Current status of and future directions for assessing technology acceptance for digital (mental) health interventions

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Citation

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Editorial: Current status of and future directions for assessing technology acceptance for digital (mental) health interventions

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Editorial on the Research Topic
Current status of and future directions for assessing technology acceptance for digital (mental) health interventions

Digital mental health interventions (DMHIs) have become increasingly widespread over the last twenty years as they demonstrated promise in the prevention and treatment of common mental health issues in a variety of settings. However, adoption is still low in many countries despite policy-makerś efforts, such as approving digital therapeutics (DTx). Developing acceptance-facilitating interventions (AFIs) and customizing DMHIs to user needs depend on an in-depth understanding of individual innovation acceptance. In fact, a growing number of studies considered measuring user acceptance and its determinants as well as attitudes and preferences among key stakeholders prior the utilization of digital health services.

The goal of this Research Topic is to gather and present empirical studies on the state of technology acceptance research dedicated to theoretical frameworks such as the Unified Theory of Acceptance and Use of Technology (UTAUT) as well as future directions for user-centered DMHIs. These assessments not only include acceptance of interventions improving mental health across various application fields and populations but also perspectives regarding therapeutic relationships and human-computer interactions.

This editorial article outlines nine contributions collected for this special issue and their role in enhancing our understanding of technology acceptance. Grounded on both quantitative and qualitative research methods, the results revealed a complex picture of the acceptance of digital interventions by different target populations.

According to the survey by Kählke et al., university students clearly favored face-to-face treatment over both stand-alone and blended DMHIs, while they highlighted a moderate acceptance for DMHIs. Reporting a mental illness, believing in DMHIś efficacy, and not intending to use traditional services were linked to a preference for DMHIs.

Based on the UTAUT model, Staeck et al. demonstrated that two latent classes of psychotherapists in training may be distinguished according to the model determinants, namely Performance Expectancy and Effort Expectancy. Interestingly, these classes also differed in therapeutic orientation.

Mental health professionals' attitudes and concerns regarding mobile health were investigated by Dominiak et al. Prioritizing telepsychiatry was indicated by the majority of them, with a surge in interest during the COVID-19 pandemic. A quarter of them expressed concerns like challenges in precisely evaluating patients' conditions and technological issues.

This Research Topic comprised two randomized controlled trials (RCTs) on AFIs. Knauer et al., building on the UTAUT, examined the acceptability of smart sensing, acceptance determinants, and the efficacy of a video-based AFI in comparison to a mindfulness video. At baseline, smart sensing was moderately accepted. Acceptance was found to be determined by trust, social influence, and performance expectations. The AFI, however, had no significant influence on acceptance ratings.

Another UTAUT-based RCT was conducted by Rottstädt et al. on promoting smart sensing's adoption. In contrast to an active control group, the AFI consisted of showing a smart sensing video. Acceptance increased moderately in the intervention group. The main factors that determine acceptance were found to be Performance and Effort Expectancy.

Lastly, this Research Topic included four qualitative studies.

A focused ethnography on the implementation, acceptance, and use of modern nursing technologies was carried out by Klawunn et al. The authors discovered that a product's acceptance or rejection does not always correspond to its use. Users' approval of technology before it is implemented frequently takes the form of prejudice, but after they have some time to test it, their intention to utilize it can turn to sustained use.

The interview study by Posselt et al. on patients' attitudes towards and intention to use DTx for depressive disorders indicated that patients do not view apps on prescription as a replacement for face-to-face treatment in terms of performance expectancies. While general practitioners play a vital role through prescriptions, effort expectations encompassed both possible benefits and obstacles linked to technical, motivational, and skill-related components.

The qualitative study by Carlisle et al. examined online forums in an effort to help young people in rural areas become more resilient. Their findings indicated that online peer support forums help strengthen resilience and a sense of belonging, as they provide a virtual space for social connections, to share information, gain knowledge, and offer mutual support.

Finally, the qualitative study by Abi Ramia et al. investigated the feasibility and uptake of Step-by-Step (SbS), a DMHI for depression. Their results revealed high acceptability of SbS among users, but it also identified subgroups for which acceptance or use might be lower, such as older users and those with restricted access to the internet or smartphones.

Taken together, recent research shows that face-to-face interactions are still favored, whereas attitudes regarding DMHIs are becoming more positive. Innovation diffusion takes time and is context-sensitive. Acceptance appears higher among those who have already dealt with mental health issues or who believe in the added value. Besides structured programs, easily accessible online forums can promote mental health by providing peer support in young people. Professionals appear largely supportive of DMHIs, which have gained acceptance throughout the COVID-19 pandemic, although they are worried about various barriers.

Consequently, promoting the informed use of DMHIs requires the active participation and education of health professionals. In line with prior research, it was found that UTAUT determinants, particularly performance expectancies, alongside with other factors like trust, represent drivers of user acceptance. Under certain conditions, AFIs such as educational videos could increase the acceptability of DMHIs. Research also emphasizes the need to differentiate between early adoption and continued use, as well as the unique needs of different populations, varying in demographics and preferences.

As digital health continues to change the landscape of health-promoting settings, it remains important to comprehend how new technologies are viewed in order to assist their uptake. Gaining insight into the factors that influence the uptake and effectiveness of digital interventions could thus help reduce the gap between the demand and supply for personalized DMHIs while improving the access to both in-person and digital interventions. Expanding the scope of research beyond the UTAUT is essential for designing and disseminating user-centered interventions, especially in light of the interaction of individual, organizational, and environmental factors in technology acceptance.

Author contributions

JA-H: Writing – original draft, Writing – review & editing. GP: Writing – original draft, Writing – review & editing. SS: Writing – original draft, Writing – review & editing.

Conflict of interest

Publisher's note

Feasibility and uptake of a digital mental health intervention for depression among Lebanese and Syrian displaced people in Lebanon: a qualitative study

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Introduction: Digital interventions are increasingly regarded as a potential solution for the inaccessibility of mental health treatment across low-and-middle-income settings, especially for common mental disorders. Step-by-Step (SbS) is a digital, guided self-help intervention for depression found effective in two Randomized Controlled Trials (RCTs) in Lebanon. For research implementation and further scale-up, this paper reports the results of a qualitative evaluation of SbS among the Lebanese and others and displaced Syrians in Lebanon.

Methods: Thirty-four Key Informant Interviews (KIIs) were executed with participants of the RCTs, SbS staff members, and external stakeholders. Questions garnered feedback about the feasibility, acceptability, enabling factors, and barriers to adhering to the research, implementation, and the SbS intervention. A thematic analysis was conducted using NVivo, and key themes, topics, and recommendations, on research methods and the intervention itself, were generated and reported.

Results: Results showed a high level of acceptability of SbS among Lebanese and Syrians and identified sub-groups for whom acceptance or use might be lower, such as older adults and people with limited access to the internet or smartphones. Furthermore, interviews identified the main enabling factors and barriers to adherence related to the research design, content, and delivery approach. Barriers related to feasibility included lengthy assessments as part of the RCTs, and mistrust related to delays in study compensations. Other common challenges were forgetting login credentials, poor internet connection, being busy and competing needs. Enabling factors and best practices included motivating participants to use the intervention through the weekly support provided by helpers, setting an oral contract for commitment, and dividing the compensations into several installments as part of the RCTs. Recommendations regarding sustainability were given.

Discussion: The findings show that overall, SbS is feasible, acceptable, and much needed in Lebanon among the Lebanese and Syrians. This assessment identifies reasons for low adherence to the research and the intervention and presents improvement solutions. Recommendations generated in this paper inform the upscale of SbS and the planning, design, and implementation of future digital interventions in research and service provision settings in the mental health field.

Introduction

Digital mental health interventions are increasingly regarded as a solution to the global inaccessibility of mental health treatment (1). They present an accessible, scalable, and practical medium for care delivery at a low cost (2). The burden of disease associated with mental health conditions is highest in Low and Middle-Income Countries (LMICs) where previous estimates suggest a large mental health treatment gap of ∼75% among adults (3). LMICs could benefit from digital mental health interventions, considering the high demand and the widespread use of smartphones and the Internet (1, 4, 5).

Strong evidence exists around the effectiveness and cost-effectiveness of digital mental health interventions (6–9). Nevertheless, there is a dichotomy between the promising evidence for these innovations and the low uptake observed among users (2, 10). Challenges to their uptake are often observed during the research phases, including low adherence to treatment among research participants, decreased completion rates at the post-assessments, and high dropout rates during research trials (11, 12). Meta-analyses showed that the average attrition rate was 57% for computerized mental health interventions; non-adherence, including dropout from the treatment or non-completion of assessments, ranged from 28% for therapist-guided digital interventions to 74% for unguided interventions (13). This high attrition could risk underpowered studies, affect the validity of the effectiveness studies, or it might indicate a low uptake in the community upon scale-up (11, 14, 15).

A few implementation studies investigated the reasons for attrition and low adherence to digital interventions in high-income settings. Reasons were categorized into intervention-related and user-related. Intervention-related reasons included poor usability of the intervention, cultural irrelevance of the content, bugginess, limited usefulness in emergencies, and time required to sign up and enter data. User-related reasons were a lack of motivation associated with depression, lack of trust or perceived benefit of the digital treatment, security and privacy concerns, losing interest, and low health literacy (2, 11). Nonetheless, little is known about the factors that may promote the uptake of digital interventions in research and real-life implementation and integration into existing health systems (3, 16). Furthermore, little is known about their uptake in LMICs and the reasons and solutions for dropout among populations affected by adversities (3); hence the need for

implementation and attrition studies to understand the barriers to adherence and enabling factors for the uptake of digital mental health interventions in LMICs.

The World Health Organization (WHO) has developed a set of scalable interventions to address common mental disorders. One of these interventions is Step-by-Step (SbS), a 5-week guided self-help intervention for adults experiencing depression. It includes a narrated story, a set of techniques and exercises to reduce depression symptoms, with minimal remote support by trained non-specialists called "e-helpers" (17, 18). SbS was developed, culturally adapted, and pilot tested by WHO and the National Mental Health Programme (NMHP) in Lebanon among the Lebanese population and displaced Syrians (19–21). A feasibility randomized controlled trial (RCT) (22) followed by two fully-powered RCTs assessed its effectiveness and cost-effectiveness in the local setting (23, 24). The intervention group had access to the SbS intervention and weekly e-helper support. The Enhanced Care As Usual (ECAU) group received access to one page of psychoeducation on depression and anxiety, a referral list to primary healthcare centers, and the national lifeline for emotional support and suicide prevention (21). Quantitative results showed that the SbS intervention is an effective and cost-effective treatment for depressive symptoms, functional impairment, and anxiety. These results informed the decision to scale it up into a national service in Lebanon; The average dropout rates reported during the RCTs at post-assessments were high, 46.2% for Syrians and 65.1% for Lebanese (23, 24). Hence the need to investigate the reasons and solutions for the high attrition encountered during the trials.

Lebanon is a middle-income country with political turmoil and a fragmented healthcare system further strained by the influx of more than 1.5 million Syrian displaced people in the past 10 years (25). In 2006, the gap in mental health treatment was ∼90% (26, 27). Since 2020, and in conjunction with the study implementation, the country has been struggling with a humanitarian emergency caused by severe political, economic, and financial problems. Additionally, COVID-19 regulations and the widespread street protests that erupted in 2019 further exacerbated the situation. In August 2020, an explosion at the Port of Beirut killed more than 200 persons, injured thousands, and critically damaged the healthcare sector, according to WHO reports (28), The systemic failures and the multilayer crises deteriorated the mental wellbeing of the population to a great extent and increased the need for nationwide mental healthcare interventions.

In this qualitative study, we aimed to assess the acceptability and feasibility of using SbS in Lebanon and investigate the reasons and solutions for dropout from the lens of the users, staff, and stakeholders. We looked into the challenges faced during the research trial, the best practices, and the recommendations for scale-up. They were examined from a multilevel perspective: content-wise, delivery approach, research methods, context-related factors, and scale-up plan. Throughout this evaluation, we aimed to answer the following research questions: (1) Is SbS considered acceptable, relevant, and beneficial among Lebanese and Syrian populations in Lebanon? (2) What are the promoting and hindering factors that affect the success of the SbS research and intervention uptake in Lebanon? (3) What are the challenges and recommended modalities for sustainability in Lebanon?

Findings should inform the upscale of the intervention into a national service beyond the scope of the research and guide the design and implementation of similar interventions worldwide.

Methods

The intervention

Step-by-Step is a brief 5-week digital, guided, self-help intervention for adults with depression, delivered through an application or a website, with a minimal 15-min a week of remote guidance provided by trained non-specialists called e-helpers (18, 29). SbS comprises core strategies, behavioral activation, stress management, problem management, increasing social support, and relapse prevention techniques. The techniques are delivered through narrated story-based weekly sessions and practical exercises, which are audio recorded and available in English and Arabic. Participants get to practice activities between the sessions, such as grounding and slow breathing exercises, scheduling activities using an online calendar, a gratitude list exercise, a mood tracker, and simple self-care, while more complex activities should be split into smaller steps. They receive brief, maximum 15-min weekly calls, or messages from e-helpers. E-helpers are supervised non-specialists trained to provide emotional support and motivation throughout the program (18). E-helpers follow preset support templates, guides, and protocols to deliver their service. In an introductory call, they set an "oral contract" with participants to motivate them to respond to their contacts and to commit to the sessions and activities to maximize their benefits. E-helpers then follow up with them weekly, as per the agreed method of contact (phone call or message support).

SbS was tested and delivered by NMHP at the Ministry of Public Health in Lebanon. One thousand two hundred and forty-nine participants were recruited through social media and outreach methods and were included in the study upon completing online self-assessments and scoring above the cut of score on depression and functioning (37, 38). Recruitment took place between December 2019 and June 2020.

Data collection and procedures

We conducted 34 Key Informant Interviews (KIIs) with study participants, SbS staff, and external stakeholders between

TABLE 1A Overview of key informant study participants form the intervention group stratified by different stakeholder groups, study groups, completion status, nationality, and sex.

	SbS Intervention group participants interviewed (n = 14)	
	Completed SbS (n = 10)	Dropped out SbS (n = 4)
Age, M (SD)	Mean 30.1 (7.47)	Mean 34.2 (10.78)
Sex, n (%)	Male = 3 (30%) Female = 7 (70%)	Male = 2 (50%) Female = 2 (50%)
Marital Status, n (%)	Single = 3 (30%) Married = 7 (70%)	Single = 2 (50%) Married = 2 (50%)
Nationality, n (%)	Lebanese = 2 (20%) Syrian = 8 (80%)	Lebanese = 1 (25%) Syrian = 3 (74%)

Dropout: study dropouts who either proactively asked to be dropped out or discontinued and did not complete the post-assessments. It's noteworthy that all the dropouts interviewed were also intervention dropouts and didn't complete the sessions.

TABLE 1B Overview of key informants stratified by different stakeholder groups, positions, and sex.

	SbS project staff and external stakeholders interviewed (n = 20)	
	SbS project staff (n = 7)	External stakeholders (n = 13)
Sex, n (%)	Male = 2 (29%) Female = 5 (71%)	Male = 3 (30%) Female = 10 (70%)
Organization	National mental health programme	National mental health programme United Nations high commissioner for refugees World Health Organization Lebanon ACTED Lebanon NGO International medical corps ABAAD - Resource Center for gender equality Syrian facebook group
Position	Project coordinator Clinical supervisor E-helper	Head of program Found and director Operations manager Service development coordinator Advocacy and policy coordinator Protection advisor Protection officer National officer for noncommunicable diseases and mental health Mental health coordinator Facebook group admin

September 2020 and January 2021. Out of the 34 KIIs, we held 14 KIIs with study participants in the intervention group who were selected following a stratified random sampling method. All participants were asked for consent to participate in the interviews by their corresponding e-helpers upon completion or dropout (Supplementary material 1). We then stratified participants by gender (male/female), nationality (Syrian/Lebanese and other populations residing in Lebanon), completion status (completer/drop-out), and preferred support method (message/call). It is noteworthy that 14 participants from the ECAU group were interviewed to understand about their perspective on the research and potential reasons for dropout or motivators for adherence, yet were not reported in this paper as the main focus is on the intervention adherence. Using the SPSS software,

we automatically generated a random sub-sample of individuals for every variable above, and we reached out to the participants identified for an interview. All seven SbS staff members, five e-helpers, the project coordinator, and the clinical supervisor (both referred to as supervisors in the results for confidentiality), were included as key informants. For the external stakeholder group, we selected 13 key informants by convenience. These were partnering with non-governmental organizations (NGOs), project counterparts from NMHP and WHO, and outreach Syrian volunteers, who were part of the project's steering committee or helped disseminate SbS among their networks. The steering committee members contributed to designing and planning the RCTs and the SbS content through binary meetings. The e-helpers contacted the external stakeholders by phone, email, or chat, and received their consent to be contacted and interviewed. Table 1A details the distribution of study interviewees across genders, age, marital status, and nationalities. Table 1B details the information on the steering committee stakeholders interviewed by organization and position. Organizations and positions were not specified in the results to maintain confidentiality, rather referred to as external stakeholders.

The project coordinator and clinical supervisor conducted in-depth interviews with the participants. An independent researcher (co-author), not part of the SbS management team or the original research trials, interviewed the study team to limit bias, as e-helpers interviewed the external stakeholders. All interviewers received a 1-h training on the semi-structured interview guides with open-ended questions. Interviews with SbS staff were conducted face-to-face, while those with participants and external stakeholders took place over the phone. Interviews lasted 45 min on average, all interviews were audio-recorded. The project coordinator and the independent researcher transcribed and translated them into English.

For stakeholders, a semi-structured interview guide with 13 open-ended questions explored their general feedback on SbS, the degree of acceptability and relevance of SbS to the different cultural groups in Lebanon, and its ease and feasibility. Furthermore, the guide explored unforeseen implementation challenges and recommendations for future integration into the healthcare system in Lebanon (Supplementary material 2).

For project staff, the guide consisted of 16 questions. They explored their general experience with SbS, rapport with participants, observed reasons for attrition and solutions to improve adherence, and recommendations on managing their workload, management system, supervision modality, and retention (Supplementary material 3).

The interview guide for study participants included 20 questions that examined their overall impressions on participating in the SbS research study, using a digital mental health intervention, and its perceived benefits. Questions also assessed SbS's feasibility and acceptability in Lebanon. Additionally, feedback and suggestions for improvement were collected on the content of the intervention, the rapport with the e-helpers, the registration process and assessments, and barriers and enablers for adherence to the study and the intervention (Supplementary material 4).

The first author conducted a thematic analysis of the transcripts using Nvivo 2017, following the framework approach.

This approach consisted of following pre-set themes that were generated from the interview guides, familiarizing oneself with the interview transcripts, and generating emerging codes under each theme (39). An independent researcher (co-author) who had conducted interviews with e-helpers then carried out random checking of the coding on a sample of the interviews and confirmed the validity of the codes and the thematic tree created. Key informant sub-groups were analyzed separately, data was triangulated to report commonalities and divergences in responses, and the final results were cross-checked between the two researchers. The participant subgroups were analyzed individually, before triangulating the data across groups to identify common themes and compare between the different groups. Figure 1 presents the thematic tree generated following the qualitative analysis.

Results

Acceptability

Acceptability was defined as the extent to which people would accept taking part in a research project, receiving online treatment, and committing to the notion of self-help for improvement. Overall, there was consensus among the 34 key informants that the SbS intervention was much needed, beneficial, practical, and culturally relevant for the different populations in Lebanon (Lebanese, Syrians, and other populations residing in Lebanon). Many found it innovative in the Arab context, especially considering the global shift toward online treatment post-COVID-19 pandemic. At first, three staff members displayed skepticism about the acceptability of this self-help digital intervention in Lebanon. Nevertheless, it became evident to them throughout the research that people accepted and benefited from the service. All seven staff members were confident that the SbS project could be well-received in Lebanon. They listed several promoting factors for the acceptability such as SbS provides an affordable and practical solution to the increasing demand for mental health services, there's a general acknowledgment and normalization of mental health, which enhances the help-seeking behavior of those in need, people are more sensitized and used to internet interventions, especially after COVID-19 pandemic, which makes it easier for them to accept the self-help digital intervention, and SbS ensures the confidentiality and privacy of users amidst the prevailing stigma around mental health. This last point was highlighted by the study whereby stigma was reported as a prevailing barrier among key informants; almost half of the study participants interviewed didn't disclose to anyone that they participated in SbS due to fear of being stigmatized.

Relevance to the target population

It was generally believed among all respondents that all cultural groups could relate to SbS and find it acceptable for them to use a digital mental health intervention. Yet, external stakeholders specified different levels of acceptability among population groups.

FIGURE 1
Thematic tree of the Step-by-Step qualitative evaluation analysis.

FIGURE 2
Quotes from key informants on the acceptability and relevance of Step-by-Step in Lebanon.

They noted that young adults and the tech-savvy would be more accepting of SbS than the rest. Additionally, some external stakeholders thought that displaced Syrians would accept SbS more than the Lebanese because the former are more exposed to mental health awareness and services through the humanitarian NGOs working in the field. On the other hand, four Syrian external stakeholders noted that it might take some time before the displaced populations accept such interventions delivered by the Ministry of Public Health due to the mistrust in applications and the government's intentions and agenda. Two external stakeholders believed that SbS would not be relevant to the older adults, people with low technological literacy, displaced populations with low literacy levels, migrant workers due to language barriers, people having intellectual disabilities, and people with impaired vision or hearing. Only one external stakeholder was skeptical about its uptake among people with depression because people living in difficult and worsening situations would be looking for solutions whereas the program did not offer solutions but rather techniques to cope with difficult symptoms. Figure 2 summarizes quotes on the acceptability, and relevance of SbS.

Satisfaction

Expectations

All 14 key informants in the participants' intervention group were satisfied with SbS and conveyed that it was up to or exceeded their expectations. Some revealed that they didn't have any expectations or thought at first it was spam but were then amazed by the benefits of this program. Most key informants valued confidentiality, credibility, and e-helpers' support. Only a few thought that face-to-face support would be more effective for some, while one was concerned that SbS might not be helpful due to the severity of the contextual problems experienced that highly impact the severity of the depressive symptoms. When asked about the underlying reasons for signing up for the SbS program, study participants' responses included shock experienced following the Beirut explosion, struggling with the deteriorating financial situation and unemployment, lack of services available, fear of contracting COVID-19 in face-to-face support, divorce, and rape by their husband.

Intervention content
Story and illustrations

All key informant study participants in the intervention group liked the story and related to the characters and the realism of the events and symptoms. Most of them appreciated being able to select their preferred character and storyline. The cultural relevance of the characters, illustrations, and storylines was highly praised by most respondents. E-helpers also confirmed that their users conveyed, during support sessions, that they benefited from and enjoyed the story content and illustrations and found them very relatable.

Several areas of improvement were identified by the e-helpers and participants. Two e-helpers considered the illustrations to be a bit childish although no negative comments were received from the participants on this matter. E-helpers also felt that repetitiveness in the storyline would be a barrier to adherence to the program, especially for people with depression. One e-helper felt that the Syrian users had more serious problems than the story could offer. For example, one Syrian female participant couldn't relate to the social support exercise as she expressed that women in Arab culture are taught to keep their feelings to themselves and not reach out for help or cry in front of anyone. Another Syrian participant felt ashamed to share her feelings but was relieved to find them in the story.

Two e-helpers mentioned that users preferred and applied the sessions that included fewer and simple exercises, while those that included multiple exercises and more complex and social activities were reported to be overwhelming, especially to those with social anxiety.

Activities and tools

Most of the study participants interviewed and all e-helpers conveyed that their favorite exercise was "slow breathing" because it was easy to implement and had direct and tangible benefits on users. Participants reported that they practiced the breathing exercise before sleeping to help relieve their anxiety and insomnia, while others used it to calm down when distressed upon encountering a stressful event. Both males and females resorted to it to manage their stress and anger during COVID-19 quarantine times. One participant voiced that the exercise was difficult to apply at first, but with practice, it became easier.

The second most preferred feature, according to most key informant participants, was the "mood tracker," which was described as a friendly way to track and notice their feelings and mood. Most users adhered to it regularly after receiving the push notifications or even without any reminders. They noted down all their moods by selecting the relevant emojis, whether happy, sad, or angry, while a few said that they didn't use it when feeling down or angry.

Among other preferred activities were the "small self-care activities" exercise (e.g., walking, drinking tea, listening to music, etc...), the "gratitude list" (list of the things in life one is grateful for), and "the positive self-talk exercise" (being kind to oneself and avoiding self-blame through encouraging words). The benefits of these activities were sensed by some participants only after finishing the program, or upon being subjected to negative talk by their surroundings. Other study participants reported benefiting from the "listing the warning signs" activity, especially among those who experienced burnout in their jobs. Only one key informant participant mentioned that he didn't use the gratitude list because he didn't understand what to write in it.

The exercise for helping the management of more challenging regular tasks, which consisted of dividing a "big task" into small steps and planning and scheduling them in a calendar, received mixed reviews from key informant study participants. Some revealed that they learned how to divide big tasks into smaller steps and plan for them ahead of time, whereas others found it difficult to apply. Participants who used to be active or had a hobby in the past found it easier to regain their activity than those who had to integrate a whole new activity into their daily life. Suggested complex activities were thought to be overwhelming and time-consuming or not feasible during COVID-19 times as most of them entailed outdoor activities. Nonetheless, some users valued their importance once they had finished the program.

Features

The audio recording feature of the intervention (the application content was fully audio recorded) was considered an important feature by almost two-thirds of the key informant study participants who used it. They reported that the recordings helped them stay focused, engaged, and interested in the program, they calmed them down and made them feel that the intervention was more personalized and humane, and they were very convenient for those who couldn't or didn't like to read. Among those who didn't use the audio feature, the common reasons reported were privacy concerns and not wanting anyone to listen, a matter of preference and better focus when reading, or because they assumed it would be a voice of a robot and not of a real person. Figure 3 reports quotes on satisfaction with Step-by-Step.

Delivery model

Support provided

All 14 key informant participants from the intervention group appreciated the support provided by the e-helpers and considered it an important motivation for them to complete the program. The majority mentioned that they wouldn't have benefited as

FIGURE 3
Quotes from key informants on satisfaction with Step-by-Step.

much from the intervention without the e-helper support. This was validated by most of the staff. Participants especially valued the great listening skills, the problem-solving approach, the safe space provided, and the punctuality of e-helpers. All key informant participants in the intervention group thought that SbS wouldn't work properly without the e-helpers' support because it would be too impersonal. According to one of the supervisors, the specificity of the culture in Lebanon promotes the e-helpers' role because people need to talk to someone about their problems and this is by far their preferred component. Overall, key informant participants were satisfied with the time and frequency of the support which was 15 min per week.

E-helpers' training, management, and supervision

E-helpers viewed the 5-day training received at the beginning as very beneficial yet condensed. Nevertheless, they reported that the training content about depression and the therapeutic approaches was found to be generic and not tailored enough to the realities of the local context. The preparatory phase, in the beginning, consisted of ∼300 h (1½ months) of on-the-job role plays, trained to use the protocols and the support templates. It was reported to be crucial in equipping them with the knowledge and skills needed to provide support. Work protocols were comprehensive yet lacked a section about implementation changes and potential risks encountered in the local context.

As for the caseload and work modality, e-helpers conveyed that their workload fluctuated starting with peaks followed by low periods, based on recruitment rates of participants. They considered the 4-h shift a fair amount of time to support six participants instead of eight, as originally designed. E-helpers reported that on average they needed more than the allocated 30 min to support every person and write the case notes, and to have some spare time to prepare for their support contacts and conduct administrative tasks. Additionally, e-helpers preferred to work from the office instead of from home during the COVID-19 pandemic because they benefited from face-to-face peer support and knowledge exchange. They felt a sense of belonging which

increased their motivation to work. As for the duration of the calls, it was noted that at the beginning, calls and messages took much longer than 15 min (~30 min to 1 h). Nonetheless, with training and further refining of the support messages templates, e-helpers were able to stick to the time range. Everyone agreed that 15-min a week was very adequate for this type of support.

With regards to management and supervision, e-helpers reported that the weekly group supervisions were very beneficial whereby they allowed information exchange with the circular round of feedback. Two e-helpers suggested that the supervision could be improved by in-depth discussions of one or two cases instead of covering all cases during every meeting. They also suggested getting optional individual supervision occasionally. The two supervisors mentioned that fidelity checks, weekly meetings, one-on-one calls, and reviewing case notes and messages were all very important for quality assurance and performance improvement. Similarly, the very safe and open work environment fostered a constructive learning space for team members. For the supervisors, the main challenge encountered, in quality assurance and conducting fidelity checks, was when it was done remotely over the phone during the COVID-19 pandemic (when e-helpers worked from home). Several challenges impeded the proper supervision of the calls such as internet problems and time conflicts between the clinical supervisor and the e-helpers' contact sessions.

Uptake

Intervention usage and adherence

Most of the key informant participants in the intervention group disclosed that they had used SbS either every day or two to three times per week at the most. Participants mostly used it at night before sleeping or in the morning upon receiving a notification to input their mood. Two participants mentioned that they opened the app whenever they felt upset. One participant revealed that she didn't use SbS much at first but then when she noticed her improvement, she started using it more often, around three times a week. Another person still revisited the story after completing the program while all the other informants mentioned that they still applied the "slow breathing exercise," the simple "self-help activities," and the "behavioral activation techniques" in their everyday life.

Barriers of adherence
Intervention usability

The most common issues raised by the study participants, confirmed by e-helpers, were struggling with the slow internet, difficulty in setting their username and password, forgetting their passwords after logging out, the two-step authentication, lack of space to download the app, forgetting to log in upon turning off notifications in the app, changing phones, forgetting how to download the app (mostly among Syrians), and having old phones (which caused problems with the SbS software). E-helpers also mentioned that the technical issues and bugs faced at the beginning of the trial were impeding their work. They reported that it was very time-consuming for them to test and report these bugs, and

to tailor their support templates to clarify all this to the users. One e-helper mentioned that some population groups encountered more difficulties while using the app than others, namely the Syrian population and older adults. E-helpers found that the back-end office of the platform was not very easy to use, and two staff members were concerned that the app would be easily outdated as compared to apps developed in the private sector. E-helpers also noticed that users who chose message support became more inactive and unresponsive as compared to those who opted for phone calls. This was validated by one participant who stressed the importance of phone calls for motivation, engagement, and effectiveness of support compared to messages.

User-related barriers

Among the intervention group, the vast majority of the key informants as well as the e-helpers mentioned that they dropped out because of their busy lifestyle. One user who completed SbS revealed that she was about to drop out but she motivated herself to continue, while another speculated that some people might just feel better and discontinue for that reason. Staff members considered the main inhibitor to users' adherence was signing up for the wrong motives such as getting compensation instead of getting treatment.

Enabling factors
Intervention design and engagement

Among the main enabling factors for using SbS mentioned by key informant participants in the intervention group, were the simplicity and user-friendliness of the app/web design, the soothing and relaxing colors, the diversity of the characters that users could relate to and identify with, and the very fast response to any technical problems encountered. Furthermore, the engagement through push notifications and the mood tracker served as reminders according to most intervention group key informants. Most Lebanese participants and staff mentioned that the calls and WhatsApp message reminders from e-helpers helped them to adhere to the intervention. Another factor mentioned by the staff was the "oral contract" that was set between the e-helpers and the intervention group participants, where the latter pledged to commit to the program and not exceed the limited number of contact sessions.

User-related factors

A small minority of the respondents, both from the Lebanese and Syrian groups, attributed their retention to their inner motivation and their perceived benefit of the free treatment.

Research procedures

The financial compensation for participating in the research was mentioned as a very effective incentive among most Syrian respondents and one Lebanese respondent. Furthermore, most respondents highly valued dividing the compensations into three installments instead of handing them in one bulk at the end of the research, as was done in the previous research phases.

Figure 4 details quotes about the delivery model and the uptake of Step-by-Step.

Delivery model:

E-helpers' support provided:

➢ "By the third time, I was eagerly waiting for her call. I liked that she listened a lot and supported me in my thinking and decision-making process" (Intervention, Female, Syrian).

➢ "Very few users will benefit from the stand-alone application" (e-helper 1).

Training, management, supervision:

➢ "I think the initiation phase was really good preparation because of all the role plays we did which were great. I think all volunteers or interns should get a month of initiation, like we did." (e-helper 2)

➢ "When we started, calls used to take 30 minutes and messaging would take an hour or two (to fix the template, answer, and so on). When we created templates for everything and when the templates had been amended, it started taking me 6 minutes to fill in the blanks and send my messages." (e-helper 1)

➢ "You sometimes feel that you do not have a specific user that you want to speak about or that there is a specific problem that you need help with." (e-helper 1)

Uptake:

Intervention usage and adherence:

➢ "At first, not much because I wasn't convinced. Then when I felt sad.. but after 2 weeks, I felt I was making progress and I was learning. I felt that someone was helping me. So I used it 3 times a week" (Intervention, Female, Syrian).

Barriers:

➢ "I liked the program a lot and I benefited from it a lot. I did 3 sessions and I stopped because of a lack of WIFI. For a while, I used to go to my neighbour to use the wifi but then I couldn't" (Intervention, Female, Syrian, Dropout).

Enabling factors:

➢ "Receiving a call from the e-helper is key. When I downloaded the app I filled in the basic information then I forgot about it; until the e-helper called me a week later. I got motivated. I committed" (Intervention, Male, Lebanon).

➢ "I know many users because they received the "mood input" notification were more inclined to adhere, and use the app" (e-helper 2)

➢ "Syrians especially preferred the WhatsApp reminders to the chat reminders. We then realized that most participants that did not answer through the app, because they couldn't log in anymore" (e-helper 2).

FIGURE 4
Quotes from key informants on the delivery model and uptake within Step-by-Step.

Sustainability of the service

E-helpers' modality

Key informant staff and external stakeholders were asked about their perception of the sustainability of the e-helper's modality in the long run, beyond the research setting. About half of the staff members envisioned that the volunteering system could work with the creation of a flexible shift schedule, thorough supervision, a culture to promote humanitarian values, a sense of belonging, and a focus on professional development. A minority of staff thought

Sustainability:

> ➢ "My feeling is that in terms of volunteering positions, it's quite difficult and could lead to more burnouts. It could work if the position is more of an internship for psychology students." (e-helper 2).
> ➢ "It's better to publish it by a governmental institution so that it can be something official." (Syrian stakeholder)
> ➢ "The biggest challenge is to spread awareness and help people understand mental health more. Once we achieve this step, everything else become easier." (Syrian outreach volunteer)

FIGURE 5
Quotes from key informants on the sustainability of Step-by-Step.

that a volunteering e-helper model would not be sustainable because it would be too draining for e-helpers and would require commitment. Another small proportion of staff suggested an internship model whereby university psychology students could be e-helpers who complete a certain number of hours in the SbS program. With regards to the internship model, one supervisor raised concerns that interns might be more motivated to fill the required number of hours for their credits than provide support to users and that there might be confusion between clinical work and basic support, especially if the interns are psychology students.

For all external stakeholders, the volunteering model was thought to be problematic because of the high risk of turnover which would jeopardize the continuity of care provided within the SbS service. Also, the e-helpers shift times are within normal working hours which might pose a limitation for the volunteers to find other jobs and hence increase the risk of turnover.

Challenges of sustaining Step-by-Step in Lebanon

External stakeholders considered the feasibility of scaling up and sustaining SbS in Lebanon using two different angles: contextual and project-related. Contextually, SbS was deemed feasible and practical to use even in the most remote settings because of the flexibility it allows in terms of time and place of usage. Nevertheless, some mentioned that the difficulty to secure an internet connection or access to smartphones, among people of low economic status or living in rural areas, might pose a barrier to downloading the application, noting that using it doesn't require internet access all the time. Other challenges listed by stakeholders were stigma, lack of awareness about mental health and self-care, the possible resistance to receiving online support, and the competing priorities related to livelihood.

Project-related challenges included difficulty in securing funding to run the intervention in the long run and to sustain the e-helper service with the high turnover expected. Additionally, there was a risk foreseen by some external stakeholders related to the surge of competing self-help programs that would be launched before scaling SbS. Furthermore, Syrian outreach stakeholders raised a concern about the absence of monetary incentives for users upon scale-up which might demotivate people to sign up or

complete the intervention. Instead, they proposed focusing on the gained benefits of this intervention. Quotes on the sustainability theme are reported in Figure 5.

Discussion

This qualitative assessment evaluated the acceptability, relevance, feasibility, and uptake of the digital mental health intervention SbS in an LMIC, Lebanon, among the Lebanese population, and the displaced Syrians. Promoting factors and barriers to the uptake were explored and recommendations of the content, delivery approach, research methods, and implementation beyond the research setting were generated. The most important findings are discussed below.

The first research question was about assessing whether SbS is considered acceptable, relevant, and beneficial among the Lebanese and Syrians in Lebanon. It was evident throughout this qualitative assessment that this was true for the Lebanese and the displaced Syrians with depression. With the deteriorating mental health of the population at large, due to the multiple humanitarian and economic crises and the worsening living conditions in Lebanon, the need for accessible, feasible, evidence-based, and free-of-charge mental health services is evident. Refugees in particular are highly prone to distress and common mental health disorders due to the displacement and stressors they endure (30, 31). Findings suggest that SbS might address some of the core barriers to seeking adequate mental health care among the displaced and host populations. It created access for people who would normally not have been able to get treatment due to stigma, lack of services, increased poverty levels, social distancing regulations, and the fuel shortage crises (23, 24, 32). As discussed by key informants, SbS was expected to tend to the needs of a big portion of the population such as young adults, the tech-savvy, the literate, and those with access to smartphones. It was also expected to be more acceptable and trusted by those who are exposed to mental health awareness, hence the need to increase mental health literacy among those residing in Lebanon to promote the acceptability and uptake of digital interventions (2, 11). Nonetheless, there is no "one solution fits all," and digital interventions will not be accessible to everyone.

It is thus recommended to integrate SbS in a system with a mix of evidence-based services in face-to-face format or other outreach methods and material, accessible to those who don't use the digital platforms for treatment.

This paper also sheds light on the exercises and features that were mostly accepted, perceived as beneficial, and feasible to apply by the participants. Straightforward techniques seemed to be more accepted than more complex and multi-step exercises among Lebanese and Syrian participants of the SbS intervention in Lebanon. Participants found those exercises easy to grasp and apply and were able to see tangible and direct benefits after practicing them. Those exercises included small "self-care activities," the "breathing exercise," a "gratitude list," and "positive self-talk."

In contrast, managing the "more challenging daily activities" that included several smaller steps and layers, the calendar scheduling, and the social activities that involved effort and reaching out to others, were perceived as more complicated to apply. These findings are relevant to consider when designing digital self-help treatments as they could impact the usability of the intervention, and the motivation to complete it (2, 11).

Another important consideration regarding the usability and uptake of digital interventions is that the real impact might be difficult to track or evaluate. Many users mentioned that they didn't input their activities online as some found the calendar and the interactive part of the platform complex. This was validated by the usage metrics generated in previous research phases, where most respondents didn't input the challenging daily activities into the online interactive platform (22). Yet, throughout this evaluation, we learned that some used these techniques offline on their personal agendas or offline calendars or implemented them in their daily life after completing the program. This finding suggests that there might be a greater impact of digital intervention on users that is not properly depicted in quantitative studies or in the dropout rates reported as it cannot be documented in the application. It further suggests the importance of understanding existing user behavior and ensuring applications are as user-friendly and easy to use as possible.

The second research question focused on assessing the uptake of SbS in Lebanon and uncovering the main enabling factors and barriers for retaining participants in the research study and preventing further dropout from the intervention. High dropout is not a unique problem to SbS; research highlights the low uptake of digital interventions and smartphone apps despite the wide use of smartphones and the internet globally and in LMICs (1). Studies have shown that dropout rates can reach up to 52% during sign-up to digital interventions, 78% during the treatment phase, and 18% during follow-ups (12). SbS was not an exception, with high dropout rates, of 46.2% for Syrians and 65.1% for Lebanese, witnessed during the RCTs (23, 24). This paper described the set of challenges related to the SbS digital intervention that hindered the retention of users. In congruence with other implementation studies on digital mental health interventions, barriers to adherence and uptake were categorized as intervention-related, research-related, and user-related (2, 11). At the intervention level, many problems in the usability and bugginess of the application were revealed in the SbS intervention. Although the appealing design, features, colors, and easy navigation in the application were highly praised by users, the poor usability and bugginess of the application was a major barrier to adherence to the experience of

the users and that of the e-helpers. Challenges included forgetting the passwords, lack of available space to download the app, slow internet connectivity, bugginess, and technical problems encountered, among others. The poor usability of the digital interventions is highlighted in the literature as a common variable affecting dropout, hence the importance to design user-centric interventions that provide a smooth and seamless journey for the users (2, 12, 33). Other barriers encountered were research-related and included demotivation to fill the long and burdening assessments and the time taken to enter data and sign-up for the intervention. This was also consistent with the literature on digital mental health research and dropout associated with the burden of assessments (2, 11, 12). Although assessments could be shortened during the scale-up, they could still pose a problem in digital research trials. The latter could be long, tedious, and repetitive, which could cause people to get impatient and stop answering them. It's thus worth exploring the modality of administering them and pacing them into smaller chunks or adding motivational messages for the users to complete them.

Additionally, user-related barriers were debunked during this evaluation, such as lack of inner motivation or perceived benefit, competing priorities, and busy lifestyles, among others. The lack of motivation is a key symptom of depression as highlighted in the literature and thus more motivation and engagement are required, as well as ensuring that the intervention is brief and efficient (2). This underlines the important role of the e-helpers' guidance and motivation and the need to preserve it for scale-up. On the other hand, perceived benefit of the intervention and high digital literacy were highlighted as user-related factors that promote adherence in a recent systematic review (33). This was comparable to the results depicted in the Step-by-Step evaluation.

In terms of promoting factors related to the intervention, our evaluation results showed that participants valued the cultural relevance of the content and its relatability. This could imply that the extensive user-testing and cultural adaptation previously conducted led to a user-friendly design and relevant content (story, illustrations, local idioms, examples, and exercises) (19). These were crucial to address the poor usability and the lack of user-centric approaches that were identified as barriers to adherence in different studies (2). Other promoting factors for adherence were related to the delivery model and follow-up approach in SbS. This entailed engaging push notifications and automated reminders, as well as active follow-up by the e-helpers. These engagement factors of the digital intervention and the team are highlighted in the literature as a best practice to engage users and retain them (11, 33). Participants in the intervention group praised the important role of the e-helpers in motivating them, supporting them, and getting them to commit to the program through the "oral contract" in the introductory call. Positive feedback and gratitude messages are recognized as promoting factors for adherence to digital interventions (11). From a research perspective, the phone credit compensations given for participation to cover the internet data costs were mentioned as an effective incentive among Syrians. They highlighted the importance of receiving smaller installments of compensation at several points upon completion of the pre, post, and follow-up assessments, instead of getting one lump sum upon completion at 5 months as was done in previous phases. The paced installments served as reminders and incentives for them to continue and helped them better manage their data consumption

in using the application. Due to the worsening financial situation and the harsh conditions endured, taking part in the research might be a way to receive financial compensation. This finding is worth exploring as a best practice during research projects. Yet, it is noteworthy that in the scale-up model, there won't be any financial compensation. Hence the need to manage expectations, ensure internet access, and stress the other benefits of the program such as the free treatment concept.

The third research question investigated the challenges and recommended modalities for sustaining SbS in Lebanon. Despite the acknowledgment of the need, relevance, and benefits of SbS among the Lebanese and the displaced populations in Lebanon, many concerns and challenges were foreseen by different stakeholders in maintaining the intervention in the long run. The barriers identified both at the project and contextual levels were retaining staff amidst the increasing brain drain, securing sustainable funds to cover the running costs of the intervention amidst competing international priorities, and accessing smartphones and the Internet in light of a deteriorating infrastructure and a severe economic crisis in Lebanon (34). The current humanitarian crisis presents different types of requirements for the sustainability of digital mental health interventions with minimal guidance. For instance, Lebanon witnessed a doubled increase in unemployment rates between 2019 and 2022 and an increase in brain drain (35, 36). Consequently, the volunteering model of the e-helpers, previously planned, might not be practical during an economic crisis where young adults and fresh graduates would tend to look for paid internships or job opportunities instead of volunteering for free. Different scenarios such as employment models or internship opportunities would need further exploration for the scale-up phase. Similarly, securing international funds and exploring local modalities for sustaining SbS as a governmental free-of-charge service is crucial for the maintenance of the service. The recommendations in Supplementary material 5 hold crucial suggestions for the maintenance, sustainability, and integration of SbS in the mental health care system in Lebanon amidst this volatile phase.

Study limitations

The main limitation of this study was the difficulty to reach people who dropped out to garner more feedback and recommendations. These participants were unresponsive to the contacts of the study team. Another limitation was the possible bias generated during the interviews since most of the interviewers were affiliated with SbS directly or indirectly. Finally, the discrepancy of interview methods for SbS staff (face-to-face) and SbS participants and external stakeholders (phone) paused a limitation to the methodology.

What this study adds

The potential of digital mental health interventions is under-researched in LMICs among vulnerable groups and populations affected by adversities. This qualitative study helps bridge this gap by providing an insight into the uptake, acceptability, and

feasibility of a digital mental health intervention in a LMIC setting, among vulnerable and displaced populations. By taking a closer look into the users, staff, and stakeholders' perspectives, this research uncovered significant barriers and enabling factors for the adherence and uptake of digital mental health interventions in such settings. Findings included crucial considerations and best practices for the implementation and scale-up of Step-by-Step in Lebanon. This paper's findings complement the effectiveness and cost-effectiveness evaluation of SbS and provide practical feedback and recommendations to ensure a proper uptake and successful implementation of a user-centered service. Researchers and project managers can benefit from the findings in this paper to make use of the design, implementation, and scale-up of digital interventions under challenging settings.

