what is being said or done by other team members.	I do not think it's that [pericardial tamponade], look, the tidals [wave-form length of breathing patterns as indicated by the AI agent] are far too low and I cannot get a clear sound on the right lung [auscultating the lungs].	0.79	4.67	2.74	5.70	3.83	−0.92	0.358	0.91	0.33
Team performance	Accuracy and timeliness of diagnosis, suitability, and quality of the medical treatment provided to the patient based on established standards in intensive care medicine and hospital best practices/guidelines.	Correct and timely diagnosis of, e.g., a pressure pneumothorax. Adequate and timely treatment, e.g., of a pressure pneumothorax (i.e., needle decompression by inserting a 14- or 16-gauge needle/Venflon into the 2nd intercostal space in the midclavicular line) and insertion of thorax drainage. Patient stabilizes after procedure (systolic blood pressure 80–140 mm Hg or MAP >50; heart rate 60–100 per minute, oxygen saturation SaO2 > 95%).	[0.87]	8.20	3.36	13.43	4.04	−4.31	0.000	−2.04	−0.67

N = 180 (45 teams). [a]Definitions based on TRAWIS (Brauner, 2006, 2018); [b]Self-developed; [c]Definitions based on the Co-ACT coding framework (Kolbe et al., 2013). [d]Cohen's kappa and [ICC] values representing acceptable to good interrater agreement (Landis and Koch, 1977); [e]Independent sample *t*-tests (two-sided) with Cohen's d Lower (LL) and Upper (UL) 95% Confidence Interval (CI).

2.3. Scenarios

Each team participated in one of three standardized scenarios designed by the last author (BPK, an experienced chief physician). Scenarios were based on documented cases of real-life events in intensive care medicine. The team's goal in each scenario consisted of diagnosing and providing treatment to a critically ill simulated patient presenting with a set of symptoms (myocardial infarction with atrioventricular block; polytrauma with pneumothorax; septic shock). At the start of the scenario, participants received realistic patient information documents drawn from real cases and detailing information on the patient's history, medication, and symptoms. Audio and video data of the study scenarios and clinical performance measures (e.g., heart rate, pulse, blood pressure, and ventilation parameters such as SaO2, and Spo2) were recorded in real-time. After each scenario, participants took part in a video-based debriefing led by simulation faculty following the Debriefing with Good Judgment approach (Rudolph et al., 2007).

2.4. AI agent

AI agents are different from other technologies insofar as they can learn from vast amounts of data and possess the agency to perform tasks that were previously performed by human team members (Kaplan and Haenlein, 2019). In this study, *Autovent*[1], a state-of-the-art auto-adaptive ventilator using complex algorithms to control patients' ventilation cycles of inspiration and expiration was used as the AI agent. The AI agent autonomously completed the task of ventilation and weaning—a task previously performed by physicians and nurses—by "continuously extracting data from patient-specific data streams (e.g., PetCO2, SpO2, lung mechanics, and muscle activity) and personalized waveform shapes of either oxygen flow or pressure" (Autovent training manual, 2023: p. 12). To assure sufficient familiarity with the AI agent, participants needed to have worked with *Autovent* for at least 6 months to be able to participate in the study.

2.5. Variables

2.5.1. Transactive memory in human-AI teams

TMS in human-AI teams was assessed with TRAWIS—a behavior observation instrument measuring processes that lead to the development of transactive memory by Brauner (2006, 2018). As described above, a major in psychology and health sciences with specialist training in behavioral observations and blinded to the hypotheses applied an event-sampling procedure by assigning one of four codes to the complete data set: (1) "accessing knowledge from a *human teammate*"; (2) "accessing knowledge from the *AI agent*" (self-developed); (3) "developing new hypotheses," and (4) "monitoring/interacting with non-AI technologies" (self-developed, to distinguish interactions with the AI from other, non-AI-based technologies used in the ICU). Every distinct behavior or utterance, i.e., sense unit (Bales, 1950) was coded in the following sequence: (A) actor; (B) code; (C) receiver, and (D) timing (beginning, end, and duration in seconds). Interact software (Mangold, 2022) was used for behavioral coding and data analysis. Please refer to Table 1 for a detailed description of all TMS codes, examples, and Cohen's Kappa values indicating considerable interrater agreement (Landis and Koch, 1977).

2.5.2. Speaking up in human-AI teams

Speaking up behavior was assessed in the identical ways as described above using the Co-ACT framework (Kolbe et al., 2013). This framework captures a broad range of verbal and non-verbal communication and coordination behavior in acute care teams, including the variable of interest—speaking up behavior (Kolbe et al., 2012; Weiss et al., 2017; Lemke et al., 2021). Because we were interested especially in doubt-focused voice (Weiss et al., 2014), speaking up was coded whenever a team member spoke up with information or knowledge that contradicted what was being said or done after accessing knowledge from either the AI agent or another human team member. Please refer to Table 1 for a detailed description of the speaking up code with an example and Cohen's Kappa values indicating considerable interrater agreement (Landis and Koch, 1977).

2.5.3. Clinical performance assessment

In a Delphi-like consensus-building process (Hasson et al., 2000), three authors (BPK, HD, CG) all specialized in intensive care medicine with more than 10 years of clinical experience developed a case-specific clinical performance measure including 29–34 items per scenario. These items are related to the specific medical condition, the accuracy and timeliness of diagnosis, and the effectiveness of selected treatment options based on established standards in intensive care medicine and best medical practice according to the Competency-Based Training program in Intensive Care Medicine for Europe and other world regions (CoBaTrICE describing 102 competencies divided into 12 domains European Society for Intensive Care Medicine, 2023). Two attending physicians (HD & CG) blinded to the hypotheses yet familiar with the hospital's best practices and standard operating procedures then independently coded the complete set of audio and video data ($N = 180$ ICU physicians and nurses split into 45 teams). They applied the checklist-based team performance measure to code each video file while also considering patient data from vital signs with target values (e.g., systolic blood pressure 80–140 mm Hg or MAP >50; heart rate 60–100 per minute, oxygen saturation SaO2 > 95%). Interrater reliability was calculated on the complete data set using the intraclass correlation coefficient, which resulted in a satisfactory reliability measure (Landis and Koch, 1977) (see Table 1).

2.5.4. Control variables

Demographic information included age (in years), sex (male–female), professional role (nurse, resident physician, attending physician), work experience since graduation from medical/nursing school (in years), and experience working with the AI agent (in months).

2.6. Data analysis

Due to the variation in the length of the simulated scenarios, we divided the number of codes per category by the length of the video in minutes and then multiplied by 20 for standardization. To

1 An acronym used to protect anonymity and non-disclosure agreements.

compare higher- versus lower-performing teams in terms of how frequently (i.e., number of occurrences) they exhibited the coded behaviors, we conducted a series of independent *t*-tests (two-sided) for each of the five behaviors. For this purpose, we previously split the data by the median, creating two groups (higher- vs. lower-performing teams) (Stout et al., 1999; Waller et al., 2004). To test the hypotheses, a lag sequential analysis was conducted (Bakeman and Gottman, 1997; Bakeman and Quera, 2011) for both higher- and lower-performing teams. This method involves generating *z*-values from frequencies of each interaction sequence to determine which temporal patterns occur more or less frequently than expected. Any *z*-values larger than 1.96 or smaller than −1.96 indicate a statistically significant interaction pattern. Positive *z*-values indicate a facilitating effect of behavior A on a subsequent behavior B, and negative *z*-values indicate an inhibitory effect of behavior A on subsequent behavior B. In this study, only behavior B directly following behavior A (lag 1) was of interest. To calculate the required event sequences based on the total number of coded events ($N = 9{,}850$) for 5 codes, the formula developed by Bakeman and Gottman (1997) was used. Interact software (Mangold, 2022) was then used to compute two interaction matrices with *z* values for teams above/below the performance measure median.

3. Results

In total, $N = 180$ ICU nurses and physicians participated in this study (45 teams). 101 participants were female (56.1%), 79 were male (43.9%) and the average age was 38.10 ($SD = 7.53$). The average experience working as a physician or nurse was 11.85 years ($SD = 8.10$) and the average experience working with the AI agent was 2.89 years ($SD = 1.90$).

Out of the 45 teams, 22 teams (48.89%) were above the median (i.e., higher-performing), and 23 teams (51.11%) were below the median (lower-performing). As shown in Table 1, the results of the independent t-tests (two-sided) for each of the five behaviors revealed no significant differences between higher- and lower-performing teams in terms of how frequently they exhibited each of the five behaviors.

To test our hypotheses, we conducted lag sequential analyses to examine the behavioral reactions to "accessing knowledge from *the AI agent*" versus "accessing knowledge from *human team members*."

Hypothesis 1a stated that in higher-performing teams, "accessing knowledge from the *AI agent*" was more likely followed by "developing new hypotheses" than in lower-performing teams. As depicted in Figure 2A (upper part), this hypothesis was supported by comparing the interaction sequences of "accessing knowledge from the *AI agent*" on "developing new hypotheses" for higher-performing teams ($z = 3.01$, $p = 0.004$) versus lower-performing teams ($z = 1.55$, $p = 0.012$).

Hypothesis 1b stated that in higher-performing teams, "accessing knowledge from a *human team member*" was more likely followed by "developing new hypotheses" than in lower-performing teams. As shown in Figure 2A (lower part), this hypothesis was not supported since "accessing knowledge from a human team member"—though significant—was *negatively* associated with the target behavior of "developing new hypotheses." This result was observed in both higher- and lower-performing teams thus indicating a suppressing effect from the behavior "accessing knowledge from a *human team member*" on "developing new hypotheses" independent of team performance (-2.68, $p = 0.007$ for higher-performing teams; $z = -3.03$, $p = 0.004$ for lower-performing teams).

Hypothesis 2a stated that in higher-performing teams, "accessing knowledge from the *AI agent*" was more likely followed by "speaking up" than in lower-performing teams. As depicted in Figure 2B (upper part), this hypothesis was supported by comparing the interaction sequences of "accessing knowledge from the *AI agent*" on "speaking up" for higher-performing teams ($z = 5.09$, $p = 0.000$) versus lower-performing teams ($z = 0.87$, $p = 0.273$).

Hypothesis 2b stated that in higher-performing teams, "accessing knowledge from a *human team member*" was more likely followed by "speaking up" than in lower-performing teams. As shown in Figure 2B (lower part), this hypothesis was not supported since "accessing knowledge from a *human team member*"—though significant—was *negatively* associated with the target behavior "speaking up." Again, this result was observed in both higher- and lower-performing teams indicating a suppressing effect from the behavior "accessing knowledge from a *human team member*" on "speaking up" regardless of team performance ($z = -2.06$, $p = 0.048$ for higher-performing teams; $z = -1.92$, $p = 0.063$ for lower-performing teams).

4. Discussion

The goal of this study was to increase our understanding of how humans collaborate with AI in a team setting and how different interaction patterns relate to team effectiveness. Drawing on the team science literature, we investigated human-AI team interaction behavior relating to TMS and speaking up by observing $N = 180$ intensive care physicians and nurses as they worked with an AI agent in a simulated, yet realistic clinical environment. The results demonstrate that in higher-performing teams accessing knowledge from an AI agent is positively associated with a team's ability to develop new hypotheses and speaking up with doubts or concerns. In contrast, accessing knowledge from a human team member appeared to be negatively associated with hypothesis-building and speaking up, regardless of team performance.

4.1. Theoretical contributions

Our findings contribute to research on TMS and speaking up and to team science more broadly in three ways. First, the identified interaction patterns between accessing knowledge from the AI agent versus from another human team member were notably different. This finding indicates that we cannot *per se* generalize theory on human-human team interactions to human-AI team interactions. This conclusion paves the way for abundant future research opportunities investigating the various team Input-Mediator-Output–Input (IMOI) factors summarized in the well-established IMOI model (Ilgen et al., 2005). For example, shared mental models (SMM)—i.e., "cognitive representations of reality that team members use to describe, explain, and predict events" (Burke et al., 2006, p. 1199)—could help increase our understanding of how members of human-AI teams can be aligned "on the same

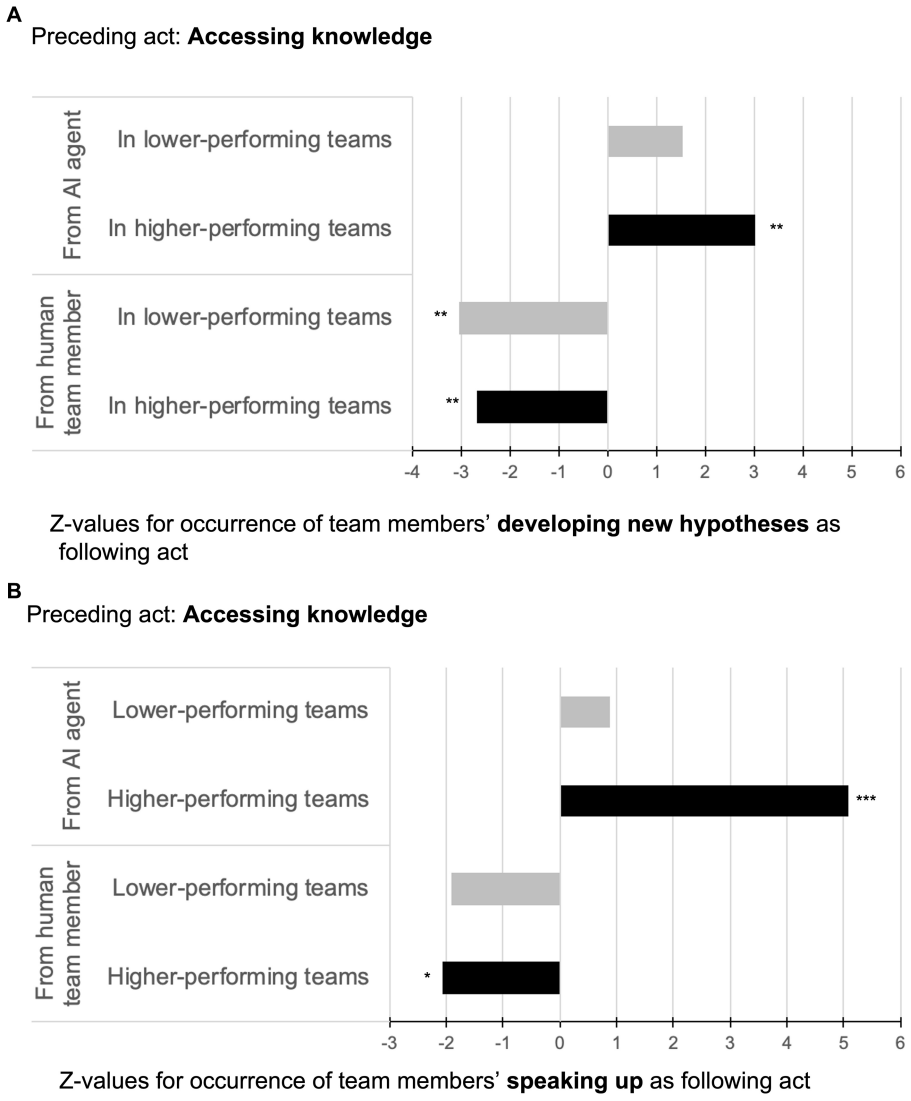

FIGURE 2
Illustration of sequential analyses for accessing knowledge from AI agents vs. from human team members followed by developing new hypotheses **(A)** and speaking up **(B)** in higher- and lower-performing teams.

page." Investigating the role of SMM in human-AI teams is an essential next step because research on human-only teams has shown that shared and accurate representations of what is going on during a team's mission facilitates team coordination and predicts team effectiveness (DeChurch and Mesmer-Magnus, 2010).

Second, even though in this study, the task of correctly diagnosing and providing treatment to a critically ill patient could be achieved also without the knowledge of the AI agent, accessing knowledge from the AI rather than a human team member was associated with developing new hypotheses and higher team performance. Because AI agents are able to compute vast amounts of data and make predictions beyond human capabilities (Kaplan and Haenlein, 2019), they likely hold unique knowledge relevant to hypothesis building. Actively integrating AI agents as sources of knowledge within a team's TMS could thus indicate a competitive advantage. A team's ability to fully leverage this advantage depends on two conditions: First, team members must be able to understand how the AI's knowledge is created. This calls for research on explainable AI (XAI) in human-AI teams, which is thus far lacking (see Bienefeld et al., 2023 for an exception). The results of this study serve as a promising foundation for future research on XAI in teams as the concept of TMS can be used to assess people's interpretations of AI on the team level. Also, team members must calibrate their level of trust in the AI agent, i.e., finding the right balance between trusting AI too much or too little, with the former posing more serious safety concerns due to the risk of overreliance (Parasuraman and Riley, 1997). Research on trust in AI has thus far focused mainly on the human-AI dyad (Glikson and Woolley, 2020). Extending this research to the human-AI team level is thus indicated and should not only focus on how trust is established between humans and the AI agent but also consider how the presence of an AI agent may affect the trust between two or more human members of the team (e.g., a senior physician may have higher or

lower trust in a junior physician depending on whether he or she collaborates with an AI agent or not).

Third, our results show that accessing knowledge from the AI agent was positively associated with speaking up, whereas the reverse pattern was found when knowledge was accessed from human team members. This suggests that people might feel more comfortable voicing concerns or expressing doubts based on information that comes from an AI agent rather than from a human team member. Future research should explore the mechanisms explaining this inclination because a better understanding of this phenomenon may provide new ways of promoting speaking-up behavior in teams more generally. The possibility of using AI to foster speaking up in teams, however, comes with one important caveat: If people were to "hide behind the technology" to speak up, their personal, equally valid doubts or concerns might get lost, or they might give up trying to overcome their social fears to enable candid communication. Researchers and healthcare practitioners should continue investing in efforts promoting speaking up both on the technological as well as on the human side, e.g., via team training and building a psychologically safe team environment (Kolbe et al., 2020; Jones et al., 2021).

4.2. Practical implications

The findings of this study offer multiple suggestions for the design of future AI agents. Considering the role of an AI agent as some kind of "teammate" rather than a tool, future AI agents should be designed with more advanced teaming capabilities. Human-AI teaming capabilities are defined as "the knowledge, skills, and strategies with respect to managing interdependence [between humans and AI …] such as being capable of observing one another's state, sharing information, or requesting assistance" (Johnson and Vera, 2019, p. 18). Take for example interactions with ChatGPT (OpenAI, 2023). Only if the capabilities of the chatbot in terms of remembering previous inputs and self-correcting its own mistakes are combined with the skill of human users entering suitable prompts, can the most reliable outcomes be produced (Lee et al., 2023). As suggested by Tartaglione et al. (2021), such advanced teaming capabilities would require the AI agent to dynamically update information based on "what human team members know" including their roles and task responsibilities, which is a challenging goal. Also, equipping AI with better teaming capabilities requires AI systems that can learn "*in situ*," i.e., systems that are able to continuously learn from new data rather than "freezing" trained algorithms once they are employed into clinical practice (as is current practice for AI agents certified as medical devices van Hartskamp et al., 2019). Nevertheless, as AI agents advance rapidly in terms of their sensing and data processing capabilities, we are hopeful that they will one day be able to proactively support human team members also in dynamic real-life settings (e.g., by prompting them to speak up with safety-critical information at the right time). Given these rapid technological developments and the fact that more and more healthcare professionals are or will be working in human-AI teams, the results of this study should also be used to train people on how to effectively interact with AI agents. The knowledge gained from this study such as how interaction patterns in human-AI teams differ from those in human-only teams in terms of TMS and speaking-up behaviors—in combination with other human-AI interaction skills—can provide healthcare professionals with a real competitive advantage.

4.3. Strengths and limitations

As with any study, there are various limitations to consider when interpreting the results. Observing how real human-AI teams interact "in the wild" (Klonek et al., 2019; Kolbe and Boos, 2019) is certainly a strength of this study; especially because prior research has relied on make-believe AI agents in laboratory settings (O'Neill et al., 2022). Another advantage of this study consists of our focus on micro-level lag sequential analyses, which allowed us to reveal differences in interaction patterns between human-AI agent versus human-human interactions and between higher- versus lower-performing teams. These design choices, however, limit our ability to infer the causality of effects, for which randomized controlled trial studies would be the gold standard. Also, due to patient safety concerns, we were restricted to a simulated setting. This may have introduced simulation artifacts like the Hawthorn effect (Wickström and Bendix, 2000). Although we minimized these effects by (1) selecting participants who were accustomed to being observed due to prior training experiences (2) using non-obtrusive cameras to make audio and video recordings (Soukup et al., 2021), and (3) investing significant time and effort into high-quality observer training (Kolbe and Boos, 2019), we cannot fully eliminate the potential for such biases.

Finally, our study design did not allow us to test for potential moderators such as team context, team size, task complexity, or team member personality. Given the unique, high-risk, and high-time–pressure context of a hospital ICU, one might find different team interaction patterns in low-risk, low-time–pressure situations. Other types of teams, even within healthcare, may face completely different challenges regarding their mission, thus requiring different interaction behaviors. We would also expect different ways of team interaction depending on the type and level of autonomy of the AI agent. The selection of the AI agent as one focused on ventilatory auto-adaptation may have somewhat limited team interaction possibilities. More sophisticated and generative AI agents such as future versions of large language models fine-tuned for healthcare (Cascella et al., 2023; Lee et al., 2023; Moor et al., 2023) would certainly offer new and different knowledge creation possibilities. We hope that this study may inspire future researchers to tackle these questions and to further advance the promising new field of human-AI team research in healthcare and beyond.

Data availability statement

The datasets presented in this article are not readily available because video data cannot be made de-identifiable and therefore cannot be shared. Requests to access the datasets should be directed to n.bienefeld@gmail.com.

Ethics statement

The studies involving human participants were reviewed and approved by ETH Zürich Ethics Committee No. EK 2019-N-190. The patients/participants provided their written informed consent to

participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

NB and PKB contributed to the study design, data analysis plan, review, and analysis of the results. NB was the principal investigator, conducted the data collection, data analysis, and implemented the study protocol. PKB provided his medical expertise to design the study scenarios, provided access to the simulation medical faculty, and participated in the development of the performance measure. MK provided access to the simulation center and technical staff. DH and GC contributed equally to assessing team performance. NB, PKB, and MK contributed to the preparation of the manuscript. All authors read and approved the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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EDITED BY
Tayana Soukup,
Imperial College London, United Kingdom

REVIEWED BY
Vera Hagemann,
University of Bremen, Germany

*CORRESPONDENCE
Michaela Kolbe
✉ mkolbe@ethz.ch

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How to enrich team research in healthcare by considering five theoretical perspectives

Julia C. Seelandt[1], Margarete Boos[2], Michaela Kolbe[1,3]* and Juliane E. Kämmer[2,4]

[1]Simulation Center, University Hospital Zürich, Zürich, Switzerland, [2]Department of Social and Communication Psychology, Institute for Psychology, University of Göttingen, Göttingen, Germany, [3]ETH Zurich, Zürich, Switzerland, [4]Department of Emergency Medicine, Inselspital, Bern University Hospital, University of Bern, Bern, Switzerland

The aim of this paper is to inspire team research to apply diverse and unconventional perspectives to study team dynamics and performance in healthcare settings. To illustrate that using multiple perspectives can yield valuable insights, we examine a segment of a team interaction during a heart-surgery, using five distinct interdisciplinary perspectives known from small group research: the psychodynamic, functional, conflict-power-status, temporal, and social identity perspectives. We briefly describe each theoretical perspective, discuss its application to study healthcare teams, and present possible research questions for the segment at hand using the respective perspective. We also highlight the benefits and challenges associated with employing these diverse approaches and explore how they can be integrated to analyze team processes in health care. Finally, we offer our own insights and opinions on the integration of these approaches, as well as the types of data required to conduct such analyses. We also point to further research avenues and highlight the benefits associated with employing these diverse approaches. Finally, we offer our own insights and opinions on the integration of these approaches, as well as the types of data required to conduct such analyses.

KEYWORDS

healthcare teams, theoretical perspectives, interaction analysis, group dynamics, small group research

1. Introduction

Communication, coordination and leadership in healthcare teams are essential for task performance and patient safety, especially during emergency situations (Tucker and Edmondson, 2003; Manser, 2009; Künzle et al., 2010; Fernandez Castelao et al., 2013; Kolbe and Grande, 2013; Tschan et al., 2014). Teamwork is especially challenging in large hospitals, where turnover rates are high, and for interdisciplinary and interprofessional *ad-hoc* teams lacking the experience of continuously working together as team (Pearce et al., 2006; Nemeth, 2008; St. Pierre et al., 2011; Fortune et al., 2012). Even the willingness and ability to work together do not guarantee success; frequent hurdles are diffuse responsibilities, role conflicts, unsuccessful communication, divergent assumptions about cooperation, skepticism toward other professional groups and the silo mentality that often prevails (Eichbaum, 2018; Rosen et al., 2018; Paige et al., 2019; Kämmer and Ewers, 2022).

How can we foster teamwork in the demanding and ever-changing healthcare environment? While past research has provided valuable insights into the input variables and processes that influence outcomes in healthcare teams (Schmutz and Manser, 2013), we still have much to learn about the temporal dynamics, power dynamics and interprofessional forces at play (Kolbe and Boos, 2019; Anderson et al., 2021). This is partly due to the fact that previous studies have tended to take a particular theoretical perspective when examining healthcare teams: applying what is called the functional perspective, they have examined how selected input factors function to influence group effectiveness (Härgestam et al., 2013; El-Shafy et al., 2018; Schmutz et al., 2018, 2019). However, the theoretical lens we use can influence our findings, and alternative perspectives may be create additional value to studying healthcare teams. Poole and colleagues (Poole et al., 2004) have identified nine interdisciplinary perspectives that can be applied to the study of small groups.

Based on our past research experience, we have noticed that we ourselves tend to act from a silo mentality: We conduct research from primarily one of these perspectives without much considering other perspectives. From our point of view, that "single-mindedness" of sticking to only one theoretical perspective is rather common in healthcare, resulting in reinventing the wheel or disregarding other relevant aspects of teamwork. We believe that using and linking diverse and unconventional perspectives for studying teams in healthcare can broaden our understanding and create additional value. This perspective article does not provide detailed how-to-instruction for conducting team research with each perspective. Instead, our intention is to provide "food for thought" to stimulate team researchers to think out of the box in their next research projects. We therefore present a thought experiment: using segments of the team interaction protocol from a heart-surgery, we demonstrate how we can extract different research questions emerge and offer unique insights when adopting five different perspectives—the functional, conflict-power-status, psychodynamic, temporal, and social identity perspectives. We have selected these five perspectives based on our own research interests, experience, and scientific curiosity; this selection does not claim to be exhaustive. By adopting these perspectives, we aim to shed light on how we can promote effective teamwork (research) in the complex and challenging healthcare environment. We hope that this illustration will offer team researchers who may feel stuck in one viewpoint a fruitful avenue to advance their research, combine certain points of view, and create new research insights that promote teamwork in healthcare. Notably, applying these different perspectives is not limited to healthcare but applicable to teams in other high risk organizations, as has been demonstrated (Hagemann et al., 2011).

2. Team interaction during heart surgery

The starting point is the transcript of an audio-recorded team interaction during a scheduled, conventional heart surgery at the University Medical Centre Goettingen (Germany). The surgery was chosen randomly from a control group of 11 surgeries used in another study (Leitsmann et al., 2021; Lehrke et al., 2022).

The surgical team consisted of six members: a primary surgeon (PS, male, age 50), an assisting surgeon (AS, male, 34), a scrub nurse (SN, female, 48), a circulating nurse (CN An, female, 61), an anesthesiologist (An, female, 49), and a perfusionist (HLM, male, 62). The MAGIX Samplitude Music Studio 2017 software (Magix Software GmbH, 2017., Berlin, Germany) was used to record and transcribe the communication, with the transcripts resulting in an Excel 2010 spreadsheet (Microsoft Corporation, 2018). The transcript was segmented into coding units (lines in Table 1) based on syntactic criteria (Kolbe et al., 2016).

The following excerpt (Table 1) captures the beginning of a coronary bypass grafting procedure using conventional extracorporeal circulation. This procedure occurs during a phase of surgery when the aorta is reopened and the patient is under cardiopulmonary support by the heart lung machine. This phase is critical, as the main procedure (bypass grafting) is executed while the patient is in a vulnerable state. At the end of this phase, the heart must pump again without machine support and recover from its protracted metabolic disturbance.

3. Five different perspectives for studying team dynamics and team performance

In the following sections, we will delve into each of the five different perspectives on studying teams. Per perspective, we will provide a brief overview of its key assumptions, discuss how it could be applied to analyze the excerpt provided and describe for which research goal it is suitable. We also share potential insights and strengths when applying the perspectives to healthcare teams and we outline possible research questions for each perspective in Table 2. All identified perspectives are marked in the excerpt in Table 1. The five perspectives are parallel, intertwined and partly overlapping. Depending on which lens we have on, we can combine up to four different perspectives with each other to analyze this excerpt (Figure 1). For each perspective, different data sources are required (Table 2).

3.1. The functional perspective

Scholars taking a functional perspective assume that groups are goal-oriented and that inputs (e.g., the group task) and/or processes (e.g., communication) influence group performance (e.g., productivity, effectiveness, satisfaction) as well as external factors (e.g., organizational structures, regulations), all of which can be evaluated (Poole et al., 2004; Hollingshead et al., 2005). Their research goal is to identify relevant group features and behaviors (such as certain communication or coordination patterns) that promote or hinder group performance (Fernandez Castelao et al., 2011; Kolbe et al., 2014; Willmes et al., 2022). For example, one result obtained by taking this perspective is that closed-loop-communication (CLC), where a command is followed by a checkback and closing the loop (Härgestam et al., 2013; El-Shafy et al., 2018), correlates with higher task performance (e.g., lower hands-off time in resuscitation, better adherence to guidelines) and thus higher patient safety (Salas et al., 2008). Research from a functional perspective is suited to inform the testing of certain interventions (e.g., checklists)(Lingard et al., 2008; Russ et al., 2015), the development of interventions to improve team performance, such as crisis resource management principles (Oberfrank et al., 2019), different mnemonics to help teams quickly organize themselves (e.g., 10 s for 10 min) (Rall et al., 2008) and briefing and debriefing interventions (Lingard et al., 2008, 2011; Russ et al., 2015).

TABLE 1 Excerpt of a transcript of an audio-recorded team interaction during a conventional heart surgery with marked perspectives.

Row	Speaker	Transcript of conversation	F	C	P	T	S
16	HLM	Two hundred lie on. %					
17	An	I just get this again forty-six twelve forty-eight. %					
18	PS	Good. #					
19	PS	Can I have the clamp? %					
20	SN	Yes, of course, with pleasure. %					
21	PS	Finally. #					
22	PS	Jesus. %					
23	HLM	Have one always to say it twice? %					
24	PS	Indeed %					
25	CN	It is here underneath. %					
26	PS	Any value to hundred. %					
27	HLM	To hundred. %					
28	An	Forty-eight. %					
29	PS	That's right. #					
30	PS	This nurse is not qualified for this kind of surgery. #					
31	PS	Jesus. #					
32	PS	As you can plainly see. #					
33	PS	That will never do. %					
34	SN	Well, so I can let myself be replaced by someone else. %					
35	PS	*Susanne, go wash yourself. %					
36	CN	No. #					
37	CN	*Xenia can handle it and stays here. %					
38	An	+Fifty-one to forty-one. #					
39	An	That is two hours that is, that is one hour and %					
40	PS	So, vent is out. %					
41	HLM	Vent is out. #					
42	HLM	Can I suck the /? %					
43	PS	*Xenia does not want to do it anymore. #					
44	PS	She is not able to do that #					
45	PS	She does not feel like it anymore, she said. %					
46	CN	She does %					
47	PS	She does. #					
48	PS	I have heard it, yes %					
49	CN	*Xenia's back hurts, that's why. %					

All identified perspectives are marked in the excerpt; the five perspectives are parallel and intertwined. F, functional perspective; C, conflict-power-status perspective; P, psychodynamic perspective; S, social identity perspective; T, temporal perspective. HLM, perfusionist; An, Anesthesiologist; PS, primary surgeon; SN, scrub nurse; CN, circulating nurse; AS, assisting surgeon. #: symbol for separation of two coding units; %: symbol for turn-taking between two speakers; *: pseudonym; /?: not understandable.

Consider the episode in lines 19–21, where the surgeon asked the scrub nurse to get the clamp and the nurse acknowledges it. Instruction-reaction episodes such as this one may be analyzed in terms of their completeness by comparing them to the "ideal" CLC cycle (Tschan, 1995, 2002). Additionally, one could check which internal and external factors prevent the correct implementation of the CLC cycles. This analysis could reveal the proportion of standard vs. non-standard forms of CLC and relate it to outcome measures such as the number of followed instructions or patient survival (Marzuki et al., 2019).

Another functional approach to the excerpt would be to code the content of utterances with an established coding scheme (i.e., assign pre-defined behavior and communication codes to sequences of the interaction). For example, researchers may code case-relevant communication (CRC) such as 'instructions', versus case-irrelevant communication (CIC) such as chitchatting (Seelandt et al., 2014; Lehrke et al., 2022). The proportions and patterns of CRC to CIC episodes could then be set in relation to outcome variables such as satisfaction with teamwork or team effectiveness [e.g., surgical site infections (Widmer et al., 2018)].

TABLE 2 Descriptions of possible research questions, strengths, and data requirements for each perspective.

Perspective	Exemplary research questions	Strengths for studying healthcare teams/potential insights when applying this perspective to healthcare teams	Potential data sources
Functional perspective	Which processes promote/hinder healthcare team performance in different tasks? How do high performing teams differ from low performing teams in terms of their composition, behaviors and dynamics? Are findings from ad hoc student teams generalizable to organizational real teams?	Ability to predict and explain team performance based on input variables, external conditions and team processes Provide an empirical basis for interventions to improve team performance Dependency of team patterns on task and situational demands Distinction of effective and non effective team routines	Information on input variables, e.g., team size, team composition, stress level, task difficulty, organizational positions, demographics, seniority, expertise Information on processes, e.g., transcripts of interactions Information on the outcome criterion / team performance, e.g., self assessments of satisfaction, quality evaluations, patient survival, information from EHR records, automatically recorded data, document analysis
Conflict-power-status perspective	How does voice and listening behavior differ with respect to role and status in hierarchical teams? How do status hierarchies relate to interprofessional stereotypes? How does tension and microaggression evolve and dissolve within teams? How does psychological safety emerge and change?	Ability to predict subgroup patterns and associated lines of conflict Examination how power is enacted via communication Identification of power relations in interhierarchical and organizationally embedded and/or interprofessional teams	Information on organizational positions, demographics, surface- and deep-level characteristics Information on interpersonal relationships, e.g., trust, cohesion, psychological safety Information in frequency of voice and listening behavior Information on socio-emotional perceptions and reactions
Psychodynamic perspective	How does humor influence communication and performance during surgeries/ handover/etc.? Which role plays humor style on team dynamics and perception of teamwork during surgical procedures? How does humor affect teamwork engagement in healthcare teams and team members' well- being?	Linkage with other perspectives and further differentiations, e.g., feminist perspective, inclusion of hierarchy Possibility to explore different sides of socio-emotional states, e.g., humor with its beneficial and obstructive facets Revelation of general psychodynamic and group dynamic regularities, e.g., conflict escalation, outsiders, scapegoat	Information about surface- and deep-level characteristics, e.g., gender, profession, age Information on processes, e.g., transcripts of interactions Information on socio-emotional perceptions and reactions, and physiological data, e.g., stress, anger
Temporal perspective	How does team interaction evolve over different phases of taskwork (e.g., different phases during surgery)? How do teams adapt from routine to non-routine situations? How do changes in team composition affect team interactions and performance?	Investigation of interaction patterns and (long-term) team development over time Ability to examine team adaptation patterns to task changes and shifts from routine to non-routine situations Provide an empirical basis for team interventions to improve team development	Information on team characteristics, e.g., developmental stage, task type Information on processes, e.g., transcripts of interactions (e.g., time-stamped data) Information on physiological data, e.g., stress, anger, and performance measures
Social identity theory	How does teamwork with ingroup members differs from teamwork with outgroup members? How do team faultlines and stereotypes affect quality of care? How to promote teamwork between subgroups?	Provide insights into effects of self- and other-categorization and stereotypes Ability to predict subgroup patterns Provide an empirical basis for team interventions to improve team identification	Information about surface- and deep-level characteristics, e.g., gender, profession, age Information on processes, e.g., transcripts of interactions Information on socio-emotional perceptions and reactions

EHR, Electronic Health Record.

In sum, researchers interested in crucial inputs and processes influencing team performance outcomes are advised to adopt this perspective. Exemplary research questions as well as recommendations for data sources are highlighted in Table 2. However, focus on the functional perspective is often limited to "team performance," disregarding other important outcomes such as well-being or system maintenance.

3.2. The conflict-power-status perspective

Scholars taking a conflict-power-status perspective assume that resources, status, and power are unequally distributed within groups (Poole et al., 2004; Sell et al., 2004). Their research goal is to understand how these inequalities, social relationships and associated group structures develop and change, and how they influence group

processes (e.g., conflict management) and outcomes [e.g., member satisfaction (Poole et al., 2004)] Healthcare teams seem to be a logical place for adopting the conflict-power-status perspective (Janss et al., 2012) given that differences in (legitimate) power and occupational status are paramount (Hollenbeck et al., 2012). In our operating room team example, surgeons, anesthesiologists, perfusionists and nurses may each have certain explicit positional status and power, yet also have implicit, subtle and relational status and power based on experience, tenure and relationships (Yule et al., 2006; Gardezi et al., 2009).

Consider the episode in lines 30–37, where we witness how the surgeon expressed his dissatisfaction with the nurse, whereupon the nurse offered to be substituted by another nurse. While the surgeon agreed with this suggestion, instructing another nurse to enter, the circulating nurse overtly objected, instructing the first nurse to stay. Applying the conflict-power-status perspective to analyzing the excerpt offers the possibility to study how power is explicitly and implicitly enacted (e.g., by examining who instructs whom), how open (vs. subtle) conflicts are enacted, or which coalitions exist. Assumptions and discussion about responsibilities, performance or authority are a frequent source of tension in the operating room (Lingard et al., 2002, 2004). Tension, frustration and conflict influence the quality of team interactions. For example, while observing disrespectful behavior may cause team members to speak up with a concern, a general lack of psychological safety or of inclusive language may impede live-saving speaking up (Edmondson, 2003; Raemer et al., 2016; Weiss et al., 2018; Krenz et al., 2020; Vauk et al., 2022).

As healthcare is more and more provided by multidisciplinary teams whose professional members each have a unique identity with potentially differing priorities, roles and expectations of how care should be delivered, micropolitical interests have to be negotiated (Taplin et al., 2015; Kolbe et al., 2019). Politics refers to the use of power, authority and influence and is a relational process between people and within teams (Rogers et al., 2020). This excerpt also gives rise to the possibility to assess emotional reactions to and satisfaction with the manner in which hierarchy is acted out and which role sarcasm, humor and irony play in such power games (Krenz et al., 2019; Long et al., 2020; Koopman et al., 2023; Weiss et al., 2023).

In sum, researchers interested in understanding status and power inequalities, group structures and their impact on team performance outcomes are directed to this approach. However, research strongly following the conflict-power-status perspective may require high levels of reflexivity from researchers who have their own personal views on conflict, power and status dynamics.

3.3. The psychodynamic perspective

Scholars taking a psychodynamic perspective assume that emotional and nonconscious processes exist within all human groups which impact their interactions and task performance (Mcleod and Kettner-Polley, 2004). Their research goal is to understand emotions and unconscious patterns of behavior (Mcleod and Kettner-Polley, 2004). To increase team performance, these nonconscious processes have to be brought to team members' conscious awareness (Mcleod and Kettner-Polley, 2004). One of these nonconscious processes is humor (Newirth, 2006).

Humor can have different functions. On the one hand, humor takes on a conducive role and positive humor has many benefits. It may alleviate tension, fatigue, and improve work relationships (Crowe et al., 2016). Humor also has a relaxing function and can buffer the negative effects of stress on health and well-being (Martin, 1996; Karl et al., 2007). In addition, humor reduces perceived stress and the likelihood of burnout and strengthens resilience (Murden et al., 2018; Rose et al., 2021). On the other hand, humor and jokes can serve as a gateway for prejudices or to devalue other individuals (Prusaczyk and Hodson, 2020). Humor can be employed to define the status quo of a group or to maintain and consolidate the hierarchy within a team (Hodson and Prusaczyk, 2021). Interestingly, gender often plays a role regarding the negative form of humor, with women being the target of sexualized humor (Tabassum and Karakowsky, 2022).

Consider the episode in lines 33–49, where two female nurses and a male surgeon were part of what appears to be a humorous interaction. The surgeon questioned the performance of one nurse and made it sound as if she could not do her job and did not feel like doing it. He used a very colloquial formulation ("She does not feel like it anymore") and this humorous interaction contains an ambiguity (which is typical for humor). He may have used humor to "soften" his message and to offer a more or less suitable excuse for what could otherwise be perceived as rude (Ringblom, 2022). Or, he may have used humor to put women (the nurses) in an inferior position and to maintain a gender- and/or status-based ingroup-outgroup distinction (Ringblom, 2022).

In this episode, it would be also interesting to examine the speaking up behavior of the participants. One might explore to what extent negative humor influences the speaking up behavior of the ironized group (the nurses) or the whole group and to clarify whether this behavior could be a hindrance or even beneficial for further speaking up (Parsons et al., 2001; Vauk et al., 2022).

Numerous studies on emotions, stress management, and burnout among health-care workers exist (e.g., during COVID-19 emergency (Di Giuseppe et al., 2021)) with only few studies on humor and well-being (e.g., effect of humor on nursing professionals' well-being (Navarro-Carrillo et al., 2020)), albeit unrelated to healthcare teams. Therefore, investigating the role of humor in healthcare teams and its relation to well-being and speaking-up could not only be promising but applying the psychodynamic perspective may provide desired guidance for researchers who wish to identify emotional and nonconscious processes within teams and their impact on further interactions and performance. However, team research mainly following the psychodynamic perspective may struggle with the multiple and even conflicting socio-emotional processes, e.g., humor may have both a beneficial and obstructive impact (Tschan et al., 2015).

3.4. The temporal perspective

Scholars taking a temporal perspective assume that groups are systems that evolve over time and in which change is generic and arises across multiple time scales (Arrow et al., 2004). Their research goal is to discriminate changes that are systematic or even regular from changes that are episodic and particular. They also aim to understand how groups systematically change over time and how this group development can be described, explained and modeled

(Harvey et al., 2023). On the micro level, the patterning of interaction in groups comes into focus and how these dynamics relate to relevant other factors like group performance, team member satisfaction etc.

Healthcare teams exhibit dynamics on both levels, the meso level of the dynamics of the team as a whole as well as the micro level of interaction patterns. For example, guideline-oriented teamwork as it is prevalent in resuscitation teams entrains the dynamics of the group as a whole, measurable by the degree of guideline adherence (Fernandez Castelao et al., 2015). Another example is an interaction pattern on the micro level who assumed that groups shift from behaviors focused primarily on the task to behaviors relating to the socio-emotional requirements of the group (Bales, 1950). This can be explained by Bales' equilibrium model (Bales et al., 1953), which claims that a group must keep a balance between task-oriented and socio-emotional needs, in order to be successful. However, socio-emotional behavior might merge into CIC which, at some point, might cause distractions for team members and impair surgical outcomes (Tschan et al., 2015; Wheelock et al., 2015). Other temporal patterns found in healthcare teams are adaptation processes where implicit vs. explicit coordination mechanisms are situationally adapted to routine vs. non-routine requirements of the task (Burtscher et al., 2011; Riethmüller et al., 2012).

Consider the episode in lines 19 to 45, where we can apply the basic distinction between CRC and CIR outlined previously in the functional perspective. From the temporal perspective, we can state that this episode is composed of different micro episodes swaying from CRC and CIC communication. This shift back and forth between CRC and CIC creates a non-random interaction pattern relating systematically to task performance and well-being functions of the team. It would also be interesting to explore whether the CIC utterances in this group serve the tension-reduction function assumed in the equilibrium model (Bales, 1950) or – on the contrary – induce interpersonal conflict and thus impair team performance. Thus, researchers aiming at detecting and describing dynamic patterns in teams and relating these patterns to diverse functions of a team are recommended to apply the temporal perspective. However, research mainly driven by the temporal perspective may involve risks that such too fine-grained analyses of micro processes leaving out structural conditions on the meso (team as a whole) and macro (embedding organization, socio-political system) levels.

3.5. The social identity perspective

Scholars taking the social identity perspective assume that relations between large-scale social categories as nations, cultural groups etc. exist and analyze the cognitive aspects of self- and other-classifications of social groups and group membership (Hogg et al., 2004). Social identity is "the individual's knowledge that he belongs to certain social groups together with some emotional and value significance to him of this group membership" (Tajfel, 1972, p. 292). These scholars' research goal is to describe how the categorization of self and others define group memberships, the construction of group norms and the enactment of these norms in group and intergroup behavior (Turner, 1985; Turner et al., 1987; Hogg et al., 2004). For example, belonging to different professional groups impacts how healthcare team members react to inclusive language and speak up (Weller et al., 2014; Weiss et al., 2018). Even more, gender stereotypes woefully impact team interaction in the OR (Pattni et al., 2017; Minehart et al., 2020). That means, in a given situation a specific social category – in our example physician or nurse – might be salient due to the context, here the heart surgery in the operating theatre.

Consider the episode in lines 30–37, one could describe the interaction between the surgeon and the nurse(s) as an intergroup situation, primarily on the interprofessional dimension physician versus nurse. In the surgeon's utterance "this nurse …," the (scrub) nurse Xenia is addressed as a member of her social category. The physician addresses her not as an individual, but through the lens of the stereotype "nurse" which means the person become depersonalized. Although the nurse is present in the situation and working at the operating desk with the surgeon, she is addressed in the third person, not with her name but with her professional classification. Her colleague, the circulating nurse, immediately comes to her defense, says her name ("Xenia") and provides cover. One could even go thus far that the circulating nurse tries to annulate the relational communication on the collective level (differentiating "we" from "them") by trying to get back to the interpersonal level of "Xenia" interacting with the other team members. Applying the social identity perspective to analyze the excerpt, we could identify which social categories are salient in this team. Besides the interprofessional categorization – physician vs. nurse – there is also the gender-dimension, man versus women. In the ironic, sarcastic or even aggressive way the surgeon comments on the competencies of the nurse, one could even see a categorization on the dimension of hierarchy which parallels the other two dimensions. Thus, the social identity perspective provides theoretical guidance if research questions focus on the conditions and effects of identification with the team, with subteams or the discrimination or even competition toward other teams or larger social units and categories. However, research mainly based on the social identity perspective risks overlooking the variety and creativity of the behavior of team members as individual persons (rather than as members of social categories).

4. Discussion

How team members work with one another, with other teams, with patients and their relatives impacts everybody's well-being (Pronovost, 2013; WHO, 2021). Teams are not black boxes and exploring how team members manage teamwork in the complexity (Lingard et al., 2004) of healthcare systems will help identifying how to support them best (Kolbe and Boos, 2019; Anderson et al., 2021). Team science provides orientation, theoretical and methodological guidance, and resources for how to study teamwork. Reflecting on how we use these methodologies is important for drawing conclusions. In our perspective article we attempted to illustrate how our theoretical lens influences how we study teamwork in healthcare. It seems fascinating that a brief sequence of an operating room team conversation can be explored from many perspectives with varying foci: performance, power, identity, time and many more. Our purpose was to highlight the benefits of leaving static research behind but use the existing versatility of team theory to inspire team research in healthcare and other high responsibility domains.

