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COVID-19: Challenges, opportunities and lessons for occupational health

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COVID-19: Challenges, opportunities and lessons for occupational health

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Editorial: COVID-19: Challenges, opportunities and lessons for occupational health

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Editorial on the Research Topic
COVID-19: Challenges, opportunities and lessons for occupational health

Introduction

We offer a collection of viewpoints from international submissions addressing the impact of the current pandemic on workers and their health.

As of end November 2022, the likely underestimated confirmed global COVID-19 death count was 6.7 million, and total confirmed cases were 650 million, among a global 8 billion population. It has exacerbated poverty and economic, social and political inequalities. The COVID-19 pandemic has incurred a devastating impact on workers globally, and has adversely affected worker rights, including those of the vast informal, migrant, temporary and unemployed workforce (1, 2).

In October 2021, *Frontiers* petitioned globally for studies of the impact of COVID-19 on occupational health to come up with lessons to prepare for future pandemics. Some key topics posted by the editorial panel for research included occupational health equity, international cooperation, medico-legal aspects, vulnerable workers, and a call for strategy and policy insights.

Since then, a total of 19 papers from 11 nations were published. Eleven papers focused on mental, physical and performance impacts of health workers, while three reported on non-healthcare front-facing services, education (teachers and students), and other sectors, respectively. One was a study of exposure risk indicators proposing a possible new job risk measure of Hospital Daily Admissions where other standard epidemiological indices might be sparse, as in low-resource settings.

Health workers were undoubtedly among the highest risk groups for adverse impacts. However, the risk of severe COVID-19 infection among health workers can be

remarkably reduced by strict adherence to public health measures at the workplace as was reported by a recent study (3). This suggests that there is still much to be investigated and learned to inform preventive and control guidance for future pandemics, not only in health work but in all work settings.

A summary of the 19 articles follows. Most were cross-sectional descriptive studies based on questionnaire surveys or records review, though qualitative reports and opinions were included.

Health workers

Mental health

A survey from Iran by Karimi et al., of 170 hospital nursing staff caring for COVID-19 patients, using the Maslach Burnout Inventory, Turnover Intention and Michigan Organizational Assessment for Intent to Leave questionnaires, suggested that reduced personal accomplishment was a strong predictor of intent to leave. They recommended coping strategy counseling.

A report by Wang H. et al., sought to clarify stressful factors affecting health workers in temporary alternative care facilities in northeast China that handled hospital overflow during the COVID-19 pandemic. They identified five major factors with passive factors related to facilities design and active factors related to personal protective equipment (PPE) and counseling.

A systematic review of 12 studies of adverse physical and psychological impacts and adaptations of 121 COVID-19 ICU nurses (China 6, Turkey 2, Iran 2, USA 1, Spain 1) by Han et al., found that managers should support nurses with strategies integrating all aspects of the work and social environment to maintain workforce coping and satisfaction.

A survey from China of comparing a total of 1,000+ nurses and COVID-19 patients by Zhao et al., using the wellknown PHQ-9 (depression) and GAD-7 (anxiety) inventories found that nurses exhibited significantly more depression than patients, while patients were more anxious than nurses. Over 95% of these frontline nurses and COVID-19 patients reported having not received pre-pandemic counseling, and such counseling was recommended.

Daryanto et al. surveyed 1,077 health workers in an urban area of Java Indonesia and found that one-fifth suffered burnout, most strongly associated with young age and long work hours.

An online descriptive psychological survey from Japan by Sawamura et al., of 4,418 occupational therapists (OT) in two work domains—physical and mental health services—assessed the prevalence of anxiety, depression, insomnia and loneliness and found decreases in OT care quality with the main factor being depression in the physical health OT service sector, and insomnia in the mental health OT sector.

Risk factors

From northern Pakistan, Manzoor and Alomari utilized a Capability Opportunity Motivation-Behavioral model (COM-B) to investigate factors among 9,000 dentists that determine degree of adherence to COVID-19 Standard Operating Procedures (SOPs) for dental surgical procedures. They suggested the importance of providing increased holistic support through infrastructure, facilities, financing, training and PPE to increase adoption of COVID-19 SOPs.

A qualitative review of COVID-19 hospital ward nurses in Iran by Mokhtari et al. identified four risk categories: sudden unknown threat exposure; exaggerated stress; feeling of being in an unequal war; and need to increase efforts to confine the threat to maintain good ethical and clinical decision-making. Their concerns were thought to be rooted in organizational and governmental issues.