Conclusion

Digital mental health interventions have great potential in improving the quality and accessibility of mental health services in low-and-middle-income countries, considering their practical use, easy dissemination, and low cost. Given their proven effectiveness, high hopes exist for these interventions to bridge the mental health treatment gap for people in need. Nevertheless, their uptake remains low, and adherence to online treatment is widely documented as a universal challenge. Research about the key barriers and enabling factors for their feasibility and acceptability among vulnerable groups, displaced populations, and those affected by adversities in low-resource settings is still limited. This qualitative evaluation analyzed the acceptability and feasibility of a digital mental health intervention for depression among Lebanese and Syrian displaced populations exposed to adversities in Lebanon. It also investigated the reasons for the high dropout encountered and shared the promoting factors for adherence. Recommendations and best practices were generated and aimed to guide the scale-up of SbS in Lebanon. The study's findings and recommendations can help explore how digital mental health interventions could be leveraged to improve access to care among people with mental disorders in low-resource settings. Findings are relevant to researchers, implementers, and policymakers to ensure a successful and sustained roll-out of such interventions upon scale-up.

Data availability statement

The datasets presented in this article are not readily available because, they contain unique information or a combination of answers that might reveal the identity of the interviewees and could risk breaching their confidentiality. The consequences of such breaches are rated as severe for the users specifically. Requests to access the datasets should be directed to JAR, jinane.abiramia@gmail.com.

Ethics statement

The studies involving humans were approved by WHO Research Ethics Review Committee and St Joseph's University

Ethics Committee in Beirut (CEHDF 862). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin because vulnerable groups interviewed included adults living in Lebanon and suffering from depression, as well as Syrian refugees. All participants displayed autonomy and capacity to provide written online consent through the app platform upon signing up and through the messaging platform before conducting the interview, and once again orally at the beginning of the phone interview (audio-recorded).

Author contributions

JAR: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing—review & editing. RAH: Data curation, Formal analysis, Investigation, Methodology, Validation, Writing—review & editing. PN: Data curation, Investigation, Methodology, Project administration, Writing—review & editing. PC: Conceptualization, Methodology, Supervision, Writing—review & editing. KC: Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Writing—review & editing. EvH: Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Writing—review & editing. EH: Conceptualization, Project administration, Writing—review & editing. EZ: Conceptualization, Funding acquisition, Project administration, Supervision, Writing—review & editing. MS: Conceptualization, Methodology, Supervision, Writing—review & editing. REC: Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, 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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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1293187/full#supplementary-material

SUPPLEMENTARY MATERIAL 1
Informed consent form - study participants.

SUPPLEMENTARY MATERIAL 2
Interview guide with external stakeholders.

SUPPLEMENTARY MATERIAL 3
Interview guide with staff.

SUPPLEMENTARY MATERIAL 4
Interview guide with study participants.

SUPPLEMENTARY MATERIAL 5
Table 2. recommendations.

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A qualitative interview study of patients' attitudes towards and intention to use digital interventions for depressive disorders on prescription

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Background: Depressive disorders are an emerging public health topic. Due to their increasing prevalence, patients with depressive disorders suffer from the lack of therapeutic treatment. Digital health interventions may offer an opportunity to bridge waiting times, supplement, or even substitute in-person treatment. Among others, the Unified Theory of Acceptance and Use of Technology (UTAUT) explains that actual technology use is affected by users' behavioural intention. However, patients' perspectives on digital interventions are rarely discussed within the specific context of primary care provided by general practitioners (GP) and need further exploration.

Method: A qualitative study design with semi-structured interviews was used to explore DTx-acceptance of patients with mild or moderate depression ($n = 17$). The audio-recorded interviews were transcribed verbatim, coded, and thematically analysed by qualitative content analysis.

Results: Patients' *performance expectancies* reveal that DTx are not perceived as a substitute for face-to-face treatment. *Effort expectancies* include potential advantages and efforts concerning technical, motivational, and skill-based aspects. Moreover, we identified *health status* and *experience with depressive disorders* as other determinants and potential barriers to patients' DTx acceptance: Difficult stages of depression or long-time experience are perceived hurdles for DTx use. *GPs'* recommendations were just partly relevant for patients and varied according to patients' consultancy preferences. But still, GPs have a crucial role for access due to prescription. GPs' influence on patients' DTx acceptance varies between three situations: (1) pre-use for consultation, (2) pre-use for access and (3) during DTx-use. Further, GPs' guidance could be especially relevant for patients during DTx-use in routine care.

Discussion: The UTAUT-based exploration suggests that acceptance determinants should be considered independently and embedded in personal and situational aspects. DTx require a healthcare professional to prescribe or diagnose the disease, unlike other digital offerings. We identified prescription- and depression-related determinants, exceeding existing theoretical constructs. GPs' guidance can compensate for some barriers to DTx use e.g., by increasing commitment and motivational support to strengthen patients' acceptance.

Abbreviations
DTx, digital therapeutics; UTAUT, unified theory of acceptance and use of technology.

Conclusion: We argue for a multidimensional integration of acceptance determinants for further development of health technology acceptance research. Future research should specify how DTx can be integrated into routine care to strengthen user acceptance.

1 Introduction

1.1 Depressive disorders and the burden of disease

Depressive disorders are one of the leading contributors to the burden of disease worldwide and among the most prevalent mental illnesses in Germany (1, 2). People with depression often struggle with access to mental health care and waiting times for specialist or psychotherapeutic treatment (3–6). Especially lower socio-economic groups are underserved by outpatient psychotherapy (7, 8). Accordingly, in the German health system, general practitioners (GPs) are the first contact for health concerns for many patients with depressive disorders and essential providers of basic psychosomatic care (9, 10). Given the lack in mental health care supply, patients do not always receive treatment according to guideline recommendations (11–13). Hence, prevention and healthcare provision for depressive disorders are important subjects and tasks for public health (4, 14).

An innovative approach in mental health care that might contribute to reducing this lack of therapeutic treatment are internet-based, digital interventions (4, 15–17). The number and variety of digital health services for mental disorders is constantly increasing over the last decade (18). Digital health services for mental health include health promotion, prevention, or treatment of some disorders, e.g., by providing behavioural information to encourage patients' self-management (19, 20). Digital interventions for mental health can be applied with professional guidance to assist and follow up the use, completely self-guided by patients or as blended approaches as an additional part of face-to-face treatments (13, 16).

In 2020, Germany was the first country worldwide where specific software applications (so-called Digital Therapeutics (DTx) for "Digitale Gesundheitsanwendungen" (DiGA)) became part of the German statutory health insurance services (21). DTx are defined as digital, low-risk medical devices to identify, monitor, treat or compensate for illnesses or disabilities (§33a SGB V). General characteristics include that they are for a specific medical condition such as depression, contain a therapeutic intervention, and are considered approved medical applications by regulatory bodies (22). To become temporarily or permanently listed in a DTx catalogue, digital applications have to pass a review process by the Federal Institute for Drugs and Medical Devices (BfArM) (23). Listed DTx have proven a positive medical benefit (e.g., improve health status, reduce disease duration, improve quality of life) or patient-relevant process improvements such as increased coordination, guideline treatment or adherence (24). DTx are available on prescription, patients can receive them from physicians or therapists or directly from statutory health insurance companies. Costs for available mental health DTx are covered by statutory health insurance vary between 178,50 € and 855,82 € per quarter (21). Almost 90 percent of patients in Germany across all disorders receive these prescriptions from physicians, mainly prescribed by GPs (25). Still, the recommendation of digital health interventions for people with depression or prescription of DTx in Germany is limited (26–28). Recently Löbner et al. (2022) identified simply forgetting and a shortage of time as major reasons for the little uptake of digital interventions by GPs in routine care. Users' acceptance is also a precondition for implementing digital mental programmes in routine care (29, 30), but little is known about patients' acceptance of DTx.

1.2 Acceptance of digital health interventions

The intention to use certain technologies and actual use is explained by technology acceptance models such as the Technology Acceptance Model (TAM) (Davis 1989) or the Unified Theory of Acceptance and Use of Technology (UTAUT) (31, 32). The UTAUT is a consolidated model, combining behavioural intention and technology acceptance models (31). According to UTAUT, the intention to use technology and actual use depends on four determinants: Performance expectancy, effort expectancy, social influence and facilitating conditions, moderated by age, gender, experience and voluntariness of an individuals' use (31). Moreover, the UTAUT is used in various research disciplines and can be successfully adapted for the health sector (33, 34), but it also needs adjustments according to the specific healthcare setting (35). Thus, the theory offers a solid framework for our research interest. At the same time, there is a risk that a strong alignment with a model may contribute to its reproduction, especially in acceptance research which nearly reached a plateau (36). This means research on technology implementation has to take health systems' complexity into account. Currently, researchers use a variety of constructs to measure technology acceptance, which shows the need for a common approach in the specific domain of mental health (37, 38). According to our research interest, an explorative approach is needed to understand users' acceptance of DTx and indicate potentially

different patient-specific influences on technology acceptance within a GP setting.

Previous research on health technology acceptance focuses on the perspective of stakeholders and health professionals, showing an ambivalent acceptance of professions towards digital interventions for mental health (29, 39, 40). Moreover, in Germany GPs' acceptance of DTx seems greater compared to regular health apps (41). Patients' acceptance of health technologies in general is less studied (34), such as specifically the acceptance of digital interventions for mental health. Further, many research results generally do not sufficiently distinguish between different digital approaches in mental health or DTx and non-medical applications (42, 43). First results indicated that patients' acceptance of digital interventions for depressive disorders in Germany in general seems limited (13, 44). Factors that promote patient engagement with digital mental health interventions are rarely applied within technology acceptance models (45). Further subgroups have to be understood to achieve patient-orientation within DTx implementation (24). Hence, it is unclear whether

(GPs') prescription for digital interventions impacts patients' acceptance or rejection (46). Further, it is unknown from patients' perspectives which factors affect acceptance of prescribed digital interventions.To explore patients' acceptance of DTx, we defined performance expectancies, effort expectancies and GPs' influence on DTx as determinants of DTx acceptance in accordance with UTAUT (*documented in* Table 1). *Performance expectancy* is defined as the degree to which patients believe that DTx will be helpful for their depressive disorder. *Effort expectancy* includes the degree to which patients believe that DTx are associated with ease of use. Primary medicine provided by GPs is often characterised by a continuous, long-standing relationship between patient and GP, a low-threshold consultation and GPs' knowledge of the psychosocial environment of their patients (47). Within a family medicine setting, GPs are both the institutional and personal point of contact for health issues and include aspects of social influence and facilitating conditions. Therefore, *GPs' influence* is defined as patients' interest in DTx-recommendation by GPs and the degree to which patients believe their GP is supportive of DTx-care. We chose UTAUT because it is based on the key determinants for our research objective, while its extension (UTAUT II) includes other factors, such as cost, that are less relevant in the context of our question.

We aimed to contribute to the further development of acceptance research by exploring patients' perspectives on DTx within a primary GP medicine with the following questions:

1) What are performance and effort expectancies encouraging or discouraging patients from the (intention to) use DTx?
2) What role do GPs play regarding the intention to use DTx from a patient's perspective?
3) What are patients' intentions to use digital interventions for depressive disorders?

2 Materials and methods

2.1 Research design

Little is known so far about patients' expectancies, intention to use and actual use of DTx for depressive disorders. Beyond technology features end-user perceptions and characteristics must be considered to achieve user-centred technologies (48). A qualitative interview design was chosen to achieve an in-depth focus on potential users, strengthening a patient-centered perspective on DTx in routine care. Therefore, we were interested in capturing patients' perspectives and experiences in everyday life, disease-specific aspects according to DTx acceptance, and particularities that may result from being prescribed by a physician. Consolidated Criteria for Reporting Qualitative Research (COREQ, Appendix 1) were consulted to comply with quality standards in research.

2.2 Sampling and recruiting

We aimed to achieve a heterogeneous sample of patients with mild or moderate depressive disorders without current specialist or psychotherapeutic treatment in primary care provided by a

TABLE 1 UTAUT-Determinants according to the research questions.

UTAUT-Determinants	Determinants according to the research questions	Definition for this research
	Patients' experience	Patients' experience include patients' descriptions of their previous experiences with digital services in the context of depression.
Performance Expectancy	Performance expectancy on DTx	Performance expectancy is defined as the degree to which patients believe that DTx will be helpful for their depressive disorder.
		This category includes expectancies on potential barriers and facilitators, e.g., health condition, disease management or access to care.
Effort Expectancy	Effort expectancy on DTx	Effort expectancy is defined as the degree to which patients believe that DTx are associated with ease of use.
		This category includes expectancies on potential barriers and facilitators, e.g., literacies or design.
Social Influence / Facilitating Conditions	GPs' Influence	GPs' influence contains: 1) The perceived meaning of a GPs' DTx-recommendation for patients 2) The degree to which a patient believes his or her GP is supportive of DTx-use (e.g., with knowledge, access, or competence) This category includes expectancies on potential barriers and facilitators.
Behavioural Intention	Behavioural Intention	Behavioural intention is defined as patients' intention to use a DTx for depressive disorders.

TABLE 2 Characteristics of participants.

Sex	Male	6
	Female	11
Education	Middle-School degree	2
	Professional training	9
	Higher education (A-Level and university degree)	6
Depression duration	Less 1 year	3
	1–5 years	3
	Above 10 years	11

GP. All participants had to be above the age of 18. Due to purposeful sampling, we composed variation in terms of sex, geographic distribution, current perceived health status, and disease biography [*Categories of the sampling process are documented in* Table 2]. Participants were recruited with posters and flyers in GP offices, medical counselling centres, and self-help facilities for people with depressive disorders. The call for participation contained the topic of the survey and information about the estimated duration of the interview. It introduced the research as part of the doctoral programme "Chronic Diseases and Health Literacy".

2.3 Data collection

The inclusion criteria were checked before the start of the interview based on participants' self-report. We used a semi-structured interview guide, following the main topics (A) Experience with digital health interventions for depressive disorders, (B) Potential chances, risks, and barriers of DTx, (C) DTx within a primary medicine setting provided by GPs and (D) Participants' intention to use DTx. At the time of the interviews, less than 20 DTx were available, therefore a short video was used as stimuli material to exemplify DTx interventions for patients. In the first part of the video, we defined DTx and explained how they differ from other apps and showed the process for patients to receive them. Further, we showed the participants examples of DTx for patients with depressive disorders. These examples included product descriptions from the DTx-catalogue and images of registered DTx to illustrate topics, structure, and use of the tool. The authors developed the interview questions and pretested them by two volunteers: A patient with a chronic disease and a patient with major depression. To explore user-centered topics, open-ended questions were conducted in the interview guide. Participants could freely describe their experiences and attitudes, further questioning was used to deepen aspects relevant for the research. All interviews were carried out between January and June 2022 by the first author in German. They were conducted via video meetings, data were audio recorded, transcribed verbatim, and anonymised according to Dresing and Pehl (49). All participants gave verbal consent prior to the start of the interviews. Anonymity and confidentiality were maintained. Participants also declared informed consent for the audio recording and scientific use of the interviews by written consent form and received reimbursement (15 €) for participation. The interviewees were not known prior to the

FIGURE 1
UTAUT determinants according to the research question.
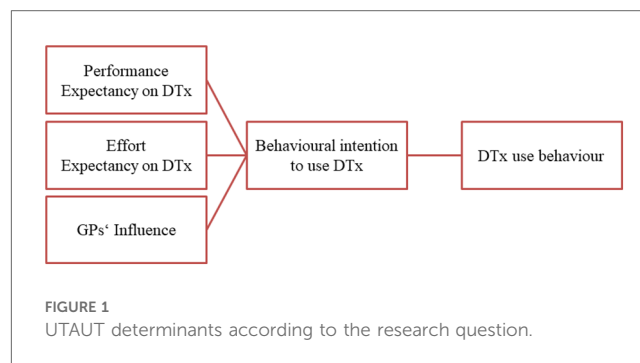
interview. Field notes were taken during interviews to document non-verbal elements e.g., interruptions. Recorded interviews lasted between 24 and 42 min. The study has received ethical approval from the Ethics Committee of Hanover Medical University (No. 10131_BO_K_2021).

2.4 Data analysis

According to Kuckartz and Rädiker (50), a qualitative content analysis was carried out to analyse the material. A coding scheme was built deductively along the interview guide and UTAUT-determinants and expanded within the main categories inductively during the coding process. For this purpose, all transcripts were first coded to build the coding scheme and afterwards to apply the material along the scheme. A second researcher coded the interview material (25%) independently, conflicts in coding were compared and discussed within consensus coding to ensure the unambiguity of the categories. The results are reported according to the research questions, which are based on the UTAUT-determinants (*see also* Figure 1):

- Patients' performance expectancy
- Patients' effort expectancy
- GPs' influence
- Behavioural intention to use DTx

According to the openness of qualitative research, we interpreted the acceptance determinants with an equal impact. To technically support the coding and analysis process the software MAXQDA (2022) was used. The research project was regularly presented in a qualitative research workshop where both coders participated to discuss and reflect on the procedure and interpretation of results. Relevant quotes from interview sequences were translated from German into English.

3 Results

3.1 General characteristics of study participants

A total of 17 patients with mild or moderate depressive disorders participated (*demographics are shown in* Table 2).

Eleven participants were female, eleven patients reported a depression history of above ten years, and three patients suffered from depression for less than one year. Nine participants completed professional training, while six patients had a higher education by completing an A-level or a university degree. Ten patients lived in urban or suburban areas.

Based on their experience with (prescribed) digital interventions, the sample is divided into four different user groups: Eight participants hadn't heard about DTx before the interview. Six participants who heard about it before but did not plan to use it or looked for further information, and one patient heard about it and was informed to propose it to a health professional. In the fourth group, patients had no experience with DTx but already used various other depression-specific digital services, from mood diaries to telemedicine consultations or meditation apps.

3.2 Patients' performance expectancy on DTx

Performance expectancy comprises patients' estimation on how DTx might achieve changes for the current healthcare situation. Participants reported on performance expectancies on DTx, but also compared DTx with in-person psychotherapy.

According to the participants ($n = 15$), DTx have a meaningful potential to bridge waiting times until patients receive appointments for further in-person treatments. During waiting times for psychological or specialist treatment, participants see a chance to increase their self-management skills. Additional support and accompaniment for "*new impulses*" (P13:48) to "*get out of the problem yourself and perhaps deal with it in a slightly different way*" (P18:29). One participant even considered DTx as a substitute for pharmaceuticals during waiting times.

Participants who were presently in good condition, described DTx as a fall-back option for difficult mental health situations in the future:

> "*Because imagine you're in a depressed situation and then you know in the back of your mind that you might have to wait another eight months for a treatment.*" (P14:48)

Some patients emphasise the emotional burden of waiting for therapeutical treatment and consider the knowledge about available alternative options as essential "*even if it's just mentally, to know that you have a chance.*" (P3:50). In this context, patients see further advantages as motivational support to improve coping with depressive disorders.

In contrast to general health information from the internet, seven participants experience information provided by DTx as more trustworthy and feel more secure using them and expect access to evidence-based information:

> "*Yes, this informative, so that you can simply read something about yourself. An information that is not somehow from Google, but medically correct.*" (P2:45)

Further participants expect improvements on access to health care professionals' advice especially for difficult situations due to communication tools such as chat within DTx:

> "*So that I don't feel completely helpless and alone about it. And still, get professional help somewhere.*" (P6:45)

Moreover, five participants expect greater anonymity as another essential advantage of digital interventions in mental health to avoid stigmatisation. While one part of the participants shares their experiences in depressive disorders with their social environment, the other part is convinced that mental health is a topic „*you don't peddle*" (P17:78). According to the participants, admitting a mental disorder is challenging, so a tool could reduce this burden without letting friends or family know.

> "*That's the very point why I think the app is good: Many people can't even tell their best friends, siblings, or parents how they're feeling. So why tell a therapist all of a sudden?*" (P3:58).

Apart from the performance expectations that relate to the DTx itself, participants describe disease- and healthcare-related influences that may limit performance expectations: Even though the participants expect advantages compared to unguided waiting times in routine care, none of them perceive digital health interventions as an alternative or substitute for psychotherapy or face-to-face consultation. Generally, DTx are considered to be less effective in improving health conditions than treatment in-person:

> "*Although I don't think I would see this as a substitute for a real conversation with a psychologist. But to bridge the time until you have a therapy place, I could imagine that it would be helpful.*" (P9:33).

According to some expectations, digital treatment options include a high level of standardisation. The participants perceived that depressive disorders are too complex and unique for a total standardised treatment option ($n = 5$):

> "*It is not a purposeful alternative because the psyche of everyone is simply too individual for that.*" (P18:41).

Besides perceived positive performance aspects, patients also have certain essential worries that could already deny the actual use or effect of those offers. According to the participants, a central barrier is the interplay between the disease and digital technologies ($n = 13$). Digital media are perceived as potential triggers or amplifiers for mental health issues and depression. The idea of such situations without personal and therapeutic support is a concern of the participants.

> "*If you know that there's a robot, I'm having a panic attack or whatever, because some thoughts are just coming up, that would be my worry, I'd say.*" (P10:62)

Moreover, patients expect further adverse effects on their health, e.g., by too frequent use of technology or "*too much brooding*" (P15:32).

Another reason not to take further interest in the use of technology is the underlying therapeutic approach ($n = 4$). Currently, many DTx for mental diseases are based on cognitive behavioural therapy [21]. Some of the more experienced patients assessed this therapy approach as not the right treatment option for themselves based on their therapeutical history:

> "No. I wouldn't use it because, based on my therapeutic experience, my priority is the relationship with the person. And no app can learn that. I need a person for that." (P7:61)

Further, performance expectancies include a variety of advantages of DTx such as tools to improve self-management skills and low-threshold access to approved health information for a limited period. Overall, participants expect lower efficacy of DTx compared to face-to-face therapy. Also, worries on opposing effects limit patients' performance expectancy on DTx.

3.3 Patients' effort expectancy on DTx

Patients' performance expectancy is the degree of ease associated with using DTx for depressive disorder. Moreover, performance expectancy includes learning and operating DTx.

Participants await more flexibility using health technologies as a "*low-threshold offer*" (P16: 48) according to personal needs ($n = 9$). Especially experienced patients who used different digital interventions for mental health reported less effort in contrast to regular mental health supply ($n = 11$). Access to digital health intervention seems less time and energy-consuming in a lethargic period.

> "Because these waiting times really drain your energy, and you don't feel like calling the fifth therapist who doesn't have an appointment for you. And this back and forth, and yes, that makes this time, I don't know this app yet, but probably more bearable." (P10:60)

Overall, additional efforts were rarely mentioned by the participants for themselves. Patients perceived little efforts or challenging factors for specific groups e.g., with less access to digital technologies or infrastructure:

> "I was thinking more of (…) older people who are perhaps not that fit and perhaps don't necessarily have a mobile phone or don't have a computer or a tablet. That's really not a problem for me, but it might be for other people." (P18:51)

In addition, digital skills could cause effort for less experienced users to become familiar with DTx ($n = 12$). Moreover, all participants depicted a challenge to regularly use DTx independently. Personal appointments in the therapy setting are perceived to be more compulsory.

In summary, *effort expectancies* on DTx revealed ease of access to mental health care and greater convenience due to digital opportunities. Expectancies include also potential barriers for people with little digital skills or competencies to become familiar with DTx.

3.4 GPs' influence on acceptance

Due to our result, *GPs' influence* on DTx acceptance varies between three situations: for consultation, for access and after prescription in routine care.

The participants reported two different positions towards GPs' consultation: Participants who experienced a trustful relationship with their GPs, assessed GPs' recommendations as highly relevant or even essential for decisions on DTx-use.

> "But I also ask the doctor how her experiences with it are so far. For example, whether she [the doctor] has a [DTx-] provider with whom she has had very good experiences with her patients so far. That would be important to me because what she says is very, very important." (P17:102)

In contrast, participants complained about the insufficient knowledge of GPs on digital interventions and mental health as marginal topics of GP training, qualification, and practice which limits the expectations on GP's recommendations ($n = 9$). Especially participants with experience on digital mental health interventions, experienced in single cases insufficient empathy from their GP which discourages them from addressing mental health issues.

> "I don't really talk to my GP. He's a very strict traditional doctor. You go there when you have a cold, that's it." (P5:65)

Thus, patients' relevance on DTx-recommendations from GPs varies, they are overall seen as important gatekeepers regardless from participants' personal attitude towards DTx ($n = 9$). GPs were described as necessary for prescriptions as patients rarely get to know the offers by themselves:

> "Well, I think that doctors should also offer this because you don't learn anything about it." (P4:70)

Even though DTx could be prescribed by different health professionals and received from health insurances directly, GPs are perceived as low-threshold prescribers. Therefore, GPs are seen as necessary for a prescription even though patients do not claim mandatory consultancy.

> "I need the prescription. But I don't consult with her [the GP]." (P18:60)

However, patients also raise concerns about GPs not fulfilling this function. GPs being unfamiliar with digital interventions could be a hurdle for DTx recommendation or prescription in primary care.

"When I talk to my GP, it's always about sick notes, medication, rehabilitation, and so on. It's not about health apps." (P8:68)

Moreover, participants being critical of the empathy and competence of their GPs on mental disorders, estimate difficulties in receiving a prescription by their GP.

"I could imagine this hurdle, I'm going to my doctor now, he might not know anything about it if you have mild depression or moderate." (P5:69)

Further, some participants liked to know earlier about the services to contact their doctor to raise awareness and receive a prescription (*n* = 8).

"I think if I had already known about the app, I think I would have really, probably really approached my doctor and asked, can you please prescribe me something like that? Because I think just out of interest or this desire to help myself." (P14:64)

To sum up, GP influence manifests itself in different facets: On the one hand, as a perceived structural prerequisite to gain access and, on the other hand, as substantive advice, which in turn depends on the competence and experience of the GP. Patients' consultancy preference causes GPs' influence on patients' intention to use, but still, GPs seemed relevant to receive prescriptions for the actual use.

3.5 Intention to use DTx for depressive disorders

Overall, after the presentation of the services, ten participants expressed interest towards DTx for depressive disorders. Moreover, some patients could imagine using the services or planning to introduce those services to their doctor.

"I found it very trustworthy. I would also make use of it." (P6:36)

The participants in our sample believed that the intention to use varied within the course of the disease. They assumed retrospectively that DTx would fit best to their needs in the early stage of depression and less experience with or knowledge about the disease (*n* = 11).

"When you realise that you have to go, but just can't go yet, but still work on yourself, that maybe you have a little, yes, a little support." (P4:47)

Further, participants claim that the actual health condition restricts the intention to use. Participants tend to see no need for DTx-use in good health, while in *"highly depressive phases where you're not capable of anything" (P14:50)*, the intention could be limited (*n* = 12).

Four Participants who declared no interest in the use explain this with their long-time experience with mental health care and depression by saying they don't see an extra value for themselves through the technology.

"No, because of all the groundwork that the app would do, I've already done quite well in the year of therapy. And now it's just sitting on your arse and maintaining the level." (P4:61)

In summary, the intention to use DTx is unstable and varies depending on the disease stage, knowledge of depressive disorders and personal coping strategies. Further, health conditions and experience can have a negative impact on DTx use intention, detached from general performance and effort expectancies.

4 Discussion

4.1 Summary of main findings

We aimed to explore inhibiting and promoting factors on patients' acceptance of prescribed digital health interventions in GP practice (Figure 2). Our research focused on patients' performance and effort expectancies and GPs' influence on the intention to use DTx for depressive disorders during waiting times. We identified expected chances and barriers on the determinants, leading to acceptance and non-acceptance on DTx. Further, we identified structural- and depression-related influences, affecting and exceeding single constructs. In conclusion, patients' acceptance includes expectancies on DTx in a GP setting and compromises determinants such as the availability of treatment opportunities, health status and personal coping strategies.

4.2 Comparison with existing literature

This study examines patients in Germany according to their attitude towards digital mental health interventions. Although Germany appears to be a pioneer in the implementation of DTx, this innovativeness may not apply to the general population: In comparison to OECD countries, German citizens are for example less likely to seek health information on the internet (51). Previous research also shows that Germans show rather low acceptance rates toward the innovative mental health treatment forms (44). The results of our study help to understand the reasons for the limited acceptance from the patient's point of view.

4.2.1 Expectancies on performance and effort

Thus far, the absence of timely face-to-face mental health care and current waiting times appear to be relevant context factors for patients to consider DTx for depressive disorders. Also Watanabe-Galloway et al. (2021) identified currently underserved patients with depression open-minded towards digital disease-specific interventions (52).

Patients' perspective on DTx for depressive disorders	Barriers and Risks	Potential and Chances
Performance expectancy on DTx	• opposing effects on depression (e.g. triggers or amplifiers) • unsuitable therapeutic approach • non-individualized content • little effect	• bridging offer for waiting times ○ tool to improve self-management skills ○ immediately available • anonymous intervention to prevent stigmatization • quality-approved content
Effort expectancy on DTx	• little mandatory • risk of digital divide	• low-threshold access to care • flexible use according to personal needs
GPs' influence	• lack of knowledge on DTx • limited expertise in mental health • lack of trust	• gatekeeper function for initial access • guidance and motivation in routine care
Behavioural intention to use DTx	varies according to health condition and personal coping strategy	

expectancies on DTx / expectancies compared to in-person care

FIGURE 2
Summary of the main findings.

Due to the non-availability of in-person services, self-management skills become more important for patients as users of digital mental health care (20, 53). From patients' perspectives, our result showed that DTx could be a tool to improve coping with major depression for a period. Further, the need for access to approved health information, especially at an early stage of disease was presented. Participants perceive DTx a reliable source of information, but apart from that appraise them as less effective than face-to-face psychotherapy. Even though DTx are not perceived as a substitute, research shows comparable effects of digital interventions and face-to-face treatment (20, 54), but reliable evaluations for digital mental health interventions are not comprehensive (20, 55). According to the admission process, permanently listed DTx fulfilled higher evaluation standards (24) to examine effectiveness and contribute to evidence-based mental health care. Our findings suggest that knowledge about the effectiveness of digital mental health in patient care needs to be strengthened to increase patients' acceptance.

Former research identified digital literacy as a predictor for patients' acceptance of digital health interventions (46) and a potential barrier to professionals' acceptance (56). Further digital technologies could reproduce social inequalities due to insufficient digital literacy, known as the digital divide (57, 58). In contrast to earlier findings, computer-specific literacies such as digital literacy or data security were little discussed and not identified as challenging for the participants themselves in our sample. Hence, these results must be interpreted cautiously because patients tend to overestimate

their technology skills within digital health technologies (59). Also, self-reported competence and actual behaviour may differ in practical situations. Another interpretation of this finding could be that digital skills have a minor role for participants: Previous research on patients' mobile health adoption identified users' self-efficacy as an essential component for digital mental health interventions adoption (19, 46, 60, 61). Taken together, this suggests that patients tend to perceive digital skills as a small hurdle if they are convinced they may benefit from DTx.

Contrasting the digital divide, the study suggests that anonymity and impersonal access to health care could be advantages of DTx. This feature could be suitable for unprovided patients who fear in-person psychotherapy (6). Currently, attitudinal barriers (e.g., being afraid to disclose in front of others or people who fear stigmatisation) are the most common reasons to refuse to find help (5, 62). Under this assumption, DTx could be an alternative and low-threshold access for specific and underprovided groups in routine care.

4.2.2 Implications for technology acceptance for mental health

Further, we identified *health status* and *experience with depressive disorders* as additional determinants on patients' acceptance of digital health interventions on prescription. Based on participants' previous illness biographies, the present study highlighted the challenges of depressive symptoms. Patients' intention to use digital health interventions is affected

by their health status, which can be negatively influenced by difficult periods. Earlier qualitative research also explored potential opposing effects between depressive disorder and the use of technology in acute or critical situations (63). These effects might limit the DTx adoption in routine care, hence low user engagement compared to study conditions is a central challenge (45). According to Nadal et al. (2020), mobile health technology acceptance is a stage in a dynamic staged process. They distinguish between pre-use, initial use and post-adoption as different stages influencing technology acceptance (37). Our results indicate that acceptance research on (mobile) technologies for long-term disease also should take factors depending on the stage of disease into account. Currently, the state of the art in terms of acceptance research comes also to a limit regarding further disease-specific challenges such as access to treatment, stigma, symptoms, and dysfunctional effects. Therefore, health status and experience with depressive disorders are other determinants of patients' intention to use DTx, influencing different acceptance dimensions. Also, determinants of patients' acceptance are embedded in personal and situational aspects. Accordingly, acceptance determinants should not be considered independently, as correlation-based models such as UTAUT suggest. Further, the results imply a connection between DTx assessment, intention to use and action to achieve access by introducing DTx to a GP. Therefore, a multidimensional integration of acceptance determinants is needed.

4.2.3 DTx in routine care

Unlike other digital offerings, DTx require a healthcare professional to prescribe a DTx or diagnose the disease. However, even primary care settings in Germany are considered to have special potential for providing digital services for depressive disorders (64). In contrast to the previous determinants, GPs' influence is a context factor for users' acceptance (65).

Although doctors have been assigned an important role in the prescription of DTx, our results showed that GPs are not perceived as competent counsellors on mental health issues. Especially DTx-interested patients were critical about this specific knowledge in routine care. GPs' influence on the intention to use DTx was limited to a specific group of patients. These results support prior research by Uncovska et al. (2023), which concluded that the physicians' prescription had a minor role in the willingness to use DTx (46). Further, patients in our sample were familiar with various technologies for depressive disorders beyond the healthcare services of routine care and without coordination of their GP. Nevertheless, due to prescription, GPs still have a crucial role for DTx access.

At present, the role of GPs in routine care after a prescription is not very specified. As DTx are considered additionally to in-person care (66, 67), GPs have the potential to provide low-threshold guidance. Thus far, GPs' guidance could compensate for adverse effort and performance expectancy of patients (e.g., less commitment

or unreliable use) during bridging waiting times or motivate patients for DTx use. Further guidance on digital interventions is necessary for effective implementation in routine care (10, 68) and could also increase patients' adherence (13). The combination of application-based and in-person care is already practised in psychotherapy, known as blended therapy (17, 29, 69, 70), with a growing interest of patients and therapists (71) and is already discussed as a gold standard for internet and mobile application used for depressive disorders (55).

4.3 Strengths and limitations of the study

This study has a few limitations to be noted when interpreting the findings. Our study examines the intention to use DTx, therefore we cannot make any conclusions about the actual use of technologies. Other studies show that the dropout in the actual use of digital intervention in routine care is meaningful (70). Further, a selection bias may have resulted that patients with an affinity for digital technologies tend to be more willing to participate in a video-based interview study. Additionally, interviews were conducted in German and translated, which may affect the tonality.

As a main strength, this study uses an exploration approach for further development of acceptance research, as patients' perspective is not yet widely considered. Thus far technology acceptance research is currently dominated by research on health professionals' perspectives. In terms of access, we reached patients with depressive disorders in their real-world environment. Therefore, the results contribute to understanding factors influencing patients' DTx acceptance within a GP setting.

4.4 Implications for clinical practice

Since it is known that patients with positive perceptions towards digital health interventions may benefit more from the offerings (60), it is relevant to consider how patients access DTx in routine care. Further, our results show that the relationship between patient and GP affects DTx acceptance differently. This observation leads to the suggestion that further health professionals should be targeted within the implementation process for digital interventions (72, 73). Therefore, further research should specify how DTx could be integrated into routine care for patients without specialised therapeutical treatment.

5 Conclusion

In conclusion, patients identified facilitators and barriers to patients' performance and effort expectancies affecting the intention to use DTx. Also, we identified *health status* and *experience with depressive disorders* as additional determinants

of DTx-acceptance. For further development on DTx acceptance, a multidimensional integration of acceptance determinants is needed. Future research should also specify how DTx could be integrated into routine care to strengthen user acceptance in GP primary care.

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 Ethics Committee of Hanover Medical University (No. 10131_BO_K_2021). 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

JP: Conceptualization, Data curation, Writing – original draft. EB: Supervision, Conceptualization, Writing – review & editing. MD: Supervision, Conceptualization, 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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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fdgth.2024.1275569/full#supplementary-material

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Mental health services for German university students: acceptance of intervention targets and preference for delivery modes

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Introduction: Most university students with mental disorders remain untreated. Evaluating the acceptance of intervention targets in mental health treatment, promotion, and prevention, as well as mental health service delivery modes is crucial for reducing potential barriers, increasing healthcare utilization, and efficiently allocating resources in healthcare services.

Aim: The study aimed to evaluate the acceptance of various intervention targets and delivery modes of mental health care services in German first-year university students.

Methods: In total, 1,376 first-year students from two German universities from the 2017–2018 multi-center cross-sectional cohort of the StudiCare project, the German arm of the World Mental Health International College Student Survey initiative, completed a web-based survey assessing their mental health. Mental disorder status was based on self-reported data fulfilling the DSM-IV criteria. We report frequencies of accepted delivery modes [categories: group or in-person therapy with on or off campus services, self-help internet- or mobile-based intervention (IMI) with or without coaching, or a combination of a in-person and IMI (blended)]. In a multinomial logistic regression, we estimate correlates of the preference for in-person vs. IMI vs. a combination of both modes (blended) modalities. Additionally, we report frequencies of intervention targets (disorder specific: e.g., social phobia, depressive mood; study-related: test anxiety, procrastination; general well-being: sleep quality, resilience) their association with mental disorders and sex, and optimal combinations of treatment targets for each mental illness.

Results: German university students' acceptance is high for in-person (71%–76%), moderate for internet- and mobile-based (45%–55%), and low for group delivery modes (31%–36%). In-person treatment (72%) was preferred over IMI (19%) and blended modalities (9%). Having a mental disorder [odds ratio (OR): 1.56], believing that digital treatments are effective (OR: 3.2), and showing no intention to use services (OR: 2.8) were associated with a preference for IMI compared to in-person modes. Students with prior treatment experience preferred in-person modes (OR: 0.46). In general, treatment targets acceptance was higher among female students and students with mental disorders. However, this was not true for targets with the highest (i.e., procrastination) and the lowest (i.e., substance-use disorder) acceptance. If only two intervention targets were offered, a combination of study-related targets (i.e., procrastination, stress, time management) would reach 85%–88% of the students.

Conclusion: In-person services are preferred, yet half of the students consider using IMI, preferably aiming for a combination of at least two study-related intervention targets. Student mental health care services should offer a combination of accepted targets in different delivery modes to maximize service utilization.

Introduction

Up to 75% of mental disorders first appear in the mid-twenties (1). In Western countries, one-third of university students have a 12-month mental disorder (2). In young adulthood, mental illness can disrupt the adoption of adult roles and identity formation (3). Alonso et al. (4) showed that about 43% of students with mental disorders report a severe role impairment related to home management, college or work issues, personal relationships, or their social life. Thus, there is a high demand for on-campus services to improve academic performance and reduce premature college drop-out (5). Yet only a fraction of those in need receive help (6, 7). Students who suffer from mental disorders and suicidal thoughts and behaviors show meager treatment rates (25%–36.3%) that increase to a maximum of 45.1% and 60% for severe cases of 12 months and lifetime disorders, respectively (8). Reasons for low treatment utilization are multifaceted, ranging from poor mental health literacy, which is fundamental for health actions (9) to stigma, limited resources on-campus, and low-risk perception (10). Reasons that prevent students from seeking help are mostly attitudinal (internal, e.g., the desire to solve problems independently) rather than structural (external, e.g., temporal or financial costs of treatment) (11, 12).

In Germany, the picture is similar: 17% of students have at least one diagnosed mental disorder (13). A report focusing on counseling services and their perception in students found that help-seeking of those in need was low and varied from 28% (depressive symptoms) to 13% (alcohol consumption). Students reported the wish to solve problems themselves (62%) or seek advice from family and friends (55%) as barriers, and they preferred in-person counseling (97%) over online-counseling (14%) (14) At universities, the Deutsches Studierendenwerk (DSW) a nationwide voluntary association offers psycho-social advice and counseling by psychologists, including the provision of further information i.e., contact of psychotherapists (15). Access to specialist care is covered by the statutory health insurance (covering 90% of the German population), yet the waiting times from initial contact to the start of psychotherapeutic treatment average 20 weeks (16). The president of the German student services released a statement that psychosocial counseling services are insufficiently prepared for the growing number of students with mental illnesses due to limited resources leading to prolonged waiting times and lack of service (17).

Internet- and mobile-based interventions (IMI) characterized by a theory base related to evidence-based psychotherapeutic models and techniques, different level of human support, various application areas and technical implementation are feasible, flexible, cost-effective, and scalable therapies that can overcome the aforementioned barriers (11, 12, 18). They are effective in treating and preventing a broad range of disorders (19, 20), yet uptake remains low as students lack knowledge and experience with IMI but show positive attitudes towards apps (i.e., future expectations and less fear of risks) (21).

An essential prerequisite to adopting and implementing interventions is the acceptance as *behavioral intention to* use them. This is the *hypothetical acceptability* referred to as willingness to use or to receive an intervention. In contrast, acceptance can also be understood or referred to as the *actual acceptability* reflecting the utilization of an intervention, as expressed in uptake rates, adherence, or reported satisfaction (22). Prior research has focused on user engagement (adherence) and acceptability of intervention utilization.

However, little is known about individuals' acceptance (intention to use) and preferred delivery modes of mental health care services and their associated factors. Meta-analytic evidence suggests that patients receiving their preferred psycho-social treatment show less drop-out and increased therapeutic alliance (23). Research on delivery mode preference among university students is limited and shows varying results: US students preferred IMIs over in-person services (24), whereas Irish students preferred in-person services (79%) over websites for mental health (25). Examining a combination of face-to-face (F2F) and IMIs (i.e., blended delivery), Benjet et al. (26) found that Mexican university students preferred in-person and blended treatments over pure IMIs.

Understanding the characteristics of individuals who prefer certain delivery modes over others is required to further improve treatment provision. So far, only one study has examined associated factors of treatment modes in students: Benjet et al. (26) showed that depression, attention-deficit-hyperactivity disorder, beliefs about treatment efficacy, feeling embarrassed or worried about the negative consequences for one's academic career, and the desire to solve problems individually were significant predictors for students to prefer internet- or mobile-based delivery. Kozlov et al. (27) showed that the preference for digital care modalities varies in the general population and is related to symptom severity (e.g., in anxiety and depression) and demographic factors. Almost half of the participants preferred video-psychotherapy, one fourth had no preference, and all others preferred self-guided modes. Those favoring video-psychotherapy had higher symptom severity of depression and anxiety and showed a greater need for higher levels of care. Self-guided digital care was preferred by older, male participants, and those not showing depression or anxiety.

A discrete choice experiment showed that German participants prefer blended care incorporating F2F contact with a psychotherapist over other or no form of human contact in online-based programs. This preference is independent from prior treatment experience and symptom severity as well as sociodemographic parameters (28). A survey by Lincke et al. (29) likewise found a preference for human contact with most participants choosing in-person therapy (81.5%, 78.1%), some choosing blended therapy (11.2%, 11.5%) and only few choosing pure online therapy (6.7%, 7%). Low acceptance rates towards online-based treatments were not affected by the COVID-19 pandemic, but participants that were younger (14–15 years old), male or students had a higher likelihood of preferring an online therapy.

Interestingly, an internet- and mobile-based delivery mode for interventions seems to be preferred in health promotion and prevention targets as opposed to treatment targets. In one study, mobile health apps for coping with stress were preferred over medication, a psychiatrist, online self-help training, or F2F group courses, and were as likely to be used as GPs, psychologists and self-help literature (30). Taking patient preference into account when considering treatment options is important, both for treatment outcome and patient rights. Meta-analytic evidence shows that accommodating patient preferences in psychotherapy (i.e., type of medication and psychotherapy) is associated with treatment completions and positive treatment outcomes (31). Patients with depression prefer psychotherapy to medication and combined treatments options. However, these patients also like low-threshold "treatments" or behaviors, i.e., self-help books, relaxation, or talking to a friend (32).

However, little is known about individuals' acceptance comparing intervention targets in students. A German statutory health insurance company reported on students' interest towards health-related services. Interest was highest in health promotion (mindfulness, resilience), study- and work-related targets (time and self-management), or physical activity and lowest for substance-use reduction (33). In general, female students showed higher interest than male students. This may be explained by higher barriers to help-seeking and service use for male students compared to female students: negative attitudes and low intention of help-seeking, poorer mental health literacy, conformity to traditional masculine norms, and higher public- and self-stigmatization (low self-efficacy beliefs in overcoming mental health problems) (34–36). Providing the most accepted interventions and delivery modes may help student mental health care services to increase treatment utilization, uptake, and completion.

AIM

In this study we used an exploratory approach to examine the frequencies of the acceptance and preference towards delivery targets and formats. In a sample of German first-year students, the study's aim was to

(1) Evaluate the acceptance of intervention targets and their association with sex and mental disorder presence.
(2) Identify the best treatment combinations for students with and without a mental disorder.
(3) Determine the acceptance of and preference for different delivery modes of care on campus in association with sex and mental disorder presence.

Additionally, we explored whether potentially relevant factors such as sex, parental education, presence of a mental disorder, prior treatment experience, intention for service use, knowledge of IMIs and beliefs about their treatment efficacy were associated with treatment mode preferences (i.e., in-person vs. IMI, in-person vs. blended mode).