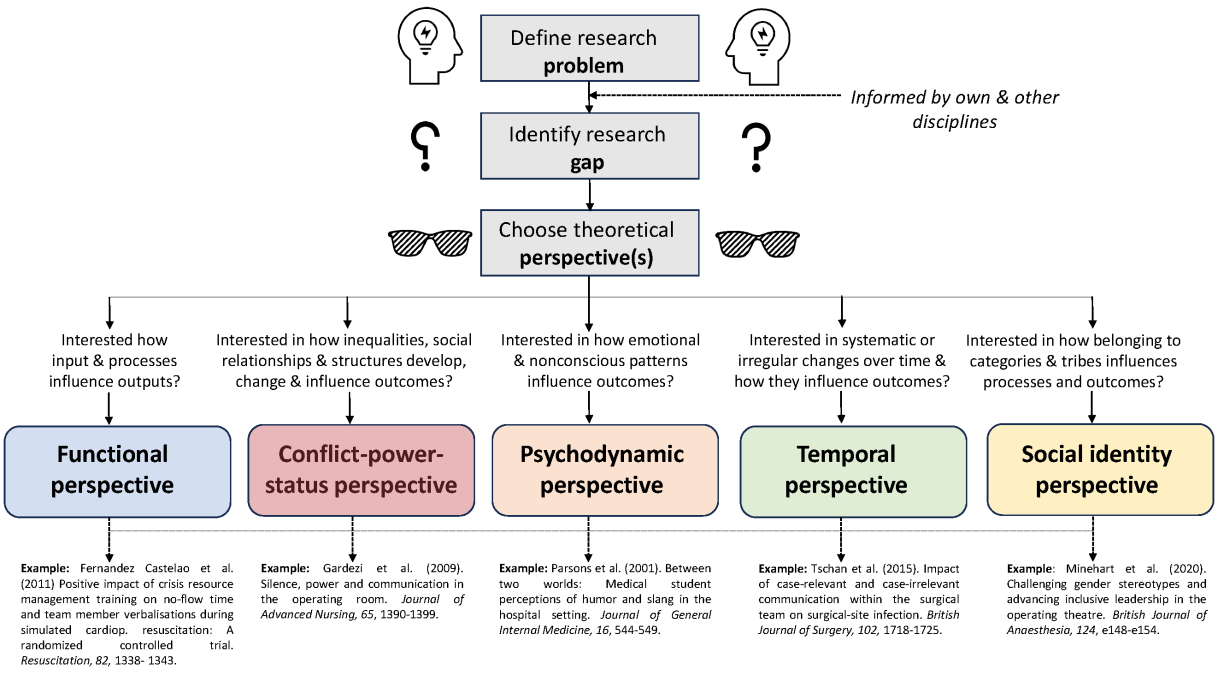

FIGURE 1
Five perspectives for analyzing team interactions.

Whether conscious or unconscious, our choice of a particular theoretical lens both sharpens our focus and leaves us blind to possible other phenomena. Applying the problem-gap-hook heuristic (Lingard and Watling, 2021), we hope that our illustration will provide guidance for studying teams in healthcare in identifying the problem, gap, and hook.

4.1. Identifying the problem

What is the problem that matters? Exposure to disrespectful team members? Impeded patient safety when team members do not share or listen to safety concerns? Lack of clarity on whether or how heart team meetings work? Precisely identifying the problem at hand is important because it will guide which theoretical lens(es) may fit best for studying it. For example, if in our heart surgery example (Table 1) the perceived stress and reduced well-being of the operating room team were problematic, applying not only the functional but also the conflict/power/status and psychodynamic perspectives might be fruitful and direct researchers to studying the tensions, potential toxic functions of humor and other forms of disrespectful communication in the OR (Lingard et al., 2004). Notably, the problem is not the same as the research gap.

4.2. Identifying the gap

What is already known about the problem and what is the current gap in the research, precisely? From our experience, a research review beyond the scope of one discipline and one theoretical perspective typically reveals plenty of existing research that will help sharpen the research question and methods. For example, when studying voice in healthcare teams, reviewing the voice literature in organizational behavior and psychology yields a variety of concepts, methods and results applicable to healthcare teams (Heaphy et al., 2022; Li and Tangirala, 2022). For broadening the research beyond healthcare, the dimensional model of Hagemann allows for identifying similarities, differences, and application (Hagemann et al., 2011). Notably, identifying the research gap can be a challenging step as research from different theoretical lenses and disciplines is frequently published in different kinds of journals; researchers may benefit from leaving the comfort zones of their field's journals.

4.3. Identifying the hook

Why does the research gap and the chosen approach to closing it matter? The team research perspectives described in this article can be a considerable hook (Figure 1): A problem may be studied from a *different perspective*. For example, while voice in healthcare teams has typically been studied from the conflict/status/power perspective, applying a psychodynamic perspective may discover unconscious voice/silence patterns (Foulk et al., 2016). Alternatively, a problem may be studied *combining different theoretical perspectives*. For example, knowledge on facilitating voice in healthcare teams may be enhanced by combining the conflict/status/power with the psychodynamic perspective, linking power, status, patterns and voice communication (Weiss et al., 2017, 2018, 2023; Lemke et al., 2021). As another example, a behavioral observation study on teamwork and communication within surgical teams has shown that more case-irrelevant communication including humor during wound closure is related to worse patient outcomes, whereas case-relevant communication during the whole surgery seems to be a protective factor against surgical site infections (Tschan et al., 2015).

This impressive study evolved through combining the psychodynamic, the temporal, and the functional perspectives. Further combinations of theoretical perspectives are conceivable: combining the functional with the conflict-power-status perspective may enrich our understanding of crucial relational aspects improving or undermining team effectiveness (Janss et al., 2012; Weiss et al., 2023). Combining the functional with the temporal perspective (Fernandez Castelao et al., 2015) to find out how effective and less effective behavioral patterns emerge and can be supported or avoided may be fruitful, e.g., by training or intervention. Similarly, the social identity perspective may fit well to the conflict-power-status and functional perspectives for exploring the effects of stereotyping on team and leadership effectiveness as well as on patient safety (Weller et al., 2014; Pattni et al., 2017; Minehart et al., 2020).

5. Conclusion

Thus, reflecting on which theoretical lenses we apply when studying dynamics in healthcare sharpens our focus. It sharpens what we are looking at, how we are looking at it and what literatures and methodologies we will use to inform our research (Weingart, 1997; Edmondson and Mcmanus, 2007).

Our analysis has limitations. First, there are more theoretical perspectives to studying team dynamics than we have discussed here (Poole et al., 2004). Our discussion is a starting point rather than a comprehensive exploration of each perspective. Further research is required; in particularly with respect to equity, diversity and inclusion in healthcare teams (Rosenkranz et al., 2021). For example, combining the psychodynamic with the so-called feminist perspective might yield important insights into how gender and privilege are enacted in team interaction (Minehart et al., 2020; Tramèr et al., 2020; Hochstrasser et al., 2022; Zwicky et al., 2022).

Second, we did not discuss why some theoretical perspectives (e.g., functional perspective) may, explicitly or implicitly, have been used more often than others (e.g., temporal perspective). Methodical constraints and required effort in accessing temporal data may play a significant role and new advances in collecting temporal team interaction may help (Weiss et al., 2023). Third, particularly the science of healthcare teams has to factor in two seemingly distinct mindsets of what constitutes "good data": On the one hand, psychological and team science involve expertise in recording and describing social phenomena, such as perceptions, attitudes, or behavior in teams (Weingart, 1997; Brauner et al., 2018). Valid measurement instruments are developed to measure these data precisely and to be able to use them in behavioral observations, surveys/questionnaires, and interviews. This type of data collection may at first seem unusual to medical researchers, who, on the other hand, rely on more "objective" data such as physiological values. On the other hand, medical science considers randomized clinical trials the state of the art (Benson and Hartz, 2000). They may represent a particular form of the functional perspective and explain why much research on healthcare teams does indeed apply a functional perspective. In our view, it is precisely the diversity of interdisciplinary methods that would allow for other, new angles for research. Studying healthcare teams by translating and applying methods from medicine and nursing, organizational behavior, psychology, mechanical engineering and informatics seems now easier than a decade ago and allows for new avenues and methodologies for studying healthcare team dynamics (Rosen et al., 2014, 2018; Hałgas et al., 2023; Weiss et al., 2023). While we are aware of the enormous effort involved in planning, conducting and analyzing healthcare team research with any of the discussed perspectives, we believe in their potential for improving teamwork and patient care.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the patients/participants or patients/participants legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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EDITED BY
Juliane E. Kämmer,
University of Bern, Switzerland

REVIEWED BY
Robert Lundmark,
Umeå University, Sweden
Rafael Wespi,
University of Bern, Switzerland

*CORRESPONDENCE
Michaela Kolbe
✉ mkolbe@ethz.ch

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"Asking for help is a strength"—how to promote undergraduate medical students' teamwork through simulation training and interprofessional faculty

Michaela Kolbe[1,2]*, Jörg Goldhahn[3], Mirdita Useini[3] and Bastian Grande[1,4]

[1]Simulation Centre, University Hospital Zurich, Zurich, Switzerland, [2]Department of Management, Technology, and Economics, ETH Zurich, Zurich, Switzerland, [3]Department of Health Sciences and Technology, ETH Zurich, Zurich, Switzerland, [4]Institute of Anaesthesiology, University Hospital Zurich, Zurich, Switzerland

The ability to team up and safely work in any kind of healthcare team is a critical asset and should be taught early on in medical education. Medical students should be given the chance to "walk the talk" of teamwork by training and reflecting in teams. Our goal was to design, implement and evaluate the feasibility of a simulation-based teamwork training (TeamSIM) for undergraduate medical students that puts generic teamwork skills centerstage. We designed TeamSIM to include 12 learning objectives. For this pre-post, mixed-methods feasibility study, third-year medical students, organized in teams of 11–12 students, participated and observed each other in eight simulations of different clinical situation with varying degrees of complexity (e.g., deteriorating patient in ward; trauma; resuscitation). Guided by an interprofessional clinical faculty with simulation-based instructor training, student teams reflected on their shared experience in structured team debriefings. Using published instruments, we measured (a) students' reactions to TeamSIM and their perceptions of psychological safety via self-report, (b) their ongoing reflections via experience sampling, and (c) their teamwork skills via behavior observation. Ninety four students participated. They reported positive reactions to TeamSIM ($M = 5.23$, $SD = 0.5$). Their mean initial reported level of psychological safety was $M = 3.8$ ($SD = 0.4$) which rose to $M = 4.3$ ($SD = 0.5$) toward the end of the course [$T(21) = -2.8$, 95% CI −0.78 to-0.12, $p = 0.011$ (two-tailed)]. We obtained $n = 314$ headline reflections from the students and $n = 95$ from the faculty. For the students, the most frequent theme assigned to their headlines involved the concepts taught in the course such as "10 s for 10 min." For the faculty, the most frequent theme assigned to their headlines were reflections on how their simulation session worked for the students. The faculty rated students' teamwork skills higher after the last compared to the first debriefing. Undergraduate medical students can learn crucial teamwork skills in simulations supported by an experienced faculty and with a high degree of psychological safety. Both students and faculty appreciate the learning possibilities of simulation. At the same time, this learning can be challenging, intense and overwhelming. It takes a team to teach teamwork.

KEYWORDS

teamwork, healthcare, training, simulation, patient safety, education, TeamSIM

1. Introduction

As of today, teams play an increasingly critical role in healthcare. Healthcare is not only getting more and more specialized, but patients live longer and new technological developments change the way healthcare is provided. The ability to team up and safely work in any kind of healthcare team is becoming a critical asset. Pandemics such as COVID-19 have required healthcare professionals with vastly differing sets of experiences to team up on the spot and learn how to care for newly emerging and changing diseases (Tannenbaum et al., 2020). In contrast with this global development, the education of teamwork skills in healthcare is still in its infancies (World Health Organization, 2021). Teamwork skills are still labeled "soft" and "non-technical" (Hamilton et al., 2019; Kerins et al., 2020; Pollard and Tombs, 2022), although evidence demonstrates that they are everything but "soft" (Nestel et al., 2011; Goldman and Wong, 2020). This dichotomy of clinical vs. non-clinical skills contributes to the minimal emphasis and widely remaining lack of awareness of the importance of teamwork in patient safety in traditional education of healthcare providers (World Health Organization, 2021). Instead, teamwork should be integrated as early as possible in medical education (Banerjee et al., 2016; Chandrashekar and Mohan, 2019).

Training is an effective intervention to improve teamwork skills in healthcare (Hughes et al., 2016; Didwania et al., 2020). Simulation-based training in particular is becoming more and more established in medical education as it allows educators and students to practice and reflect on skills in specialized settings without risking patient safety (Jowsey et al., 2018, 2020). Simulations of clinical teamwork situations provide students with possibilities to reflect on own actions within the context of clinical work. Its particular use for improving interprofessional teamwork skills is growing (Chakraborti et al., 2008; Fox et al., 2018; Hamilton et al., 2019; Sivarajah et al., 2019; Challa et al., 2021; Pollard and Tombs, 2022) and even undergraduate students with limited clinical exposure seem to be able to manage the considerable cognitive load involved in simulation-based learning (Tremblay et al., 2023). However, despite teamwork being part of the learning objectives, it is frequently taught in the context of managing medical emergencies in teams (Weller, 2004; Jowsey et al., 2020; Rouse et al., 2022; Soellner et al., 2022) or in an individual setting (e.g., a single learner performing a tasks with multiple simulated team members and being debriefed individually, Schober et al., 2019). The importance of teamwork skills in healthcare expands beyond emergencies and comes into play in a variety of tasks and team settings such as medical board meetings, handovers or preparing a child for general anesthesia (Foster and Manser, 2012; Schmutz and Manser, 2013; DiazGranados et al., 2014; Taplin et al., 2015; Kolbe and Boos, 2019; Schmutz et al., 2019; Mendoza et al., 2021; Walsh et al., 2021; Zajac et al., 2021; Greilich et al., 2023). Students should be given the chance to "walk the talk" of teamwork by training and reflecting in teams (Arabi and Kennedy, 2022). Our goal was to design, implement and explore the feasibility of a simulation-based teamwork training (TeamSIM) for undergraduate medical students—training in teams—that puts generic teamwork skills centerstage. The goal of this study is to evaluate the feasibility of TeamSIM based on students' reactions, reflections, and skills.

2. Simulation-based teamwork training: TeamSIM

Ten teamwork skills are considered particularly important for working in healthcare teams: (1) recognizing criticality of teamwork, (2) creating a psychologically safe environment, (3) structured communication, (4) closed-loop communication, (5) asking clarification questions, (6) sharing unique information, (7) optimizing team mental models, (8) mutual trust, (9) mutual performance monitoring, and (10) reflection/debriefing (Greilich et al., 2023). We designed TeamSIM to allow medical students to develop, experience and reflect on concepts and strategies for the majority of these teamwork competencies. TeamSIM aims at providing medical students with the possibility to learn principles of working together efficiently, effectively and safely in any interprofessional healthcare teams in a variety of clinical situations, both emergency and routine (Kolb, 1984; Salas et al., 2013; Walsh et al., 2021).

2.1. TeamSIM's pedagogical framework and principles

Based on experiential learning within simulation-based education, TeamSIM is designed for undergraduate medical students. Organized in teams, they are invited to participate and observe each other in simulations of different clinical situation. Guided by an interprofessional clinical faculty with simulation-based instructor training (i.e., nurses, midwifes, physicians, psychologists), student teams reflect on their shared experience in structured team debriefings. They practice essential teamwork skills such as handover communication and speaking up and can experience the translational effects of psychological safety (Pollard and Tombs, 2022; Purdy et al., 2022).

A core pedagogical principle of TeamSIM is single and double-loop learning (Argyris, 2002). Single-loop learning involves learning and refining skills by comparing one's behavior with practice standards (Argyris, 2002). Here, simulation faculty support learners by teaching and coaching (Fey et al., 2022). Double-loop learning helps learners to identify the frames (i.e., assumptions, beliefs, mental models) that drive their particular behavior (Argyris, 2002). Students may learn that the assumptions they think they hold (i.e., espoused frames, e.g., "teamwork is important") differ from the assumptions that actually drive their behavior (i.e., actual frames, e.g., actually thinking that "clinical skills are much more important than teamwork skills" and, as a consequence, not engaging in shared pre-briefings to plan their work). Here, simulation faculty supports via facilitation by sharing their observations and points of view and inquiring the students' point of view (Rudolph et al., 2007, 2008b; Fey et al., 2022).

Single and double-loop learning are represented in SimZones—a system to organize simulation activities based on learners, learning objectives, signal and noise and action, feedback and debriefing. We consider TeamSIM in between SimZone 2 (i.e., acute situational instruction) and 3 (i.e., team and system development, Roussin and Weinstock, 2017). Simulation faculty engages students in coaching and debriefing conversations (Fey et al., 2022). Simulation activities in SimZone 2 and 3 typically involve complex and challenging team tasks and allow learners to deliberately learn from "productive" failure (Sinha and Kapur, 2021). To be able to learn, however, students must

feel valued, appreciated and feel that they can share what is on their mind without any repercussions (Edmondson, 1999). This psychological safety is one of TeamSIM's fundamental pedagogical principles and tracked during TeamSIM's formative feasibility evaluation (Edmondson, 1999; Rudolph et al., 2014; Johnson et al., 2020; Kolbe et al., 2020; Kostovich et al., 2020; Lackie et al., 2022; Purdy et al., 2022).

2.2. Competencies underlying TeamSIM

In Switzerland, the Joint Commission of the Swiss Medical Schools has issued the Principal Relevant Objectives and Framework for Integrated Learning and Education (PROFILES). They explicitly include the ability to work in healthcare teams as learning objective (Michaud et al., 2016). PROFILES displays three interdependent chapters focusing on General Objectives, Entrustable professional activities (EPAs) and the 265 most common clinical situations. TeamSIM covers learning objectives of the General Objectives, which relate to the different roles of physicians as well as several EPAs, which focus on the main tasks a physician must be able to perform autonomously. Specifically, students examine their roles as medical expert, collaborator, scholar, and professional. The EPAs covered here focus on activities that particularly include teamwork.

3. Learning environment and format

3.1. Learning objectives

TeamSIM includes 12 learning objectives (Figure 1) around recognition and management of knowledge within teams, teaming up, communicating clearly and respectfully, embracing and managing dissent, voice and listening, asking for help and reflexivity (Larson et al., 1998; Christensen et al., 2000; Baron, 2005; Riskin et al., 2015; Schmutz and Eppich, 2017; Hamilton et al., 2019; Riskin et al., 2019; Schwappach et al., 2019; Long et al., 2020; Jones et al., 2021; Kolbe et al., 2021; Lemke et al., 2021; Rudolph et al., 2021; Bamberger and Bamberger, 2022; DiPierro et al., 2022; Taiyi Yan et al., 2022; Vauk et al., 2022; Greilich et al., 2023; Tannenbaum and Greilich, 2023). Additionally, it provides students with the possibility to reflect on the consequences of teamwork for well-being and performance of healthcare professionals as well as for patient care and safety and on implications for their career management.

3.2. Learning environment

Guided by an interprofessional clinical faculty, student teams are invited to reflect on their shared experience in structured team debriefings following each simulated case. Experiencing the transformational effects of team psychological safety and practicing teamwork skills in this learning environment is the core of TeamSIM (Roussin et al., 2014; Rudolph et al., 2014; Edmondson and Bransby, 2023). Simulation is a powerful teaching tool and psychological safety and high-quality facilitation are important. We deliberately aimed at establishing a faculty team of experienced simulation educators (rather than student teachers) who are able to guide students respectfully through challenging simulation exercises, debriefings and deal with difficult situations (Grant et al., 2018; Jowsey et al., 2020; Kolbe et al., 2020). They work as physicians, nurses, midwifes, psychologists, and an airline pilot, and typically train their peers rather than students. For TeamSIM, they underwent specific faculty development: the course directors provided detailed orientation on

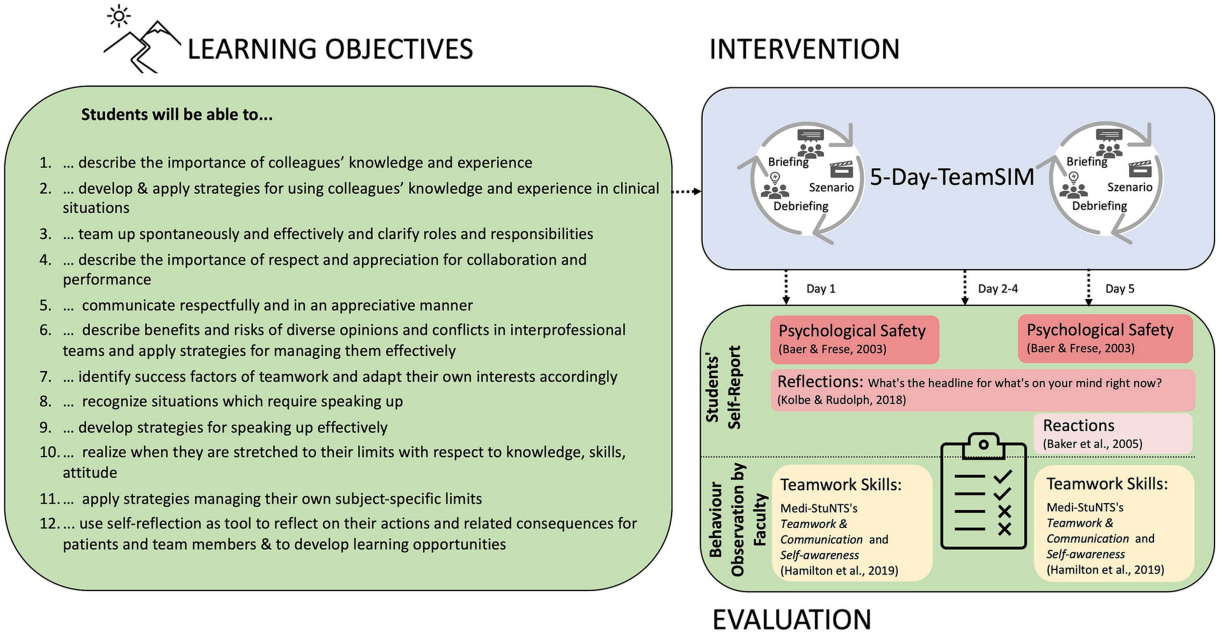

FIGURE 1
Learning objectives and feasibility evaluation of TeamSIM.

TeamSIM's learning objectives and curriculum; coordinated objectives and simulation across sessions, scheduled faculty briefing and debriefings, reviewed each of the eight different simulation sessions's modules, and conveyed their commitment to psychological safety. If possible, faculty conducts debriefs each day over lunch during TeamSIM.

3.3. Pedagogical format

TeamSIM is designed as week-long course and is open to all third-year medical students of a new bachelor on human medicine at ETH Zurich, Switzerland (Weissmann et al., 2020). We invite students to "walk the talk" of teamwork by training teamwork in teams.

We organize students in teams of 11 to 12 people. They remain in their respective team for the full week and participate in eight, in-person, four-hour-simulation sessions representing different clinical situations with varying degrees of complexity (e.g., deteriorating patient in ward; trauma; labor and delivery, Figure 2). Due to logistical reasons, each of the teams follows a slightly different schedule: Team 1 starts with "Teaming up for patient emergency" and ends with "Speak up in teams" (Figure 1) while Team 2 starts with "Managing teamwork and career" and ends with "Teaming up for patient emergency," etc. Each of the eight 4-hour simulation sessions includes participation in two to three rounds of briefing, simulated case, and debriefing (Figure 2). Students can practice teamwork skills such as leadership from three different perspectives. For example, they can lead the team (1st-person practice), be led by a team member (2nd-person practice) and observe team leadership and followership from the outside (3rd-person practice, Chandler and Torbert, 2003). That is, depending on the case, four to six of the students actively participate while their peers observe them; roles are switched in the subsequent case. The simulated cases are developed by the faculty teaching the respective session (Figure 2).

For the debriefings, the faculty follows the Debriefing with Good Judgment (Rudolph et al., 2007, 2008a) and TeamGAINS (Kolbe et al., 2013) approaches. They use their observations of the students' actions during the scenarios to provide feedback, inquire their perspectives and discuss different approaches with all team members. During both briefing and debriefing faculty focuses on selected learning objectives. For example, during the session "managing trauma as team," the faculty introduces and discusses tools for developing the learning objectives #2 (develop & apply strategies for using colleagues' knowledge and experience in clinical situations), #3 (team up spontaneously and effectively and clarify roles and responsibilities), #10 (realize when they are stretched to their limits with respect to knowledge, skills, attitude), and #11 (apply strategies managing their own subject-specific limits). In addition, the faculty adapts their focus depending on the students' needs (Cheng et al., 2016). For example, students can re-do or practice certain team actions.

We introduce all students to the course during the formal TeamSIM briefing on Monday morning. Using Zoom (Zoom Video Communications, Inc., San Jose, United States), we discuss expectations, course of events, learning objectives, confidentiality, roles, and logistic details to provide orientation and contribute to a psychologically safe learning environment (Rudolph et al., 2014; Kolbe et al., 2020). We introduce simulation as a teaching tool, reflect on its advantages and limitations, provide recommendations for how to engage in simulation and demonstrate our commitment to respecting students and their perspective. We then invite students into breakout groups in their respective teams to brief themselves and ask them to develop a set of guiding principles for their team (Mathieu and Rapp, 2009). Simulation sessions start Monday afternoon and end Friday morning. TeamSIM ends with a formal TeamSIM debriefing on Friday

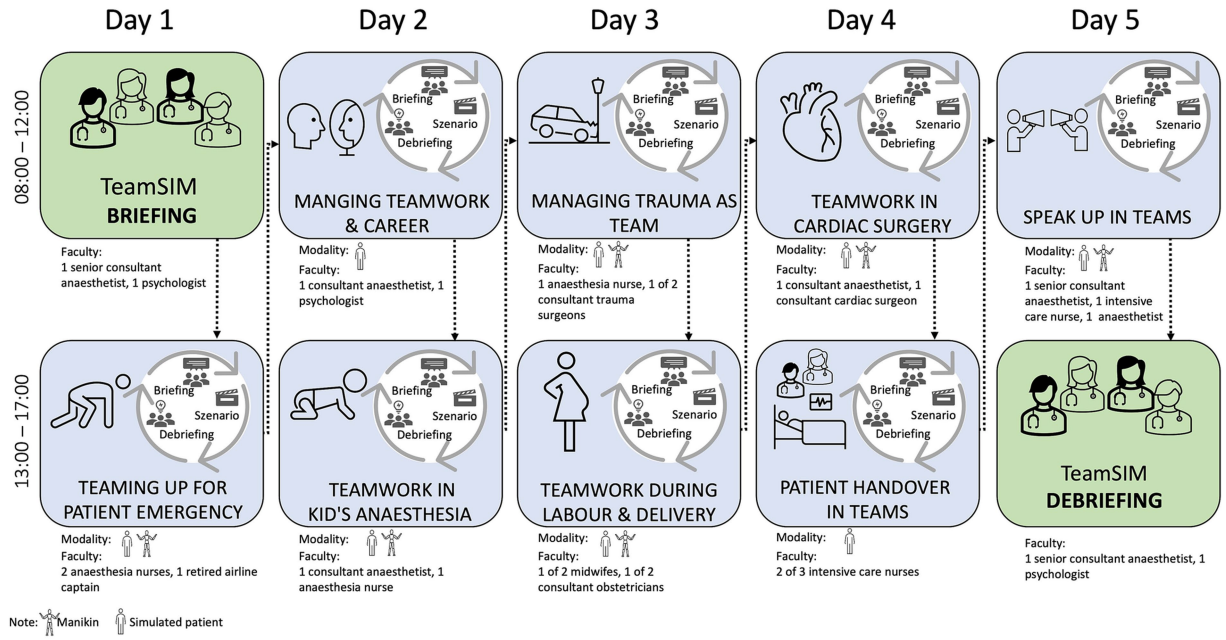

FIGURE 2
TeamSIM sample curriculum for team 1 with simulation sessions, modality, and faculty.

afternoon when we invite all teams back into Zoom to review TeamSIM. In particular, we ask all student teams to formally debrief themselves based on a structured tool adapted to TeamSIM (Welch-Horan et al., 2021).

Students' actions are not graded. To pass the course, 90% attendance of the sessions is required.

4. Feasibility evaluation of TeamSIM and its evaluation model

Our goal was to explore the feasibility of conducting TeamSIM and its evaluation model. As the course is quite intense with a considerable number of students, faculty, learning objectives, and simulation operations, we intended to investigate the practicability of a pre-post evaluation of each student by the faculty who already has a high workload. The data we collected as described below was merely used for this purpose, treated as confidential, and not reported back to the students. (Students receive immediate feedback as part of the debriefings during each simulation session.)

4.1. Methods

4.1.1. Study design and ethics

Our intention was to explore the feasibility of evaluating TeamSIM with the a pre-post, mixed-methods design which required both students and faculty to collect data (Figure 1). We conducted TeamSIM and collected feasibility evaluation data from 13 March until 17 March 2023 at the Simulation Centre of the University Hospital Zurich, Switzerland. The ethics committee of the canton of Zurich, Switzerland granted this study exemption (Registry no. 2023-00194). Study participation was voluntary and participants' consent was obtained at the time of enrolment.

4.1.2. Sample

Ninety four third-year medical students participated in TeamSIM; 53 students (56.4%) were female, 41 (43.6%) male. We randomly assigned students to eight teams of 11 to 12 students and provided each team with a rotation time table. A pool of 23 experts participated as faculty training each of the teams participating in the simulation sessions with 2 to 3 faculty members. Nine faculty members (39.1%) had a background in anesthesiology, 4 (17.4%) in intensive care, 2 (8.7%) in traumatology, 4 (17.4%) in labor and delivery, 1 (4.3%) in cardiac surgery, 2 (8.7%) in psychology, and 1 (4.3%) in commercial aviation.

4.1.3. Measures

4.1.3.1. Students' reactions to TeamSIM

At the end of the final simulation session we measured students' reactions to TeamSIM using a German version of a scale measuring trainee's reactions to the training (Baker et al., 2005; Kolbe et al., 2013). This scale contained nine items which students rated on a 6-point Likert scale ranging from 1 (strongly disagree) to 6 (strongly agree). Sample items were "The training was an effective use of my time" and "The training was well organised." In addition, we asked students to respond to four open-ended questions: "What did you particularly like?," What did you not like?," "What was your most important learning experience?," "What do you need to apply the skills learned in this course?"

4.1.3.2. Perceptions of psychological safety

After the introduction to TeamSIM as well as after final debriefing session, we measured psychological safety by administering six items from the validated German translation (Baer and Frese, 2003) of Edmondson's (1999) team psychological safety scale: (1) "Everyone will be (was) able to bring up problems and tough issues"; (2) "No one would (did) deliberately act in a way that undermines my efforts"; (3) When someone makes (made) a mistake it will be (was) always held against him/her"; (4) "Some people will be (were) rejected for being different"; (5) "Others will (did) value and utilize my unique skills and talents"; (6) "It will be (was) difficult to ask others for help." Items number 3, 4, and 6 were reverse coded to mitigate response set bias. Items were rated on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

4.1.3.3. Reflections

Via experience sampling we tracked what captivated, concerned or transformed students and faculty as they moved through TeamSIM (Larson and Csikszentmihalyi, 1983; Kerins et al., 2020). We applied a modified "Headline"-method (Kolbe and Rudolph, 2018): after each simulation session, students were invited to access an online, two-minute free writing task via QR-code. The writing task was entitled "headline" and included the following open-ended question: "What is the headline for what is on your mind right now?" and the prompt "Headline:," followed by a blank line indicating participants should answer the question with a few words only.

4.1.3.4. Teamwork skills

TeamSIM faculty aimed to assess teamwork skills using two skill categories of Medi-StuNTS (Hamilton et al., 2019). Medi-StuNTS is a behavioral marker system designed to assess "non-technical" skills of medical students. It comprises of five skill categories: *situation awareness*, *decision-making and prioritization*, *teamwork and communication*, *self-awareness* and *escalating care*. For the purpose of evaluating TeamSIM, we selected *teamwork and communication* and *self-awareness* as relevant skill categories because they appropriately represented TeamSIM's learning objectives (Table 1). For each skill category, Medi-StuNTS provides three skill elements and respective positive and negative behavioral markers (Hamilton et al., 2019). The skill category teamwork and communication includes the elements (1) establishing a mental model, (2) demonstrating active followership, and (3) patient involvement. The skill category self-awareness includes the elements (1) role awareness, (2) coping with stress, and (3) speaking up (Table 1). Faculty were asked to rate students on a 5-point Likert scale ranging from 1 (poor performance, threatens patient safety, improvement required) to 5 (excellent performance, a positive example for others, Hamilton et al., 2019). A study testing Medi-StuNTS validity and reliability found evidence for discriminatory validity (e.g., experts scoring better than intermediates who scored better than novices) and inter-rater reliability (e.g., disagreement of more than one point in less than one-fifth of cases, Phillips et al., 2021). Medi-StuNTS was designed to be used with minimal training (Hamilton et al., 2019). MK discussed Medi-StuNTS' content and use with the TeamSIM faculty 1 week prior to TeamSIM start.

TABLE 1 Teamwork skills rated by TeamSIM faculty using Medi-StuNTS categories teamwork and communication and self-awareness after the first (pre-test) and last (post-test) simulation session.

	Pre-test *N* = 52 (55.3%)			Post-test *N* = 61 (64.9%)		
	M	SD	Not observable (*n*)	M	SD	Not observable (*n*)
Category teamwork and communication						
Establishing a mental model	3.84	0.83	3	4.15	0.41	2
Demonstrating active followership	3.75	0.84	4	4.17	0.46	2
Patient involvement	3.57	0.85	17	4.18	0.44	12
Role awareness	3.91	0.75	5	4.21	0.49	5
Coping with stress	3.56	0.81	16	4.13	0.46	16
Speaking up	3.70	0.87	6	4.09	0.35	7

4.1.4. Data collection

We created online versions and respective QR access codes of all measures and placed them either on the walls of the training rooms or provided the instructors with them. Both students and instructors could access the measures with their smart phones. Upon the start of the course, we verbally provided all students with information on course evaluation, uploaded detailed information and the consent form on their online learning platform as well as handed them out prior to the start of their first simulation session. We instructed the faculty to support students accessing the evaluation measure. We also asked them to assess teamwork skills at the beginning and end of the course and discuss the Medi-StuNTS with them.

4.1.5. Data analysis

We conducted statistical analysis for trainee reactions, psychological safety, and teamwork skills with SPSS V.26 software (IBM, Armonk, NY, United States). The statistical tests were two-sided using 0.05 as the threshold for statistical significance.

We analyzed responses to the open-ended training reaction questions via applying a multistep, thematic analysis to identify evident topics (Miles and Huberman, 1994; Braun and Clarke, 2006). We considered each response one analytic unit. Following procedures for linking inductive and theory-driven coding we started inductively for each of the four open-ended questions by reviewing response after response and generating a list of rough categories in an open-coding process (Boyatzis, 1998; Fereday and Muir-Cochrane, 2006). We subsequently reviewed rough categories and identified clusters of categories which we used to analyze all responses. We determined absolute frequencies for the resulting categories.

For the headline reflections, we coded the original headlines based on an analytical approach reported for similar data (Kolbe and Rudolph, 2018): we assigned each headline to one or more of five themes: (1) metacognitions of one's learning process (i.e., statements on monitoring one's learning progress), (2) evaluations of sessions and performances (i.e., critically reviewing a particular session or how something worked), (3) notes to self (i.e., reflections on specific concepts introduced during TeamSIM), (4) anticipations of applying the learnt skills in the future (i.e., predicting how particular competencies would be used in the future), and (5) emotions in the learning process (i.e., affective statements). We determined absolute frequencies for the resulting groups of codes. We illustrated selected headline reflections using Graphpad.[1]

4.2. Results

Of the 94 students participating in TeamSIM, 81 (86.2%) responded to the pre-psychological safety measurement; 45 (47.9%) students completed the post-psychological safety and training reactions survey, 22 (23.4%) of which we could match.

4.2.1. Reactions to TeamSIM

Students reported positive reactions ($\alpha = 0.87$) to TeamSIM ($M = 5.23$, $SD = 0.5$). In response to what the students particularly liked, the three most frequently mentioned topics were the *simulation method* as such, specific *simulation sessions*, and the *way the faculty engaged with them* (Figure 3A). In response to what they did not like about TeamSIM, the three most frequently mentioned topics were *nothing*, *long, repetitive debriefings*, and specific *simulation sessions* (Figure 3B). As their most important learning experience, students reported in particular communication such as *closed-loop communication* and *speaking up*, *teamwork and leadership*, *role distribution*, and a variety of other insights such as "not yet knowing is okay if one knows how to get help," "thinking out loud," "admitting one's fallibility," or "asking for help is a strength" (Figure 3C). In response to what they might need to apply the skills learned in TeamSIM, students mentioned *practice*, *courage*, a *"good" employer or team* and a variety of other factors such as community and team orientation (Figure 3D).

4.2.2. Perceptions of psychological safety

On a scale from 1 to 5, students' mean initial reported level of psychological safety ($\alpha = 0.44$) was $M = 3.8$ ($SD = 0.4$). At the end of the course, this level ($\alpha = 0.53$) rose to $M = 4.3$ ($SD = 0.5$). For the $n = 22$ students for whom we could match pre and post responses we found a significant increase in perceived psychological safety [$T(21) = -2.8$, 95% CI −0.78 to −0.12, $p = 0.011$ (two-tailed)].

1 www.graphpad.com

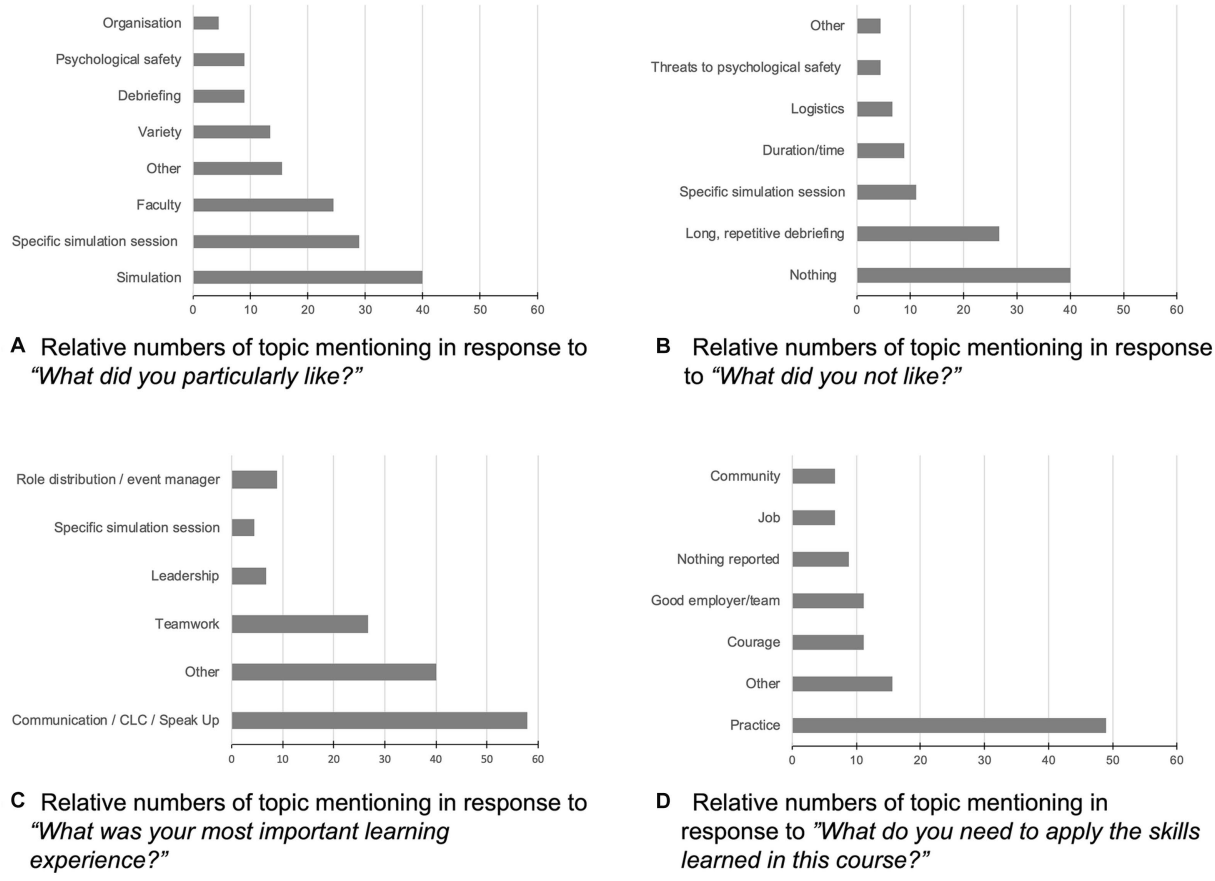

FIGURE 3
(A–D) Relative numbers of topic mentioning in response to four open-ended training reaction questions ($n = 45$). CLC, closed loop communication.

4.2.3. Reflections

We obtained $n = 314$ headline reflections from the students and $n = 95$ headline reflections from the faculty. For the students, the most frequent theme assigned to their headlines was *notes to self* (57.6%) which involved students' reflections on the concepts taught in the course such as closed-loop communication, speaking up and "10 s for 10 min" (Figure 4A). Other themes of student headlines were *evaluations* (33.4%), *emotions* (10.2%), *anticipations* (4.8%), and *metacognitions* (3.5%). For the faculty, the most frequent theme assigned to their headlines was *evaluation* (61.1%), i.e., reflections on how their simulation session worked for the students or how students seemed to react to the simulation (Figure 4B). Other themes of faculty headlines were *emotions* (35.8%), *notes to self* (15.8%), *metacognitions* (9.5%), and *anticipations* (1.1%). Looking at emotions, for students these emotions were mixed, ranging from joyful to overwhelmed (Figure 4C). For the faculty, the reflected emotions were rather positive, in particular seeing the students improve over the course of TeamSIM (Figure 4D).

4.2.4. Development of teamwork skills

For the rating of teamwork skills, the faculty was able to rate the selected teamwork skills for 52 (55.3%) students immediately following the first TeamSIM simulation session and for 61 (64.9%) students immediately following the final TeamSIM simulation session (Table 1). On a scale from 1 to 5, faculty rated the students initial teamwork skills from $M = 3.56$ ($SD = 0.81$) to $M = 3.91$ ($SD = 0.75$). At the end of the course, these values rose to $M = 4.09$ ($SD = 0.35$) to $M = 4.21$ ($SD = 0.49$). Due to challenges in matching students' pre and post values we refrained from performing inferential statistical analysis.

5. Discussion on the practical implications, objectives, and lessons learned

Our goal was to design, implement and evaluate the feasibility of a simulation-based teamwork training—TeamSIM—for medical students. Based on experiential learning within simulation-based education, TeamSIM aims at providing students with the possibility to learn principles of working together efficiently, effectively, and safely in interprofessional healthcare teams. In what follows, we discuss the effectiveness of TeamSIM, challenges, constraints, limitations, and highlight our lessons learned.

5.1. Effectiveness of TeamSIM

The feasibility evaluation data suggests that students reacted rather positively to participating in activities simulating their future

A Words in the **students'** responses to *"What's the headline for what's on your mind right now?"* coded as 'notes to self'

B Words in the **faculty's** responses to *"What's the headline for what's on your mind right now?"* coded as 'evaluations of sessions and performances'

C Words in the **students'** responses to *"What's the headline for what's on your mind right now?"* coded as 'emotions in the learning process'

D Words in the **faculty's** responses to *"What's the headline for what's on your mind right now?"* coded as 'emotions in the learning process'

FIGURE 4
Quantitative graphic representations of the words in the students' headline reflections coded as "notes to self"(n = 181) **(A)** and "emotions in the learning process" (n = 32) **(C)** and in the faculty's headline reflections coded as "evaluations of sessions and performance" **(B)** and "emotions in the learning process" (n = 34) **(D)**. More frequently used expressions are represented by larger front sized. Common filler word (i.e., the, is, and) were excluded. The graphics were created using WordArt.com (accessed on 05 April 2023).

work with each other. They seemed to engage in in-depth examination of their approaches to teamwork. Students' teamwork skills seemed to improve and their take-aways indicate specific teamwork capabilities. At the end of the course they felt more psychologically safe than at the start. This is an important finding because simulation is an intense teaching tool which involves social risk-taking and, thus, high level of psychological safety (Edmondson and Bransby, 2023). Importantly, the psychological safety that emerges during the simulation may leak into other fields and transfer to clinical practice (Pollard and Tombs, 2022; Purdy et al., 2022). Although our cross-sectional data prevents us from drawing an empirical conclusion, we assume that the reported learnings, improved teamwork skills, and positive reactions are related to the psychologically safe learning culture. While the students' seemed to have benefited from a learning environment with a high degree of psychological safety, TeamSIM's week-long intensity seemed to have asked a lot of their perseverance. The emotions reported by students (Figure 4C) suggest that TeamSIM was—beside being "fun" and "joyful"—"overwhelming" and "too much" at points. While this is normal in most complex, simulation-based training (Kolbe and Rudolph, 2018; Keskitalo and Ruokamo, 2021), distributing TeamSIM over a few weeks rather than 1 week might have provided students with more possibilities to digest their learning. However, given the logistical constraints of the medical curriculum and simulation operations, re-building the TeamSIM infrastructure once a week over a few weeks seems daunting.

5.2. Interprofessional faculty and their development

According to the evaluation data, the students appreciated the teaching, coaching, and facilitation by the interdisciplinary and interprofessional simulation faculty whom they perceived as very engaged and committed. This is to some degree reflected in TeamSIM faculty's reflections which indicated their ongoing concern about the effectiveness of their educational interventions. In our experience, working with this faculty prior to the course was critical and a necessary ingredient: multiple disciplines and professions went along with multiple approaches to simulation; establishing and maintaining a shared mental model of TeamSIM was important and required various faculty development measures (Cheng et al., 2020; Kolbe et al., 2020; Kostovich et al., 2020; Roze des Ordons et al., 2022).

5.3. Challenges and constraints

We experienced three particularly challenges. First, designing, planning, coordinating, and conducting TeamSIM involved effort with respect to course curriculum design and coordination of faculty. In addition to preparing the simulation space, equipment and designing sessions, we needed to recruit and develop the interdisciplinary, interprofessional, clinical faculty. Their availability and willingness to make time and engage in this course in their busy clinical schedules was crucial for its success (Fox et al., 2018).

Second, the complexity of TeamSIM and our deliberate choice to engage an experienced, clinical faculty rather than student peer coaches made this course expensive. Simulation-based education is considered a privilege (Lillekroken, 2020; Mosher et al., 2021). While we think that high-quality education will create long-lasting value, we are aware that finding ways to establish TeamSIM's sustainability will be challenging. We all did, however, consider the significant investment of time and financial resources also as in investment in the faculty's educational careers. According the headline reflections, the faculty enjoyed teaching this course.