A Patient Safety Culture Survey using a six-dimension safety attitudes questionnaire of 706 COVID-19 health workers in Taiwan by Wang S. J. et al., intended to address improvement in patient outcomes and health worker risks, revealed that key risk factors affecting patient safety were health worker emotional exhaustion (EE) and work-life balance (WLB) disruption. Government interventions that decreased workload to reasonable levels and that enhanced communication, improved health worker attitudes from negative to positive on safety climate, job satisfaction and perception of management. EE and WLB also improved.

Over 4 weeks at a hospital outpatient clinic in China, Zhang et al. surveyed body temperature and symptoms by questionnaire of all, >60,000, patients. They recommended increasing strategies for patient screening to improve prevention of health worker COVID-19 infection risk.

Compliance with IPC best practices by 600 health workers in Malaysia was assessed by Mohamad et al., using the WHO Interim Guidance questionnaire on exposure risk assessment and management for health workers. They reported a 63.7% compliance rate (all responses "always"), leaving a significant >36% of health workers not compliant. The authors recommended intervention and monitoring programs for IPC and OH programs such as an OH committee.

A creative study from France, Valter et al., proposed a possible new standard for COVID-19 exposure risk for communities and work places (JEM, job exposure matrices) that we already know locally to include these four: ICU % occupancy; reproductive number (R_0), COVID-19 test positivity rate; and number of positive cases per population reference. These epidemiological risk estimates are often difficult to truly compare. The authors proposed a fifth JEM called Daily Hospital Admissions (DHA) on a population level that can be applied to specific local job titles. They suggested DHA might be particularly useful in low-resource settings where data are lacking for other JEMs.

Hand dermatitis and workplace violence

Clinical and hierarchy of control interventions were the focus of presumptive irritant contact hand dermatitis among a cohort of 21 health workers in a Singapore hospital related to ABHR (alcohol-based hand rub) product use averaging 50 times daily, and possibly glove use including latex, reported by Loi et al. Clinical outcomes were followed by the hospital occupational health service doctors over several weeks. While some health workers were variably relegated to topical treatment and to temporary work restriction, or to modified duties to reduce exposures, ∼80% reported improved symptoms, some with full resolution. Authors recommended milder ABHRs and if needed temporary job modification, with consideration of elimination of latex gloves and further evaluation.

Patient and visitor violence (PVV), a kind of Work Place Violence (WPV), toward health workers is common and during COVID-19 was studied in a survey of 754 health workers in China by Guo et al., who reported doctors were at 5.3 times higher risk of physical PVV compared with nursing staff. The authors identified that security measures are very important to protect health workers from PVV, and recommended comprehensive IPC and WPV programs.

Workers of other sectors

A qualitative interview by Wei H. et al., of 11 frontline workers in 6 companies in the "logistics" sector in the UK (takeaway and food delivery, goods delivery, home appliance installation, and tech services) identified drivers of and obstacles to rapid implementation of Public Health Non-Pharmaceutical Interventions and Occupational Hygiene Hierarchy of Controls including COVID-19 testing. They recommended a "rapid response model" to address IPC and RMM (risk mitigation measures).

An online survey of 27,036 workers in Japan (50% desk work, 25% laborers, and 25% customer communicators) by Tesen et al., suggested that loneliness should be considered a risk for sleep problems and that family and friend support may have a modifying effect on sleep disturbance.

Canadian teachers were surveyed cross-sectionally using the WHO Disability Assessment Schedule-2.0 by Serrano et al., on their perception of COVID-19 impact on work function. Six functional domains (cognition, mobility, self-care, getting along, life activities, participation) were assessed as either unchanged, worse, or better. Risk factors included pre-existing inequality and mental health challenges as predictors. Educators reported worsening of work function from the start of the COVID-19 pandemic. Mental health challenges and pre-existing inequality were considered predictors of pandemic-related performance difficulties. Recommendations included worker telehealth counseling services and policies for overall self-health promotion.

A descriptive study by Wei C.-F. et al., of 780 health workers and customer facing workers at a community COVID-19 testing center in the USA reported a four-fold risk of COVID-19 infection in health workers and a two-fold risk of COVID-19 infection among customer facing workers. This was compared with non-customer facing workers.