Methods

Participants and procedures

Participants from the second (2017–2018) cohort of the StudiCare project (37) received a web-based survey, via the Qualtrics survey platform as part of their participation in the World Mental Health International College Student (WMH-ICS) initiative (38). The sample was comprised of first-year students at the Friedrich-Alexander-University Erlangen-Nuremberg (FAU) and at the University of Ulm (UUlm) in Germany. All students of an undergraduate program aged ≥18 years ($n = 9,853$) were eligible for participation, which included students with previous study experience in another program. Of the 2,201 (22.3%) students starting the survey, 1,376 students (14%) completed all items. Sixty-two percent of these were female, with an overall mean age of 20.06 years (SD = 1.73). Informed consent was obtained before survey start and participation was confidential and voluntary. The research protocol was approved by the Research Ethics Committee of the FAU (12.07.2016, 193_16 B). and the UUlm (04.08.2017, 281/17).

Measures

The web-based WMH-ICS survey (38) consisted of validated self-report measures that screened for a wide range of mental health disorders and correlates. In Germany, the survey also included items on acceptance of and preference for delivery modes of mental health services and various clinical (e.g., depression) and preventive (e.g., resilience, mindfulness) intervention targets. The different measures used in the present study are reviewed below.

Acceptance and preference of treatment delivery modes

Participants were introduced to different types of available treatments delivery modes with a focus on internet-based interventions, as we assumed that they knew little about them. Acceptance of and preference for seven different delivery modes of

mental health services were assessed using a binary (yes vs. no) item: "*If you had an emotional problem, which mode of treatment would you like to utilize?*" Participants could indicate their preference in a drop-down list of the seven delivery modes [*group or in-person therapy with on or off campus services, self-help internet- or mobile-based intervention (IMI, i.e., digital) with or without coaching, and a combination of in-person and IMI (blended)*]. For analyses, we aggregated a categorical variable with three mutually exclusive levels: (1) in-person services (i.e., in or off campus, group therapy), (2) IMI (i.e., self-help intervention with or without coaching) and (3) blended services (in-person and IMI combined).

Mental health services: acceptance of intervention targets

Acceptance of various intervention targets in mental health prevention, promotion, and treatment was assessed with the following item: "For *future development of mental health services, we would like to know which of the following intervention targets you would be interested in to help you better cope with emotional and study-related problems and to promote your well-being.*" Participants were asked to indicate (i.e., yes vs. no, multiple answers) which of the following targets (treatment options) they were interested in: disorder-specific targets (reduction of social phobia, depressive mood, reduction of alcohol or cannabis consumption, body dissatisfaction, media consumption), study-related (reduction of test anxiety, procrastination, stress and time management, perfectionism reduction), or targets focusing on general well-being (improvement of sleep quality, resilience).

Willingness or intention to use mental health services

Participants were then asked to report their intention to use mental health services if they developed an emotional problem by answering "*If during this coming college year, you developed an emotional problem that caused you a lot of distress and interfered with your college work, how likely would you be to go to the student Counseling Center for help?*" and "*How likely would you be to go somewhere else for help, like to your doctor, a mental health professional, or a religious advisor?*". This 5-point Likert scale (ranging from "Would definitely go" – "Would definitely not go") was adapted from an assessment of risk and resilience in service members (39) and recoded into a binary variable [yes ("would definitely go", "would likely go") vs. no].

Experience and attitudes toward internet- and mobile-based interventions

In addition, knowledge of and experience with internet-and mobile-based interventions were assessed by asking the students "*Have you ever heard about internet- and mobile-based interventions? Have you ever used one?*" (yes vs. no). Additionally, students were asked to indicate their beliefs about the efficacy of IMIs by rating the following statement "*Internet-based interventions could be an effective way of improving mental health and symptoms*" on a 5-point Likert scale ("Does not apply at all" "Fully applies"). For analyses, the categories were collapsed into a binary measure [yes ("Largely applies", "Fully applies") vs. no].

Treatment utilization/experience

Mental health service utilization was assessed with the following item "*Did you ever receive psychological counseling or medication for an emotional or substance problem?*" (39). This item was shown to any student meeting criteria for any mental health disorder (over their lifetime). All persons who sought help for a mental problem (i.e., medication, counseling) in the past were coded as help-seeker (binary measure: yes vs. no).

Sociodemographics

Of the many variables assessed in the survey, age (continuous variable), sex (male or female), relationship status (being in a relationship, marriage vs. being single, divorced, or widowed), parental education (binary, at least one parent with college education), study type (full-time or part-time), nationality (German or other), university (FAU or UUlm), and study experience [first-time student (freshman) vs. prior university study experience] were reported to describe the sample.

12-month history of or self-assessed DSM-IV diagnosis

The following 12-month DSM-IV disorders were assessed using the validated self-report Composite International Diagnostic Interview Screening (CIDI-SC) (40, 41) scales: major depressive episode (MDE), generalized anxiety disorder (GAD), panic disorder (PD), broad mania, and drug abuse or dependence (i.e., cannabis, cocaine, or any other street or prescription drug). The CIDI-SC scales conform to blinded clinical diagnoses based on the Structured Clinical Interview for DMS-IV [SCID-IV (42);] in the area under the curve (AUC) range of .70–.78 (40, 41).

Alcohol abuse or dependence was assessed using the alcohol use disorders identification test [AUDIT, (43)]. Alcohol use disorder was defined as a total score of ≥8 and a dependence score of ≥4 (44). This AUDIT version conforms with clinical diagnoses in the AUC range of 0.78–0.91 (45). Twelve-month suicidal thoughts and behaviors (STBs) were assessed using the Columbia Suicidal Severity Rating Scale [CSSRS (46),]. This modified version assessed death wish ("*Over the past 12 months, did you wish you were dead or would go to sleep and never wake up?*"), suicide plans ("*Over the past 12 months, did you think about how you might kill yourself or work out a plan of how to kill yourself?*") and attempted suicide ("*Over the past 12 months, have you made a suicide attempt*"). The last two items (suicide plans and/or attempts) were collapsed into a binary measure (yes vs. no).

Any mental health problems

We created a binary variable indicating the presence of at least one mental health disorder over the past 12 months (excluding suicidal plan and attempt). All previously described DSM-IV disorders were included. Subsequently, a variable indicating the number of mental disorders present was created (3-level: one, two, three or more mental disorders).

Statistical analysis

In total 1,376 students fully completed (i.e., no missing variables at the item level) the survey and were included for the final analyses. Specific information on the entire student population was provided by the university administrations allowing us to calculate propensity score weights to adjust for differences between the sample obtained and the entire population (47, 48). We chose predictors previously identified as relevant for mental health, such as demographic (age, sex, nationality) and study-related variables (study program, type of undergraduate degree), that were significant in predicting non-response. First, a dependent variable indicating survey (non-)response (yes = 1, no = 0) was created. Second, a binary logistic regression model was used to estimate the propensity score for each participant. Third, the model results were converted to predicted values, which were used as weights.

All analyses were conducted with the R (version 4.3.1) statistical software extended by following packages: tidyverse, mlogit, survey, gtsummary. The Holm correction was used to control for family-wise error rate and adjust for multiple testing (49). This correction is recommended as it is less conservative and more powerful than the commonly used Bonferroni correction (50). Regarding the delivery modes, we first calculated the proportion (and standard error) of those willing to use each type of mental health care service delivery mode and preference for treatment delivery mode among the total sample. Then we report the willingness to use among those with and without any of the mental disorders and females and males, testing the difference between each of these two groups with χ^2 test adjusted by a design effect estimate (weights).

Second, the "dredge" function in the package MuMin in R was used to identify the best models, using the average of the best models with $\Delta < 2$ as measured via Aikake's Information Criterion (51). We used a bivariate multinomial logistic regression to analyse the association between sex, parental education (as an indicator for socio-economic status), any 12-month mental disorder, treatment experience, treatment efficacy beliefs, and intention to use services with preference for in-person over IMIs and in-person over blended services.

Third, we calculated the proportion and standard error of the acceptance of each intervention target and calculated the willingness to use for participants with and without any 12-month mental disorder grouped by sex, testing the difference between these two variables with a χ^2 test adjusted by a design effect estimate (weights).

Fourth, for each subset by sex, we tested for a difference in target acceptance between those with and without mental disorder (χ^2 test adjusted by a design effect estimate). We report odds ratios as effect sizes for interpretation purposes.

Fifth, we explored the combination of treatment targets and the relative change in overall acceptance. i. e. which two interventions would lead to the highest joint acceptance. Thus, we operationalized the optimal treatment mix as the joint acceptance of at least two of the offered treatment targets. The treatment mixes with the highest acceptance are reported for all students with and without mental disorder as well as each disorder separately. A sensitivity analysis including a combination of three targets evaluated if there is a higher acceptance when offering one additional intervention.

Results

Sample description

The weighted and unweighted sample characteristics ($N = 1,376$), such as demographical variables, clinical variables, and experience with IMI are shown in Supplementary Tables S1, S2. Additionally, we added demographic variables on all fully eligible students, the completer and the drop-out sample in Supplementary Table S3. Students who completed the survey were on average 21.1 years old (SD 3.4), predominately German (91.20%) and showed a balanced sex ratio (female: 50.5%). Most students were freshmen (62.9%) and enrolled in a full-time program (98.7%). Forty percent of participants were in a relationship and half (48%) had at least one parent with a college degree. The prevalence of mental disorders was high with 32.3% of students meeting the clinical criteria for at least one 12-month disorder. The most prevalent disorders were MDE (20.7%), GAD (13.2%) as well as suicidal plans and attempts (10.7%). Additionally, one fourth of students (24.0%) had some prior treatment experience. In general, knowledge about IMI was low; one third (33.4%) had heard about IMI before and only three percent had used one previously.

Willingness and preference to use treatment delivery modes

Table 1 shows the willingness to use (acceptance) and preferred treatment delivery modes among the total sample and among those with a 12-month prevalence of a mental disorder.

Among the total sample, the highest rated delivery modes were in-person off-campus services (76%), followed by in-person on campus services (71%). In comparison, half of the students were interested in IMIs (44%–48%) and even more accepted a blended delivery mode combining in-person with digital services (57%). Group therapy on- and off-campus were the least accepted (31%–36%) modalities. In general, only very small differences in the acceptance of delivery modes were found between students with and without mental disorders. However, students with mental disorders showed lower acceptance towards group therapies (28%–33% vs. 32%–38%) and significantly higher acceptance for self-help IMI (56% vs. 44%, $p < 0.001$).

Delivery mode preferences varied: 72% indicated in-person, 19% internet-based intervention, and 8.6% blended interventions. Preferences were similar among those with and without any 12-month mental disorder ($p > 0.05$). Table 2 contains the results of a bivariate multinomial logistic regression for the relative association between preference for in-person, digital or blended mental health care services and various predictors. The final

TABLE 1 Willingness to use (acceptance) and preferred treatment delivery modes among the total sample and among those with 12-month prevalence of a mental disorder (N = 1,376).

Delivery Mode	Total, N = 1,376	Mental disorder N = 445[1]	No mental disorder N = 932[1]	F	p-value[2]	q-value[3]
	N[1] (%, SE)	N[1] (%, SE)	N[1] (%, SE)			
Group therapy on campus services	427 (31%; 0.01)	126 (28%; 0.02)	301 (32%; 0.03)	2.2	0.2	>0.9
Group therapy off-campus services	502 (36%; 0.01)	147 (33%; 0.02)	355 (38%; 0.02)	3.2	0.11	0.6
In-person on campus services	977 (71%; 0.01)	311 (70%; 0.02)	666 (72%; 0.02)	0.38	0.6	>0.9
In-person off-campus services	1,047 (76%; 0.01)	355 (75%; 0.02)	713 (76%; 0.02)	0.26	0.7	>0.9
Self-help internet intervention	662 (48%; 0.02)	249 (56%; 0.03)	413 (44%; 0.02)	16	<0.001	0.002
Guided internet intervention	611 (44%; 0.02)	200 (45%; 0.03)	411 (44%; 0.02)	0.07	0.8	>0.9
Blended in-person and internet intervention	781 (57%; 0.02)	245 (55%; 0.03)	536 (58%; 0.02)	0.69	0.5	>0.9
Preference	N[1] (%[4], SE)	N[1] (%[4], SE)	N[1] (%[4], SE)	6.7	0.074	
In-person treatment	996 (72%; 0.01)	309 (69%; 0.02)	687 (74%; 0.02)			
Digital treatment	263 (19%; 0.01)	102 (23%; 0.02)	160 (17%; 0.01)			
Blended treatment	118 (8.6%; 0.01)	34 (7.6%; 0.01)	84 (9.1%; 0.01)			

[1]Weighted.
[2]χ^2 test adjusted by a design effect estimate.
[3]Holm correction for multiple testing.
[4]Percentages may not total 100 due to rounding.

model containing the following predictor variables explained more variance compared to the baseline model (containing all candidate variables): any 12-month mental disorder, sex, intention to use services, treatment efficacy beliefs and prior treatment experience. Knowledge of and experiences with IMI and parental education did not contribute to a reduction in variance. Both digital and blended treatments were compared to in-person (reference category). A preference for digital over in-person delivery was significantly associated with efficacy beliefs of IMI, no prior treatment experience, no intention for service use, and having a mental disorder. Individuals that believe in the efficacy of IMI were significantly more likely to prefer digital over in-person delivery modes compared to individuals that thought they were ineffective (OR: 3.15, 95% 2.9, 4.35; $p < .001$). Participants with a

mental disorder showed higher odds of preferring digital modalities [OR: 1.56, 95% (1.14, 2.12); $p = .005$]. Students without intentions to use services were more likely to prefer digital over in-person modes [OR: 2.75, 95% (1.95, 3.98); $p < .001$], compared to students with these intentions. Participants with treatment experience were less likely to choose digital over in-person treatment [OR: 0.48, 95% (0.31, 0.73); $p < .001$]. Preferring a blended over an in-person treatment was significantly associated with perceived IMI efficacy, indicating that individuals believing in their efficacy were significantly more likely to prefer digital over in-person services compared to individuals who thought they were ineffective [OR: 2.8, 95% (1.82, 4.3); $p < .001$]. Additional information on the model can be found in Supplementary material S4.

TABLE 2 Bivariate multinominal logistic regression of mental health care modality preferences for relative associations between preferred modes, and demographic, clinical predictors, and intention to use treatment.

Factor	Digital vs. In-person			Blended vs. In-person		
	OR[1]	95% CI[1]	p-value	OR[1]	95% CI[1]	p-value
Mental disorder						
(0) no disorder (ref)	1	–	–	1	–	–
(1) any 12-month disorder	1.556	1.140, 2.124	0.005	0.954	0.610, 1.494	0.8
Perceived efficacy of IMIs						
(0) no effect of IMI (ref)	1	–	–	1	–	–
(1) efficacious treatment	3.153	2.287, 4.347	<0.001	2.789	1.816, 4.284	<0.001
Treatment Experience						
(0) No prior treatment (ref)	1	–	–	1	–	–
(1) Prior treatment	0.464	0.306, 0.704	<0.001	0.661	0.395, 1.108	0.12
Sex						
Male (ref)	1	–	–	1	–	–
Female	0.817	0.611, 1.092	0.2	1.234	0.834, 1.826	0.3
Intention to use services						
(0) Willing to use services when needed (ref)	1	–	–	–	–	–
(1) Not willing to use services	2.749	1.949, 3.878	<0.001	1.180	0.787, 1.769	0.4

AIC = 1,976; No. Obs. = 1,376.
[1]OR, odds ratio; CI, confidence interval; ref, reference.

TABLE 3 Willingness to use (acceptance) treatment targets among those with and without 12-month mental disorder presence by sex ($N = 1,376$).

Target		Mental disorder ($N = 445$)			No mental disorder ($N = 932$)		
	Total, $N = 1,376$	Male, $N = 221$[1]	Female, $N = 260$[1]	OR[2,3]	Male, $N = 461$[1]	Female, $N = 435$[1]	OR[2,3]
	N[1] (%, SE)	N[1] (%, SE)	N[1] (%, SE)	OR (95% CI)	N[1] (%, SE)	N[1] (%, SE)	OR (95% CI)
Stress	1,001 (73%; 0.01)	131 (67%; 0.04)	201 (80%; 0.03)	0.52 (0.34, 0.80)*	321 (66%; 0.03)	349 (79%; 0.02)	0.52 (0.39, 0.70)**
Stress management	981 (71%; 0.01)	129 (67%; 0.04)	187 (75%; 0.03)	0.68 (0.45, 1.03)	339 (70%; 0.03)	326 (73%; 0.02)	0.83 (0.62, 1.10)
Body-dissatisfaction	527 (38%; 0.01)	71 (36%; 0.04)	130 (52%; 0.03)	0.53 (0.36, 0.78)*	139 (28%; 0.03)	187 (42%; 0.02)	0.54 (0.41, 0.71)**
Cannabis	33 (2.4%; 0.00)	10 (5%; 0.02)	6 (2.2%; 0.01)	2.34 (0.81, 6.75)	11 (2.2%; 0.01)	7 (1.5%; 0.01)	1.46 (0.55, 3.89)
Alcohol	47 (3.4%; 0.01)	13 (6.5%; 0.02)	9 (3.5%; 0.01)	1.90 (0.79, 4.58)	18 (3.7%; 0.01)	7 (1.5%; 0.01)	2.51 (1.03, 6.11)
Procrastination	1,030 (75%; 0.01)	159 (82%; 0.04)	198 (79%; 0.03)	1.22 (0.76, 1.97)	361 (74%; 0.02)	312 (70%; 0.02)	1.20 (0.90, 1.61)
Sleep	798 (58%; 0.02)	117 (61%; 0.05)	166 (66%; 0.03)	0.79 (0.53, 1.16)	273 (56%; 0.03)	242 (55%; 0.02)	1.05 (0.81, 1.37)
Perfectionism	527 (38%; 0.01)	73 (38%; 0.04)	131 (52%; 0.03)	0.55 (0.38, 0.81)*	130 (27%; 0.03)	193 (44%; 0.02)	0.47 (0.36, 0.62)**
Social anxiety	744 (54%; 0.02)	130 (67%; 0.04)	160 (64%; 0.03)	1.17 (0.79, 1.74)	245 (50%; 0.03)	208 (47%; 0.02)	1.14 (0.88, 1.48)
Test anxiety	760 (55%; 0.02)	109 (56%; 0.04)	169 (67%; 0.03)	0.63 (0.43, 0.92)	224 (46%; 0.03)	259 (58%; 0.02)	0.60 (0.47, 0.78)**
Resilience/well-being	742 (54%; 0.02)	129 (67%; 0.04)	195 (78%; 0.03)	0.57 (0.38, 0.87)	169 (35%; 0.03)	249 (56%; 0.02)	0.41 (0.32, 0.54)**
Depression	632 (46%; 0.02)	130 (67%; 0.04)	185 (74%; 0.03)	0.74 (0.49, 1.11)	148 (30%; 0.03)	168 (38%; 0.02)	0.72 (0.54, 0.94)
Media consumption	434 (32%; 0.01)	70 (36%; 0.04)	95 (38%; 0.03)	0.93 (0.63, 1.38)	156 (32%; 0.03)	113 (25%; 0.02)	1.38 (1.04, 1.84)

OR, odds ratio; SE, standard error; CI, confidence interval.
*Applies if the post-hoc adjustment by holm is significant ($p < 0.001$).
**Applies if the post-hoc adjustment by holm is significant ($p < 0.05$).
[1]Weighted percentages may not total 100% due to rounding.
[2]χ^2 test adjusted by a design effect estimate.
[3]Holm correction for multiple testing.

Willingness to use different treatment targets

Most students favored study-related intervention targets such as procrastination (75%), stress (73%), and time management (71%) (see Table 3). About half of the students were interested in interventions focusing on problems that commonly occur in college years, i.e., sleep (55%), social anxiety (50%), test anxiety (46%), and depression (46%). Well-being (resilience) was interesting for 54% of the students. Less prevalent behavioral problems, such as body-dissatisfaction (38%), media consumption (32%), and perfectionism (38%) received less interest. The least accepted treatment targets were cannabis use (2.4%) and alcohol use reduction (3.4%).

Targets differed in their acceptance showing higher rates for students with mental disorders. The highest differences were seen for resilience (67%–78% vs. 35%–56%) and depression (67%–74% vs. 30%–38%). Also, interventions targeting procrastination (79%–

82% vs. 70%–74%), sleep (61%–66% vs. 55%–56%), perfectionism (38%–52% vs. 27%–44%) or social anxiety (64%–67% vs. 47%–50%) showed higher acceptance among students with mental disorder. The other targets were similarly distributed between students with compared to students without mental disorder.

Among students without a mental disorder, female students indicated significantly higher levels ($p > 0.001$) of acceptance for interventions on stress, body-dissatisfaction, perfectionism, test-anxiety, and resilience, as compared to male students. For all other targets acceptance was similar between sexes. Among students with a mental disorder, a similar pattern of acceptance could be observed. The only significantly higher level of acceptance in female students compared to male students was found for the intervention targets: stress, body-dissatisfaction, and perfectionism.

The optimal combination of intervention targets Table 4 shows preferred treatment combinations ($k = 2, 3$) among the total sample and with or without any 12-month mental disorder present. If we

TABLE 4 The treatment target combinations ($k = 2, 3$) reaching the highest acceptance among the total sample and by 12-months mental disorder presence.

Two treatment targets	%	Three treatment targets	%
Total sample		Total sample	
Procrastination + Stress	88.18	Procrastination + Stress + Time management	91.49
Procrastination + Time management	86.20	Procrastination + Stress + Social anxiety	91.39
Stress + Time management	85.49	Procrastination + Stress + Sleep +	91.31
Any disorder		Any disorder	
Procrastination + Depression	90.99	Procrastination + Sleep + Resilience	94.06
Procrastination + Resilience	90.63	Procrastination + Social anxiety + Resilience	93.40
Procrastination + Social anxiety	88.83	Procrastination + Perfectionism + Depression	93.34
No disorder		No disorder	
Procrastination + Stress	87.93	Procrastination + Stress + Time management +	91.57
Procrastination + Time management	85.56	Procrastination + Stress + Test anxiety	90.85
Stress + Time management	85.84	Procrastination + Stress + Sleep	90.79

only had resources to offer two interventions, a combination of stress, procrastination, or time management, would reach acceptance rates of 85%–88%. Offering all three treatments would increase the joint acceptance to 91%. For students with a mental disorder a combination of procrastination and depression as treatment targets (91%), and a combination of sleep, procrastination, and resilience would lead to high acceptance rates (94%).

Supplementary Table S5 presents the optimal treatment mixes per 12-month mental disorder. For MDE, PD and suicide plan and/ or attempt, a combination of procrastination and depression targets are most accepted (range: 92.10%–92.63%). Among participants with GAD the preferred 2-treatment mix was resilience and procrastination (94.09%) followed by stress and social anxiety. Students with drug abuse or dependence showed the highest willingness to use for interventions combining time management with stress or resilience (84.16%). Students with alcohol abuse or dependence preferred intervention targeting time management and stress (96.75%). For students with broad mania, the highest-rated 2-treatment mix was test anxiety in combination with procrastination (94.33%). A 3-treatment mix only showed a minimal increase in acceptance (range: 0%–3.24%) across all disorders.

Discussion

Principal findings

This study's sample showed that German university students' acceptance varies depending on the delivery mode (in-person 71%–76%, IMI 44%–48%, blended 57%, group therapy 31%–36%). Students with mental disorders indicated a higher acceptance of internet- and mobile-based self-help services compared to students with no disorder. Regarding delivery mode preference, in-person services were preferred over digital and blended modalities. High treatment efficacy beliefs, no intention for service use, having a mental disorder, and lack of treatment experience were significantly associated with preferring digital over in-person treatment.

The study is the first to evaluate the acceptance of intervention targets among students with and without a 12-month mental disorder in Germany. Study-related targets (i.e., procrastination) showed the highest acceptance, while reducing cannabis or alcohol were the least accepted targets. In general, female students with a mental disorder showed higher interest in various intervention targets. Analysis of treatment combinations, (both overall and among those without a mental disorder) indicated that a two-way combination of procrastination, stress, or time-management is favorable. Students with a mental disorder favored a combination of procrastination and depression as treatment targets. Offering three instead of two targets led to a negligible increase in acceptance.

Comparison with prior work

Our findings are consistent with existing evidence on the acceptance of treatment modalities in the student population.

One prior study involving Mexican students found similar acceptance rates for any in-person service (74%) and digital (42%) delivery mode. Likewise to our study, the acceptance for IMIs was significantly higher among students with a mental disorder (26). Moreover, in our sample in-person group therapy was the least accepted treatment mode, which may be explained by the desire to solve problem independently (11, 12).

Our findings regarding the preference for delivery modes differed, in part, from previous evidence. Students in Germany and Mexico preferred in-person treatments. However, Mexican students showed similar preference for blended (36%) and in-person therapy (38%), and low preference for IMIs (7%), and one fifth reported no preference at all (26). German adults significantly preferred blended over internet-delivered modes for programs focusing on stress coping (52), whereas German students in our sample preferred an internet-and mobile-based (19%) over a blended mode (9%). The reason for this difference remains unclear and evidence regarding the predictors of delivery mode preference is limited. We found efficacy beliefs of IMIs to be associated with blended and digital mode preference. Benjet et al. (26) also found treatment efficacy beliefs to be associated with IMI preference, while sex and parental education had no effect. Apolinário-Hagen et al. (52) showed a higher stress level to be a predictor of the preference for digital intervention modes. Similar to the findings in Apolinário-Hagen et al. (53), our study identified that having prior experience with a specific treatment mode positively predicted the preference for this mode among participants. In line with findings by Benjet et al. (26), existing hesitancy towards service use was a predictor for digital mode preference in our sample. That is, students who stated they would definitely not seek help commonly preferred to solve problems by themselves, hence preferred digital self-help intervention modes.

Our findings are supported by data on the general German population which prefers in-person therapy. Lincke et al. (29) found younger age and student status to be positively associated with IMI preference which may explain why we found blended therapy to be the least preferred option. However, a discrete choice experiment showed blended therapy to be the preferred mode. Unfortunately, the study only measured preferences towards IMIs and did not include in-person therapy as a selectable option (28).

Common reasons for the low acceptance and preference of IMIs are low efficacy beliefs, confidentiality and privacy concerns, scepticism about self-guided IMIs and low motivation (54). This is underscored by a relatively low uptake of reimbursable digital health applications (DiGA) that were introduced via the Digital Healhcare Act (Digitale-Versorgungs-Gesetz; DVG) in 2019. The monthly number of used DiGAs tripled from 5.000 in December 2021 to 15.000 in September 2023 (55). However, a statutory health insurance remarked that the uptake of DiGAs is relatively low and growth may be due to increased uptake of existing interventions (56).

Our study was the first to evaluate the acceptance of different treatment targets and complements previous findings on student's interest in health services and research on patient preferences for psychotherapy treatment options. In the present study acceptance was highest for targets related to problems at

campus (study-related e.g., stress, procrastination) especially among students with a mental disorder, and lowest for alcohol and cannabis reduction. Procrastination, which is very prevalent in student populations and associated with lower quality of life, symptoms of stress, depression, and anxiety in university students (56), was of particular interest for students. Students with a mental disorder showed a higher acceptance of treatment targets than student without any mental disorder. This aligns with findings from two prior studies: first, Canadian students with high self-reported symptoms use more health care services (60). Second, a recent report on student health by a German statutory health insurance provider (TK), (33) showed high interest in resilience, mindfulness, and time and self-management, and low interest in substance abuse, and more interest among female students than male students. Acceptance rates of other targets, such as sleep, and media consumption, were similar to our results. In the same report, students identified study-related problems as the causes of stress they are exposed to at university. Research shows that primary care patients favor treatments that help them understand the causes of their feelings and problems and that they like to learn new skills and relaxation techniques (58). Following this logic, procrastination, stress and time-management interventions may constitute the favored treatments for university students as they help them to decrease their main stressors and increase their coping skills.

Limitations

Some limitations of the present study should be discussed. First, the intention to use a treatment target or delivery mode does not fully translate to actual utilization behavior, i.e., the intention-behavior gap (60). We were unable to assess differences between willingness and preference to use treatment targets compared to the actual treatment utilization data. This was due to the cross-sectional design and limited access to service use data. Future studies with a longitudinal design and access to actual treatment utilization may address this issue. Yet, intention can be used as proxy for treatment utilization. Past research shows that most students expressing an interest in a digital stress management intervention also registered for it (61). Second, the drop-out was substantial due to the length of the survey as part of the WMH-ICS project and the exclusion of incomplete surveys. Although we attempted to address this issue by applying propensity score weighing, less drop-out may have revealed additional insights. Third, participants had no response category for treatment rejection, nor did we directly ask about the preferred treatment target. This may have led to skewed results, forcing students to select a response that did not reflect their true preference. Fourth, not all predictors that could be relevant for the acceptance and preference of delivery modes were included in the survey. Adding new predictors, such as fear of stigma and preference to handle problems on one's own, might help to further investigate delivery mode preferences and improve treatment provision. Fifth, due to the high drop-out and

potential occurrence of selection bias, the generalizability is limited. This is especially true as both universities are in the south of Germany and results may therefore not be generalizable to all German universities. Sixth, the use of accepted and preferred intervention targets and delivery modes is a good way to increase the mental health service use. However, we do not know if these interventions are also the most effective treatments. Therefore, clinical trials need to confirm whether there is a difference in the effectiveness of preferred treatments compared to treatments that are recommended by an expert or clinician. Seventh, due to the relatively old data, preferences and attitudes may have changed over time, as efforts for the digitalization of the health care sector have sharply increased, for example, due to the COVID-19 pandemic. However, a more recent qualitative study on digital mental health services showed that German students only have little experience with this kind of services (62). Eighth, the 12-month mental disorders were solely based on self-reported DSM-IV criteria which may have led to inflated prevalences due to self-selection and recall bias. Despite these limitations, this study provides new insights and evidence regarding the acceptance for treatment targets and their delivery modes.

Clinical implications and future research

Based on our findings, recommendations for future research and clinical implications can be made. Offering students with mental disorders their preferred treatment option minimizes their treatment reluctance and increases their intention to use treatment while reducing mental health symptoms. Meta-analytic evidence on in-person or internet-based interventions targeting resilience and stress management supports their efficacy in reducing symptoms of depression, anxiety, and stress (63, 64). This concept is known as indirect prevention and treatment which focuses on intervention targets that are less stigmatized, but still related to disorders. In depression such intervention targets are insomnia and stress (65). Thus, future research should include more prevention and health promoting targets to assess their acceptance and preference relative to the others.

Acceptance of IMIs is moderate among students, but their preference is much lower than for in-person treatments. Given the limited resources of student counseling centers and the growing number of students with mental health problems, IMIs could still be useful. IMIs are similarly effective as face-to-face counseling in the treatment of mental disorders (69) and mental health promotion (64) and prevention (66); they are low-threshold, can reach students (with mental disorders, no intention of seeking help, and no treatment experience) who would otherwise not receive care, and have the potential to be cost-effective (68). Meta-analytic evidence of IMIs in routine care shows promising effects in the treatment of mental disorders in adults (69). However, the reach (initial contact with service) among university students remains low while the uptake of those enrolled in the interventions is high (70). Stakeholders view data security, privacy concerns and limited in-person contact as

barriers for a successful implementation (71). Facilitators of implementation are evidence-based, attractive and updated IMIs adapted for contextual factors (71) and the use of evidence-based frameworks such as RE-AIM (reach, effectiveness, adoption, implementation, and maintenance) (72) or the Consolidated Framework for Implementation Research (73). IMIs, as scalable, low-threshold interventions that can be easily tailored, are an indispensable ingredient of sustainable student health care management assuming their successful implementation.

Research shows that students who cannot be offered immediate in-person treatment would prefer digital treatment to waiting (74). Students are not inherently averse to using IMI, but limited knowledge about and experiences with IMI demonstrated in our study and many others may explain students' preferences for in-person delivery modes as "the" standard treatment.

Another barrier for IMI preference could be scepticism towards and perceived risk of use, as shown in mental health apps (75). The same authors who validated the Unified Theory of Acceptance and Use of Technology (UTAUT) model for digital health care also found internet/technology anxiety ("fear or mistrust experienced while using the internet") to be a moderating factor for the acceptance of IMIs (76). Concerns about the protection of sensitive data in digital health apps are well-known (77) and relevant to students. This is supported in a study by Dederichs et al. (78) where students emphasized data security and the scientific evaluation of IMIs as relevant topics for mHealth app development.

One strategy to increase participants' willingness to use, treatment uptake, and treatment adherence of IMIs are acceptance facilitating interventions (AFI). We suggest AFIs that focus on providing knowledge on the effectiveness of IMIs, intervention procedures, and data security to reduce the fear of technology. This may help to strengthen positive attitudes (e.g., awareness, treatment efficacy beliefs) toward IMIs, which are known to be strong predictors for their use (52). There is evidence that AFIs can increase the acceptance of IMIs. Ebert et al. (11, 12) found internet-based personalized feedback on symptom severity and information on available services, which was integrated in our survey, to be effective in increasing help-seeking intentions. In another survey, students received different informational materials on a digital resilience training. Here, the intention to use services was associated with a higher level of stress and self-identification with testimonials. Therefore, information must be adapted to the student setting. Interestingly, most students who were offered an intervention shortly after exposure to an AFI signed up for it (61). Another promising method to increase the acceptance of IMIs involves participatory research design. Dederichs et al. (78) conducted co-design workshops to identify medical students' preferences and ideas for mobile health apps to increase their acceptance, demonstrating the feasibility and acceptance of such workshops.

In conclusion, students are interested in different intervention targets and delivery modes, partly depending on mental disorder status, treatment experience, sex, and their knowledge of treatment options. Offering one-size-fits-all interventions which are currently widely implemented in student mental health care

do not match our findings. Thus, we recommend further research on the preference and acceptance of treatment targets and delivery modes in form of needs assessments to confirm and extend the available evidence. In practice, we recommend decision-makers and practitioners to follow five steps to increase the acceptance of mental health care services at university: first, evaluate current services used. Second, decide if services should cater to all students or specific target groups only (e.g., students with mental disorders). Third, choose the most accepted interventions and delivery modes. Fourth, plan and conduct AFI in general (i.e., on mental health literacy, efficacy of treatments) or specifically for delivery modes that are available and scalable, but not the most accepted (e.g., on efficacy beliefs and data protection of IMI). Fifth, if AFI are used, available services should be offered directly afterwards.

Designing and building needs-based student mental health care services, while respecting different student groups' diverse acceptance of and preference towards treatment targets and delivery modes improves the provision of optimal treatments. This increases engagement and service use, reduces treatment reluctance, improves mental health, avoids premature college drop-out, and allocates limited resources in the best possible way.

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 humans were approved by the Research Ethics Committee of the Friedrich-Alexander-Universität Erlangen Nürnberg (12.07.2016, 193_16 B). and the University of Ulm (04.08.2017, 281/17). 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

FK: Data curation, Formal Analysis, Project administration, Writing – original draft, Writing – review & editing. PH: Supervision, Writing – review & editing. A-MK: Project administration, Writing – review & editing, Data curation. HB: Funding acquisition, Supervision, Writing – review & editing.

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Conflict of interest

HB reports having received consultancy fees and fees for lectures/workshops from chambers of psychotherapists and training institutes for psychotherapists in the e-mental-health context.

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.

The authors declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fdgth.2024.1284661/full#supplementary-material

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Exploring subgroups of acceptance prediction for e-mental health among psychotherapists-in-training: a latent class analysis

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Theoretical background: Research of E-Mental Health (EMH) interventions remains a much-studied topic, as does its acceptance in different professional groups as psychotherapists-in-training (PiT). Acceptance among clinicians may vary and depend on several factors, including the characteristics of different EMH services and applications. Therefore, the aims of this study were to investigate the factors that predict acceptance of EMH among a sample of PiT using a latent class analysis. The study will 1) determine how many acceptance prediction classes can be distinguished and 2) describe classes and differences between classes based on their characteristics.

Methods: A secondary analysis of a cross-sectional online survey was conducted. N = 216 PiT (88.4% female) participated. In the study, participants were asked to rate their acceptance of EMH, as operationalized by the Unified Theory of Acceptance and Use of Technology (UTAUT) model, along with its predictors, perceived barriers, perceived advantages and additional facilitators. Indicator variables for the LCA were eight items measuring the UTAUT-predictors.

Results: Best model fit emerged for a two-class solution; the first class showed high levels on all UTAUT-predictors, the second class revealed moderate levels on the UTAUT-predictors.

Conclusion: This study was able to show that two classes of individuals can be identified based on the UTAUT-predictors. Differences between the classes regarding Performance Expectancy and Effort Expectancy were found. Interestingly, the two classes differed in theoretical orientation but not in age or gender. Latent class analysis could help to identify subgroups and possible starting points to foster acceptance of EMH.

1 Introduction

The need for reliable and effective interventions to support mental health has grown rapidly, pushing the health system to its limits in many countries. One way to address this need is through E-Mental Health (EMH) interventions. EMH may be especially suited to address treatment barriers of underserved populations (e.g., rural areas, avoidance behavior due to shame/stigma) or waiting times. In recent years EMH has evolved and shown promising results in many studies in decreasing symptomatology (1), also in low- or middle-income countries (2). While evidence supports the effectiveness of EMH for mild to moderate mental health issues, caution is needed when considering its generalizability (e.g., selection bias, drop-out rates). Nevertheless, it remains of interest why EMH is rarely used in many countries (3). Therefore, barriers and facilitators to the integration of EMH in routine care have been discussed (4). One of the most frequent determinants of providing and receiving EMH in routine care is the acceptance of mental health care providers and patients (5). Interestingly, there is a systematic review suggesting that people with mental disorders and general practitioners have a more favorable view of EMH than psychotherapists, which poses a barrier to its implementation (6). This result was also found in more recent studies (7), however COVID-19 has accelerated the use of EMH (8, 9) and thus more positive attitudes towards online therapy were found (10). There are different theoretical models (e.g., Technology Acceptance Model, Unified Theory of Acceptance and Use of Technology - UTAUT) to operationalize acceptance of EMH f.e. as the intention to use technology such as EMH in general or a specific EMH application.

The UTAUT (11) contains four key constructs, namely Performance Expectancy (belief that using the system will enhance job performance), Effort Expectancy (expected ease of use), Social Influence (extent to which one believes significant others endorse using the new system), and Facilitating Conditions (organizational or technical resources exist for technology use) as predictors. This theory has been expanded in a variety of other studies using additional determinants ("knowledge of eHealth Interventions" cf. 12). Acceptance varied significantly between modalities (e.g., videoconferencing vs. unguided programs; cf. 13, 14). Also, UTAUT has been used in many studies which consider the perspective of the client (15, 16) as well as the perspective of the medical/psychological staff (12, 14, 17). Therefore, the UTAUT holds particular relevance regarding the acceptance of EMH in a medical context (12) in different target groups. Psychotherapists-in-Training (PiT) are an understudied and undervalued population which provide insight into the psychotherapy training. This bears relevance as the acceptance of EMH among PiT could influence the future of healthcare systems. However, to date, research on this specific group has been scarce, with only two studies utilizing the same dataset as the present study being published (14, 17): The overall acceptance of EMH among PiT, which was assessed on a 1-5 Likert scale and then categorized into the categories low (1–2.34), moderate (2.35–3.67), or high (3.68–5), can be described as moderate in N = 216 German-speaking PiT (14). This research also highlights the fact that Performance Expectancy, Social

Influence and concerns about the therapeutic alliance determine EMH acceptance. Moreover, acceptance of psychotherapy via videoconference was rated the highest (M = 3.7, SD = 1.15) and acceptance of unguided programs was rated the lowest. In a secondary analysis interaction between the different application purposes (e.g. prevention, treatment addition, treatment substitute and aftercare) and different EMH modalities (e.g. telephone, videoconference, VR, unguided programs, guided programs) were analyzed (17). Although research has explored the general acceptance of EMH among PiT and other determinants of EMH (e.g., barriers, advantages) it remains unclear whether there are subgroups in this population and, if so, what characterizes those subgroups. So far, subgroup analysis using the UTAUT in a medical context has been conducted with dichotomized variables, employing a median-split (18) or using pre-existing categories (e.g., gender, no prior experience) (19, 20). Latent class analysis aims to achieve homogeneity within clusters while fostering heterogeneity between clusters (21). The number of distinct classes is not defined *a priori* but is chosen based on statistical criteria (22). In contrast to previous research using the same dataset (14, 17), which mainly focused on the determinants of EMH and interaction effects, LCA can provide insight into latent subgroups that may be present in the current sample but have not yet been explored. These classes could help researchers and practitioners understand differences and similarities between groups, with implications for future research and the development of tools to foster EMH acceptance.

Therefore, the present study aims to 1) determine how many acceptance prediction classes can be distinguished and 2) describe the classes and differences between classes based on their characteristics (e.g., theoretical orientation, sociodemographic characteristics, perceived advantages and barriers of EMH).

2 Methods

2.1 Participants and procedures

This analysis is a follow-up to a cross-sectional online study conducted at the University of Zurich during the summer of 2020. Between June and July 2020, participants were recruited using E-mail invitations through well-established educational institutions for psychotherapy in both Germany and the German-speaking region of Switzerland. The survey consisted of 50 questions, and it took participants on average 19.1 minutes to complete (SD = 5.9). In total, outreach efforts were made to 29 institutions in Switzerland and 232 institutions in Germany. However, only a limited number of institutions provided feedback regarding the distribution of the questionnaire, making it impossible to determine the response rate at an institutional level. In total, the survey received 692 visits, out of which 228 participants successfully finished the survey, resulting in a dropout rate of 68.7%. Twelve individuals were omitted from the analysis due to their emergent status as psychotherapist trainees. These participants had solely engaged in the theoretical segment of their training, lacking any clinical experience. Consequently, the final sample size was reduced to 216 participants. The

comprehensive outcomes of the original study have been documented separately (14) but can also be found in brief in the introduction of this publication. Ethical safety was provided according to a checklist of the ethics committee of the University of Zurich not requiring any other ethical approval of the ethics committee.

2.2 Measures

The survey contained items on sociodemographic characteristics including age, sex, education, country of education (Switzerland or Germany) and theoretical orientation (i.e. cognitive behavioral therapy, depth psychology or psychoanalysis). Acceptance of EMH was operationalized according to the UTAUT (11) and assessed using three items, which were adapted from previous studies (12, 18, 23, 24). A definition of EMH was given to the participants in the beginning of the survey and can be found in the Supplementary Materials. UTAUT predictors (Performance Expectancy, Effort Expectancy, Social Influence and Facilitating Conditions) were each assessed with two items. Perceived advantages (time flexibility, simplified information provision, geographic flexibility, and simplified contact maintenance) and barriers (data insecurity, impersonality, irresponsibility, legal concerns, concerns about therapeutic alliance) to EMH were assessed using single items. Three items were adapted from Hennemann et al. (12) and Ebert et al. (25) to assess knowledge about EMH. Experience with EMH was dummy coded into two groups with and without experience. The subjective estimation of evidence on EMH was rated on a visual analogue scale ranging from 1-101. The questionnaire in full can be found in the Supplementary Materials.

2.3 Statistical analysis

Data was analyzed using IBM SPSS Statistics (Version 27) and R (Version 4.0.0). The LCA computation utilized the poLCA package (26) using the UTAUT predictors as indicators and initially starting with a single-class solution and progressively adding classes. LCA is a popular method for extracting meaningful homogenous subgroups from data (27). Identifying the optimal number of classes is based on indices, such as the Bayesian Information Criterion (BIC), Akaike Information Criterion (AIC), and relative entropy. Notably, the BIC is considered the most robust criterion as it imposes a harsher penalty on the number of parameters than the AIC (22). Smaller AIC and BIC values suggest a more favorable model fit, while greater relative entropy values indicate improved precision concerning the identified classes, with an advisable threshold of 0.8. (22). Upon determining the optimal LCA model based on previously mentioned criteria, individuals were allocated to distinct classes predicated on their posterior class membership probabilities. Differences between the classes were calculated using Chi-Squared tests for count data, Wilcoxon-Test for ordinal variables and t-tests for continuous variables.

3 Results

3.1 Model selection

Table 1 shows all tested models and the model-fit criteria. Model 5 showed higher entropy values compared to Model 2, but classes would have been small (around 6% of sample) and the BIC was lowest in Model 2, supporting the two-class solution. In the Supplementary Material descriptive statistics of the indicator variables for the two-class solution are also further described and illustrated.

3.2 Class description

The first class included the majority of participants (63.4%) and was characterized by very high scores across all UTAUT predictors. The only exception was the second item for Social Influence ("Our patients endorse the use of the following EMH services"), which had the lowest score compared with the other indicator variables. This class was therefore labeled as *highly beneficial factors*. The second class was characterized by moderate expressions across the UTAUT predictors. Next to the second Social Influence item, also one Facilitating Condition item ("The technical equipment of my professional environment is adequate for the implementation of EMH services") showed lower scores compared to the other predictors. Class 2 was therefore labeled as having *moderately beneficial factors*. Regarding the indicators, the biggest differences between the classes were found in Performance Expectancy and Effort Expectancy (r = 0.67 and r = 0.60). Figure 1 illustrates, distinctively for class 1 and class 2 the proportion of responses for the eight UTAUT predictors.

While the classes did not differ significantly in terms of age and gender distribution or country of origin, they did differ in therapeutic orientation. Class 1 had significantly ($\chi2(1) = 5.13$, *p* <.05) more participants with a cognitive behavioral orientation compared to Class 2. Descriptive statistics and class comparisons for sociodemographic variables are shown in Table 2.