The third challenge involved a potential mismatch of expectations and experience: while the faculty was highly trained in working with clinicians and aware of the importance of reflecting on practice, students seemed to struggle at points with the expected "amount" of reflection and the difficulties of the cases. This might be a common struggle in simulation-based education (Loo et al., 2018), particularly for students (Jowsey et al., 2020). Meeting their various needs for instruction vs. reflection was challenging, and likely reflects variances in their own personal development (Kerins et al., 2020). More in-depth research on how to support students while they learn to embrace reflecting on their actions will be helpful.

5.4. Limitations

Our feasibility evaluation of TeamSIM revealed limitations. First, we were not able to collect as much evaluation data as planned. We experienced that performing evaluations (i.e., inviting students again and again to complete surveys and headline reflections, rating teamwork behavior of multiple students, each team following a slightly different schedule) added another layer of workload for the faculty and resulted in a lack of interrater reliability data, low response rates, and dropouts which limit the generalizability of our results. We have learned we should more deliberately plan for collecting complex yet important evaluation data (e.g., engaging additional raters, collecting videos and performing the rating based on videos, peer-observation with pre-trained peers, additional evaluation training, etc.). Second, our emphasis on anonymity limited our ability to track individual students' over time; matching pre and post measures was challenging and in many cases not possible. It also prevented us from conducting multilevel analysis which would have been required because students were nested in teams (Raudenbush and Bryk, 2002). In addition, it prevented us from exploring effect differences between simulation sessions. Third, we did not perform reliability checks for the qualitative data analysis and the α-values of the psychological safety scale were rather low, again limiting the validity of our evaluation findings. Finally, in designing, conducting and evaluating TeamSIM we did not yet factor in potential cultural differences in both students and faculty, nor did we reflect on aspects of equity, gender and inclusion, which are significant limitations and call for change in future TeamSIM iterations (Palaganas et al., 2021; Purdy et al., 2023).

5.5. Lessons learned

The lessons learned from designing, conducting and evaluating the feasibility of TeamSIM are threefold: first, it takes a team to teach teamwork: a team of interprofessional faculty that embraces simulation-based learning and the psychological safety it requires. Second, both students and faculty appreciated the learning possibilities of simulation-based education, in particular for learning teamwork skills. In line with other research, this project endorses simulation as a teaching method that enables students to experience the complexity of interprofessional teamwork in healthcare and to try out and reflect on different approaches for managing this complexity that work for them. As one of the students remarked, it had helped them to develop "cornerstones in midst of the chaos." At the same time, this learning can be challenging, intense and overwhelming. Importantly, it should be considered in the context of how psychologically safe the students felt during training. Simulation-based training is a powerful tool; without psychological safety it may significantly impede students' capacity to learn and develop professional identities (Rudolph et al., 2013; Purdy et al., 2022; Edmondson and Bransby, 2023). Thus, while we think that versions of TeamSIM might be useful for training students of other healthcare professions, we strongly recommend to put high emphasis on establishing and maintaining psychological safety. For example, providing orientation about expectations and learning objectives, engaging learners in a sort of "fiction contract," caring about logistic details, conveying respect for learners and concern for their psychological safety, and maintaining awareness of the dynamics of psychological safety are helpful actions (Rudolph et al., 2014; Kolbe et al., 2020; Somerville et al., 2023). Third, while teamwork in healthcare may involve a somewhat stable set of skills (Greilich et al., 2023), the way students learn may constantly change with their exposure to an increasingly digital world (Balmaks et al., 2021). The pedagogical format of TeamSIM may need to adapt as well. Finally, evaluating such a complex and intense simulation-based teamwork requires additional preparation. In our view, inspite of the involved effort, simulation-based teamwork trainings such as TeamSIM are a valuable contribution to the teamwork capabilities of our future healthcare workforce.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The study was ruled exempt by the Kantonale Ethikkommission Zürich. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

MK and BG designed TeamSIM. MU and JG oversaw its integration into the bachelor of human medicine's overall curriculum. MK designed the evaluation and performed the data analysis and drafted the manuscript. MK and BG lead the data collection. All authors contributed to the article and approved the submitted version.

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Conflict of interest

MK, JG, MU, and BG are faculty of ETH Zurich where the curriculum evaluated in this study is offered. JG is the director of medical studies at ETH Zurich. MU leads the curriculum development of medical studies at ETH Zurich. MK and BG are directors of the TeamSIM course and faculty of the Simulation Centre of the University Hospital Zurich.

Publisher's note

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EDITED BY
Margarete Boos,
University of Göttingen, Germany

REVIEWED BY
Yun Hu,
Shanghai Jiao Tong University, China
Michaela Kolbe,
University Hospital Zürich, Switzerland

*CORRESPONDENCE
Hujie Wang
✉ wang@eshpm.eur.nl

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Factors and interventions determining the functioning of health care teams in county-level hospitals in less affluent areas of China: a qualitative study

Hujie Wang[1]*, Jeroen van Wijngaarden[1], Martina Buljac-Samardzic[1] and Joris van de Klundert[1,2]

[1]Erasmus School of Health Policy and Management, Erasmus University Rotterdam, Rotterdam, Netherlands, [2]School of Business, Universidad Adolfo Ibáñez, Santiago, Chile

Background: Teamwork is essential for the quality and safety of care, and research on teamwork in health care has developed rapidly in many countries. However, evidence from less affluent, non-Western countries is scarce, while improving teamwork may be especially relevant to be able to increase the quality of care in these settings. This study aims to understand the main factors that influence, and interventions used to improve, the functioning of health care teams in the context of county-level hospitals in less affluent areas of China.

Methods: We conducted semistructured interviews to explore the factors that influence team functioning and the interventions implemented to improve team functioning in these hospitals. 15 hospital presidents and 15 team leaders were selected as respondents.

Results: From the interviews, we have identified five main factors that influence team functioning in these hospitals: "stuck in the middle", local county setting, difficulty in attracting and retaining talent, strong focus on task design, and strong focus on leadership. The interventions for improving team functioning can mostly be categorized as the following: 1) measures to attract and retain talent (e.g., increase salary, train talent in national or provincial level hospitals, and provide fast-track promotions), 2) interventions focused on monodisciplinary teams (e.g., changing the team structure and leadership, and skill training), and 3) interventions to establish and improve multidisciplinary teams (e.g., simulation training and continuous team process improvements).

Conclusion: With the introduction of multidisciplinary teams, interventions into team processes have started to receive more attention. The findings depict an overview of the main factors and interventions as specifically relevant for team functioning in county-level hospitals in less affluent areas of China and may help these hospitals benefit from additional process interventions to improve teamwork and the quality of care.

KEYWORDS

teamwork, team functioning, team interventions, leadership, multidisciplinary team, county-level hospitals, less affluent areas, China

Introduction

Health care is a highly demanding industry, which requires effective teamwork to provide high-quality care for patients. The landmark publication "To err is human" has pointed out the key role of teamwork in reducing medical errors (1). Since then, the evidence base supporting the impact of teamwork on the quality and safety of care has continued to grow. Manser's (2) review confirms that teamwork plays a key role in preventing adverse events. Schmutz et al.'s (3) systematic review and meta-analysis more generally shows that teamwork is positively related to the clinical performance of health care teams.

Due to the importance of teamwork in the quality and safety of care, research on the functioning of health care teams has been blooming in recent decades. Lemieux-Charles & McGuire have proposed the Integrated (Health Care) Team Effectiveness Model (ITEM) to describe the relationships among team inputs (i.e., social and policy context, organizational context, and task design), processes, and outcomes (4). This model is the foundation and starting point of many teamwork studies in health care. Other researchers have focused on interventions to improve team functioning in health care. For example, Buljac-Samardzic et al. (5) have proposed four categories of such interventions in health care: training, tools, (re)design, and combinations of interventions from multiple categories. McCulloch et al. (6) have reviewed the effects of teamwork training on health care professionals' performance and found enhanced teamwork after training, as well as improved staff attitudes, efficiency, and reductions in medical errors.

The existing evidence on teamwork in health care is, however, mostly from Western countries. Evidence from less affluent, non-Western contexts is especially lacking. This can be viewed as problematic in contexts such as less affluent Chinese areas, as the World Bank and the World Health Organization have advocated enhancing teamwork in Chinese hospitals as one of the strategies to improve the quality of care delivered by Chinese hospitals (7). This calls for research to increase the evidence base and close the knowledge base by exploring the functioning of health care teams and the interventions for improving team functioning in these hospitals, which may also be relevant for other less affluent, non-Western areas in the world.

A recent review of the evidence on teamwork in Chinese hospitals finds that most of the included studies were conducted in national and provincial level hospitals and that the evidence base for county-level hospitals and primary care institutions is scarce (8). The 17,294 county-level hospitals play a pivotal role in the Chinese health system (9). Positioned between primary care institutions on the one hand and national and provincial level hospitals on the other hand, they are required to provide an extensive variety of health services for the population of more than 498 million living in counties and county-level cities (10).

Governmental authorities and populations of counties and county-level cities in less affluent areas of China often face resource shortages that can negatively impact the health services delivery infrastructure, particularly for county-level hospitals. Thus, county-level hospitals in less affluent areas face unique context-specific challenges. The validity of existing evidence on teamwork in China's national and provincial level hospitals in affluent areas may therefore be limited for this context. In this study, we aim to extend the understanding of team functioning and team interventions in these hospitals. More specifically, we propose the following two research questions:

(1) What are the main factors that influence the functioning of health care teams in county-level hospitals in less affluent areas of China?

(2) What interventions have been implemented by county-level hospitals in less affluent areas of China to improve the functioning of health care teams?

Abbreviations: ITEM, Integrated (Health Care) Team Effectiveness Model; SRQR, Standards for Reporting Qualitative Research; MDT, multidisciplinary team.

Materials and methods

Research method

The ITEM shows that social and policy context plays an indispensable role in team functioning, as is further emphasized by the Context-Interventions-Mechanisms-Outcome logic that explicitly captures the role of context in understanding the effects of interventions on outcomes (4, 11). Because of the scarce evidence on team functioning and team interventions in the context at hand, i.e., county-level hospitals in less affluent areas of China, and the limited validity of existing evidence in this unique context, it is necessary to construct our understanding of factors influencing team functioning and interventions to improve functioning specifically in this context rather than assuming that the known factors from research are valid. Therefore, our study is of explorative, phenomenological nature, following the constructivist paradigm and using semi-structured interviews for data collection (12–14). The reporting of this study follows the Standards for Reporting Qualitative Research (SRQR) guideline (15). The SRQR checklist is attached as Supplementary File S1.

This study was approved by the Research Ethics Review Committee of Erasmus School of Health Policy and Management, Erasmus University Rotterdam (Approval No. 21–035). Oral informed consent was obtained from all the participants before the data collection.

Interview topics

The interviews have two parts. The first part addresses the factors that influence team functioning, and the second part considers the interventions implemented to improve team functioning. Each part includes both general, open-ended questions, and more structured questions based on a list of topics extracted from the literature. The interview guide is presented in Supplementary File S2.

The topic list for the first part is rooted in an input-process-outcome-based teamwork model as also adopted in the aforementioned ITEM which forms the corresponding theoretical framework (4, 16, 17). Within this framework, we specifically consider the "social and organizational context" and address the specificities of the less affluent county settings and China's ongoing national health reforms.

Team composition and individual characteristics are important team inputs that are well researched in China but not for county-level hospitals (8). These inputs therefore need to be explicitly addressed. The Chinese culture emphasizes the hierarchy in organizations (18, 19), which implies that "leadership" is an important teamwork input

and process worthy of special attention. Finally, we are especially interested in exploring team processes, as they have thus far received little attention in Chinese health services research on teamwork (8).

The topic list for team interventions studied in part two contains the aforementioned categories "training", "tools", and "(re)design" (5). Furthermore, as the Chinese government promotes the development of multidisciplinary teams (MDTs) and requires county-level, provincial level, and national level hospitals to establish MDTs, MDTs receive special attention within the category "(re)design" (20).

Inclusion criteria and sampling

We consider a hospital to be a county-level hospital if it is located in a county or in a county-level city in China. We consider a county or county-level city to be less affluent if its GDP *per capita* level was below the national average in 2020, i.e., 72,447 Chinese Yuan (10,154 US Dollars) (21). We initially selected 15 county-level hospitals from areas thus identified as less affluent by purposive convenience sampling with the aid of the Health Human Resources Development Center of the National Health Commission of China and the Health County Media (22). The research team has no direct connections with these studied hospitals. In addition, the first author is from China and has worked as a health care professional in China for several years, so he well knows the Chinese health system and the context of this study, which will be helpful for conducting the study and analyzing data.

From each county-level hospital, we intended to interview the hospital president and one team leader who was in turn proposed by hospital senior management. The reason for enrolling hospital presidents and team leaders is that they, as both health care professionals and managerial personnels, most clearly know the influence of the unique context (i.e., county-level hospitals in less affluent areas of China) on team functioning and will provide the most valuable perspectives for this study. Data saturation determined the final sample size as we checked for saturation (i.e., all relevant themes were identified, and the same themes repeatedly emerged.) after conducting interviews with the respondents from hospitals in the initial set (23, 24).

Data collection

Ultimately, 30 interviews were conducted *via* WeChat voice calls between September and December 2021. These interviews lasted from 38 min to 79 min and were recorded for further analysis. The first author transcribed all the audio-recordings in Chinese, translated 5 Chinese transcripts into English to be used for the independent coding process and alignment of the codes between the first and second author, and pseudonymized them to protect participants' privacy.

Data analysis

A thematic analysis was conducted via the software Atlas.ti and Microsoft Excel to generate codes and themes (25). The data analysis is characterized by a combination of an inductive and deductive approach (26, 27). The first and second authors independently analyzed and coded the English transcripts. While the interview questions were partly based on theory, we primarily used open coding in the data analysis (following an inductive approach). During the coding process, the first and second authors first familiarized themselves with the transcripts and created preliminary codes. Thus, these codes primarily emerged inductively from our data. Further synthesis of the codes also adopted a deductive approach when interpreting and reflecting from the perspectives of the theories used to generate the interview guide (4, 5, 16, 17).

After the preliminary coding process was finished, the first and second authors compared and discussed dissimilarities in their independent codes until consensus was reached. Then, the first author continued analyzing and coding the remaining Chinese transcripts based on the preliminary codes. After the coding for all transcripts was completed, discussion took place again between the first and second authors to resolve any issues with the codes. Next, themes were derived from these revised codes and subsequently merged into several overarching themes. These overarching themes were discussed and revised multiple times among all the authors in the process of data synthesis and developing the results section until consensus was reached. This triangulation of researchers ensures the rigor, credibility, and reliability of the study.

Results

The data obtained during part one of the interviews, which addresses the first research question, yielded five main factors that influence team functioning in county-level hospitals in less affluent areas of China. These main factors are "stuck in the middle", local county setting, difficulty in attracting and retaining talent, strong focus on task design, and strong focus on leadership. The results for part two which addresses the second research question on team interventions are presented subsequently. The overview of the results is shown in Figure 1. Dash lines and arrows indicate the connection between the ITEM and the findings of this study.

The main factors that influence team functioning

"Stuck in the middle"

From the interviews, we learn that county-level hospitals are viewed as "stuck in the middle" between primary care institutions on the one hand, and national and provincial level hospitals on the other hand. Primary care is seen as the main point of access for patients with mild diseases, whereas patients with more severe and complex conditions prefer to visit national or provincial level hospitals. County-level hospitals are, however, expected to contribute to servicing both types of patients, which puts them in a difficult position.

> *"There is a very important responsibility for county-level hospitals. We have to treat not only common and frequently occurring diseases but also emergency cases and critically ill patients."*

Moreover, the reputation of county-level hospitals is perceived as poor, which further exacerbates the difficulties in attracting patients and continuing providing health services for severe and complex patients.

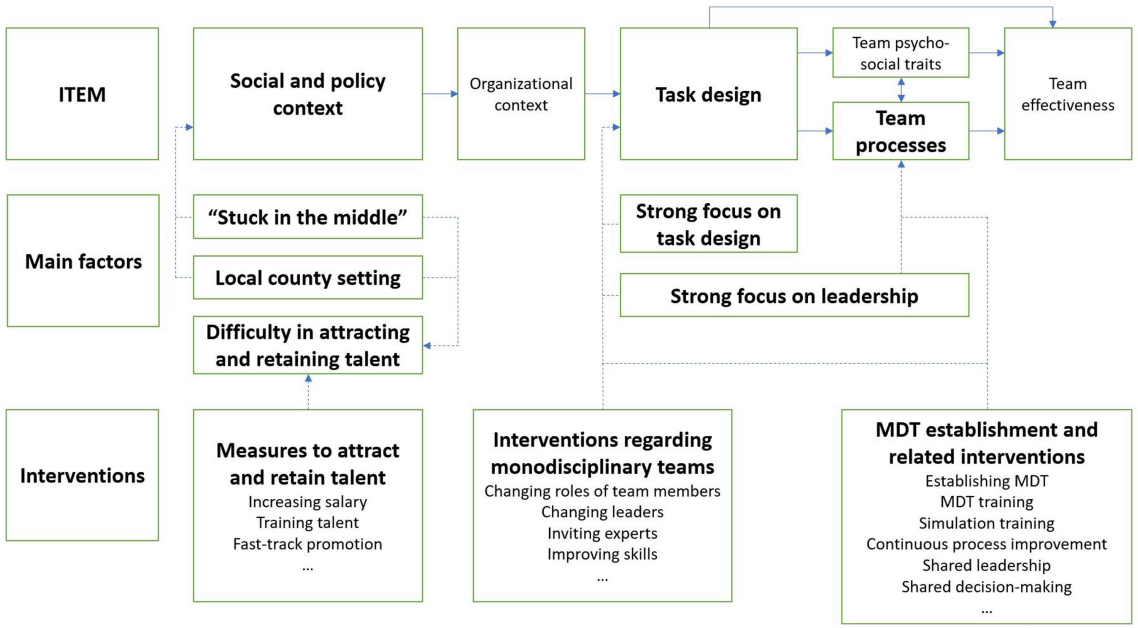

FIGURE 1
Overview of the results.

> *"Many patients who are critically ill, such as with cancer, have been more willing to visit national or provincial level hospitals instead of staying here."*

As a consequence, health care professionals in county-level hospitals have few opportunities to practice all of their discipline-specific clinical skills, which makes it hard to maintain or improve the abilities of health care teams to provide appropriate care for complex cases.

> *"Patients, such as those with tumors, will go to the hospitals in the prefecture-level city or even Beijing and Tianjin when they are diagnosed with tumors. You cannot retain such patients, so it is difficult to improve the clinical skills of the team."*

Another consequence brought by the poor reputation of county-level hospitals is the lack of revenue. As county-level hospitals mainly earn their income by providing patient care, their poor reputation may negatively impact patient volumes and subsequently available financial resources. This inhibits these hospitals from buying necessary equipment for health services and can negatively impact the salary budget. When this translates into lower salaries, fewer professionals, or both, it can in turn negatively impact team functioning, health services provisioning, hospital reputation, and income, causing these hospitals to feel even more stuck.

> *"The insufficiency of funding is very normal. …… First, …… you cannot carry out some health services without necessary equipment, so you are not able to treat patients. Another thing is the motivation and incentives. …… If you cannot provide enough salary, staff are not able to work well as they need to live and support their families."*

Local county setting

Our respondents tell us that county-level hospitals are located in specific local county settings. These areas are typically more mono-cultural than China's big cities and have their local customs, norms, values, and dialects. Furthermore (close) interpersonal relationships are likely to exist outside of work among staff of county-level hospitals because counties and county-level cities are relatively small. The shared cultural background and social relations facilitate communication and teamwork, according to the respondents.

> *"A good thing is that this is a small place, so everyone is familiar with each other. There are many social relationships behind us. … Therefore, various communication modes exist in a team."*

However, these local county characteristics can cause integration difficulties for nonlocals, as they may have different working habits or struggle to understand the local dialect. Rather than creating an open environment for "outsiders," county-level hospitals are often prone to recruiting local professionals.

> *"We mainly recruit local employees whose families and social relationships are in our county. These employees can adapt well to our local culture and customs. Outsiders really do not fit in."*

Difficulty in attracting and retaining talent

As a result of the two aforementioned factors, most county-level hospitals have experienced difficulties in attracting and retaining talent. Talented professionals are reported to be likely to leave as they

find it difficult to improve their clinical skills due to the lack of complex cases. The aforementioned limitations in salary budgets may further add to these challenges and cause talented professionals to seek alternative employment elsewhere.

> *"There are not many patients for some disciplines, for instance, pediatrics and oncology. Then, it is hard to improve the clinical skills. The salary is also low. Therefore, they will resign."*

Moreover, the less affluent character of the county context has further exacerbated the talent insufficiency beyond the aforementioned salary limitations.

> *"Then, the living condition is also a key consideration, for example, children's education. Nearly all the aspects here are worse than those in big cities."*

In this case, the lack and loss of talent hinder the influx of new knowledge and skills into the health care teams in county-level hospitals, which in turn impedes effective communication between team members.

> *"If the degree level of a team is too low, the acquisition and renewal of the state-of-the-art medical knowledge is limited. This will hinder the communication within a team as no one understands the latest knowledge."*

To change this situation, county-level hospitals have taken measures in recent years to recruit young talent (The specific measures will be discussed later when reporting interventions). As a consequence, an increasing number of young health care professionals appear in county health care teams, increasing intergenerational interactions with both positive and negative consequences.

Different respondents stress the harmony and energy that young health care professionals bring to the teams, which increases the vitality within teams and is beneficial for the interaction between these team members.

> *"Most of the team members are young. They are energetic. The atmosphere within the team is harmonious. Therefore, it is easy to arouse their enthusiasm for work."*

Some older doctors are willing to teach and support their young colleagues, improving their clinical skills and the cohesion and communication within teams.

> *"Young doctors are less experienced. Then, the older doctors teach them. … This is the mode of teaching and helping. Everyone feels happy to work on the team. The whole team is also harmonious."*

However, not all older doctors are cooperative. Some feel threatened by these young professionals and refuse to share their knowledge and support their younger colleagues. As a result, these young health care professionals may experience difficulties integrating and be more likely to leave.

> *"A team recruited a professional with a high degree. The older staff on the team felt threatened and did not support the professional's work. This young talent found himself unable to use his knowledge there, so he finally left."*

Strong focus on task design

From the interviews, we learn that most health care teams in county-level hospitals are monodisciplinary and adopt a monodisciplinary basis for the task design within the teams.

Our respondents especially emphasize the importance of disciplinary clinical skills, team composition, and role clarity with respect to task design. Moreover, most respondents believe that clinical skills positively impact team performance.

> *"It is sure that if the health care professionals' clinical skills are better, this team will function better."*

An appropriate team composition, for example regarding educational background and seniority, is perceived to be beneficial for team functioning by most respondents as every health care professional in the team is seen to have a well described specific role.

> *"The team composition is very important. The ideal status is that old, middle-aged, and young staff should all be involved in a team. It is very helpful for team functioning."*

Strong focus on leadership

In addition to the importance of task design elements, most respondents also stress the pivotal role of leadership in team functioning. Team leaders must be regarded as leading experts in their field, with excellent clinical skills, for a team to function well.

> *"As a team leader, he or she must be a leading expert of the discipline. Namely, his or her clinical skills are very good. If every decision and each step arranged by the team leader is reasonable, the team members will firmly support his or her leadership."*

Furthermore, team leaders' individual characteristics and leadership skills are seen as crucial to ensure high-quality team functioning.

> *"First, a team leader should have foresight; otherwise, the team planning will be influenced. Second, he or she needs to possess executive ability. … Third, a team leader must be fair, or the team will not be cohesive. Fourth, decisiveness, which is part of decision-making, is needed for a team leader."*

In addition, some of the respondents mention the crucial role of hospital management in team functioning. They not only monitor team functioning but are also involved in resolving operational issues and in introducing interventions.

> "*The hospital administrators usually visit each health care team. … Staff can report issues to the hospital president via WeChat or telephone. Then, these issues will be solved."*

Despite the importance of a clear hierarchy and strong leadership, most of the respondents do not think there is a substantial power distance within teams in county-level hospitals. This relates to the shared backgrounds and social ties between the team members.

> *"Although the team leaders have some power and managerial ability, the power distance in our area is not that high. All the team leaders get along with team members in real daily life, so there is no barrier to the communication between team leaders and team members."*

In particular, young leaders are seen as more open-minded and willing to listen to others.

> *"The team leader and the doctors on the team are young, so there is no barrier to the communication between us. … When team members raise the issues they find, it helps the team develop or even helps the team leader better manage the team. We need to adopt their good suggestions."*

Furthermore, a few respondents even state that managerial delegation is encouraged and supported by team leaders and seen as beneficial for team functioning.

> *"A good team is a team on which everyone participates in management under the supervision of the team leader. … We have taken some measures, for example, assigning some administrators for quality control, nosocomial infection control and team operation. These people can help the team leader better manage the team. … On some specific things, team leaders do not know better than the team members."*

Interventions for improving team functioning

County-level hospitals have implemented different interventions to improve team functioning as addressed in the second part of the interviews. These interventions can be synthesized into three categories: measures to attract and retain talent, interventions mainly focused on monodisciplinary teams, and interventions to establish and improve MDTs.

Measures to attract and retain talent

Facing the difficulty of attracting and retaining talent, most county-level hospitals have taken measures to reverse this situation. These measures include increasing talent salaries, sending staff to learn clinical knowledge and practice their clinical skills in national or provincial level hospitals, and promoting them to a higher professional title or managerial position at an early stage. Together, these interventions are intended to make county-level hospitals more attractive for recent university graduates.

> *"If this young recruit is full of positive energy and good at every aspect of his or her job, we will promote him or her to a managerial position to stimulate his or her enthusiasm for work and let him or her see the hope to work here."*

Interestingly, one of the hospitals in our study has introduced a form of unified personnel management to attract talent from primary care institutions. Well-performing professionals from primary care institutions have the chance to be promoted to this county-level hospital while at the same time poorly performing professionals from the county-level hospital are considered to be reemployed in primary care. This human resource management practice is perceived as effective.

> *"Staff from primary care institutions can compete for the opportunity to work in our hospital. … This mode gives these staff the hope to work in better hospitals and improve their quality of life. Meanwhile, the staff in our hospital feel a sense of crisis. If they do not work well, it is also possible for them to work in primary care institutions."*

Respondents have not been able to present evidence (beyond anecdotal evidence) on the effectiveness of any of the interventions to recruit qualified staff and mitigate their willingness to leave.

Interventions regarding monodisciplinary teams

County-level hospitals display a preference for interventions on task design, in particular for leaders, to improve the performance of monodisciplinary teams. These interventions, for instance, include changing the roles of team members, changing leaders, and inviting experts from national or provincial level hospitals. In addition, interventions include the improvement of task related skills such as clinical skills and managerial skills.

> *"If a team leader cannot help the team function well, … we will change the team leader. … We have successful examples. Some teams have obviously functioned much better after we changed their team leaders."*

> *"We usually organize training around clinical skills. For instance, cardio-pulmonary resuscitation, …, and emergency tracheal intubation. … It is very effective."*

Multidisciplinary team (MDT) establishment and related interventions

County-level hospitals have come to realize that the conventional monodisciplinary setting does not meet the demands of the increasing volumes of patients with complex, critical, conditions. These multimorbid conditions especially need the expertise of multiple specialties. Furthermore, the Chinese national health reforms stipulate that county-level hospitals have to establish MDTs to improve the quality of care for emergency patients and critically ill patients by introducing five MDT centers, i.e., chest pain center, stroke center, trauma center, critically ill maternal treatment center,

and critically ill neonatal treatment center (20). County-level hospitals have taken up the establishment of MDTs for these centers to improve the consultation for complex cases (e.g., oncological patients) and to ensure integrated care for common conditions that require the involvement of multiple specialties (e.g., diabetes and hypertension).

As was the case for the monodisciplinary teams, task design elements regarding clinical skills, team composition, and hierarchy are stressed to be of importance for the functioning of MDTs. For example, multidisciplinary consultation teams often have a fixed composition (i.e., chief physicians and deputy chief physicians) to ensure the quality of consultation. Likewise, the leader of the core discipline of an MDT center reportedly always leads the multidisciplinary collaboration within the center. In multidisciplinary consultation teams, the most experienced doctor is typically appointed to lead and integrate the views of the team members from various disciplines.

> *"Take the chest pain center as an example. The main discipline of this center is cardiology. The leader of cardiology, who is also the leader of the chest pain center, is responsible for arranging everyone's work within the team. Other team members are in a cooperative position and should follow the team leader's arrangement."*

Experts from national or provincial level hospitals may be invited to help make final decisions when the team leader is not able to deal with divergent opinions within the MDT due to the limited knowledge and clinical skills in county-level hospitals.

The newly built MDTs also bring new challenges for teamwork, especially regarding collaboration. For instance, some health care professionals are reluctant to work with those from other disciplines. Therefore, in some of these cases, county-level hospitals have organized training to increase staff awareness of MDT collaboration.

> *"These doctors and nurses have received specialized MDT training. Their thinking is unified, and they have awareness of MDT collaboration."*

The multidisciplinary collaboration difficulties have caused hospital management to initiate interventions targeting the improvement of team processes (e.g., communication, collaboration, and coordination) rather than intervening in task design. Simulation training is frequently reported with the purpose of promoting the coordination and collaboration within MDTs. Most respondents perceived teamwork improvements from simulation training.

> *"After the operation of the MDT and simulation, the communication and coordination between disciplines improved. … Another thing is that doctors' and nurses' clinical skills have also improved. … Now, they also have knowledge of other disciplines; their capabilities in their basic clinical work to treat patients have improved."*

Furthermore, there were reports that hospital management implemented continuous improvement of MDT processes after simulation training and the initial implementation of MDTs. Shared leadership and decision-making are seen to contribute to such process improvement.

> *"This is a process of gradual optimization. After the MDT collaboration, … we usually discuss the existing issues. Everyone expresses their opinions on how to optimize the procedures and workflows, how to save time and how to improve efficiency. This is what we are continually improving."*

Discussion

In this study, we aim to understand the main factors that influence team functioning and the interventions implemented to improve team functioning in county-level hospitals in less affluent areas of China.

These main factors are covered below following the logic of the synthesis presented in the results section. For each of the factors, we additionally discuss whether they can be viewed as facilitators, barriers, or both. The main interventions and their associated barriers are discussed next.

Respondents' views on the factors regarding the contextual setting of the studied hospitals (i.e., the intermediate position in the Chinese health system and the local county setting) indicate that the contextual setting may bring both barriers and facilitators.

The context-specific barriers mostly relate to resource shortages such as staff shortages, lack of equipment, and insufficient funding. These resource shortages have been reported for hospitals in other low-income and middle-income countries and are seen as a barrier to health care delivery (28–30). Personnel shortages are also reported in rural areas in high-income countries (31, 32). Our results confirm that these context-related resource shortages may negatively impact health care delivery and additionally show that they may exacerbate the personnel and financial shortages. Moreover, the relatively poor living conditions provided by the less affluent settings can cause young staff to leave. All these barriers negatively influence team functioning in county-level hospitals and can cause them to be stuck even deeper between primary care and provincial and national level hospitals.

At the same time, our results reveal that the local county setting can facilitate team functioning in county-level hospitals due to the strong sense of community and shared local culture and values. This confirms previous evidence from rural areas in other countries (33, 34). These local idiosyncrasies can enhance the communication between local team members in county-level hospitals. However, we also find that local culture and values can turn into a barrier when "outsiders" may perceive it as difficult to integrate and subsequently are more likely to leave.

From the findings, we know that Chinese county-level hospitals have implemented various interventions to overcome these barriers. Fast-track promotion (i.e., promoting talent to a higher professional title or managerial position at an early stage) aims to attract and retain talent as it provides a faster career path in comparison to national and provincial level hospitals. The resulting influx of young talent may bring intergenerational differences to health care teams. The emergence of these differences was found to be a barrier and a facilitator, depending on the attitudes of older health care professionals toward their younger colleagues. We present suggestions for overcoming intergenerational barriers below when discussing interventions into team processes.

The medical treatment alliance initiated by the Chinese authorities helps county-level hospitals overcome resource shortages and improve

team functioning by training staff in national or provincial level hospitals and inviting experts to support county-level hospitals (35). Our respondents provide little evidence on the effectiveness of such interventions yet, which therefore is an interesting area for future research.

The scientific literature provides suggestions for other interventions that thus far appear to have been disregarded. The integration of "outsiders" can, for instance, be promoted by diversity awareness training for team leaders and team-building exercises for team members (36, 37). Such interventions can more generally contribute to building a cohesive and inclusive organizational and team culture that facilitates attracting and retaining "outsiders" to advance hospital performance.

Our results on team interventions show that county-level hospitals prefer interventions to improve technical skills and interventions in team structure to improve team performance, especially for monodisciplinary teams. A recent systematic review on teamwork in Chinese hospitals also shows a preference for training clinical skills and redesigning team structure (8). Based on the ITEM, both technical skills and team structure belong to task design (4). It may then be noted that the identified preference to intervene in task design in Chinese county-level hospitals contrasts with the predominant focus of Western hospitals to intervene in team processes, which more frequently involve simulation training and crew resource management training and use tools for promoting and facilitating communication (5).

One explanation for this difference is that team processes such as communication and collaboration are not perceived to require improvement interventions because of the shared cultural background and close social relationships among team members. Moreover, the "collectivist" values of Chinese organizational culture may naturally facilitate cooperation within teams, thus reducing the (perceived) need to improve processes (18, 19).

Another explanation may lie in the cultural differences between China and Western countries. Chinese culture emphasizes hierarchy in organizations (18, 19), which helps clearly define the hierarchy and leadership within teams and subsequent top-down communication. As a result, teamwork problems are preferably resolved by changing the team leader or team structure rather than by intervening in team processes.

Despite the emphasis on task design interventions, team process interventions can still be valuable when issues in team processes appear to be rooted in team structure. For example, interpersonal conflicts may occur due to the intergenerational differences in values, personality, and behaviors brought by the influx of young staff, as discussed above (38–40). The literature summarizes a number of interventions for relieving such conflicts, for instance, reframing intergenerational differences, organizing team building activities, providing equal development opportunities for all generations, and facilitating communication by using other generations' language (41, 42). To avoid and resolve potential intergenerational conflicts within teams, county-level hospitals may learn from these interventions and develop their own tailored interventions.

As the Chinese health reforms are deepening, the Chinese government has promoted "Patient-Centered Care" and advocated the establishment of MDTs in Chinese hospitals to address patients' multimorbidity (7, 20). Successful implementation of MDTs can promote desired team and patient outcomes, such as increased team innovation capacity, reduced incidence of adverse events, and improved staff and patient satisfaction (43, 44). Compared to monodisciplinary teams, newly built MDTs were found to exhibit distinct features and confront new barriers for which different (types of) interventions are implemented.

Our findings show the difficulty of collaborating across disciplines surfaces as a main barrier to MDT effectiveness. This difficulty might be rooted in the traditional Chinese value "collectivism," which causes professionals to commit to and behave more cooperatively with the "in-group"—their discipline—and show a corresponding tendency to disregard those outside of the "in-group"—staff from other disciplines (19, 45–47). Although MDTs are a new "group" gathering health care professionals from many disciplines, staff may continue to consider professionals from other disciplines as "out-groups" and thus be reluctant to collaborate with them in MDTs. The literature provides further evidence that language barriers between disciplines and conflicts across disciplines can form barriers to MDT collaboration (48–50).

Our results indicate that these barriers to MDT collaboration have prompted an interest in team processes, and county-level hospitals have started to implement team process interventions to improve MDT functioning. From the findings, we know that Chinese county-level hospitals have organized simulation training to promote the coordination and collaboration within MDTs. Moreover, hospital management has initiated corresponding continuous improvement of MDT processes.

The shared leadership and decision-making in such continuous improvement further strengthens our finding that the low power distance is perceived to be low in county-level hospitals, which is seen as conducive to effective teamwork by the respondents.

These interventions are broadly in line with the recent international literature on team processes and the positive impact of improving team process elements such as communication, collaboration, coordination, and decision-making on the effectiveness of MDTs (43, 51, 52).

Our findings on the main factors that influence team functioning and team interventions in county-level hospitals in less affluent areas of China may be generalized to other less affluent, non-Western contexts. However, as specific Chinese cultural traits appear to be embedded in our findings, the external validity in the aforementioned contexts may be limited.

Limitations

There are some limitations of this study. First, all respondents have managerial roles, and we did not enroll other health care professionals. Hence, those professionals' perspectives on team functioning are not included. Second, we selected 15 hospitals to advance the understanding of team functioning in county-level hospitals in less affluent areas of China. Larger-scale studies can provide a stronger evidence base for team functioning in county-level hospitals. Third, as we did not enroll participants from primary care institutions, national or provincial level hospitals, or hospitals in more affluent areas, it remains unclear to what extent the identified factors and interventions are specific to county-level hospitals in less affluent areas of China. Fourth, this study focused on the main factors and interventions to be particularly relevant for county-level hospitals in

less affluent areas of China. Therefore, it does not provide a general analysis of teamwork and team functioning in these hospitals. Last, this study focused on factors and interventions that were commonly reported and has not analyzed differences between county-level hospitals, which may therefore be an interesting direction for future research.

Conclusion

The specific contextual features and the focus on task design and leadership influence the functioning of health care teams in county-level hospitals in less affluent areas of China. There is a strong preference to intervene in team structure and leadership to improve team functioning. Due to the integration difficulty for "outsiders," intergenerational interaction and the establishment of MDTs, process interventions are likely of additional benefit for county-level hospitals to improve team functioning and the quality of care. Recent initiatives in this direction are a promising area for practice and scientific research, strengthening the evidence base.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by The Research Ethics Review Committee of Erasmus School of Health Policy and Management, Erasmus University Rotterdam. Written informed consent was not required for this study in accordance with the local legislation and institutional requirements. The participants provided their informed consent on record to participate in this study.

Author contributions

HW, JW, MB-S, and JK: conception or design of the work, data analysis and interpretation, critical revision of the article, and final approval of the manuscript. HW: data collection and drafting the article. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1082070/full#supplementary-material

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EDITED BY
Juliane E. Kämmer,
University of Bern, Switzerland

REVIEWED BY
Shaista S. Guraya,
Royal College of Surgeons in Ireland (Bahrain), Bahrain
Reimer Riessen,
University of Tübingen, Germany

*CORRESPONDENCE
Jan M. Zottmann
✉ jan.zottmann@med.uni-muenchen.de

†These authors have contributed equally to this work

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FINCA – a conceptual framework to improve interprofessional collaboration in health education and care

Matthias J. Witti[1†], Jan M. Zottmann[1†*], Birgit Wershofen[1], Jill E. Thistlethwaite[2], Frank Fischer[3] and Martin R. Fischer[1]

[1]Institute of Medical Education, LMU University Hospital, LMU Munich, Munich, Germany, [2]Faculty of Health, University of Technology Sydney, Ultimo, NSW, Australia, [3]Chair of Education and Educational Psychology, Department of Psychology, LMU Munich, Munich, Germany

The health care system in Germany and in many other countries is facing fundamental challenges due to demographic change, which require new integrated care concepts and a revision of the collaboration between health care professions in everyday clinical practice. Internationally, several competency framework models have been proposed, but a framework that explicitly conceptualizes collaborative activities to improve interprofessional problem-solving competency in health care is still missing. Such a framework should define contextual, person-related, process-related, and outcome-related variables relevant to interprofessional problem solving in health care. Against this background, we present a conceptual framework to improve interprofessional collaboration in health education and care (FINCA) developed with scientific consideration of empirical data and various theoretical references. FINCA reflects an interprofessional learning and interaction process involving two persons from different health care professions and with different individual learning prerequisites. These two initially identify a problem that is likely to require interprofessional collaboration at some point. FINCA acknowledges the context of interprofessional learning, teaching, and working as well as its action-modifying context factors. We follow the reasoning that individual learning prerequisites interact with the teaching context during learning activities. At the heart of FINCA are observable collaborative activities (information sharing and grounding; negotiating; regulating; executing interprofessional activities; maintaining communication) that can be used to assess individuals' cognitive and social skills. Eventually, the framework envisages an assessment of the outcomes of interprofessional education and collaboration. The proposed conceptual framework provides the basis for analysis and empirical testing of the components and variables it describes and their interactions across studies, educational interventions, and action-modifying contexts. FINCA further provides the basis for fostering the teaching and learning of interprofessional problem-solving skills in various health care settings. It can support faculty and curriculum developers to systematize the implementation and improvement of interprofessional teaching and learning opportunities. From a practical perspective, FINCA can help to better align curricula for different health professions in the future. In principle, we also see potential for transferability of the framework to other areas where different professions collaborate.

KEYWORDS

interprofessional education, interprofessional collaboration, collaborative problem-solving skills, observable collaborative activities, learning, teaching, scaffolding

1. Introduction

The health care system in Germany, as well as in many other countries, is facing fundamental challenges due to demographic change. With the aging of the world's population, on the one hand, the care of the elderly is gaining in importance – on the other hand, the associated need for treatment and management of complex chronic long-term conditions is becoming increasingly important (1, 2). These changes require new integrated care concepts and a revision of the cooperation between health care professions in everyday clinical practice. Numerous position papers and strategic plans have therefore been calling for an increased integration of interprofessional education in under-and postgraduate training in medicine as well as other health care professions (3–7).

Interprofessional collaboration (IPC) involves different health and social care professions meeting regularly to negotiate and agree on how to solve complex care problems or deliver services. Interprofessional teamwork is characterized by a high level of team identification and close networking and interdependence. The dimensions of IPC also include clear team goals, a shared team identity, shared team commitment, and clear role allocation (8). Interprofessional education (IPE), which is necessary to prepare for IPC, takes place whenever trainees, students, or professionals from two or more professions come together to learn with, from, and about each other in order to optimize collaboration in patient care (9). Both definitions reflect the need for IPE and IPC to include interactive problem-solving processes and related activities.

Similarly to other educational interventions, it remains challenging to demonstrate a causal relationship between IPE and general care system outcomes (such as improved clinical experience or improved patient experience). Multiple studies have demonstrated that IPE interventions can lead to improved patient care in specific contexts [e.g., (10, 11)]. It must be noted, however, that due to the heterogeneous nature of these studies and the variety of IPE interventions, it is rather difficult to integrate and generalize results of these interventions to inform general theory-building (12).

Several competency framework models in IPE have been proposed internationally, primarily motivated by health policy makers [e.g., (13–16)]. These framework models address both IPE and IPC and formulate overarching competency goals for successful interprofessional work. The frameworks include ethics and values, teamwork, leadership, conflict resolution, communication, mutual respect, role clarity and patient-centredness as important areas (17).

As the need for IPE and IPC increases due to the demands brought about by demographic change, we believe there is also a growing need for a framework that explicitly conceptualizes collaborative activities to improve interprofessional problem-solving skills in health care. Such a framework should define contextual, person-related, process-related, and outcome-related variables relevant for interprofessional problem-solving in health care. At the same time, it should be based on observable activities that allow for an operationalization of interprofessional problem-solving skills.

In this paper, we propose a framework based on a combination of three theoretical strands from educational psychology research on collaborative learning: (1) fostering of diagnostic competencies (18), (2) collaboration scripts (19), and (3) collaborative problem-solving skills (20). These theoretical strands have proven useful in different contexts and domains such as teacher and medical education (see Section 2.2). To our knowledge, these generalizable educational frameworks and theories have not yet been utilized to inform and enrich the development and design of competency framework models for improved IPE and IPC.

On this basis, we offer definitions and operationalizations that will enable empirical research studies to assess and subsequently foster collaborative problem-solving skills, as well as the integration of results across diverse IPE and IPC contexts. Quantitative methods could thus be increasingly employed in the study of IPC, which to date has been primarily of a qualitative nature (21). Moreover, such a framework could serve as an educational tool by providing the foundation for fostering the teaching and learning of interprofessional problem-solving skills in various health care settings.

2. Developing a conceptual framework for analyzing and fostering interprofessional problem-solving skills

2.1. Development context

The conceptual **F**ramework to **I**mprove i**N**terprofessional **C**ollaboration in health education and c**A**re (FINCA) presented in this article was developed by the authors in the context of the Graduate School "Interprofessional Teaching in the Health Professions" (ILEGRA) which was funded by the Robert Bosch Stiftung from 2018 until 2022. ILEGRA served to promote young scientists and was conducted in cooperation between the University of Osnabrück and LMU Munich. ILEGRA research fellows came from a variety of health care professions and worked on dissertation topics related to teaching, assessing and evaluating in the context of IPE or health care practice. ILEGRA brought together researchers from different disciplines to serve as scientific supervisors or advisory board members, some of whom work outside the health professions. This allowed for a broad exchange of experts from the health professions with experts from educational psychology, adult education, work and organizational psychology, and sociology. The approach resembled focus group discussions (22) and took into account existing framework concepts and the variables they contain. The iterative discussion rounds with all experts and with the ILEGRA fellows informed the development and conceptual design of the present framework, offering new perspectives beyond the health professions.

2.2. Theoretical sources beyond IPE and IPC to inform the development process

The proposed framework addresses all educational scientists and curriculum developers in the field of IPE to contribute to better IPC processes and outcomes. The development of FINCA was guided by three theoretical strands beyond the aforeementioned competency framework models for IPE and IPC:

(1) The first strand is an *interdisciplinary framework on the acquisition and fostering of diagnostic competencies* by

Heitzmann et al. (18) with its basic assumption that one's own cognitive activities are an important prerequisite for the acquisition of competencies. Disciplines are defined as broad academic fields, such as anthropology, economics and geography (8). We propose to conceptualize collaborative activities for interprofessional problem-solving on the basis of this framework which also considers a wide range of individual prerequisites (cognitive professional abilities as well as motivational and affective factors) and also context factors that could potentially moderate collaborative activities. FINCA was further inspired by Biggs' 3P model (Presage, Process, and Product) of teaching that shows how learner prerequisites interact with the teaching context during learning activities and relates them with learning outcomes (23).

(2) The second strand assumes that the extent to which IPC takes place in specific situations depends on the thought processes and activities of the individuals involved, drawing on cognitive structures like *illness scripts* and *collaboration scripts*. Illness scripts were first used to explain the diagnostic behavior of physicians. However, their usefulness is also being advocated in the nursing context [e.g., (24)]. In short, medical or nursing knowledge is organized into illness scripts which consist of patterns for diseases or clinical dysfunctions, their underlying pathophysiological processes and symptoms, as well as their care courses including therapeutic interventions (25). With clinical experience, these illness scripts develop further as increasingly efficient ways of thinking and work organization of physicians, nurses, and allied health professionals to solve and manage clinical problems. Thus, the continuous development of illness scripts enable health professionals to speed up and improve the quality of their decisions based on recurrent patterns.

Particularly in the educational context, collaboration scripts are also described in the literature (19). *Internal collaboration scripts* can be understood as a person's current knowledge of implicit and explicit rules for effective and efficient collaboration. *External collaboration scripts* can, in turn, be understood as sets of scaffolds that help to structure collaborative learning processes. They may gradually become internalized as learners act in accordance with the script content (26). While only few empirical studies are available to date regarding the use of collaboration scripts in a medical context [e.g., (27, 28)], the consideration of internal collaboration scripts of health professionals in the context of IPE and IPC is promising to support the development and application of collaboration knowledge.