Opportunities

Sara from the US outlined three opportunities for lasting public health change and future pandemics crises: tele-healthcare, remote work and remote education, and vaccinations.

Lessons and recommendations[1]

Nineteen studies were published in 2022 in the Research Topic co-edited by us. Most were cross-sectional surveys, a majority on health workers, and there were a few other work group studies with recommendations for future prevention.

Contributions were very enlightening. We find however that there is still a paucity of studies to help explain the hideous ways of pandemics among working populations. As such, there is a need to continue pandemic research globally with regard to workers in all sectors. It clearly has a place among health workers but also among so many other vulnerable worker sectors who lack adequate individual means of infection prevention and control.

Studies published in this Research Topic indicate that pro-active workplace implementation of evidence-based public health and occupational health measures regarding principles of IPC and of occupational hygiene hierarchy of controls, including vaccinations and honest media communication, is the key to workplace pandemic preparedness and trust. We wish to add that the implementation of preventive basic occupational health services especially for vulnerable workplaces and communities in low- and middle-income countries, with proper foresight, planning and finance, will contribute to mitigating future pandemics.

For the world to be better prepared for future pandemics, the followings could be emphasized: (1) A global need for better mechanisms for prediction, risk assessment, and preparedness for pandemics, paying attention to the workers, working environment and occupational hygiene of the most vulnerable sectors; (2) Strategies, policies, and programs for earliest possible warnings and actions for eliminating the sources of local epidemics and preventing them from growing

1 Recommendations in this editorial are of the opinion of co-editors, not of their employers by any means.

to a pandemic, taking into account of the workplace, which is often on the frontline of epidemic risks and may also be a distributor of risks to the rest of society (health sector, food industries, service sectors, schools, etc.); and (3) Sufficient and well-maintained resources and reserves at the workplace, local community, national and global levels for effective prevention and management of epidemic risks, including juridical, organizational, material, information, and human resources.

In the global context of international cooperation, the most equitable approach to mitigating the future pandemics is the universal provision of preventive occupational health services for all workers, especially for the vulnerable, within the framework of the UN Sustainable Development Goals (SDGs) on Universal Health Coverage (SDG-3) and Decent Work (SDG-8).

Author contributions

MZ drafted the first manuscript and other co-editors provided comments. TG, JR, and YA contributed to formulating key lessons. TG and RK prepared the final version which was approved by all co-authors. All authors contributed to the article and approved the submitted version.

Conflict of interest

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

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Nurse's Psychological Experiences of Caring for Severe COVID-19 Patients in Intensive Care Units: A Qualitative Meta-Synthesis

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Background: COVID-19 has been listed as an international public health emergency. During the pandemic, the nurses were affected physically and mentally when in contact with and caring for patients infected with COVID-19, especially those in intensive care units (ICUs).

Objective: To summarize and evaluate the actual psychological experience of nurses caring for patients with severe pneumonia in the ICUs during the COVID-19 pandemic.

Methods: Relevant publications were identified by systematic searches across 11 databases in December 2021. All qualitative and mixed-method studies in English and Chinese from 2019 that explored the experiences of nurses who cared for severe COVID-19 patients in ICUs were included. The qualitative meta-synthesis followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) recommendations. Two independent reviewers selected the studies and assessed the quality of each study. Meta-synthesis was performed to integrate the results.

Results: A total of 12 studies revealed 9 sub-themes and 3 descriptive themes: physical reactions and psychological changes, the need for support from multiple sources, and increased adaptation and resilience.

Conclusion: Nurses who treated severe COVID-19 patients have experienced severe work trials and emotional reactions during the pandemic. They have also developed personally in this process. Managers should develop strategies that address the nurse's needs for external support, reasonably respond to public health emergencies, and improve nursing care outcomes.

Keywords: nurses, severe COVID-19 patients, intensive care unit, psychological experiences, meta-synthesis, qualitative systematic review

INTRODUCTION

The World Health Organization (WHO) declared the outbreak of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) that caused the 2019 coronavirus disease (COVID-19) as the public health emergency of international concern and characterized it as a pandemic (1). The virus is mainly transmitted through saliva droplets or discharged from the nose when an infected

person coughs or sneezes or *via* the air through aerosols (2). The infection symptomatology varies drastically from no symptoms to life-threatening complications, including acute respiratory distress syndrome, multisystem organ failure, and death (3). Patients in critical condition have a greater risk of death and require intensive care (4). Treating and caring for critically ill patients is a difficult task with a high risk of infection.