Additionally, differences between the classes regarding EMH specific variables were tested. Class 1 scored significantly higher on all perceived advantages and lower on all perceived disadvantages, the only exception being data security where no difference manifested itself. Class 1 also showed significantly (*p* <.01) more experience with and knowledge about EMH. Likewise, the evidence rating and the acceptance of EMH in Class 1 was significantly higher. Descriptive statistics and comparisons across the two classes can be found in Table 3.

4 Discussion

Our study showed that two classes can be distinguished when using the UTAUT predictors as indicators for the LCA. The first class showed high levels on all UTAUT predictors, the second class revealed moderate levels on the UTAUT predictors, no class

TABLE 1 Evaluating class solutions and model fit criteria.

Model	log-likelihood	resid. df	BIC	aBIC	cAIC	likelihood-ratio	Entropy
Modell 1	-2083.4	184	4338.81	4237.4	4370.81	1906.04	–
Modell 2	**-1903.98**	**151**	**4157.35**	**3951.37**	**4222.35**	**1547.2**	**0.808**
Modell 3	-1821.56	118	4169.89	3859.35	4267.89	1382.36	0.82
Modell 4	-1777.28	85	4258.72	3843.6	4389.72	1293.8	0.816
Modell 5	-1736.29	52	4354.13	3834.44	4518.13	1211.83	0.953

Selected model in bold.

showed particularly low scores on the UTAUT predictors, which is in line with previous research (28). The largest differences between classes were found in Performance Expectancy and Effort Expectancy of EMH, which highlights the fact that these aspects would require special attention when developing interventions to foster acceptance. The two classes also revealed differences, regarding the acceptance of EMH, the estimation of evidence, knowledge, and experience. Previous studies have already highlighted the fact that knowledge and experience are positively associated with higher acceptance (10, 12, 25, 29, 30), so it is unsurprising that Class one had higher acceptance scores, more knowledge about and more experience with EMH. This suggests potential directions for future research and underscores key areas for enhancing acceptance facilitating interventions (31).

It is worth mentioning that no class-difference arose among the high scores on data security as a barrier, which emphasizes that this aspect needs to be addressed by either training institutions or the developers of EMH independently of the class membership. Additionally, the fact that Class 2 scored lowest on one of the Facilitating Condition Items ("The technical equipment of my professional environment is adequate for the implementation of EMH services") highlights the need for workplaces to invest in technology and technical equipment if EMH is planned to be

implemented in routine care. Due to the low scores on item 2 of Social Influence ("Our patients endorse the use of EMH services") it became evident for both classes that the patient's perspective plays an important role and that the acceptance of PiT needs to be addressed in the clinical context as well.

So far, no other study has tried to build subgroups among PiT focusing on the acceptance of EMH using a LCA. There have been few studies, focusing on patients, that tried to find subgroup-specific differences for established groups (e.g., gender, education) or used median-splits to artificially build subgroups (18, 20). Hennemann et al. (18) showed that acceptance significantly differed between age groups, yielding a significantly higher acceptance score in the youngest quartile. They also found differences in acceptance regarding prior EMH use and higher educational status. Compared with our classes, we did not find any significant difference regarding age, but in line with Hennemann et al. (18) more prior experience was also found in Class 1, which also had a higher acceptance score. Interestingly the theoretical orientation of the PiT was distributed unevenly across the two classes, with significantly more PiT with a cognitive behavioral orientation in Class 1. This suggests that EMH has a distinct role in the training of cognitive behavioral therapists, which most likely can be attributed to the fact that many EMH programs are rooted in cognitive
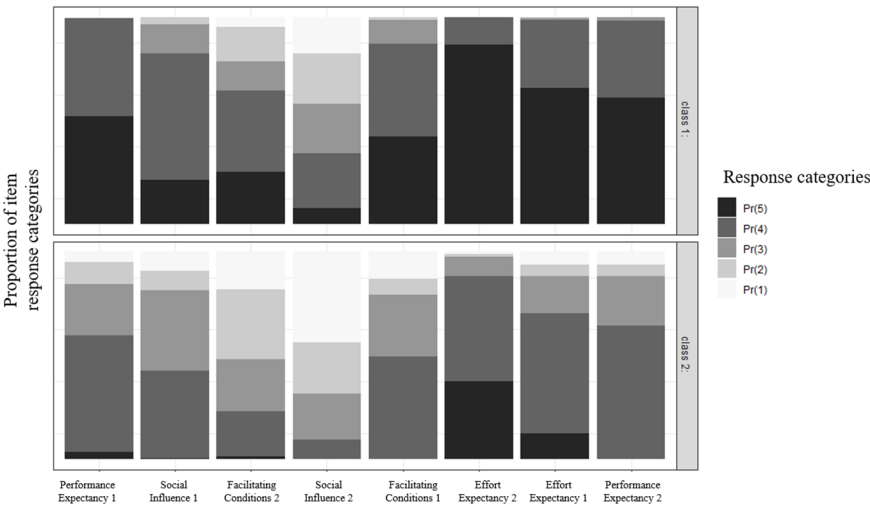
FIGURE 1
Item ratings across classes.

TABLE 2 Sociodemographic variables across classes.

Variable	Total (n = 216)	Class 1 (n = 137)	Class 2 (n = 79)	Statistics
Age, n (%)				$\chi^2(7) = 9.88$, $p = .20$, $V = 0.21$
20-24	5 (2.3)	3 (2.2)	2 (2.5)	
25-29	90 (41.7)	61 (44.5)	29 (36.7)	
30-34	61 (28.2)	42 (30.7)	19 (24.1)	
35-39	28 (13.0)	12 (8.8)	16 (20.3)	
40-44	19 (8.8)	13 (9.5)	6 (7.6)	
45-49	7 (3.2)	3 (2.2)	4 (5.1)	
50-54	1 (0.5)	0 (0.0)	1 (1.3)	
55-59	5 (2.3)	3 (2.2)	2 (2.5)	
Gender, n (%)				$\chi^2(1) = 0.02$, $p = .84$, $V = 0.03$
Female	191 (88.4)	122 (89.1)	69 (87.3)	
Male	25 (11.6)	15 (10.9)	10 (12.7)	
Country of Training, n (%)				$\chi^2(1) = 0.02$, $p = .89$, $V = 0.02$
Germany	156 (72.2)	98 (71.5)	58 (73.4)	
Switzerland	60 (27.8)	39 (28.5)	21 (26.6)	
Background in, n (%)				
Psychology	197 (94.9)	130 (94.9)	67 (84.8)	$\chi^2(1) = 5.15$, $p < .05$, $V = 0.17$
Medicine	6 (2.2)	3 (2.2)	3 (3.8)	$p = 0.67$ [a], $V = 0.05$
Therapeutic Orientation, n (%)				
Cognitive/cognitive-behavioural	145 (67.1)	100 (73.0)	45 (57.0)	$\chi^2(1) = 5.13$, $p < .05$, $V = 0.16$
Psychodynamic/ psychoanalysis	35 (16.2)	18 (13.1)	17 (21.5)	$\chi^2(1) = 2.01$, $p = .16$, $V = 0.11$
Systemic	27 (6.9)	14 (4.4)	13 (11.4)	$\chi^2(1) = 1.26$, $p = .26$, $V = 0.09$
Humanistic	9 (2.3)	5 (2.2)	4 (2.5)	$p = 0.73$ [a], $V = 0.03$
Other	22 (10.2)	13 (9.5)	9 (11.4)	$\chi^2(1) = 0.04$, $p = .83$, $V = 0.03$

[a]Fischer Exact Test if group size smaller than 5.

behavioral principles (32). However, due to small numbers of PiT from humanistic or systemic orientations, the previously contrasting results regarding orientation and acceptance were not observable in our sample (33).

LCA was applied in this study to explore whether there were underlying homogenous subgroups among the previously heterogenous sample of PiT. It is surprising that no other study has applied LCA in the field of acceptance of EMH while it has been used to find subgroups for other interventions (34), measurements (35) and particularly often in the field of finding sub-groups in patient populations (36, 37). Thus, we conclude it is a big strength of

this study to compute multiple class solutions and not rely on using a median split.

4.1 Limitations and future research

We encourage other researchers to validate the classes presented here using larger samples, since we were unable to conduct any validation of the two-class solution as our sample size would have been decreased too much. Thus, it would be worth exploring whether a two-class solution still emerges in larger

TABLE 3 EMH variables across classes.

Variable	Total (n = 216)	Class 1 (n = 137)	Class 2 (n = 79)	Statistics
Advantages of EMH, *Mdn* (*SD*)				
Time flexibility	4.00 (1.03)	4.00 (0.97)	3.00 (1.06)	*Z = 3.67, p <.01, r = 0.25*
Simplified information provision	4.00 (0.90)	4.00 (0.71)	4.00 (1.04)	*Z = 5.01, p <.01, r = 0.34*
Geographic flexibility	4.00 (0.87)	5.00 (0.69)	4.00 (0.93)	*Z = 6.59, p <.01, r = 0.44*
Simplified contact maintenance	4.00 (1.14)	4.00 (1.00)	3.00 (1.10)	*Z = 6.14, p <.01, r = 0.42*
Barriers of EMH, *Mdn* (*SD*)				
Data insecurity	4.00 (1.08)	4.00 (1.11)	4.00 (1.02)	*Z = 6.14, p =.57, r = 0.04*
Impersonality	3.00 (1.06)	3.00 (1.04)	4.00 (0.90)	*Z = -5.16, p <.01, r = 0.35*
Irresponsibility	4.00 (1.07)	4.00 (1.10)	4.00 (0.98)	*Z = -2.46, p <.05, r = 0.17*
Legal concerns	3.00 (1.18)	3.00 (1.22)	4.00 (1.00)	*Z = -3.76, p <.01, r = 0.26*
Concerns about therapeutic alliance	4.00 (1.12)	4.00 (1.17)	4.00 (0.85)	*Z = -4.34, p <.01, r = 0.30*
EMH Knowledge, *Mdn* (*SD*)	3.66 (1.12)	4.00 (0.72)	3.33 (0.91)	*Z = 5.65, p <.01, r = 0.38*
EMH Experience yes, *n* (%)	121 (56.0)	84 (61.3)	42 (46.8)	$\chi^2(1) = 3.70, p = .05, V = 0.14$
EMH Evidence rating, *M* (*SD*)	53.56 (24.90)	59.8 (22.55)	42.75 (25.19)	*t = 4.98, p <.01, D = 0.73*
EMH Acceptance, *Mdn* (*SD*)	3.66 (1.12)	4.00 (1.00)	2.67 (1.03)	*Z = 6.25, p <.01, r = 0.43*

samples, especially if they are more heterogenous in theoretical orientation of the PiT. In our study the 5-class solution showed the highest entropy. However, due to excessively small class sizes, resulting in a low-subject-to-estimated-parameter ratio that is likely to produce unstable results and since the highest entropy may not necessarily represent the best fitting model but possibly an overfit model, it was not investigated further (38, 39). It is also worth mentioning that even though some statistical differences between the classes could be observed, further research is required to determine to what extend those differences are meaningful for practical implications (e.g., interventions to foster acceptance of EMH). One possibility would be to assess other variables such as EMH literacy or internet usage of PiT to gain a more detailed picture. Another limitation to note is that the presented results are descriptive in nature, precluding causal interpretations. It also needs to be added that the internal consistency for the two-item subscales was not calculated to avoid underestimating of the true reliability (40). However, it is a limitation of this study relying on two-item scales to assess several constructs. Lastly, this has been a secondary analysis with data being collected during the Covid-Pandemic and it remains unclear how much practice and acceptance has changed in the meantime.

5 Conclusion

The value of this publication lies in the successful identification of two classes of PiT using Latent Class Analysis, based on the UTAUT predictors. Classes showed some distinct features in respect to the indicator variables, especially regarding Performance and Effort Expectancy. Our study revealed that while sociodemographic characteristics did not differ between the classes, knowledge, estimation of evidence, experience and acceptance did. Also, we found that most perceived barriers were rated higher and all advantages rated lower in the *moderately beneficial factors* class. In the future, latent class analysis could help to identify subgroups and highlight possible starting points to foster acceptance of EMH.

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 humans were approved by the ethics committee of the University of Zurich via a checklist indicating that the ethical safety of the study was guaranteed, no further approval of the ethics committee was necessary. 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

RS: Conceptualization, Data curation, Formal analysis, Methodology, Visualization, Writing – original draft. MS: Formal analysis, Supervision, Visualization, Writing – review & editing. MD: Conceptualization, Methodology, Supervision, 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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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2024.1296449/full#supplementary-material

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Mobile health for mental health support: a survey of attitudes and concerns among mental health professionals in Poland over the period 2020-2023

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Introduction: Mobile health (mHealth) has emerged as a dynamic sector supported by technological advances and the COVID-19 pandemic and have become increasingly applied in the field of mental health.

Aim: The aim of this study was to assess the attitudes, expectations, and concerns of mental health professionals, including psychiatrists, psychologists, and psychotherapists, towards mHealth, in particular mobile health self-management tools and telepsychiatry in Poland.

Material and methods: This was a survey conducted between 2020 and 2023. A questionnaire was administered to 148 mental health professionals, covering aspects such as telepsychiatry, mobile mental health tools, and digital devices.

Results: The majority of professionals expressed readiness to use telepsychiatry, with a peak in interest during the COVID-19 pandemic, followed by a gradual decline from 2022. Concerns about telepsychiatry were reported by a quarter of respondents, mainly related to difficulties in correctly assessing the patient's condition, and technical issues. Mobile health tools were positively viewed by professionals, with 86% believing they could support patients in managing mental health and 74% declaring they would recommend patients to use them. Nevertheless, 29% expressed concerns about the effectiveness and data security of such tools. Notably, the study highlighted a growing readiness among mental health professionals to use new digital technologies, reaching 84% in 2023.

Conclusion: These findings emphasize the importance of addressing concerns and designing evidence-based mHealth solutions to ensure long-term acceptance and effectiveness in mental healthcare. Additionally, the study highlights the need for ongoing regulatory efforts to safeguard patient data and privacy in the evolving digital health landscape.

1 Introduction

Over the last few years, mobile health (mHealth) has been one of the most dynamic sectors of medicine. Initially, mass internet access and then smartphones, which offer mobile applications, enabled this trend. Research to date suggest that mobile apps applied in mental health can support the diagnosis of mental disorders, psychoeducation, provide various forms of psychotherapy, or facilitate contact with a specialist, including serious mental illnesses such as bipolar disorder or schizophrenia (1, 2) and health crisis such as suicide risk (3). Smartphones also allow patients with mental disorders to be monitored continuously, in real time (4, 5). These solutions can both provide a complementary form of patient care, but also enable a personalized approach to the patient.

An important stimulus for the development of mHealth in mental health was the COVID-19 pandemic, which made the traditional form of contact with a doctor impossible. In particular, there has been a sharp increase in the use of two solutions offered by mHealth, namely telepsychiatry and mHealth self-management tools (especially mobile apps) in psychiatric care compared to previous years (6, 7). At the same time, this contributed to an increase in mental distress and psychiatric symptoms in the community during this period (8–10). The pandemic has therefore forced a transformation of healthcare and the spread of these solutions, but they can still be widely use afterwards. However, the use of telemedicine (telepsychiatry in the field of mental health) to treat patients is nothing new. It was first used in psychiatry in 1959 and mainly served geographically isolated populations. This is what is currently known as telepsychiatry, which is defined as 'the delivery of psychiatric assessments or follow-up interviews from a distance using technologies such as telephone calls, audio and video digital platforms, and healthcare monitoring devices' (11).

Mobile Health is a rapidly growing field that use the capabilities of mobile devices such as smartphones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices to enhance healthcare services (12). It extends the reach of medical care by enabling remote monitoring and consultations, making healthcare more accessible. Furthermore, mHealth allows individuals to manage their health actively through apps and

wearable technology (12). As this solution evolves, it has the potential to revolutionize healthcare delivery and improve patient outcomes while also presenting challenges related to privacy and regulation that need careful consideration (13). In the mental health realm, mHealth offers innovative solutions such as internet-based therapies, text messaging for psychiatric services, and smartphone apps for monitoring and treating various psychiatric conditions including depression, bipolar disorder, schizophrenia and other health crises (1, 3, 14–17). These technologies improve clinical outcomes, but also reduce stigma and improve access to care, while initiatives like SMS campaigns, community outreach, and medication tracking further strengthen mental health support (18). As mobile technology advances, mHealth plays a crucial role in expanding access to quality mental healthcare.

Several factors will determine whether mobile solutions in mental health will become widely implemented. Firstly, there is a need for reliable, validated apps and websites that can truly help patients (19–21). The perception of such solutions by people with mental illnesses is also extremely important, as this may determine their ultimate use (22, 23). Studies conducted on this group showed high satisfaction with tested interventions (23, 24). Notably, studies emphasized that user interest in these solutions decreased over time. A Polish study using a mobile app for monitoring BD patients observed a 44% dropout rate at one year (25). In studies conducted to date, patients emphasized the necessity for approaches that are tailored to their preferences and needs, characterized by user-friendliness and genuine helpfulness. Negative aspects included continuous reminders, a sense of being monitored, and loss of dignity and autonomy (22, 26, 27). A key, but often ignored and consequently much under-researched perspective is how mental health professionals view such solutions (28). Although some solutions are already implemented, especially in the therapeutic process (29), and research to date indicates that mental health professionals are aware of their existence, they rarely use them (30, 31). One pre-pandemic study (2019) found that professionals (psychiatrists and psychotherapists) know significantly less about mental health apps than patients (30). Only 33.7% of experts were familiar with at least one e-mental health app and 8.7% had tried it. However, more clinicians were advocates than sceptics of these solutions 68.3% vs 29.8% (30). They also believe that these solutions

will become more important in the future (30). Time has shown that we did not have to wait long. After the outbreak of the pandemic, the market for mental health apps grew exponentially, and the subject of consideration was not what professionals thought of them, but whether they should prescribe them to patients (31). In a 2022 Portuguese survey of 160 clinician, mainly psychologists but also psychiatrists, as many as 87.2% supported the possibility of prescribing mental health apps (31).

Regarding professionals' perceptions of telepsychiatry, three surveys at the beginning of the pandemic (2020) conducted in the US (32, 33) and the UK (34) indicated high levels of satisfaction with video consultations. Furthermore, 95.5% of clinicians responded that they would like telepychiatric visits to make up at least 25% of their practice in the future (33). As the pandemic continued, perceptions might have changed. This is shown in a 2021-2022 multicenter study conducted in the UK and Italy (35). In general, telepsychiatry was perceived as most convenient for purpose-specific follow-up visits, such as medication checks, however, it was perceived as less effective for setting up a therapeutic relationship or assessment of mental status in acute mental crisis.

It is also important that clinicians recognize the real needs and concerns that mHealth may confront in mental health (34, 36, 37). Engaging them in the development process is therefore crucial to their use and proper application. To date, only a few studies have assessed the attitudes and concerns of mental health professionals toward mobile solutions (30, 34, 36–38), while far more attention in the literature has been given to health professionals working in other fields of medicine (39–41). No study on mental health professionals has been conducted in Poland to date either. This may seem surprising given that the mobile app market, as well as video consultations, is currently primarily concerned with mental health.

The aim of this study was to assess the attitudes and expectations towards mHealth in particular telepsychiatry (video/teleconsultations) and mobile health tools such as applications, wristbands, smart watches etc., among mental health professionals (psychiatrists, psychologists, psychotherapists) in Poland.

2 Materials and methods

2.1 Research questionnaire

A questionnaire was created taking into account the available literature, knowledge of the specificity of mental disorders and the experience of clinicians from the Institute of Psychiatry and Neurology, who have conducted Polish research implementing mHealth in the field of mental health. The research questions were related to the final shape of mHealth solutions, mainly telepsychiatry and mHealth self-management tools, that will be acceptable to professionals in the perspective of their long-term use. We sought to assess the needs, expectations and areas of application of mobile technologies from a professional perspective. Following the development of the survey questionnaire, a pilot study was conducted to assess the ease of using the questionnaire, answering the questions asked, and collecting comments on the survey instrument. For this questions on respondents' evaluation of the survey in terms of the number of questions, as well as the ease of understanding the questions and answering them. The original version of the questionnaire was tested on 18 clinicians (7 psychiatrists and 11 psychologists). According to 72.2% (n=13) of respondents, the number of questions in the questionnaire was appropriate, according to 11.1% (n=2) too few, and according to 16.7% (n=3) too many. According to 88.9% (n=16) of respondents, the questions were formulated in a clear and understandable way, while 11.1% (n=2) of respondents assessed them as somewhat too complicated. Respondents did not make significant comments on the content of the questions asked, 22.2% (n=4) respondents made technical comments regarding division of the survey into 3 separate parts. All raised issues were taken into account, discussed in the research team and resulted in the development of the final version of the survey.

The research questions were grouped into three issues (Supplementary Material). At the forefront of the questionnaires, there is brief information about the purpose of the survey. This is followed by research questions, both closed and open, covering the following three main areas:

1) the prevalence of mobile device and internet usage and clinicians' current experiences with the use of mHealth solutions in the area of health and mental health (what percentage of respondents already have some experience);

2) clinicians' attitudes, opinions, and preferences regarding mHealth solutions in mental health, in particular views regarding telepsychiatry and self-management tools. The questions relate to interest in the use of mobile technology in mental health, the opportunities that it can offer for patients, the level of readiness to use it, factors influencing clinicians' attitudes, needs, expectations and areas of application of mHealth technology from the clinicians' perspective;

3) concerns and risks associated with the adoption of mHealth solutions for mental health management.

The questionnaire ended with a metric collecting data on the demographic characteristics of the respondents. The survey consisted of 26 questions that could be answered on either a 3-point, 5-point Likert scale, had a choice of one of two yes/no options or were open-ended. Some questions were multiple choice. The survey was also designed in an online traditional version and for mobile users.

The study was notified to the Bioethics Committee at the Institute of Psychiatry and Neurology in Warsaw, Poland. A formal approval of the Bioethics Committee was not required as it was a questionnaire surveys not endangering the well-being and interests of the participants. Data were treated with confidentiality, equality and fairness, respecting the Helsinki principles (42).

2.2 Study sample and recruitment

The survey was conducted among professionals working in mental health care and involved psychiatrists, psychologists, therapists agreeing to participate in the survey. The survey was conducted on a random representative sample of Polish professionals working in mental health facilities. Individuals were recruited from a representative sample, the sample frame was a registry of all mental health facilities in 16 regions (voivodeships) in Poland. The study selected a stratified random sample with proportional allocation. The questionnaire was distributed initially to professionals working in the Institute of Psychiatry and Neurology and then sent to mental health service providers (counselling centers and hospitals) in 16 regions (voivodeships) in Poland. Information with an invitation to take part in the survey was sent out via email. To ensure diversity of the sample we recruited respondents through additional sources, including social media and forums for professionals. The distribution ran continuously from May 2020 to the end of April 2023. Over 250 invitations were sent to mental healthcare professionals. In total, 148 professionals completed the survey (response rate 59.2%). Details of how the recruitment process was conducted are included in the Figure 1.

2.3 Statistical analysis

Statistical analyses was carried out using Statistica 13.3 software. Descriptive statistics were calculated using means and standard deviations, as well as median and interquartile range - for data not meeting the criteria for normal distribution. Chi-square (χ^2) tests were used if the variables were presented on a nominal scale and Kruskal-Wallis test if the study variables were collected on an ordinal scale and did not have a normal distribution. In the case of small group sizes, the chi-square test combined low-ranked responses, as long as this did not interfere with the interpretation of the results. For *post-hoc* comparisons, the Bonferroni correction was used to give confidence in the power of the test. Relationships between variables were verified using regression and correlation methods The influence of age, gender, specialty (doctor/psychologist/therapist), size of the town in which the specialist practices on the responses were analyzed. Differences were be assessed at an assumed statistical significance level of $p<0.05$.

3 Results

3.1 General characteristics of the respondents

The web-based survey was completed by 148 mental health professionals (n=148). All closed questions were completed by respondents (100%). The participants characteristics is shown in Table 1.

TABLE 1 General characteristics of the respondents (n=148).

Variables		Percent
Sex	Female	67%
	Male	32%
Age	25-39	27%
	40-55	56%
	55-64	15%
Education	Medical doctor	57%
	Psychologist/ psychotherapist	42%
Professional activity	Outpatient clinic	59%
	Hospital/psychiatric ward + Outpatient clinic	21%
	Hospital/psychiatric ward	3%
	Private practice	14%
	General hospital + Outpatient clinic	1%
Workplace	City > 250 000	69%
	City 50 000 – 250 000	25%
	City <50 000	5%
Type of psychotherapy used by psychotherapists (n=62)	Cognitive-behavioral therapy	29%
	Integrative/holistic therapy	26%
	Interpersonal therapy	24%
	Psychodynamic therapy	13%
	Humanistic therapy	8%
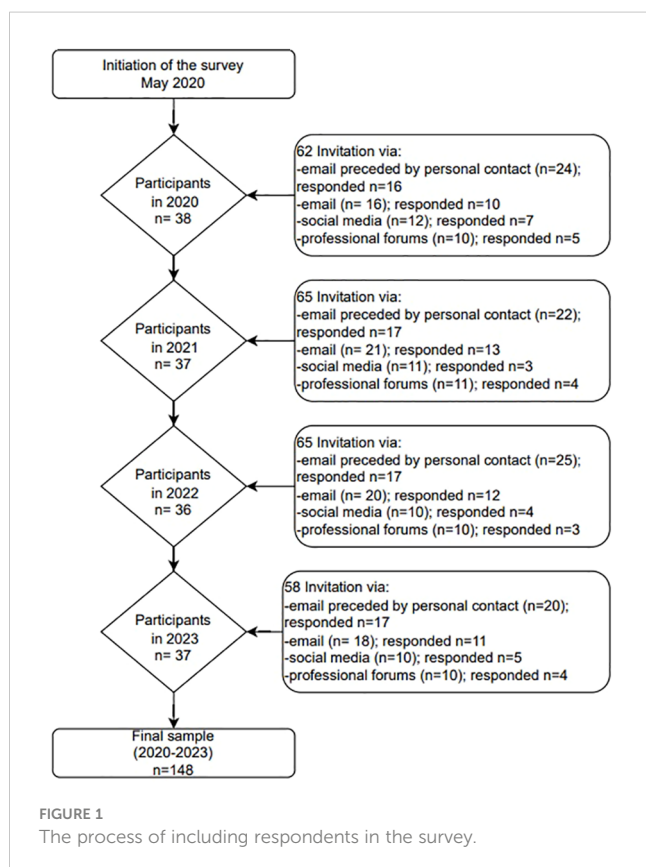
3.2 Prevalence and usage of mHealth

3.2.1 Prevalence and usage of mobile devices and mHealth solutions – aggregate analysis (2020–2023)

A substantial number of respondents declared that they use mobile devices at least once a week (91.89%). In addition, the majority of them at least once a week (70.3%) use remote patient contact techniques (video/teleconsultation). Noticeably fewer respondents - 52.7% - stated that they were interested in the topic of mHealth tools, or recommended it to patients. Simultaneously, 41.9% of respondents had heard little or nothing about it. The exact distribution of responses to questions related to the prevalence and usage of new technologies is presented in Figure 2.

3.2.2 Changes in prevalence and use of mobile devices and mHealth solutions between 2020 and 2023

Prevalence of using video/teleconsultation in mental health between 2020 and 2023 is shown in Figure 3A (χ^2 = 55,08556, df=3, p<0.001; statistically significance: 2020 vs 2023: χ^2 = 40,58, df=1, p<0.001; 2021 vs 2023: χ^2 = 28,45, df=1, p=<0.001; 2022 vs 2023: χ^2 = 27,55, df=1, p=<0.001). Prevalence of using mobile devices between 2020 and 2023 is shown in Figure 3B. The "Never", "Rarely – once a year or less often" and "Sometimes – at least once a
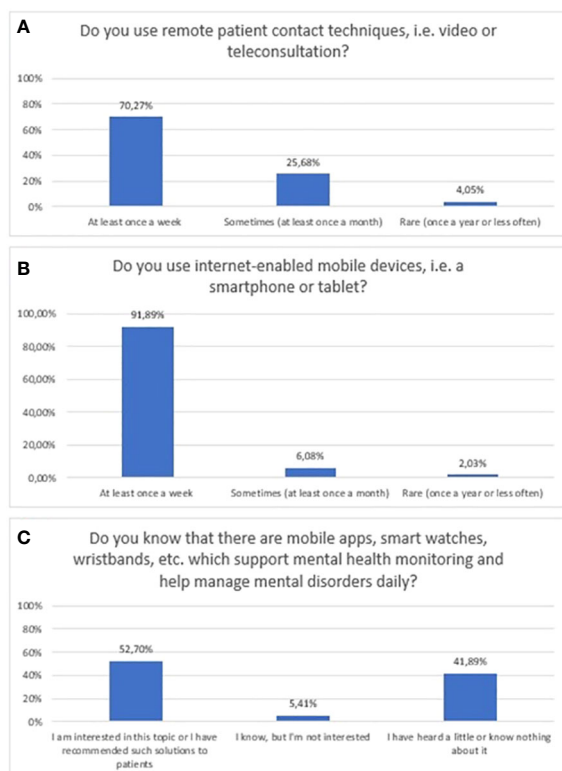
Responses regarding prevalence and usage of mHealth among mental health professionals; **(A)** Usage of remote techniques to communicate with patients; **(B)** Usage of mobile devices; **(C)** Awareness of mHealth tools in mental health.
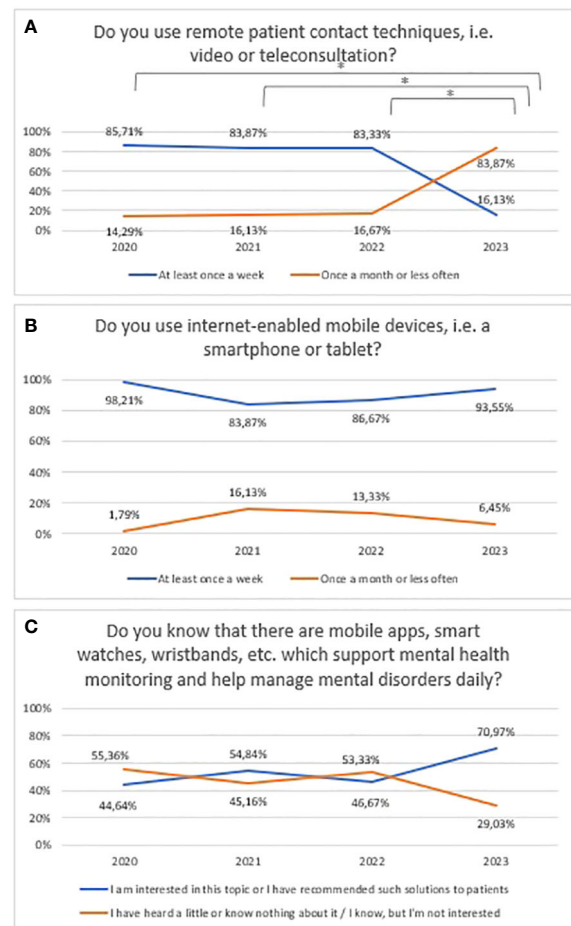
Responses regarding prevalence and usage of mHealth among mental health professionals between 2020 and 2023; **(A)** Usage of remote techniques to communicate with patients; **(B)** Usage of mobile devices; **(C)** Awareness of mHealth tools in mental health. *statistically significant difference.

month" responses have been summed to ensure sufficient group numbers to perform a chi-square test. However, in Figure 3B χ^2 test was impossible to implement due to the still too-small numbers in the groups. Prevalence of awareness of mHealth tools in mental health between 2020 and 2023 is shown in Figure 3B. The " I know, but I'm not interested", and "I have heard a little or know nothing about it" responses have been summed to ensure sufficient group numbers to perform a chi-square test (χ^2 = 6,10, df=3, p=0.107).

3.3 Attitudes, expectations, and preferences towards telepsychiatry and mHealth tools in mental health care

3.3.1 Attitudes, expectations, and preferences towards telepsychiatry and mHealth tools in mental health care - aggregate analysis (2020–2023)

The majority of respondents liked the idea of using video and teleconsultation as a support tool for patients with mental disorders
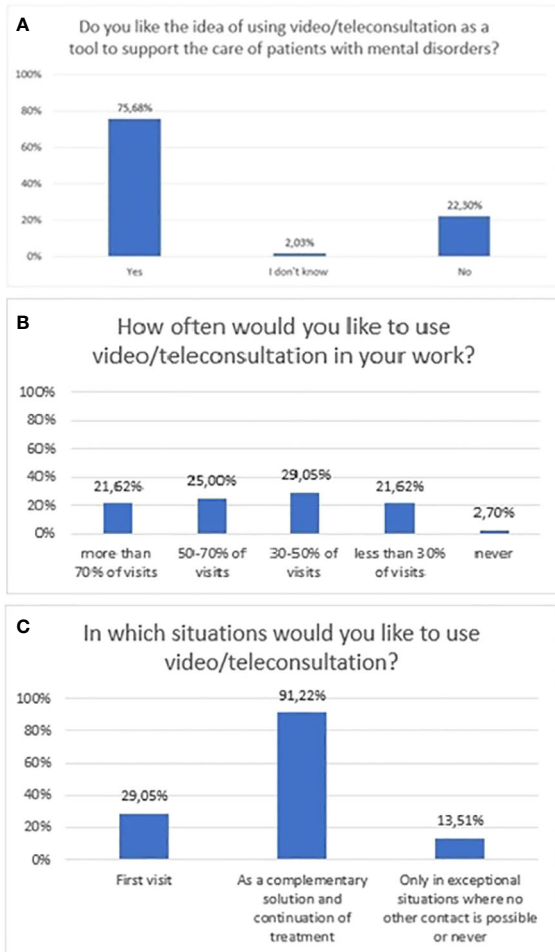
FIGURE 4
Responses regarding attitudes, expectations, and preferences section; **(A)** attitudes towards video/teleconsultation; **(B)** expected frequency of video/teleconsultation use at work; **(C)** Situations in which respondents would like to use video/teleconsultations.

FIGURE 5
Responses regarding attitudes towards new technologies; **(A)** opinions regarding new technologies as a tool to support patients; **(B)** stated readiness to use new technologies.

(75.7%, n=112). In a multiple-choice question, the majority of respondents declared it could be applied as a complementary solution, used in the continuation of treatment (91.2%, n=135). According to a minority, 29.1% (n=43) of respondents, these can be applied at the first visit (Figure 4). Also, a minority of respondents would like to use remote visits more than 50% of the time - 21.6% (n=32) would like remote visits to account for 70-100% of all visits, and 25% (n=37) of respondents thought 50-70%. The exact distribution of responses to questions related to attitudes towards video/teleconsultations is shown in Figure 4.

According to the majority of respondents, mHealth tools can help patients to better cope with their mental illness (86.5%, n=128). Furthermore, the majority of respondents rated their readiness to use them as "4" (29.7%, n=44) or "5" (44.6%, n=66), where 5 meant full readiness. The exact distribution of responses to questions related to attitudes is shown in Figure 5.

3.3.2 Changes in attitudes, expectations, and preferences towards telepsychiatry and mHealth tools between 2020 and 2023

A statistically significant decrease was found between 2020 and 2022 regarding attitudes towards video/teleconsultation ($\chi^2 = 14,98$, df=3, p=0.002). The Bonferroni correction was included in the comparisons for each year (statistically significance: 2020 vs 2022: $\chi^2 = 12,72$, df=1, p=<0.001; 2021 vs 2022: $\chi^2 = 7,94$, df=1, p=0.005; 2022 vs 2023: $\chi^2 = 14,98$, df=3, p=0.002). The trend is presented in Figure 6. From 2022 onwards, there is an upward trend, but in 2023 not statistically significant when compared to the baseline assessment in 2020, which is when the pandemic began. Over the period 2020-2023, there was an upward trend but not a statistically significant in the preference for the use of video/teleconsultation in certain situations (firs/subsequent visits) (Figure 6). Changes in the declared frequency to use video/teleconsultation frequency are shown in Figure 6. The variable was tested on an ordinal scale and the Kruskalla-Wallis test showed statistical significance (H=27.70, p<0.001). The greatest difference between years relates to the shift in the declared intention to use view/teleconsultation starting in 2022 from over 50% of all visits towards a frequency of less than half of all visits in 2023.

No statistically significant difference was claimed between 2020 and 2023 with regard to attitudes towards mHealth tools ($\chi^2 = 26,72$, df=6, p=0.348) (Figure 7).Over the period 2020-2023, a similar number of respondents declared a preference for
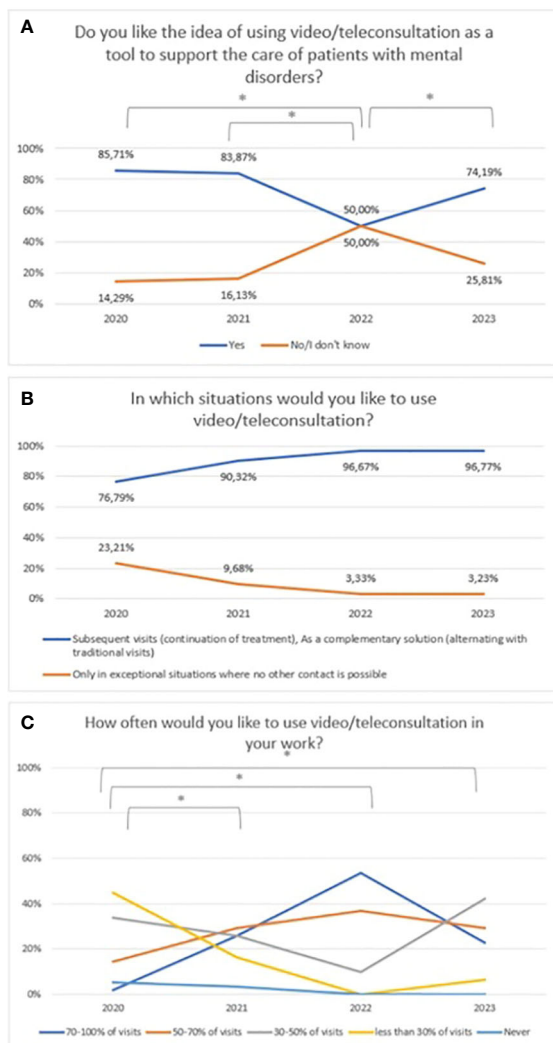
Responses regarding: **(A)** idea of using video/teleconsultation over the period 2020-2023. *statistically significant difference; **(B)** the desire to use video/teleconsultation in specific situations over the period 2020-2023; **(C)** the declared desire for frequency of use video/teleconsultation over the period 2020-2023. *statistically significant difference.

Responses regarding **(A)** idea of using mHealth tools over the period 2020-2023; **(B)** the declared desire recommend mental health applications over the period 2020-2023; **(C)** The percentage of mental health professionals who declared they were ready to use new technologies between 2020 and 2023. *statistically significant difference.

3.4 Concerns and risks towards telepsychiatry and mHealth tools in mental health care

3.4.1 Concerns and risks associated with the use of telepsychiatry and mHealth tools in mental health care – aggregate analysis (2020−2023)

recommending mental health apps to their patients (Figure 7). Responses of 'No' and 'I don't know' were combined to ensure adequate group sizes were tested, but the chi-square test did not show statistical significance (χ^2 = 0,29, df=3, p=0.961).The percentage of mental health professionals who declared they were ready to use new technologies between 2020 and 2023 is presented in Figure 7 (χ^2 = 9,19, df=3, p=0.027; statistically significance: 2020 vs 2021: χ^2 = 6,35, df=1, p=0.012; 2021 vs 2023: χ^2 = 6,15, df=1, p=0.013). A statistically significant increase was noted from 2021.

A quarter (n=37) and 29% (n=43) of respondents had some concern regarding the use of video/teleconsultation and mHealth tools, respectively. The exact distribution of responses to questions related to concerns over the use of new technologies is shown in Figure 8.
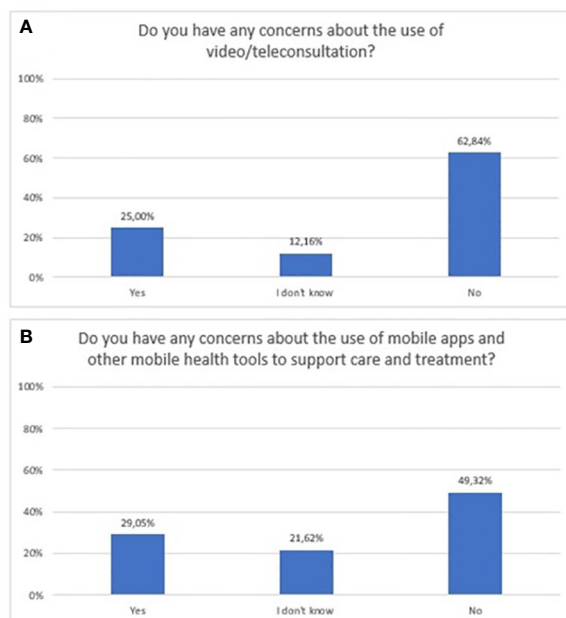
Responses regarding concerns and risks associated with the use of new technologies in mental health; **(A)** video/teleconsultation concerns; **(B)** mobile technologies concerns.

3.4.2 Change in perceived concerns and risks associated with the use of telepsychiatry and mHealth tools in mental health care between 2020 and 2023

Concerns about video/teleconsultation and mobile technology in mental health between 2020 and 2023 are shown in Figure 9 (χ^2 = 7,72, df=3, p=0.052) and Figure 10 (χ^2 = 6,21, df=6, p=0.400). For Figure 10, the "No" and "I don't know" responses have been summed to ensure sufficient group numbers to perform a chi-square test. The difference between years were not statistically significant.

3.5 Influence of age, profession, professional activity, workplace, and sex on readiness to use new technologies

The Kruskal-Wallis test showed that age (H=5,87; p=0.53), education (H=2,94; p=0.09), professional activity (H=1,87; p=0.17) and workplace (H=0,98; p=0.32) did not affect readiness to use new technologies. The Wilcoxon rank sum test showed that sex did not affect readiness to use new technologies (U=1936, p=0.58).

3.6 Analysis of open-ended responses

3.6.1 Attitudes, expectations and preferences towards telepsychiatry and mHealth tools – analysis of open-ended questions (2020–2023)

In response to why respondents like the idea of video/teleconsultation as a tool to support the care of patients with
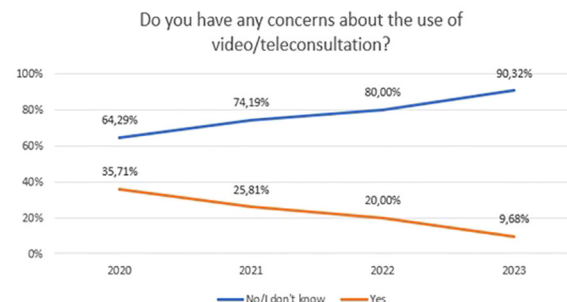
Responses regarding concerns about the use of video/teleconsultation over the period 2020-2023.

mental disorders, the majority mentioned the possibility to contact a patient who cannot come for an appointment or is required by a pandemic situation (n=16). Three respondents described that it facilitates ongoing, continuous contact with the patient (n=3). In addition, 1 respondent each indicated that it improves the quality of patient care, support in disease monitoring, and "going with the times". Among the respondents who did not like this idea, 4 indicated a preference for personal contact (n=4), one person indicated that such contact was difficult and exhausting, one described his doubts "it's not for me".

The majority of respondents who answered the question what they would like to improve indicated the quality of the call (n=10) and the need for a dedicated medical platform (n=6). In addition, they indicated confidentiality of the call and data protection (n=2), the possibility to assess wellbeing/risk of self-injurious actions, which could be visible to the therapist (n=1).

The participants gave a variety of responses as to why they liked the idea of using mobile technology, such as: to help monitor treatment and the therapeutic process (n=4), to help remission, support daily coping with the illness for chronically ill patients (n=3), to collect objective data (n=1), they can be an extra support for patients (n=1) and give the feeling of being taken care (n=1), to indicate that current apps are reliable and researched (n=2). Three respondents indicated that if they do not harm patients and they
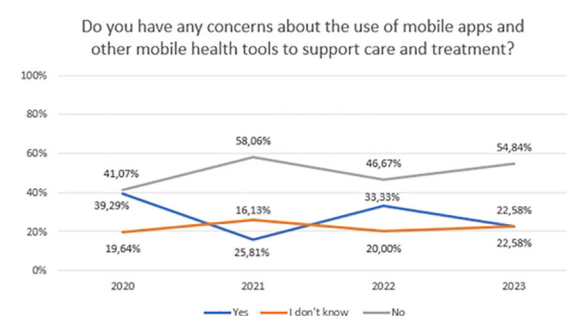
Responses regarding concerns about the use of mobile apps and other mobile health tools to support care and treatment over the period 2020-2023.

accept them then they should be used (n=3), while one respondent indicated that this "is the future". Among those who did not like the idea, responses included inexperience and unfamiliarity with such apps (n=7), making long-term contact with the therapist more difficult (n=2), distracting patients from agency (n=1), driving them into an unreal world (n=1), and holding them as a 'leash' (n=1). Three respondents had mixed feelings about whether such solutions would help or harm patients (n=3).