(3) The third strand encompasses *collaborative problem-solving skills* that are crucial when two or more health professionals interact and orchestrate knowledge and skills to solve a shared problem. Interprofessional interactions are characterized by a diversity of professional backgrounds, distribution of responsibilities, and different approaches and values with regard to the provision of care. Interprofessional collaborative practice is dependent on the competencies of each professional group to ensure optimal care for patients, families and communities. In such situations, competencies must be integrated and a common level of information must be established, which requires a high degree of collaborative problem-solving competence from all professionals involved. Liu et al. (20) studied collaborative problem-solving in groups, describing social skills such as sharing ideas, negotiating ideas, regulating problem-solving activities, and maintaining communication. Following these considerations, we consider collaborative problem-solving skills as indispensable prerequisites for a person to participate effectively in a process in which two or more participants attempt to solve a problem together.

3. Structural components of FINCA

FINCA (see Figure 1) reflects an interprofessional learning and interaction process that involves two different health care professionals (i.e., person in profession A and person in profession B) with different *individual learning prerequisites* (18). These two persons recognize a problem that presumably requires interprofessional collaboration at one point – we term this *noticing*, which involves recognition and identification, but can be explicit or implicit/tacit (29, 30). FINCA further acknowledges the context of interprofessional learning, teaching, and working and its *action-modifying context factors*. We follow the reasoning that individual learning prerequisites interact with the teaching context during learning activities (18, 23). At the core of FINCA are *observable collaborative activities* [*cf.* (20)]. At the same time, the framework envisages an assessment of the *outcomes of IPE and IPC*. In the following sections, the core content aspects of the framework are explained and pragmatic research approaches will be outlined.

3.1. Teaching and scaffolding in IPE

Learners and practitioners across all health professions collect and evaluate multiple pieces of clinical information to make decisions about patient care. In doing so, both learners and practitioners use an analytical approach called clinical reasoning. Clinical reasoning refers to all cognitive processes underlying these decisions (31) and includes medical problem-solving and medical decision-making.

In an interprofessional context, collaborative clinical reasoning can lead to a shared mental model about patient problems and further care (32, 33). This includes an interprofessional comparison of different diagnoses or dysfunctions and the process of care, patient monitoring, explanation of treatment options, and team communication. Visser et al. (34) conclude that learners from different health professions discussing treatment plans together would benefit more in their learning process. This is because learners would have to (a) structure their thoughts (cognitive level) and (b) have to provide explanations for learners from other professions, answer their questions, and give feedback to them (metacognitive level) in order to create a common knowledge base.

Both educational research in general and research in health professionals' education in particular have shown that additional instructional support is needed for learning from challenging problems in complex learning scenarios (18, 28, 35, 36). FINCA therefore suggests various support measures in the context of teaching and learning as important variables that may influence or moderate the observable collaborative activities.

Central to *scaffolding* is supporting learners by directing attention while they work on a task. This can, for instance, be done by providing cues, case illustrations, or prompts. Numerous empirical studies have demonstrated the effectiveness of scaffolding for *knowledge transfer* [see (35)]. A wide variety of types of socio-cognitive scaffolding have been developed for collaborative problem-solving scenarios, e.g., in

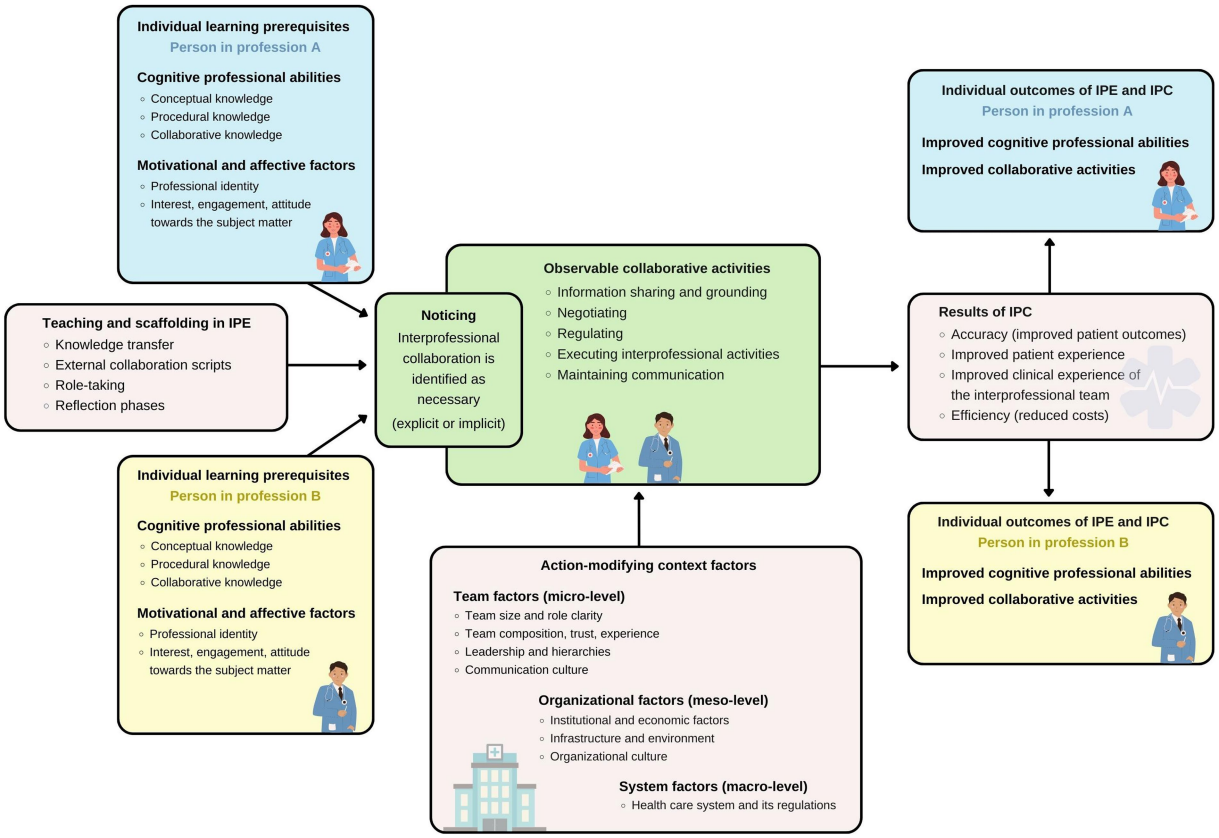

FIGURE 1
The conceptual framework to improve interprofessional collaboration in health education and care (FINCA). Arrows visualize the influence of the respective activities and factors. For instance, teaching and scaffolding in interprofessional education (IPE) affects noticing and the partially overlapping observable collaborative activities. Both individual learning prerequisites of the persons from different professions involved in the interprofessional collaboration (IPC) and action-modifying context factors influence these collaborative activities. Eventually, results of IPC arise from the collaboration and individual outcomes of IPE and IPC can be assessed for the persons involved.

the form of *external collaboration scripts* (19). Instructional support with external collaboration scripts can foster learning processes by introducing a sequence for collaborative activities. External collaboration scripts can (a) specify certain activities to be performed by learners, (b) predetermine the timing of activities, or (c) specify collaboration roles and interaction activities (37). *External collaboration scripts* have been developed for both face-to-face and computer-mediated settings and have been largely successful in improving collaboration processes as well as individual learning outcomes (38). In addition, scripts promote collaborative activities such as exchanging new ideas, asking questions, or negotiating between learning partners. Furthermore, collaboration scripts support deeper cognitive elaboration in individual learners. The use of collaboration scripts such as the handover tool SBAR (Situation, Background, Assessement, Recommendation) and its derivatives has shown promising results in mono-and interprofessional patient care [e.g., (39, 40)]. The SBAR tool is a scheme for structuring communication processes for the exchange of patient information (41) that organizes this information, reminds of important content and details that may otherwise be lost, and reduces leaps of thought and omissions which is critical to patient safety in a complex system (42, 43). The use of SBAR has even been recommended by the WHO (44).

Another promising type of scaffolding for IPE could be provided by assigning specific roles to learners to reduce the full complexity of a task. Through *role-taking*, the perspective on the full task can be focused on key learning points. In interprofessional encounters, the roles of the collaborating health professionals and the role of the patient are typical. Systematic role change allows for new perspectives and learning. Additionally, learners can be assigned the role of an observer. Results on acquiring diagnostic competences in the role of an observer are still lacking, but Stegmann et al. (45) showed that communication skills can be acquired effectively in this role.

Reflection phases are another scaffolding approach that holds potential to foster IPE. Nguyen et al. (46) provided a comprehensive definition of reflection as "the process of engaging the self in attentive, critical, exploratory and iterative interactions with one's thoughts and actions, and their underlying conceptual frame, with a view to changing them and with a view on the change itself" (p. 1182). Guided reflection can take place before, during, or after an event that requires IPC. Different types of guided reflection have been reported to efficiently foster the acquisition of diagnostic competences in medicine (47, 48). There are three main reasons why reflection could be beneficial for learning: (1) Reflection phases add a pause that learners might use to better retrieve and apply conceptual knowledge with less time pressure. Learners might also use such a pause to

evaluate the selected strategy and think about alternatives. (2) Learners may generate self-feedback to advance their learning during guided reflection. (3) Reflection phases may also support the planning of subsequent steps in the collaboration process.

To date, there has been little systematic research on what forms of scaffolding are suitable in IPE to foster interprofessional problem-solving skills (49). However, *learning with simulations* has been shown to have great potential in this regard (50, 51). Against this background, the following support measures have been included by way of example in FINCA, but this list can of course be extended: *knowledge transfer, external collaboration scripts, role-taking,* and *reflection phases*.

3.2. Individual learning prerequisites

In any interprofessional interaction, at least two persons from different professions learn and work together (52). Therefore, FINCA takes the individual learning prerequisites of two or more persons from health care professions A and B into account. IPE is about mutual recognition of roles and responsibilities. These vary from profession to profession as well as within professions that specialize. When collaborating interprofessionally, it is important to understand who you are working with and how best to use the skills of each profession and individual for successful collaborative problem-solving. Less optimal practice results from not having this understanding (1).

In the context of teaching and learning, knowledge is understood as the mental representation of information (53). Under *cognitive professional abilities*, FINCA includes *conceptual* and *procedural knowledge* as well as *collaborative knowledge* (54). Under *motivational and affective factors*, FINCA includes *professional identity* as well as *interest*, *engagement*, and *attitude toward the subject matter.*

A comprehensive research program on IPE and its instructional facilitation must address the question of how and to what extent individual learning prerequisites affect the outcomes of IPE and IPC. The benefit of clarifying the relationship between instructional effects and pre-existing individual differences among learners is obvious. Systematically incorporating individual learning prerequisites addresses the question for whom particular instructional designs are likely to be effective. Scientific insights into the moderating effects of individual learning prerequisites can help make interprofessional learning environments more effective and could serve as the basis for individualized and adaptive facilitator support measures that address the learning needs of each professional. This could involve the aforementioned use of simulations that address learning outcomes relevant to learners of all health professions involved (55, 56).

In the following, we propose cognitive, affective, and personality related moderators which can serve as a starting point for more systematic research on how learning prerequisites affect the processes and outcomes of interprofessional patient care and learning with and without additional instructional support.

3.2.1. Cognitive professional abilities

The basis of knowledge acquisition lies in the formation of concepts and contexts in a specific learning area, such as medicine or care. In contrast to this *conceptual knowledge*, which can also be referred to as factual knowledge, *procedural knowledge* focuses on the procedure and steps to be followed in clinical problem-solving. Procedural knowledge includes both strategic knowledge (about typical problem-solving strategies) and conditional knowledge (about conditions of application of conceptual and strategic knowledge) (54, 57). Besides individual cognitive structures of learners, *collaborative knowledge* is an essential element of cognitive professional abilities in FINCA. Collaborative knowledge comprises cognitive activities (e.g., explaining, questioning, summarizing), metacognitive activities (e.g., observing, regulating, formulating arguments), as well as social activities (e.g., taking turns, listening) (19). Although collaborative practice is commonplace in clinical settings, there has been little empirical research on how to analyze and promote the skills required for it (12).

Another view on the professional knowledge base in health care differentiates between biomedical and clinical knowledge (58, 59). Biomedical knowledge includes knowledge about physiological, pathological, as well as psychosocial elements. Clinical knowledge, on the other hand, includes symptoms, symptom patterns and clinical pictures, typical disease courses, as well as suitable therapeutic procedures. While the biopsychosocial model of medicine by Engel (60) is still relevant, there are calls for expanding this model toward a health care system perspective (61). From an interprofessional perspective, such an expansion should comprise perspectives and values of all professions contributing to health and patient care. One outcome of IPE could be, for instance, that health professionals better understand the importance of social and cultural factors for health and illness from diverse professional perspectives and recognise their significance in the care process [*cf.* (62)].

3.2.2. Motivational and affective factors

FINCA systematically addresses individual learning prerequisites. This includes *motivational and affective factors* such as *interest*, *engagement*, and *attitude toward the subject matter*. The framework also considers the influence of the development of *professional identity* in the respective professions involved in IPC. At this point, however, it should be pointed out that there is currently no uniform definition of professional identity within an interprofessional context (63, 64). To our knowledge, there has been no systematic research examining potential moderating effects of motivational and affective factors on the development of interprofessional activities in IPE.

3.3. Noticing

In teacher education research, *noticing* has been described as a process that lets teachers' pay attention to significant events within teaching and learning in the classroom (29, 30). Applied to the clinical context, we suggest that noticing can analogously be understood as a psychological process leading to interprofessional interaction and the corresponding collaborative activities.

We propose that noticing occurs at the beginning of any interprofessional interaction or collaboration when there is a realization that collaboration with other health care professions must be initiated to jointly address specific needs of a patient. A distinction can be made between spontaneous noticing, when an unexpected situation requires IPC (e.g., decision to treat a wound with a vacuum pump), and ritualized IPC where noticing happens implicitly (e.g., interprofessional surgical ward rounding). In FINCA, noticing marks

the transition to observable collaborative activities (see Figure 1). The communicative part of noticing itself might already be observable and thus amenable to an assessment.

Linking the theoretical elements described earlier, one could hypothesize that noticing leads to an activation of illness scripts and the complementary internal collaboration scripts among the individuals involved. The interaction of individual participants in a given situation thus depends on their memory structures related to their respective memories of a specific social situation (e.g., patient handover). In our view, these memory structures can be conceptualized as internal collaboration scripts that individuals can draw on depending on the situation (19, 25).

3.4. Observable collaborative activities

At the heart of FINCA are observable collaborative activities that can be used to assess individuals' cognitive and social skills. Liu et al. (20) postulate that collaborative learning scenarios can promote greater integration of knowledge and thus lead to better learner performance. To this end, they propose a conceptual model that includes a matrix of individual cognitive and social skills involved in collaborative problem-solving. This model can also serve as a basis for assessing an individual's collaborative problem-solving skills. Liu's assumptions are based on research in computer-supported collaborative learning (65) and also draw on the PISA 2015 Collaborative Problem Solving Framework (66). The conceptual model by Liu and colleagues also considers individual cognitive prerequisites and assigns the following key social skills to them: *information sharing*, *negotiating*, *regulating*, and *maintaining communication*. In order to incorporate clinical practice, FINCA further adds the more practice-oriented activity *executing interprofessional activities*.

3.4.1. Information sharing and grounding

The activity *information sharing* captures how individual group members contribute different ideas to a common conversation (20) or point to relevant resources that help to solve a problem that requires IPC. However, it is important that not only information is shared, but that communication partners also strive for mutual understanding. Clark and Brennan (67) refer to this process as *grounding*.

3.4.2. Negotiating

In the context of IPC, the term *negotiating* is often used in the sense of negotiated order theory [e.g., (21, 68)]. In FINCA, negotiating refers specifically to conversations about the team's collaborative knowledge construction by comparing alternative ideas and information resources, presenting evidence, and justifying an argument. Subcategories of this activity include asking for clarification, elaborating/reformulating a collaboration partners' ideas, identifying knowledge gaps, and revising/reformulating one's own ideas (20).

3.4.3. Regulating

Regulating problem-solving activities refers to conversations about clarifying objectives, monitoring, evaluating, and confirming team understanding of problem-solving. This category focuses on the collaborative regulation aspect of team conversations. It includes subcategories such as identifying aims, evaluating teamwork, and checking mutual understanding regarding aims that were jointly agreed upon (20). In clinical practice, this would occur, for example, when an interprofessional team agrees on a joint management plan for a patient.

3.4.4. Executing interprofessional activities

The observable collaborative activities mentioned previously refer to cognitive and communicative skills. They prepare for *executing interprofessional activities* that can be assessed on the grounds of clinical standards, guidelines, and patient safety requirements. Instruments for the assessment of interprofessional team collaboration have recently been developed and evaluated [e.g., (69–71)].

3.4.5. Maintaining communication

Maintaining communication includes all activities related to the conversational climate. This encompasses all conducive activities that enable efficient and effective dyadic communication between a person A and a person B (see Figure 1) or within interprofessional teams. This also includes avoiding professionally irrelevant social communication (20).

To exemplify the proposed observable collaborative activities we describe a realistic clinical scenario in Table 1. It is important to note that the procedures can be repeated several times and are by no means a linear process. In our example, a nurse and a physician on a ward must jointly decide whether to place a permanent bladder catheter in a patient based on clinical data and observations.

3.5. Action-modifying context factors

FINCA acknowledges *action-modifying context factors* as potentially significant moderators of interprofessional collaborative activities. The literature suggests a variety of such factors that may influence the effectiveness and efficiency of interprofessional collaborative practice [e.g., (5, 72, 73)]. However, the evidence base regarding their impact is not sufficient (74). Mulvale et al. (75) identified a number of studies that measured correlations between collaborative processes in interprofessional practice and structural and process factors. Thus, FINCA includes action-modifying context factors which can be divided into *team factors (micro-level)*, *organizational factors (meso-level)*, and *system factors (macro-level)*. At each level, we focus on the contextual and process-related factors that we propose to be associated with interprofessional collaborative activities. While not all of the relevant factors on the respective levels can be influenced to the same extent, we believe they are important to a framework that aims to comprehensively address IPC in health education and care.

3.5.1. Micro-level

Under the micro-level, we subsume formal and informal factors that can influence a team, such as *team size and role clarity*, *team composition*, *trust* between team members, as well as the team's *experience* with IPC. We also consider *leadership and hierarchies*, as well as *communication culture* within teams as important (76, 77).

3.5.2. Meso-level

The meso-level comprises *institutional and economic factors*, *infrastructure and environment*, and *organizational culture*. It should

TABLE 1 Placement of a catheter as an illustration of observable collaborative activities.

Clinical scenario: The patient is Mr. Anton Smith, 88 years old, with a diagnosis of congestive heart failure. Mr. Smith was admitted yesterday after a fall at home with a fracture of the neck of the femur. The ward physician orders a 24-h fluid balance for the patient.	
Activity	Description
Noticing	The nurse seeks discussion with the ward physician because she considers fluid balancing with the urine bottle Mr. Smith uses to be unfeasible.
Maintaining communication	Before the conversation begins, the ward physician asks about the current mood in the nursing team as a nurse is sick today. That is why the team is under high time pressure.
Information sharing and grounding	The nurse reports that Mr. Smith is unable to perform his intimate toilet independently and has difficulty urinating as he is partially incontinent. The ward physician informs the nurse about Mr. Smith's prostate adenoma and a worsening of the lung congestion in the chest X-ray.
Negotiating	The nurse suggests placing a transurethral indwelling bladder catheter for accurate fluid balancing due to the severity of Mr. Smith's clinical condition. The ward physician agrees and additionally suggests daily weight measurement.
Regulating	After a joint consideration of the benefits for the patient, the ward physician and the nurse jointly decide to insert a transurethral permanent bladder catheter. Because of the prostate adenoma, they decide to place the catheter together under ultrasound control.
Executing interprofessional activities	The nurse informs Mr. Smith about the indication to place a permanent catheter and obtains his consent. She informs the ward physician and prepares all necessary materials for the procedure. She positions Mr. Smith flat on his back and the bladder catheter is placed under ultrasound control. The ward physician sounds and instructs. The nurse inserts the permanent bladder catheter under sterile conditions into the bladder and attaches the urine bag. She performs intimate care and repositions Mr. Smith together with the ward physician. The nurse then instructs Mr. Smith on how to use the indwelling urinary catheter.

be noted that context factors on the meso-level are typically beyond the control of individual health professionals.

3.5.3. Macro-level

The macro-level includes the *health care system and its regulations*, which should be considered on both the educational planning and the organizational side. The context factors on the macro-level are even harder to change in order to improve IPE and IPC.

3.6. Outcomes of IPE and IPC

Following Heitzmann et al. (18) and Liu et al. (20), FINCA aims to capture and assess outcomes of IPE and IPC, both of which are complex and multifaceted constructs. In addition to assessing entire teams and their performance, there is an urgent need in research to develop stable and robust outcome criteria to demonstrate a causal relationship between IPE, IPC, and overall health care system outcomes.

3.6.1. Results of IPC

Bodenheimer and Sinsky's (78) Quadruple Aim concept is now widely recognized as a compass for optimizing health care delivery and is being further developed as a standard assessment criterion for IPC [e.g., (79)]. Following this concept, we have included the following promising criteria for assessing results of IPC in FINCA: (1) *Accuracy* (improved patient outcomes); (2) *Improved patient experience*; (3) *Improved clinical experience of the interprofessional team*; (4) *Efficiency* (reduced costs).

3.6.2. Individual outcomes of IPE and IPC

On top of the prevalent profession-specific assessment instruments for conceptual and procedural knowledge (*improved cognitive professional abilities*), instruments are needed that allow for the assessment of interprofessional collaborative activities [e.g., (71)]. According to the current IPE literature (80), individual performance should be assessed separately from team performance when evaluating collaboration in health care (*improved collaborative activities*). One possibility in this respect is offered by the concept of entrustable professional activities (EPAs). Simply put, this is about detailed authentic descriptions of clinical activities that health care trainees can be entrusted with (81). Recently, transdisciplinary EPAs have been conceptualized to be used for multiple professions (82).

4. Discussion

The present conceptual framework has been developed with scientific consideration of empirical data under various theoretical references. In our view, FINCA adequately reflects the process of IPC in a clinical context building on established theoretical foundations – it operationalizes contextual, person-related, process-related, and outcome-related variables (23) to capture what we postulate to be the observable part of IPC. In this way, the framework provides the basis for analysis and empirical testing of the components and variables described, as well as their interactions across different studies, educational interventions, and action-modifying contexts (micro-, meso-, and macro-level). FINCA further provides the basis for fostering the teaching and learning of interprofessional problem-solving skills across different health care settings.

In addition, FINCA may support faculty and curriculum developers to systematize the implementation and improvement of interprofessional teaching and learning opportunities [*cf.* (83)]. From a practical perspective, FINCA can help to better align curricula for different health professions in the future.

The proposed framework does not claim to be a theory or model yet – as yet, this is a qualitative synthesis of published literature, the empirical confirmation of which is pending. We invite readers to

discuss modifications, additions, innovations, or other perspectives with us. Perspectives from all professional groups involved in health care are explicitly welcome. In principle, we also see potential for transferability of the framework to other domains where different professions collaborate.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

MW, JZ, BW, FF and MF jointly developed the first version of the framework model. MW and JZ wrote the first draft of the manuscript with support from BW. This draft was commented on and expanded by FF, JT and MF. The manuscript was eventually revised by MW, JZ, JT and MF. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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EDITED BY
Evangelos Himonides,
University College London, United Kingdom

REVIEWED BY
Katelynn A. Kapalo,
National Fire Academy, United States
Elizabeth Austin,
Macquarie University, Australia

*CORRESPONDENCE
Rafael Wespi
✉ rafael.wespi@extern.insel.ch

†These authors have contributed equally to this work and share last authorship

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Exploring objective measures for assessing team performance in healthcare: an interview study

Rafael Wespi[1,2*], Tanja Birrenbach[1], Stefan K. Schauber[3], Tanja Manser[4,5], Thomas C. Sauter[1†] and Juliane E. Kämmer[1,6†]

[1]Department of Emergency Medicine, Inselspital, Bern University Hospital, University of Bern, Bern, Switzerland, [2]Graduate School for Health Sciences, University of Bern, Bern, Switzerland, [3]Center for Educational Measurement (CEMO) and Unit for Health Sciences Education, University of Oslo, Oslo, Norway, [4]FHNW School of Applied Psychology, University of Applied Sciences and Arts, Northwestern Switzerland, Olten, Switzerland, [5]Division of Anesthesiology and Intensive Care, Department of Clinical Sciences, Intervention and Technology, Karolinska Institutet, Huddinge, Sweden, [6]Department of Social and Communication Psychology, University of Göttingen, Göttingen, Germany

Introduction: Effective teamwork plays a critical role in achieving high-performance outcomes in healthcare. Consequently, conducting a comprehensive assessment of team performance is essential for providing meaningful feedback during team trainings and enabling comparisons in scientific studies. However, traditional methods like self-reports or behavior observations have limitations such as susceptibility to bias or being resource consuming. To overcome these limitations and gain a more comprehensive understanding of team processes and performance, the assessment of objective measures, such as physiological parameters, can be valuable. These objective measures can complement traditional methods and provide a more holistic view of team performance. The aim of this study was to explore the potential of the use of objective measures for evaluating team performance for research and training purposes. For this, experts in the field of research and medical simulation training were interviewed to gather their opinions, ideas, and concerns regarding this novel approach.

Methods: A total of 34 medical and research experts participated in this exploratory qualitative study, engaging in semi-structured interviews. During the interview, experts were asked for (a) their opinion on measuring team performance with objective measures, (b) their ideas concerning potential objective measures suitable for measuring team performance of healthcare teams, and (c) their concerns regarding the use of objective measures for evaluating team performance. During data analysis responses were categorized per question.

Results: The findings from the 34 interviews revealed a predominantly positive reception of the idea of utilizing objective measures for evaluating team performance. However, the experts reported limited experience in actively incorporating objective measures into their training and research. Nevertheless, they identified various potential objective measures, including acoustical, visual, physiological, and endocrinological measures and a time layer. Concerns were raised regarding feasibility, complexity, cost, and privacy issues associated with the use of objective measures.

Discussion: The study highlights the opportunities and challenges associated with employing objective measures to assess healthcare team performance. It particularly emphasizes the concerns expressed by medical simulation experts and team researchers, providing valuable insights for developers, trainers, researchers, and healthcare professionals involved in the design, planning or utilization of objective measures in team training or research.

KEYWORDS

team performance, objective measures, healthcare, medical simulation training, performance assessment

1. Introduction

1.1. Team significance and measures

Collaborative efforts are undeniably essential in providing healthcare. Health-care teams operate in situations that require making high-risk and high-stakes decisions while facing time constraints (Teuma Custo and Trapani, 2020). Empirical research demonstrates that the performance of such teams relies not only on their medical expertise and technical skills but also on their teamwork, that is, their ability to work together effectively (Manser, 2009; Schmutz and Manser, 2013; Schmutz et al., 2019). Furthermore, effective teamwork within health-care teams significantly impacts patient outcomes, as well as staff satisfaction, well-being, and overall organizational success (Heinemann and Zeiss, 2002; Pronovost et al., 2006; Schmutz and Manser, 2013; Rosenman et al., 2018).

Teamwork is a collaborative process in which team members interact and pool their collective resources to meet task requirements such as resuscitating a patient (Fernandez et al., 2008). To ensure high performance, Salas et al. (2008b) have highlighted the importance of various elements of effective teamwork, such as high team cohesion, adaptability, flexibility, and problem-solving skills. However, effective teamwork is often hindered by communication failures, coordination problems, and interprofessional stereotypes (Kozlowski and Klein, 2000; Devine and Philips, 2001; Dietz et al., 2014). Numerous reviews suggest that team trainings and interprofessional education activities can mitigate these obstacles and improve teamwork (Chakraborti et al., 2008; Salas et al., 2008a; Weaver et al., 2014; Fox et al., 2018; Hughes et al., 2019).

In order to identify areas for improvement and to provide feedback to team members in such trainings, it is essential to evaluate team performance in a reliable and valid way (Edmondson, 1999). Establishing appropriate methods for assessing and evaluating team performance is also essential for measuring and monitoring medical teams in their working environment, understanding how to develop and maintain "good" teamwork, and identifying the criteria for "good" teams and outcomes (Jeffcott and Mackenzie, 2008). Measuring team performance is similarly relevant for research purposes, such as when investigating the components of successful teamwork (Murray and Enarson, 2007). However, assessing team performance can be challenging due to the complexity of team dynamics, lack of clear metrics, and limited data and resources (Marlow et al., 2018).

Currently, a multitude of different measures of teamwork is used in the context of team trainings and research. While self-reports and peer assessments are well established, including physiological measures such as the team members' heart rate variability (HRV) or electrodermal activity (EDA) as indicators of their arousal or stress level are relatively new and still unexplored ways of teamwork assessment. Yet, they deserve a closer exploration as they can potentially mitigate some of the limitations associated with traditional measures such as susceptibility to self-reporting bias (Kozlowski et al., 2013). With our study, we aim to capture the opinions of experts in the fields of medical team training and research on the potentials and challenges associated with integrating physiological and, more generally, objective measures of teamwork into the evaluation of healthcare teamwork. By seeking insights from key stakeholders, this study endeavors to contribute to the theoretical discourse on healthcare teamwork assessment, while also highlighting practical implications for medical training and research.

1.2. Traditional and novel evaluation approaches

For a comprehensive evaluation of team performance, it is essential to assess both team processes and outcomes. Team processes include the strategies, steps, and procedures used by the team to accomplish a task (Salas and Cannon-Bowers, 1997). Team performance outcomes focus on results, such as treatment and patient condition. To assess training benefits, medical training studies usually focus on reporting outcomes such as triage accuracy, time to triage, and occasionally administer the perceived benefits from participants (e.g., Luigi Ingrassia et al., 2015; Dittmar et al., 2018; Baetzner et al., 2022). Team researchers typically use the same measures, often assessing time intervals during medical processes, such as decision or execution latency (Burtscher et al., 2011), percentage of hands-on time during resuscitations (Tschan et al., 2009), or durations required to complete a specific task (Tschan et al., 2009). Adherence to institutional standards (Kolbe et al., 2012) or the diagnostic process itself (Tschan et al., 2009) are also considered as measures of teamwork quality.

Traditional data sources for assessing team performance have their advantages and disadvantages (Salas and Cannon-Bowers, 2001; Marlow et al., 2018). Self-reports and peer-assessments can provide access to unobservable reactions, attitudes, and emotions, but may suffer from biases, particularly if individuals are motivated to present themselves in a favorable light. Expert observations based on standardized tools, such as the Team Emergency Assessment Measure (TEAM; Cooper et al., 2010) or Medi-StuNTS (Hamilton et al., 2019), can provide reliable assessment of relevant attributes, but are time- and resource-intensive. On the positive side, measuring these observable behaviors provides actionable guidance for team members to improve their future performance (Rosen et al., 2010).

Research on the unobtrusive measurement of team members' physiological parameters (biosignals) suggests that an additional source of data can provide valuable information about team processes and unobservable states, such as stress levels, and allow objective assessments of relevant parameters in real time: team physiological dynamics (Kazi et al., 2021; Hałgas et al., 2022). This endeavor is in line with the growing recognition of the multidimensional nature of effective teamwork, highlighting the benefits of considering both visible behaviors and underlying physiological responses (Rojo López et al., 2021). By monitoring physiological signals such as HRV, researchers can assess the arousal, attention, and emotional states of team members during training or real-life scenarios. This information can complement traditional measures to provide a more comprehensive and objective picture of team performance. Moreover, the use of objective measures offers the possibility to shift the focus from an outcome-based assessment toward a process-oriented assessment (Salas et al., 2017; Hałgas et al., 2022). They include specific and

measurable data obtained through standardized measurements that are not influenced by personal biases or subjective interpretations. The crucial advantage of objective measures is their ability to capture data at a fine resolution over long periods of time, which cannot be achieved with conventional measures. However, the strategic implementation of objective measures such as physiological data requires a user-friendly methodology that simplifies the analysis and interpretation of data. Furthermore, the collection and analysis of physiological data, for instance, still incurs inherent costs in terms of time and resources.

Despite these potential benefits, the effective use of physiological data in team training and its relationship to higher-order constructs such as successful coordination is still poorly understood. To date, most practical studies in the field of physiological team dynamics have been conducted using simulations of work-related tasks (Kazi et al., 2021; Hałgas et al., 2022). In addition to simulation studies, there are also laboratory studies that investigate physiological team dynamics in video games, simple tasks, or similar (Chanel et al., 2012; Järvelä et al., 2014; Fusaroli et al., 2016). In the medical field, however, there are only a handful of studies, which have investigated only one or two physiological measures like direction of gaze and pupillometry (He et al., 2021) or EDA (Misal et al., 2020). The complexity of the topic and the challenges associated with significant and appropriate implementation could be possible explanations. Therefore, research in this area is essential for the future use of objective data to capture team performance indicators.

1.3. Research questions

Our proposed vision is to use objective measures to assess team performance during team training and research to complement traditional team performance assessment. Hereby, objective measures are understood as factual and quantifiable information obtained through standardized measurement and free from personal bias or interpretation, including bio-signals, time stamps, checklists, and the like. By integrating these measures into team assessments, layers of team interactions that often remain concealed may be unveiled, representing new dimensions for the analysis and comprehension of teamwork.

With our study, we aim to contribute to the discussion and ultimately the effective implementation of objective measures into teamwork assessment in training and research contexts. Thereby, we follow the principles of participatory action research, with active engagement of stakeholders who will play a role in its implementation. The primary focus is thus to assess the views of medical team coaches and researchers, key stakeholders in healthcare teamwork, on the viability of integrating objective measures, with particular reference to physiological data, and to identify the potential benefits, challenges and acceptability associated with this approach. We have three main research questions (RQ):

> RQ 1: What do experts think about the vision of evaluating team performance with objective measures?
>
> RQ 2: Which objective measures could be used to evaluate medical team performance?
>
> RQ 3: What could be obstacles with the approach of using objective measures to evaluate team performance during team training and research?

In summary, our approach envisions the harmonious integration of objective measures, including physiological indicators, to holistically assess team performance. The aim of this study was to find out what experts in medical education and team research think and know about the opportunities and barriers to evaluating medical team performance using objective measures. In doing so, we aim to provide insights that will shape medical education, research and the wider understanding of teamwork in healthcare.

2. Methods

2.1. Study design

An exploratory qualitative study design was utilized. We conducted a semi-structured interview study with two expert-groups, followed by a brief on-line survey.

2.2. Participants

To answer the three research questions, medical team training and scientific team experts were recruited and interviewed. The inclusion criterion for participation in the interviews was thus either team training expertise as a trainer in medical team training or expertise as a team researcher. Experience in the field of physiological data collection was not required. In addition, we aimed to include an equal number of women and men in the sample.

To identify relevant experts in the field, we used the snowball sampling procedure (Parker et al., 2019). The medical experts were solicited with the help of recommendations from the co-authors, after which they were in turn asked for recommendations at the end of the interviews. For the team researchers, researchers with publications in the field of team research were sought, who were then also asked for recommendations.

2.3. Material

The interview questions were developed by the authors in line with the research questions. The complete interview guide can be found in the Supplementary material 1.1. The following analysis will focus on the interview questions from the third block: (a) What comes to your mind when you hear about our vision/goal? (b) Have you considered using objective measures such as biosignals in team training/research to evaluate team performance, and if so, which ones? (c) What are the factors and challenges in assessing team performance using physiological parameters? Where can objective measures be used?

In order to keep the interviews as short as possible, an on-line questionnaire was sent to the interviewees after the interview (via www.soscisurvey.de). It consisted of three questions on age, gender, and expertise (i.e., number of years of experience in training/research context).

2.4. Procedure

Identified experts were invited via email to participate in a 30–60 min interview. They were informed that (a) the interview would

be recorded, transcribed, and analyzed, (b) their identity would remain confidential, and (c) that participation was voluntary and could be withdrawn at any time.

Interviews were conducted in German or English, according to the preference of the interviewee. At the beginning of an interview, consent was again obtained for the interview to be recorded. The interview procedure was then explained and the interview conducted. Finally, the experts were thanked for their participation, the literature on objective measures of performance was briefly explained, and open questions were answered. They were also offered the opportunity to receive news about the project by email.

After the interviews, participants were sent the on-line survey on demographics. If this was not completed after 7 days, the participants were reminded by email.

2.5. Setting

All interviews and questionnaires were collected between June and August in 2022 and were conducted by the first author of this paper. All interviews were conducted using Zoom (Zoom Video Communications Inc., 2016) and recorded using the integrated tool.

2.6. Analysis

The transcription of interviews was carried out verbatim by the first author with the help of a speech recognition software (Dragon NaturallySpeaking, Nuance Communications Inc.).

The content analysis was based on the approach of Kuckartz, 2019, which is a rigorous and systematic method used in qualitative research to analyze textual data. It involves the identification and categorization of specific content patterns, themes or codes within the data, providing valuable insights and interpretations for the research study.

All categorizations were carried out by one rater, checked by another rater, and then aggregated into categories by two raters using a consensus procedure. We used MAXQDA 2022.2 (VERBI Software, 2022) for the process of data analysis.

For RQ1 (i.e., opinion on vision), responses were categorized into three categories (positive, neutral, and negative) according to their valence. The positive category included responses that were predominantly positive about the vision presented. The neutral category included all responses that did not have a clear value or where the question was not answered. The negative category included responses where experts expressed a negative or hesitant view such as when they could not relate to the vision or pointed to unsurmountable obstacles.

For RQ2 (i.e., possible measures), responses were categorized based on the measures mentioned. Higher order categories were created to group related measures together such as EDA and electrocardiogram (ECG) together to electrophysiological measures.

For RQ3 (i.e., obstacles), responses were categorized according to the named obstacles identified. Similarly, higher-order categories were established based on the source of these obstacles such as whether they originated from an individual, the model or concerned the implementation.

We decided not to weight the identified categories by their frequency but to treat all responses equally in order to receive a comprehensive overview.

In order to explore how familiar interviewees were with objective measures in the context of team training and research, all responses were examined to determine whether participants had reported personal experience or had undertaken projects or experiments involving objective measures (categorized as "having experience") or not (categorized as "not having experience).

Demographic data was collected and are presented as means and standard deviations. In addition, *t*-tests were conducted with the software "R," version 4.3.0, for the variables age and expertise to check whether the two expert-groups differed from each other.

2.7. Ethics

The studies involving human participants were reviewed and approved by The Bern Cantonal Ethics Committee (CEC, BASEC Nr: Req-2022-00684). All methods were carried out in accordance with relevant guidelines and regulations. Informed Consent to participate was recorded in writing, at the beginning of the interview and in the survey by each participant. The data were collected, analyzed and stored in pseudonymised form.

3. Results

3.1. Sample

3.1.1. Demographics

In total, $N = 34$ interviews were conducted (44.1% women, Age: $M = 48.8$ years, $SD = 11.1$, Expertise: $M = 17.2$ years, $SD = 8.4$). One person from the medical group did not respond to the survey. Interviews were conducted with $n = 21$ medical experts who trained medical staff as simulation trainers in Switzerland, Germany, and Austria (38.1% women, Age: $M = 46.8$ years, $SD = 9.3$, Expertise: $M = 15.5$ years, $SD = 7.2$), and interviews with $n = 13$ team research experts conducting research in Europe and the United States (53.9% women, Age: $M = 51.9$ years, $SD = 13.2$, Expertise: $M = 19.7$ years, $SD = 9.9$). The expert groups did not differ significantly from each other in terms of age [$t(32) = -1.309$, $p = 0.1$] and expertise [$t(32) = -1.435$, $p = 0.080$].

3.1.2. Experience with objective measures in simulation training and research

In total, 10 of the 34 experts (29.4%) stated that they had experience with physiological measurements in the context of simulation training and research such as with heart rate or examinations of volume. Of these, eight were from the group of team researchers.

3.2. Interview responses

3.2.1. RQ1: experts' opinion about vision

Of the 34 responses, 19 were positive, 13 were neutral, and three were negative. Both neutral and positive responses were consistently constructive, with curious and skeptical elements. In terms of content, the responses of the expert groups did not differ meaningfully from each other. All three negative responses came from the medical experts.

An example of a positive response:

> "[…] In principle, I don't think it's a bad idea. If it were possible to measure stress levels before, during and after a task in a less annoying, less invasive and relatively chic way that would certainly be a good addition to self-reported levels. And I can also see us getting to the point where fitness trackers alone can tell me how well I slept, which means they can certainly tell me how much stress I was under"—(Medical Expert, CM).

An example of a neutral response:

> "[…] So what I don't know at the moment is how to do this better in an automated way, although there are certainly people who are extracting data from measurements, whether it's videos, coding or something like that to make it objective but I haven't seen any implementation of that in science yet"—(Research Expert, SK).

An example of a negative response:

> "I think it's very challenging, very difficult. It seems very complex and the scenarios are often difficult even for the instructors because you have to be very flexible. Just because we've thought about something in the planning and we know which way it's going to go, doesn't mean it's going to work that way. It is insanely difficult to somehow get a standardized evaluation out of it"—(Medical Expert, DH).

3.2.2. RQ2: possible measures

Answers to the second research question were categorized into five main categories: visual, acoustical, physiological, and endocrinological measures, and a time layer (see Figure 1 and Supplementary Table 1 for a list of exemplary answers).

Concerning the time layer, our interview partners highlighted the importance of utilizing time stamps and duration tracking to gain a better understanding of the temporal aspects of social interactions. They emphasized the need for capturing social dynamics in various contexts, particularly in medical settings, and the potential benefits of data-driven approaches for analyzing them.

In terms of physiological data, the experts suggested measuring blood pressure, temperature, electroencephalogram (EEG) signals, and EDA and ECG variables (heart rate and heart rate variability) as potential indicators of stress levels or other relevant factors. Endocrinological measurements, such as analyzing saliva or urine samples, were also named. As they are usually evaluated using laboratory analyses after a training session, rather than in real time, they are depicted as a separate category in Figure 1.

Visual methods named involved observing behavior and movements to indicate the actions taken and the stage of a process. In addition, eye-tracking measures such as pupillography to measure cognitive load, as changes in pupil width can reflect this, and tracking the direction of view to enhance situational awareness and interface design were proposed. Experts acknowledged that careful preparation and interpretation of the data are essential to avoid misinterpretation.

Acoustical measures from the field of communication analysis were suggested to provide useful insights into interpersonal dynamics. These measurements consist of conversational changes that track interaction frequency and nature to assess leadership roles and psychological safety. Conversation fraction analysis captures patterns of interaction and communication frequency among team members. Speech content analysis focuses on the quality of communication. In addition, acoustical indicators like pitch, volume, and speech pace could be studied to comprehend how they impact responses and interactions between individuals.

The list of answers given by the two groups of experts differed only slightly. For example, "pupillography" and "temperature" were mentioned by the medical experts but not by the research experts. On the other hand, the research experts mentioned EEG, which was not mentioned by the medical experts.

3.2.3. RQ3: obstacles

Answers to the third research question were categorized into four main categories: individual, implementation, doubts, and model/concept. The last category consisted of two sub-categories: bias and situation-dependent output. Each category comprised several obstacles, which are summarized in Figure 2.

The interviews disclosed integrated themes that covered the model, bias and situation-dependent output in evaluating the performance of medical teams. Experts acknowledged the importance of artifacts, illustrating how they could both improve and impede training. This encouraged an analysis of the quality and legitimacy of measuring techniques, as well as the difficulty in differentiating individual from collective performance within a convoluted team context. As experts explored the meaning of measurements, they emphasized the importance of validation samples to enhance the reliability of objective evaluation. The discussion broadened to encompass prejudices that arose from training specificity, where particular case requirements and the participants' consciousness of simulation conditions could influence the outcomes. The experts considered the potential influences of training-induced biases and the impact of team adaptation in simulated scenarios. Moreover, the experts dealt with the situation-specific aspects of output, recognizing the complexities of different medical contexts and the impact of proficiency levels on performance deviation. The efforts to establish the criteria for "good" team performance were emphasized, highlighting the need for flexible measurement standards.

In the interviews, concerns were raised regarding the complete objectification of measuring team performance. Experts acknowledged the complex relationship between factors that influence team dynamics. There were queries about the hurdles of achieving objectivity and separating training effects from a variety of covariates. Worries were expressed about the potential peril of overly fixating on certain metrics, which may overshadow subtle aspects of team interactions. The complexity of assessing and interpreting objective measurements of team performance was recognized, highlighting the multidimensional nature of this subject.

Experts emphasized the delicate balance between obtaining objective data and maintaining the authenticity of the simulation environment. Challenges related to the invasiveness of measurement devices, associated costs, and time constraints were named. Several experts emphasized the importance of a gradual, step-by-step approach to implementation, and ensuring effective navigation of challenges. In parallel, experts recognized the need to address issues related to individual acceptance, data protection, and privacy to ensure the successful integration of objective measurement methods.

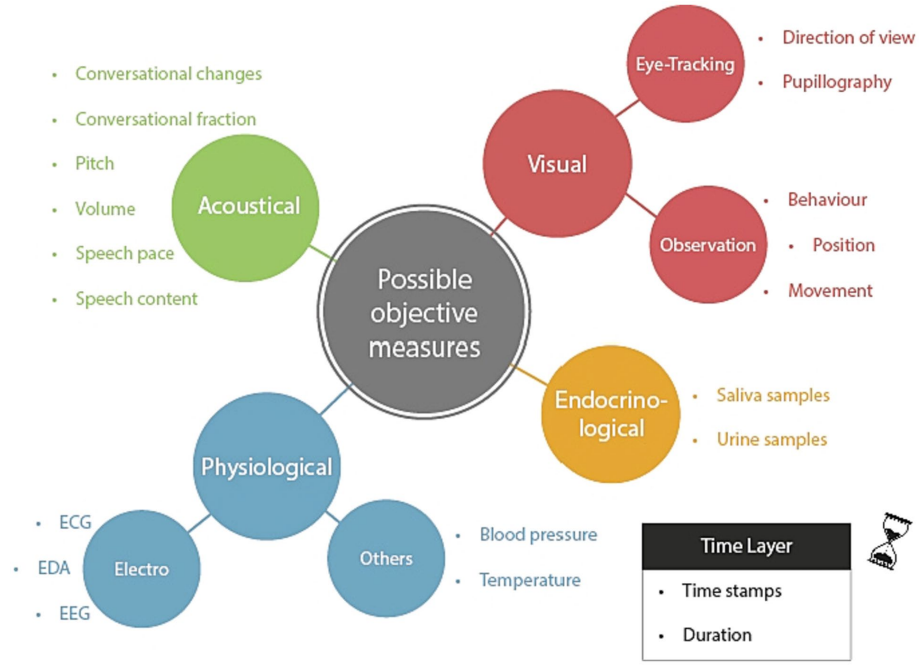

FIGURE 1
Overview of main and sub-categories concerning the question for potential objective measures. The time layer is to be understood as a meta-layer, which may be integrated with the other layers so that the measured values can be located in their time and duration. EEG, Electroencephalography; EDA, Electrodermal activity; and ECG, Electrocardiogram.