The intensive care unit (ICU) was the primary venue for the treatment and nursing patients with severe COVID-19, which could provide advanced medical technology and special monitoring. An average of 25% (5–32% dependent on the institution and the country) of hospitalized patients were treated in the ICU (5, 6). In the early months of 2020, more than 42,000 medical staff supported Hubei province from other regions in China, nurses accounted for >60% of all medical staff (7). The nurses were the primary caregivers for COVID-19 patients in the ICU. They monitored the vital signs, collected specimens, provided nutritional support, carried out disinfection and other basic work, and also provided professional nursing such as non-invasive and invasive ventilation, conventional acute respiratory distress syndrome procedures, mechanical circulation support (ECMO), and coped with the disease changes occurring in patients at any time; hence, they are always considered a highly stressed group (5, 8, 9). Frontline nurses were directly exposed to the COVID-19 virus and were at high risk of infection without adequate protection (10). Moreover, faced with the high intensity of work, many of them worked long shifts for weeks without a sufficient number of days off, and their physical and mental health was at a disadvantage (11).

An increase in the amount and intensity of work was inevitable for nurses during the pandemic. In addition, they had to get accustomed to risks, practices, and new protocols (12). The WHO pointed out that healthcare professionals faced multiple psychosocial hazards during the COVID-19 pandemic, which could lead to fatigue, occupational burnout, increased psychological distress, and decreased mental health. These affected the health of the healthcare workers and the quality and safety of the care delivered (13). In addition, in similar crises, such as severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS), nurses were exposed to severe stresses sources, including the fear of infection, stigma, and lack of human workforce and trust (14, 15). Some studies have pointed to higher rates of anxiety, depression, and posttraumatic stress disorder (PTSD) among nurses during and after the pandemics compared to other health care professionals (16, 17). This situation required close attention to the physical, psychological, and social requirements of nurses working under extremely stressful conditions, ensuring the advancement of nursing work (18, 19).

The emotions and stress experienced by nurses caring for severe COVID-19 patients may be related to their experience. The health departments of various countries and regions paid attention to the protection of nurses but were limited (10, 20). Thus, understanding nurse's experiences while treating patients in ICUs during the pandemic would help to understand their needs. The present study aimed to synthesize the research literature on the psychosocial experience of nurses caring for severe COVID-19 patients in the ICUs and point them in the direction of obtaining a comprehensive and effective support system during public health emergencies.

METHODS

Design

This study aimed to identify, appraise, and synthesize data from qualitative studies that describe the psychosocial experience of caring for patients with severe COVID-19 from clinical nurse's perspectives. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) (21) was used as a basis for reporting the review. A meta-synthesis approach was used to combine and present the qualitative findings (22). Relevant articles were searched, and data were extracted and critically evaluated using a thematic synthesis based on the three steps outlined by Thomas and Harden (23): text coding line by line, developing descriptive themes, and generating analytical themes.

Search Methods

Qualitative studies published from January 2019 to December 2021 in PubMed, Cochrane Library, CINAHL, Web of Science, Embase, Ovid, Elsevier, and Chinese databases, including Chinese National Knowledge Infrastructure (CNKI), Wanfang Database (CECDB), VIP Database, and China Biomedical Database (CBM), were searched by two authors in December 2021.

The search terms were developed, and subject headings were used where possible and adjusted for different databases. Four groups of keywords or MeSH terms were included and combined using Boolean operators: (1) nurs*; (2) COVID-19*, coronavirus disease 2019*, 2019-nCoV, coronavirus, covid pandemic; (3) severe case, serious illness, critical, intensive care unit, ICU, severe pneumonia (4) qualitative study*, qualitative research*, qualitative method*. To determine the eligibility of the potentially relevant studies, all titles and abstracts were reviewed by a researcher.

Inclusion and Exclusion Criteria

Study Design(S)

The qualitative research or mixed-method studies from which qualitative data could be extracted, the primary qualitative research studies were included but were not limited to methodologies, such as phenomenology, grounded theory, action research, ethnography, and feminist research.

Participant(P)

Nurses that have taken care of severe COVID-19 patients in ICUs during the pandemic.