3.6.2 Concerns and risks associated with the use of telepsychiatry and mHealth tools – analysis of open-ended questions (2020–2023)

Among the concerns about teleconsultation in the open questions, respondents mentioned: difficulties in assessing the patient's condition (n=7), inability to build an adequate therapeutic relationship (n=3), it is more tiring than face-to-face contact (n=3), contact with the patient is weaker (n=2), patients may give a feeling of being monitored (1), patients may want non-stop contact (n=1).

Among the concerns about mobile solutions in the open questions, respondents mentioned: lack of opportunity to try such effectiveness solutions, or not knowing which ones to recommend (n=8), security and privacy risk (n=6), mobile solutions may do more harm (n=2), mobile solutions may get boring (n=2), patient expectations may be too high (n=1), may delay contact with doctor (n=1). The detail results are given in Supplementary Materials (Supplementary Material).

4 Discussion

The growth of new technologies and digitalization is proceeding at a speed that is difficult for people, as well for science or legislation to keep up with. Moreover, it is not a temporary phenomenon, but rather an inevitable process, with any stabilization difficult to foresee. This expansion, especially in medical services, was greatly accelerated by the pandemic (43). Remote specialist-patient contact has become, in many areas of medicine, the only form of visits at the peak of the pandemic. This was undoubtedly a lever for telepsychiatry – currently a rapidly growing and constantly evolving branch of mHealth (6, 8). Clinical trials of new medical services and devices are struggling to follow the growth of the digital medical marketplace (44). These studies address both the effectiveness, safety and satisfaction of their users.

While much attention has been paid to the assessment and expectations of patients in this respect, the perspective of –clinicians remains under-researched (28). Studies to date have also had a short time frame, usually during a pandemic, which may not quite truly reflect attitudes in the absence of any other option for patient contact. Therefore, findings of this make a unique contribution to the literature on this rapidly evolving area, detailing clinicians' attitudes and expectations towards digital technologies in mental health during and after Covid-19 outbreak.

Today, telepsychiatry delivered via tele/videoconferencing is an established and routinely used form of care delivery by mental health specialists (45). The efficacy of telepsychiatry is well documented in research (46). Its undoubted advantages include the ability to conduct a visit from anywhere, even a very remote location, easier appointment scheduling and easier rescheduling of appointments. Barriers identified for telepsychiatry include older age, lack of digital access, limited technical competence and hearing and visual impairment, and on the side of the professionals, the difficulty of convincing some of clinicians to use this form of consultation (13).

The APA and WPA have developed guidelines to provide a framework for ensuring the quality and safety of telepsychiatry (47, 48). It is worth highlighting at this point the difference that separates telepsychiatry and the rapidly growing digital health market, including online therapy provided by commercial firms. The latter, unlike telepsychiatry, has unproven security and is unregulated. This problem is evident in various countries, including Poland. An evaluation of this market in the United States revealed that most online therapy websites and applications are not regulated by the federal Health Insurance Portability and Accountability Act (HIPAA) (49). The paradox is that the same sensitive personal information protected by HIPAA when obtained by a doctor is not subject to any protection when obtained by mental health companies providing online therapy (50). These differences do not seem to be recognized by patients, so it is worth making them aware of this risk. This is especially true in terms of the security patients' sensitive data, but also in terms of the unproven efficacy of the services offered by digital mental health companies.

Overall, patients' and clinicians' satisfaction with online consultations are rated highly. In recent survey, nine out of ten psychiatrists felt satisfied with telepsychiatry service (51). Previous satisfaction surveys on the use of tele/video consultation by mental health professionals, including those from the beginning of the pandemic, have also shown that this form of contact is well appreciated (32–34, 52–54). In this aspect, therefore, the results of our study are in line with those of the previous ones. In this survey, the willingness to use such a tool during work was expressed by up to 76% of respondents, with 70% of professionals stating that they use telepsychiatry at least once a week. In addition, however, our survey shows a longer time perspective and the changes that have occurred since the beginning of the pandemic, during its peak and with the end of the pandemic. A high level of interest was recorded especially in 2020-2021, while a decrease to 50% was recorded in 2021-2022 and then a slow rise again until 2023. One possible explanation could be a return to the traditional form of post-pandemic contact in those professionals who do however prefer the traditional form of contact with patient. It may be interesting to further observe this trend over time and investigate whether this is a temporary decline in interest, or whether some professionals will return to remote contact in the longer term. This will certainly be shaped from both sides i.e. patients and professionals. At the moment, however, there is a decrease in the declared intention to use video/tele-consultation from 2022, from more than 50% of all visits to less than half of all visits in 2023. It is also worth noting that a consistent proportion of professionals (25%) reported some

concern about the use of video/teleconsultation over the 2020s to 2023. This may indirectly reflect a certain proportion of professionals for whom telepsychiatry will be a necessary choice rather than their preference.

Interestingly, in the open-ended questions, the study participants who had negative attitudes toward telepsychiatry most often indicated a preference for personal, traditional contact with the patient. Concerns about the use of telepsychiatry were mainly related to difficulties in correctly assessing the patient's condition and establishing an appropriate therapeutic relationship. This is in line with the results of the survey from 2021-2022 (35). Professionals perceived telepsychiatry as a convenient solution for follow-up visits, however, it was perceived as less effective for setting up a therapeutic relationship or assessment of mental status in acute mental crisis. We also examined in our study what needs to be improved in telepsychiatry. Among the points indicated there were the quality of the connection and the lack of a platform dedicated to this solution.

In one study some gender differences have been detected, showing that women are more willing to use are more satisfied with the use of telepsychiatry (55). In this study, however, we found no differences regarding gender, age, or place of work.

A more constant and unchanged attitude over the years of the survey was presented by professionals regarding new mHealth tools, i.e. mobile apps, smart watches, monitoring wristbands, etc. More than half of the professionals were interested in the possibilities of mobile mental health aids, some have already recommended them to their patients. According to the majority of respondents (86%), mHealth tools can help patients to better cope with their mental illness and 74% declared recommending patients to use of mental health apps. This result is in general consistent with other identified studies (30, 34, 56, 57). Moreover, in a 2022 Portuguese survey as many as 87% clinicians supported the possibility of prescribing mental health apps (31). Although professionals' attitudes about mHealth tools supporting patients may not necessarily translate into behavior, so much interest is encouraging. However, it is worth to mention that 29% of respondents had some concerns about the use of such devices by patients. These concerns were mainly related to the unknown effectiveness of these devices and doubts about the security of the data entered there by patients. In another study also pointed to technical problems encountered by clinicians and organizational and social factors related to concerns about implementing these solutions in daily practice (28). The problem of failing to protect sensitive user data that can threaten patient safety has been recognized for several years now. The business practices of digital companies are still not subject to proper scrutiny and may put profits ahead of security. Some authorities even suggest that specialists should screen apps before recommending them to patients (58).

Although regulations have already appeared in both the EU (59, 60) and the US (61) addressing this issue, they are still not perfect and most applications are not under the strict control of the relevant authorities. According to the 2017 EU Medical Device Regulation. Medical mobile apps require CE marking. In addition, the EU regulation has forced many app developers to improve privacy policy transparency. These regulations are expected to be clarified in

the future, allowing the broad market for medical apps to be covered (62).

A good example of how to solve this problem is the German system. In 2019, a law was passed allowing doctors to prescribe certain health apps. In order to obtain such status, apps must undergo a comprehensive certification process and provide scientific evidence of efficacy and safety confirmed by clinical trials. Such certified apps are called DiGA, a specialist can prescribe it to a patient, and statutory health insurance covers the costs incurred. This seems to have solved both the problem of specialists unsure of what is effective and safe, as well as ensuring the security of sensitive patient data. This is confirmed by a willingness to use DiGA of as much as 76%. Therefore, it seems that it is not only the attitudes of clinicians to new technologies themselves that are important here, but also their confidence and knowledge based on evidence-based medicine, so that they can recommend such new solutions to their patients without any doubt. A multidisciplinary approach is needed to develop a tool that is effective and safe for patients. This requires the sound knowledge and experience of mental health professionals, a patient-assessed usability perspective, as well as the technical expertise of computer scientists. Although individual apps and smartwatches are being validated in clinical trials, the number of randomized clinical trials on large groups of patients is particularly low.

This study has also found that the use of internet-enabled mobile devices is widespread among mental health professionals, with as many as 92% using them at least once a week. Furthermore, over the period of the survey, there has been an increase in the percentage of professionals declaring that they feel ready to use new digital technologies in mental health, rising to 84% in 2023. This is generally in line with the data from the systematic review of this topic. These results allow us to look optimistically to the future and the development of medical devices and new channels for specialist-patient communication. However, the need to adapt legal solutions to the evolving digital market should not be overlooked, so that patient safety and the privacy of the patient's sensitive data is not compromised.

This study has certain limitations that should be considered. Firstly, the mental health professionals who decided to participate in the survey may be predisposed to have positive attitudes toward telepsychiatry and m-health. Secondly, the response rate was 59.2%, which may have affected the results. Thirdly, most of the data came from mental health professionals working in urban areas and providing outpatient treatment. Lastly, the cross-sectional design and self-reported data were also limitations of this study. Therefore, the results should be generalized with particular care.

5 Conclusions

The study contributes to the body of knowledge on the attitudes, expectations and concerns of mental health professionals regarding the use of mobile digital technology and how these change over the onset, peak and extinction of the COVID-19 pandemic (2020–2023). The willingness to use telepsychiatry was expressed by up to 76% of

respondents. However, since 2022 (pandemic extinction) there has been a decrease in the declared intention to use this modality from more than 50% to less than half of all visits in 2023. It is also worth noting that a consistent proportion of professionals (25%) reported some concern about the use of telepsychiatry, mainly related to difficulties in correctly assessing the patient's condition. Furthermore, they indicated that technical issues such as the connection quality or special platform presence needed to be addressed.

According to the majority of respondents (86%), mHealth tools can help patients to better cope with their mental illness and 74% declared recommending patients their use. However, 29% of respondents had some concerns about the use of such devices by patients. These concerns were mainly related to the unknown effectiveness of these devices and doubts about the security of the data entered there by patients.

Finally, over the period of the survey, there has been an increase in the percentage of professionals declaring that they feel ready to use new digital technologies in mental health, rising to 84% in 2023. Determining concerns and expectations will enable the design of tools that are better suited and able to serve in the long term, rather than just being a short-term novelty.

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 Bioethics Committee at the Institute of Psychiatry and Neurology, Warsaw, Poland. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements.

Author contributions

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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/fpsyt.2024.1303878/full#supplementary-material

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Enhancing the acceptance of smart sensing in psychotherapy patients: findings from a randomized controlled trial

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Objective: Smart sensing has the potential to make psychotherapeutic treatments more effective. It involves the passive analysis and collection of data generated by digital devices. However, acceptance of smart sensing among psychotherapy patients remains unclear. Based on the unified theory of acceptance and use of technology (UTAUT), this study investigated (1) the acceptance toward smart sensing in a sample of psychotherapy patients (2) the effectiveness of an acceptance facilitating intervention (AFI) and (3) the determinants of acceptance.

Methods: Patients ($N = 116$) were randomly assigned to a control group (CG) or intervention group (IG). The IG received a video AFI on smart sensing, and the CG a control video. An online questionnaire was used to assess acceptance of smart sensing, performance expectancy, effort expectancy, facilitating conditions and social influence. The intervention effects of the AFI on acceptance were investigated. The determinants of acceptance were analyzed with structural equation modeling (SEM).

Results: The IG showed a moderate level of acceptance ($M = 3.16$, SD = 0.97), while the CG showed a low level ($M = 2.76$, SD = 1.0). The increase in acceptance showed a moderate effect in the intervention group ($p < .05$, $d = 0.4$). For the IG, performance expectancy ($M = 3.92$, SD = 0.7), effort expectancy ($M = 3.90$, SD = 0.98) as well as facilitating conditions ($M = 3.91$, SD = 0.93) achieved high levels. Performance expectancy ($\gamma = 0.63$, $p < .001$) and effort expectancy ($\gamma = 0.36$, $p < .001$) were identified as the core determinants of acceptance explaining 71.1% of its variance. The fit indices supported the model's validity (CFI = .95, TLI = .93, RMSEA = .08).

Discussion: The low acceptance in the CG suggests that enhancing the acceptance should be considered, potentially increasing the use and adherence to the technology. The current AFI was effective in doing so and is thus a promising approach. The IG also showed significantly higher performance expectancy and social influence and, in general, a strong expression of the UTAUT factors. The results support the applicability of the UTAUT in the context of smart sensing in a clinical sample, as the included predictors were able to explain a great amount of the variance of acceptance.

1 Introduction

Digital technologies have the potential to significantly transform psychotherapeutic treatment and care (1–3). The hope is that they can help to bridge healthcare gaps and make treatments more effective and efficient (4–6). Smart sensing is one of those technologies that may contribute to improvements in psychotherapy. It primarily involves the passive analysis and collection of data generated by digital devices, such as smartphones or smart wearables (7, 8). Such data may encompass measurements like step counts, sleep duration, or smartphone usage. In the future, smart sensing could even capture more complex biophysiological data (9). This technology vastly extends the information available to psychotherapists during the treatment process. Smart sensing offers the distinct advantage that fine-grained data (e.g., continuous assessment of activity) can be collected unobtrusively without burden on patients. Furthermore, the technology enables more objective data collection in the natural life context of patients leading to high ecological validity and the elimination of common biases such as recall biases or social desirability, which have long posed challenges in psychotherapy (10, 11). The gathered information can be integrated at every stage of the psychotherapeutic process: diagnosis and problem analysis, treatment planning, implementation of interventions, monitoring, and the evaluation of the treatment process (3, 12).

Data collected through smart sensing has already been utilized in various domains of health research (13–15), such as measuring physical activity or sending activity-promoting app notifications in cases of extended sitting (16), or monitoring chronic conditions like Parkinson's disease (17). In the context of mental health conditions, smart sensing has also been employed (7, 8). From cross-sectional observation studies, there is evidence that mental symptoms are associated with smartphone or wearable data (18–20), which might enable predictions of mental disorders by this data in the future. There is also evidence for phenotyping and diagnosing diseases such as psychosis (21) and bipolar disorder (22) or for mood prediction (23, 24).

However, various steps need to be taken before integrating smart sensing technology into standard clinical care. One is to gauge its acceptability and discern the factors linked with its adoption. The Unified Theory of Acceptance and Use of Technology (UTAUT) (25) offers a model for investigating the acceptance of technology and its influencing factors. It is a well-established framework for understanding the adoption and acceptance of digital health applications (26, 27), and has already been applied to diverse contexts (27–29). The theory identifies performance expectancy, which relates to the perceived personal benefits of using the technology, effort expectancy, denoting the anticipated ease of use, social influence, representing the belief that others find the technology valuable, and facilitating conditions, encompassing the expected support and availability of practical resources, as the fundamental determinants of acceptance (25, 26). A first study also applied the UTAUT model in the context of smart sensing (30). While the study supports the general applicability of the UTAUT model for smart sensing, it was conducted in the general population and currently no evidence of the model is available in patients in psychotherapy. Hence, it is of importance to investigate the generalizability of the UTAUT model in a clinical sample.

In addition to understanding the determinates of acceptance, it is essential to explore opportunities for enhancing the acceptance to ensure the successful implementation of smart sensing. It has been proven before that Acceptance Facilitating Interventions (AFIs) can be effective in enhancing the acceptance of internet-based or blended psychotherapy (31–35). AFIs typically align with an acceptance model such as UTAUT (26) or other models [e.g., the Health Action Process Approach (36)]. To directly target the presumed determinants of acceptance, a UTAUT-based AFI should emphasize performance expectancy by pointing out the personal benefits, effort expectancy by demonstrating the technology in action, social influence by providing expert or user experiences, and facilitating conditions by addressing concerns regarding practical resources or the availability of technical assistance.

The present study aimed to (1) assess the acceptance toward smart sensing in a sample of psychotherapy patients (2) investigate the effectiveness of a UTAUT-based AFI in enhancing the acceptance of smart sensing and (3) investigate the determinants of acceptance. The AFI was presented to the intervention group (IG) in the form of an information video on smart sensing, while the control group (CG) was shown a control video that contained information about depression and anxiety (active control condition). Two hypotheses were investigated: (a) Patients who watched the AFI-video show a higher acceptance of smart sensing. (b) The UTAUT model applies to psychotherapy patients, which means that the covariance matrix implicated by the UTAUT does not differ significantly from the observed covariance matrix. In addition, we conducted exploratory analyses to assess the effect of the AFI on relevant subgroups and to investigate the association between psychological distress and the acceptance of smart sensing.

2 Materials and methods

2.1 Sample and study design

We report on a randomized controlled trial focusing on the cross-sectional comparison of two groups. The study was conducted in April and May, 2023. In this online intervention study patients were randomly assigned to either the control group (CG) or the intervention group (IG). A simple, unrestricted randomization was used, which was carried out by an automated and validated tool by the survey software (LimeSurvey Community Edition Version 6.2.9). The algorithm initially led to different group sizes (IG: 80, CG: 69). Assignment to CG or IG was obscured for participants. Patients in the IG received an informational video (AFI) on the topic of Smart sensing. Patients in the CG, on the other hand, received a video

on the topic of depression and anxiety instead. Further details about the videos are provided in Section 2.5.1.

Patients were invited to participate via email. In order to be included in the study, patients either had to be undergoing psychotherapeutic treatment at the psychotherapeutic outpatient clinic of Friedrich-Schiller-University Jena, be on the waiting list for such treatment or have completed their psychotherapy within the last 2 years. Participants also had to have sufficient knowledge of the German language, and be over 18 years of age. Participants did not receive any reimbursements for participation.

To determine the required sample size, an *a priori* power analysis was conducted. Previous AFI interventions on acceptance ranged from no significant effects to significant effects with large effect sizes (31–34). Based on these study results, the

effect size was assumed to be $d = 0.40$. With a power of 80%, a one-sided t-test and a significance level of 5%, a sample size of 78 participants per group was required.

A total of 433 patients were contacted. Out of the contacted patients, 205 clicked on the study link. The final analysis included data from $N = 116$ patients, Figure 1 depicts the study flow.

Patient ages ranged from 18 to 87 years ($M = 38.86$, SD = 15.83). Of the patients, 63.8% were female ($n = 74$), 33.6% were male ($n = 39$), and 2.6% identified as gender-diverse ($n = 3$). Additionally, 39.7% had a university degree ($n = 46$). There were $n = 64$ patients in the intervention group and $n = 52$ in the control group. Table 1 presents sociodemographic data separately for both groups and Table 2 shows that both groups reported the same amount of psychological distress.
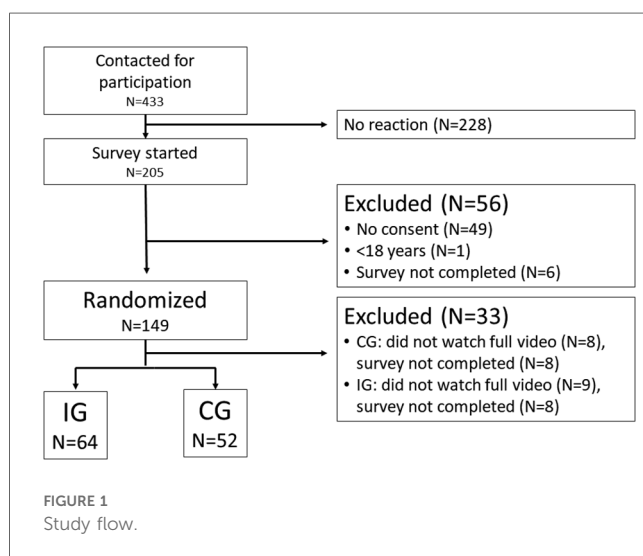
2.3 Ethics statement

The study followed the Declaration of Helsinki for medical research involving human subjects and was approved by the Ethics Committee of the Friedrich-Schiller University Jena (Reg.-Nr.: FSV 22/103). All participants provided written informed consent.

2.4 Questionnaires

2.4.1 Acceptance

The assessment of acceptance and its determinants was grounded in the Unified Theory of Acceptance and Use of Technology (UTAUT) model (25). To gauge the efficacy of the intervention and the impact of these determinants, we utilized a slightly modified questionnaire, similar to those employed and validated in prior research endeavors aimed at measuring the

FIGURE 1
Study flow.

TABLE 1 Characteristics of IG and CG.

	Intervention group		Control group	
	n ($N = 64$)	%/M (SD)	n ($N = 52$)	%/M (SD)
Age in years		38.17 (15.06)		39.71 (15.87)
Sex				
Male	18	28.1	21	40.4
Female	44	68.8	30	57.7
Diverse	2	3.1	1	1.9
Country of origin				
Germany	59	92.2	52	100
Other	5	7.8	0	0
Education				
University degree	28	43.8	18	34.6
University entrance qualification	20	31.3	19	36.5
Intermediate secondary school	11	17.2	10	19.2
Other	5	7.8	5	9.6
Employment status				
Employed full-time	21	32.8	16	30.8
Education/study	19	29.7	15	28.8
Employed part-time	13	20.3	10	19.2
Retired	4	6.3	7	13.5
Other	7	10.9	4	7.7

M(SD), mean (standard deviation).

TABLE 2 Psychological distress of IG and CG.

	Intervention group N = 64				Control group N = 52				Comparison	
	M (SD)	Median (IQR)	Mean rank	Sum rank	M (SD)	Median (IQR)	Mean rank	Sum rank	Z	p
Depression	6.17 (5.17)	4.5 (7.0)	55.4	3,545.5	7.54 (5.88)	6.5 (8.0)	62.3	3,240.5	−1.11	.269
Anxiety	4.48 (3.41)	3.0 (4.0)	57.4	3,674.5	4.48 (3.03)	5.0 (5.0)	59.8	3,111.5	−0.39	.689
Stress	7.56 (4.01)	7.5 (5.0)	56.5	3,613.5	8.34 (4.81)	8.0 (8.0)	61.0	3,172.5	−0.73	.467
SUM	18.22 (10.38)	15.5 (13.75)	55.7	3,565.0	20.37 (12.21)	19.0 (18.0)	61.9	3,221.0	−0.99	.320

For comparison of both groups Mann-Whitney-*U*-test was used. M(SD), mean (standard deviation), Mean Rank, mean rank according to Mann-Whitney-*U*-test. Sum Rank, sum rank according to Mann-Whitney-*U*-test.

acceptance of internet-based interventions (30, 31, 33, 35). The questionnaire comprises 5 scales (acceptance, performance expectancy, effort expectancy, social influence, facilitating conditions) and a total of 14 items. All items were rated on a 5-point Likert scale, ranging from 1 = "strongly disagree" to 5 = "strongly agree." Detailed information on the questionnaire's scales and items, along with reliability statistics for this study, are presented in the supplement (Supplementary Tables S1 and S3).

2.4.2 Psychological distress

Psychological distress was assessed using the German version of the Depression-Anxiety-Stress Scale (DASS) (37). The questionnaire comprises 21 items and gauges psychological distress across the domains of depression, stress, and anxiety, each consisting of seven items. Responses were captured on a 4-point Likert scale ranging from 0 = "Did not apply to me at all" to 3 = "Applied to me very much, or most of the time." The DASS was selected due to its economy, ability to provide nuanced insights into various symptom domains of psychological distress, and established reliability and validity. Convergent validity was demonstrated through the correlation between the Beck Anxiety Inventory (38) and the DASS anxiety scale ($r = .76$), as well as the correlation between the Beck Depression Inventory (39) and the DASS depression scale ($r = .68$).

2.5 Material

2.5.1 Intervention video

The AFI video had a duration of approximately 9 min. The video aimed to address the acceptance predictors outlined in the UTAUT model, with a particular focus on performance expectancy. The video was tailored to the target audience of psychotherapy patients, implemented a narrative style, and was based on a whiteboard design to achieve load reduction (40–42). Content within the video included an explanation of what smart sensing entails, how it can be utilized, information regarding data collection, data privacy considerations, and the benefits of smart sensing. The potential applications of smart sensing were further elucidated through a fictional patient scenario, highlighting the advantages of smart sensing. In this scenario, a therapist and a patient jointly recognize a positive correlation between physical activity and the patient's satisfaction. Subsequently, an objective is formulated within the therapy to increase physical activity. Furthermore, the video

emphasized the use of smart sensing to monitor treatment progress and goal achievement during therapy, devising additional treatment objectives, and underlining the potential utility of smart sensing even beyond the course of therapy. Towards the end of the video, an expert statement from a psychotherapist was presented, expounding upon further advantages of Smart sensing and recounting personal positive experiences with it. A script outlining the video's content is provided in the appendix.

2.5.2 Control video

The control video for the control group was thought as an active control condition. It had a duration of approximately 8.5 min. This video consisted of two psychoeducational segments, one addressing depression and the other focusing on generalized anxiety disorders. Both videos were created by the German Federal Ministry of Health and are publicly available (43, 44). These segments were amalgamated into a single video to ensure a comparable duration to that of the AFI Video. The aim of this video was to capture the participants' attention due to the perceived importance of the subject matter without influencing their acceptance of smart sensing. Notably, smart sensing was not discussed in this video.

2.6 Implementation and Procedure

Patients initially completed the questionnaire pertaining to their sociodemographic characteristics. Subsequently, patients were presented with either the AFI video or control video. To ensure that the video was viewed, patients were required to wait for a minimum of 4 min before they could click on the "continue" button. Additionally, they were asked to confirm whether they had watched the video in its entirety. Following this, patients received information on smart sensing to ensure that even the CG had a basic understanding of the topic. The following information was provided: "Smart sensing involves the continuous passive collection of digital markers while using smart devices such as smartphones or smartwatches. Digital markers include parameters such as the range of motion, step count, and sleep patterns. Smart sensing, for instance, records your step count via a smartphone or your sleep patterns through a smartwatch." Following the information session, patients completed the UTAUT questionnaire and the DASS. At the end of the study, participants were also given the option to receive automated feedback on the results of the DASS questionnaire. Furthermore, patients had the

opportunity to provide their email address if they were interested in participating in further studies involving smart sensing.

2.7 Statistical analyses

The data was analyzed using IBM SPSS Statistics 29.00 and IBM SPSS Amos 29. To compare level of acceptance between IG and CG, the Mann-Whitney U test was employed due to deviations from the assumption of normal distribution. To examine the influence of the surveyed acceptance predictors (performance expectancy, effort expectancy, social influence, facilitating conditions), a confirmatory structural equation model was applied to the whole sample, whereby the CG and IG were combined. The structural equation model was developed based on UTAUT and validated by Philippi et al. (27). The influence of the acceptance predictors on acceptance was tested using standardized regression weights and their significance. Model fit was evaluated using the Comparative Fit Index (CFI), the Tucker Lewis Index (TLI) and the Root Mean Square Error of Approximation (RMSEA). RMSEA as a non-centrality parameter was used to assess the goodness of fit due to the tendency of the χ^2-test to reject the misspecified models too harshly (45–47). Following well-established guidelines we defined a good model fit as CFI and TLI >.90, RMSEA <.08 (48).

Additionally, exploratory t-tests were conducted. The effects of the intervention on various subgroups were also examined to analyze in which groups the intervention is particularly meaningful and to explore potential mechanisms of the intervention. Exploratory analyses were performed for the following subgroups: male vs. female, young vs. old (with the median age as the cutoff point) as well as lower vs. higher educational levels (higher degrees beyond secondary school were considered as higher education). To investigate the association between acceptance and psychological distress, Pearson correlation coefficient was computed.

3 Results

3.1 Group Comparison of acceptance and its predictors

On a 5-point Likert scale, the IG showed a moderate level of acceptance ($M = 3.16$), while the CG showed a low level

($M = 2.76$). Table 3 presents the comparison of groups in terms of acceptance and acceptance predictors. The IG showed significantly higher acceptance than CG ($U = 1,299.0$, $Z = -2.033$, $p = .042$). The effect size was $d = 0.40$ (95% CI: 0.03–0.77), corresponding to a moderate effect. Hence, hypothesis (a) was confirmed. Furthermore, patients in the IG had significantly higher performance expectancy toward smart sensing ($U = 2,404.5$, $Z = -3.575$, $p < .001$), with an effect size of $d = 0.74$ (95% CI: 0.36–1.11), as well as significantly higher scores on social influence ($U = 1,056.0$, $Z = 3.460$, $p < .001$), with an effect size of $d = 0.63$ (95% CI: 0.25–1.00).

3.2 Model for prediction of acceptance of smart sensing

Performance expectancy ($\gamma = 0.63$, $p < .001$) and effort expectancy ($\gamma = 0.36$, $p < .001$) were identified as predictors of acceptance in the structural equation model. Together, the two determinants explained 71.1% of the variance of the latent acceptance factor. Social influence did not achieve statistical significance as a predictor of acceptance ($\gamma = -0.08$, $p = .551$). The fit indices supported the model's validity (CFI = .95, TLI = .93, RMSEA = .08). Hence, hypothesis (b) was confirmed. Figure 2 depicts the structural equation model with estimated parameters. The full parameter list of the measurement model and correlations between the acceptance predictors and acceptance of smart sensing are presented in the supplement (Supplementary Tables S2 and S3).

3.3 Exploratory analyses

3.3.1 Subgroup analyses

Subgroup analyses revealed meaningful interaction effects regarding gender, age, and education level. A significant intervention effect on acceptance was found in the subgroup of women ($t = 3.54$, $p < .001$) with an effect size of $d = 0.84$ (95% CI: 0.35–1.32). Conversely, there was no significant effect in men ($t = -0.59$, $p = .561$). Furthermore, a significant intervention effect was observed in the older patient group ($t = 2.37$, $p = .021$) with an effect size of $d = 0.62$ (95% CI: 0.09–1.14), whereas there was no significant effect in the younger patient group ($t = 0.55$,

TABLE 3 Acceptance and predictors of acceptance for smart sensing.

	Intervention group $N = 64$			Control group $N = 52$			Comparison		
	M (SD)	Mean rank	Sum rank	M (SD)	Mean rank	Sum rank	Z	p	d
Acceptance	3.16 (0.97)	64.2	4,109.0	2.76 (1.00)	51.48	2,677.0	−2.03	**<.05***	**0.4**
Performance expectancy	3.92 (0.70)	68.5	4,381.5	3.31 (0.97)	46.2	2,404.5	−3.60	**<.001***	**0.74**
Effort expectancy	3.90 (0.98)	63.6	4,072.0	3.60 (1.02)	52.2	2,714.0	−1.84	.065	
Social influence	3.34 (0.83)	68.0	4,352.0	2.83 (0.79)	46.8	2,434.0	−3.50	**<.001***	**0.63**
Facilitating conditions	3.91 (0.93)	59.6	3,812.5	3.82 (1.00)	57.2	2,973.5	−0.39	.698	

For comparison of both groups Mann-Whitney-U-test was used. M(SD), mean (standard deviation), Mean Rank, mean rank according to Mann-Whitney-U-test. Sum Rank, sum rank according to Mann-Whitney-U-test.
Significant p-values are written in bold.
*<.05, ***<.001.
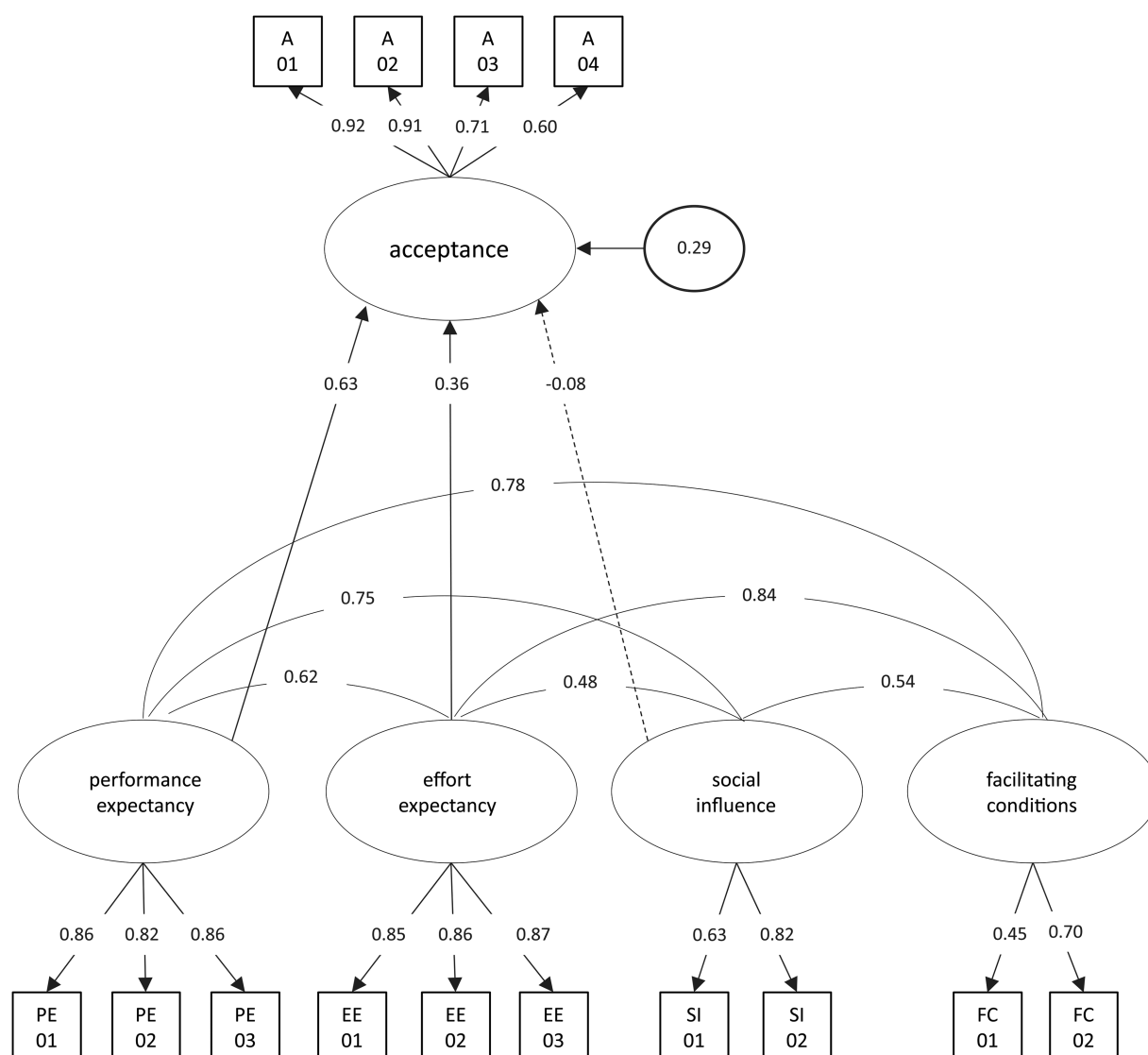
FIGURE 2
Structural equation model for the acceptance toward smart sensing. Latent variables are represented in ellipses: A, acceptance; PE, performance expectancy; EE, effort expectancy; FC, facilitating conditions; SI, social influence. The dashed line indicates a nonsignificant path. Observed items are indicated as rectangles. Path loadings are represented as single-headed arrows. All exogenous latent variables were allowed to correlate. For improved readability, all latent correlations and residual variances of manifest items were omitted.

$p = .586$). Similarly, a significant intervention effect was observed for patients with lower educational levels [$t = 2.92$, $p = .007$, $d = 1.15$ (95% CI: 0.30–1.97)], but not for patients with higher education ($t = 1.56$, $p = .114$). Table 4 includes the means and standard deviations of acceptance for each subgroup, along with the p-values of the intervention effects.

3.3.2 Psychological distress and acceptance

There were no significant associations in the overall sample between acceptance and depression [$r = .02$ (95% CI: −.17 to −.20), $p = .867$], acceptance and anxiety [$r = .01$ (95% CI: −.17 to −.20), $p = .893$], acceptance and stress [$r = .06$ (95% CI: −.13 to −.24), $p = .560$], or between acceptance and overall psychological distress [$r = .03$ (95% CI: −.15 to −.21), $p = .728$].

4 Discussion

4.1 Effect of AFI

Acceptance is a fundamental precondition for the dissemination, uptake, and clinical impact of smart sensing. The mean acceptance of the CG suggests that the baseline acceptance for smart sensing in psychotherapy patients is at a low to

moderate level. We hence conclude that enhancing the acceptance should be considered, potentially increasing the use and adherence to the technology. The present UTAUT-based AFI was able to significantly increase the acceptance of smart sensing in psychotherapy patients and increased performance expectancy and social influence as well. The effect size of the intervention on acceptance ($d = 0.40$) fell within moderate range. Considering determinants of acceptance according to the UTAUT model, performance and effort expectancy achieved high levels with means close to 4 on a 5-point Likert scale in the IG (compare Table 4). Social influence was increased by the AFI reaching a moderate to high level. Additionally, the overall sample showed high levels of facilitating conditions.

To the best of our knowledge, this is the first study to explore the use of an AFI for smart sensing in psychotherapy patients. Consequently, a direct comparison with study outcomes in similar clinical populations is not feasible. Compared to the general population (30), psychotherapy patients exhibited similar levels of acceptance for smart sensing in the control group, while this study revealed a greater intervention effect by the AFI. We identified the following reasons for the greater intervention effect: (1) The AFI in this study was tailored to the group of psychotherapy patients and specifically targeted their needs, whereas the AFI in the comparative study did not address specific needs but introduced the technology and possible applications in a more general manner. (2) The AFI in this study was three times longer than in the comparative study, which allowed us to provide more in-depth information about smart sensing. (3) Performance expectancy was the most important predictor of acceptance for smart sensing in both this patient population and the general population (30). However, it is questionable whether a population with good mental health expects meaningful benefits from smart sensing, while a population of psychotherapy patients might have a clearer connection to the benefits of the technology. Lastly, we optimized the intervention by applying state of the art instructional design principles to split the cognitive load across auditory and visual channels in the white-board video and implemented a narrative explanation style in the AFI (40–42).

For clinical practice our results support the implementation of scalable AFI in an online video format to increase the acceptance of smart sensing in patients. Given the time- and location independent nature of such AFI, they may become a feasible and effective way to implement smart sensing at various stages before (e.g., installation and symptom tracking before treatment for a data informed decision and recommendation of psychotherapeutic modules), during (e.g., to monitor treatment progress via smart sensing), and after psychotherapy [e.g., using smart sensing to recognize re-establishing dysfunctional behavior patterns and initiate just-in-time interventions (3)]. That said, the therapeutic relationship between the patient and therapist (49) represents one of the most crucial therapeutic factors in psychotherapy. Hence, it is reasonable to assume that a recommendation for the use of smart sensing by the treating psychotherapist would significantly enhance the acceptance and could outperform the effects of digital AFI. The evaluation of

TABLE 4 Subgroup analyses of acceptance.

	Intervention group N = 64			Control group N = 52			Comparison		
	N	M	SD	N	M	SD	df	t	p
Sex									
Male	18	3.06	1.06	21	3.25	1.00	37	−0.59	.561
Female	44	3.22	0.96	30	2.45	0.86	72	3.54	<.001
Age in years									
<34	34	3.16	0.86	26	3.03	0.98	48	0.55	.586
≧34	30	3.15	1.09	26	2.51	0.96	54	2.37	.021
Education									
Low	16	3.52	0.85	15	2.58	0.79	39	2.92	.007
High	48	3.16	0.93	37	2.82	1.06	83	1.56	.114

M(SD), mean (standard deviation), For the separation between older and younger patients, the median age (34) of the entire sample was used high educational status = any person holding a university entrance qualification or higher.

expert-delivered face-to-face AFIs or stepped-information processes combining digital and face-to-face AFIs would be a very valuable addition to this study.

4.2 Influence of acceptance predictors

We confirmed our hypothesis that the UTAUT holds in the context of smart sensing in a clinical sample as the included predictors explained a great amount of the variance of acceptance. This finding aligns with previous findings (30). The results also emphasize that the most critical factor for the acceptance of smart sensing is the expected personal benefit to the patient. Also consistent with prior research, the second most influential predictor was effort expectancy, albeit with a significantly greater impact on acceptance than could be expected based on previous findings (27, 30). One possible reason for this could be that a common symptom in mental disorders, particularly in cases of depressive symptoms, is aversion or a lack of motivation (50). Therefore, any additionally perceived effort is likely to have a more negative impact on acceptance in psychotherapy patients compared to other populations. Thus, the perceived minimal effort appears to be of importance for the acceptance of smart sensing in this context. While social influence showed a significant positive correlation with acceptance, social influence did not remain a predictor of acceptance in the structural equation model. This could be attributed to its contribution to the explained variance in acceptance, which was already accounted for by performance expectancy and effort expectancy, both of which were also significantly correlated with social influence.

Hence, we strongly recommend to focus on the performance expectancy when aiming to successfully implement smart sensing in clinical practice as the influence is almost twice as strong than effort expectancy. For instance, this could be done by highlighting the benefits of smart sensing and how the psychotherapeutic process can benefit from it (e.g., trajectory modeling, early-warning systems). Besides, the already outlined

potential to increase the feasibility of smart sensing in clinical practice, AFI may also hold the potential to increase the adherence to smart sensing sample protocols in research to counteract missingness and increase data quality (18, 19, 51).

4.3 Exploratory analyses

The Subgroup analyses are of particular interest when it comes to the question for which subgroups the AFI had the largest impact. However, these analyses must be interpreted in light of the fact that the group sizes were neither large nor balanced with respect to key individual variables. Therefore, they can only provide a hint for future research questions of interest. The results indicate that the AFI particularly enhanced acceptance among females, older patients, and patients with lower education. This appears to be due to lower baseline acceptance of smart sensing in these groups compared to their respective counterparts. This suggests that those are the groups that should especially be provided with an AFI when smart sensing is recommended. Future research is necessary to replicate those findings and might test if AFIs that target specific needs or concerns of those groups could further enhance the acceptance of smart sensing.

Neither stress, anxiety, depression, nor overall psychological distress exhibited a significant association with acceptance. This finding contrasts with other studies reporting a positive relationship between symptom severity and the acceptance of modern technologies in treatment (31, 35, 52). However, it should be noted that the studies by Lin et al. (35) and Baumeister et al. (31) examined different patient groups (pain patients and diabetes patients) and focused on Internet- and mobile-based interventions.

4.5 Limitations

It is important to address certain limitations when interpreting the results. (1) The present study was designed to investigate the acceptance of smart sensing in psychotherapy patients, but did not make a differentiation between mental diagnoses, which could have an impact on the acceptance. To infer to moderation effects on the symptomology level, we conducted exploratory correlation analyses between depression, anxiety, stress, and distress, which yielded non-significant findings. Besides, a clinical discussion for which patient groups the technology might be suited at all, future studies should explore the acceptance in more detail in specific patient groups. (2) Despite contacting every potentially available patient at the site twice, only 149 patients could be recruited for randomization. This means that the final recruitment target of 156 patients could not be reached. At this point, the recruitment capacity at the site was exhausted in terms of patients. Future studies should aim for a confirmatory study and could base their calculations on an effect size of $d = 0.4$. (3) The active control condition might also have had an effect on the acceptability towards mental health interventions in general, which might carry over to smart

sensing. This would mean that baseline acceptance might be even lower, which could be investigated in future studies. (4) Future studies should follow-up with a closer investigation of the acceptance towards specific sensor modalities, such as screen usage, location, biophysiological data or language usage. For instance, Nicholas and colleagues (53) found differences in the acceptance towards health information (e.g., sleep, mood data), and personal data (e.g., communication logs, or location features). To which extent the acceptance might vary across sensors in psychotherapy patients is currently unknown. (5), the present sample showed an imbalance in gender and education leaning towards a female highly educated population. While this may reflect imbalances in prevalence rates for some disorders (e.g., increased prevalence of depression in women) and help seeking behavior to some extent, it also limits the generalizability of the present findings highlighting the need for replication studies. The slight imbalances between the IG and CG concerning gender and education were due to the randomization process but did not influence the overall effect of the AFI on acceptance (please compare Supplementary Material S5). Lastly, like many previous studies, this research primarily assessed acceptance and attitudes towards new technology by predicting behavioral intentions. While behavioral intentions are widely recognized as a proximal indicator of actual behavior, a gap often exists between intention and behavior (54). Therefore, future research should take into account the volitional aspect and incorporate actual smart sensing use, such as uptake rates, as an outcome measure (30, 36, 55).

5 Conclusion

In summary, our study provides evidence that acceptance of smart sensing among psychotherapy patients can be significantly increased by an AFI based on a time- and location independent video format. The low to moderate baseline acceptance level in the CG simultaneously emphasizes the importance of such interventions to potentially ensure technology usage and compliance.

Our IG exhibited high levels of performance expectancy, effort expectancy, and facilitating conditions after exposure to the AFI. This outcome is particularly promising from a scalability perspective, as such videos offer a versatile means of dissemination through various communication channels, including waiting rooms, the Internet, or television. This widespread distribution can significantly contribute to the adoption of these innovative digital health applications.

The study demonstrates that the UTAUT model is applicable within the context of smart sensing in a clinical sample. The findings highlight that the most critical factor for the acceptance of smart sensing is performance expectancy. Therefore, when recommending smart sensing to patients, the focus should be on their expected personal benefits. Exploratory findings suggest that this approach may be especially beneficial for increasing acceptance among females, older patients, and those with lower levels of education.

Data availability statement

Data requests should be directed to the corresponding author (FR). Data can be shared with researchers who provide a methodologically sound proposal, which is not already covered by other researchers. Data can only be shared for projects if the General Data Protection Regulation is met. Requestors may need to sign additional data access agreements. Support depends on available resources.