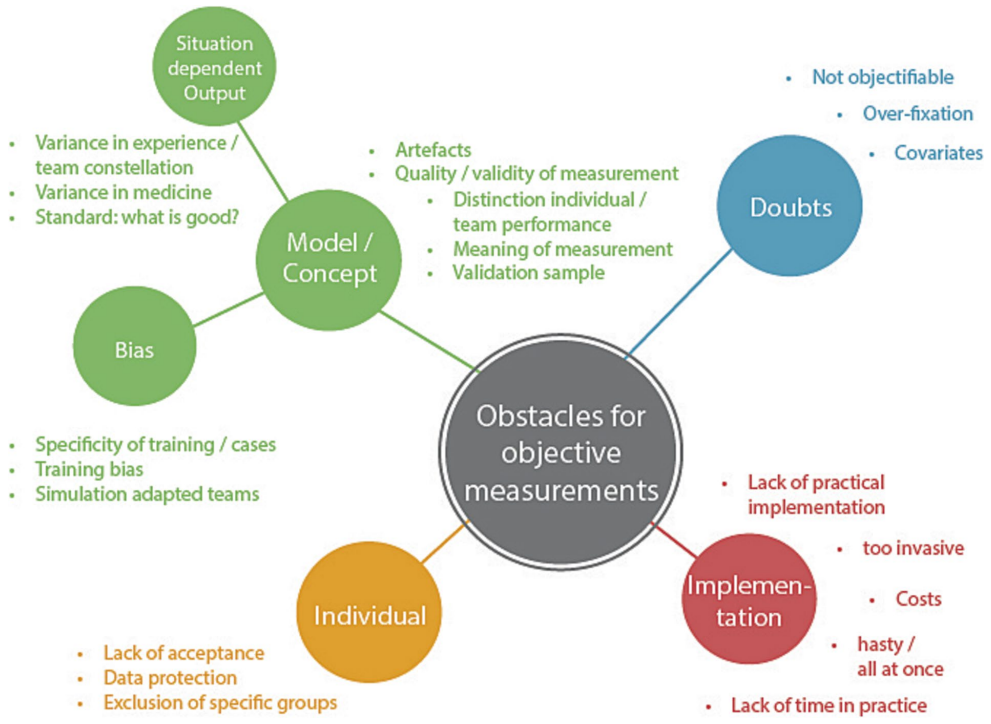

FIGURE 2
Overview of main and sub-categories concerning the question for potential obstacles of objective measures.

The importance of individual factors in measuring the performance of medical teams was identified as a critical theme. Experts acknowledged the need to consider inclusivity and potential exclusions of groups while developing measurement approaches. They considered the complexities involved in ensuring that assessment methods support varied team compositions while accounting for roles

and levels of expertise. In addition, they discussed the importance of participants accepting measurement devices and protocols. They raised concerns regarding the potential violation of data protection and privacy while considering the collection of sensitive physiological data. The experts stressed the significance of creating an environment where individual rights and sensitivities are upheld while enabling the thorough measurement of team performance.

Additional obstacles mentioned included technical challenges and biases in the training process as well as the difficulty to distinguish between individual and team performance. To get a more nuanced understanding of the stated obstacles, see Table 1.

The list of answers given by the two groups of experts differed only slightly from each other. The points "Bias: simulation-adapted teams," "hasty/all at once," "costs," and "lack of time in practice" were only mentioned by the medical experts, while all other points were mentioned by both expert groups.

4. Discussion

The aim of this study was to explore together with relevant stakeholders the potentials and challenges of a novel approach for evaluating team performance for research and training purposes, namely the use of objective measures, by asking experts in the field of research and medical simulation training for their opinions, ideas, and concerns.

To the best of our knowledge, this study is the first to explore the opportunities and challenges of objectively measuring team performance by consulting experts in the relevant fields. Given the increasing feasibility of automated solutions (Kazi et al., 2021; Hałgas et al., 2022), our work thus provides insights to help implement the use of objective measures in the fields of medical simulation training and research, and hints to aspects deemed relevant for the development of such measures from the perspective of its future users.

4.1. Reflections on the results

We found that the use of objective measures to assess medical team performance was met with a combination of interest, goodwill, and a degree of skepticism by the participating experts. Responses included a variety of proposed measurement modalities and potential challenges associated with collecting objective data on team performance. Importantly, the responses from both research and medical experts showed a remarkable level of agreement, reinforcing the consistency within the categories and responses identified.

With respect to RQ1 (vision), we found that the approach to use objective measures to evaluate team performance was received largely positively from the experts. However, it must be acknowledged that only a minority of experts had previous practical experience of measuring objective measures such as physiological data. Consequently, the majority of the experts lacked extensive expertise in the specific area under investigation, which is to be expected given the novelty of the topic. It is important to consider this limitation when interpreting the data collected and drawing conclusions from the study.

With respect to RQ2 (measures), experts saw potential in a variety of measurement methods for assessing the performance of medical teams including acoustical, visual, physiological, and endocrinological measures as well as a time layer. All of the listed measures (Figure 1) have already received some attention in research on team performance assessment in different domains (Elkins et al., 2009; Guastello and Peressini, 2017). For example, there is evidence suggesting that team performance correlates with movement patterns (Calabrese et al., 2021) and several physiological measures such as EDA (Pijeira Díaz et al., 2016), ECG (Rojo López et al., 2021), eye-tracking (He et al., 2021), as well as attention (Mahanama et al., 2022). In the majority of these papers, team performance has been inferred using 1–2 measures, although the use of multiple modalities in one measurement would likely add value to the evaluation of team performance (Hałgas et al., 2022). Moreover, most of the existing studies that have attempted to assess team performance using physiological data have focused on simple tasks that may not be directly relevant to medical procedures, and have been conducted under conditions of low movement, which may mask potential artifacts (Stuldreher et al., 2023; van Eijndhoven et al., 2023). Therefore, it is crucial to address these limitations and ensure that future studies properly account for movement and stress artifacts to ensure the validity of performance evaluations.

Various measures have been used to assess not only overall team performance, but also specific elements of team performance, such as shared cognitive load (Collins et al., 2019; Dias et al., 2019; Dindar et al., 2020), shared attention (Stuldreher et al., 2020; He et al., 2021; Pérez et al., 2021), and stress (Cao et al., 2019; Bhoja et al., 2020; Misal et al., 2020). Existing research has largely focused on assessing team performance using measures such as heart rate and EDA, while limited attention has been paid to using motion and voice data for this purpose.

With respect to RQ3 (obstacles), a number of potential barriers to assessing team performance using objective measures were identified. From a research perspective, one of the most relevant obstacles likely is that it is difficult to define a standard for "good" team performance that takes into account the different contexts and preconditions of teams. In fact, the lack of a gold standard for measuring team performance is a widely acknowledged problem (Heinemann and Zeiss, 2002). A standard of team performance should be established via consensus with relevant stakeholders to enable the development and research of objective measures as a solution to this problem. When conceptualizing an objective approach, it is crucial to consider that, depending on the training and its associated learning objectives, various aspects of a teamwork may be emphasized. Thus, a thorough task analysis will be detrimental for establishing standards for "good" teamwork (Tschan et al., 2011).

Another crucial challenge is the question of how to distinguish between team and individual performance, which needs further theoretical work. Challenges specific to the objective measurement approach included the fear of impaired results due to (e.g., movement) artifacts or low measurement quality, which need to be taken into account by developers and users. This concern points to the need for further development and research efforts to optimize the use of physiological data and ensure their reliability and validity in the context of medical team training. Further research is needed to address the remaining obstacles, including the development of a user-friendly measurement process and the establishment of reliable performance assessment models.

From a medical trainer-centered perspective, the most relevant challenges included concerns about trainee privacy and data

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TABLE 1 Example answers for each category of obstacles.

	Subgroup	Example
Model/Concept	Artifacts	"There are quite a few artifacts in a simulation training that can change the behavior accordingly, which can be both good and bad for the training."
	Quality/validity of measurement	"And how is this objective data? Or how can it be collected in real time? How much error is there in collecting it? What the benchmark of the measurement should be and whether it is at an individual level? This is making it difficult to compare individuals within a team."
	Distinction individual/ team performance	"And the question is also what is really teamwork in the sense of individual behavior in the group and how much of the behavior and action is shaped by conflicting goals again within its context?"
	Meaning of measurement	"In the perfect dynamic "online measurement world," where you see what they see, where they move, what they touch combined with physiological data that connects performance, the question is whether you can make sense of it. So the question is that even if you can collect all this data, can you make sense of it? This is for me one of the biggest hurdles in this regard and should be considered and worked on very carefully."
	Validation sample	"What comes to mind now is the validation of objective measurements and what that means in terms of significance in the real world. I think that is very important."
Bias	Specificity of training/ case	"You have to accept that teamwork is always very contextual and that you probably cannot say that you always have to do it exactly the same way."
	Training bias	"And the problem in simulations is that the training participants expect something like this and are prepared to act in such a way, which is absolutely out of touch with reality. Accordingly, they are much more likely to improvise what to expect. In reality, on the other hand, it is so hard to know when to deviate from the procedures because it is a crisis."
	Simulation adapted teams	"There could be a bias in simulation-adapted teams, which is already known."
Situation dependent output	Variance in medicine	"This is somewhat difficult in medicine, since there are usually several possibilities and there is usually no absolute correctness, since there is often not one way to solve a problem. As an example in anaphylaxis, that one should deviate from the classic procedure of first placing intravenous access and instead first inject something intramuscularly. That is something that from my point of view the literature is strong enough where the algorithm is also clear. That's something that's measurable whether it happens and how fast. That's the kind of thing you can do well. In some of the other processes or problems, we are a little less clearly structured because the work instructions are also somewhat open-ended."
	Variance in experience/ team constellation	"So let me get this straight, this is extremely complicated, you are going to have a lot of different medical personnel there, with focus on a specific role, with a variety of them and a perceived infinite amount of variance. So I find it exceedingly difficult to measure team performance objectively."
	Standard: What is good?	"In the end, it boils down to the question of the gold standard, although there are of course other challenges as well. What's more, performance is currently not very well defined, not to mention not very well discussed."
Doubts	Not objectifiable	"If we go back to question one, what are the most important things in a team, the question arises whether there are ways to derive these values objectively and how this should be done."
	Covariates	"I think that it is extremely difficult to find a clear assignment that the training has an effect. Since there are so many things that have an influence."
	Over-fixations	"I think it would be important to me that you do not shoot down too strongly and that is not the main point in the evaluation. I think we observe a lot as experts and cannot really verbalize why we liked it or not, that's exactly the development stage from novice to expert. And if I see then only, what key figures from the evaluation have, like so many look contacts for that and so fast until the first support is requested, I could lose myself in these things after."
Implementation	Lack of practical implementation	"Of course, it is important that the simulation itself is not disturbed. If, for example, the participants had to be completely wired and any bio parameters had to be measured, this would interfere with the simulation. It must also be manageable in the implementation that if you say that a classical simulation is already very complex and if you then have to take very complex measures to determine that, I think that you would not use it so much, because you have to get there first to be able to trust that it also brings something and it has a benefit."
	Too invasive	"We then realized that this strapping on of ECG cables etc. was already perceived in the study as so invasive that we realized that we could not imagine that in the training context."
	Costs	"If it is too complex and consumes too much time then it loses a lot of its charm, which would make it very costly and unattractive."
	Hasty/all at once	"I think that this should be implemented step by step. If you implement this from the beginning with large teams in shock room simulation, you will probably reach your limits relatively soon."
	Lack of time in practice	"In addition, the time factor is also an important thing, because it must not take significantly longer than usual."

(Continued)

TABLE 1 (Continued)

	Subgroup	Example
Individual	Exclusion of specific groups	"The first thing I would add is that you cannot get access for implementation if the teams you want to do it with do not accept it."
	Lack of acceptance	"In addition, the focus must be on acceptance, so that people can accept the devices for measurement and wear them voluntarily."
	Data protection	"And you get there into an intimate area of people, which is delicate."

handling. Ensuring self-determination and privacy were considered crucial for a positive working environment. According to the experts, implementing an objective measurement approach in real-life settings will require considerations of cost effectiveness and smooth integration. Especially limited resources in the health-professions education sector require a simple and reliable measurement system (Maloney and Haines, 2016). Moreover, the approach must be designed such that it is user-friendly and the data output is easily interpretable to generate enhanced values. Therefore, collaborative development of objective indicators along with simulation trainers and medical educators is not only recommended, but also crucial.

4.2. Outlook

Objective measures can complement traditional methods and, together, offer a more comprehensive perspective on team performance, although the extent of their impact is currently uncertain. The hope connected with this approach is that objective measures may provide more fine-grained process data and thus enable a greater focus on team dynamics, leading to novel training and research insights. They may thus mitigate shortcomings of, for example, behavior observations that typically result in an average rating per dimension for an entire scenario. Moreover, besides training and research settings, it is possible to gather such data in routine clinical practice to assess team dynamics, improve processes, and identify critical issues. Nevertheless, it is crucial to exercise great caution as this approach should not create any sense of control or supervision among medical personnel at any point.

In particular, training concepts using Virtual Reality (Bracq et al., 2019) provide the opportunity to automatically collect numerous objective measures (e.g., eye tracking-, acoustical-, movement tracking-, and behavior data) without much effort since these sensors are part of a classical head mounted display, which may benefit their training outcomes. Moreover, gathering and integrating physiological data with additional devices are also possible, and unlikely to cause significant disruption during routine simulation training. It is worth noting that virtual, augmented, and mixed reality are relatively new in medical education; nevertheless, they are currently used for this purpose, and extensive research exists that attest to their usefulness and effectiveness in various settings (Barteit et al., 2021; Birrenbach et al., 2021). Consequently, the inclusion of various objective parameters in the assessment of these tools in different contexts is the next logical step. This could also provide benefits for new training and evaluation approaches in the domain of health care education (Collins et al., 2019).

It is important to note that the objective approach to team performance evaluation is not intended to supplement traditional performance evaluation, but rather to focus on the processes and thus enrich the overall evaluation. We acknowledge that each measure alone provides only limited insight into team performance. Therefore, Salas et al. (2017, p. 25) proposed to measure team performance in a comprehensive way by triangulating data in terms of (a) collecting data from diverse sources, including self-reports, peer ratings, and observations, in addition to objective outcomes, (b) measuring performance at the individual and team levels, and (c) measuring both processes and outcomes. Such a triangulation approach also promises a rich basis for debriefing, an essential part of medical team training.

4.3. Limitations

Our study comes with some limitations. One limitations is that the majority of the experts we interviewed had no expertise in the specific area of physiological measurement in simulation training or objective assessment using physiological measures. Consequently, their responses were primarily based on subject-specific knowledge or personal beliefs. Yet, the selected experts were key stakeholders in the fields of team research and training and thus representative of the "end users" of objective measures, making it relevant to explore their opinions. It is also worth noting that the field of objective performance assessment, particularly in relation to physiological measures, is still in its infancy and as a result, there are only few experts in this area. To progress, collaboration with experts from relevant adjunct fields is required. Participatory-based model and approach development, based on data, must be continued and consistently improved. Furthermore, it is necessary to involve specialists in the field of measurement technique to prevent issues like unreliable data.

Another limitation is inherent in the interview method, including the potential for respondents to engage in socially acceptable behavior, thereby not fully expressing their true thoughts. To mitigate this risk, participants were assured anonymity to encourage open and honest feedback. Further, it is important to acknowledge that the conclusions drawn from these studies may be limited by the selection of experts (Parker et al., 2019) and the specific questions asked (Halbig et al., 2022).

4.4. Conclusion

In conclusion, this study represents an advance in the exploration of objective measures for evaluating medical team

performance by providing insights into the opportunities and challenges observed by the relevant stakeholders. The study provides relevant insights for the future development of objective measurement methods in medical simulation training, research, and beyond. Although challenges related to privacy concerns, resource limitations, and complexity may arise, they should be viewed as opportunities for further research and development. Proactively, addressing these challenges will refine and optimize the use of objective measures and provide a robust framework for assessing team performance in healthcare settings. Future research should focus on expanding the scope of physiological data, designing measures with teams, and collecting data to achieve a comprehensive assessment of team dynamics and build a measurement model. By harnessing the potential of objective measures in close collaboration with experts from relevant fields, this study informs future investigations, developments and utilization, ultimately contributing to the advancement of medical education and training practices, leading to improved patient outcomes. However, it is important to note that this is only the first step in a long journey that will continue to rely on close collaboration with medical simulation trainers and team researchers to further develop and implement team assessment using objective measures.

Data availability statement

The datasets presented in this article are not readily available because consent to share the interviews has not been obtained. Requests to access the datasets should be directed to RW, rafael.wespi@extern.insel.ch.

Ethics statement

The studies involving humans were approved by The Bern Cantonal Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

RW served as the main author and led each part of the working progress. JK and TS made equal contributions in the planning, data acquisition, analysis, and writing stages. TB, SS, and TM contributed to the planning, analysis, and writing steps. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2023.1232628/full#supplementary-material

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EDITED BY
Juliane E. Kämmer,
University of Bern, Switzerland

REVIEWED BY
Keri L. Heitner,
Saybrook University, United States
Jennifer Weller,
The University of Auckland, New Zealand

*CORRESPONDENCE
Mirjam Körner
✉ mirjam.koerner@mps.uni-freiburg.de

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Effectiveness and feasibility of an interprofessional training program to improve patient safety—A cluster-randomized controlled pilot study

Mirjam Körner[1,2]*, Julia Dinius[1], Nicole Ernstmann[3,4], Lina Heier[3,5], Corinna Bergelt[6,7], Antje Hammer[3], Stefanie Pfisterer-Heise[7] and Levente Kriston[7]

[1]Medical Faculty, Institute of Medical Psychology and Medical Sociology, University of Freiburg, Freiburg, Germany, [2]Department of Health Professions, Competence Centre Interprofessionalism, Bern University of Applied Sciences, Bern, Switzerland, [3]Institute for Patient Safety, University Hospital Bonn, Bonn, Germany, [4]Chair of Health Services Research, Faculty of Medicine and University Hospital Cologne, Institute of Medical Sociology, Health Services Research and Rehabilitation Science, University of Cologne, Cologne, Germany, [5]Department for Psychosomatic Medicine and Psychotherapy, Center for Health Communication and Health Services Research, University Hospital Bonn, Bonn, Germany, [6]Department of Medical Psychology, University Medicine Greifswald, Greifswald, Germany, [7]Department of Medical Psychology, University Medical Center Hamburg-Eppendorf, Hamburg, Germany

Introduction: Interprofessional healthcare teams are important actors in improving patient safety. To train these teams, an interprofessional training program (IPTP) with two interventions (eLearning and blended learning) was developed to cover key areas of patient safety using innovative adult learning methods. The aims of this study were to pilot test IPTP regarding its effectiveness and feasibility. The trial was registered with DRKS-ID: DRKS00012818.

Methods: The design of our study included both a pilot investigation of the effectiveness of the two interventions (eLearning and blended learning) and testing their feasibility (effectiveness-implementation hybrid design). For testing the effectiveness, a multi-center cluster-randomized controlled study with a three-arm design [intervention group 1 (IG1): eLearning vs. intervention group 2 (IG2)]: blended learning (eLearning plus interprofessional in-person training) vs. waiting control group (WCG) and three data collection periods (pre-intervention, 12 weeks post-intervention, and 24 weeks follow-up) was conducted in 39 hospital wards. Linear mixed models were used for the data analysis. The feasibility of IPTP was examined in 10 hospital wards (IG1) and in nine hospital wards (IG2) using questionnaires (formative evaluation) and problem-focused interviews with 10% of the participants in the two intervention groups. The collected data were analyzed in a descriptive exploratory manner.

Results: Pilot testing of the effectiveness of the two interventions (eLearning and blended learning) showed no consistent differences between groups or a clear pattern in the different outcomes (safety-related behaviors in the fields of teamwork, error management, patient involvement, and subjectively perceived patient safety). Feasibility checks of the interventions showed that participants used eLearning for knowledge activation and self-reflection. However, there were many barriers to participating in eLearning, for example, lack of time or access

to computers at the ward. With regard to in-person training, participants stated that the training content sensitized them to patient-safety-related issues in their everyday work, and that awareness of patient safety increased.

Discussion: Although the interventions were judged to be feasible, no consistent effects were observed. A possible explanation is that the duration of training and the recurrence rate may have been insufficient. Another conceivable explanation would be that participants became more sensitive to patient safety-critical situations due to their knowledge acquired through the IPTP; therefore, their assessment post-intervention was more critical than before. In addition, the participants reported high pre-measurement outcomes. Future studies should examine the evidence of the intervention within a confirmatory study after adapting it based on the results obtained.

KEYWORDS

patient safety, teamwork, patient involvement, error management, healthcare, training, cluster randomized controlled study

1. Introduction

Patient safety is a cornerstone of healthcare delivery. It aims to ensure that patients receive the best possible care free from preventable harm. It refers to the prevention of errors and adverse events in healthcare, and encompasses a wide range of issues and concerns, including preventing errors in the administration of medications and in medical procedures, and reducing the risk of infection (Mitchell, 2008). Patient safety is an interprofessional effort that requires the active engagement of different healthcare providers (interprofessional teams), patients, and their families; effective communication and collaboration among them is essential for patient safety (Berry et al., 2020; Dinius et al., 2020). Additionally, patient safety also involves educating patients and their families about their own health and healthcare and encouraging them to actively participate in their caregiving (Wright et al., 2016; Wu and Busch, 2019). Proactive measures for identifying and addressing any potential hazards are also important to reduce the risk of errors and adverse events (Spurgeon et al., 2019).

Improving patient safety is a political goal in healthcare globally (World Health Organization [WHO], 2021). Interprofessional healthcare teams are the relevant actors in achieving this goal. Internationally, especially in North America, training programs exist, but often focus on one specific patient safety topic, for example, the prevention of falls, and infection control. Furthermore, they are often developed for healthcare professionals but do not cover the interprofessional aspects of working together in a team (Reeves et al., 2017; Dinius et al., 2019; Amaral et al., 2023). An exception is the TeamSTEPPS® 2.0 training program, which is a comprehensive, evidence-based, and commonly used program in North America that was brought to Germany at the same time, but independently of our study.[1]

A meta-analysis by Schmutz et al. (2019) showed that interprofessional teamwork has a medium-sized effect on team performance. Therefore, healthcare organizations should bolster interprofessional teamwork to enhance patient safety (Schmutz et al., 2019). Furthermore, teamwork interventions have a positive and significant medium-sized effect on teamwork and team performance (McEwan et al., 2017). In turn, teamwork is associated with improved patient outcomes and increased patient safety (Dinius et al., 2020).

There are different approaches to improve patient safety. Previous research suggests that interventions such as trainings effectively improve teamwork, patient engagement, support of cultural changes, and information technology to subsequently reduce medical errors (Woodward et al., 2010; Amaral et al., 2023). A culture of safety can be built through open discussions regarding adverse events, errors, and their consequences for quality of care (Hofinger, 2009). Furthermore, patients should play an active role in error prevention (Schwappach, 2010), which can be achieved by intensifying patient participation, such as, by involving patients in patient safety management (Wright et al., 2016), by informing patients and encouraging them to participate, providing necessary information promptly and comprehensibly, and enhancing their ability to identify patient safety incidents. However, patient participation in patient safety is lacking in clinical practice. Training programs are required to create a culture of safety that includes patient participation in healthcare processes (Sahlström et al., 2019). Such a culture, in which all professionals of the interprofessional team and patients are seen as equal partners, is still missing. Since the participation of both patients and healthcare professionals is a major factor in high-quality and safe patient-centered care, addressing these topics in training may be advantageous (Quaschning et al., 2013; Hwang et al., 2019).

To address this gap, the KOMPAS project (KOMPAS = German acronym for "Development and evaluation of a complex training program to improve patient safety") developed and implemented an interprofessional training program (IPTP)

1 https://www.teamstepps.de/

with two interventions. These utilized eLearning as well as blended learning, with both covering three key areas of patient safety (teamwork, patient involvement, and error management). The aims of this study were to pilot-test the IPTP by comparing the two types of interventions (eLearning and blended learning) with a waiting control group. The study also aimed to pilot test the effectiveness and the feasibility of these interventions.

The improvement in safety-related behavior regarding teamwork, patient involvement, and error management, as well as subjectively perceived patient safety, was expected to be significantly higher in intervention group 1 (IG1: eLearning) and intervention group 2 (IG2: blended learning: eLearning and interprofessional in-person training) than in the waiting control group (WCG). The greatest improvement was predicted for IG2.

In the course of piloting the effectiveness of the interventions, the following research question and hypothesis were pursued:

1. Do the interventions improve safety-related behavior?

> H1: The improvement of safety-related behavior in IG1 and IG2 is significantly higher than in WCG.

In the eLearning course, the participants worked individually on the theoretical foundations for the three key areas. Due to the additional interprofessional in-person training, the participants tried out and consolidated their knowledge. This led us to the following hypothesis:

> H2: The greatest improvement in safety-related behavior is in IG2.

2. Do the interventions improve subjectively perceived patient safety?

> H3: The improvement of subjectively perceived patient safety in IG1 and IG2 is significantly higher than in WCG.

> H4: The greatest improvement of subjectively assessed patient safety is in IG2.

In course of evaluating the feasibility of the interventions the following research questions were investigated:

3. How do trained professionals assess the feasibility of eLearning and interprofessional in-person training?

4. Which facilitators and barriers to implementing the interventions can be identified?

2. Materials and methods

For the following description of the study design and outcomes, intervention, data collection process, and data analysis, the CONSORT guidelines extended for cluster randomized trials (Campbell et al., 2012) and randomized pilot and feasibility trials (Eldridge et al., 2016) were used as standards.

2.1. Study design and outcomes

The design included both a pilot investigation of the effectiveness of the interventions and testing their feasibility. Accordingly, our investigation can best be labeled as a pilot study using a hybrid effectiveness-implementation design (Curran et al., 2012).

2.1.1. Pilot test of the effectiveness

To pilot test the effectiveness of the IPTP, a multi-center cluster-randomized controlled study with a three-arm design [intervention group 1 (IG1)]: eLearning vs. intervention group 2 (IG2): blended learning vs. waiting control group (WCG) and three data collection periods (t1: pre-intervention, t2:12 weeks post-intervention, and t3:24 weeks follow-up) was conducted at three study sites (Freiburg, Hamburg, Bonn) between 2017 and 2020. Randomization took place at the ward/team level (clusters). The teams were randomly assigned to the three study arms by an independent statistician, who was not involved in the recruitment or implementation of the intervention based on a computer-generated randomization sequence with a 1:1:1 treatment allocation ratio. For detailed information see study protocol by Dinius et al. (2019).

The outcome subjectively perceived patient safety was assessed with a single item from the German Hospital Survey on Patient Safety (HSPSC-D) (Gambashidze et al., 2017, value range five level: insufficient, poor, acceptable, very good, and excellent). To measure the safety-related behavior regarding teamwork, error management, and patient involvement situational judgment tests (SJT) (McDaniel et al., 2007; Lievens et al., 2009; Christian et al., 2010) consisting of three self-developed vignettes aligned with the three topics were conducted. The situations depicted in the vignettes were exemplary for situations with special relevance for patient safety (e.g., patient mix-up, adverse drug events, team communication about a doubtful diagnosis). In all three vignettes, the description of the situation was followed by the instruction "Put yourself in the situation and imagine how you actually would react." The answer categories were developed by the research team and reviewed in an interprofessional expert workshop. Participants were instructed to rank the five response alternatives by assessing the letters A-E depending on which behavior would be best and which behavior would be worst in their perspective. The ranking positions ranged from 1 (this action is the most consistent with my reaction) to 5 (this action is the least consistent with my reaction). The ideal sequence, based on results of the expert workshop, was scored with 30 points ($= 4 \times 4 + 3 \times 3 + 2 \times 2 + 1 \times 1 + 0 \times 0$). The worst sequence was scored with 10 points ($= 4 \times 0 + 3 \times 1 + 2 \times 2 + 1 \times 3 + 0 \times 4$). For better interpretation of the data, scores were transformed from 0 to 100. **Figure 1** shows an example of a vignette on teamwork.

Owing to the longitudinal study design, the above-mentioned outcomes were assessed at all three data collection periods. The questionnaire during the first data collection period also included sociodemographic information (age, gender, profession, leadership position, duration of hospital affiliation and occupational affiliation in years).

Last night 55-year-old Mr. Müller was admitted to the internal medicine ward with suspected pneumonia and appropriate therapy was started. Based on the patient history and some atypical symptoms, you have doubts about the diagnosis.

What corresponds most closely to your reaction? Please think of how you would react in your everyday work. This is not a knowledge test, but an assessment of your actual behavior.

Put yourself in the situation and imagine how you would actually react.

Rank the five response alternatives by assigning the letters A-E to the ranking positions 1-5.
(1 = This action is the most consistent with my reaction.
5 = This action is the least consistent with my reaction.).

Alternative Answers		Ranking	
A	I clearly state that in my opinion it is not pneumonia but exacerbated COPD in the context of an infection.	1.	_____
B	Despite the initial doubt, I trust the assessment of my experienced team and support the initiated therapy.	2.	_____
C	I clearly express my doubts and request a short meeting to clarify our further course of action.	3.	_____
D	I discuss my doubts with a more experienced colleague in the team.	4.	_____
E	I clearly express my doubts about the diagnosis.	5.	_____

FIGURE 1
Vignette on teamwork. Participants had to rank the five response alternatives by assessing the letters A–E to the ranking positions 1–5.

2.1.2. Pilot test of the feasibility

To pilot test the feasibility of the interventions short self-developed written surveys (formative evaluation) and problem-focused individual interviews were used. Participants evaluated eLearning in an online written survey using seven items to assess satisfaction, acceptance, and user-friendliness on a scale of 1 (strongly disagree) to 5 (strongly agree) using adapted items from the two standardized questionnaires: System Usability Scale (SUS) (Brook, 1996) and the measure success inventory (MEI) (Kauffeld et al., 2009). The items are listed in **Table 4**. The evaluation could be completed after finishing the eLearning intervention.

A short self-developed paper-based survey was distributed by the instructors after finishing the interprofessional in-person training. Participants rated in-person training using nine items on a scale of 1 (strongly disagree) to 5 (strongly agree). The interventions were evaluated with respect to satisfaction and acceptance. The items are listed in **Table 5**.

Additionally, each intervention also received an overall grade from the participants using the German school grading system from 1 (very good) to 6 (deficient).

Problem-focused individual interviews with 10% of the participants in the intervention groups (IG1 and IG2) were conducted as part of the post-measurement. In these interviews, facilitators, and barriers to implementing training in the participants' daily work routines were explored. Questions related to context, design, and comprehensibility were also included.

2.2. Intervention

Our intervention consists of two components: eLearning and interprofessional in-person training. In recent years, eLearning has become a standard methodological approach in teaching (George et al., 2014). It offers participants flexibility in terms of place and time of learning. From a learning theory perspective, the same basic concepts are used as they are found in other forms of teaching. Our training based on the following pertinent learning theories:

1. Adult Learning Theory (Knowles, 1984): We designed for the eLearning interactive, case-based, and experiential

learning opportunities that actively engage participants and promote critical thinking and problem-solving skills.
2. Cognitive Load Theory (Sweller, 1988) means simplifying complex concepts, providing clear and concise instructions, and using multimedia and interactive elements effectively to manage cognitive load and enhance learning outcomes in both components of our intervention.
3. Social Learning Theory (Bandura, 1977) to conceptualize the interprofessional in-person training. This theory underscores the importance of role modeling and peer learning. In the interprofessional in-person training the participants can learn from experts, engage in discussions and collaborative learning.

For developing the IPTP we considered the key patient safety principles, such as human factors, systems approach, teamwork, communication and error reporting (Lee et al., 2022). Based on the learning objectives of the Patient Safety Curriculum Guide of the World Health Organization [WHO] (2011), the Patient Safety Curriculum Guide of the Patient Safety Action Alliance (Aktionsbündnis Patientensicherheit, 2022), and a focus group study of our research group (Dinius et al., 2017), an IPTP was developed. It consists of two parts: a 3-h eLearning and a three and a half hour interprofessional in-person training. In both the eLearning and the in-person training three learning modules (topics: teamwork, error management, patient involvement), which are essential for patient safety, were conducted. These three topics are interrelated and associated with learning objectives for individual healthcare professionals.

For the development of the KOMPAS eLearning, ELPAS (eLearning Patient Safety), which is used at the Albert-Ludwigs University of Freiburg for training medical students, served as a basis. All modules were programmed with Adobe Captivate and were made available to the participants password-protected via the learning platform Weiterbildungs-Ilias at the Albert-Ludwigs-University of Freiburg. Meanwhile, eLearning is open access.[2] A video served as an introduction to eLearning, in which participants were introduced to the central learning objective -the improvement of patient safety–and were familiarized with the use of eLearning. This was followed by three learning modules on the key aspects of patient safety. Each module started with an introductory video on the respective topic followed by the related content, which was presented in smaller submodules (completion time 5–10 min) (**Figure 2**). Participants had the possibility to pause eLearning at any time and continue at a later point in time. The end of each learning module was a short summary of the content (take-home messages).

To obtain the continuing education points (CME points for physicians or continuing education points for voluntarily registered professional nurses) after completing the eLearning modules, all participants completed a final test with 39 questions (13 questions per module). There were five alternative answers to each question, of which one answer was correct. The pass mark was 70%. All participants were given two attempts to pass the final test.

2 https://wb-ilias.uni-freiburg.de/ilias.php?ref_d=291255&cmd=render&cmdclass=ilrepositorygui&cmdnode=111&baseclass=ilrepositorygui

Corresponding to the eLearning design, the interprofessional in-person training also consisted of three modules. Interactive video analysis was conducted in the teamwork module. In this video, the patient is being returned to spontaneous circulation by a team. The participants' task was to analyze the interprofessional teamwork of the resuscitation team and develop suggestions for improvement based on their analysis. This was followed by group work in which the following questions were to be worked on: "Are there specific situations in which safety concerns are not addressed?" as well as "Are there typical strategies that team members use to avoid having to address safety concerns?" At the end of the teamwork module, the participants were instructed to put themselves in the role of a member of the resuscitation team from the video and to practice the "Speak Up" method. A prepared flipchart of the theory and formulation possibilities of Speak Up was available as an aid.

In the error management module, the participants were given a critical incident reporting system (CIRS) case, which they had to analyze in their respective small groups with regard to cause and effect. The developed worksheet "Identifying Factors Promoting Errors," which shows examples at different system levels, such as patient factors, team factors, or factors of the working environment, served as an aid. For the cause-effect analysis, participants received a prepared Ishikawa diagram including the "bones": patient, team, staff/individual, organization/management, and environment. The results of the group work were presented by the participants in a plenary.

In the patient involvement module, a 10-min input was first given on the topic of "communicating an adverse event," followed by role play on the same topic. The input, based on the brochure "Reden ist Gold" ("Talking is Gold") by the Patient Safety Action Alliance (Aktionsbündnis Patientensicherheit, 2017), gave an overview of the following points and questions: why communication with patients is important, especially after harm; when, where and with whom communication should happen after an incident; what should and may be said; what is the difference between an apology and an acknowledgment; and what patients want after an incident. The subsequent role play in communication after an adverse event was developed based on a case of CIRS Network Berlin. To facilitate the transfer of the training content into everyday work, the participating teams received two posters that could be hung in the ward room in a clearly visible place: each poster included the essentials of each of the topic areas of teamwork and error management. To remind participants of the contents of the topic area of patient involvement, postcards with key messages were sent to the wards on a monthly basis (e.g., "Your teach-back moment?").

2.3. Data collection process

Each study site (Freiburg, Hamburg, Bonn) was responsible for recruiting at least 12 wards with 120 participants, so that a total of at least 36 different wards with 360 participants had agreed to participate. The inclusion criteria were: inpatient care teams (1) with at least 10 members, and (2) with an interprofessional composition. We excluded emergency and intensive care due to high regimentations and standardized procedures in teamwork.

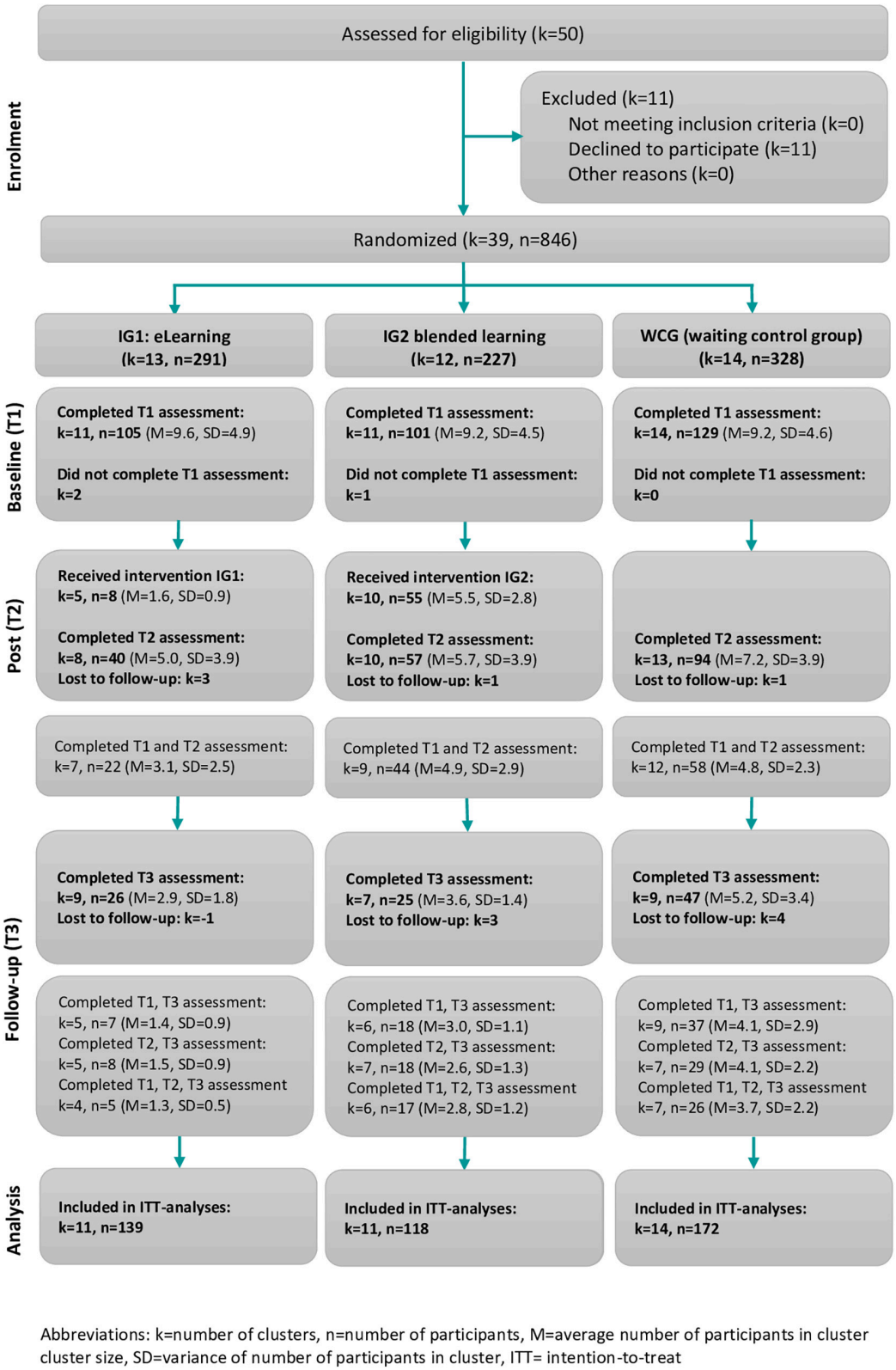

FIGURE 2
Consort flow diagram.

Furthermore, we excluded pediatrics, because patient involvement would not be comparable to other wards. A local study coordinator per ward (mostly ward manager) supported the research team regarding staff recruitment and data collection at their ward. The following inclusion criteria for study participants were applied: (1) member of an interprofessional inpatient care team (e.g.,

physician, nurse, therapist), (2) at least 18 years old, and (3) fluent in German.

Data were collected via online or paper-pencil questionnaire according to participants' preferences. Prior to the start of data collection, the local study coordinators received an Excel list containing so-called one-time passwords (individual access codes) and the URL link to the online survey tool. They transmitted the access data (URL link and passwords) in-house to the participants via email. The stored data set contained a participant number corresponding to the access code (but no contact data) and was thus pseudonymized. This approach allowed data from all three data collection periods to be matched. If participants preferred paper-pencil questionnaires, the local study coordinator received the questionnaires marked with a version number as well as the data protection concept. The version number made it possible to track which wards were assigned to which group. The local study coordinator printed out the questionnaires and the data protection concept and distributed them to the participants. Completed questionnaires were collected in locked boxes. At the end, the questionnaires were entered manually into the online survey platform UniPark by researchers of the corresponding study site, so that all data were available in electronic form.

To increase the response rate in the three data collecting periods, multiple reminders following the Total Design Method of Dillman (2000) were sent to the participants. After sending an initial invitation to the survey, the participants received a first reminder to participate within 2 weeks. Within another 2 weeks, a second reminder containing the link to the questionnaire was sent. For data protection reasons and to prevent participants from recognizing those who had already answered the questionnaire, all thank-you letters and reminders were sent to all potential respondents by e-mail.

For the in-person training, the study coordinators in the hospitals recruited the participants.

The feasibility of eLearning was evaluated using an online questionnaire, whereas a questionnaire for evaluating the interprofessional in-person training was distributed directly after the training. The problem-focused interviews were conducted between June and October 2019. Interview appointments were requested electronically and confirmed via telephone or email. They were organized together with the study coordinators on the wards and held either face-to-face at the wards or over the phone.

2.4. Data analysis

The collected pilot test data was analyzed using descriptive and inferential statistical analyses to describe the sample and test the effectiveness of the interventions according to a modified intention-to-treat approach. These analyses included all participants providing data for at least one measurement and for at least one of the three measurement time points, randomizing all participant data at the ward level. Missing values were considered missing at random, dependent on information in the model, and accounted for using mixed models. The mixed models were calculated by including the intervention group (tree-level factor), time of measurement (three-level factor), interaction between the intervention group and time of measurement, sex (two-level factor), age (continuous variable), occupation (two-level factor), and fixed effects. Ward membership was modeled as having a random effect on the intercept. Statistical significance was set at $p < 0.05$. As the study was a pilot, no adjustment was made for multiple testing. Intracluster correlation coefficients were calculated to determine the proportion of the total variance that could be explained by ward affiliation. The standardized effect sizes (Cohen's d) for pairwise group comparisons were calculated by dividing the estimated mean differences by the pooled observed standard deviations. To achieve robustness of the findings, a sensitivity analysis was performed with a subsample of participants from whom pre- and post-measurement data were available. Data were analyzed using IBM SPSS version 26 (IBM Corp., Armonk, NY, USA).

The questionnaires used to measure the feasibility of the interventions were analyzed using descriptive statistics. The interview data were transcribed externally according to the rules of Dresing and Pehl (2015). They were analyzed based on structured content analysis (Mayring, 2022) and used exploratively to cross-check the quantitative data. The categories were deductively derived. For subsequent data analysis, MAXQDA Plus 12 (VERBI Software Company) was used.

2.5. Ethics Statement and registration of the study

The project was approved by the ethics commissions at three study sites (Albert-Ludwigs-University of Freiburg: 4/16_170397, Friedrich-Wilhelm-University of Bonn: 329/17, Medical Association of Hamburg: MC-298/17). Participation was voluntary for the wards and team members. Consent for participation was obtained in written form. The study was registered in the German Register of Clinical Trials (DRKS-ID: DRKS00012818) on August 8, 2017.

3. Results

3.1. Pilot-testing

The study included at the beginning 39 interprofessional teams (mainly nurses and physicians) of different wards (ear, nose and throat wards; surgical wards; internal medicine wards; urology wards; gynecology wards; hematology wards; neurology wards; cardiology wards; orthopedic wards; psychosomatic wards) in 13 German hospitals. Participant characteristics are reported in **Table 1**. The majority of participants were female and were not older than 40 years of age. Most were nurses with several years of work experience.

A total of 846 individuals were randomly allocated to one of the three study arms (see **Figure 3**). The participation rate in interventions was 24.2% the blended learning group (IG 2) and 2.7% in the eLearning group (IG1: Out of 846 persons data from 335 persons were collected at baseline (response rate 39.6%), 191 of 846 persons (22.6%) at 12 weeks post-intervention, and 98 of 846 persons (11.6%) at 24 weeks follow-up. A total of 429 of 846 persons (50.7%) were included in the modified intention-to-treat analysis (see **Figure 3**).

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TABLE 1 Description of the sample (N = 249).

	Included in the analysis					
	IG1 eLearning (n = 139)		IG2 blended learning (n = 118)		WCG (n = 172)	
	N	%	*N*	%	*N*	%
Gender						
Female	95	68	79	67	139	81
Male	44	32	39	33	33	19
Age						
≤ 30 years	48	35	44	37	43	25
31–40 years	53	38	26	22	53	31
41–50 years	21	15	27	23	35	20
> 50 years	17	12	21	18	41	24
Profession						
Physician	34	25	42	36	38	22
Nurses	99	71	70	59	109	63
Others	6	4	6	5	24	14
Leading position						
Yes	30	22	31	26	25	15
No	108	78	81	69	147	85
Duration of hospital affiliation						
< 3 months	4	3	3	3	3	2
> 3 months < 1 year	12	9	17	14	15	9
1–5 years	51	36	49	42	47	27
> 5 years	71	51	49	42	107	62
Duration of occupational affiliation						
< 3 months	5	4	2	2	2	1
> 3 months < 1 year	9	5	8	7	8	5
1–5 years	33	24	36	31	33	19
> 5 years	92	66	72	61	129	75

Table 2 presents the observed means and standard deviations of the outcomes. It is notable that between-group differences at baseline often exceed the average within-group changes across time, suggesting a limited capacity of the cluster-randomization procedure to ensure balanced groups. The SJT for error management had a significant ceiling effect.

Table 3 shows the results of effectiveness testing via linear mixed modeling. After 12 weeks, participants with IG2 showed significantly higher teamwork in the SJT than participants in the WCG ($p = 0.03$, $d = 0.42$). No other statistically significant between-group differences were observed after 12 weeks. After 24 weeks, the IG2 group was significantly superior to IG1 ($p = 0.01$, $d = 0.90$), but not the WCG, which was also statistically significantly superior to IG1 ($p = 0.01$, $d = -0.72$). No other statistically significant between-group differences were observed. In the global tests, the mean changes across time were not statistically different between groups.

Sensitivity analysis did not show statistically significant differences between the groups at the two measurement time points for any of the primary outcomes.

Intracluster correlation coefficients were calculated to determine the variance between wards. The proportion of variance explained by ward affiliation for the primary outcomes ranged from 0.0 (SJT teamwork) to 0.14 (subjectively perceived patient safety) at pre-assessment; from 0.05 (SJT teamwork) to 0.23 (subjectively perceived patient safety) at post- assessment; and from 0.05 (SJT teamwork) to 0.43 (SJT error management) at follow-up-assessment. The substantial contribution of ward affiliation to the overall variance sometimes supported the cluster-randomized approach and the approach of examining patient safety at the ward level.