Interest of Phenomena(I)

Nurse's actual psychological experience of caring for patients with severe COVID-19. The psychological experience in this study was defined as the subjective experiences, perspectives, feelings, and views of the influences on mood status, cognitive-behavioral responses, and social factors of a person (24).

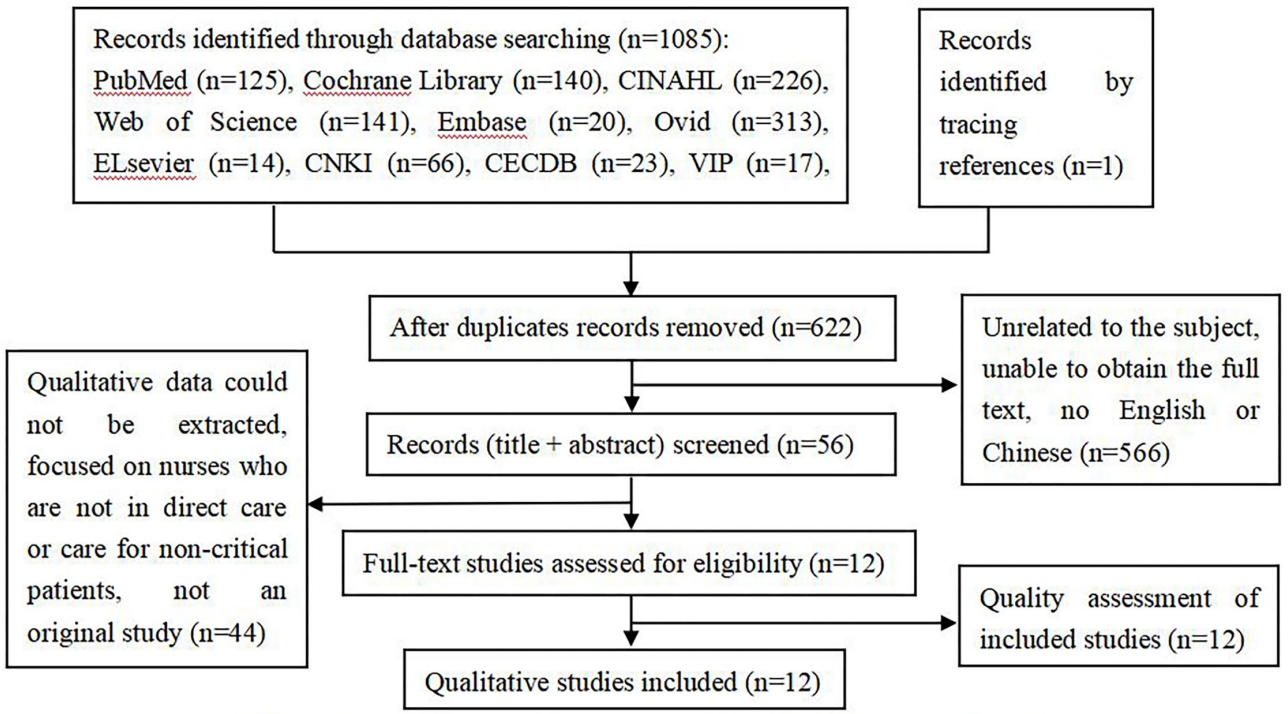

FIGURE 1 | Flowchart of the search strategy and results (PRISMA flow diagram).

Context (Co)

Nurses had completed or were continuing to care for patients with severe COVID-19 in the ICUs.

Exclusion Criteria

Not qualitative research or collected qualitative data but analyzed using quantitative methods; Not written in English or Chinese; Not published in peer-reviewed journals, Case reports, conference proceedings, poster abstracts, and theses. Systematic reviews and other reviews were excluded, but their references were examined to identify a possible relevant study.

Search Outcomes

According to the inclusion and exclusion criteria, two researchers independently screened and extracted the literature. An initial search using the above strategy yielded a total of 1,085 articles. First, the title and abstract of the articles were read to exclude those unrelated to the subject, were repetitive, and full text could not be obtained. Subsequently, 566 articles were excluded. After reading the full text, 44 articles were excluded, and finally, 12 articles were identified as relevant, and one was traced from a reference. This search process is illustrated in **Figure 1**.