Ethics statement

The studies involving humans were approved by Ethikkommission der Friedrich-Schiller-Universität Jena (Ethics Committee of the Friedrich Schiller University Jena). 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

FR: Conceptualization, Data curation, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing, Software. EB: Data curation, Formal Analysis, Investigation, Software, Writing – review & editing. GW: Conceptualization, Writing – review & editing. IC: Project administration, Writing – review & editing. HB: Supervision, Writing – review & editing. YT: Conceptualization, Investigation, Methodology, Supervision, Validation, 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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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fdgth.2024.1335776/full#supplementary-material.

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Beyond technology acceptance—a focused ethnography on the implementation, acceptance and use of new nursing technology in a German hospital

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Introduction: Hospitalised patients could benefit from the emergence of novel technologies for nursing care. There are numerous technical products available, but these rarely find their way into practice. Further knowledge is required about the circumstances under which technology in nursing is accepted and used. In the research project "Centre for Implementing Nursing Care Innovations", technical innovations are implemented on a trauma surgery inpatient ward in Germany. After implementation, it was investigated: Which implemented technologies are accepted/rejected, and which factors influence the acceptance/rejection of technology for nurses?

Material and methods: A focused ethnography was used, containing two approaches: *First*, participant observation was conducted to examine nurses' and patients' interaction with technologies. Observations were fixed in a field research diary and analysed using evaluative qualitative content analysis. *Second*, a questionnaire was used by nurses to provide information about the use frequency and technology suitability. The results of the study were consolidated and analysed using the UTAUT model.

Results: Seven studied technologies can be summarised in four result categories: (1) A Mobilising mattress, a Special projector and a Sound pillow are accepted and used by nurses and patients, because they offer a way to provide high quality care with little additional effort. (2) A Fall prevention system is consistently used in patient care as a work obligation, but since nurses consider the system error-prone, acceptance is low. (3) An Interactive therapy ball is accepted but nurses cannot use it due to the high workload. (4) An App for nurse-patient communication and a work-equipment tracking system are not used or accepted because nurses do not see a practical benefit in the systems.

Discussion: Acceptance or rejection of a product does not necessarily equate to use or non-use of the technology. Before implementation, technology acceptance among users occurs as prejudice—when users are given time to experiment with technology, intention-to-use can stabilize into sustained use. Accepted and used technologies can serve to mask problems (such as staff shortages) and encourage problematic developments, such as the reduction of contact time at the bedside. Therefore, technology acceptance should be qualified in asking *to what* accepted technology contributes.

KEYWORDS

ethnography, technology acceptance, UTAUT, participant observation, nursing care, implementation, technical innovations, Germany

1 Background

1.1 Nursing, technology and acceptance

With the growing use of digital technologies in healthcare, new technologies become increasingly available for nursing in recent years. For this profession in particular, technology is one possible response to the challenges of an ageing population being cared for by a decreasing number of available professionals (1, 2). Technology uptake in nursing care needs to accelerate to use the potential benefits of new technologies, and enablers and barriers related to technology implementation should be investigated and understood. Potential factors are numerous, e.g., a lack of fit between technology output and user need, inappropriate design for use needs, misguided implementation efforts or institutional limitations (3, 4). These could have an impact on the use and acceptance of nursing technologies.

Behavioural intention *or* actual use of technology has been studied regarding the acceptance of nursing technology. However, while new technology is implemented, the user's perspective may change due to the occurrence of unintended or unanticipated consequences of technology use (5), the social and contextual influences of implementation or facilitating conditions. For instance, through getting to know a new device and getting used to its functions and abilities, a negative expected usefulness and ease of use may shift to a positive attitude and vice versa. More research is needed to learn how and why behavioural intention shifts to a sustained and accepted actual use or a disruption of use and rejection of technology.

1.2 State of research

The adoption of new technologies in nursing is related to various determinants of technology acceptance. In the case of tele-nursing and remote visual monitoring of patients, studies have indicated that while the technology may reduce the number of falls, the acceptance of technology may only be moderate (6). Similarly, in the case of mobile healthcare communication tools, it has been shown that promoting early adopters can significantly influence user's behavioural intention to use the technology (7, 8). Similarly, in the case of mobile healthcare communication tools, it has been shown that promoting early adopters can significantly influence user's behavioural intention to use the technology (9). Users tend to favour mobile tools for inter-professional or professional-patient communication when tools are easy to use and efficient (10, 11). For AI technology that improves decision-making, another study have found that technology acceptance may be high among nurses and other professionals if the technology incorporates professional expertise and evidence into decision-making (3). However, such a technology may be associated with fears of loss of autonomy and expected negative impact on clinical workflows (12).

Only some studies have investigated how and why the intention to use technology in nursing may shift towards accepting or rejecting it after implementation. One study in a critical care nursing unit has demonstrated in a pre/post comparison of technology implementation that self-concern and expectation for ease of use decreased for nurses after adapting the technology (13). However, concerns about technology's impact on practice and perceived usefulness increased at the same time (ibid.). Another study has investigated the implementation of a digital oral healthcare intervention in Norway. As users adopted the new technology, they gradually changed their mode of use from—what the authors described as—"norm-based to routine-based behaviour", highlighting the relevance of familiarisation with technology and the corresponding shift of user behaviour (14). For tele-nursing technology, it has been shown that only the performance expectancy was significant for caregivers' behavioural intentions. After introducing the technology, the facilitating conditions and the performance became relevant for caregivers (15).

1.3 Research project and research question

The "*Centre for Implementing Nursing Care Innovations*" study (Funding: German Federal Ministry of Education and Research, funding number 16SV7892K) aims to implement new technologies in a trauma surgery inpatient ward of a university hospital in Germany. After technology introduction, we investigate the modes nurses' use technologies and how patient care and nursing processes will change during technology implementation. The research question is:

> *Which implemented technologies are accepted/rejected by nurses, and which factors influence the acceptance/rejection of these technologies?*

We conducted an ethnographic study and evaluated and reported the results using the *Unified Theory of Acceptance and Use of Technology 1*-model (16). The advantage of this model, which unifies eight separate models, is the provision of various explanatory factors that can predict or explain both the intention to use technology and the actual use (17). UTAUT conceptualises acceptance and use not merely as individual user decisions but places user behaviour and intentions in the context of institutional, organisational, and social environmental factors that may be influenced by mediating factors (age, gender, experience and voluntariness of use).

The study's implementation strategy allows to investigate how behavioural intention to use technology may shift to actual acceptance or rejection. Following Greenhalgh et al., this strategy involves two approaches: (1) We cooperated with the study hospital and managerial nursing staff to create institutional conditions for a successful and sustainable introduction of new technology to facilitate change of working structures (implementation) (18). (2) To select suitable technologies, we involved nurses from the study ward in a participatory manner by consulting them about potential technology and its usefulness (dissemination) (ibid.). For this purpose, we identified areas of nursing care on the project ward that could be supported with technical solutions—these areas

involved, for instance, assistance with geriatric patients, dangers related to falls or pressure ulcers, inefficient patient communication or long walking distances (19). Based on these areas of need, the research project first took a closer look at potentially useful technologies and examined their implementability. For this purpose, an internal guideline was developed that included the IT perspective, nursing science, ethical, legal and social implications and the known study literature on the technology (19, 20). Once the potential technical and organizational implementability of the technology had been confirmed, it was presented to nursing staff. In workshops, they reflected on their behavioural intention to use the technology within their daily working routine (21, 22). If nurses showed their interest in using the presented technology and therefore articulated their intention to use it, the implementation of the product followed. Afterwards, the use of technology and patterns of acceptance or rejection has been observed. All costs that are associated with the purchase and maintenance of the technology were covered by the project budget as part of the research project. In the case of maintenance and repair work, the corresponding effort was shared between employees of the project station and the research project (see Limitations).

1.4 Overview of implemented technology in the research project

During the research and implementation activities, seven technologies were implemented and researched at the project ward, the technologies can be found in Table 1.

2 Materials and methods

2.1 Study design

The study used a focused ethnographic, multi-methods investigation with a distinct qualitative emphasis. Focused ethnography is suitable for investigating social fields with high degrees of professionalism and functional differentiation by studying the entanglements and interactions between individual actors, institutional processes, settings and technologies (23). A main goal is to investigate social and cultural processes that are implicit or difficult to articulate for those being studied (24, 25). Compared to anthropological ethnography, the focused account is characterised by short field stays and an intense data collection phase (26). The following methods were applied:

TABLE 1 List of implemented and studies technologies.

Short description	Information on technical integration
Technology for fall and pressure ulcer prevention	
1. An automated mobilisation mattress system that repositions patients in the bed to prevent pressure ulcers. ■ Active Mobilisation System, Compliant Concept	The device runs autonomously from other technical systems, it requires a power connection. To document the use of the mattress, a checkbox was integrated into the patient documentation system. It collects usage data (frequency and duration of use) which, however, can only be retrieved by the manufacturer on site in the event of troubleshooting.
2. An automated fall prevention system that uses the nurses' call light to send an alarm in case of patient bed exits. ■ SafeSense Bed Exit System, Wissner Bosserhoff	The device connects to the nurse call system in the hospital ward via a cable connection. This is a closed system; the system merely registers a bed exit impulses. There is no automatic forwarding and documentation to other systems. It does not collect any data.
Technology for patients with challenging behaviour	
3. An audio-haptic sound pillow that plays atmospheric sounds and uses vibration to calm patients with dementia, agitation or restlessness. ■ inmuRELAX, inmutouch	The system is powered by a rechargeable battery. It operates autonomously, there is no connection to other technical systems. It does not collect any data.
4. A special projector/beamer designed for health care institutions to calm or activate patients with dementia, agitation and restlessness. ■ Qwiek.up, Qwiek	The system is powered via a socket. It operates autonomously, there is no connection to other technical systems. It collects usage data (frequency and duration of use) which, however, can only be retrieved by the manufacturer on site in the event of troubleshooting.
5. An interactive therapy ball that helps to activate patients or stimulate memories in patients with dementia. ■ ichó therapy system, icho systems	The system is powered by a rechargeable battery. It operates autonomously, there is no connection to other technical systems. It does not collect any data.
Technology for improvement of communication and organisation during nursing care	
6. A Patient-Nurse communication app to facilitate communication between nurses and patients and assists nurses in organising and prioritising work processes. ■ Cliniserve CARE, Cliniserve	The app is operated by the manufacturer via an external server in compliance with European data protection regulations. There is no connection to internal hospital IT systems. Accordingly, there is no automatic transfer of information for documentation purposes. Usage data is stored anonymously (without reference to the separate patient). Patients consent to the use of the app via the clinic's data protection regulations. To use the app, patients can access mobile data or a Wi-Fi connection for patients and nurses can access a Wi-Fi connection for staff.
7. A webpage-based tracking system to locate work-related equipment on the project ward. ■ Tracking System HYPROS TTI, HYPROS	The location information is sent via Bluetooth beacons to Wi-Fi hotspots. The location data is displayed and evaluated via a separate website. This website is password-protected and has no connections to internal hospital IT systems. There is no automatic transfer of information for documentation purposes.

1. **Participant observation** of nursing workflows to explore the use of implemented technologies and
2. **Questionnaire survey** to explore the nurses' perspective on the usability of the implemented products.

The steps of data collection, processing and analysis are described in the following sections, an overview of the research design can be found in Figure 1.

2.2 Methods 1: data collection

(a)   Participant observation

The observation aimed to follow professional nurses during their workday for several hours to explore work processes and interactions with patients and other nurses with the introduced technologies. The observation was carried out by the author RK and conducted as an "observer as participant", which means that the observer role tends to be passive, yet transparent to all participants in the field. The choice of non-functional, everyday clothing and a restrained accompaniment was intended to keep the observer passively in the background while enabling the investigation of a native perspective of the observed concerning specific "situations, activities and actions" (26).

One of the members of the research project (not the observer and no co-author) acted as a gatekeeper to gain access to the field, as he also worked as a nursing professional on the project ward. In the course of the observations, it was possible to establish personal relationships with other nursing staff who

allowed access to the ward to observe shifts. In terms of recruitment, all nurses were eligible to participate whom: (1) worked as professionally trained on the project ward, (2) were currently using a technology of interest, (3) would like to be accompanied and (4) gave written consent to be observed (see Ethical Considerations section).

At the beginning, fixed time points for the observations were set. However, this pattern needed to be adjusted, e.g., because some technology was not used for an extended period and then used intensively for a short period. These required spontaneous station visits outside the fixed observation pattern until sufficient information for each technology was gathers. Another way of achieving data saturation was to present and discuss the results with the nursing staff on the ward (see section Quality Assurance).

An observation guideline (see Table 2) with specific questions was designed to help the observer during the field stay (27). These questions were developed deductively from existing models on technology implementation (28), adoption (29, 30), technology acceptance (16) and intention (31)—the guideline is shown in Table 2. The instrument was developed based on multiple theoretical starting points to integrate different perspectives on technology use. The categories were later integrated into the UTUAT model, which can also be found in Table 2 (see also *2.4, Methods III*). The guiding questions were discussed by the research team and field tested before its initial use—no changes were needed afterwards.

During the field stays, handwritten notes containing summaries, situation descriptions, reflections and ideas were taken. After each observational unit, the observation questions
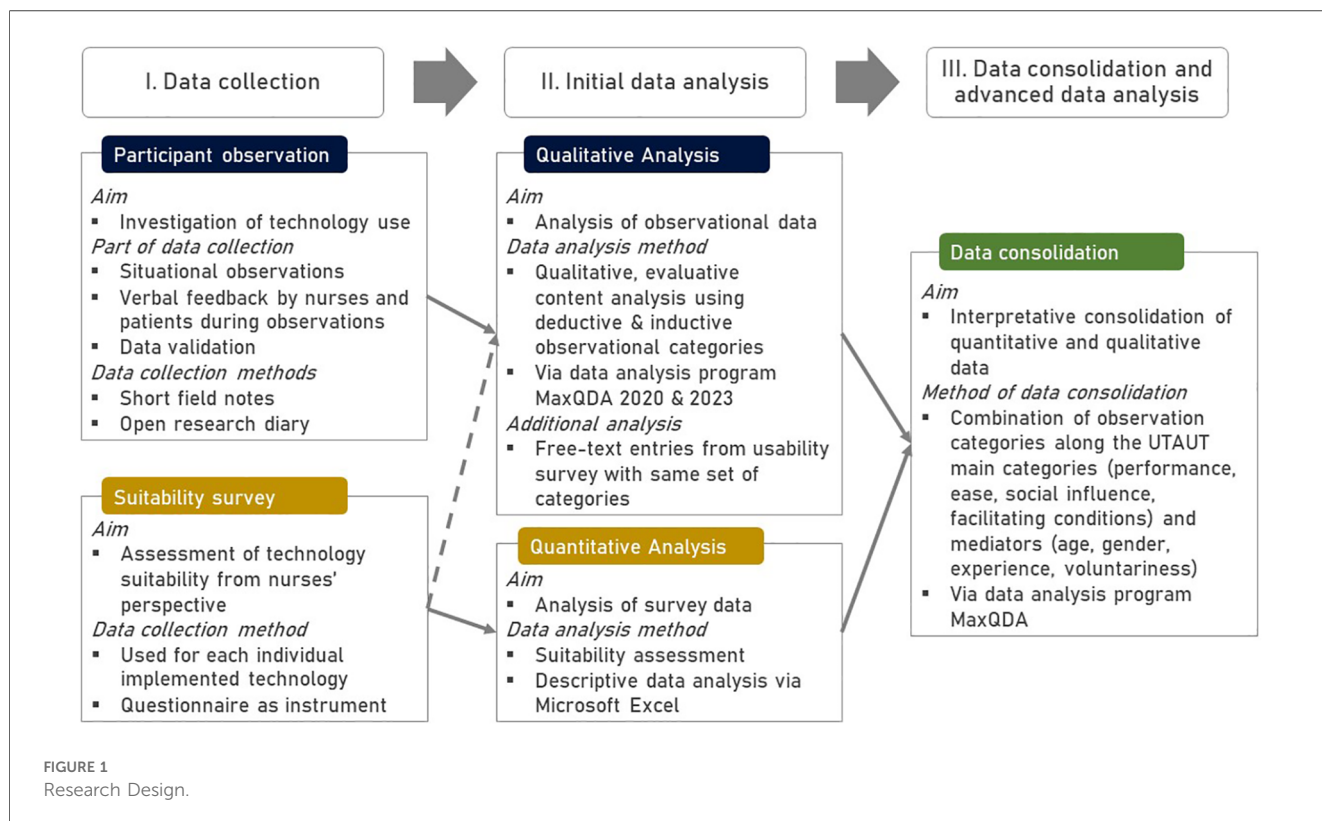

FIGURE 1
Research Design.

TABLE 2 Deductive categories and guiding questions for the observational units.

Deductive category	Guiding question	Transferred observational categories into UTAUT categories
Decision making	For which patients (health condition/disease) is the device used? What factors can be observed in the decision to use it (such as sociocultural, patient comorbidity, consent)?	(Observed) performance
Task	For which tasks is the device used? What unexpected uses can be observed?	
Information	What kind of information does the device provide to the nursing professionals and how do they deal with it? What processes are enabled by the new information?	
Effects on patients	Can changes in patient condition be observed over the course of using the device?	
Satisfaction	In which situations are forms satisfaction, acceptance, criticism or rejection observed towards the device by the nursing professionals and/or patients?	(Observed) effort
Workplace integration	How does the integration of the device take place in the everyday work of the nursing professionals?	
Team communication and team work	How do the nursing professionals talk about the device among themselves and with the patients? Can changes in the teamwork of the nursing staff be recognized using the device?	(Observed) social influence
Expectation towards and reaction from patients	What do nurses expect from patients when using the device? How do patients react to the use of the device?	
Social interaction and substitution	How and in what form does social interaction between nurses and patients take place when using the device? Is there a substitution of nursing activities by the device?	
Resources	How will decisions be made if there are more patients than devices?	(Observed) facilitating conditions
Access to training and technology competence	In which situations do nursing professionals feel confident or insecure when using the device? Are the training formats during implementation (manufacturer training, additional material by the research team) sufficient to use the device?	
Technology characteristics	How can the characteristics of the device in use be described? What is the quality of the product?	

listed in Table 2 were used to structure the writing of open-ended, chronological fieldwork diary entries that reflect observed situations in detail, reproducing dialogues, and characterising people, technologies and situations (32).

(b) Questionnaire-based survey on technology suitability

A technology suitability questionnaire was used to investigate the range of opinions of the nursing professionals. This instrument was used additionally to the observations, because the observation could only incorporate the views of individual employees (who were working at the times observed), rather than obtain the diversity of opinions on a technical product. Therefore, a questionnaire was used that *descriptively* included the respondents' views on the suitability of the technology for use. Since no meaningful case numbers can be obtained on the project ward, the use of the questionnaire can only be classified as a supplement and contextualization of the qualitative results from the observation. This instrument was developed and used in another research projects (22, 33). The questionnaire was provided to all nurses on the project ward for each implemented product. It contained four sections:

1. Three items on the general use of the product since its introduction (use yes/no, frequency of use and, reasons for not using the technology).
2. *General* questions covering usability, workflow, compatibility, functionality, product quality and patient well-being.
3. Questions *specific* to the technology covering power supply, alarms, screens, mobility, consumables, and reprocessing.
4. Further comments on the device to be entered in free text entries.

In the general and specific sections, the questions were answered using a five-point Likert scale from 'Strongly agree' to "Do not agree at all"—or "not applicable".

This is a measurement instrument for technology suitability and not an instrument from the field of technology acceptance/ UTAUT research. Therefore, the findings of the suitability survey are classified under the UTAUT category of (observed) effort.

All nurses received the questionnaire for each of the implemented technologies three months after the first deployment of the given technology, either in workshops or in their mailboxes on the ward. In the case of using the individual post box, they were notified at the time of distribution and with a reminder by E-Mail. Due to the long implementation phase in the study, the number of employees on the project ward varied significantly, but on average 22 full-time staff are employed on the ward. However, this number varies, mainly due to staff shortages. As the study design was set up in such a way that only one ward was equipped with technology, the questionnaire could only be used in one setting and comparisons with other wards/settings were not planned in the study design (see also Limitations).

2.3 Methods II: initial data analysis

(a) Qualitative data analysis—evaluative qualitative content analysis

The entries from the open field research diaries and the free text entries from the technology suitability survey were analysed using evaluative qualitative content analysis (34). While applying this method, each deductive main code received a set of at least three sub codes for (1) a positive manifestation, (2) a negative

manifestation and (3) a neutral or non-evaluative category (35). For example, the main code of "work integration" received the sub codes (1) "smooth integrated", (2) "problems with integration" or (3) "other"—in this care, a forth sub code for ambivalent observations were also used.

The guiding questions in Table 2 were used to develop the main codes deductively. Only one inductive main code was added for "Expectations of new technologies". Through this approach, a code system of main codes and sub codes (see Supplementary Data Sheet) were developed that helped to organise the data material and to perform a pre-analysis.

(b) Quantitative data analysis

In the questionnaire-based survey on technology suitability, the answers to the second and third areas (general and specific aspects of the technology) were analysed quantitatively (33). For this purpose, the scores achieved by the technology in each area were first expressed as a percentage of the maximum possible score. These two percentage results were then weighted according to the number of items in each area, and an average, general value were given. If a technology achieved up to 49%, it is considered *unsuitable*; if it achieved 50%–69%, it is rated as *suitable to a limited extent*; and if it achieved 70% or more, the technology is rated as *very suitable.*

2.4 Methods III: data consolidation

Quantitative results were compared with the qualitative analysis of the observation data and the free-text entries of the appropriate questionnaires. The data collection and analysis was performed parallel rather than sequentially. We merged and compared the data to identify consistencies, inconsistencies or complementarities (36). The basis for data consolidation and analysis was the UTAUT model, initially presented by Venkatesh in 2003 (16). Four main categories are presented in this model:

- ■ "**Performance expectancy** is defined as the degree to which an individual believes that using the system will help him or her to attain gains in job performance." (ibid.)
- ■ "**Effort expectancy** is defined as the degree of ease associated with the use of the system." (ibid.)
- ■ "**Social influence** is defined as the degree to which an individual perceives that important others believe he or she should use the new system." (ibid.)
- ■ "**Facilitating conditions** are defined as the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system." (ibid.)

The use of the UTAUT model in our study served two purposes. (1) To arrange and summarise the results along these categories for transparent reporting. (2) To use a mix of qualitative and quantitative findings to explore how much influence each category had on technology use, acceptance, rejection, and adaptation. Therefore, the observation categories from Table 2 were assigned to one of the four main categories, which can be found in the same table. The survey results were assigned to

effort expectance based on the construct "Suitability". In our study, the UTAUT model was used to evaluate observed user behaviour (therefore "Observed Performance" etc.), not used to predict user intention or behaviour. The four mediators' gender, age, experience, and voluntariness of use (ibid.) will be addressed in the results section if relevant to the reporting.

2.5 Ethical considerations

The research project was approved by the Ethics Committee of the Hannover Medical School on the 6th of July, 2018, ID: 7933_Bo_K_2018 (amended 16th of July, 2020). The procedure was reviewed by the hospital's staff council and the clinic data protection officer. The data protection-compliant processing of research results (above all with the aim of protecting study participants) was carried out in accordance with the guidelines of the University Hospital, above all with the help of lockable rooms in the case of hard copies and password-protected drives in the case of digital data. Raw data was only shared with research project participants, and patient care leaders were merely given access to analysed, non-personal, summarized data as required, making re-identification implausible.

(a) Participant observation

The scheme for situationally appropriate privacy expectations was used to identify which individuals in the field should be asked for written consent to observation (37). Written informed consent was obtained from professional nurses observed during their shifts. Before giving their consent, nurses received an introduction to the study's goals and reasons. If possible, participants in the field were informed of the observer's presence, especially to patients when first entering the patient's room (38).

(b) Questionnaire-based survey on technology suitability

Nursing professionals who completed the questionnaire also filled out a written consent form. Sociodemographic data (such as years of professional experience or age) were not collected due to the small size of nursing staff to avoid re-identification.

2.6 Quality assurance

For the reporting on methical decisions and processes in this paper, the COREQ-Checklist was used (39)—all relevant information are provided in the dedicated section of the paper or in Supplementary Image S1.

(a) Participant observation

(1) Key observational findings on the impact of technology implementation were presented, discussed and again documented in dedicated validation workshops as a form of "respondent validation" (40). (2) The research team reviewed and discussed result plausibility and implications at periodic meetings internally and in external research workshops. (3) Parts of the results have already been presented regarding individual technologies and selective research questions at conferences (41, 42). (4) The

observed nurses were offered to read the diary entries after completing them; however, no participant used this offer. Coding and consolidation of the data material was performed independently by two authors (RK & DK) and then compared. Intercoder reliability was not numerically calculated.

(b) Questionnaire-based survey on technology suitability

Two independent data entries were made to ensure no errors occurred during the transfer. The main results of this survey were presented in the validation workshops to the nurses mentioned above. All results from the questionnaire survey were presented, interpreted and discussed within the interdisciplinary team of the research project.

3 Results

3.1 Participant observation

Observations began in July 2020. New technology has been explored in 23 observation units, representing 38.5 h of observation time. The author RK conducted all observations. The average time of an observation unit is two hours. These observations resulted in 132 pages of field research diary entries. Member validation workshops were protocolled. The results of these data collections are summarised in this chapter. In the course of the participant observations, fifteen nurses could be accompanied on their shift. All but one of the nurses responded positively to be observed—the person who did not wish to participate has been omitted from all observational descriptions.

Table 3 provides an overview of the observations' results on the implemented technologies reported by UTAUT's main categories. The boxes in the table are marked with colours and indicate whether the observation results for the corresponding UTAUT category are characterised as favourable for the use of the technology (green box), adverse and unfavourable (red box), or both positive and negative and thus ambivalent (yellow box). Categories with no effect are left blank.

3.1.1 (Observed) performance

The mobilisation mattress and the special projector provide a positively perceived performance from the point of view of nurses and patients. The mobilising mattress is frequently used on the project ward. The individual risk assessment for the development of pressure ulcers is not the sole deciding factor for whom, when and how the system is used:

While we walk to the next patient room, the nurse says that the mattress: "almost does not matter during the day". She explains that many patients lying in the systems require intensive care anyway, such as patients with incontinence pads that need to be changed regularly. For these patients the mattress is advantageous at night because using the system helps position patients less frequently, and one needs to wake them up less often. [...] Patients who suffer from much pain are an exception: People who have suffered trauma will experience

less pain due to the system's movement. (Field Research Diary_Mobilization mattress-BE04, p. 2)

Other nurses run the system on all patients and use the system's pause function instead to perform interventions. The special projector is primarily used in patients with dementia or agitated behaviour in two different ways: One is to calm nervous patients and address challenging behaviour. The other way is by reactivating apathetic patients, in whom the use of the projector activates memories. According to the nurses, both ways can help improve care of these patients, making care delivery easier. The decision-making is biography-based or stems from getting to know the patients' behaviour. The special projector and the mobilisation mattress are often used together.

Technologies that have shown **mixed and thus ambivalent performance** in the ward are observed for the sound pillow, the fall prevention system and the communication app. The sound pillow functions according to its intended purpose, as the following situation description shows:

A mask for inhalation is placed on the patient's face—the sound pillow lies on his chest. The nurse seems surprised and says this was not easy in the last few days because the patient kept pulling the mask off his face. The patient now seems sleepy—about 2 min pass. The patient gets quieter and finally almost falls asleep. The patient seems so calm that the nurse wants to leave him alone to return in 15 min. (Field Research Diary_inmu-BE01, p. 28)

Most patients lose interest in the technology after a few days due to its repetitive sound. Therefore, an actual benefit is limited to a time range that is shorter than the patient's hospital stay. For the communication app, situations are observed where patients send their requirements, nurses read them and can react according to the current workflow, for instance to take medication with them to the room. However, the app is rarely used since some nurses question whether the app makes a difference in everyday work. For the fall prevention system, it is observed that nurses respond immediately to a bed exit. However, the perceived performance of the system is low as users report frequent false alarms or missing alarms, resulting in low system confidence.

The nurse reports that the system was running overnight but did not activate even when the patient already stood in the room. (Field research diary_SaSe-BE01, pos. 9)

The perceived performance of the system for equipment tracking is low. The system proves to have no technical problems in practical tests, so non-use initiates from a lack of practical relevance for the users. Communication and teamwork among nursing colleagues to find equipment is easier to realise according to nurses.

The interactive therapy ball is rated as **neutral** regarding its perceived performance because users cannot operate the technology as intended (this will be explained in detail below).

TABLE 3 Results of ethnographic observations analysed by UTAUT-categories.

UTAUT categories	(Observed) performance	(Observed) effort	(Observed) social influence	(Observed) facilitating conditions
	Note: The colour coding in the fields indicates whether the corresponding factor bundle is predominantly positive (green), negative (red) ambivalent (yellow) or has no influence on technology acceptance (not filled).			
Mobilisation mattress	Decision for using based on risk assessment and professional intuition and depends on: Diagnosis, especially postoperative patients with pain during positioning Time of the day (only in the night or 24 h) General patient condition (few proper motion, high risk for pressure ulcer) Perceived overall reduction of pressure ulcer frequency from nurses perspective	Reliable system, performs work "*in background*" that relieved time resources for other tasks Perceived reduction of back pain for nurses Became part of routine practice in course of research project	Collaboration with colleagues during decision making, actual use is done in individual work routine Patients usually get informed by nurses on function of the mattress Patients report better sleep, few patients report form of "motion sickness", most get used to the sensation. Nurses perceive improvement of relationship to patients due to better sleep Substitution or reduction of social interaction not observed	High demand by nurses led to an increase in stock to sufficient number of systems Upper body elevation up to 50 degree is optimal (former 30 degree version also tested; led to additional problems) No lack of competences to use system observed, calibration is perceived to be simple
Fall prevention system	Use in patients prone to falls due to individual medical condition (e. G. dementia) Mixed reports on whether technology actually reduces falls Nurses report false alarms and see technology as unreliable Use even when it is unreliable	Dissatisfaction based on time-consuming installation, false alarms and frequent defects that require external repair	Preparation of the use of the systems (installation in the patient bed) in teams, especially in the night shift Team work performed while users take care of small repairs of malfunctioning systems in teams No change in social interaction between nursing professional and patients due to technology observed	Resource scarcity depends on dysfunctional systems Nurses report false alarms or not activating alarms in case of real bed-exit attempt Insecurity about correct installation and use of the system even after manufacturer trainings
Audio-haptic sound pillow	Mainly used for patients with agitation, challenging behavior and pain Positive response from patients (calming, activity/interaction with the technology) Patients lose interest after few days based on monotony of the melody and deactivation of the technology after inactivity Use during night times limited to patients in single bed room	Used to increase patient adherence to nursing intervention Used as an additional means of calming patients down Nurses have to reactivate pillow due to automatic stand-by Technology allows nurses to leave patients unattended for short periods of time	No relevant team work or communication observed Nurses try to present device in an interesting way for patients If patients will not respond to verbal presentation, they present it non-verbally Some patients are not interested, others are highly interested	No resource problem observed The cover can be disinfected with wipe disinfection Every new employee receives a short introduction into the technology, no competence related problems observed
Special projector	Patient-dependent decision-making process made by nurses (who, where, when, which module?) Positive response from patients Used in patients with agitation, challenging behavior Outcome depends on desired goal: Calming modules at night when patients need to rest Activating methods during the day with agitated patients	Ease of nursing care, especially for time and effort to be spent on patients with challenging behaviors Nurses are satisfied with use and the outcomes Nurses perceive (de-) installation and use as easy, technology became part of routine practice	No relevant team work or communication observed Nurses perceive technology to have a positive effect on nurse-patient relationship Some patients' reaction is negative on particular modules, nurses have to respond to patient reaction and chose suiting module Fellow patients could perceive technology (sound, light) as annoying	No resource problem observed Technology offers a variety of modules with different visualizations, sounds and operating modes Every new employee receives a short introduction into the technology, no competence related problems observed
Interactive therapy ball	Primary use for patients with mild states of confusion or dementia, but who are still oriented Supposed to lead to an improvement in the general mental state of patients; however, the technology has been used too rarely in practice, so that no observations could be made on effects	Nurses see positive and easing benefits of the technology, but cannot use it in everyday practice (familiarization and use is too time-consuming). No sustained use was observed, tested on few occasions, especially in educational situations	Few uses are observed in training situations, trainees have more time to interact with patients Potential for positive influence on nurse-patient relationship is suspected by nurses, but work conditions prevent regular use	Time is a limiting factor Functional spectrum is complex and menu navigation needs time for using Nurses workload is too high for using the technology Operation via remote control, nurses wish for voice control
Patient-Nurse communication app	Use depends on nurses' assessment of whether patients can operate an app Used to remind nurses about upcoming tasks, events or to prioritize patient requests Use of the technology can reduce redundant path and/or reduce noise from acoustic nurses call sign However, nurses doubt performance for work after few weeks of use Empirically app is mostly used for nursing care (not service) related requests	Nurses are concerned about what app suggests to patients about nature of nursing care (*nursing care as a service instead of a health care profession*) Some nurses refuse to work with additional (smart) phone Doubt that redundant path reduction has a relevant ease in daily walking distance Nurses criticise that nursing care is more than the reaction to articulated patient wishes but an interaction that allows to grasp patients' needs	Successful use of app requires continued use of app between shifts, which is rarely observed Ambivalent reaction by patients that used app: most find it helpful and easy to use, some do not see the benefit for patients (but recognise benefits for nurses) Faster and more transparent communication between nurses and patients was observed Nurses expect patients to use app primarily for nursing (not service) related requests	A smartphone for each section of the ward is provided for using the tec. The patients have to use their own smartphone, download app and register via specific code High technology competence required for patients and nurses, merely fraction of patients on ward are suitable
Tracking system	[Contrary to initial nurses intention to use the technology, tracking turned out to be not helpful] Nurses report that when they are searching for a product, they ask colleagues or have seen it during their daily activities No effects on patients observed	Low satisfaction due to lack of relevance No integration into routine practice (although full technical implementation), because no practical relevance for work Nurses suggest that technology would be helpful if it could be applied to the entire clinic	Communication with other colleagues about where (technological) products are makes the technology useless No effects were observed regarding the social interaction and substitution with patients	Wi-Fi and tablet to use system was installed and is functioning, no technical issues are observed The system could find products which are provided with a Bluetooth-tracker

3.1.2 (Observed) effort

Nurses perceive the mobilising mattress and the special projector as easy to use. Both systems are perceived to be reliable and supportive of work processes, saving effort on time-consuming tasks and helping cope with work process-related requirements. They are perceived as being easy to install and are considered part of daily work routines. The devices do not need to be operated constantly but can be used partly autonomously (in the background), as the following entry illustrates:

> *While documenting, the nurse said, "On days like today, the system is worth its weight in gold." I asked what she meant by that. She explained that with the system, she could sit at the PC for as long to document. Repositioning the patient to prevent pressure ulcers would require her to interrupt her current activity regularly. I asked her if she was confident the system was doing a good job in the background. She confirmed this and said that it was a great relief. (Field Research Diary_Mobilization mattress-BE04, p. 3)*

The nurses repeatedly emphasise that using the mattress and the projector does not mean patients are left alone for long periods and interactions between nurses and patients are not reduced. Instead, it changes the nature of the interaction by removing specific tasks perceived as unpleasant, such as positioning patients.

Positive effects and ease of use are identified with the sound pillow and the interactive therapy ball, but to a limited extent. Nurses evaluate that the sound pillow has a calming effect on patients. This calming effect, in turn, directly influences patient adherence to specific therapeutic measures and makes it easier for patients to cope with difficult emotions or pain. However, many patients lose interest in the technology after a few days of use. A patient can use the pillow without the constant supervision of a caregiver. For the therapy ball—that in contrast needs the permanent presence of a caregiver –, no sustainable use can be observed. Nurses and trainees use this device in a few instances and have positive experiences, but could not use it in everyday practice due to a lack of time. Therefore the technology's easing effect could not be realised under the given work organisation.

In the case of the communication app, the tracking and fall prevention systems, findings suggest that the devices require additional effort for **little to no benefit**. Nurses do not see any practical benefit for the tracking system. However, an expansion within the entire hospital could be beneficial. For the communication app, some nurses find the additional smartphone impractical in everyday practice, because they are not always within reach or their pocket are already packed with other items. While the fall prevention system is used in practice, nurses mention frequent technical problems, most of the users see the product as having little overall benefit:

> *The nurse currently has a patient lying in the fall prevention system. This patient has not tried to get up recently, but the system has been alarming at regular intervals. This makes the system unusable; she adds "You make an effort to set it up, and then it does not even work". (Sound pillow_Fragment 01)*

3.1.3 (Observed) social influence

Four of the introduced technologies **positively influenced the interaction** between nurses and patients. The three technologies for patients with challenging behaviour performed similarly in this area. Teamwork is performed merely when a nurse seeks advice from colleagues on selecting suitable patients. After that, the nurses work with the technology without further cooperation. The technologies have a positive impact on nurse-patient interactions, as the following two research notes demonstrate:

> *For the special projector, the nurse likes the forest-walk module. She had a patient with dementia who used this module and, while watching, tried to find out where the shots might have been taken. (Special projector_Fragment_01, pos. 13)*

> *The nurse had a night shift, and a patient could not find rest and walked around the room for several hours. She gave him the sound pillow. After that, the patient slept soundly for hours. (Field Research Diary_Communication app _BE02, Pos. 5)*

Nurses also emphasise a module that displays a night sky with shining stars that is selected for patients to fall asleep at night. Nurses say that the calming and activating use of the sound pillow and special projector enable easier interaction with these patients and fewer challenging situations and conflicts. While using the mobilizing mattress, patients find better sleep than those who have to be woken several times during the night for positioning. Nurses describe that sleep improvement also improves relationships with patients.

An **ambivalent influence** of technologies on the social interaction of users is found in the fall prevention system and communication app. The fall prevention system does not directly affect the relationship between nurses and patients. Although patients are repeatedly surprised that nurses quickly enter the room when they try to stand up. Repeated technical problems, malfunctioning components, or the system installation lead to negatively perceived collaboration between nurses. The mediator category *voluntariness of use* explains why the product is frequently used on the project station. It seems plausible that the nursing supervisor requires the system to be used for liability. This factor is part of why the device is frequently used, but the overall satisfaction is low. While the Patient-nurse communication app is used, some patients particularly emphasising the benefit of additional information, such as how long they must wait for a response. The following conversation is observed between a nurse and a patient:

> *A feature of the app that both consider useful is task prioritisation. Both talked about how it can make sense if you know that a request such as "close the window" occurs in one*

room and "severe pain" in another. Both agree that it is good to process first the pain and then the window request. (Field Research Diary_Communication app_BE01, Pos. 21)

For other patients, the app has no advantage because the waiting time does not change. In addition, nurses are cautious in selecting the appropriate patient to use the app. They are concerned about low-skilled patients who send requests by accident. Others fear that the app suggests professional nursing to the patients as a (hotel) service.

None of the technologies introduced have an **overall negative impact** on the users' social relationships. Regarding the tracking system, nurses find no support for the technology because communication between colleagues is more effective. Therefore, the social factor is still a robust explanatory category for non-use of technology.

3.1.4 (Observed) facilitating conditions

For the special projector, the sound pillow and the mobilisation mattress, **sufficient resources** for using the technologies—like technical infrastructure—are provided. Therefore, no conflicts about too few devices are found for these technologies. All nurses receive detailed training for these devices. The mobilising mattress had a problematic feature at the beginning that deactivated the system if the patient raised the head of the bed by more than 30 degrees. This often leads to unintended deactivation by patients. After consultation with the manufacturer, the limit was elevated to 50 degrees. Since this update, nurses reporte fewer problems. The sound pillow and the special projector are easy to integrate into existing facilities. All three systems can be cleaned with the regular disinfectant on the ward and no severe technical malfunctions are reported.

For the tracking system and the communication app, the findings indicate that facilitating conditions have **both positive and negative influences on** the use of technology. Although nurses receive training on how the technologies work, in practice, there are regular uncertainties about use. The tracking system and the communication app run mostly without technical problems. The wi-fi coverage on the station is sufficient to provide both services most of the time. In a few instances, there have been examples of the tracking system showing the wrong location of the tracked equipment:

The nurse says there was an incorrect location in the system for an electronic rail. He says that it was indicated in a different room than it was. […].The access points are installed too close to each other […].' (Field Research Diary_Communication app_BE02, item 31)

Nurses suspects that messages from the communication app sometimes do not get through in real-time. For patients, there are currently no input devices for the app on the ward so patients must bring their smartphones to use the app. Nurses must explain the downloading and functioning to patients if they require assistance. The nurses receive this point critically since they have no time to train patients. For this reason, nurses select

patients in particular by anticipating their technical abilities and patients must be motivated to use the app.

The technical and organisational conditions are **limiting factors** for the therapy ball and the fall prevention system:

"I have no time for [the therapy ball]. An everyday companion would have time." "I dealt with it once and then I knew how it worked, but now I have already forgotten about it." (Protocol of member validation meeting, June 2023)

Hence, the device's menu navigation is seen as complicated. The nurses would like to use the therapy ball and would enjoy working with it but do not see the time for this. The fall prevention system exhibits system errors and false or outstanding alarms that hinder its use. Caregivers repeatedly report that the device's correct installation and operation is complicated, resulting in uncertainties.

3.2 Technology suitability from nurses' perspective

The survey on technology suitability could be conducted on all technologies. The results can be found in Table 4.

The number of participants varies because the average number of nurses working on the project ward varied during the research project and not all nurses participated in the survey. Similarly, not every technology was used by all employees; in particular, temporary workers often stated that they had not used the technology due to short training periods on the ward. Other people also stated informally that they did not have time to complete the questionnaires during daily work. For these reasons, the number of participants in the surveys varied from five to twelve employees (as described above, an average of twenty-two people work on the ward at full-time employment).

The comparison between the observational results and the standardised survey shows a coherent picture. The technologies are described as easing and beneficial (mobilisation mattress and special projector) are also evaluated positively. In contrast, the ambivalent (sound pillow and therapy ball) and unfavourable technologies (fall prevention system, communication app, and tracking) receive mixed evaluations. The frequency of use is also consistent to qualitative results; The technology that stood out in the observations as accepted and used received a higher frequency in the survey, like for the mobilization mattress (used daily or multiple times a week).

3.3 Summary of results

A summary of results can be found in Table 5. The results are consistent with the observational data and the survey on technology suitability.

TABLE 4 Results of the suitability survey by nurses that used implemented technology.

Technology	No. of participants	No. of participants that used the technology*	Frequency of use				Reasons for not using the technology**	General suitability***		
			Daily	Weekly	Monthly	Less often		Low	Medium	High
Mobilisation mattress	12	12	1	4	5	1	[None]	1	2	9
Fall prevention system	10	8	1	4	2	1	No opportunity (1) Does not help me with my work (1) Workflow is faster without (1) The handling was not clear to me (2)	3	2	3
Audio-haptic sound pillow	9	7	0	2	7	0	No opportunity (2)	0	0	9
Special projector	5	5	n. a.	n. a.	0	0	5			
Interactive therapy ball	6	4	0	0	1	3	Workflow is faster without (1) Setup/handling not practical (1) Unaware of the technology (1)	0	3	1
Patient-Nurse communication app	9	3	0	1	1	1	No opportunity (3) Does not help me with my work (3) Workflow is faster without (1)	0	1	2
Tracking system	6	3	0	0	0	2	Does not help me with my work (3) Workflow is faster without (1) The handling was not clear to me (1)	1	1	1
Free text entries										
Mobilisation mattress	One person noticing that battery operation would be more practical, especially when patients move within the clinic. Another person reports that it is easy to forget the reactivation of the mattress after pausing it during meals. Five people comment that the automatic deactivation of the system is impractical.									
Fall prevention system	One person rates the device positively, and one mentioned "constant false alarms". Another notices that it is impractical when the system can only be turned on and off directly at the bed and that it is difficult to see whether the system is activated.									
Patient-Nurse communication app	One participant notes that he or she does not want to use the app. Another person says that he or she likes the app but had no opportunity to use it.									

*The difference between this number and the number of participants represents the number of people who filled in the questionnaire but have not (yet) used the product.
**Number (in brackets) indicates the number of participants who have selected the corresponding item.
***Numbers indicate the calculated item of general suitability per technology (e. G. a 9 for "high" indicates that nine participants rate the general usability of the technology as high). For example, technology can achieve 56 points in the general area, but it is assessed with 30 points or 53%. In the specific area, 32 points can be achieved, and 30 points are awarded, giving a score of 93%. When weighted, these sub-scores give a technology suitability of 68%.
n. a. Due to an error in the preparation of the questionnaire, no feedback on frequency of use could be collected for the special projector, which is why the data is missing from the table.

4 Discussion

4.1 How accepted and not used technology can (not so easily) be distinguished

The observation results of the study were summarised along the four main UTAUT categories and the positive, negative or ambivalent influence on technology acceptance per category per product was identified. These results can be compared with the technology suitability survey, which provides information on the assessment of nurses and the frequency of use. But how to answer which technology was used, which was not and how to distinguish the influencing factors as enabling or hindering factors?

The conclusion of whether a technology was accepted or rejected cannot be based solely on the positive, negative or ambivalent results of individual UTAUT categories, because this would confuse the phenomena to be explained (explanandum) with what it is explained by (explanans) (43). Until the outcome of the implementation process is uncertain, classifying the influential factors from the UTAUT categories in the implementation process is unattainable. At this point, frequency of use could be utilised as a proxy for general product acceptance but little data could be collected on this. In addition, a technology may be highly accepted even though it does not need to be used regularly.