3.2. Feasibility

3.2.1. Feasibility of eLearning

Overall, adherence to eLearning participation was low despite the possibility of completing it independently of time and location. In both intervention groups, a total of 491 people were invited for eLearning and were entered into the system (IG1: N = 291, IG2:

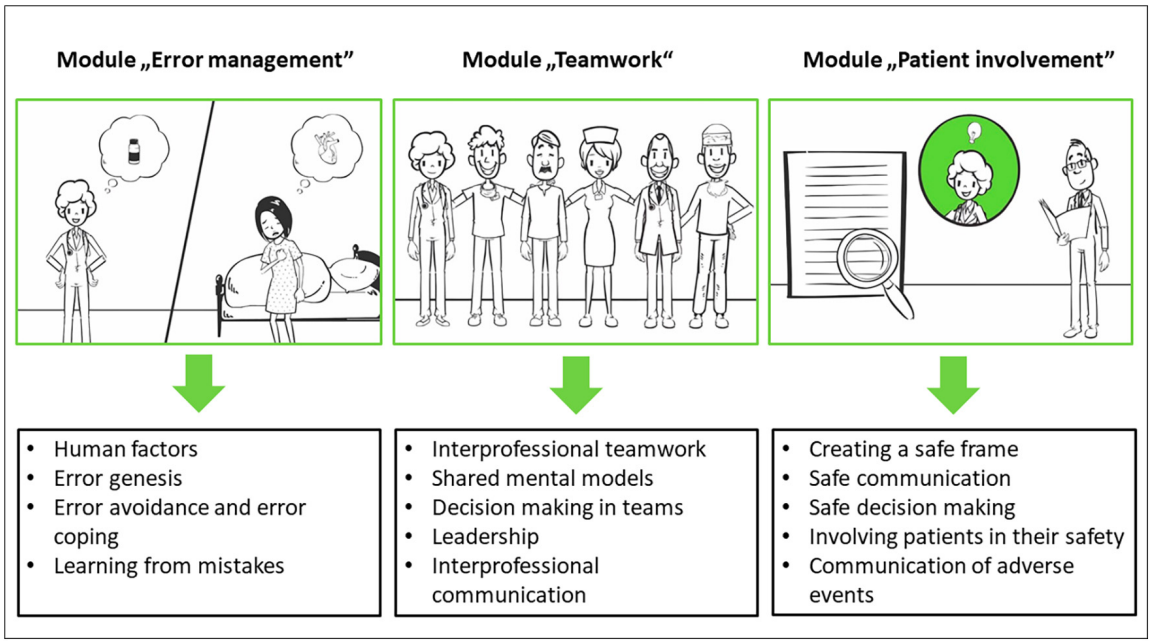

FIGURE 3
Modules of the eLearning (taken from the study protocol, Dinius et al., 2019).

TABLE 2 Observed values for outcomes.

	IG1 (eLearning)			IG2 (blended learning)			WCG (waiting control group)		
	N	*M*	SD	*N*	*M*	SD	*N*	*M*	SD
Subjectively perceived patient safety (min-max)									
Pre-intervention	101	3.36	0.73	98	3.51	0.65	126	3.36	0.72
Post-intervention	38	3.29	0.90	54	3.67	0.51	92	3.49	0.64
Follow-up[2]	26	3.46	0.90	25	3.72	0.54	45	3.51	0.73
SJT teamwork (0–100)									
Pre-intervention	91	55.49	24.05	93	60.48	24.08	119	54.50	26.47
Post-intervention[1]	31	56.45	27.84	47	67.77	23.45	82	55.85	28.27
Follow-up[2]	20	49.50	20.19	19	48.42	21.54	38	42.63	22.17
SJT error management (0–100)									
Pre-intervention	95	90.74	13.43	94	91.22	15.29	120	91.21	14.71
Post-intervention[1]	32	89.69	9.75	49	88.27	16.85	86	90.64	13.17
Follow-up[2]	22	86.14	20.06	20	91.25	12.13	39	91.79	10.85
SJT patient participation (0–100)									
Pre-intervention	95	72.11	21.25	96	78.54	18.82	122	73.07	21.76
Post-intervention[1]	31	71.61	25.64	49	73.67	26.24	87	71.67	24.67
Follow-up[2]	19	69.21	20.77	20	79.50	19.73	39	81.15	15.71

[1] After 12 weeks. [2] After 24 weeks. SJT, situational judgment test.

N = 200), of which N = 103 (IG1: N = 43, IG2: N = 60) opted in. This corresponds to a response rate of 20.98%. Due to stipulations in the ethics application, no information can be provided on the number of participants who completed eLearning in full.

The online questionnaire on eLearning was answered by 16 participants after completing the program (response rate 15.53%), and data was analyzed descriptively and exploratively. Participants rated eLearning using seven items on a scale of 1 (strongly disagree) to 5 (strongly agree). Table 4 presents the descriptive statistics for the individual items.

Participants rated the comprehensibility of the content and the fact that the different forms of presentation contributed best to the understanding of the content. The design of eLearning was evaluated as the worst (see Table 4).

TABLE 3 Results of the pilot test of effectiveness.

	Blended learning vs. eLearning				Blended learning vs. waiting control group				eLearning vs. waiting control group				
	Adj. effect	95% CI	*p*	Stand. effect *d*	Adj. effect	95% CI	*p*	Stand. effect *d*	Adj. effect	95% CI	*p*	Stand. effect *d*	Global effect *p*
Subjectively perceived patient safety (min-max)													0.27
Post- intervention	0.34	−0.06 to 0.75	0.09	0.51	0.08	−0.29 to 0.46	0.64	0.12	−0.26	−0.64 to 0.12	0.17	−0.39	
Follow up	0.07	−0.37 to 0.50	0.76	0.10	0.07	−0.34 to 0.48	0.73	0.10	0.001	−0.40 to 0.40	0.99	0.001	
Situational judgment—teamwork (0–100)													0.71
Post-intervention	9.86	−2.60 to 22.31	0.12	0.37	11.29	1.32 to 21.26	0.03	0.42	1.43	−9.96 to 12.82	0.80	0.05	
Follow-up	−1.24	−15.10 to 12.62	0.86	−0.06	4.19	−8.05 to 16.43	0.50	0.20	5.43	−6.47 to 17.33	0.37	0.26	
Situational judgment—error management (0–100)													0.48
Post-intervention	−1.35	−6.92 to 4.21	0.63	−0.10	−1.62	−6.15 to 2.91	0.63	−0.12	−0.27	−5.38 to 4.84	0.92	−0.02	
Follow up	5.12	−3.68 to 13.92	0.25	0.37	1.29	−6.33 to 8.90	0.74	0.09	−3.84	−11.52 to 3.84	0.32	0.27	
Situational judgment—patient involvement (0–100)													0.13
Post-intervention	5.53	−5.90 to 16.97	0.34	0.22	4.63	−4.70 to 13.97	0.33	0.18	−0.90	−11.43 to 9.64	0.87	−0.04	
Follow up	16.13	4.67 to 27.59	0.01	0.90	3.19	−6.68 to 13.06	0.52	0.18	−12.94	−23.16 to −2.72	0.01	−0.72	

Adj. effect, mean difference in estimated marginal means; CI, confidence interval; Stand. Effect d, Cohen's d; global effect *p*, *p*-value of the F-test of the group × time interaction examining whether mean changes across time were different between the groups.

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TABLE 4 Descriptive evaluation of the eLearning.

Item	Median (range)
The content of the eLearning was comprehensible.	4.5 (1)
The different forms of presentation (video, text, interaction) contributed to a better understanding of the content.	4.5 (1)
The eLearning was easily completed in the allotted time frame (60 min for each of the three topics: teamwork, error management, and patient involvement).	4.0 (3)
The eLearning was easy to use.	4.0 (2)
I liked the design of the eLearning.	4.0 (3)
I would use the eLearning again if I would refresh my knowledge in the topics of teamwork, error management, and/or patient involvement.	4.0 (5)
I would recommend the eLearning to colleagues who want to educate themselves in patient safety.	4.0 (5)

All items are rated from 1 (strongly disagree) to 5 (strongly agree).

TABLE 5 Descriptive evaluation of the in-person team training.

Item	Median (range)
The eLearning prepared me well for the in-person training.	4.0 (3)
The in-person training complemented the eLearning well.	5.0 (3)
The in-person training picked up relevant content from the eLearning.	5.0 (3)
The teaching methods used in the in-person training (e.g., video analysis, role play) are well suited for understanding the content.	5.0 (4)
The in-person training encouraged critical thinking about patient safety.	5.0 (3)
The in-person training taught me useful behavior that I will adopt in my daily work.	5.0 (3)
The in-person training had a positive impact on my team.	4.0 (3)
The amount of work required for in-person training is commensurate with the benefits.	4.0 (3)
The trainers were well prepared.	5.0 (3)

Items 1 to 7: Scale of 1 (strongly disagree) to 5 (strongly agree).

Additionally, using the German school grading system (1 = very good, 2 = good, 3 = satisfactory, 4 = sufficient, 5 = poor, 6 = deficient), participants awarded the program with an overall average grade of 2.13 (good).

3.2.2. Feasibility of the interprofessional in-person training

For in-person training, 232 invitations were sent to 10 wards of IG2, of which 59 participants took part in the in-person training. The response rate was 25.43%.

A paper-based questionnaire on in-person training was completed by 57 participants (response rate: 96.61%). The item "The presenters were well prepared" received the highest ratings, while the item "The eLearning prepared me well for the in-person training" received the lowest ratings. Overall, the interprofessional in-person training was evaluated as good (Table 5).

Additionally, using the German school grading system (1 = very good, 2 = good, 3 = satisfactory, 4 = sufficient, 5 = poor, 6 = deficient) to evaluate in-person training in total, it was rated by the participants with an average grade of 1.7 (good).

3.3. Qualitative results regarding feasibility

In addition, from the results of 30 problem-focused individual interviews, further indicators regarding the feasibility of the interventions were identified. Facilitating factors and barriers to the successful implementation of the intervention in the daily work routine were explored. Interviews were conducted between June and October 2019, and lasted 20 min on average. The sample consisted mainly of physicians and nurses, with most of them having less than 10 years of professional experience in their job and no leading position. The following categories were applied: user-friendliness, barriers, and facilitators.

The eLearning was described as well structured ("*It was well structured, articulated.*", "*Structurally it was well done.*"), clear, realistic, and understandable, ("*So that it was realistic and easy to understand.*", "*Basically you couldn't go wrong.*"). The visual design was assessed as appealing ("*The design was good and clear.*"). Participants particularly emphasized the variety of task formats, visual presentation of the content, and videos used ("*The videos and the pictorial representation–I really liked that.*"). The processing time is sometimes too long ("*But I found that I was taking too much time. It was just too long for me.*"). The difficulty level was described as appropriate, and tasks and answer options as understandable ("*In terms of difficulty, I actually found it quite ok.*").

Participants stated that they had difficulties integrating eLearning into their daily work routine. Implementation during working hours on the wards was hardly possible due to lack of time and interruptions ("*So at work [it] was just not possible for me*," "*A point that is relatively difficult when you try to do it on the ward, you don't have any peace and quiet.*", "*Because when the patients see me, yes, they always talk to me*"). The possibility of conducting

eLearning in sections was mentioned as being positive for feasibility ("*You are flexible, you can schedule it yourself, when, how, where, what. You don't have to do everything at once.", "However, I then simply did it in sections, then it was easier to do.*"). The reminder to carry out eLearning by study coordinators ("*I also had to [. . .] be reminded again and again by Ms X, which simply helped me a lot*"), and the offer of some hospital wards to participate in eLearning credited as working time were experienced as beneficial ("*And we got time off work for the training, so we were sort of released from work.*"). On the other hand, a lack of technical equipment (lack of computer workstations), time pressure, and quiet in the daily work routine during the completion of eLearning, and IT security standards had a hindering effect on participation ("*Unfortunately, I couldn't integrate it at all because I couldn't open it here in my PC.*").

Participants stated that they used eLearning primarily for knowledge activation and self-reflection ("*I found it very exciting because you can question yourself, but you probably wouldn't go into the situation or question on your own.*", "*You reflect in a completely different way.*", "*And I think I've questioned myself a lot more now in relation to the patient.*") and that the subsequent in-person training served to apply this knowledge.

Overall, participation adherence in eLearning was low. Additionally, participants reported that the learning effect of blended learning was higher than that of eLearning alone because of practical testing and the opportunity for interprofessional exchange during in-person training.

Moreover, it led to greater learning through hands-on testing ("*This group work in particular, where you can then exchange ideas with one another, where you can also talk to the lecturers, makes more sense, or I learn or I take more with me.*"). The ability to ask questions directly has been highlighted ("*I found the in-person training easier to understand because I could ask directly if I didn't understand something.*"). Participants emphasized that the training content made them more aware of their everyday work, that their sense of safety was enhanced by the application of learned communication strategies, and that awareness of patient safety was increased ("*[.] I feel safer now that I [.] have a scheme like this that I can use to shimmy along*," "*[. . .] you look at certain situations or certain things from a different perspective and question things differently.*", "*Afterward we talked about it in the team and it really became clear to everyone how important communication is and that you talk to each other and that you take the initiative and in such situations ask clear questions, give clear answers and so on.*"). In addition, the participants reported that their courage to approach colleagues about mistakes increased. "*Since then, I've been taking a closer look. That's because the program has brought it to the foremind again.*", "*[. . .] and we could talk more openly about problems and mistakes now*," "*[.] as the head of the ward, I observed that the participants returned to the ward with great commitment [. . .] and have spoken more consciously with colleagues about mistakes or even approached colleagues.*").

Facilitation of training participation for in-person training was done through the exemption of teams from their shifts in the ward. Participants particularly emphasized the comprehensible and motivating didactic delivery of the content and indicated a lot of enjoyment and an open atmosphere when working on the tasks in groups and plenary sessions ("*The group work was fun for us.*", "*Well, that was really, really good, very pleasant atmosphere, I have to say. The learning material that was presented to us was really conveyed in a way that we understood it straight away, and that we were able to get involved very well.*"). However, the participation of all professionals from one ward was compromised because of conflicting schedules ("*We couldn't all attend together because our schedules are different.*").

4. Discussion

The aim of the study was to pilot the effectiveness and feasibility of interventions. To this end, a cluster-randomized study on the effectiveness of the training program and a descriptive-explorative study regarding its feasibility were conducted. While the cluster-randomized study on the effectiveness of the interventions did not show consistent differences between the groups or a clear pattern in the different outcomes, the formative study analysis (feasibility study) resulted in a high level of acceptance and stressed the importance of daily work for participating in the intervention. At present, there is insufficient evidence to support our hypothesis that IPTP improve safety-related behavior with regard to teamwork, error management, and patient involvement as well as subjectively perceived patient safety. We can only assume why no empirical effects were found in this study. The main assumptions about this are as follows. First both interventions are not effective because they are carried out once (there are no booster sessions) and they are too short. Second, if the interventions are not tested as planned because of the low response rate, they will not have an effect. Third, the outcome measures did not capture the effects of the interventions reliably and validly. A possible solution would be to check the methodological quality of the SJT. Regarding the implementation of the in-person intervention, a trainer model should be considered in follow-up studies to test the sustainability of the in-person intervention and organizational learning in clinics. Managerial support is especially important; therefore, a step-by-step approach could be a solution for the better utilization of both interventions.

Overall, the professionals participated in the interventions rated the intervention as positive and described the content as extremely helpful for their everyday work. The insights gained in the formative evaluation include the following. First, participating wards in the eLearning intervention should be provided with technical equipment (tablet computers). Second, both eLearning and interprofessional in-person training should explicitly consider working schedules, particularly when seeking to train the entire team. Third, at least two different dates should be offered for each in-person training for employees who otherwise could not take part due to conflicting schedules. Fourth, the importance of participation should be communicated, particularly to ward managers who have a role model function, so that they can participate in training and encourage their employees to participate.

Amaral et al. (2023) summarized studies on the effectiveness of patient safety training, stating that there are still few studies that test patient safety training programs. Most studies focus on the development of training programs and do not provide evaluation data. Furthermore, training programs are mostly designed for special healthcare professional groups, and the interprofessional aspect is not explicitly considered (Dinius et al., 2019). Amiri et al. (2018) conducted a RCT (randomized controlled trial, RCT) and showed a significant improvement in safety culture. However, the dimensions of non-punitive responses to errors

reported as adverse events did not improve, indicating that additional actions are necessary (Amiri et al., 2018). Overall, there is moderate to high-quality evidence that team training has a positive impact on healthcare team processes and patient outcomes (Weaver et al., 2014). Several studies have reported positive outcomes, such as patient-centered communication, improved clinical outcomes, collaborative practice, reduction of clinical error rates, and improved team behavior (Reeves et al., 2013). A current systematic review and meta-analysis (Agbar et al., 2023) including 16 studies and 6,559 participants from healthcare professional staff showed that the interventions have a positive effect on safety culture. However, the interventions varied between the studies and there was a significant heterogeneity among the studies assessing patient safety culture (Agbar et al., 2023, p. 1471). Furthermore, the effects were no longer significant after the exclusion of studies with low quality scores (Agbar et al., 2023). The integrative review of Lee et al. (2022) identified also "non-significant and inconsistent relationships between safety culture and patient safety and quality of care outcomes" (p. 279). Several different factors could contribute to these inconsistent and non-significant results, such as the lack of a theoretical framework, inconsistent outcome criteria, missing validity of the instruments, etc (Lee et al., 2022). Overall, the study situation is inconsistent, so that the present study fits into the previous picture. Interprofessional training has become increasingly common in recent years. The KOMPAS training program was explicitly interprofessional, but in some clinics, only nurses participated. In addition to the lack of doctors, the participation of health professionals in the training sessions and surveys was very low. The dropout rate was 22.5%. The reasons for dropout included refusal to participate in part of the contacts and difficult accessibility. The healthcare professionals struggled with the lack of support, lack of resources, time constraints, or conflicting priorities in their clinics that hindered an adequate training implementation. Furthermore, the evaluation methods used rely on self-report measures that do not capture the true impact.

As most interventions include narrative reviews on the nature of interprofessional interventions to promote patient safety by Reeves et al. (2017), our intervention is an educational intervention to address individuals' skills and behaviors. The key principles (human factors, systems approach, teamwork, communication, and error reporting) of our patient safety training are comparable to other training programs (Lee et al., 2022).

To measure the feasibility and effects of the intervention, we conducted surveys, as most of the reported studies in the narrative review. However, in contrast to the vast majority (86 out of 89) of the studies included in the review, we applied a mixed-methods approach and conducted qualitative interviews. Most studies have concentrated on nurses and physicians in acute care, as in our study. A dearth of studies has reported changes in safety behaviors, which we aimed to measure using SJTs. The choice of SJTs as our main outcome measures could be a crucial aspect of the inconsistent and non-significant results.

4.1. Limitations

The moderate response rates and exclusion of pediatric, emergency, and intensive care wards limit the generalizability of the study results only to the target population of individuals. Concurrently, the inclusion of hospitals from different regions in Germany may strengthen the generalizability of the results to the populations of targeted organizations. As participation was voluntary, we must assume a selection bias because we cannot exclude that we mainly reached motivated and well-functioning interprofessional teams. A serious limitation was the low proportion of invited participants who received the interventions. In addition, the internal validity of the pilot effectiveness test is likely to be limited by the imperfectly balanced groups at baseline, missing controls of possible co-interventions, and the high attrition rate across measurements. Concerning the instrument, we developed specific SJTs based on current literature and experts' opinions on the primary outcomes. However, these are not psychometrically validated instruments. Patient safety is measured using only one ordinal-scale item, which possibly restricts the variability of participants' responses. Future studies should use objectively measured outcomes to assess patient safety.

Moreover, it is worth considering the appropriateness of utilizing RCTs for assessing these interventions. There is a significant challenge evaluating changes and improvement in practice at this level. We encountered several challenges during the study. Given that both the tested interventions and the circumstances can be considered "complex," it is possible that other (e.g., multi-level designs, sequential designs, non-randomized designs) might have suited better to our research aims than a RCT (Skivington et al., 2021).

The curriculum was feasible and judged as relevant and useful, but the participation rate was very low and we had a high drop-out rate. This can be due to the wrong implementation strategy in a very complex setting with a high workload. This means that an actual study with the developed intervention was not conducted. For further studies, the design and implementation of the intervention in particular must be redesigned with a comprehensive participatory research approach.

4.2. Future development

Future studies should further examine the effectiveness of the intervention within a confirmatory study after the implementation of the intervention has been further developed based on the current results. To anchor the knowledge comprehensively in clinics, a multi-stage procedure should be chosen, starting with clinic and ward managers. This approach is intended to communicate the importance of participating in such an intervention to ward managers, who function as role models, so that they can disseminate on the topic top-down to their staff. As a result, improved adherence to participation in the intervention and evaluation could be encouraged.

To implement the intervention in a sustainable way, the wards should offer booster sessions after the intervention. Furthermore, individual and group coaching sessions are proven methods to increase participants' self-efficacy and further steps for evaluating the training program include consideration of the patients' perspectives and the organizational preconditions. To consider these long-term outcomes, longitudinal mixed methods and multilevel studies are required.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Albert-Ludwigs-University of Freiburg: 4/16_170397, Friedrich-Wilhelm-University of Bonn: 329/17, Medical Association of Hamburg: MC-298/17. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

LK designed the pilot effectiveness trial, performed data analysis, and interpreted the results. MK developed the initial article, whereas JD, NE, LH, CB, AH, and SP-H read the manuscript critically and provided relevant corrections, additions, and comments. All the authors established the project application, collectively provided the basis for this study, critically reviewed, and approved the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Juliane E. Kämmer,
University of Bern, Switzerland

REVIEWED BY
Margarete Boos,
University of Göttingen, Germany
Lianghao Dai,
Zhejiang University, China

*CORRESPONDENCE
Stefan Schilling
✉ s.schilling@exeter.ac.uk

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"Trust people you've never worked with" – A social network visualization of teamwork, cohesion, social support, and mental health in NHS Covid personnel

Stefan Schilling[1,2]*, Maria Armaou[3], Zoe Morrison[4], Paul Carding[5], Martin Bricknell[6] and Vincent Connelly[2]

[1]Psychology, Faculty of Health and Life Sciences, University of Exeter, Exeter, United Kingdom, [2]Department of Psychology, Health and Professional Development, Oxford Brookes University, Oxford, United Kingdom, [3]School of Health Sciences, University of Nottingham, Nottingham, United Kingdom, [4]Aberdeen Business School, Robert Gordon University, Aberdeen, United Kingdom, [5]Oxford Institute of Nursing, Midwifery and Allied Health Research, Oxford Brookes University, Oxford, United Kingdom, [6]King's College London, School of Security Studies, London, United Kingdom

Background: The unprecedented rapid re-deployment of healthcare workers from different care pathways into newly created and fluid COVID-19 teams provides a unique opportunity to examine the interaction of many of the established non-technical factors for successful delivery of clinical care and teamwork in healthcare settings. This research paper therefore aims to address these gaps by qualitatively exploring the impact of COVID work throughout the pandemic on permanent and deployed personnel's experiences, their ability to effectively work together, and the effect of social dynamics (e.g., cohesion, social support) on teamwork and mental health.

Methods: Seventy-five interviews were conducted across the UK between March and December 2021 during wave 2 and 3 of COVID-19 with 75 healthcare workers who were either permanent staff on Intensive Care/High Dependency Units used as COVID wards, had been rapidly deployed to such a ward, or had managed such wards. Work Life Balance was measured using the WLB Scale. Interview transcripts were qualitatively coded and thematic codes were compared using network graph modeling.

Results: Using thematic network analysis, four overarching thematic clusters were found, (1) teamwork, (2) organizational support and management, (3) cohesion and social support, and (4) psychological strain. The study has three main findings. First, the importance of social factors for teamwork and mental health, whereby team identity may influence perceptions of preparedness, collaboration and communication, and impact on the collective appraisal of stressful events and work stressors. Secondly, it demonstrates the positive and negative impact of professional roles and skills on the development of teamwork and team identity. Lastly the study identifies the more pronounced negative impact of COVID work on deployed personnel's workload, mental health, and career intentions, exacerbated by reduced levels of social support during, and after, their deployment.

Conclusion: The thematic network analysis was able to highlight that many of the traditional factors associated with the successful delivery of patient care

were impeded by pandemic constraints, markedly influencing personnel's ability to work together and cope with pandemic work stressors. In this environment teamwork, delivery of care and staff well-being appear to depend on relational and organizational context, social group membership, and psycho-social skills related to managing team identity. While results hold lessons for personnel selection, training, co-location, and organizational support during and after a pandemic, further research is needed into the differential impact of pandemic deployment on HCWs mental health and teamwork.

KEYWORDS

COVID-19, inter-professional, inter-disciplinary, healthcare, teamwork, mental health, leadership, preparedness

1 Introduction

The complexity, patient volume, and severity of COVID-19, exacerbated by already existing staff shortages in the healthcare sector, required an unprecedented upscaling of capacity during the peak phases of COVID-19. Hospitals around the world relied on the deployment of nurses, doctors, and allied health professionals to provide relief and support for overwhelmed and understaffed personnel in Intensive Care, Infectious Disease, and High Dependency Units (ICU, IDU, HDU) (Mahendran et al., 2020; Soled et al., 2020; Tannenbaum et al., 2020). As many of those deployed had little to no prior experience or training in intensive, acute, or infectious disease (ID) care, such *ad-hoc* deployment of health-care workers (HCW) into COVID ICUs may have undermined many of the antecedents of inter-professional teamwork in healthcare teams. For example, research has repeatedly found substantial benefits of interprofessional/interdisciplinary (IP/ID) teamwork on staff well-being and social support and was linked to improved integrated care and patient outcomes, patient satisfaction, as well as reduced treatment costs, mortality rates, length of in-patient stay, and clinical error rates (Husebø and Akerjordet, 2016; Ballangrud et al., 2017; Schmutz et al., 2019). However, effective IP/ID teams rely on prior relational coordination and establishment of shared mental models, something that the rapid and often fluid amalgamations of personnel from different professional backgrounds during COVID may not have had.

In addition to the fluid composition of teams, the hazardous environment alongside social distancing, and personal protective equipment (PPE) may have weakened many of the established non-technical factors influencing delivery of standardized care: teamwork, communication, social support, relational coordination, and exacerbated pre-existing occupational identities and spatial–temporal separation with other team-members and leaders (O'Leary et al., 2011; Salas et al., 2016; Dinh et al., 2019; Schilling and Armaou, 2023). A recent review, examining barriers and facilitators for teamwork in IP/ID teams, found that the literature on rapidly deployed personnel in intensive and acute care settings found that little is known about how permanent and rapidly deployed personnel experience teamwork on intensive care wards (Schilling et al., 2022). Likewise, despite socially supportive, and cohesive teams often described as instrumental in countering conflict within work teams, few studies in the review detailed the role of social group membership on IP/ID teamwork.

Additionally, ample research has demonstrated the negative consequences of pandemic work on HCWs mental health and well-being (Vyas et al., 2016; Kisely et al., 2020; Spoorthy et al., 2020), with clinical personnel exhibiting higher rates of mental health problems than the general population, and high prevalence rates of depression (27–40%), anxiety (27–37%), and PTSD (20–49%) in HCWs (Wu et al., 2020; de Sousa et al., 2021; Saragih et al., 2021). For example, a large UK survey of over 6,000 healthcare staff showed not only an increase in probable mental health disorders during the COVID-19 pandemic, but also emphasized the elevated risk of mental health disorders for younger and less experienced nursing staff (Hall et al., 2022). While some studies have examined the lived experience of HCWs during COVID, most of these occurred during or shortly after Wave 1 (Feb. to June 2020 in the UK) (Grailey et al., 2021; Jesuthasan et al., 2021; Manthorpe et al., 2021; Conolly et al., 2022; Kotera et al., 2022; Maben et al., 2022; Stayt et al., 2022), resulting in a scarcity of qualitative evidence from HCWs on the effect beyond Wave 1. Similarly, limited research is available on how social and non-technical factors for care delivery were impacted by COVID-19 guidelines. This research paper therefore aims to address these gaps and expand upon the existing literature by qualitatively exploring 1) how COVID work during the first and second wave was experienced by permanent and deployed personnel, 2) how deployed and permanent staff discussed the impact of such work on their mental health 3) how non-technical factors (e.g., teamwork, communication, cohesion, social support) were influenced by workplace adjustments, and 4) how they consequently developed inter-professional teamwork.

The unprecedented rapid re-deployment of personnel from different care pathways into fluid COVID-19 teams provided a unique opportunity to examine the interaction of many of the established non-technical factors for standardized care while also addressing the impact of COVID work on personal health, family life and career intentions. This study enriches the theoretical understanding of teamwork in healthcare during crises by exploring the difficulties faced by *ad-hoc* and rapidly formed inter-professional personnel in establishing and maintaining many of the non-technical team factors necessary for successful delivery of patient care. By interviewing and comparing both permanent (e.g., ICU/HDU personnel) and deployed personnel from non-intensive care background as well as their leaders the study provides a nuanced

overview of the structural, psychological, and organizational issues encountered by such emergent healthcare teams.

2 Methods

Our study adopted a qualitative deductive exploratory methodology (Bitektine, 2008; Stebbins, 2011; Casula et al., 2021; Schilling, 2022), aimed at expanding upon the pre-existing theoretical knowledge by exploring the lived experience of HCWs during the COVID-19 pandemic. Considering the methodological difficulties of observing team processes during an active Highly Infectious Disease (HID) outbreak, semi-structured video-interviews were chosen to assess HCWs self-reported experiences, and evaluations of their teamwork with colleagues on COVID-19 wards. Two semi-structured interview guides were developed for: 1) frontline facing staff aimed at exploring HCWs perceptions, motivations, shared beliefs, values, and attitudes towards their group and their leaders during their work in IP/ID COVID-19 frontline teams; and 2) leaders (i.e., Clinical or Nursing Directors, Matrons, Senior Managers) aimed at exploring workforce allocation, ward management practices and unearth potential innovations and best practices (The semi-structured interview guides are Data-sheet 1 and 2). These interview guides were designed based on the results from a systematic review of the available scientific evidence on teamwork in *ad-hoc*, fluid, IP/ID healthcare teams during crisis situations (Schilling et al., 2022) and pilot interviews with medical, nursing, and allied health professionals to gain a preliminary understanding of the issues and experiences faced by HCWs during COVID-19 work.

Interview data were analyzed using a sequential Thematic Network Analysis approach (Pokorny et al., 2018; Schilling, 2022), which used network graph modeling to supplement thematic analysis of qualitative interview data. While most thematic analyses are restricted to summary description of the qualitative data, the utilization of network graph modeling permits the added benefit of exploring the inherent structure between themes in a form that is transparent of the research process and replicable by other researchers, without neglecting the qualitative nature of the data (Bruns, 2012; Steinfeld, 2016; Pokorny et al., 2018; Schilling, 2022). Additionally, by utilizing network metrics, (e.g., weighted degree or modularity), the importance of particular themes, the relationships between themes and the potential thematic clustering of themes can be illustrated and further analyzed by showing consistency of themes across different samples (e.g., deployed vs. permanent personnel). Alongside the "rich description" of the participants voice (Maguire and Delahunt, 2017; Castleberry and Nolen, 2018) which allows some insight into potential pathways, the visualization of the textual data allows for both increased transparency about the analytic process and the differences between participant groups as well as improved reproducibility.

2.1 Participants

Eligibility criteria for participation were: 18 years or older and a healthcare worker having worked on or managed a COVID-19 ward. Seventy-five interviews were conducted across the UK by two experienced interviewers (SS, MA) between March 2021 and December 2021 (i.e., at the tail end of the second wave and well into the third wave of COVID-19 in the UK) using online video-chat platforms (Google Meet, Zoom, MS Teams). Interviews lasted, on average, 74 min (ranging from 24 min to 125 min). Participants were recruited through 1) designated NHS research sites participating in the study ($n = 42$), and 2) purposive sampling using UK-wide online social media advertisements and snowball sampling ($n = 33$). Recruitment concluded after the recruitment target deemed necessary for adequate representation of all occupational groups and agreed with participating trusts of 12–20 leaders and 55–70 frontline staff had been met. Thirteen participants were recruited in their capacity as leaders (e.g., Matrons, Clinical or Nursing Directors, Senior Manager) and asked questions from the management interview guide. Of these 6 were working on the frontline in patient-facing roles, and 4 were male. The remaining 62 respondents were frontline patient-facing staff, who were predominantly deployed to Intensive Care and High Dependency Units ($n = 53\%$) and other non-specified COVID-19 wards ($n = 18$), these could be wards that had been repurposed to function as COVID-19 isolation wards (e.g., rehabilitation or geriatric wards). These were issued the frontline interview guide. There were 55 participants who reported having been deployed or rotated into a COVID-19 ward, 14 participants remained in their permanent team, and seven of the leaders did neither work nor were deployed to a COVID ward.

Of all participants, 30 were registered nurses, 12 doctors, 20 allied health professionals, and four healthcare assistants, nine were "other" various positions in the wider healthcare team (e.g., administration or managerial roles; See Table 1). A total of 27 participants (36%) were in senior roles (e.g., Medical consultants, senior management or Nursing, Midwifery and Health professions Band 7 and above), with the remainder being grade 2–6 (including junior doctors). Participants were primarily female ($n = 58$, 77%), thus matching the gender imbalance in the NHS workforce (NHS Employers, 2019). Most participants identified as White British or White other ($n = 63$, 84%), with the remaining 12 participants identifying as multiple ethnic ($n = 6$), Black African Caribbean ($n = 3$) or Asian and Asian British ($n = 3$). The low percentage of personnel with minority backgrounds may be a consequence of NHS guidance for black, Asian and minority ethnic (BAME) HCWs to reduce risk of infection following early evidence of disproportionate mortality and morbidity among BAME personnel (NHS England, 2020).

Of all participants 45 reported prior experience working in intensive, critical, or emergency care environments, with 27 reporting no such experience (three gave no details). Participants' occupational specialty was predominantly intensive or critical care and general medicine, with nine from non-intensive care specialties with COVID-19 relevant expertise and procedures such as infectious disease, respiratory or hematology. At the time of the interviews, participants had been working in a COVID area for an average of 8.8 months, with the longest duration being 20 months. Most of the short-term exposure on COVID wards were deployed personnel during COVID wave 1 (Feb. to June 2020) or wave 2 (September 2020 to March 2021), while the long-term staff were predominantly qualified permanent ICU staff. Not all staff were deployed during all waves, overall, 47 of the patient-facing staff had experience of working during wave 1, 47 in wave 2, and 11 in wave 3.

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TABLE 1 Overview of participant demographics.

Participant demographics		
Total participants	*N* (Total)	*N* (Deployed)
	75 (100%)	55 (73%)
Gender		
Female	58 (77%)	41 (55%)
Male	17 (23%)	1 (<1%)
Frontline staff vs. Leader		
Frontline staff	62 (83%)	50 (66%)
Leaders	13 (13%)	5 (6%)
Seniority		
Junior (Band 3–6 & jun. Doctor)*	48 (64%)	38 (51%)
Senior (Band 7–8 & Registrar/Consultant)*	27 (36%)	17 (23%)
Prior intensive/critical care experience		
NO	27 (36%)	23 (31%)
YES	45 (60%)	32 (43%)
N/A	3 (4%)	
Occupational group		
Registered nurse	30 (40%)	22 (29%)
Medical doctor	12 (16%)	9 (12%)
Allied health professional	20 (27%)	15 (20%)
Wider healthcare team/management	8 (11%)	5 (7%)
Nursing or healthcare assistant	4 (5%)	3 (4%)
Physician associate	1 (<1%)	1 (<1%)
Occupational specialty	N (Total)	N (Deployed)
Intensive/Critical/A&E	20 (27%)	11 (16%)
General medicine	20 (27%)	19 (27%)
Infectious, respiratory, hematology	9 (12%)	7 (9%)
Other (e.g., metabolic, pediatric, palliative, skeletal)	12 (16%)	11 (16%)
Other (e.g., sexual, mental, diet, occupational)	10 (13%)	6 (8%)
No Clin Specialty	4 (5%)	1 (<1%)
Ward location		
COVID ward	18 (24%)	16 (21%)
Emergency Dept (ED)	7 (9%)	4 (5%)
High dependency unit (HDU)	12 (16%)	10 (13%)
Intensive care unit (ICU)	28 (37%)	21 (28%)
Other	3 (4%)	1 (<1%)
N/A	7 (9%)	
Total Length of COVID work		
N/A	14 (19%)	8 (11%)
01–03 months	14 (19%)	13 (17%)
04–07 months	20 (27%)	20 (27%)
08–11 months	4 (5%)	3 (4%)
12–15 months	5 (7%)	2 (3%)
16–19 months	13 (17%)	6 (8%)
19–22 months	5 (7%)	3 (4%)
Ethnicity	N (Total)	N (Deployed)
White (British)	55 (73%)	40 (53%)
White (Other)	8 (11%)	7 (9%)
Mixed/multiple ethnic	6 (8%)	3 (4%)
Black/African/Caribbean	3 (4%)	2 (3%)
Asian/Asian British	3 (4%)	3 (4%)

2.2 Data collection

The semi-structured character of the interviews provided a basis to explore topics identified through systematic review and pilot interviews (e.g., COVID-19, Work and Team Integration, Cohesion, Teamwork, Leadership, Mental Health and Support, Career Implications, Impact on Personal Life and Family). This allowed participants the opportunity to direct the discussion and provide a rich understanding of leadership, teamwork, team bonding, and social support as discussed by both leaders ($N = 13$) and patient-facing frontline staff ($N = 62$) (Creswell et al., 2013). Additionally, some demographic measures were included to allow for subsequent cross-sectional analysis across different occupational groups (e.g., nurses, doctors, and allied health professionals) covering deployment status (e.g., deployed versus permanent staff), ICU experience, specialization, age, and work length. Some standardized survey items were used to assess the level of work life balance (WLB) (Sexton et al., 2017; Schwartz et al., 2019) and common mental disorders (using the GHQ-12) (Goldberg and Hillier, 1979; Goldberg et al., 1997; Anjara et al., 2020) to provide additional context (Creswell et al., 2013) Participation was voluntary following informed consent with interview sessions being audio-recorded, with the audio transcribed verbatim, cleaned and pseudonymized.

2.3 Data analysis

The qualitative interviews were analyzed using a Thematic Network Analysis approach (Pokorny et al., 2018; Schilling, 2022), which first investigated the transcripts via thematic analysis, using NVivo (release 1.6.2; Woolf and Silver, 2017; QSR, 2020). Transcripts were double-coded by two experienced coders (SS, MA) using a sequential deductive exploratory coding method, by which we coded the transcripts (a) using the 13 themes identified in our prior systematic literature review (e.g., "shared mental models" (Cannon-Bowers et al., 1993; Salas et al., 2016), "formal communication", "cohesion" (Schilling et al., 2022) as initial deductive coding guide, which was then extended upon through (b) inductive coding focused on themes emerging from the data, reflective of the topics brought forward by the participants (Braun and Clarke, 2012; Braun and Clarke, 2021), and not previously identified as deductive themes (e.g., "familiarity with tasks", "inside vs. outside of ward"). To maintain the context and reflect human speech, whereby a speech fragment is discussing several different themes simultaneously, the data was coded en-bloc (e.g., one paragraph) and against all potential codes within that paragraph (e.g., Teamwork, Leadership, Anger and Frustration. Supplementary Table 5). The resulting codes were tested for inter-rater reliability, before the deductive and inductive themes were merged and synthesized to ensure they adequately represented the interviewees' narrative accounts. The final 80 thematic codes were presented to the study's advisory board and an expert panel of healthcare professionals who verified and confirmed them.

In a second step – once thematic coding had been completed – the coded data was further explored using network modeling. A matrix table (see Masterfile), consisting of all thematic codes and the number of shared references between them (e.g., Teamwork and Cohesion share 200 references) was extracted from NVivo. The resulting table was formatted with the number of references shared between codes formatted as edge-weight and uploaded into a network analysis and exploration software program [Gephi release 0.10, (Cherven, 2015)]. Edges in the network were undirected and created based on code co-occurrence in the same paragraph. The resulting weighted network was filtered by applying edge-weight and the association rule measure "lift" to minimize noise, with the lift and edge-weight threshold determined using the elbow method for cluster detection (Braesemann, 2019; Humaira and Rasyidah, 2020; Shi et al., 2021). The resulting graphs (Figures 1–3) were visualized in Gephi with the Force Atlas 2 graph layout algorithm (Fruchterman and Reingold, 1991; Gemici and Vashevko, 2018) and using the Leiden modularity algorithm to determine communities within the data (Blondel et al., 2008; Drieger, 2013; Ji et al., 2015; Kang et al., 2017). The visualization of the graph is determined by 1) the importance of particular constructs, represented by the centrality and distance of the node from the center; 2) the size of the nodes based on the number of shared references with other codes (weighted degree); 3) the number of shared references between two codes represented by the thickness and color of the connections between codes (i.e., edges); and 4) the community structure of the codes, representing which cluster of codes are more closely related to each other (modularity clusters). A modularity comparison identified whether thematic codes consistently appeared in specific clusters across different participant groups see Supplementary Table 4.

To provide context about participants' work, group differences of perceived Work-Life Balance Impairment (WLB) and Common Mental Disorders (GHQ-12) between deployed and permanent personnel, those with and without ICU experience, and between junior and senior staff were analyzed using an independent t-test. Due to the small sample size no further statistical analysis – which could allow for generalizable correlational results – were conducted.

2.4 Ethical considerations

Ethical approval was gained from the Oxford Brookes University Research Ethics Committee (UREC# E20025) and regulatory approval was gained through the UK Health Research Authority (IRAS# 294169). All participants provided written informed consent prior to being contacted for the interview, and verbal consent at the beginning of the interview.

3 Results

Impaired work life balance was experienced by 51% of participants on two or more days per week ($M = 2.02$, SD = 0.505) with nutrition, coming home late from work, and difficulty sleeping showing the highest reported impairment. The 14 permanent participants ($M = 1.74$, SD = 0.375) compared to the 55 deployed participants ($M = 2.07$, SD = 0.507) showed significantly lower WLB scores, $t(66) = 2.21$, $p = 0.026$, $d = 0.68$, indicating less impaired work-life balance per week. Similarly, participants with ICU experience ($N = 45$, $M = 1.92$, SD = 0.491), showed statistically significant lower rates of WLB scores than personnel without any ICU experience ($N = 27$, $M = 2.18$, SD 0.505), $t(70) = 2.14$, $p = 0.036$, $d = 0.531$. Interestingly, those who

identified as junior (i.e., junior doctors and band 6 and below) showed significantly lower levels of WLB scores ($N = 48$, $M = 1.93$, $SD = 0.417$), than participants with band 7 or higher and consultants ($N = 25$, $M = 2.19$, SD = 0.616), $t(71) = 2.12$, $p = 0.038$, $d = 0.522$ (see Table 2). Higher WLB scores were stable in deployed and those without ICU experience across different occupational specialties (i.e., Intensive Care, Infectious Disease and Respiratory, General Medicine; Pediatric and Palliative, and Mental Health, Dietician, Occupational, Sexual Health). Sixteen participants scored above the threshold of 3 on the GHQ-12 (GHQ scoring), indicating potential common mental disorders in 21.3% of participants. No statistically significant differences were found between leaders and frontline staff and between those deployed and permanent.

3.1 Thematic findings

The thematic analysis of the interviews identified 80 codes, of which 18 were excluded as subsidiary codes. The interactions between the remaining 62 codes were visually explored in three graphs, one containing all references from all personnel interviewed, including leaders (Figure 1), the second containing only deployed personnel (see Figure 2) and one containing only permanent personnel (see Figure 3). Modularity calculation using the Leiden algorithm found evidence of four thematic community clusters within the graphs, namely 1) Teamwork (teal), 2) Organizational Support & Management (purple), 3) Cohesion & Social Support (khaki), and 4) Psychological Strain (green) (Examples for the themes can be Supplementary Table 5). The clusters showed a high degree of consistency across the three graphs, with 65% of codes in the cohesion cluster occurring in this cluster in all three graphs, followed by teamwork (52%), psychological strain (48%), and organizational support and management (30%) (see Table 3) An overview of the codes with corresponding number of references, weighted degree, their clusters in each of the three graphs, can be Supplementary Table 4.

3.1.1 Thematic cluster 1: teamwork in COVID wards

Represented by the thickness of the connecting edges, the graph emphasizes that individual references discussing teamwork most consistently included procedural (e.g., shared mental models and SOPs), professional (skills and experience, professional roles), relational (familiarity with colleagues and their skills), and communication codes (formal and informal team communication). Emotional codes such as appreciation and feedback, trust in colleagues, and respect for colleagues were also associated with this cluster. The adjacency of shared mental models, team communication, and familiarity with colleagues in the graph highlights that effective communication, a common understanding of goals and responsibilities, and common procedures are most closely aligned to the description and perception of teamwork and interprofessional collaboration across the sample. For example, differing communication standards between intensive care and deployed personnel, increased noise levels on the wards, and usage of PPE undermined communication, and reportedly led to miscommunication within the team.

Considering these difficulties, the interviews frequently emphasized the importance of communication as critical for the development of teamwork and shared mental models. Specifically in the first wave, where clinical guidance and SOPs for COVID were rare, formal communication during handovers and ward rounds, using bedside clinical documentation, or virtual communication between IP/ID team-members, were crucial for the development of shared mental models and the allocation of responsibilities and tasks, involving a range of IP/ID professional skills and experiences. While the graph of the wider sample (Figure 1), shows informal communication to be in the cohesion cluster, both the deployed and permanent graphs, show informal team communication as contributing to teamwork, suggesting that peers consider informal communication (e.g., check up on each other, communicate breaks, or provide brief moments of respite) as important as formal communication procedures. In fact, many participants emphasized the importance of such informal communication due to reductions in social interactions outside of the ward, or due to social distancing guidelines on the ward. Relatedly, familiarity with colleagues was highly important to staff members' perception of teamwork, with permanent personnel in large hospital trusts more likely to accentuate a lack of familiarity with colleagues as impeding teamwork, due to higher fluctuation of staff, while participants from smaller NHS trusts, reported lower disruption to their teams, but – in some cases – higher levels of difficulty integrating deployed staff into long-standing fixed teams.

Importantly, the graph also highlights that besides the codes in the teamwork cluster, other codes outside of the immediate cluster impact upon teamwork. For example, teamwork shares a lot of references with cohesion, indicated by the closeness of these codes to each other and the thickness of the edge between them. The adjacency of these codes to each other and the overlap of some of the surrounding codes (e.g., informal communication, familiarity, shared experiences) underscores the importance of social factors and camaraderie on effective

TABLE 2 Group results for work life balance scores (WLB) for permanent vs. deployed participants and participants with ICU and no ICU experience.