Quality Appraisal

Two authors independently assessed the methodological quality of the 12 included studies. Initially, the authors worked independently using the Joanna Briggs Critical Assessment Tool for Methodological Quality Assessment (25). It consists of 10 questions designed to evaluate the studies quickly and efficiently with a simple yes, no, or unclear to each question. Each criterion was allocated a score (Yes = 2, No = 0, Unclear = 1), giving a total score of 20 for each study. These scores were then converted to a percentage. Subsequently, the results were discussed to reach a consensus, as all studies scored at least 70%, and none were excluded from the quality appraisal process (**Table 1**).

Data Extraction

A comprehensive study was conducted to characterize the quality of the content and assess the methodological development in the collected studies (37, 38). The extracted data included the author, the year of publication, country or region, research method, research subjects, interesting phenomena, and main research results. The results were cross-reviewed by two investigators, and any disagreement was resolved by discussion with a third investigator. These results are summarized in **Table 2**.

Data Analysis and Synthesis

We used meta-aggregation to synthesize the findings of the qualitative studies. This is a method of systematic review that involves categorizing and re-categorizing of the synthesized findings of two or more studies (25).

First, each identified article was read multiple times to increase the familiarity and obtain a thorough understanding of the study aims, methods, and outcomes. Then, each discovery was extracted with the text data explaining or supporting the finding. The consistency between the research results and

TABLE 1 | Quality assessment of included studies in accordance with the criteria of the Joanna Briggs Critical Appraisal tool for qualitative research.

Reference	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Result (%)
Tu et al. (26)	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	18/20(90%)
Liu et al. (27)	Y	Y	Y	Y	Y	N	U	Y	U	Y	16/20(80%)
Shi et al. (28)	Y	Y	Y	Y	Y	N	Y	Y	U	Y	17/20(85%)
Guo et al. (29)	Y	Y	Y	Y	Y	Y	U	Y	U	Y	18/20(90%)
Muz et al. (12)	Y	Y	Y	Y	Y	N	N	Y	Y	Y	16/20(80%)
Su et al. (30)	Y	Y	Y	Y	Y	N	U	Y	Y	Y	17/20(85%)
Jiang et al. (31)	Y	Y	Y	Y	Y	N	U	Y	Y	Y	17/20(85%)
Gordon et al. (32)	Y	Y	Y	Y	Y	N	U	Y	Y	Y	17/20(85%)
Moradi et al. (33)	Y	Y	Y	Y	Y	N	U	Y	Y	Y	17/20(85%)
Chegini et al. (34)	Y	Y	Y	Y	Y	N	U	Y	Y	Y	17/20(85%)
Ozdemir et al. (35)	Y	Y	Y	Y	Y	N	U	Y	Y	Y	17/20(85%)
Fernandez-Castillo et al. (36)	Y	Y	Y	Y	Y	N	N	Y	Y	Y	16/20(80%)

Critical appraisal (n = 10) of (Y, yes; N, no; U, unclear; NA, not applicable). Question, Q. Q1, Is there congruity between the stated philosophical perspective and the research methodology? Q2, Is there congruity between the research methodology and the research question or objectives? Q3, Is there congruity between the research methodology and the methods used to collect data? Q4, Is there congruity between the research methodology and the representation and analysis of data? Q5, Is there congruity between the research methodology and the interpretation of results? Q6, Is there a statement locating the researcher culturally or theoretically? Q7, Is the influence of the researcher on the research and vice-versa addressed? Q8, Are participants and their voices adequately represented? Q9, Is the research ethics according to the current criteria or for recent studies, and is there evidence of ethics approval by an appropriate body? Q10, Are the conclusions drawn in the research report arise from the analysis or interpretation of the data?

supporting data was evaluated by two researchers independently. Each finding provided some credibility: unequivocal, credible, or unsupported (25). The researchers studied the coded text to find the similarities and contradictions between these findings and descriptive data, each step was discussed by researchers to reach an intercoder agreement, and then created a classification to determine the meaning of the initial data set. For each theme, when needed, sub-themes were also developed following the same process. Finally, these categories were assessed repeatedly to identify the similarities and obtain synthesized results. In addition, emerged themes and sub-themes were evaluated in their occurrence by calculating the intra-study intensity and the inter-study frequency effect size to avoid under or overweighed themes and/or sub-themes.