To solve this problem, we use ethnographic sensibility. This term refers to a feeling or impression towards the *ethnographic*, i.e., the lived and experienced reality in the research field, about

its "complexity, contradictions, possibilities, and grounds [for the observed] cultural group" [(44), see also (45)]. This sensitivity was gained by the observer over years of field research activity and enables knowledge about the users' general attitude towards the technologies, which was needed to situate the results eventually.

The above presented summary of four result categories leads to the follow consequences:

(1) A predominantly positive influence of the technology in terms of the UTAUT categories (see Table 3, green fields) strongly indicates that the technology is used and accepted.

(2) Use and acceptance cannot be equated. The fall prevention technology—acceptance low, but regularly used—and the interactive therapy ball—high acceptance, but not used—shows that these outcomes do not have to exist simultaneously.

(3) The occurrence of more than one origin of negative and ambivalent influence of the technology (see Table 3, red and yellow fields) strongly indicates that the technology is not accepted or used regularly.

(4) The main categories of the UTAUT model can be a strong indicator for explaining technology acceptance. However, they should be distinct from explanatory factors because factors like perceived usefulness or ease of use occur within broader socio-technical constellations and contexts of actualised technology use (46). Explanatory power unfolds with an understanding of the use context. This context was approached in our study by using ethnographic sensitivity.

To conclude the four consequences, it takes more than adding variables to predict user acceptance towards technologies. Instead, acceptance emerges as the result of complex socio-technical arrangements in which users must convince themselves of the benefit of technology for their actions by constantly trying, failing and succeeding.

4.2 Intention to use technology must be stabilized by experimenting

Some expectations users set regarding a technology's usefulness were not met after implementation. The intention to use technology indicates a necessary *curiosity* that motivated the start of technology use. However, this is *no guarantee* that a sustainable technology acceptance will occur. Users take cautious first steps in using novel technologies when familiarity with and skill to use technology still needs to be established. In this initial, critical experimentation phase, users renegotiated attitudes toward the technologies through positive or negative experiences.

On the one hand, unanticipated adverse effects—such as frequent false alarms—could change a high expectation into scepticism or reservation (5). On the other hand, surprising or hoped-for effects that turn out to be true could result in positive attitudes among users. This was frequently observed, for instance, when nurses asked whether they could be supplied with more system mattress, sound pillows or special projectors to cover demands.

Different users face the introduction of technologies with different skills and prior experience and with varying degrees of optimism or scepticism. Age and experience as mediator variables in the UTAUT model provided a valuable orientation for our analysis. However, introducing a helpful technology can transform existing work conditions, changing how a work field and a social reality functions (47). While the different preconditions among users may provide clues to different levels of acceptance and rejection, a helpful technology can *change* these preconditions among users [for the case of generalised distrust among nurses towards technology, see (48)]. Thus, it is more plausible to assume that a rejected technology does not bring any actual benefit instead of assuming a primordial attitude of rejection among users who would not give valuable technologies a chance (and vice versa).

4.3 Acceptance may not be sufficient

Our results show that four technologies—the mobilising mattress, the special projector, the sound pillow and the fall prevention system—offer a way to mitigate the high demands of a professional nursing work environment that is increasingly characterised by staff shortages and a growing number of multi-morbid patients. The other three technologies—the tracking system, the communication app and the therapy call—could not meet these demands. From an

TABLE 5 Summary of results according to use and acceptance.

	Technology accepted	Technology not accepted
Technology used	The *Mobilizing mattress*, the *Special projector* and *the Sound pillow* are accepted and regularly used. The technologies are positively classified in terms of usability and either scored positively in all four UTAUT categories or, in the case of the sound pillow, in two of the four outcome categories. Thus, the social environment and the facilitating conditions influence all three products' acceptance. The products received predominantly positive feedback regarding perceived performance and ease of use, with limitations for the sound pillow that was accompanied by conflicts.	The *Fall prevention system* is used regularly on the ward. However, its acceptance is low, and nurses view the system negatively. In their experience, it regularly indicates false alarms, does not register attempts of bed-exit and is complicated to set up. Nevertheless, the fact that the system is used can be explained by the mediator variable "Voluntariness of Use". Several nurses noted that they would stop using the technology as soon as a better alternative is available.
Technology not used	The *Interactive therapy ball* is not used on the ward, because workload and lack of time makes it hard to use. However, the nursing professionals' general attitude towards the technology is high. The nurses would like to use the technology in their everyday work, and they would also see a benefit but cannot actualise it.	The *Patient-Nurse communication app* and the *Tracking system* are neither regularly used on the ward nor do nurses see benefits from these technologies. Although expectations were initially high for both products to have a meaningful impact on the ward—and in technical terms, the systems function well—the nurses were unable to identify any meaningful forms of use for the technologies, even after several months of implementation.

acceptance perspective, this can be understood as fulfilled or unfulfilled device performance expectations.

Alternatively, these results can also be explained by the fact that the successful technologies can be operated in a background mode. A "background relation" between a technology and a user can be explained by a device that the user does not continuously operate —i.e., it works in the background—but nonetheless shapes the environment and the user's experience (49). A background technology does its work without the need for permanent operation. Solely in case of a malfunction, users are reminded about its importance and have to act in an effort to repair it—an example would be an air conditioning system. It is opposed to a technology that requires the user's constant input.

The features of the mobilising mattress, the fall prevention system, the special projector and sound pillow can be utilised without constant manipulation and nurses' presence, which makes them handy on stressful workdays. The communication app, the tracking system and the interactive therapy ball cannot be used similarly. For the therapy ball, for instance, nurses emphasised that the permanent input needed for the system's operation is the reason they were not using the system after all.

However, when viewed from the perspective of patients, the background characteristic is problematic. After all, this implies that patients receive parts of care by technology. For instance, in the case of the mobilising mattress, re-positioning a patient to prevent pressure ulcers is not executed by a human but by the technical system, changing the caregivers' task from an active part of *doing the reposition* to the *passive part or controlling* the technologies output. At the same time, nursing action as interaction work consists of more components than executing a nursing care action (50). As such, it also consists of emotional and sentimental labour, in which the nurse can recognise the patient's needs through interaction and communication with them and then react based on these encounter (ibid.).

The mere adoption of tasks by technology is no evidence of less social interaction between professionals and patients—also we did not collect data on contact times. However, technology that is successful *because* it is usable in the background may eventually reduce opportunities for interaction. The evidence of successfully implemented technology that supports nurses in managing their increasingly demanding workday under staff shortages might indicate that technology is accepted because it enables them to continue working under problematic conditions. Implementing technology may therefore reinforces problematic developments (more missing human resources) rather than questioning it. For this reason, looking purely at acceptance as a measure of successful use of technology in care may fall short. Instead, the potential change in the levels of interaction and resonance between nurses and patients caused by technology use would be a possible outcome for qualifying technology acceptance (51).

4.4 Limitations

(1) Effects were primarily perceived by the observers and the perspective of the observed is only described from "outside" No interviews were conducted—at the time of reporting—to involve the individual perspectives. However, at least in their validity, results could be discussed and confirmed with nursing professionals.

(2) The results from the questionnaire are subject to substantial limitations since participation varies to a high degree.

(3) The study's argument is based on the assumption that, due to a participatory introduction process, only those technologies found their way onto the ward that the nurses also desired. However, it was impossible to verify whether this assumption could be applied to all nurses.

(4) The narrow patient population on the project ward influenced the selection and the use of the technologies. In the example of the communication app, little benefit for the nurses could be seen because too few patients had the skills to use an app. In this respect, the (qualitative) transferability of the results to other clinical settings is limited.

(5) Patients' perspective is marginally represented in this paper because patients in the case of the project station are mostly passive technology users or beneficiaries and have no direct experience with the devices or cannot verbalise this, for example, due to dementia.

(6) All costs associated with the acquisition, operation, malfunction and repair of the technologies were covered by project funds. Therefore, the transfer of interpretations to other health care settings is restricted, particularly in terms of (sufficient) resources. In other health care institutions, for instance, budget restrictions could trigger negative usage effects. The German healthcare system continues to lack sustainable, cross-setting and comprehensive solutions for financing innovative technologies. The same applies to the *amount of work* required for maintenance, servicing and in the event of malfunctions and repairs. In non-research settings, this must be carried out by employees and can have additional, negative consequences for the use of innovative technologies.

(7) The decision to equip one ward with technology in the course of the implementation activities was designed to achieve a summative (qualitative) effect through the combination of different technology approaches. Although this decision enables the investigation of interaction of technologies in one setting, it disqualifies cross-setting comparisons of the effect of technology.

(8) The seven selected systems are not integrated into existing hospital IT-systems—either because they have their own technical infrastructure (e.g., the app for communication or the tracking system) or because they do not need to communicate with other systems. This limits the implications of the study through the selection of technologies, as it was not possible to make any statements about the usage effects of interoperable systems and their advantages and disadvantages. The decision in favour of isolated solutions was made due to closed hospital IT systems that did not allow the installation of integrated systems.

(9) A direct calculation of the frequency of technology use (e.g., how often nurses used technologies or on how many patients

the technologies were used on) was not achieved. The main reason for this is that it would only have been possible to count on site, but the research team could have not been permanently on the side and the nursing staff refused to document the frequency of use due to a lack of time. For this reason, the feedback from the observation and validation workshops and the corresponding item in the written survey were used. Although these are merely indications and no hard figures, they are not of primary interest in the context of the research question, as the aim is to identify qualitative reasons for use and non-use.

(10) The influence of the mediator variable gender cannot be systematically evaluated in this study, as most employees on the ward are female. However, a direct comparison of the data with the few (three to four) male nurses does not reveal any relevant differences in use patterns or attitudes toward technology.

5 Conclusion

In the research project "*Centre for Implementing Nursing Care Innovations*", we explored the implementation and use of seven technologies intended to support nursing care in a hospital-based trauma surgery ward. The question was investigated which of these technologies are used and accepted or not used and rejected and which factors are responsible for this.

A Mobilising mattress, a Sound pillow and a Special projector were accepted and used, whereas a Fall prevention system was used but technology acceptance among nurses were low do to a perceived low technology quality. A system to track work equipment and an communication app for patients and nurses were neither used nor accepted because users were not able to find a suitable use case, whereas an Interactive therapy ball was accepted among nurses but work condition prevented its application.

The following practical implications can be drawn:

- The finding indicates that acceptance of a technology should not be confused with the use of a technology. The technology might be used but acceptance is low, if, for instance, the use of the product is expected as a work obligation. In this case, users may find the technology not helpful and sustainable transfer of technology in routine practice is weak. Likewise, a technology may be accepted and users would like to transfer it into routine practice but circumstances hinder its use. In this case, an institution should facilitate chancing working conditions if the technology is desired.
- The categories of performance, effort, social influence, and facilitating conditions provide a practical analytical approach to identifying acceptance or rejection factors. However, they merely provide indications of actual usage and acceptance patterns. The analysis and thus the understanding of the context of technology application itself is necessary in order to be able to classify and qualify overall acceptance.

- Experimenting with technology stabilises the intention-to-use into a sustainable use of technology that is adapted to the application context. If users do not find a way to transform this intention into a helpful benefit or if negative unintended or unanticipated consequences emerge, acceptance of the technology remains low. Intention-to-use is not a solid characteristic among users. Users should be given the opportunity to experiment with a new technology to stabilize an intention to use.
- In the practical field of nursing, the outcome of technology acceptance should not be viewed simply as the realised use of technology but rather against the background of whether nursing tasks and goals have been achieved through the use and acceptance of technology, such as the improvement of emotional, sentimental and interactive work between nurses and patients.

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 Ethics Committee of the Hannover Medical School. 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

RK: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. U-VA: Conceptualization, Data curation, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. DK: Data curation, Formal Analysis, Investigation, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. M-LD: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fdgth.2024.1330988/full#supplementary-material

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A qualitative exploration of online forums to support resilience of rural young people in Australia

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Introduction: Prevention and early intervention are crucial strategies for improving young people's mental health and well-being. Building resilience is a key component of these strategies, especially among young individuals in rural areas who face well-documented mental health disparities. This study aimed to investigate how online mental health forums can contribute to enhancing individual resilience in young rural users.

Methods: A sample of forum posts ($n = 1,000$) made by Australian rural users (18−25 years) on an online peer support mental health forum were qualitatively analyzed. The analysis was guided by themes derived from the literature on indicators of rural resilience.

Results: Analysis of forum posts showed evidence of rural resilience in forum users. Online peer support forums offered a virtual space for individuals to establish social connections, experience a sense of belonging, share information, acquire knowledge, and offer mutual support. There were indications of increased self-efficacy among forum users, as they demonstrated their ability to implement strategies for better managing their mental health.

Discussion: These findings significantly contribute to our understanding of how online forums can enhance resilience factors that are beneficial for young people living in rural communities. In the context of prevention and early intervention, this study illustrates the intricate connections between forum design and user activity with resilience outcomes, providing valuable insights into the underlying causal mechanisms. Consequently, it emphasizes the importance of incorporating such digital interventions as integral components of mental health service ecosystems.

KEYWORDS

rural, mental health interventions, online peer support forums, resilience, youth–young adults

Introduction

This study explores how an online peer support mental health forum contributes to building resilience of young Australians aged 18–25 living in rural areas. Building resilience is an important protective factor as part of mental health prevention and early intervention strategies (1), and is particularly significant for the young, rural group we consider. Globally, mental ill-health is a major contributor to the burden of disease in young people. It is estimated that one in seven (14%) of those aged between 10 and 19 years experiences a mental health condition (2), with suicide being the fourth leading cause of death in 15–19 year-olds. In Australia, nearly two in five (39.6%) of those aged 16–24 years experienced a mental health condition in 2020–21 (3). Internationally, adolescence and young adulthood are high-risk life-stages when many common mental health conditions emerge, with approximately 75% of these conditions starting by the age of 24 (4, 5). Rural is the specific geographical focus here due to well-documented rural mental health deficits when compared with urban counterparts (6, 7).

Given the specific salience of adolescence as a time when well-designed interventions could influence life-long mental health and well-being, effective strategies to stop exacerbation of health issues are imperative. However, young people with mental health issues are less likely to access mental health services compared with the general population (8). Frequently cited barriers include perceived stigma and societal attitudes toward mental health, poor mental health literacy and prior negative experiences of mental health services as well as a preference for self-sufficiency (9, 10). With specific reference to young people experiencing mental illness in rural communities, the focus here, there is evidence of limited choice of, and access to, mental health services, cost associated with treatment, and cultural barriers (11, 12). Without adequate supports, rural young people can experience high rates of relapse, poor health outcomes, and reduced quality of life (11, 13).

Prevention and early intervention are key policy and practice-based strategies to enhance the mental health and well-being of young people. Implementation of these strategies aims to halt the onset or development of illness, thus minimizing impacts on individuals, families, and communities (1). Most mental health conditions arise from combined risk factors - biological, genetic, psychological, family-related, and social - which interact in complex ways. Protective factors, such as social connectedness, access to education and employment, and a stable family environment can reduce the likelihood of experiencing a mental health condition, enhancing a person's mental health and wellbeing, or acting as a buffer against a person's exposure to risk factors. This reduces the likelihood of becoming unwell (14).

By implementing preventive measures that reduce exposure to risks and increase exposure to protective factors, it is possible to reduce occurrence of mental health conditions across the community (1, 15). Early intervention aims to lessen ill-health duration and impact by identifying early signs of mental ill health (16). Effective prevention and early intervention can prevent the progression of mental health conditions and reduce the mortality and long-term morbidity often associated with these conditions, including premature death, social isolation, poor functioning, and reduced educational and vocational productivity (17).

This study considers how using an online mental health forum influences resilience. Building resilience has received increasing

interest as foundational in informing design of preventative and early intervention, protective, approaches for mental health (14, 18). The term resilience is used across a variety of contexts, and sometimes in relation to structural features of communities, regions and their populations (19, 20). In this study, we focus on individual resilience. Individual resilience can be described as a composite psychological outcome generated through a process of building strength and coping strategies to deal with adversity and adapt to overcome trauma or other vulnerabilities (21). We define resilience using a framework of indicators of resources – social connection, learning, belonging, self-efficacy and adaptive capacity. These are acknowledged to assist in dealing with adversity in a rural context (21, 22). Rural people experiencing mental ill-health are understood to experience contextual layers of adversity including having to deal with isolation, service inaccessibility, hostile or declining environmental conditions and a set of social attitudes from living in close proximity with a limited number of people (7).

Evidence suggests that mental health interventions emphasizing protective factors that build resilience, can act as a psychosocial buffer for young people when exposed to stressors (23, 24). Research with young people living in rural Australia, for example, found that a school-based program which focused on active learning and peer interactions led to self-reported improvements in self-efficacy and application of healthy coping strategies when faced with adversity (25). There are also increased calls to include young people as active co-contributors in mental health interventions to build resilience by giving opportunities to express their 'voice' leading to a sense of ownership and agency for change in their own lives (17, 26, 27).

Given rising mental health need among young people and the potential of building resilience for prevention or early intervention, the question arises of how to enable equitable and ubiquitous access to services and supports. Young people might be considered "digital natives" who have grown up immersed in technology with access to the internet a normal part of everyday life. The Australian Bureau of Statistics, report on household use of technology highlighted that 98% of young people aged between 15 and 24 years used the internet with social networking and entertainment the most common activities this age group engaged in (28). This level of digital native-ness among young people means that online interventions should be increasingly regarded as a valuable aspect of mental health service delivery models for young people (29). Online delivery of mental health services has potential to address some of the workforce and mental health service maldistribution across rural areas (30) and to overcome some of the confidentiality and agency barriers rural young people experience when seeking help for mental health issues (31).

Within the available options for digital mental health services, online peer support forums have potential as a "virtual social space where people come together to get and give information or support, to learn, or to find company" p348 (32). Face-to-face peer support has been increasingly recognized as valuable in mental health, for both giver and recipient (33) and, more recently, this has also been shown valid where peer support is mutually given via online forums (34). Beneficial outcomes are likely due to the interesting phenomenon of value co-creation (35) in peer service delivery where services can be tailored by a service-giver to fill any 'structural holes' (36) experienced by a peer who asks for help and seeks that in language they can understand. Simultaneously, the giver of help experiences a sense that they are valued because their help is needed

and appreciated by another. Mental health service providers often incorporate online peer-to-peer support forums as part of online and in-person interventions to enable people to connect, share experiences and provide social support and advice. Mental health online peer support forums used by health organizations are typically managed and moderated by trained staff and peer volunteers who are trained and have recognized experience and expertise (37). Studies exploring the experiences of young people using mental health online forums have reported benefits in terms of symptom alleviation, a reduction of feelings of isolation, feelings of belonging, information sharing and emotional support (38). This is, in part, due to online forums affording young people alternative opportunities to connect with their peers in a supportive environment to manage their mental health and wellbeing. What is less understood is how online forums as a prevention/early intervention strategy can contribute to enhancing protective resilience resources that are associated with mental ill health in young people, particularly for those young people living in rural areas.

This study adds important new knowledge, therefore, from qualitative analysis of a sample of 1,000 posts (2018–20) made by Australian rural users, aged 18–25 years, on the ReachOut online peer support mental health forum. The study specifically examined how the forum influences resilience of its young rural users. By exploring the interactions between online forum users, the study shows how resilience is built by exchanges that are facilitated and encouraged to address a specific context and that harness a set of practices that are clever and adaptive to the young person group in a changing milieu. By engaging the young people this helps to effect the ongoing freshness, vibrancy and relevance that engages users. Helping to build resilience is significant as part of mental ill-health prevention and early intervention strategy. Findings of this study contribute to understanding the role of specialist digital services as part of health systems for key demographics – here a young, rural group that is both at risk and hard-to-reach.

Materials and methods

This descriptive qualitative study is part of a larger project called (Identifying and optimising the roles of online communities in building rural resilience), which aims to understand if, and to what extent, rural people experiencing mental ill-health can realize resilience through participation in online communities. In this study, we focus on exploring how using the ReachOut forum influences resilience-building among young people aged 18–25 and living in rural contexts.

Study setting

ReachOut is Australia's most accessed online mental health service for young people. It was established in 1998 and is run by a non-profit organization. It is national in scope and accessed by more than 2 million Australian users annually, with around 9% of these residing in rural areas (39). The online peer support mental health forum (henceforth "forum") aims to provide a safe, inclusive, empowering space that improves mental health outcomes (40). Its' objectives are to build young people's awareness and capabilities to:

- Recognize indications that something is not right – before reaching a crisis stage;
- Understand the importance of accepting and working with their mental health and psychological distress issues;
- Engage in informal and formal help-seeking and self-management as needed; and
- Support social connectedness and promote a positive sense of self and wellbeing.

The forum is informed by a theory of change that depicts it as an intervention aiming to expand the protective factors for young people's mental ill-health, leading to prevention or delay of the onset of mental health issues, reducing their incidence, severity, duration or frequency (39). The forum targets those with low to severe symptoms with whom ReachOut can intervene 'early' to facilitate access to more intensive support, while providing 'adjunctive support' (39). Adjunctive support refers to being used in conjunction with other services, potentially while on waiting lists or between appointments, but the forum is also suggested to act as an alternative support for young people who may have had negative experiences with mental health professionals (40).

Young people can access the forum via the ReachOut website. ReachOut is an 'open access' forum, meaning anyone under 25 with an internet connection can view and register to post on the forums. To make a post, registered users must select a pseudonym associated with their profile to ensure all posts remain anonymous. Young people use the forum voluntarily by choosing to post on existing threads, or by creating their own new thread. Existing threads include topics on managing mental health, self-care, relationships and other topics relevant to young people. During 2020, over 65,000 posts were made on the ReachOut forum (41). The forum has paid moderators who: establish a safe space for all young people, monitor adherence to community guidelines, and facilitate safe conversations about sensitive topics (e.g., suicide, self-harm, trauma). Moderators ensure users do not disclose personal information, remove spam content, and prevent prescriptive advice or abusive and triggering language from reaching the forums.

As well as these paid moderators with specific roles, ReachOut users can access additional capability-building and formal helping roles within the forum by volunteering to become 'community builders'. In that role, they receive training and are encouraged to provide peer support, start threads and engage in online events – thereby helping to keep the online forum active, dynamic and vibrant through user activity. Active users who demonstrate natural leadership in their posting activity and are over 18 years old may be invited by ReachOut to become an unpaid 'peer moderator' after receiving additional training on how to effectively provide peer support beyond the entry level community builder program. Through these means, ReachOut builds confidence among users and a kind of 'career development' for them, while keeping the forum fresh, active and co-created.

Data collection

To gain ethics approval to source ReachOut data, a data sharing agreement was developed between the research team and ReachOut that ensured sensitive forum data would not be shared with third

parties. Once retrieved, the data was stored securely on university servers and remained unmodified other than being completely de-identified (42). The data sharing agreement was used to inform ethical approval for this study gained from Swinburne University Research Ethics Committee (R/2019/033).

In accordance with data governance practices, forum users consent to the use of their anonymized post data for research when they register to use the forum. In this study, to ensure data was de-identified, users' online pseudonyms and other potentially identifying features (e.g., references to specific locations in posts) were removed prior to analysis. A sample of posts from 1 August 2018 to 31 December 2020 (inclusive) of de-identified and time-stamped forum posts was obtained ($n = 80,174$ posts) and cleaned for analysis. As this study focused on rural young people, posts made by rural-located users were selected-out by linking their post codes (provided when registering) to each of their posts and then selecting posts for Outer regional, Remote and Very Remote categories (i.e., not including posts for 'Major cities' and 'Inner regional' areas) as defined by the Australian Statistical Geography Standard (ASGS) Remoteness Structure (41). The ASGS categorizes locations based on population distribution and distance to services. To generate a manageable sample for labor-intensive qualitative thematic analysis, we selected a sample of 1,000 posts, including all Remote posts ($n = 57$), all Very remote posts ($n = 23$) and a random sample (using Excel feature) of 920 Outer regional posts.

Data analysis

Forum post data were analyzed deductively for themes derived from the literature on indicators of rural psychological resilience (21, 22, 43–45). The process of theme development is described in more detail in the larger study (46). A deductive approach was used as we were interested in exploring the utility of applying established resilience themes from the literature to the data set. Table 1 shows the

themes and the topics of posts coded to these. Regarding the focus of this study – i.e. that it involves rural-dwelling young people experiencing mental ill-health - we draw on ways resilience is construed through the sequence of studies undertaken by Berkes, Ross and colleagues cited above. In their studies, they combined a psychological perspective on resilience with a rural community development perspective (to acknowledge the nuanced challenges and thus strength and coping strategies required for dealing with generating psychological coping resources in rural communities). That is, resilience as broadly involving access to a set of resources: social support and the ability to access networks of contacts for support; learning or access to new knowledge and skills (43); a sense of belonging or inter-connection with a community or place (47); self-efficacy which relates to an individual's belief about their capabilities to reach goals and to exercise influence over their lives (48); and adaptive capacity to enable adaptation and behavior change in relation to taking agency in changing circumstances (49). As we did more widely in our larger study (46), we applied this rural and psychological framing of resilience to analyze resources exchanged or developing through forum posting.

Analysis of posts followed Braun and Clarke's (50) thematic coding method. Four researchers (PK, JF, EC, and TD) initially read all of the posts in the sample, noting themes and other ideas independently. A codebook was developed outlining what would be included/excluded for each thematic code (See Table 1 for forum post topics coded to each theme). Using the codebook PK, EC, TD systematically coded forum posts independently using the qualitative coding software NVivo. This coded data was reviewed and discussed with the wider research team with agreement reached on inconsistencies. It was agreed that where consensus on coding could not be reached, that data was not coded. Following this stage, data was grouped by each thematic code and explored in-depth to understand how each post related to the resilience themes in Table 1. For this paper, the coded data was then reviewed and refined by KC by re-reading the posts/post extracts to ensure a close fit between the data

TABLE 1 Resilience themes and topics in data coded to themes.

Resilience themes	Description of what was coded to this theme
Social connection	Includes: (i) descriptions of relatedness or empathy between people. Captures examples of one person describing to another, their similar experiences; (ii) expressions of friendship and friendly encounters between peers. This includes people offering encouragement to one another, referring to each other as friends, thanking each other for trusted friendships and describing the value of the friendships.
Learning	Includes: (i) formal knowledge resources or where people *ask for* advice and information about practical things, e.g., how to access services. Also *sharing* online resources, strategies for coping with symptoms and best-practices for improved mental health; (ii) informal knowledge or where information or advice is shared that is about others' lived experiences, e.g., asking or sharing how medications made them feel, how they navigate relationships and situations.
Sense of belonging (to the forum community)	Includes: (i) people initially joining and posting messages indicating they seek to belong to this community, e.g., introducing themselves, telling their story; (ii) posts that tell members they belong. This captures the variety of ways members try to make others feel included and valued. (iii) posts that reference the forum as a beneficial place. Includes naming the forum, discussing features of the forum like it's a physical place and testimonials about benefits of the forum.
Self-efficacy	Includes where people describe (i) feeling they have lost control. We interpret this as meaning they are taking steps to regain control by being on the forum; (ii) where people post in such a way that they are asking for others on the forum to 'hold them accountable'; (iii) where people tell their story as a kind of 'unmasking', 'offloading' or getting it out there, with sometimes explicit discussion and sometimes implied that this helps to move on.
Adaptive capacity	Captures where people describe how interacting on the forum has changed what they do, how they approach certain situations and how they have changed since interacting online. Any post that mentions a change in behavior, approaches to talking to doctors or any other relevant change in behavior is captured here.

and interpretation of them leading to their coding. This refined analysis was examined by PK and EC and any agreement reached about inconsistences. Some posts were coded to more than one theme.

Results

Evidence of resilience

Below we show evidence that each of the resilience themes from the framework (see above Methods) was present in the forum data and how the themes were manifest in the data. Figure 1 provides an overview of the number of posts coded to the resilience themes.

Social connection

The most frequently coded theme was social connection, with 416 posts coded to this topic. The resource of social connection was manifested in posts where users provided encouragement to other users, and shared experiences and expressions of friendship. Posts were mainly conversational in tone and included discussions about challenges with school, university and work, providing a context for users to connect. The following post illustrates how users shared thoughts about their everyday lives, in this case about challenges with their work environment.

> *I feel imposter syndrome a LOT at work now! (It has a name!) I know it's okay to make mistakes and that we learn from our mistakes, my current manager doesn't have a relaxed attitude to mistakes as the previous one…... (Post #324)*

Users connected through using words of encouragement and relating to each other about experiences they were going through together.

> *I'm glad things are starting to feel a little better for you and hope they continue that way. How is the assignment coming along? How*

amazing is it going to be when we're all finished for the year?! I know I cannot bloody wait (Post #37)

Posts also reflected benefits of social connection particularly for people living rurally who may lack connection with others their own age in their local community. Being able to form connections online appeared to enable young people to know they are not alone in how they feel, as often the posts about social connection contained phrases like: *I can totally relate (*Post #226), and *you and I are going through some similar things (Post #462).*

Expressions of reassurance were shared through showing concern about others' safety by reminding them they are connected to a wider, strong support network. Typical posts included 'checking in' and asking questions about the other person's life or day.

> *Hey I also wanted to check in and see how you're doing? I'm hoping the absence means you've just been busy baking Christmas cookies and your rice bubble slices!! Sending you some positive vibes - you've got this. Don't forget we are here okay? Ready to listen when you need someone! Thinking of you! (Post #15)*

How the forum operated also helped to facilitate social connections to happen. 'Tag games' was a tool used on the forum and refers to specific posts initiated by moderators aiming to acknowledge and encourage users who had contributed positively to the forum that week. Moderators would start tag games by posting questions for users to answer to encourage discussion and inspire new users to post as illustrated below:

> *Awesome answer Since this is soo late (sorry guys!) I'm going to post today and tomorrow's questions 4. Are comparisons bad and what can we do to help prevent upwards comparison? (i.e., thinking someone is prettier or better than oneself) 5. How can we promote positive thoughts surrounding body (Post #236)*

This type of post helps users to connect easily with one another - particularly new users; as it does not involve one to one chat. Once a
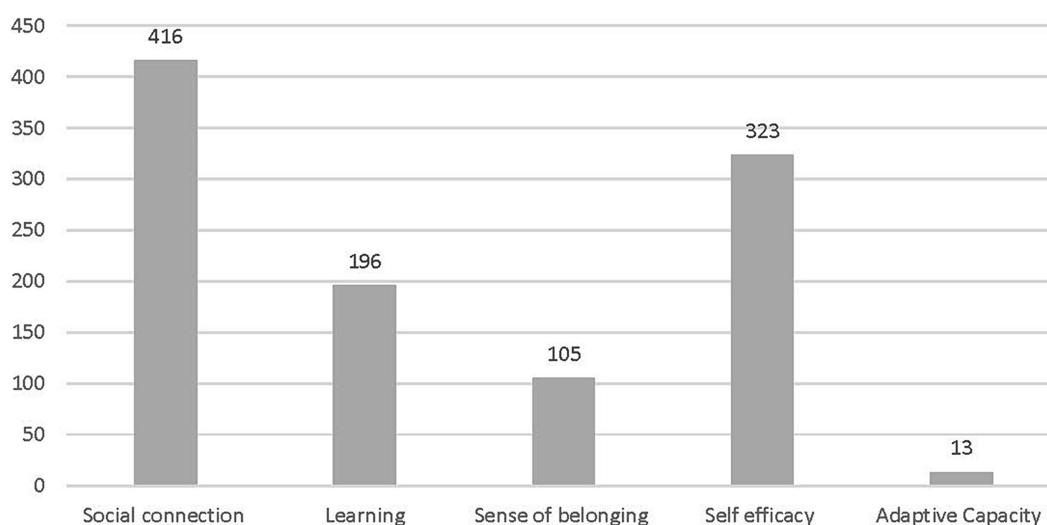

FIGURE 1
Number of posts coded to resilience theme (*n* = 1,000).

user has answered a tag question, there is no onus to reciprocate. 'Tag games' enabled users who were seeking connection as their purpose is to bring about new connections between users with little proactive effort from users:

> … here's our Friday Fives for creating this thread to talk about the recent attack in Melbourne and linking resources for help! for always being sympathetic and caring toward other users for opening up to friends about how they've been feeling…. (Post #884)

Learning

Nearly a fifth of posts ($n = 196$) showed evidence of learning facilitated through gaining and taking onboard new information shared on the forum by other users. Some of this was based on users' experiences, opinions or feelings and some was based on asking for or sharing sources of advice, knowledge or evidence. Users would access the forums to ask for advice on issues that were affecting their daily lives. Typically, those seeking advice would provide some contextual description about their circumstances to find people who had experienced similar issues.

> Because I am in a very small school, it is very difficult to find people with a similar mindset as me toward learning. What could I do to strengthen my mindset and lessen the chance of being negatively influenced in my situation? Much help would be appreciated (Post #14)

Advice shared by users was often couched in similar experiences to the person posting or it would relate to the situation they were going through. At times young people in the forum would frame their advice with a question. This way of communicating the advice could be viewed as a less direct way of encouraging the person to consider the advice provided.

> Yeah I'm worried about that too!! Do you have the option to sit them on campus if you want to? I know with my uni you could register to sit them on campus and they have rooms set up with social distancing and stuff in place. I ended up applying for it cause I already don't do well with exams so needed to keep things as normal as possible so am very thankful my uni has those measures in place! Could be worth checking out? (Post #513).

> I think it's important you try your best to work on supporting and relying on yourself for the next few weeks? Maybe chat with your psych and see what she suggests? (Post # 157).

The forum was also used to exchange information about how to find professional help (as access to services is a common challenge in rural areas). Receiving lived experience advice from peers who have recently navigated the mental health system was often noted as helpful in supporting recovery, demonstrated here:

> Regarding the [time I was with the] crisis team, that is an interesting question. I am guessing perhaps about 7 months. However, I only stopped with them because the mental health nurse I had left and the new person I didn't click with, and I was too scared to ask for someone

different. Around the time I had started seeing a new GP who got my referral done for headspace and got me in quickly, so there really wasn't much time where I was unsupported if that makes sense. Was there anything you wanted to ask about seeing a crisis team? (Post #397)

Users would ask for or receive practical tips for managing mental ill-health - for example, sharing ways to use crisis helplines. The following post is an example of advice on how to use helplines. It is interesting to note that the user has not written out the word "suicidal" in full as a tactic to avoid content being picked up and possibly removed by moderators.

> Remember that you can always get immediate and temporary support from helplines and crisis lines if you are really struggling and are having s*cidal thoughts, it's good to speak to someone… (Post #24)

Knowledge was sometimes obviously shared by moderators who would post and facilitate threads discussing practical ways to prevent mental ill-health, exemplified below:

> Welcome everyone Tonight our chat is all about ROUTINES! I'm facilitating the chat tonight with the lovely [name removed] & we have some builders who are going to help us out too (Post #489)

Belonging

Through connecting with one another on the forum, users began to form a sense of belonging to the online community and 105 posts were coded to this theme. Many posts were directed to other users being told they belong and were reassuring in nature.

> Sending you some positive vibes - you've got this. Don't forget we are here okay? Ready to listen when you need someone! Thinking of you! (Post #65)

Several posts depicted the forum as a space or place, drawing on features of the forum to help depict its place-ness. Posts were welcoming and reflected 'safe space' language.

> Hehe, don't worry about the long posts, I tend to ramble on and on too! And I find that it's super easy when you're in a safe supportive place (Post #698)

Users also described the benefits of belonging or being part of the forum in terms of finding support through difficult periods in their life.

> Thanks heaps I really do value everyone's support on here because I'd have completely lost my mind by now otherwise!! (Post #241)

Others discussed how joining the forum had furthered them in their journey of dealing with their mental health condition. At first, they appreciated receiving advice, and later, they experienced benefits from advising others.

When I look back to when I first joined RO [ReachOut], I would never have imagined I could be a mod [moderator] and be helping people the way I do now, but I did, and it started by helping give others advice when I can, and it also helped that I was taking suggestions and implementing them. (Post #748)

Discussing the benefits of belonging, some users indicated a preference for using the forum when in need of immediate help rather than using crisis hot lines such as Lifeline (the most prominent Australian crisis help-line). Reasons for this were that they could connect with like-minded people and receive support from more than one person.

I'm far too scared to make the call even when I really need it, and I've tried their online/text options but didn't find them very helpful which is why I use ReachOut instead. (Post #627)

RO is my best source of support in terms of online/phone supports, I find everyone on here is just so amazing, understanding and accepting and it's nice. (Post #342).

I think just knowing I can come on here and chat to like-minded people has been my favourite wellbeing activity this year. I am so glad I found this community because there is no other like it and for once I feel like i am supported and can speak out about how I'm truly feeling so thankyou to everyone on here!! (Post #10)

Self-efficacy

Almost a third of posts (n = 323) were coded to self-efficacy which can be understood as having skills and applying strategies that promote emotional coping. As an example, being able to identify things causing emotional distress and being able to make changes for the better or accept what cannot change, would be expressions coded to self-efficacy. Self-efficacy was evidenced in users discussing how they deal with their mental health in their day-to-day life and in forum threads such as one called 'negatives and positives', where users share positive changes they experience over time.

I managed to walk to the end of my street AND I managed to go for a run on this quiet little track behind my house!! Double win!! Sorry, I know it's pathetic but I'm on a bit of a high and just so proud of myself for actually doing it!! Feels amazing!! (Post #682)

I spoke to my psych today cause it's just been too much for me and making me sick. She reminded me that I don't have to put up with verbal abuse and be walked all over. She's given me a couple of numbers I can call for actual legal advice for house shares so I might try calling them tomorrow to see what they say. I'm just trying not to think about it now and try chill out for the night (Post #305)

Some posts illustrating self-efficacy responded to experiences shared on the forum and promoted a change in thinking or taking action.

"Thanks for sharing your experience I really appreciate it! I have an appointment with my psych tomorrow and have just spent the last

couple hours trying to word an email to her cause I'm not good at talking so hopefully she'll bring it all up tomorrow and I'll sort through some of it" (Post #281)

Hey thanks! Things around that topic are doing just fine now, which is good, it feels I've had ten tone taken off my chest and I've already noticed a really positive difference in my general mood (Post #200)

Absence of self-efficacy was also evidenced and highlighted challenges faced by young people in rural areas when seeking help. Users expressed inability to get what they want because they are too young, cannot afford professional help, or legally cannot access a service due to their young age. Posts on this theme often implicitly noted lack of agency or were supportive responses to those experiencing the problem.

I'm sorry to hear you felt that you weren't able to answer the GPs questions honestly with your parents in the room. (Post #365)

I have severe insomnia and general anxiety. Paranoia decided to join, too. I've mentioned this to my family, and the first time, they were going to take me to a doctor. But they didn't end up doing it. The second time I reminded them, they shook it off and said: "You're fine, stop worrying" (Post #11)

A prominent theme within those coded to self-efficacy involved discussions about managing interpersonal relationships, with n = 39 quotes on this issue. Some showed evidence of users helping each other to navigate complex interpersonal relationships in their offline life. The opportunity to discuss this with others online seems significant to prevention strategy as these relationship issues are depicted as deeply impacting users' mental health. An example is given below where a user expresses problematical family conflict and they post repeatedly regarding this specific situation.

There was another argument tonight, except this time it was my grandad being disrespectful and rude to my dad who was only trying to help. I don't know why but it just makes me scared and feel really upset. (Post #262)

Adaptive capacity

Only 13 posts had evidence of adaptive capacity. Possibly this small number is because we only coded clear instances of behavior change to adaptive capacity. Some posts show evidence of people changing their behavior based on their forum activity. The following posts are examples of users describing how advice from other users led to changes in managing their mental health.

I appreciate your, help, and so much, and I did talk to my boyfriend about it and I feel so much better. (Post #18)

Today I practiced self-care by reading back through my threads and taking note of all the wonderful suggestions and advice this community has shared with me so far. (Post #229).

Users expressed capturing advice in the moment for later use - as reflected below - where the user states that seeing a post reminded

them of the importance of self-care and prompted creating themselves a list of self-care methods.

> *Thanks heaps for sharing this I came across it the other day when I was feeling really down and needing help and this was a great reminder of how important self-care actually is. I haven't had much time to myself lately with uni exams and work but have finally got a day off today and have just put together a list that works for me in the hope I can just turn to it and pick something off the list to do when I'm feeling really low. Thanks for the little reminder!* (Post #645)

Discussion

Supports that prevent or delay onset of mental ill-health by intervening early are critical for rural young people who are a particularly high-risk group (17). Building and enhancing protective factors – understood as supported, here, through resilience-building– is central to prevention and early intervention strategy. In this study, through qualitative analysis of 1,000 posts, we found that key resilience resources are built through young peoples' engagement with the ReachOut forum, a service intentionally designed and targeted at users aged 18–25 years. The study found that through fostering young people's exchanges of messages on the forum, a safe and trusted space for social connection, opportunities for learning and the building of self-efficacy, is created.
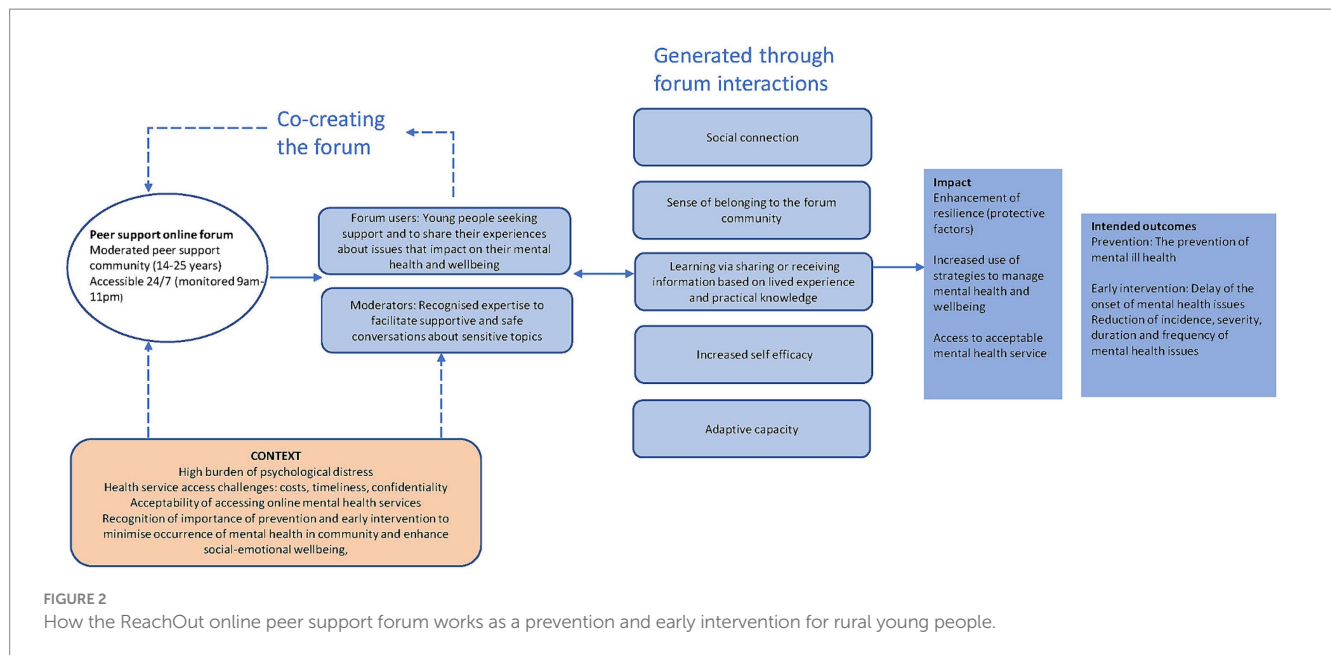
The forum supports young people in rural communities by helping them to reach specific resources that are hard to attain in rural places due to stigma, lack of privacy and lack of access to services and amenity. Finding others who are like you can be a challenge in rural places (51), so forums help young people to gain access to empathetic peers. Prescott et al. also described young peoples' experiences of online forums as supportive environments to access information which may not be readily available offline (52) Specifically, young people can gain access to resources that are key to wellbeing, fulfilment and capability. Social relationships and a sense of belonging are important among these as determinants of mental health and predictors of quality of life and health outcomes (53). Social connection was enacted on the forums in several ways, by users, through encouragement, expressions of friendship (checking in) and sharing of experiences. Paid forum moderators and volunteer peer moderators, who are hidden but substantial co-creators of forum activity, facilitate connections through applying intentional tactics and techniques such as 'tag games' to engage users with each other. Moderators also curate the forum as a space of safety by carefully managing content to remove negative or triggering posts, while encouraging posting and development of forum users' conversations. Peers in 'community-builder' roles keep forums active by posting and making encouraging responses to others. This seamless co-creation of a safe space fostered a sense of belonging and mutual support as a forum community which was expressed as beneficial for users particularly when faced with difficult situations, such as negative experiences in their community life. While the forum was not designed to manage crisis situations, some users would seek immediate help online. Reasons for this help seeking behavior are linked to understanding forum users as people who have empathy from sharing a similar situation (54), and from repeated, safe

interactions making the forum a trusted support network (55). This might be contrasted with negative experiences of other 'on-premises' mental health services that young people might have used (40).

Young people engaged with the forum to learn from others and share their knowledge in return – particularly around seeking advice about preventing and managing mental health as well as navigating the mental health system. Use of forums for practical advice has been previously highlighted by other studies (38, 56). Of interest here is the experiential knowledge exchange and the value ascribed to the forum as a resource for sharing individual's lived experiences. Many posts were grounded in personal experiences of managing users own mental health and contrasting difficult experiences within the public mental health system. This suggests forums accrue a form of legitimacy as an authoritative space to offer credible strategies to others and to seek advice from peers who understand you (37). This quality of forums is particularly relevant for the forum users who are living in rural, often isolated communities with limited access to appropriate mental health services. The availability of a 24/7 anonymous online forum is a valuable resource for young people distant from other services and perhaps isolated, lacking access to transport and agency, in rural places.