	Group	*N*	Mean	SD	SE
WLB Scale	Permanent	14	1.74	0.375	0.1
	Deployed	55	2.07	0.507	0.0684
	ICU Exp	45	1.92	0.49	0.073
	Non-ICU Exp	27	2.19	0.505	0.097
	Junior	48	1.93	0.417	0.06
	Senior	25	2.19	0.616	0.123

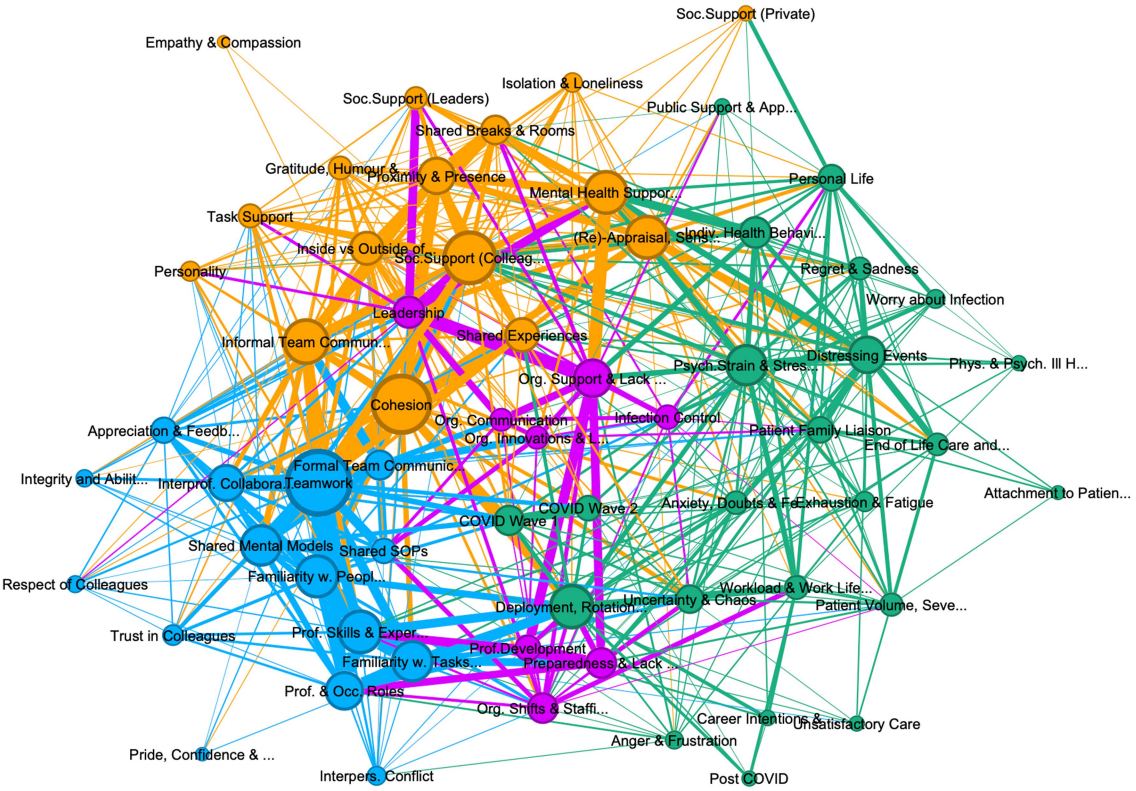

FIGURE 1
Graph of connections between codes in all personnel, showing 62 codes, with 4 community clusters: (1) teamwork (teal 24%), (2) psychological strain (green, 37%), (3) organization support and management (purple 13%), and (4) cohesion and social support (khaki, 26%). Lift >5, edge weight >10, graph density: 0.271, size average weighted degree (722.58), and communities by modularity (Modularity: 0.295).

teamwork. Descriptions such as "*collective identity [as] one team [with] the same goal of treat[ing] patients and looking after each other*" (RES027) were very common, highlighting the convergence of teamwork and social care of colleagues.

Across the entire sample, professional and occupational roles, prior professional skills, and familiarity with COVID specific tasks (e.g., ventilation, turning patients with IV lines, giving medication) were emphasized as contributing factors for effective teamwork. In particular, trust in colleagues was based on both having a shared understanding of the team's goals and everyone's role within it, and on the perceived skills and abilities deduced from someone's occupational category (e.g., "oncology personnel can handle IV lines and cytoxic medications", "respiratory physios can support CPAP training"). However, many participants reported a higher degree of teamwork within the IP/ID team in the first wave, precisely because of a "blurring" of these roles and a reduction of medical hierarchies, whereby doctors, AHPs and nurses often shared tasks that normally are provided by only one occupational group (e.g., patient care, proning/turning of patients).

This reduction of hierarchies and blurring of roles was often attributed to the uncertainty of wave 1, in which the lack of clinical guidance flattened hierarchies and elevated personnel with COVID-19 relevant skill sets. For example, nurses or AHPs were included into bedside rounds and those with respiratory expertise were given additional responsibilities training up personnel on CPAP ventilation and co-developing local clinical procedures. Nevertheless, many of the references discussing professional roles or skills were also related to anger and frustrations, interpersonal conflict, and career intentions. For example, ICU/HDU personnel routinely reported that lack of experience by deployed staff undermined teamwork, trust, and communication, and increased the responsibility and workload of experienced staff. In contrast, participants across the sample underscored that showing willingness to learn, asking questions, and receiving feedback from experienced colleagues as well as being able to admit lack of knowledge were effective ways to increase teamwork by establishing common procedures and enhancing integration into the team.

With shared uncertainty providing a unifying experience, interpersonal conflict reportedly occurred less in the first wave, but increased in the second wave with the dissemination of established clinical management guidelines, the need for more personnel, and refined Infection Prevention and Control (IPC) measures. Such measures reportedly deterred large handovers or bed-side rounds involving the entire IP/ID team and led to more social distancing in staff and break rooms, and a return of medical hierarchies. For example, many nurses and AHPs who had perceived working relatively equally with doctors in the first wave, spoke of a perceived loss of responsibility and involvement in the second wave, and personnel reported not being able to attend meetings or break rooms

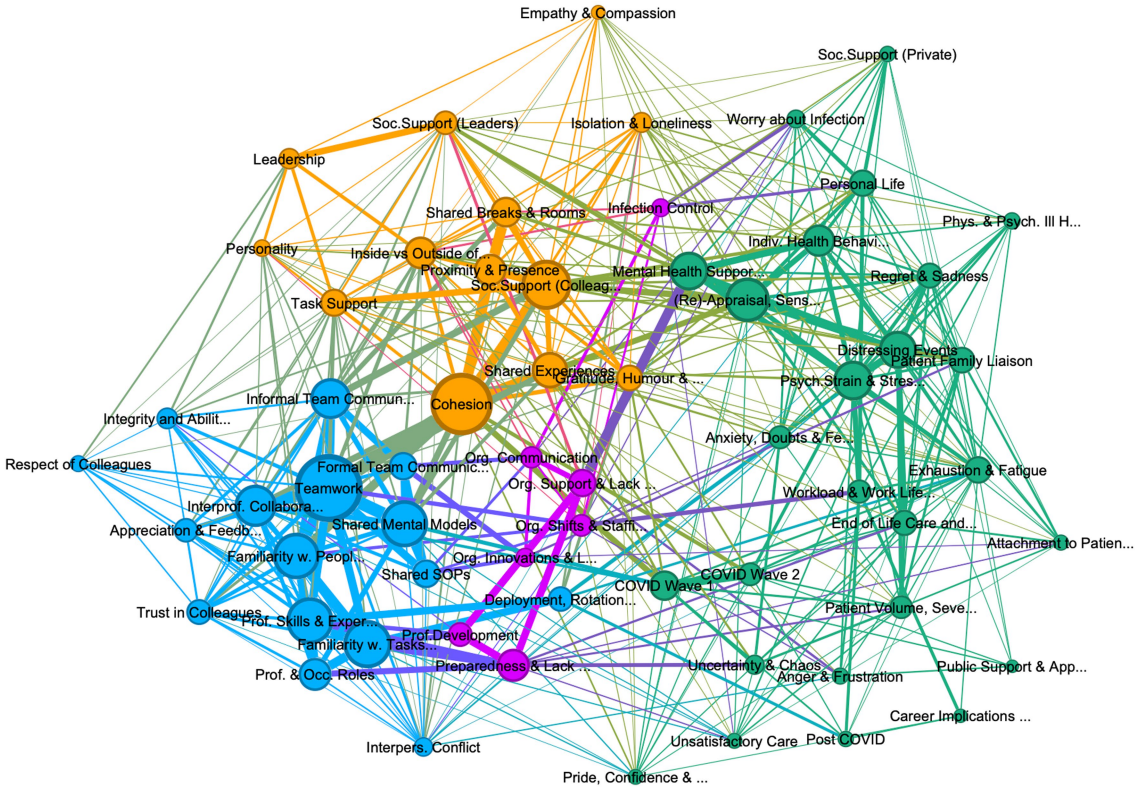

FIGURE 2
Graph of connections between codes in deployed personnel, showing 62 codes, with 4 community clusters: (1) teamwork (teal 26%), (2) psychological strain (green, 42%), (3) organization support and management (purple 11%), and (4) cohesion and social support (khaki, 21%). Lift >5, edge weight > 10, graph density: 0.241, size average weighted degree (414.6), and communities by modularity (Modularity: 0.384).

that had now been segregated by occupation. Two frequently cited issues for conflict were the inability to fulfill role expectations (for example deployed staff being admonished for not knowing how to do medication rounds or read blood gasses), or overconfidence in a task performed without formal training, increasing the risk for mistakes. Much of such conflict appears most strongly linked to professional roles and skills, and familiarity with tasks, with participants reporting that misperceptions about someone's responsibilities or false expectations about their occupational skills were often at the root of interpersonal conflict. Particularly in the second wave's surge in personnel, some team-leaders highlighted the importance of short introductions at the beginning of every shift to identify everyone's professional skills and abilities and thus appropriately assign responsibilities and patients based on someone's experience.

It is worth noting the differences between deployed and permanent staff's description of teamwork. This difference is best highlighted by comparing Figures 4, 5, which depict the codes most closely linked to teamwork in deployed and permanent personnel, respectively. It highlights that while for both groups' professional skills and experiences, interprofessional collaboration, informal team communication, and cohesion are linked to teamwork in familiarity with both people and tasks as well as appreciation and feedback play a stronger role in deployed personnel, with interpersonal conflict occurring in the teamwork cluster in deployed personnel (Figure 2). This could suggest that rapid integration of deployed individuals into a team, alongside creating familiarity with other personnel and important tasks is particularly important to achieve team working and to reduce conflict.

3.1.2 Thematic cluster 2: cohesion and social support

The cohesion and social support cluster was characterized by a close interaction between codes denoting physical closeness (i.e., proximity, being inside verses outside of the ward, shared breaks and staff rooms), assistance (e.g., task and social support provided by colleagues, leaders or family, and friends), evaluation (e.g., shared experiences, re-appraisal, and sense-making) and emotions (such as gratitude and humor, empathy and compassion, isolation, and loneliness). The graph highlights how often references discussing cohesion or social support occurred alongside comments about shared experiences or being inside the ward as opposed to outside. Cohesion, for many participants appears to be bound intimately to the shared experience of "being in it together," which determined not only ingroup status, but also provided a basis for emotive evaluation and social support. For example, for many participants in wave 1 the uncertainty of COVID-19, alongside the blurring of roles created a collective identity of being on the frontline of COVID-19 and provided a basis for social support, task support, (i.e., helping colleagues with practical tasks) as well as increased care for the welfare of colleagues. Many participants were thankful for being actively involved in the pandemic response as it allowed for social interactions with colleagues, while everyone else was required to isolate. This was

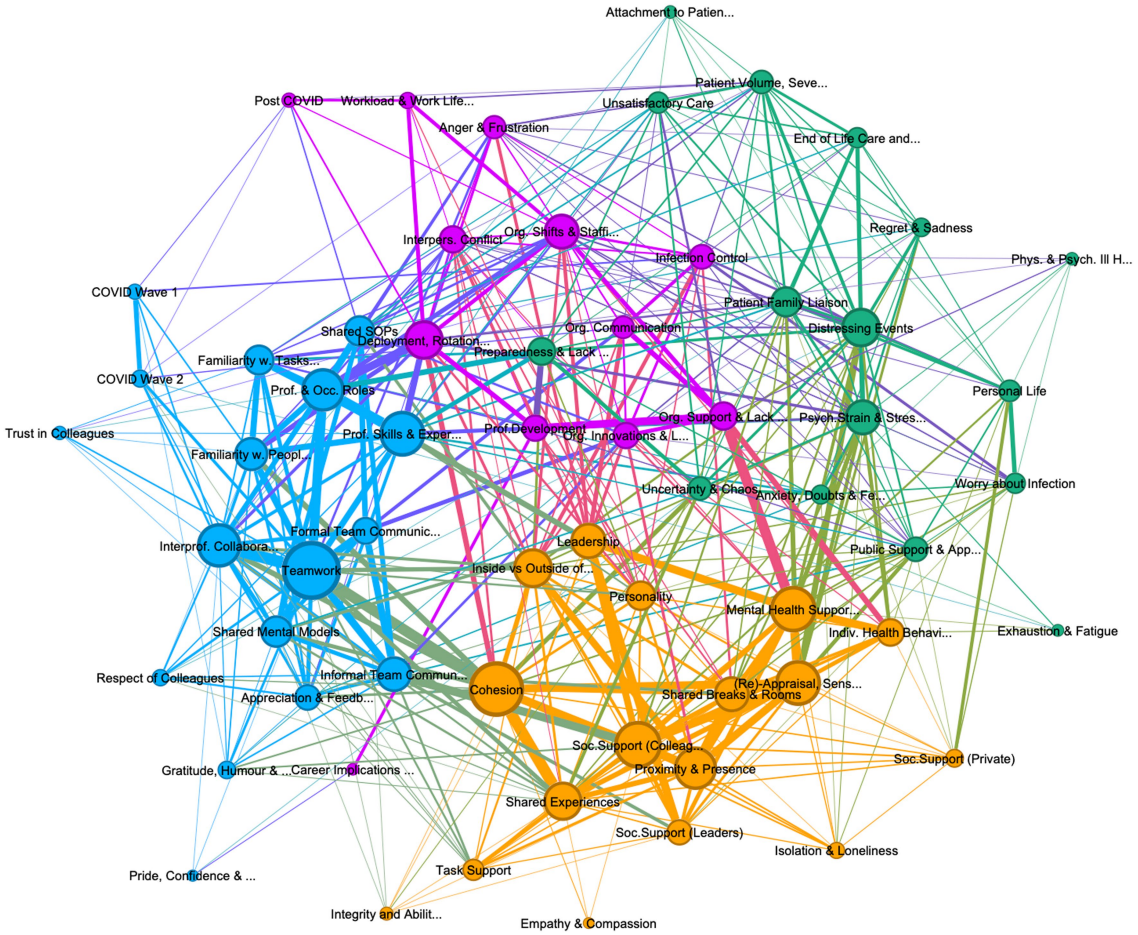

FIGURE 3
Graph of connections between codes permanent personnel, showing 62 codes, with 4 community clusters: (1) teamwork (teal 27%), (2) psychological strain (green, 27%), (3) organization support and management (purple 19%), and (4) cohesion and social support (khaki, 27%). Lift >8, edge weight > 4, graph density: 0.235, size average weighted degree (141.09), and communities by modularity (Modularity: 0.331).

TABLE 3 Overlap of codes within the four identified clusters.

	Teamwork in COVID wards	Cohesion and social support	Organization support and management	Psychological strain
# of Codes occurring in all 3 graphs	12	11	6	15
% of overlap	52%	65%	30%	48%
# of Codes occurring in 2 graphs	4	5	1	7
% of overlap	17%	29%	5%	27%
# of Codes occurring in 1 graph	4	3	7	6
% of overlap	17%	18%	35%	23%
Total Codes in Cluster	20	19	14	28

particularly strong in the first wave and for junior and single staff without established social ties outside of work, for whom colleagues on the ward provided an important – and sometimes the only – protective factor against the isolation and loneliness many of them felt outside of work hours during the lockdowns. While descriptions of shared experiences in wave 1 were sometimes even joyful, these changed in the second wave to focus more on distressing events and hardship.

In the graphs (Figures 1–3) for all personnel and permanent personnel, team cohesion and social support is closely tied to mental health support and re-appraisal suggesting a protective function against many of the stressful events and experiences during their COVID work (also compare Figure 1 in Supplementary information). Colleagues were reported to be crucial in providing social support by making sense of individual events on the wards and the pandemic in general,

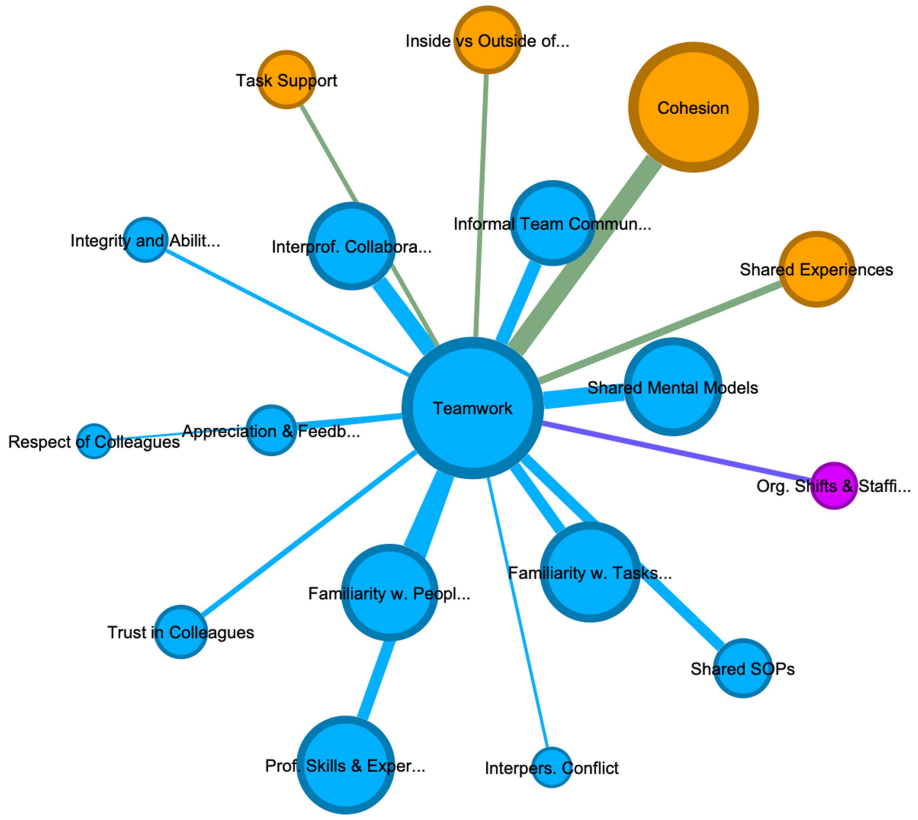

FIGURE 4
Teamwork in deployed personnel: this graph displays the codes most connected to Teamwork in deployed personnel, by filtering Figure 2 using an ego network to only display codes connected to Teamwork. Additionally, a Fruchterman Reingold layout algorithm was applied to further highlight, through adjacency to the code teamwork, which codes share the most references with teamwork in this group.

venting about distressing moments, and seeking reassurance about adequate patient care. Seeking reassurance appeared to be most pronounced in deployed personnel with no intensive care experience or junior personnel, who reported struggling with self-doubt or anxiety more often. One participant deployed in wave 2 described it as *"starting to read a book from the middle"* (RES009), where her permanent colleagues explained what had happened in wave 1 and provided reassurance and meaning about the high mortality rate and patient distress. Considering this link between social support, appraisal and mental health, most interviewees pronounced the importance of keeping mental health support within the team (e.g., through mutual peer support sessions), with many making comments like *"the support from other nurses was kind of sufficient for me"* (RES008). Such peer support was reportedly less stigmatized and allowed individuals to make sense of their experiences with those that "had been there" with them.

However, the analysis would indicate that the protective link between team cohesion, social support and mental health relies on stable team-membership, which deployed personnel often were not privy to and correspondingly they reported more difficulties in accessing social support. This is seen in deployed personnel in Figure 2, where re-appraisal and mental health support occur in the patient care and stress cluster. For example, during deployment some reported feeling unable to access support in neither the COVID ward nor their routine place of work, due to their transient status. Many described not being able to discuss their COVID experiences with colleagues upon their return to their old position. Those who were deployed individually felt isolated from colleagues while HCWs who had deployed as a group reported feeling separate from colleagues who had not deployed. It appears that poor cohesion and social support impacts on deployed staff well-being, but also that deployed personnel may be more reliant on organizational efforts to counteract loneliness and negative mental health consequences.

Informal communication – most commonly occurring during breaks or handovers – appeared to be highly important for team cohesion and feeling supported by colleagues. Many participants described the social support arising from moments where colleagues or leaders enquired about one's welfare, offered a cup of tea, enjoyed happy moments with sometimes dark humor, or the opportunity to sit down and reflect or vent. Such interactions with colleagues were labeled as not only facilitating emotional regulation, but several participants also discussed the importance of colleagues in making sense of their experience. Interestingly, collegial welfare enquiries and corresponding attempts to support each other were reported as more sincere during wave 1, showing a decline during wave 2 with increased fatigue and exhaustion setting in. Similarly, with increased social distancing during the second wave, social isolation and loneliness encroached on cohesion as personnel spent breaks socially distanced or alone and meetings outside of work were further curtailed.

FIGURE 5
Teamwork in permanent personnel: this graph displays the codes most connected to Teamwork in deployed personnel, by filtering Figure 3 using an ego network to only display codes connected to Teamwork. Additionally, a Fruchterman Reingold layout algorithm was applied to further highlight, through adjacency to the code teamwork, which codes share the most references with teamwork in this group.

3.1.3 Thematic cluster 3: organizational support and management

Interviewed HCWs portrayed a range of organizational factors pertaining to the day-to-day management of COVID wards and the provision of organizational support, influenced by shift and staffing decisions, organizational communication, IPC measures and professional development. Organizational support was seen by participants as both a resource and a challenge, which was associated with psychological stress and mental health and impacted teamwork. For example, lack of opportunities for professional development, disorganized staff allocation and management, and lack of common break rooms not only impeded information exchange but were consistently mentioned as impacting teamwork. Likewise, some occupational health and well-being support mechanisms introduced by NHS trusts during the pandemic were perceived as well-meaning but problematic by the frontline staff interviewed. For example, many described being unable to attend yoga or mindfulness classes, which tended to occur during their shifts. On the other hand, practical organizational innovations to improve IP/ID relations and communication, such as skills stickers or badges on HCWs PPE, use of iPads or videocall software, improvements to electronic health records, or designated communal rest areas and fixed intra-group debriefs were highly valued.

Organizational communication was reportedly an issue. Specifically, deployed personnel felt frustrated by staffing decisions, commenting on having been deployed or redeployed with little warning, or returning to their routine wards without decompression periods. Constant changes to clinical guidelines, shifting IPC instructions or unclear communication channels were also highlighted as impeding the day-today processes on the wards.

Considering the often very rapid deployment of HCWs, many not having intensive care experience, references about deployment were intimately tied to both technical and psychological preparedness. For example, participants with prior intensive care experience reported a high level of technical preparedness, while those without highlighted a lack of technical training prior to their wave 1 deployment. This changed somewhat in wave 2 with an increase of clinical guidelines and online courses. Nevertheless, almost all participants felt unprepared for the psychological aspects of working with COVID patients, (i.e., the uncertainty and chaos of COVID wards, the patient volume, symptom severity, patient deterioration, distress, and mortality). This suggests that lack of preparedness was an important contributor to psychological stress and in many cases was associated with lack of organizational support. Considering that permanent members discussed preparedness in terms of psychological rather than technical readiness, this code occurs in the stressor cluster in Figure 3. While personnel with prior ICU experience portrayed working on COVID wards as their job or a responsibility to their fellow HCWs, several deployed participants commented on the involuntary nature of their deployment.

While leadership occurs in the organizational cluster in the all personnel graph (which includes leaders, see Figure 1), in both the deployed and permanent participants it occurs in the cohesion cluster, highlighting the ambivalent character of leadership for frontline staff vs. organizational leaders. For example, staff on the wards routinely commented on leadership being performed by near peers, such as junior nurses with critical, intensive, respiratory, or infectious disease expertise (Band 5 and 6), who were allocated leadership over deployed staff termed "bedside buddies" and were thus able to support them on difficult or unfamiliar tasks. Leader legitimacy was closely associated with physical presence, with prior leaders (e.g., matrons, consultants, or ward managers) reportedly losing legitimacy if they were not present on the ward and *"seeing for themselves."* Specifically in newly opened COVID wards leadership was depicted as shared between different staff members taking on different roles and responsibilities in leading the teams. However, leaders themselves often portrayed their role as having to mitigate a lack of organizational support and supporting staff members mental health and welfare. This stretching of leadership to span social, team-managerial, and organizational functions is also visible in the leadership behaviors described across the sample, e.g., be visible and approachable, lead by example and set the team climate, provide support, check up on staff and "have their back," provide role clarity and guidance, and assign responsibilities. The range of these leadership behaviors – as well as the adjacency of leadership to other codes such as cohesion, social support and being inside vs. outside the ward (see Figure 1) – highlight why leadership does not fall neatly in one cluster but suggests that during crisis leadership across hierarchical levels is more nuanced.

3.1.4 Thematic cluster 4: psychological strain and stressors

The final cluster is characterized by HCWs reports of psychological strain caused by distressing events, patient care duties, workload, deployment, personal life, and public support which resulted in a range of emotional, physical, and professional responses. Across the sample, the codes which share the most references with psychological strain were patient care tasks and experiences, often labelled as traumatic or distressing. Specifically, patient death related incidents such as informing patients' families or facilitating last conversations between patients and their families over phones or iPad, alongside witnessing the quick deterioration of patients, were reportedly most problematic (see Figure 1 in Supplementary information) Participants often commented on their disbelief in the first wave at patients' unprecedented symptom severity and their quick deterioration. While permanent staff and those deployed in wave 1 became used to these symptoms, they reported their shock at the sheer patient volume and the young age of those dying in the second wave. For many staff members, therefore, end of life care and witnessing patients' distress was problematic, both due to losing unprecedented number of patients – many of their own age – but also because of the level of their distress and the inability to provide patient care in line with their training or professional standards. Many, therefore, discussed perceptions of providing unsatisfactory care due to time, staffing or resource constraints (e.g., not knowing how to treat patients, not having enough oxygen for ventilation, not being able to provide personal care due to patient volume). Finally, some participants, especially those from A&E or ICUs reported increased attachment to patients due to longer hospitalization, making coping with patients' death harder, and recovery also becoming more meaningful. Interestingly, a lot of participants– even experienced intensive/critical care, and infectious disease staff – would point out that patient care tasks and experiences were something that they were not prepared for. As such, many of these references co-occur with discussions about anxiety and personal doubts, sadness and regret, anger and frustrations, and the negative impact on their own physical and psychological health. Nevertheless, some participants described becoming numb to these experiences, highlighting a gradual normalization to mortality rates, patient distress, and traumatic experiences.

Another repeatedly cited issue related to psychological strain was the sheer workload experienced during COVID work. Although many participants discussed the impact of workload, there appeared to be a more pronounced negative effect of workload on mental health in deployed than permanent personnel. While the latter benefitted from a drop in patients between waves, allowing for some short-term respite, deployed personnel, especially those that returned to their routine positions, reported increased workload due to the backlog in elective treatments. For example, a range of deployed participants on return to routine working described a substantial worsening of symptom patterns in their routine patients (e.g., diabetes, arthritis, cancer), due to not being treated during the lockdowns. More senior deployed personnel, or those in an administrative role, often struggled with the dual pressures of working on COVID wards and supporting their normal team.

The increased stress and workload in deployed personnel appears related to career implications, as many deployed participants depicted these in terms of a re-evaluation of their role after COVID work (e.g., moving into a non-clinical role), alongside career setbacks, such as losing out on important routine rotations or development opportunities. It is important to note that some deployed personnel also perceived their work on these wards as a source of pride, leading to more confidence in their abilities, with a few participants even deciding to retrain as intensivists. One participant, inspired by the camaraderie of wave 1 to retrain as ICU nurse, voiced regret over her decision to when faced with the second wave's increased stress and exhaustion. The differential impact on workload and career implications is clearly visible by the closeness of these two codes to psychological strain in deployed personnel (Figure 2), compared to permanent personnel, where both codes are associated with codes in the organizational cluster (Figure 3). Correspondingly, permanent staff portrayed career implications in terms of both renewed commitment to their role as intensivist or career progression (i.e., advancing skill sets, changing bands). Interestingly, many junior doctors reported losing out on routine rotations or career opportunities.

Besides these job-internal stressors, most participants reported their COVID work had an impact on their private life. For example, many participants – specifically single, female HCWs – discussed the negative impact on care responsibilities for children or parents as well as the inability to visit friends or family, utilize leisure activities, or access social support outside of work. This was particularly pronounced where family members or friends did not work in healthcare or blue light services and were perceived to "*not know what it's like,*" resulting in adding additional burden. Interestingly,

frustrations and dissatisfaction with public support became a more frequent theme during data collection, with many participants commenting on a reduction of public support in the second wave compared to the first and voicing anger about nonadherence to COVID guidelines and dissatisfaction with the hero dialog exemplified by the public clapping on Thursdays. Many of these comments were made alongside remarks about increased levels of exhaustion and fatigue, suggesting that job-external factors, such as private demands or fading public and governmental support, may impact upon levels of burnout and fatigue in healthcare personnel.

To actively counteract the negative effects on their mental health, participants routinely discussed individual health behaviors for coping with difficult situations, which they developed during the lockdowns. These included for example increased mental health awareness and self-care, seeking help from colleagues, family, and leaders, or seeking professional help from occupational health and psychological services. While the latter were utilized by some, who reported being diagnosed for burnout, PTSD or depression, the emphasis for most participants was on team-internal solutions. In a few instances, where psychological personnel were embedded into wards (e.g., taking on family liaison roles) participants were more likely to report "opening up" about difficult moments than in 1-on-1 counseling, which was often portrayed as less helpful than group sessions with colleagues, due to counselors perceived as not knowing what it was like to work on COVID wards.

4 Discussion

This study investigated how deployed or permanent IP/ID personnel working on COVID wards experienced their COVID work and the described impact on their mental health, how permanent and deployed personnel discussed their teamwork, and whether non-technical factors for healthcare delivery (e.g., teamwork, communication, cohesion, social support) were influenced by workplace adjustments and social dynamics within the team. The semi-structured interviews with 75 HCWs, from different occupational background who had been either working (as deployed or permanent staff) on NHS wards treating COVID patients or had managed such wards, were analyzed using thematic coding of transcripts supplemented by a network analysis of the resulting relationships. The thematic network analysis was able to identify four thematic clusters in the data set pertaining to permanent and deployed personnel's experience of their COVID work, namely 1) Teamwork; 2) Organizational Support and Management; 3) Cohesion and Social Support; and 4) Psychological Strain. Importantly, the adjacency of some codes from neighboring clusters (e.g., cohesion and teamwork) in the graph suggests that the clusters cannot be seen in isolation, but rather that participants frequently discuss these codes within the same reference. While these four thematic clusters are reminiscent of the thematic communities unearthed in our prior systematic review (Schilling et al., 2022 Plos One) suggesting that the literature on teamwork can account for many of the issues discussed by healthcare staff during COVID-19 - it is noteworthy that some of the themes and interactions arising from our interviews received limited exploration in the literature to date. The discussion will consider some of these interactions across community clusters. .

4.1 Importance of social relations for teamwork and mental health

The analysis demonstrates that social dynamics within the team (i.e., cohesion, social support, proximity, collective appraisal) were pivotal for participants' description of both teamwork and mental health. Across the sample, descriptions of effective teamwork frequently discussed operational and professional aspects of their work alongside their shared experience and physical proximity of being inside the ward, and the social support they received from colleagues. Cohesion and social support, based on the recognition of "*being in it together*", also appear to be important protective factors for many, and for most junior personnel seemingly the only one, by aiding the alleviation of stress and making sense of difficult events (Schug et al., 2021). Nevertheless, our study also highlighted that bonds between HCWs as being based on the shared experiences of being on the frontline – a much-reported finding from studies in wave 1 (Jesuthasan et al., 2021; Manthorpe et al., 2021; Conolly et al., 2022; Kotera et al., 2022; Maben et al., 2022) – appeared much more difficult to maintain during the second wave. Echoing the results from a recent study in two U.S. primary care clinics (Lim et al., 2021) it appears that the organizational, and spatial changes, due to increased infection control measures (e.g., social distancing, single occupancy break rooms, or virtual meetings in lieu of large handovers) undermined access to many of these important social resources and thus exacerbated loneliness and isolation. The discussion around public support, alongside the negative impact on personnel's private life (e.g., changes in care responsibilities, decreased leisure activities, lack of social support), further suggests that for many participants job external factors, may have further contributed to increased levels of burnout and fatigue, and warrants more research.

Our study supports research on the importance of group membership for mental health (Cruwys et al., 2013; Haslam et al., 2019; Bentley et al., 2022) by submitting that many participants described the collective identity as frontline personnel as a protective factor from COVID stressors and distressing events. However, further research is needed to assess the impact of social attraction to the COVID team on the ability to cope with stressors and distressing events experienced during their COVID work. Furthermore, the results hint that older, and more experienced participants with established social circles outside of work were likely more protected from job demands and stressors than junior personnel precisely because they had more group memberships (Cruwys et al., 2013; Steffens et al., 2016; Jetten et al., 2022; Van Dick et al., 2023). Alongside the finding that increased social distancing guidelines in wave 2 increased feelings of social isolation this could suggest that the higher risk for mental health problems in younger and more junior personnel during COVID-19 (Khajuria et al., 2021; Frenkel et al., 2022; Hall et al., 2022) may result from a lack of other avenues of social support (Sani et al., 2015; Steffens et al., 2016). While these relationships need to be further assessed, the results may indicate a potential pathway to decrease elevated risks of mental health problems in more junior personnel (Hall et al., 2022) through measures which increase cohesion and social support. For example, mutual team-based support groups (e.g., Schwartz rounds) may provide safe spaces to share emotional and moral impact of work events while creating shared experiences and shared commonality with colleagues (Dawson et al., 2021; Maben et al., 2021).

4.2 Managing interprofessional dynamics and identity to increase teamwork and reduce conflict

The study highlights that effective teamwork in COVID wards was consistently linked to IP/ID dynamics such as team-members differing professional roles and skills, and technical familiarity. The perceived increase of teamwork in the first wave was often attributed to an absence of such dynamics as the general uncertainty and lack of clinical guidance flattened medical hierarchies and led to a blurring of occupational roles and the elevation of personnel with COVID-19 relevant skill sets irrespective of professional background. The subsequent introduction of enhanced clinical guidelines and a surge of personnel during the second wave reportedly restored prior medical hierarchies which again led to a perceived decrease in teamwork. This "slipping into hierarchies" (Dit Dariel, 2018) and the corresponding categorical misperceptions about responsibilities and occupational expectations also appears to be at the root of much of the reported interpersonal conflict described in wave 2. This is in line with previous research in IP/ID personnel in non-pandemic settings, whereby interprofessional power dynamics have been found to can rupture team cohesiveness and trust and increase interpersonal conflict between personnel from different occupational backgrounds (Almost et al., 2016; Keller et al., 2020). Nevertheless, across the waves, occupational categories were used as heuristic shortcut to determine trustworthiness (Davidson et al., 2022; Schilling, 2022). While allowing for quick integration of personnel with relevant skill sets into the team, it also undermined teamwork and integration of deployed personnel without critical care experiences. Despite this finding, professional categories were not always viewed as negative, suggesting that teamwork between IP/ID personnel was often reliant on the individual contribution of a team-member to the team, whereby individual professional skills and experience were used in favor of furthering the team-wide development of shared goals. The study therefore highlights the ambivalent impact of professional categories for teamwork, suggesting that effective teamwork in pandemic healthcare teams requires the reduction of interprofessional power dynamics by transcending prior occupational categories in favor of a new team-wide emergent identity.

Teamwork (and Mental Health) were both further impacted by levels of preparedness, highlighting the need for psychological preparedness of staff as the patient care duties which were most frequently described as being related to psychological strain were those for which participants felt unprepared, including for example patient family liaison, patient distress and deterioration, patient volume and end of life care. More research is therefore needed to assess how different pandemic experiences impact mental health and the differential role of psychological and technical preparedness.

4.3 Risk for deployed personnel due to lack of preparedness and social isolation

While many of the above findings are applicable to staff across the occupational spectrum working on COVID wards, the study outlined some important differences between deployed and permanent personnel with regards to the impact on teamwork and cohesion as well as mental health and personal life. The quantitative finding that deployed personnel reported higher levels of impaired work life balance than permanent staff, was supported by the thematic analysis which emphasized that the negative effect of workload on mental health and career intentions appeared to be more pronounced in deployed than permanent personnel. Similarly, higher levels of WLB impairment in HCWs without ICU experience supports the thematic finding that deployed personnel were more likely to discuss not being technically prepared for the work on COVID wards and more likely to deploy involuntarily.

Many deployed personnel, especially those without intensive-care experiences or adequate training, reported lower levels of familiarity with tasks and equipment, which impacted their levels of confidence and sense of contributing to the team, while increasing self-doubt and anxiety. Considering that these personnel were also more likely to discuss ostracization due to a lack of relevant skill sets, this finding is in line with recent work associating lack of technical preparation and unsatisfactory training with higher levels of mental health problems and harmful consequences for people's job performance (Khajuria et al., 2021; Frenkel et al., 2022). The findings suggest that levels of preparedness may impact upon teamwork, performance, and mental health via lack of group membership.

Likewise, deployed staff were more likely to discuss an absence of social support and opportunities after their deployment and discussed being excluded in meetings or forced to have separate break rooms, which increased social isolation and ostracization. This suggests that in addition to higher risks going into deployment, they faced more issues after deployment, due to not receiving the same care and support that permanent team members enjoyed. As such rapid deployment and redeployment without adequate support risks undermining many of the discussed benefits of cohesion on mental health for this cohort. While this study could not provide correlational data, evidence from other occupational contexts has repeatedly highlighted the increased risk of mental health problems in individually deployed augmentees (Ursano et al., 2017; Cucciare et al., 2020). This suggests that deployed augmentees would benefit the most from interventions that guard against social isolation and ostracization during deployment and the need for specific post-deployment support systems.

4.4 Limitations

Due to the inability to conduct observational measures for teamwork during an active pandemic outbreak the study was forced to rely on self-reported descriptions of teamwork, which holds obvious disadvantages compared to other approaches of measuring teamwork in HCWs (Frankel et al., 2007; Kiesewetter and Fischer, 2015; Cooper et al., 2016; Freytag et al., 2019). Likewise, the study relied on a convenience sample of nurses, doctors, allied health professionals and senior leaders who self-referred to participate in the study, thus reducing generalizability of the results. However, considering the large sample size for a qualitative study as well as the diverse participants recruited from NHS trusts across the UK and the comparative character enabling comparison between deployed and permanent staff we believe that the results represent a realistic reflection of the differential experiences and issues faced by personnel working on COVID wards. Another limitation is that as the graph edges are undirected – based on code co-occurrence – the networks must

TABLE 4 Overview of suggestions for better teamwork, team integration, and mental health from the evidence provided.

Overview of suggestions		
Organizational and institutional support	*Integration of pandemic/crisis response* into non-intensive care personnel's education and periodic training modules prior to deployment in basic skills required.	Pandemic/Crisis preparedness
	Development and maintenance of a staff roster, including prior pandemic, infectious disease, or intensive care experience as well as specialized training and skill sets by staff to quickly allocate and deploy during outbreak.	
	Utilization of skill signifiers, using stickers or badges on HCWs PPE aids in signifying specific skillsets during high pressure situations and with reduced facial recognition due to PPE (e.g., CPAP trained, intensive care family liasion).	
	Wide-spread involvement of IP/ID teams into handovers/ rounds and usage of virtual communication tools to ensure widespread information exchange and development of shared mental models.	Pandemic /Crisis Response
	Simplicfication and access of health records, to provide clearly accessible and visible health records in patients rooms to ensure every member of the team can access and contribute to them.	
	Provision of intra-group debriefs to facilitate after action review after particular difficult shifts (e.g., with high mortality) and to document clinical procedures and lessons learned.	
	Integration of designated personnel for specialty taks (e.g., patient-family liasion) to reduce the burden on frontline HCWs of particular distressing incidents.	
	Optimisation of designated communal staff rooms and rest areas to ensure co-location of staff – even during social distancing – as a basis for maintaining information exchange, team cohesion, and familiarity with colleages from all backgrounds.	
Team and ward manager support	*Emphasize visibility and presence on the ward* to facilitate leader legitimacy and be present, and approachable, to all members of the team.	
	Utilize brief team introductions during handovers, to ascertain skill-sets of deployed staff and assign responsibilities and tasks based on skill-sets.	
	Enhance familiarity between personnel, by de-emphasizing professional categories, but highlighting skill-sets and value to the team and increase personal familiarity.	
	Establishment of role clarity and vision across the team, to develop a common understanding of goals and responsibilities and ensure buy-in of all team-members irrespective of prof. Background.	
	Clearly defined leadership structures, which empower junior leaders and those with particular professional skill-sets (e.g., family liasion), utilize shared leadership where possible to ensure both managerial and psycho-social support.	
Mental health support	*Re-instate in-person social events, meetings and professional development courses* as quickly as Infection Control guidelines allow, to ensure personnel can benefit from the social interactions with coleagues outside of direct patient contact.	
	Team-leader support for well-being, which emphasizes well-being and allows to exhibit mental health awareness, model healthy behaviors and open space to discuss mental health, by regularly checking up on staff to ensure staff well-being and "have their back" vis-à-vis organizational support.	
	Integration of psychological personnel into frontline teams was highlighted by many participants as "having been there" was perceived as pivotal for an ability to open up, and allowed the alleviation of immediate concerns and team-wide discussion.	
	Decompression spaces (e.g., Wobble Rooms), allowing staff – either in isolation or with a colleague/ leader – to temporarily retreat, recharge and recuperate after particularly difficult moments.	
	Mutual support sessions, with deployed and permanent personnel supported by leaders or psychologists to discuss emotional aspects of their experience, aid in sense-making, find closure, reassure colleagues, and find similarity of experiences (e.g., Schwartz rounds).	Pandemic/crisis Follow up
	Occupational health support services (e.g., Psychologists, mental health courses) for personnel to find 1-on-1 support if needed.	

be interpret as relationships without the ability to infer causal statements about directionality. Nevertheless, the results of this exploratory study while providing important lessons for personnel selection, training, co-location, and organizational support during and after a pandemic (Stebbins, 2011; Casula et al., 2021), also inform further research into the differential impact of pandemic deployment on HCWs mental health, interprofessional care delivery, teamwork, and leadership. We therefore propose to test the relationships outlined above in a quantitative dataset. Despite these limitations we believe that the novel approach of utilizing Thematic Network Analysis (Pokorny et al., 2018; Schilling, 2022) to visualize thematically analyzed semi-structured interviews with 75 British HCWs at the frontline of COVID-19 allowed a reproducible visualization of the inherent complexity of qualitative data by highlighting thematic connections and communities which may not be documented using traditional thematic analytic methods.

4.5 Implications for practitioners

Participants provided a range of different organizational suggestions and innovations which can aid both managers and leaders during the preparation and response for future pandemics that may require the rapid deployment of personnel from non-intensive care backgrounds into such wards. For example, during rapid upscaling, intervention such as stickers or badges on HCWs PPE, involvement of IP/ID teams into handovers/rounds, designated communal rest areas and fixed intra-group debriefs can increase teamwork, allow information exchange and enable familiarity between colleagues. Similarly, when attempting to increase teamwork and team integration across the wider team, leaders must pay special attention to both the integration of junior or deployed personnel – as these rely more on colleagues for social interactions than senior staff. – and on the management and coordination of social identities capable of transcending prior occupational categories (e.g., 'we the COVID ward' vs. 'them, the physios'). Senior leaders and ward managers should ensure that adequate measures are taken to alleviate stressors (e.g., by employing psychological staff to deal with patient family liaison) while preparing staff for the potential psychological impact of such work. Considering the importance placed on team-based support for the provision of social support and sense-making (e.g., team support groups, social events, debriefs), and the difficulties of many deployed staff to access social support within their teams, it is highly important for hospitals to ensure that all personnel have access to the same team-based support as permanent staff and ensure that organizational support to tackle loneliness and negative mental health consequences are available. Table 4 outlines a range of important organizational, managerial, and mental health suggestions gleaned from the research across the different stages of pandemics, preparation, response, and aftermath.

5 Conclusion

This study explored permanent and deployed personnel's experience of COVID work, assessed how interprofessional teamwork was established or maintained despite substantial workplace adjustments and the ways in which participants discussed their mental health during this time. Summarizing such broad issues in one paper inevitably leads to a loss of some of the narrative detail inherent in qualitative data. However, we believe that the novel approach of using thematic network analysis utilized here, offers both the illustration of the inherent complexity of thematic data and a more robust representation of inherent relationships between codes than standard thematic analysis would allow. The presented results show a complicated picture. While the importance of many of the traditional factors associated with the successful delivery of patient care (e.g., team coordination, composition, and team dynamics (4–6)) were highlighted by our participants, they also reported that many of these factors were impeded by pandemic constraints. Hindering 'business as usual' by limiting effective collaboration and communication between team-members, depriving leaders of their ability to coordinate and support personnel, and undermining HCW's access to social and organizational support, pandemic work influenced HCWs ability to effectively work together and cope with stressors both during and after their work on COVID wards. Our research demonstrates that during crisis situations teamwork and successful adaptation to pandemic exigencies may rely on psycho-social, relational, and organizational factors currently under researched. For example, both the relational and structural context of pandemic work (e.g., familiarity with colleagues and tasks, perceived isolation from those outsides of wards, inter-professional hierarchies, (in)voluntary deployment, lack of training) appear to be influencing team-members ability to work effectively with each other, suggesting that successful delivery of care during crisis requires increased attention to the structural consequences of HID clinical guidance. Simultaneously, rapidly developing shared mental models, appraising shared experiences, reducing inter-professional conflict, or creating a socially supportive atmosphere across and beyond occupational boundaries emerge as crucial psycho-social skills when both developing teamwork in rapidly deployed ad-hoc teams and supporting HCW's ability to cope with pandemic stressors. Considering that leadership was often limited by physical presence on the wards and therefore perceived as shared and attributed to junior leaders, we therefore urgently advocate for the inclusion of training on identity management into team and leadership education. Lastly, the described link between social relationships and participants' ability to appraise their experience, emphasizes the need for more research on the effect of social group memberships for HCW resilience and continued delivery of care.

Data availability statement

The datasets generated and analyzed for this study can be found in the supplementary information.

Ethics statement

The studies involving humans were approved by Oxford Brookes University Research Ethics Committee and the UK NHS Health Research Authority. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

SS: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Software, Validation, Visualization, Writing – original draft, Writing

– review & editing. MA: Conceptualization, Data curation, Formal analysis, Investigation, Writing – original draft, Methodology. ZM: Conceptualization, Funding acquisition, Resources, Validation, Writing – review & editing. PC: Conceptualization, Funding acquisition, Validation, Writing – review & editing. MB: Conceptualization, Funding acquisition, Supervision, Validation, Writing – review & editing. VC: Conceptualization, Data curation, Funding acquisition, Methodology, Project administration, Resources, Supervision, Validation, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2024.1293171/full#supplementary-material

SUPPLEMENTARY FIGURE S1
Psychological Strain and Stressors in all personnel: This graph displays the codes most connected to Psychological Strain and Stressors in all personnel, by filtering Figure 1 using an ego network to only display codes connected to Psychological Strain and Stressors. Additionally, a Fruchterman Reingold layout algorithm was applied to further highlight, through adjacency to the code teamwork, which codes share the most references with teamwork in this group.

SUPPLEMENTARY TABLE S1
Masterfile for all personnel. This matrix table derived from NVivo, shows the number of shared references for the 62 codes used in the thematic network analysis. The association rule lift was calculated and the matrix transformed into a range, which was imported into gephi.

SUPPLEMENTARY TABLE S2
Masterfile for deployed personnel. This matrix table derived from NVivo, shows the number of shared references for the 62 codes used in the thematic network analysis. The association rule lift was calculated and the matrix transformed into a range, which was imported into gephi.

SUPPLEMENTARY TABLE S3
Masterfile for permanent personnel. This matrix table derived from NVivo, shows the number of shared references for the 62 codes used in the thematic network analysis. The association rule lift was calculated and the matrix transformed into a range, which was imported into gephi.

SUPPLEMENTARY TABLE S4
Modularity Clusters and Heatmap of Cluster association of codes across all three graphs. This table shows the calculated modularity cluster of each code across the three graphs. Additionally, a heatmap and summary of overlap is included.

SUPPLEMENTARY TABLE S5
Data Extraction Table: This file contains an example of references which were coded in NVivo against corresponding themes (codes). The table shows both the narrative interpretation of the reference and the different codes that this reference was coded against. The shared occurrence of codes across references is visualized in Figures 1–3.

SUPPLEMENTARY DATA SHEET 1
Interview guide for frontline staff.

SUPPLEMENTARY DATA SHEET 2
Interview guide for leaders.

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EDITED BY
Julia Carolin Seelandt,
University Hospital Zürich, Switzerland

REVIEWED BY
Vera Hagemann,
University of Bremen, Germany

*CORRESPONDENCE
Eduardo Salas
✉ eduardo.salas@rice.edu

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Beyond communication: an update on transforming healthcare teams

Gabriela Fernández Castillo, Maha Khalid and Eduardo Salas*

Making Effective Teams Laboratory, Department of Psychological Science, Rice University, Houston, TX, United States

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1 Introduction

In 2018, Salas et al. (1) offered 10 observations on the science of teams in healthcare. This perspective article offers a quick update, providing a new set of observations based on the latest findings. As a point-of-departure for these observations, we use one of medicine's most cited culprits of error: communication [see Table 1 for a complete list of articles discussing communication; see also Etherington et al. (2), Street et al. (3), Tiwary et al. (4)]—and our belief that while important, a sole focus on it fails to take a holistic approach.

Upon surveying recent literature (i.e., 2018–2023), we found that 89% of articles discuss communication in some way, and 28% mention communication as one of the leading causes of medical error (5–8). However, in the following piece, our stance is that despite communication having been repeatedly cited as "the" medical culprit, it may not be the source of all contention (9). More recent findings identify other challenges, such as accountability (10), conflict management (11, 12), decision-making (13), reflecting on progress, and coaching as the primary challenges healthcare teams face (14). Moreover, communication is a multi-faceted competency that also requires a holistic view.

In our review, it was clear that research on interprofessional collaboration was alive and well (around 48% of articles fit in this general category; see Table 1). However, more specific areas of research on interdisciplinary collaboration emerged, pointing to four primary areas of development: interprofessional education (24%), team development interventions [TDIs, see Lacarenza et al. (15); 20%], simulation-based training (SBT; 8%), and lastly, measurement (8%). Together, these areas point to a growing attention on the team as a whole—rather than on a single competency (i.e., communication). Guided by the findings from Table 1 and other extant developments, we provide an update on the observations made by Salas et al. (1). Doing so highlights what the last 5 years have taught us.

In the following subsections, we discuss how these observations can continue to transform healthcare teams for the better and how they all work together to foster teamwork throughout healthcare practitioners' workplace lifespans. Figure 1 summarizes this update.

2 Observation 1: communication matters, but more is not always better

A plethora of teamwork competency frameworks exist. However, team scientists widely recognize that for teams to function effectively, they need to communicate [see Bollen et al. (16), who found communication is the most commonly reported influencing factor

TABLE 1 Articles included in the review of the literature.

#	Authors	Title	Focus of research ($N = 171$)	Was communication discussed? ($n = 153$, ~89%)	Was communication noted as a source of medical error? ($n = 41$ ~28%)
1	Cervantes-Sudio et al. (2021)	Are Filipino students ready to collaborate? Comparing the readiness of healthcare students for interprofessional education in the Philippines	Education on collaboration and teamwork ($n = 41$, ~24%)	Yes	Yes
2	Cerbin-Koczorowska et al. (2019)	As the twig is bent, so is the tree inclined: A survey of student attitudes toward interprofessional collaboration supported with the curricula analysis		Yes	No
3	Roberts et al. (2019)	Assessing students' and health professionals' competency learning from interprofessional education collaborative workshops		Yes	No
4	Oikawa and Donkers (2022)	Assessment of teamwork in interprofessional education		Yes	No
5	Kaifi et al. (2021)	Attitudes of nurses and physicians toward nurse–physician interprofessional collaboration in different hospitals of Islamabad–Rawalpindi region of Pakistan		Yes	No
6	Vincent-Onabajo et al. (2019)	Attitudes toward interprofessional practice among healthcare students in a Nigerian University		Yes	No
7	Flato et al. (2022)	Awareness of interprofessional learning as a tool to improve a Brazilian university curriculum		Yes	No
8	Watanabe et al. (2019)	Changes in attitudes of undergraduate students learning interprofessional education in the absence of patient safety modules: Evaluation with a modified T-TAQ instrument		Yes	Yes
9	Naumann et al. (2021)	Designing, implementing and sustaining IPE within an authentic clinical environment: The impact on student learning		Yes	No
10	Prill et al. (2022)	Determinants of interprofessional collaboration in complementary medicine to develop an educational module 'complementary and integrative medicine' for undergraduate students: A mixed-methods study		Yes	No
11	Waltz (2020)	Determining the effectiveness of an interprofessional educational intervention for teamwork competencies among nursing, physical therapy, and pharmacy students		Yes	No
12	Naumann et al. (2021)	Designing, implementing and sustaining IPE within an authentic clinical environment: The impact on student learning		Yes	No
13	Caratelli et al. (2020)	Development and evaluation of an interprofessional seminar pilot course to enhance collaboration between health professions at a student-run clinic for underserved populations		Yes	No
14	Hammond and Morgan (2022)	Development of interprofessional healthcare teamwork skills: Mapping students' process of learning		Yes	No
15	Ganotice and Chan (2022)	Does collective efficacy drive readiness for interprofessional learning? Evidence from a large-scale interprofessional education program in Hong Kong		Yes	No
16	Clouder et al. (2022)	Education for integrated working: A qualitative research study exploring and contextualizing how practitioners learn in practice		Yes	No
17	Fenn et al. (2022)	Empathy, better patient care, and how interprofessional education can help		Yes	No
18	Huebner et al. (2021)	Establishing a baseline of interprofessional education perceptions in first year health science students		Yes	No

(Continued)

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TABLE 1 (Continued)

#	Authors	Title	Focus of research ($N = 171$)	Was communication discussed? ($n = 153$, ~89%)	Was communication noted as a source of medical error? ($n = 41$ ~28%)
19	Gary et al. (2018)	Health science center faculty attitudes toward interprofessional education and teamwork		No	
20	Brewer and Flavell (2021)	High and low functioning team-based pre-licensure interprofessional learning: An observational evaluation		Yes	No
21	Raynault et al. (2021)	How interprofessional teams of students mobilized collaborative practice competencies and the patient partnership approach in a hybrid IPE course		Yes	Yes
22	Lairamore et al. (2018)	Impact of team composition on student perceptions of interprofessional teamwork: A 6-year cohort study		Yes	No
23	Chen et al. (2018)	Implementation, evaluation, and outcome of TeamSTEPPS in interprofessional education: A scoping review		Yes	No
24	Spaulding et al. (2021)	Interprofessional education and collaboration among healthcare students and professionals: A systematic review and call for action		Yes	No
25	Katoue et al. (2021)	Interprofessional education and collaborative practice in Kuwait: Attitudes and barriers from faculty		Yes	No
26	Machin et al. (2019)	Interprofessional education and practice guide: Designing ethics-orientated interprofessional education for health and social care students		Yes	Yes
27	Fenn et al. (2020)	Interprofessional education for complex neurological cases		Yes	No
28	Morrell et al. (2021)	Interprofessional Education Week: The impact of active and passive learning activities on students' perceptions of interprofessional education		No	
29	Winkler et al. (2021)	Interprofessional education workshop on aging: Student perceptions of interprofessional collaboration, aging, and cultural fluency		Yes	No
30	Seidlein et al. (2022)	Interprofessional health-care ethics education for medical and nursing students in Germany: An interprofessional education and practice guide		Yes	Yes
31	Browne et al. (2021)	Longitudinal outcomes of a brief interprofessional educational experience with or without an interprofessional education course		Yes	No
32	Roberts et al. (2018)	Perceived relevance mediates the relationship between professional identity and attitudes toward interprofessional education in first-year university students		Yes	No
33	Fox et al. (2018)	Teaching interprofessional teamwork skills to health professional students: A scoping review		No	
34	Brashers et al. (2020)	The ASPIRE model: Grounding the IPEC core competencies for interprofessional collaborative practice within a foundational framework		Yes	No
35	Keshmiri et al. (2021)	The effectiveness of interprofessional education on interprofessional collaborative practice and self-efficacy		Yes	No
36	Nyoni et al. (2021)	Toward continuing interprofessional education: Interaction patterns of health professionals in a resource-limited setting		Yes	Yes
37	House et al. (2018)	Medical student perceptions of an initial collaborative immersion experience		Yes	No
38	Botma and Labuschagne (2019)	Students' perceptions of interprofessional education and collaborative practice: Analysis of freehand drawings		Yes	No

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TABLE 1 (Continued)

#	Authors	Title	Focus of research ($N = 171$)	Was communication discussed? ($n = 153$, ~89%)	Was communication noted as a source of medical error? ($n = 41$ ~28%)
39	Olander et al. (2018)	A multi-method evaluation of interprofessional education for healthcare professionals caring for women during and after pregnancy		No	
40	Kara et al. (2018)	An interprofessional patient assessment involving medical and nursing students: A qualitative study		No	
41	Harris et al. (2021)	An innovative interprofessional curricular model for diverse partners who team up to support behavior change in individuals with chronic disease		Yes	No
42	King and Shaw (2022)	"… breaks down silos": Allied health clinicians' perceptions of informal interprofessional interactions in the healthcare workplace	General interprofessional care research ($n = 82$, ~48%)	Yes	No
43	Wei et al. (2020)	A culture of caring: The essence of healthcare interprofessional collaboration		Yes	No
44	Johnson and Mahan (2019)	A qualitative investigation into behavioral health providers attitudes toward interprofessional clinical collaboration		Yes	No
45	Wei et al. (2022)	A systematic meta-review of systematic reviews about interprofessional collaboration: Facilitators, barriers, and outcomes		Yes	No
46	Seaton et al. (2021)	Allied health professionals' perceptions of interprofessional collaboration in primary health care: An integrative review		Yes	No
47	Cutler et al. (2019)	Are interprofessional healthcare teams meeting patient expectations? An exploration of the perceptions of patients and informal caregivers		Yes	No
48	Ulrich et al. (2019)	Attitudes toward interprofessional collaboration in young healthcare professionals		Yes	Yes
49	Walton et al. (2020)	Clinicians' perceptions of rounding processes and effectiveness of clinical communication		Yes	No
50	Bjørkquist et al. (2019)	Collaborative challenges in the use of telecare		Yes	No
51	Fox et al. (2021)	Communication and interprofessional collaboration in primary care: From ideal to reality in practice		Yes	No
52	Garner et al. (2021)	Cross cultural team collaboration: Integrating cultural humility in mHealth development and research		Yes	No
53	Kannisto et al. (2021)	Daily functioning support—A qualitative exploration of rehabilitative approach in acute hospitalized care		No	
54	Haruta et al. (2018)	Development of an interprofessional competency framework for collaborative practice in Japan		Yes	Yes
55	Albarello et al. (2019)	Does Hub-and-Spoke organization of healthcare system promote workers' satisfaction?		Yes	No
56	Capari et al. (2018)	Dynamics of an orthopedic team: Insights to improve teamwork through a design thinking approach		Yes	Yes
57	Madsen et al. (2022)	Effectiveness of an interprofessional ambulatory care model on diabetes: Evaluating clinical markers in a low-income patient population		Yes	No
58	Neuhaus et al. (2022)	Emergence of power and complexity in obstetric teamwork		Yes	No

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TABLE 1 (Continued)

#	Authors	Title	Focus of research ($N = 171$)	Was communication discussed? ($n = 153$, ~89%)	Was communication noted as a source of medical error? ($n = 41$ ~28%)
59	Hertel et al. (2019)	Engaging patients in primary care design: An evaluation of a novel approach to codesigning care		Yes	No
60	Pakkanen et al. (2022)	Ethical issues identified in nurses' interprofessional collaboration in clinical practice: A meta-synthesis		No	
61	Oblea et al. (2019)	Evaluation of clinical nurse transition program at US Army Hospitals		Yes	No
62	Kinnaer et al. (2022)	Evaluation of interprofessional care processes for patients treated with oral anticancer drugs		Yes	No
63	Heath et al. (2018)	Exchanging implements: The micro-materialities of multidisciplinary work in the operating theater		Yes	No
64	McNaughton et al. (2021)	Existing models of interprofessional collaborative practice in primary healthcare: A scoping review		Yes	No
65	Lam et al. (2018)	Exploring healthcare professionals' perceptions of the anesthesia assistant role and its impact on patients and interprofessional collaboration		Yes	Yes
66	Sukhera et al. (2022)	Exploring implicit influences on interprofessional collaboration: A scoping review		Yes	Yes
67	Waggie and Arends (2021)	Exploring interprofessional teamwork at a tertiary public hospital in South Africa		Yes	Yes
68	Papermaster and Champion (2021)	Exploring the use of curbside consultations for interprofessional collaboration and clinical decision-making		Yes	No
69	Bollen et al. (2019)	Factors influencing interprofessional collaboration between community pharmacists and general practitioners—a systematic review		Yes	Yes
70	Manspeaker et al. (2019)	Fostering interprofessional teamwork through an immersive study abroad experience		Yes	No
71	Sutherland et al. (2022)	Good working relationships: How healthcare system proximity influences trust between healthcare workers		Yes	No
72	Leonardsen et al. (2018)	Handovers in primary healthcare in Norway: A qualitative study of general practitioners' collaborative experiences		Yes	No
73	Bilodeau and Tremblay (2019)	How oncology teams can be patient-centered? Opportunities for theoretical improvement through an empirical examination		Yes	No
74	Thomas et al. (2019)	How pharmacy and medicine students experience the power differential between professions: 'Even if the pharmacist knows better, the doctor's decision goes'		Yes	No
75	Sifaki-Pistolla et al. (2020)	How trust affects performance of interprofessional health-care teams		Yes	Yes
76	Walmsley et al. (2021)	Identifying practical approaches to the normalization of interprofessional collaboration in rural hospitals: A qualitative study among health professionals		Yes	No
77	McKay et al. (2021)	Impact of interprofessional embedding of physical therapy in a primary care training clinic		Yes	Yes
78	Farooqui et al. (2020)	Interpersonal communication, teamwork effectiveness, and organizational commitment in Pakistani nurses		Yes	Yes

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TABLE 1 (Continued)

#	Authors	Title	Focus of research ($N = 171$)	Was communication discussed? ($n = 153$, ~89%)	Was communication noted as a source of medical error? ($n = 41$ ~28%)
79	Chew et al. (2019)	Interprofessional bedside rounds: Nurse-physician collaboration and perceived barriers in an Asian hospital		Yes	Yes
80	Ulrich and Breitbach (2022)	Interprofessional collaboration among sport science and sports medicine professionals: An international cross-sectional survey		Yes	Yes
81	Adamson et al. (2018)	Interprofessional empathy: A four-stage model for a new understanding of teamwork		Yes	No
82	Beaird et al. (2021)	Interprofessional rounding design features and associations with collaboration and team effectiveness		Yes	No
83	Bentley et al. (2018)	Interprofessional teamwork in comprehensive primary healthcare services: Findings from a mixed methods study		Yes	No
84	van Zijl et al. (2021)	Interprofessional teamwork in primary care: The effect of functional heterogeneity on performance and the role of leadership		Yes	No
85	Kvarnström et al. (2018)	Introducing the nurse practitioner into the surgical ward: An ethnographic study of interprofessional teamwork practice		Yes	No
86	Norful et al. (2022)	Mitigating primary care provider burnout with interdisciplinary dyads and shared care delivery		Yes	No
87	Hult et al. (2021)	Patient representatives: Crucial members of health-care working groups facing an uncertain role and conflicting expectations A qualitative study		Yes	No
88	Algahtani et al. (2021)	Perceptions and attitudes of different healthcare professionals and students toward interprofessional education in Saudi Arabia: A cross-sectional survey		No	
89	Rahman et al. (2019)	Perceptions of patient-centered care among providers and patients in the orthopedic department of a tertiary care hospital in Karachi, Pakistan		No	
90	Ylitörmänen et al. (2019)	Perceptions on nurse–nurse collaboration among registered nurses in Finland and Norway		Yes	Yes
91	Albassam et al. (2020)	Perspectives of primary care physicians and pharmacists on interprofessional collaboration in Kuwait: A quantitative study		Yes	Yes
92	Hickey et al. (2018)	Prospective health students' perceptions of the pharmacist role in the interprofessional team		No	
93	Schmutz et al. (2018)	Reflection in the heat of the moment: The role of in-action team reflexivity in health care emergency teams		Yes	No
94	Fernandez et al. (2020)	Revealing tacit knowledge used by experienced health professionals for interprofessional collaboration		Yes	No
95	Carroll et al. (2021)	Seeing what works: Identifying and enhancing successful interprofessional collaboration between pathology and surgery		Yes	Yes
96	Kämmer and Ewers (2022)	Stereotypes of experienced health professionals in an interprofessional context: Results from a cross-sectional survey in Germany		Yes	Yes
97	Chollette et al. (2022)	Teamwork competencies for interprofessional cancer care in multiteam systems: A narrative synthesis		Yes	No
98	Best et al. (2021)	Teamwork in clinical genomics: A dynamic sociotechnical healthcare setting		Yes	No

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TABLE 1 (Continued)

#	Authors	Title	Focus of research ($N = 171$)	Was communication discussed? ($n = 153$, ~89%)	Was communication noted as a source of medical error? ($n = 41$ ~28%)
99	Brewer et al. (2020)	Teamwork, collaboration and networking: Self-reported behavioral change following pre-licensure interprofessional clinical learning		Yes	No
100	Rowan et al. (2022)	The impact of huddles on a multidisciplinary healthcare teams' work engagement, teamwork and job satisfaction: A systematic review		Yes	No
101	Katoue et al. (2021)	The perceptions of healthcare professionals about accreditation and its impact on quality of healthcare in Kuwait: A qualitative study		No	
102	Durand et al. (2022)	The role of gender, profession and informational role self-efficacy in physician–nurse knowledge sharing and decision-making		Yes	No
103	Sena and Liani (2020)	The role of relational routines in hindering transdisciplinary collaboration: The case of the setting up of a team in an Italian Breast Unit		Yes	No
104	Real et al. (2019)	The social logic of nursing communication and team processes in centralized and decentralized work spaces		Yes	Yes
105	Mitchell and Boyle (2021)	Too many cooks in the kitchen? The contingent curvilinear effect of shared leadership on multidisciplinary healthcare team innovation		Yes	No
106	Yamamoto et al. (2022)	Understanding interprofessional team delivery of patient-centered care: A qualitative secondary analysis		Yes	No
107	Schilling et al. (2022)	Understanding teamwork in rapidly deployed interprofessional teams in intensive and acute care: A systematic review of reviews		Yes	Yes
108	Rydenfält et al. (2019)	What do doctors mean when they talk about teamwork? Possible implications for interprofessional care		Yes	No
109	Hu et al. (2018)	Investigating student perceptions at an interprofessional student-run free clinic serving marginalized populations		Yes	No
110	Pinho et al. (2018)	Investigating the nature of interprofessional collaboration in primary care across the Western Health Region of Brasília, Brazil: A study protocol		No	
111	Assafi et al. (2022)	It's all about presence: Health professionals' experience of interprofessional collaboration when mobilizing patients with hip fractures		Yes	Yes
112	Karlsson et al. (2020)	Organizing for sustainable inter-organizational collaboration in health care processes		Yes	No
113	Wieser et al. (2019)	Perceptions of collaborative relationships between seven different healthcare professions in Northern Italy		Yes	No
114	Dahl and Crawford (2018)	Perceptions of experiences with interprofessional collaboration in public health nursing: A qualitative analysis		Yes	Yes
115	Hasan et al. (2018)	Physicians' perspectives of pharmacist-physician collaboration in the United Arab Emirates: Findings from an exploratory study		Yes	No
116	Jones et al. (2021)	Physiotherapy new graduate self-efficacy and readiness for interprofessional collaboration: A mixed methods study		Yes	No
117	Collins et al. (2021)	Self-efficacy and empathy development through interprofessional student hotspotting		No	
118	Forsagärde et al. (2021)	The dialogue as decision support; lived experiences of extended collaboration when an ambulance is called		No	

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TABLE 1 (Continued)

#	Authors	Title	Focus of research ($N = 171$)	Was communication discussed? ($n = 153$, ~89%)	Was communication noted as a source of medical error? ($n = 41$ ~28%)
119	Burm et al. (2019)	Using a sociomaterial approach to generate new insights into the nature of interprofessional collaboration: Findings from an inpatient medicine teaching unit		Yes	Yes
120	Lee et al. (2021)	Understanding decision-making in interprofessional team meetings through interpretative repertoires and discursive devices		Yes	No
121	Karam et al. (2022)	Interprofessional collaboration between general practitioners and primary care nurses in Belgium: A participatory action research		Yes	No
122	Pomare et al. (2020)	Interprofessional collaboration in hospitals: A critical, broad-based review of the literature		No	
123	Schot et al. (2020)	Working on working together A systematic review on how healthcare professionals contribute to interprofessional collaboration		Yes	No
124	Bajwa et al. (2020)	Intra versus interprofessional conflicts: Implications for conflict management training		Yes	Yes
125	Keller et al. (2019)	Disruptive behavior' in the operating room: A prospective observational study of triggers and effects of tense communication episodes in surgical teams	Measurement ($n = 13$, ~ 8%)	Yes	Yes
126	Khoshab et al. (2019)	A survey on teamwork status in caring for patients with heart failure: A cross-sectional study		Yes	No
127	Bajwa et al. (2023)	Development and validity evidence for the intraprofessional conflict exercise: An assessment tool to support collaboration		Yes	Yes
128	Jaruseviciene et al. (2019)	Development of a scale for measuring collaboration between physicians and nurses in primary health-care teams		Yes	Yes
129	Peltonen et al. (2020)	Instruments measuring interprofessional collaboration in healthcare – a scoping review		Yes	No
130	O'Neill et al. (2018)	Team dynamics feedback for post-secondary student learning teams		Yes	No
131	O'Neil et al. (2020)	Team dynamics feedback for post-secondary student learning teams: Introducing the 'Bare CARE' assessment and report		Yes	No
132	Ganotice et al. (2022)	To IPAS or not to IPAS? Examining the construct validity of the Interprofessional Attitudes Scale in Hong Kong		Yes	No
133	Etherington et al. (2021)	Measuring the teamwork performance of operating room teams: A systematic review of assessment tools and their measurement properties		Yes	Yes
134	Blumenthal et al. (2022)	Development of a questionnaire to assess student behavioral confidence to undertake interprofessional education activities		Yes	No
135	Sicks et al. (2022)	Measuring interprofessional education and collaborative practice competencies: A content validity study of the Jefferson Teamwork Observation Guide®		Yes	No
136	Wooding et al. (2020)	Evaluation of teamwork assessment tools for interprofessional simulation: A systematic literature review		Yes	No
137	O'Neill et al. (2018)	A taxonomy and rating system to measure situation awareness in resuscitation teams		Yes	No
138	Cunningham et al. (2018)	Interprofessional education and collaboration: A simulation-based learning experience focused on common and complementary skills in an acute care environment	Simulation-based training (SBT) ($n = 14$, ~8%)	Yes	No

(Continued)

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TABLE 1 (Continued)

#	Authors	Title	Focus of research ($N = 171$)	Was communication discussed? ($n = 153$, ~89%)	Was communication noted as a source of medical error? ($n = 41$ ~28%)
139	Connolly et al. (2022)	A narrative synthesis of learners' experiences of barriers and facilitators related to effective interprofessional simulation		Yes	Yes
140	Stehlik et al. (2018)	Effect of hospital simulation tutorials on nursing and pharmacy student perception of interprofessional collaboration: Findings from a pilot study		Yes	No
141	Register et al. (2019)	Effect of interprofessional (IP) faculty development on perceptions of IP collaboration and on IP behaviors		Yes	No
142	Jakobsen et al. (2018)	Examining participant perceptions of an interprofessional simulation-based trauma team training for medical and nursing students		Yes	No
143	Wai et al. (2021)	Exploring the role of simulation to foster interprofessional teamwork among medical and nursing students: A mixed-method pilot investigation in Hong Kong		Yes	No
144	Costello et al. (2018)	Student experiences of interprofessional simulation: Findings from a qualitative study		Yes	Yes
145	Hughes et al. (2021)	Trauma, teams, and telemedicine: Evaluating telemedicine and teamwork in a mass casualty simulation		Yes	No
146	Leithead et al. (2019)	Examining interprofessional learning perceptions among students in a simulation-based operating room team training experience		Yes	No
147	Villemure et al. (2019)	Examining perceptions from *in situ* simulation-based training on interprofessional collaboration during crisis event management in post-anesthesia care		Yes	Yes
148	Astbury et al. (2021)	High-fidelity simulation-based education in pre-registration healthcare programmes: A systematic review of reviews to inform collaborative and interprofessional best practice		Yes	No
149	Jowsey et al. (2020)	Performativity, identity formation and professionalism: Ethnographic research to explore student experiences of clinical simulation training		Yes	No
150	Laco and Stuart (2022)	Simulation-based training program to improve cardiopulmonary resuscitation and teamwork skills for the urgent care clinic staff		Yes	Yes
151	Chamberland et al. (2018)	The critical nature of debriefing in high-fidelity simulation-based training for improving team communication in emergency resuscitation		Yes	Yes
152	Baik et al. (2018)	Examining interprofessional team interventions designed to improve nursing and team outcomes in practice: A descriptive and methodological review	Team development intervention (TDI) ($n = 20$, ~12%)	Yes	No
153	Lumenta et al. (2019)	Quality of teamwork in multidisciplinary cancer team meetings: A feasibility study		Yes	No
154	Clapper et al. (2019)	A TeamSTEPPS® implementation plan for recently assigned interns and nurses		Yes	No
155	Hendricks et al. (2018)	Fostering interprofessional collaborative practice in acute care through an academic-practice partnership		Yes	No
156	Weinstein et al. (2018)	Integration of systematic clinical interprofessional training in a student-faculty collaborative primary care practice		Yes	No

(Continued)

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TABLE 1 (Continued)

#	Authors	Title	Focus of research ($N = 171$)	Was communication discussed? ($n = 153$, ~89%)	Was communication noted as a source of medical error? ($n = 41$ ~28%)
157	Junge-Maugh et al. (2021)	Key strategies for improving transitions of care collaboration: Lessons from the ECHO-care transitions program		Yes	Yes
158	Blakeney et al. (2019)	Purposeful interprofessional team intervention improves relational coordination among advanced heart failure care teams		Yes	Yes
159	Grant et al. (2018)	We pledge to improve the health of our entire community': Improving health worker motivation and performance in Bihar, India through teamwork, recognition, and nonfinancial incentives		Yes	No
160	Fox and Brummans (2019)	Where's the plot? Interprofessional collaboration as joint emplotment in acute care		Yes	No
161	Block et al. (2021)	A novel longitudinal interprofessional ambulatory training practice: The improving patient access care and cost through training (IMPACcT) clinic		Yes	No
162	Kuner et al. (2022)	Clinical outcomes of patients treated on the Heidelberg interprofessional training ward vs Care on a conventional surgical ward: A retrospective cohort study		No	
163	Zhang et al. (2021)	Developing interprofessional collaboration between clinicians, interpreters, and translators in healthcare settings: Outcomes from face-to-face training		Yes	Yes
164	Gregory et al. (2020)	Examining changes in interprofessional attitudes associated with virtual interprofessional training		Yes	Yes
165	Mink et al. (2021)	Impact of an interprofessional training ward on interprofessional competencies—A quantitative longitudinal study		Yes	No
166	Luo et al. (2022)	Relationships between changing communication networks and changing perceptions of psychological safety in a team science setting: Analysis with actor-oriented social network models		Yes	No
167	Vatnøy et al. (2022)	Associations between nurse managers' leadership styles, team culture and competence planning in Norwegian municipal in-patient acute care services: A cross-sectional study		Yes	No
168	Iachini et al. (2019)	Examining collaborative leadership through interprofessional education: Findings from a mixed methods study		No	
169	Willgerodt et al. (2020)	Impact of leadership development workshops in facilitating team-based practice transformation		Yes	No
170	Wu et al. (2018)	Promoting leadership and teamwork development through Escape Rooms		Yes	No
171	Körner et al. (2018)	A patient-centered team-coaching concept for medical rehabilitation		No	

Full references available upon request.

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of collaboration]. Nevertheless, simply communicating is not enough, as meta-analytic evidence has shown that more is not better: better is better (17). In other words, the quantity of communication may not rectify teamwork issues. Quality is more indicative of better performance (17), and to have communication quality, teams need to ensure they have four things. Teams need to share unique information (such as a critical detail of a patient's history), have closed-loop communications (initiating, following up, and closing conversations), convey information when received (i.e., "I understand I need to be here in person for the meeting"), and make sure boundary spanners exist to communicate with individuals outside of the team (18). Understanding communication as simply sending information is an incomplete picture—and, as is now widely recognized, many environments are not conducive to it at first.

One of the most pivotal factors in ensuring communication *quality* is psychological safety—loosely defined as the ability to take intrapersonal risks [(19, 20); also see Keller at al. (12) and Luo et al. (21)]. In order to foster psychological safety and enable teams to speak up when necessary [a problem consistent in healthcare—where medical hierarchies persist, see Neuhaus et al. (22) and Seaton et al. (23)], teams need to engage in a variety of behaviors—involving specific implicit and explicit actions from clarifying expectations to promoting inclusivity [for a complete list of behaviors, see Kolbe et al. (24)]. Moreover, research has shown that healthcare teams must adapt, listen, and speak up properly and definitively amongst their colleagues and collaborators (25).

Therefore, not only is communication multi-faceted, but it is also one of multiple team competencies. For this reason, we argue that if healthcare professionals require all these skills, it is worth investing in strategies that target most teamwork competencies at once and let go of the idea that communication is a sole perpetrator of medical mistakes. This is not to say communication is unimportant, but simply that it is a piece of a larger puzzle. If an improvement in communication is not complemented by other teamwork competencies, teamwork as a whole is not likely to improve. In other words, good communication does not directly translate into good teamwork, and a more holistic approach is necessary.

3 Observation 2: internal team coaches are needed and must be developed

Team development interventions (TDIs) are designed with distinct purposes in mind. For example, there are training and process approaches that are necessary on different occasions (15). From our literature review, it became evident that there is a growing interest in testing and developing distinct types of TDIs in everything from leadership training (26) to process interventions (27). However, in the entirety of our review, only one article (27) touched upon what we thought to be a holistic TDI fitted to healthcare's immediate leadership needs: team coaching. Using extant supporting research, we provide rationale for its strength as an intervention and call attention to it as a great tool in nurturing teams in their lifespan.

Salas et al.'s (1) review [and more recently, Vatnøy et al. (28)] corroborated the importance of team leadership—which, as many have found (29), can help members coordinate their collective resources in accomplishing the team's work (27, 30). Furthermore, as the team coaching literature has evolved, it has been mostly conceptualized as a leadership strategy that both internal and external coaches can provide (31). Körner et al. (27) systematically developed a team coaching approach with the goal of leaving behind a team leader empowered enough to coach their teams. More recent advancements made by Maynard et al. (29) suggest that for healthcare, a profession with high power distance and a high degree of technical skills, internal coaches might be more successful in yielding improvements in team performance. This is because internal team coaches are experts in their field who understand immediate teamwork needs (31), allowing them to adapt with the team during times of need.

Körner et al.'s (27) team coaching approach and Maynard et al.'s (29) empirical study provided the primary advancements made in the last 5 years in team coaching in healthcare. Maynard and colleagues had a retired surgeon coach current surgeons, and these surgeons proceeded to utilize coaching skills on their surgical teams [Körner et al. (27) had a professional coach aid healthcare teams]. The results indicated that teams that underwent the intervention showed better surgical outcomes over those that did not (29). However, team coaching is supported by literature compromising the last 5 years and beyond, with fields like technology showing great potential in nurturing a team's overall health rather than a single aspect [e.g., Liu et al. (32); also see Fernández Castillo and Salas (33)]. Team coaching offers a powerful avenue to foster teamwork because it can tackle multiple teamwork competencies simultaneously (29, 33). We know that it can do three specific things (33): increase group effort (27, 32, 34), better interpersonal processes via improvements in psychological safety (19, 35), and lastly, increase team knowledge and learning (27, 36). By improving these things, general teamwork is improved. For example, if a team is failing because of a lack of information sharing (a facet of quality communication), improvements in group effort where people are encouraged to share can address this issue [see Körner et al. (27), who approach this issue via goal attainment]. Suppose a team is failing because people have information but do not feel safe speaking up. In that case, team coaching can alleviate this by creating a climate for safety where the internal leader establishes norms of respect regardless of medicinal hierarchies (33). We seek to highlight the fact that rather than focusing on communication or any other single teamwork competency, team coaching seeks to nurture team wellbeing as a whole and over time—leaving behind team leaders who can guide their teams without external intervention (27). Moreover, if implemented as more than a one-time intervention over the lifespan of healthcare practitioners' professional development, we could see other benefits, such as improving teamwork outcomes stemming from teaching leadership competencies in healthcare curricula (37). For this reason, we believe team coaching should be the avenue to fostering healthcare leaders, as by doing so, we simultaneously create a climate where teamwork is valued and fostered and where team members learn to communicate and *beyond*. We hope the next 5 years invest in team coaching as a TDI for leadership training, as gaps in the field (such

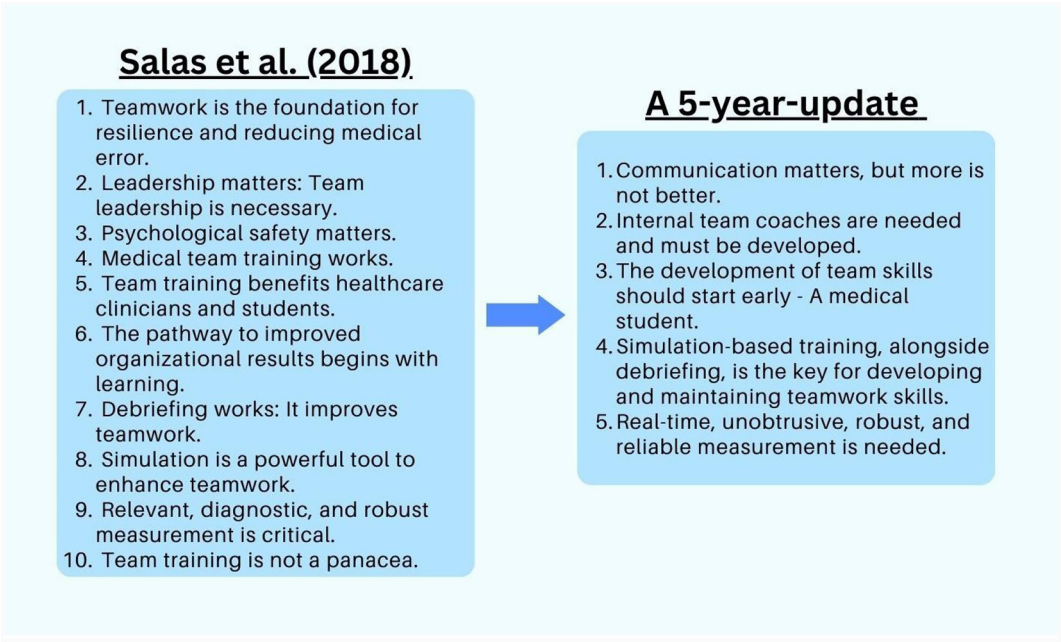

FIGURE 1
Holistic teamwork strategies.

as a lack of research with *ad-hoc* teams) are prominent and fruitful avenues of research.

4 Observation 3: the development of team skills should start early—A medical student

As observed in Figure 1, Salas et al. (1) offered the observations that team training works, benefits healthcare students and clinicians, and organizational results begin with learning. They noted that future research needed to focus on training sustainment and emerging teamwork modalities. This is more important than ever before, with some arguing that healthcare curricula as they stand today do not provide students with the competencies they need to be successful team players in the workplace (9, 14). Although training is an umbrella, we believe that team-based curricula can be a path to take, as they ensure that medical students have teamwork skills that are vastly important in healthcare (9).

During the last 5 years, the literature on team-based curricula and interdisciplinary education has flourished—representing a near quarter of identified literature (see Table 1). Most importantly, educators are continually encouraging the idea that healthcare education needs to be constructivist. Learners can take part in their own learning through methods such as SBT, which has shown to increase teamwork competencies (38, 39). Recent findings state that the most effective healthcare curricula are those that incorporate interprofessional simulation-based education [IPSE, Sezgin and Bektas (40)]. Alongside other types of interprofessional training (41), these methods provide students and clinicians the capability to learn to interact with healthcare professionals without compromising patient safety (42, 43). Moreover, the reason we believe team-based curricula is a holistic approach that allows students to grow in their teamwork abilities beyond and including communication—is that these methods provide students with social capital (44). As proposed by Burguess et al. (44), methods such as interprofessional team-based learning strategies allow students to build trust in their network, access and build resources such as knowledge and skills that each individual holds, and lastly, develop norms and rules for a team; which we believe can also aid in a team's coordination (18) and reflection capabilities (45). In other words, team-based curricula and interdisciplinary methods teach students to be well-rounded team members, not simply *communicators*. Though we do not believe team-based curricula is the end-all-be-all, a broad incorporation of team-based curricula can help healthcare practitioners develop teamwork competencies from the inception of their careers. This allows them to have built-in experience by the time they get to work on surgical teams, on research teams, and so on. Accompanied by other strategies, such as team coaching and continued SBT, it works to nurse teamwork competencies over time.

However, the literature has continued to emphasize that team-based curricula face the challenge that current healthcare structures do not support such interventions (46). While students like these approaches, some concerns are the lack of infrastructure for said interventions and the time required for implementing them (47). Notwithstanding, this should not dissuade hospitals, medical schools, and undergraduate institutions [see Kolbe et al. (48)] from aiming for an overhaul. While recent years have reiterated the challenge of incorporating these practices, the research continues to uncover that interprofessional methods yield significant results, such as improvements in shared decision-making and teamwork

competencies (49) and improvements in clinical skills and a sense of belonging in the workplace (50). Curricula that take these reforming steps, such as incorporating TeamSTEPPS into healthcare students' education, have already shown promising results (51, 52). In addition to this, some medical schools are already incorporating these findings into their educational structures. One concrete example is the multimodal curriculum TeamFIRST, which aims to equip students with ten teamwork competencies necessary for team-based, interprofessional care.[1] In this program, things like patient handovers are explicitly taught to students. TeamFIRST includes modules where students actively learn to communicate with their teams during handovers to improve patient safety. Students complete a simulated handover, practice sending and receiving information, and reflect on the experience to learn what can be improved.[1] Such techniques have resulted in better handoffs in perioperative environments (46).

Overall, a multitude of research supports teamwork curricula's ability to show improvements, such as increasing student teamwork competencies (52). Therefore, the last 5 years have left us with the following takeaway: in a world that increasingly requires more interpersonal skills as technology fills in technical ones, systems and critical thinking are necessities that interdisciplinary team-based methods can provide (53). We believe that if we are to move forward with a focus on training sustainment as remarked by Salas et al. (1), we need strategies from beginning to end, and team-based education provides the first step in doing so.

5 Observation 4: simulation-based training, alongside debriefing, is the key for developing and maintaining teamwork skills

Salas et al. (1) stated that debriefing works, and simulation is a powerful tool to enhance teamwork. The last 5 years of research support these observations, with many studies remarking on how SBT should be incorporated alongside team-based curricula (40). SBT provides realistic clinical scenarios that closely mimic the challenges and complexities students encounter in their actual settings, enhancing the probability of transferring learned skills to real scenarios (54, 55). However, the core element of SBT lies in debriefings, which enable structured feedback and reflection, enhancing patient care by providing controlled, planned opportunities for facilitator training (56–59).

Recent developments show that SBT has successfully increased teamwork perception levels (60) and enhanced interprofessional collaboration in post-anesthesia care units (43). Moreover, simulation allows team members to undergo conflict in real-time, which could increase their conflict management skills (14). This training also allows teams to maintain teamwork skills over time (61) and improve attitudes toward teamwork (62). While we face the continuing challenge of refining methodological design (55), SBT (alongside debriefing) is a holistic approach that allows teams to face problems repeatedly and without risk. This targets more than one team competency, allowing members to develop trust with each other and allowing for more efficient team functioning.

In a field short on time, with team training and education often being set on the back burner, it is tempting to try and use one-time interventions. While these can yield some improvements (and are sometimes a necessity), if we are to tackle deep-rooted issues, we have to approach problems as what they are: a web instead of a needle in a haystack. Focusing on these evidence-based strategies allows healthcare practitioners to become more well-rounded team leaders and members. Team-based education supports teamwork competencies through a healthcare practitioner's workplace lifespan; SBT allows student and clinician teams to work and fail together without the fear of harming patients; debriefs allow them to discuss learnings; and internal team coaches foster teams in action, making for a system that supports teamwork every step of the way. However, in order to strengthen these strategies, the aid of real-time, unobtrusive, robust, and reliable measurement is needed.

6 Observation 5: real-time, unobtrusive, robust, and reliable measurement is needed

In relation to real-time, unobtrusive, robust, and reliable measurement in clinical practice, progress is being made. There are several methods that can be utilized that support ongoing assessment and feedback to improve patient care. Examples of effective methods include direct observations of clinical encounters (DOCEs), event-coding, entrustable professional activities (EPAs), and behavioral markers of specific observable behaviors or action that serve as indicators of proficiency in a particular skill or competency (63–66). However, as some note, assessment tools rely on the assumption that team measurement is equivalent to adding individual performance together (67). In order to continue advancing the science of teaming, we must move past this and look at team systems holistically. Recommendations include studying methods that examine the team system as a whole. One is the Team Emergency Assessment Measure (TEAM), an assessment that moves away from the summative assumption (67). Yet, we need more studies that study methods like TEAM in distinct clinical settings (as TEAM has only been examined in emergency settings) as a "one-size-fits-all" approach is not recommended.

Effective design of team-based strategies is closely tied to sound measurement practices like those mentioned above. Akin to blaming communication for medical error as a one-size-fits-all response, tailored measurement is frequently overlooked when designing team interventions. Though typical, this "one-size-fits-all" approach is misguided, as individuals operate in diverse contexts and take on tasks of varying complexities throughout their career trajectory. Measurement should be rooted in an evidence-based model that targets the specific context and clinical area being examined (68) while continuing to place the team where it belongs: an intricate and never-isolated system.

1 Paquette S, Hernandez J, Preble R, Sadighi M, Kilcullen M, Hoffman O, et al. Team first: An innovative educational strategy for teaching teamwork competencies to health profession and medical students. (2023). Unpublished manuscript.

The gap between research and practice is well-documented but remarked for a reason: teams exist in the wild and not in a laboratory setting.

Healthcare settings are highly controlled environments regarding personnel, procedures, and protocols. Learning and development can be enhanced in such complex settings when individuals are provided with real-time, unobtrusive, robust, and reliable feedback. While we recognize that this research is expensive and time-consuming, we must expand our understanding of measurement and be willing to take on the challenge that teams do not exist in isolation because measuring them as if they do provides limited opportunities for our science. The last 5 years have not provided a significant comprehensive strategy to address this problem—and it may be another five before there are any comprehensive strategies to discuss. However, by pivoting research to enhance our understanding of design measures related to team performance, we believe we can better diagnose a team's root issues instead of attributing errors to "communication gaps" in the field. For this reason, we recommend focusing on strategies that foster teams while continuing to develop measurement strategies that look at them in their real-time context. This could mean using strategies such as DOCEs and making sure they are accurately contextualized with clinical environments and team- and organizational-level factors.

7 The next 5 years

The last 5 years have highlighted the resiliency of the healthcare field over a pandemic, fluctuating demands, and mass technological change. Notwithstanding, such events have highlighted the need for new methods. With healthcare burnout at an all-time high (69, 70), as well as a lack of psychological safety in the field (71), we need methods that work together and nurse systems as a whole. It starts with teaching students to be team players, allowing them to practice, measuring teamwork robustly and reporting results accurately, and coaching teams throughout their life cycle. Effective teamwork in healthcare requires a holistic approach beyond a focus on communication. Moreover, we must understand that communication itself is multi-faceted, part of a system, and should be treated as such. To address these issues, we highlighted five observations that need further improvement but show extreme promise: higher *quality* communication, team coaching, team-based curricula, and SBT, and continued reliable measuring practices. By implementing these strategies and considering these observations, healthcare teams can work toward improving overall teamwork competencies and ultimately enhance patient care and outcomes.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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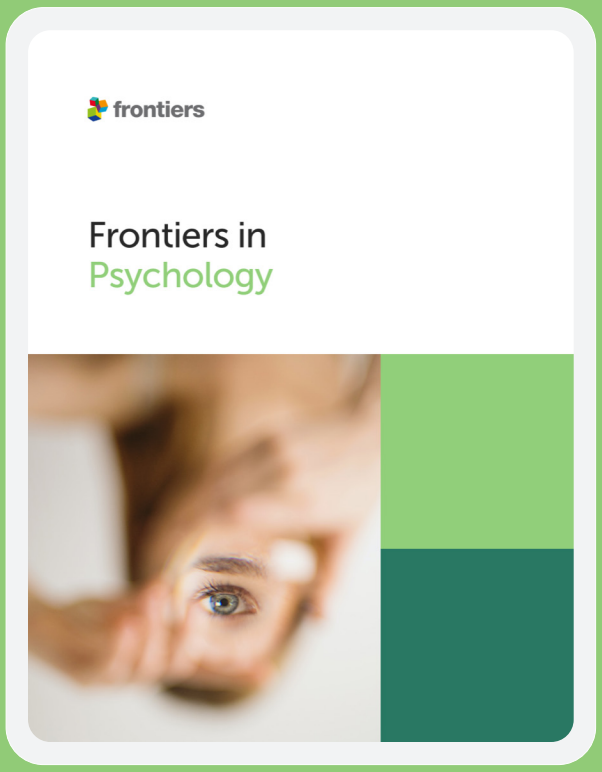

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Avenue du Tribunal-Fédéral 34
1005 Lausanne, Switzerland
frontiersin.org

Contact us

+41 (0)21 510 17 00
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