Another aspect of resilience which was prominent in the forum was evidence of self-efficacy. Self-efficacy can influence individuals' thinking, feelings and behavior and is a strong predictor of health behavior change (57). Self-efficacy features in key program objectives of ReachOut online communities around accepting and working with mental health issues and engaging in self-management (39). Self-efficacy was manifest where forum users commented about taking control or working on changing their circumstances. This was often catalyzed by connecting with others with comparable experiences. This study provides insights into the role of connecting with others in similar circumstances and sharing knowledge via online forums as a mechanism influencing self-efficacy. Other studies have emphasized this contribution, showing that people sometimes use forums to record their feelings and observations, and to gain support during times when they are facing challenging circumstances (58).

The intentional design of the forum is significant to how forums contribute as a prevention and early intervention support. Figure 2 depicts how the forum is designed to address specific contextual conditions experienced by young people. A range of tactics are used (e.g., intentionally applied 'games', encouragement of users through different roles they may be assigned, removing sensitive and triggering posts) to enable co-creation between forum users (who exchange emotional attachment, support and information), and moderators. The co-creative activity creates a space where it is the norm to exchange knowledge and information in friendly, supportive ways, meaning people make positive connections with each other and build a reciprocal community. The focus of ReachOut is increasing self-efficacy so moderators are able to influence the flow of activity and information as positive, enabling and exchanging coping strategies. These, in turn, lead to instances of changed behavior and attitude, understood by us here as bringing the resilience resource – adaptive capacity. The impact of co-creating these resilience resources is raising the level of social factors protective to wellbeing (connection and belonging). The forum helps young people to manage their mental health and minimize symptoms by gaining strategies tailored to their age group and circumstances as provided by and discussed by, their peers. In addition, young people living in rural communities are

FIGURE 2
How the ReachOut online peer support forum works as a prevention and early intervention for rural young people.

afforded access to a mental health service they experience as acceptable – that is, which is available when needed, and addressing issues such as confidentiality and stigma. This acceptable online service is, unfortunately, often to be contrasted with hard to access 'on-premises' services that may be inappropriately designed for young people (59). Based on existing evidence of what contributes to prevention and early intervention, by helping to build resilience, and enable protection and service access, we can say that the ReachOut forum conforms to depictions of a prevention and early intervention service or intervention. That is, is likely to help in delaying the onset of mental ill health and reducing mental ill-health duration and severity.

This analysis suggests that online peer support mental health forums have a role to play as part of the suite of mental health interventions offered for young people in rural communities. With an ever-increasing demand for mental health services, service providers should find online forums fruitful to complement other modes of service delivery to facilitate timely access to help. Forums might be understood as particularly useful for young people as they tend to lack power and agency (in rural places, this includes potentially exacerbated lack of access to services through lack of agency around transport) (60). They represent the potential of a private space, easily accessible, where young people can go to be themselves, express themselves and explore identities that are under-represented in their immediate locale. Forums are spaces where parents, teachers and 'grown-ups' cannot prevent their expression or monitor them – providing, of course, they have internet access, which is a question in itself because rural places still experience lower digital inclusion compared with other demographic groups.

Strengths and limitations

A strength of the study is the data collection method adopted. The data set that we analyzed comprised of 1,000 forum posts made directly by young people from outer regional, rural and remote Australia providing a rich, authentic source of information about questions and challenges, and tactics in addressing them, for this hard-to-reach population. Sourcing and analyzing data 'already there' helps circumvent the need to create and obtain data using surveys, interventions or other requests for data collection. Findings may be limited due to the deductive application of the resilience framework to forum posts, however the framework is based on a chronology of work specifically about rural psychological resilience, providing a framing specifically tailored to context. Other resilience frameworks and other methods of surfacing protective factors, from the data, might have been used in analyzing the data. We mentioned there are different 'levels' of users and indeed moderators whose posts may be in the dataset. It is impossible to separate out these types of actors within the dataset so we cannot understand any distinct differences between user status, the nature of posts and how dynamics within the forum might affect what is posted and significantly, what is not posted (61).

Implications

This study provides evidence of links between activity on the ReachOut forum and building of resilience factors that are beneficial to young people as part of prevention and early intervention supports and services. It is well documented in the literature that the use of online mental health interventions for young people can increase access to mental health services that are timely, acceptable and can improve mental health outcomes for users (37, 38, 56, 62, 63). This forum and its building of resilience can be viewed as additionally significant to rural young people as they navigate a distinct context and set of additional challenges in addressing their mental ill-health. While there have been other studies highlighting the benefits of online mental health forums, this study explicitly

links forum activity with resilience outcomes and provides fine-grained evidence that informs depiction of causal mechanisms (as illustrated in Figure 2).

This study also examines the capabilities of ReachOut as a forum operator in crafting and curating the desired outcomes to happen - particularly in addressing its goal of generating self-efficacy. It cleverly does this through combinations of skilled staff managing the forums, moderators, experienced users (peer moderators and community builders), teaching and skilling peers, moderation practices, games and tactics. Further, this practice does not seem codified and is adaptive and represents an example of benefits or good outcomes from more adaptive and co-creative practices in health and wellbeing services.

Finally, the study highlights the significance of this type of digital intervention – that enables young people to escape the surveillance of life in physical communities, is open and inclusive, available at all times and confidential. As we have noted, a beneficial set of characteristics of a service for rural young people who live in highly socially monitored contexts of few services, embedded in communities where everyone knows everyone else. While ReachOut understands this service as adjunctive and complementary, our findings suggest it is perhaps *an essential service*. If we are to understand young people as digital natives, the study highlights that service systems – and perhaps particularly rural service systems - should now consider online options as a routine part of adequate service ecosystems.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: The datasets generated for this article are not readily available because signed data sharing agreements by partner organizations and Swinburne University used to receive ethics approval prevents us from making sensitive mental health data available. Access to the de-identified data is considered on request by the participating organization. Requests to access these datasets should be directed to karen.carlisle@jcu.edu.au.

Ethics statement

The studies involving humans were approved by Swinburne University Research Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The ethics committee/institutional review board waived the requirement of written informed consent for participation from the participants or the participants' legal guardians/next of kin because in Australia people who sign up to use ReachOut forums, agree that their de-identified posts can be reused for research.

Author contributions

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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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Acceptance of smart sensing, its determinants, and the efficacy of an acceptance-facilitating intervention in people with diabetes: results from a randomized controlled trial

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Background: Mental health problems are prevalent among people with diabetes, yet often under-diagnosed. Smart sensing, utilizing passively collected digital markers through digital devices, is an innovative diagnostic approach that can support mental health screening and intervention. However, the acceptance of this technology remains unclear. Grounded on the Unified Theory of Acceptance and Use of Technology (UTAUT), this study aimed to investigate (1) the acceptance of smart sensing in a diabetes sample, (2) the determinants of acceptance, and (3) the effectiveness of an acceptance facilitating intervention (AFI).

Methods: A total of $N = 132$ participants with diabetes were randomized to an intervention group (IG) or a control group (CG). The IG received a video-based AFI on smart sensing and the CG received an educational video on mindfulness. Acceptance and its potential determinants were assessed through an online questionnaire as a single post-measurement. The self-reported behavioral intention, interest in using a smart sensing application and installation of a smart sensing application were assessed as outcomes. The data were analyzed using latent structural equation modeling and t-tests.

Results: The acceptance of smart sensing at baseline was average ($M = 12.64$, $SD = 4.24$) with 27.8% showing low, 40.3% moderate, and 31.9% high acceptance. Performance expectancy ($\gamma = 0.64$, $p < 0.001$), social influence ($\gamma = 0.23$, $p = .032$) and trust ($\gamma = 0.27$, $p = .040$) were identified as potential determinants of acceptance, explaining 84% of the variance. SEM model fit was acceptable (RMSEA = 0.073, SRMR = 0.059). The intervention did not significantly impact acceptance ($\gamma = 0.25$, 95%-CI: $-0.16-0.65$, $p = .233$), interest (OR = 0.76, 95% CI: $0.38-1.52$, $p = .445$) or app installation rates (OR = 1.13, 95% CI: $0.47-2.73$, $p = .777$).

Discussion: The high variance in acceptance supports a need for acceptance facilitating procedures. The analyzed model supported performance expectancy, social influence, and trust as potential determinants of smart sensing acceptance; perceived benefit was the most influential factor towards acceptance. The AFI was not significant. Future research should further explore factors contributing to smart sensing acceptance and address implementation barriers.

1 Introduction

Diabetes emerged as one of the most serious and common chronic diseases with approximately half a billion people affected worldwide (1, 2). The metabolic disease has far-reaching implications (3–7), creating an immense burden for affected individuals as well as health care systems (2, 8). Moreover, the prevalence rates of mental health problems are significantly higher among people with diabetes (9). For instance, studies show prevalence rates of comorbid depression in people with diabetes ranging from 12%–27% (10, 11), which is considerably higher compared to the general population. Comorbid mental health problems may not only aggravate the burden associated with diabetes but also give rise to an even greater strain of affected individuals and healthcare systems (12–14). Hence, effective treatments supporting mental health are needed for this population.

Current mental health treatment options for people with diabetes range from face-to-face treatment (15–17) to digital interventions (18, 19). In order to provide optimal and effective treatment, accurate and early detection of mental problems is key. Early detection of symptoms enables affected individuals to take preventive measures and clinicians to intervene appropriately (20–22). However, due to economic constraints and limited resources in health care systems (23, 24), mental health problems often go unrecognized and untreated in general practice (25, 26), thus creating a need for innovative diagnostic methods. One such method could be smart sensing, with the goal of achieving scalable, precise, and time-effective detection of symptoms (27–29). Smart sensing refers to the passive collection of digital markers and features via smartphones and other wearables (30). Tracking usage data from mobile devices as well as built-in sensor data (e.g., GPS, accelerometer, light sensors) offers the possibility to draw conclusions about health status and behaviors of individuals (31, 32). Recent studies support the great potential in the context of mental health (33–38). For example, studies were able to distinguish between individuals with vs. without depressive symptoms based on their GPS data with an accuracy of 86% (39) and could classify depressive symptoms based on sensing variables with an accuracy of 81% (40).

In the daily lives of individuals with diabetes, sensor and tracking technologies already constitute integral components frequently (41). The continuous monitoring and self-regulation necessitated by the metabolic disorder commonly involve the prominent utilization of sensor technology and insulin pumps (42). Within this framework, smartphones take over an increasingly crucial and efficient role as an interface (43–46). Considering the existing prevalence of monitoring and sensing modalities for individuals with diabetes, this demographic may constitute a noteworthy target group for the implementation of smart sensing technologies with a focus on mental health.

However, parallel to integrating innovative diagnostic methods like smart sensing into clinical practice, it is necessary to evaluate its acceptance among people with diabetes as a prerequisite for utilization. The framework for technology acceptance and usage, known as the Unified Theory of Acceptance and Use of Technology (UTAUT) (47), has found extensive application (48, 49). The

UTAUT pinpoints four factors influencing acceptance and behavioral intention. Accordingly, the fundamental determinants of acceptance are: (1) performance expectancy (perceived personal advantage gained from using the technology), (2) effort expectancy (expected simplicity of use), (3) social influence (belief that the technology is valuable to others), and (4) facilitating conditions (anticipated assistance and accessibility of tangible resources). This model could serve as a framework for exploring acceptance of smart sensing and its underlying factors. Furthermore, trust has been recognized as a pivotal factor influencing the acceptance of technology and artificial intelligence augmented systems in various application domains (50–52). For example, an individual may receive feedback from a smart sensing system indicating the detection of heightened stress levels and an increased risk of worsening mental symptoms, thus suggesting preventive measures. Depending on the trust in the system, users could either follow the recommended actions or reject them. The first studies that applied the UTAUT framework in the context of smart sensing therefore additionally assessed trust in the technology as a potential facilitator and predictor towards acceptance (53).

Following up on a previous study conducted in a healthy population (53), the present study explores the acceptance of smart sensing a population of people with diabetes to address the following question:

> What is the acceptance of smart sensing in the context of mental health for people with diabetes?

Furthermore, the present study seeks to apply the extended UTAUT framework to validate this model in a diabetes sample.

> We hypothesize that the UTAUT factors performance expectancy, social influence as well as the factor trust are potential determinates of acceptance of smart sensing.

To successfully implement technologies and ensure uptake and optimal use, it is essential to investigate options to promote the acceptance of said technologies. One way to influence acceptance is using acceptance facilitating interventions (AFI). With a theory-based approach (e.g., UTAUT), AFI target specific factors to influence acceptance—for example, by emphasizing personal gain (performance expectancy) or depicting positive user reports (social influence). Considering possible modalities for AFI, especially video-based AFI offer numerous benefits and have been successfully implemented in the context of blended therapy and internet-based mental health interventions (54, 55). Furthermore, with regard to the situational circumstances suitable for the deployment of AFI, optimizing the time spent in clinical waiting rooms for the implementation of video-based interventions could prove advantageous. Although, AFI have been effectively used in numerous studies (55–58), there has been limited research on the impact in the context of smart sensing as well as in a diabetes population.

Thus, the present study investigates how the acceptance of smart sensing in a diabetes sample is influenced by a UTAUT-based AFI compared to an attention control group.

We hypothesize that (a) the self-reported acceptance, (b) the interest in using a smart sensing app, and (c) the rate of actual installation of a smart sensing app on personal smartphones will be higher in the intervention group compared to the control group.

Lastly, in order to understand the acceptance of smart sensing in a more comprehensive way there are a few factors possibly influencing behavioral intention that should be paid attention to. A meta-analysis of the UTAUT (49) found education to be an important factor influencing behavioral intention ($r = 0.18$, $p < 0.05$). Furthermore, a study on personality traits as predictors of perceived and actual usage of technology (59) found significant correlations between behavioral intention to use a technology and conscientiousness ($r = 0.15$, $p < .05$) and agreeableness ($\gamma = 0.29$, $p < .05$). Hence, in sensitivity analysis we analyzed the correlations between behavioral intention to use smart sensing and (a) education and (b) personality.

2 Methods and materials

2.1 Study design and sample

A short-term randomized controlled trial with one measurement time point at post-treatment was conducted online to investigate the effect of the AFI. Participants were randomly assigned to either an intervention group (IG) or a control group (CG). The randomized allocation of participants was automatically managed by the online survey platform LimeSurvey. The study was approved by the Ethics Committee of Ulm University (398/21 – CL/bal.). Participants were enrolled from June 1, 2022 till December 31, 2022. Reporting on this study we follow the CONSORT guidelines (60) (see Supplementary S1).

2.2 Inclusion criteria and data collection procedures

The survey, including all procedures and data collection, was conducted online. Participants were recruited via an e-mail list targeting a study panel of people with diabetes diagnosis as well as study flyers. People were eligible to participate if they met the following self-reported inclusion criteria: (1) aged 18 years or older, (2) being diagnosed with diabetes, (3) having internet access, (4) providing informed consent, and (5) agreement to data processing procedures according to the European General Data Protection Regulation. If any criteria were not fulfilled, participation was rejected.

After answering socio-demographic questions, participants were randomized to either the IG or CG and watched the according video (AFI or control video). Although group allocation was not explicitly mentioned, participants were aware of two study conditions due to the informed consent. After watching the video, the acceptance of smart sensing as well as all assumed determinants were assessed. Furthermore, interest in

signing up for a smart sensing study and actual installation rate of a smart sensing app was assessed.

2.3 Intervention and control condition

Participants in the intervention group watched a whiteboard based AFI video with a total duration of 4:34 min. The UTAUT model served as a basis for the structure and content of the video. Accordingly, the video focused on the following assumed determinants of acceptance: performance expectancy (e.g., application areas, such as self-monitoring and early recognition of mental health symptoms, personal benefits), effort expectancy (e.g., passive data collection, personal involvement), facilitating conditions (e.g., low necessary personal resources), and social influence (e.g., population-specific positive examples and user reports). Based on previous studies, the video additionally aimed to generate trust in the technology (e.g., data safety, anonymized processing). The AFI video started with a general explanation of smart sensing. Next it delved into which data can be collected via smart sensing as well as the process of data collection. The video further explored different application areas of smart sensing. Lastly, positive user experiences, tailored to a population with diabetes, were presented. A more detailed outline of the AFI can be found in Supplementary S2.

Participants in the control group watched an educational video on the concept of mindfulness, the influence of mindfulness on health, and suggestions on how to integrate mindfulness into one's daily life. The duration of the video was 3:00 min.

2.4 Measures and outcomes

2.4.1 Participant characteristics

Demographic variables (i.e., age, gender, nationality, relationship status, and education level), personality dimensions, general mental health symptoms, and diabetes-specific mental health aspects were assessed using a set of questionnaires.

Basic personality dimensions were assessed with the 10-item version of the Big Five Inventory (BFI-10) (61). The BFI-10 evaluates openness, conscientiousness, extraversion, agreeableness, and neuroticism with a 5-point Likert scale from "fully disagree" to "fully agree". For evaluation purposes, the mean score was computed for each subscale.

2.4.1.1 Health status

Depression symptoms over the past two weeks were assessed using the 8-item Patient Health Questionnaire (PHQ-8). Using a 4-point Likert scale ranging from "Not at all" to "Nearly every day", a sum score is computed (range 0–24). Higher scores indicate higher depressive symptoms, and scores of 10 or higher are considered to indicate clinically elevated depressive symptoms (62).

Anxiety symptoms over the last two weeks were assessed with the 7-item Generalized Anxiety Disorder Questionnaire (GAD-7). Items are answered on a 4-point Likert scale from "not at all" to

"nearly every day". Sum scores range from 0 to 21 with higher scores indicating higher anxiety symptoms (63).

Sleeping problems were assessed with the Insomnia Severity Index (ISI-7). The scale consists of seven questions regarding worries, occurrence, and severity of abnormal sleep patterns, and their harmful effects. The questions are answered on a 5-point Likert-scale ranging from 0 to 4. High sum scores (range 0–28) indicate more sleep problems (64).

The Self-Efficacy Scale (SES) assesses self-efficacy using questions on one's perceived personal competence and control. The inventory consists of 10 items answered on a 4-point Likert scale with higher scores (range 10–40) indicating higher self-efficacy (65).

The Fear of Progression Questionnaire Short Form (FoP-Q-SF) assesses worries and fear of disease progression and its consequences using 12 items and a 5-point Likert scale (from "never" to "very often"). Higher total scores (range 12–60) indicate higher fear of progression (66).

To assess the degree of possible participation and hindrance, the Index for the Assessment of Health Impairments (IMET) was used. The IMET consists of nine questions answered on a 11-point Likert scale. Item scores are summed to a total score (range 0–90) indicating the extent of impairment (67).

Emotional distress related to diabetes was assessed using the Diabetes Distress Scale (DDS). The questionnaire consists of 17 items requesting emotional problems related to diabetes in the last 4 weeks. The items can be summed to a total score as well as four subscale scores to evaluate specific levels of distress. The scale scores range from 0 to 6 with higher scores indicating higher distress (68).

The Diabetes Self-Management Questionnaire–Revised (DSMQ-R) is a 20-item battery which assesses diabetes self-care activities aiming to manage glucose levels and prevent long-term complications. For analysis of diabetes self-care, the sum score (range 0–10) was calculated (69).

2.4.2 Acceptance measures

Self-reported acceptance was assessed with the behavioral intention scale of the UTAUT questionnaire (47, 49, 70). The scale consists of four items rating one's intention to use a smart sensing app on a five-point Likert scale (ranging from "fully disagree" to "fully agree"). The sum score was categorized as suggested in previous studies (54–58): low acceptance = sum scores from 4 to 9, moderate acceptance = sum scores from 10 to 15, and high acceptance = sum scores from 16 to 20. Secondly, the level of interest was gauged based on the count and proportion of participants who explicitly expressed a willingness to utilize a smart sensing app. Subsequently, the behavioral outcome was evaluated directly by examining the count and percentage of actual installations of the smart sensing app.

2.4.3 Determinants of acceptance

As potential determinants of acceptance, performance expectancy (3 items), effort expectancy (3 items), social influence (2 items), and facilitating conditions (2 items) were assessed with the UTAUT questionnaire (47, 49, 70). All items were rated on a

five-point Likert scale from "fully disagree" to "fully agree". All UTAUT items can be found in Supplementary S3.

Trust in the technology was assessed with the short form of the German Automation Trust Scale, adapted to the digital health context (50, 71). Seven items are rated on a seven-point Likert scale from "fully disagree" to "fully agree". The sum score ranges from 7 to 49 with high scores indicating high trust in the technology.

2.5 Statistical analysis

All data analysis followed the per-protocol principle. Participants that dropped out before the randomization or did not receive the intervention as well as were removed. Demographic, mental health, and acceptance-related variables were analyzed using standard descriptive statistics. P-values <0.05 were considered to indicate statistical significance in all analyses.

2.5.1 Acceptance of smart sensing for health

Following previous studies on the acceptance of digital interventions (54–58), the acceptance of smart sensing was assessed as self-reported acceptance, rates of self-reported interest in using smart sensing, and actual installation rates of a smart sensing application (technologically validated via a smart sensing app). The general acceptance of smart sensing is assumed using the acceptance in the CG which did not receive any AFI.

2.5.2 Predictors of acceptance: latent structural equation modeling

The influence of potential determinants of acceptance was investigated using latent structural equation modeling (SEM). A measurement model consisting of latent factors for all items of acceptance, performance expectancy, effort expectancy, facilitating conditions, social influence, and trust was defined as a first step. In the next step, the effects of the latent factors on acceptance were introduced. The proposed predictors performance expectancy, social influence and trust were tested one-sided based on the previous model on acceptance of smart sensing (53).

The root mean square error of approximation (RMSEA) as a non-centrality parameter and the standardized root mean square residual (SRMR) as a residual index were used to assess the goodness of fit (72–74). Acceptable model fit was determined using accepted cut-off guidelines for RMSEA (<0.08) and SRMR (≤0.08) (75–77). Missing date was handled using full information maximum likelihood (78). Robust (Huber-White) standard errors were obtained.

2.5.3 Intervention effects

The effects on acceptance were analyzed on a dimensional level. A t-test was used for the observed data and effects on the latent level were investigated using the SEM, introducing group allocation into the model as a dummy-coded predictor.

2.5.4 Sensitivity analysis

To explore the relationship between education, personality and acceptance we performed correlative sensitivity analysis. Education

level (higher values indicating higher education) was summarized according to the International Standard Classification of Education: ISCED-11. Personality was investigated for each subscale (openness, conscientiousness, extraversion, agreeableness, and neuroticism).

2.6 Software

The statistical software R was used for all analyses (79). The R package "lavaan" was used as the core package for all structural equation models (80). See Supplementary S4 for an overview of all packages and versions used in the present analysis.

3 Results

A total of $N = 132$ individuals provided informed consent, were included in the study, and randomized to their groups (CG: $n = 72$; IG: $n = 60$). The study flow is depicted in Figure 1. Participants were between 27 and 81 years of age ($M = 57.63$, $SD = 12.39$). Gender was distributed unequally (40.2% female, $n = 53$). Most participants (60.6%, $n = 80$) had an advanced qualification level (e.g., bachelor degree and higher). A majority had a diabetes type-1 diagnosis (74.2%, $n = 98$) compared to a diabetes type-2 diagnosis (25.8%, $n = 34$). On average, participants reported mental health symptoms below clinical relevance (PHQ-8: $M = 5.74$, $SD = 4.57$; GAD-7: $M = 4.32$, $SD = 3.72$; ISI-7: $M = 7.60$, $SD = 5.76$). Diabetes Distress was $M = 1.71$ ($SD = 0.86$), whilst the average diabetes self-management score suggested suboptimal behavior ($M = 4.13$, $SD = 0.51$). For further details and group-specific information see Table 1.

3.1 General acceptance of smart sensing

In the CG a total of $n = 20$ participants (27.8%) reported low, $n = 29$ (40.3%) moderate, and $n = 23$ (31.9%) high acceptance
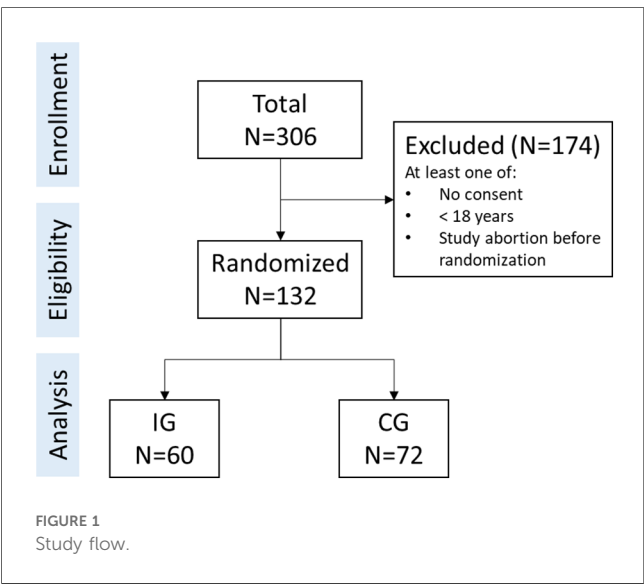

FIGURE 1
Study flow.

TABLE 1 Sample characteristics.

	All $N = 132$	IG $n = 60$	CG $n = 72$
Demographics			
Age, mean (SD)	57.63 (12.39)	58.23 (12.64)	57.125 (12.25)
Female gender	53 (40.2%)	26 (43.3%)	27 (37.5%)
Nationality			
German	127 (96.2%)	59 (98.3%)	68 (94.4%)
Others	5 (3.8%)	1 (1.7%)	4 (4.6%)
Relationship status			
Single	27 (20.5%)	11 (18.3%)	16 (22.2%)
In relationship	105 (79.5%)	49 (81.7%)	56 (77.8%)
Qualification level[a]			
Basic	2 (1.5%)	0 (0%)	2 (2.8%)
Intermediate	50 (37.9%)	20 (33.3%)	30 (41.7%)
Advanced	80 (60.6%)	40 (66.7%)	40 (55.6%)
Diabetes type			
Type-1	98 (74.2%)	48 (80%)	50 (69.4%)
Type-2	34 (25.8%)	12 (20%)	22 (30.6%)
Personality facets, mean (SD)			
Openness	3.28 (0.94)	3.27 (1.02)	3.29 (0.88)
Conscientiousness	2.90 (0.77)	2.86 (0.70)	2.94 (0.82)
Extraversion	3.12 (0.95)	2.96 (0.86)	3.26 (1.00)
Agreeableness	3.16 (0.79)	3.19 (0.70)	3.14 (0.87)
Neuroticism	2.78 (0.99)	2.59 (0.98)	2.95 (0.97)
Health variables, mean (SD)			
Depressive symptoms (PHQ-8)	5.74 (4.57)	5.36 (4.14)	6.08 (4.92)
Anxiety symptoms (GAD-7)	4.32 (3.72)	3.80 (3.54)	4.77 (3.85)
Sleep problems (ISI-7)	7.60 (5.76)	7.98 (5.97)	7.29 (5.61)
Diabetes distress (DDS)	1.71 (0.86)	1.66 (0.90)	1.76 (0.83)
Fear of progression (FoP-Q-SF)	24.91 (8.69)	23.78 (8.71)	25.88 (8.63)
Self-efficacy (SES)	29.73 (3.89)	30.00 (4.09)	29.50 (3.73)
Diabetes self-management (DSMQ)	4.13 (0.51)	4.23 (0.57)	4.04 (0.43)
Health impairment (IMET)	16.67 (17.12)	17.81 (16.63)	15.73 (17.62)

[a]Education level is summarized according to the International Standard Classification of Education: ISCED-11.

(see Figure 2). The unmanipulated self-reported acceptance of smart sensing in the CG was average $M = 12.64$ ($SD = 4.24$, Min = 4, Max = 19).

A total of $n = 36$ (50.0%) participants indicated interest in trying out smart sensing in another study (no interest: $n = 16$, 22.2%; not responded: $n = 20$, 27.8%). Of all 36 participants with interest, only $n = 12$ (33.3%; 16.7% of all participants in the CG) installed the smart sensing app.

3.2 Predictor variables associated with acceptance

The final measurement model for acceptance, performance expectancy, effort expectancy, facilitating conditions, social influence, and trust, showed an acceptable fit (RMSEA = 0.074, SRMR = 0.058). See Supplementary S5 for all model parameters.

In the next step, the latent effects on acceptance across groups were analyzed. Performance expectancy ($\gamma = 0.64$, $p < .001$), social influence ($\gamma = 0.23$, $p = .032$) and trust ($\gamma = 0.27$, $p = .039$) were
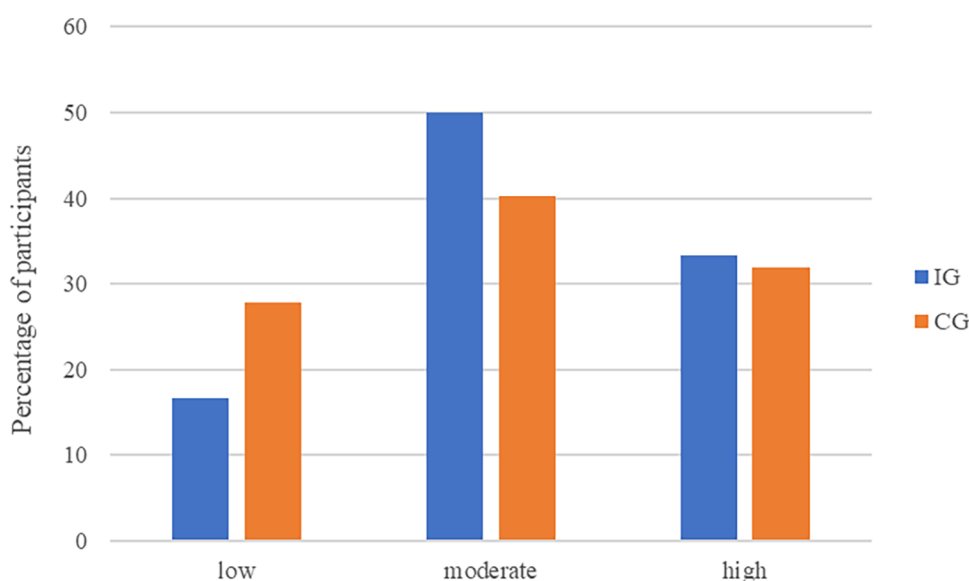
FIGURE 2
Acceptance of smart sensing levels across treatment groups. The UTAUT behavioral intention sum score categorized acceptance as low (sum score: 4−9), moderate (sum score: 10−15), and high (sum score: 16−20).

identified as predictor variables of acceptance (overall model fit: RMSEA = 0.073, SRMR = 0.059). Effort expectancy and facilitating conditions were not significant. The three variables explained 83.8% of the variance of the latent acceptance factor. The final path model is displayed in Figure 3. All model parameters are included in Supplementary S6.

3.3 Intervention effects

With an average self-reported acceptance of $M = 13.47$ ($SD = 3.80$, Min = 4, Max = 20) in the IG, the level of acceptance of smart sensing was not significantly higher than in the CG ($d = 0.20$, 95%-CI: −0.14–0.55, $t = 1.17$, $df = 130$, $p = .244$). This result was corroborated by the SEM analysis on latent level ($\gamma = 0.25$, 95%-CI: −0.16–0.65, $p = .233$). The distributions of acceptance levels in the IG and the CG are displayed in Figure 2.

In the IG, $n = 26$ (43.3%) participants stated interest to try smart sensing in a subsequent study (no interest: $n = 20$, 33.3%; not responded: $n = 14$, 23.3%). Among the 26 participants with interest, $n = 12$ (46.2%; 20.0% of all participants in the IG) actually installed the smart sensing app on their smartphones. The intervention effects and group-specific results are given in Table 2.

3.4 Sensitivity analysis

We found no significant correlation between education and behavioral intention ($r = 0.06$, $p = .513$). For personality only conscientiousness significantly correlated with behavioral intention ($r = 0.22$, $p = .031$). For the correlation matrix see Supplementary S7.

4 Discussion

We investigated the acceptance of smart sensing and the effect of an AFI towards smart sensing in a diabetes sample. The general acceptance toward smart sensing varied a lot between participants. The hypothetic model of acceptance towards smart sensing with three significant predictors (performance expectancy, social influence and trust) fit the data well, explained 84% variance of the self-reported acceptance, and thereby supported the validity of the model. The UTAUT-based intervention was not able to affect the acceptance of smart sensing.

Given that the treatment guidelines for diabetes recommend yearly and occasion-related diagnosis of common consequential and comorbid diseases including depression and other psychological disorders (81, 82), the integration of smart sensing systems, offering fine-granular, unobtrusive, objective and ecological valid assessments, could function as a form of passive screening support. This has the potential to improve healthcare systems, where resources are often restricted and time-efficient solutions are needed (23, 24). In order to translate encouraging findings from smart sensing studies (37, 38, 83) into tangible healthcare solutions, it is essential to address underlying processes governing both initial and long-term use. This involves a comprehensive understanding of user acceptance and the influencing factors. However, the challenge at hand appears to be two-fold. First, it necessitates a comprehensive examination of general acceptance, and second, it involves addressing the disparity between acceptance and the tangible use of the technology.

This study revealed an average baseline acceptance within our somatic sample (M = 12.64, SD = 4.24) which was higher compared to a healthy population (M = 10.9, SD = 3.73) (53). This inclination could be attributed to the pervasive presence of sensing and
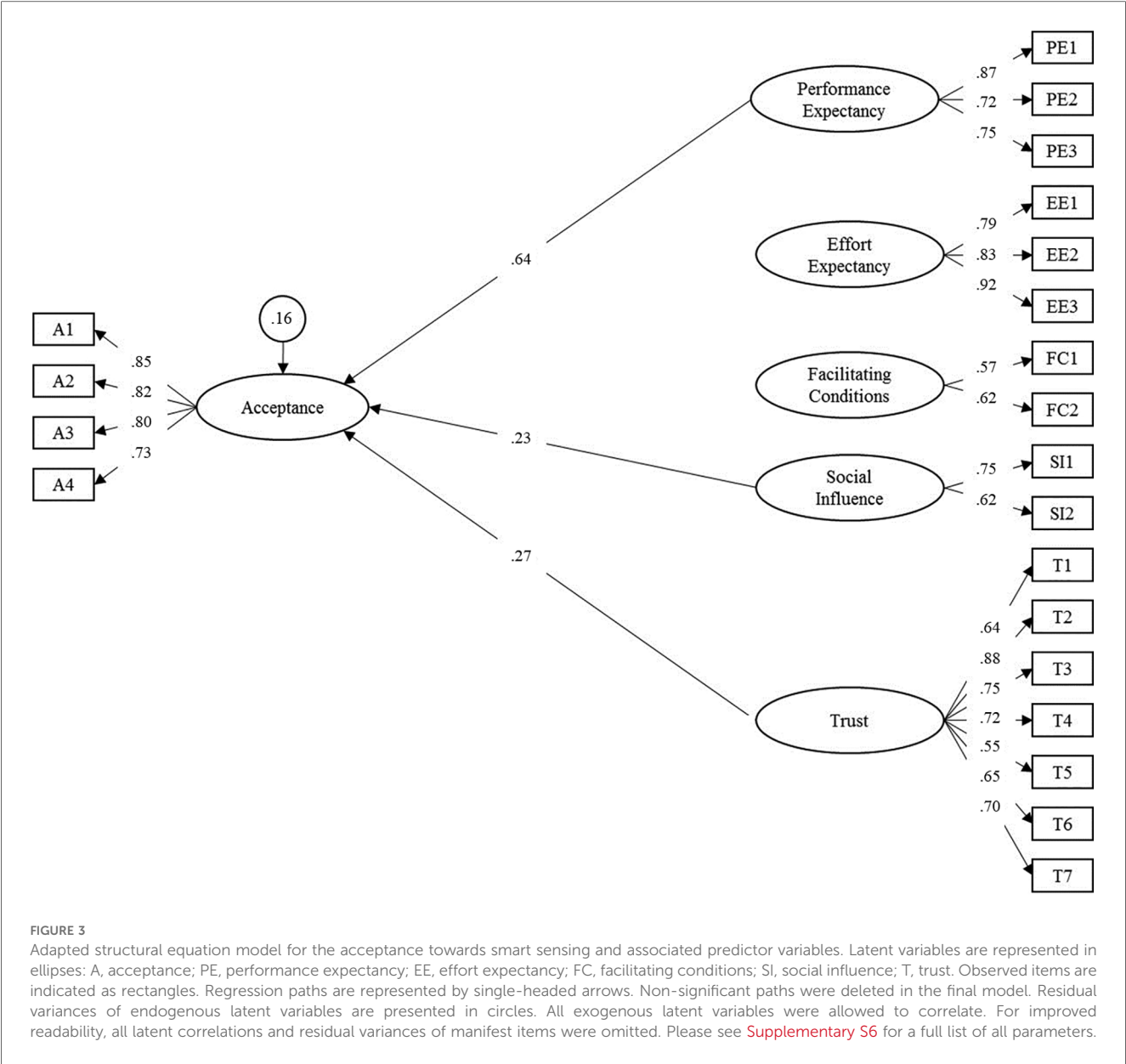
FIGURE 3
Adapted structural equation model for the acceptance towards smart sensing and associated predictor variables. Latent variables are represented in ellipses: A, acceptance; PE, performance expectancy; EE, effort expectancy; FC, facilitating conditions; SI, social influence; T, trust. Observed items are indicated as rectangles. Regression paths are represented by single-headed arrows. Non-significant paths were deleted in the final model. Residual variances of endogenous latent variables are presented in circles. All exogenous latent variables were allowed to correlate. For improved readability, all latent correlations and residual variances of manifest items were omitted. Please see Supplementary S6 for a full list of all parameters.

TABLE 2 Summary of intervention effects.

Outcome	CG	IG	Effect size	CI	P-value
Acceptance	12.64 (4.24)[a]	13.47 (3.80)[a]	$d = 0.20$[b]	−0.14–0.55	0.244
			$\gamma = 0.25$[c]	−0.16–0.65	0.233
Interest	$n = 36$ (50.0%)	$n = 26$ (43.3%)	OR = 0.76	0.38–1.52	0.445
Installation	$n = 12$ (16.7%)	$n = 12$ (20.0%)	OR = 1.13	0.47–2.73	0.777

CI, confidence interval; OR, odds ratio.
[a]Mean (and standard deviation) of behavioral intention.
[b]Mean difference between IG and CG based on observed data.
[c]Unstandardized group difference between IG and CG based on SEM.

monitoring technologies in the daily routines of individuals living with diabetes (42). Although, this trend extended to the installation rates of smart sensing applications, a mere half of the study participants expressed interest in a smart sensing application. Moreover, only

17% and 20% of the CG and IG, respectively, proceeded to install the smart sensing app. Thus, the transfer from intention to use towards actual utilization needs to be addressed in future studies. This seems particularly relevant for the diabetes population, where existing daily self-management must be considered (84). Furthermore, it is important to not only measure the initiation of smart sensing usage but also its continuous use, including frequency and duration. Given that effective smart sensing systems often function as longitudinal assessments, it becomes crucial to explore strategies that foster optimal user performance. Within this context, user engagement and usability play a crucial role, warranting further investigation into personal habits that may facilitate the utilization of smart sensing (85, 86). Additionally, future research could additionally focus on design aspects supporting uptake of smart sensing applications (87, 88) as well specific factors such as potential structural or attitudinal barriers (89).

Consistently with a parallel study involving a healthy population (53), this study identified performance expectancy, social influence, and trust as associated factors of acceptance. Results regarding the hypothetic factor model of smart sensing acceptance and its potential determinants were consistent across these studies, supporting validity of the model. Notably, in our study, performance expectancy was of even greater importance in relation to other potential determinants. This could indicate the importance of addressing crucial needs and pointing out provided benefits of smart sensing.

In this study, the concept of trust was defined as the confidence that a system has the capability to assist in accomplishing an individual's objectives within situations characterized by uncertainty or vulnerability (52). With this understanding, people would show trust by believing in system predictions and following recommendations. However, given that privacy and data security are pivotal considerations in the implementation of smart sensing, future studies should delve into more nuanced distinctions within the realm of trust factors and explore diverse aspects. Smart sensing has the potential to facilitate highly sensitive health predictions, such as mental health screenings. Consequently, it would be beneficial to differentiate between trust in the system, trust in the potential predictions made by the system, and trust in the proper handling of this data. This distinction becomes particularly pertinent in light of political developments, underscoring the need for measures to ensure data privacy, security, and prevention of misuse (90). Moreover, the type of data collected and the entities with whom this data is shared play a crucial role in acceptance. For instance, in a recent study people indicated higher willingness to share sleep data with their physicians than location data, while the acceptance of the inclusion of this data in patient records was rather low in general (91). On a more general note, the public attitude and acceptance of digital health care systems remains a major barrier (53, 92–94). Broader public approaches could play a role in educating and thus leading to familiarization of digital healthcare on a population level. Moving forward, transparency concerning the usage, processing, and storage of data, as well as delineating who has access to the data and who does not, should be emphasized. This could be helpful to fostering user trust and, consequently, enhancing the acceptance of smart sensing technologies.

The implemented AFI did not impact acceptance of smart sensing. Therefore, a pivotal consideration is the improvement of the intervention itself. The current AFI format strategically targeted acceptance determinants based on the UTAUT, supplemented with everyday examples in a whiteboard design. Based on the cognitive theory of multimedia learning, dividing information into verbal and visual components results in reduced cognitive load (95). This could be further improved through a strengthened narrative approach, such as illustrating app functions and presenting extended case examples or short hands-on experience (95–97). Furthermore, expert opinions, as demonstrated in previous (53, 54, 56), might be useful to influence acceptance. It may be worthwhile to explore a mixed modality approach that includes expert opinions tailored to the specific needs and characteristics of the target population,

alongside with dynamically visualized content. A similar study on acceptance of smart sensing in psychotherapy patients that focused on information presented by an expert showed promising results for an AFI to influence behavioral intention to use smart sensing (94). Future studies could additionally focus on the effectiveness of interventions in relation to baseline levels of acceptance. Given the above average acceptance in our sample a targeted approach towards individuals with lower levels of baseline acceptance could prove to be more beneficial. This could be implemented using a Solomon four-group study design and looking at interaction effects (98). Consequently, the effectiveness of AFI formats within the realm of smart sensing remains unclear and requires further exploration.

While interpreting the results and discussing future implications, it is crucial to acknowledge several limitations of the present research. First, the trial was critically underpowered to detect a significant intervention effect on acceptance, emphasizing the need for future confirmatory studies with an appropriately sized sample. Second, cross-sectional data are an insufficient basis for uncovering causal relationships. To comprehensively understand the dynamics of smart sensing acceptance and its potential determinants, longitudinal assessments featuring multiple measurement time points are needed. Third, the consideration of common-method bias is necessary, given that acceptance and its predicting variables were evaluated with the same questionnaire. This introduces a source of variance attributable to the measurement method rather than to the constructs, potentially inflating higher variable correlations. To mitigate this, further independent acceptance outcome measures should be considered. The generalization of our findings is further limited as our sample exhibited an overrepresentation of individuals with reported German nationality and high education levels. Moreover, despite covering a broad age range (27–81 years), the relatively high average age (58 years) poses a limitation on the transfer of the findings to a younger population. This is particularly pertinent given the elevated technological affinity and smartphone usage rates among younger individuals (99), potentially leading to distinct differences in the acceptance of smart sensing. Furthermore, the reported mental health symptoms, including depression, anxiety, and diabetes distress, were within a sub-clinical range. Given that performance expectancy emerged as the most strongly associated correlate of acceptance, it is plausible that the perceived personal benefit might be higher for more burdened individuals. These nuances should be taken into account in future research to provide a more comprehensive understanding of smart sensing acceptance across diverse contexts.

5 Conclusions

This study found a heterogenous distribution of acceptance of smart sensing with a relatively large percentage of participant reporting low acceptance, posing a hindrance to the implementation of smart sensing in research and practice. Performance expectancy, social influence, and trust in smart

sensing were strongly associated with higher acceptance, suggesting that these aspects may constitute relevant influencing factors towards acceptance. Especially perceived benefit influenced the acceptance amongst the diabetic sample and should be paid special attention in the future. The developed AFI did not affect smart sensing acceptance, thus more effective intervention strategies must be developed. Further exploration of acceptance facilitating interventions on smart sensing are needed. Moving forward, research should look into barriers towards acceptance of smart sensing, which are essential for future implementation in routine health care. The results from this study of people with diabetes furthermore suggest that looking into different somatic areas and groups might detect important individual differences regarding smart sensing acceptance. To fully harness the potential of smart sensing technologies, acceptance, implementation and relevant stakeholders need to be taken into account.

Data availability statement

Data requests should be directed to the corresponding author (JK). Data can be shared with researchers who provide a methodologically sound proposal, which is not already covered by other researchers. Data can only be shared for projects if the General Data Protection Regulation is met. Requestors may need to sign additional data access agreements. Support depends on available resources.

Ethics statement

The studies involving humans were approved by Ethics Commitee of Ulm University. 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

JK and YT initiated this study. JK, YT and HB contributed to the study design and concept. JK, YT, and AS contributed to the study recruitment and data collection. JK performed the analysis and drafted the manuscript. All authors had access to all the data in the study, revised the manuscript, approved the final version, and agree to be accountable for the content of the work.

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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/fdgth.2024.1352762/full#supplementary-material

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