RESULTS

The studies were conducted in the following countries: China ($n = 6$), Iran ($n = 2$), Turkey ($n = 2$), USA ($n = 1$), and Spain ($n = 1$). These 12 studies involved 161 nurses. All the included studies were descriptive qualitative analyses ($n = 5$) or phenomenological approaches ($n = 7$), wherein the data were collected by interviews. All studies published in 2020 or 2021 were original articles (**Table 2**). Three major themes emerged from the selected studies, reflecting the experience of nurses in caring for severe COVID-19 patients: physical reactions and psychological changes, the need for support from multiple sources, and increased adaptability and resilience. The themes were divided into several sub-themes of meaningful units, as demonstrated in **Table 3**.

Theme 1: Physical Reactions and Psychological Changes

Physical Symptoms Caused by Work Characteristics

Overall, this review found that almost all studies reported various physical conditions among participants (12, 26, 28–36), including, but not limited to, sleep disturbances, headaches, damaged skin, exhaustion, and breathlessness. These conditions could be attributed to long working hours and high working intensity, and the treatment of critically ill patients increases the physical consumption of nurses. *"For patients requiring mechanical ventilation, strictly, we help them turn over and backslap every two hours, and have little time for rest at work"* (31); *"We are truly tired. In this ward, all female nurses are covered in spots because of stress, and some have hormonal disorders"* (33). Owing to the specificity of the infectious diseases, the protective equipment brought heavy burden and trouble to the nurses. *"Once, after putting on protective clothing, I had difficulty breathing, sweating, and felt unsteady to collapse"* (30); *"Due to the lack of protective equipment, we often do not eat or defecate in a shift, the whole body is wet. Protective masks also pressure forehead and face with a magic spell, too tired every day"* (29).

Life-Threatening Pandemic Induced Anxiety

Nurses were exposed to the virus in their workplaces, rendering them at high risk of infection. The nurses felt fearful and anxious. *"How can I not be nervous and worried? What if I get infected by spatter from a patient?"* (26); *"I'm worried about getting the disease, I'm worried about spreading it"* (32). As a result of negative news reports and other reasons, the grim situation and unknowns about the disease made nurses hypochondriac, worried that protection was not sufficiently safe. *"The stress caused by this disease has made me a little more aggressive, as I sometimes even become hostile toward my family, especially my*

TABLE 2 | Description of the included studies.

References/ Country	Research method	Participants	Aim	Results
Tu et al. (26)/China	Descriptive qualitative research; semi-structured interviews	15 ICU nurses who had treated severe COVID-19 patients in Zhejiang province in China	To explore the true care experience of ICU nurses who have close contact with severe COVID-19 patients	8 themes in 3 stages: before participating in treatment: fear of inadequate self-protection, anxiety is not up to the task, a sense of vocation; participating in the treatment: nervousness and restlessness, quickly adapt to the intensive isolation ward into the treatment state, perception of lack of business knowledge; after participating in treatment: the symptoms of body discomfort were enlarged, stimulation of a sense of professional worth
Liu et al. (27)/China	Descriptive qualitative research; semi-structured interviews	12 ICU nurses who participated in the treatment of COVID-19 patients from a hospital in Beijing	To investigate the psychological status of ICU nurses at different stages during the treatment of COVID-19 in Hubei	8 themes in 3 stages: from receiving tasks to arriving in Wuhan: excitement and nervousness, lack of confidence; from arriving at the mission area to 4 weeks before work: fear and anxiety, frustration and helplessness, efforts to adapt to the situation; after the fifth week of the mission: missing family and tired, calm and confident, moved and grateful
Shi et al. (28)/China	Phenomenological approach; semi-structured diary analysis	9 nurses from a hospital in Jiangsu province in China who rushed to Wuhan's ICU ward in February 2020	To understand the changes of resilience of nurses who rushed to Wuhan's ICU under the COVID-19 epidemic, and to provide theoretical basis for nurses' psychological adjustment and intervention in public health emergencies	3 first-level themes and 8 second-level themes: Stress period (intrusive thoughts, physical challenges, psychological distress); Buffer zone (mobilization of psychological capital, stimulation of team resilience, understanding of social support); Reorganization (balance recovery, self-transcendence)
Guo et al. (29)/China	Phenomenological approach; semi-structured interviews	10 nurses worked in the isolation wards for severe COVID-19 patients in a hospital in Wuhan	To learn about the work experience of nurses in isolation wards for severe COVID-19 patients	Seven themes: sense of responsibility and mission, sense of achievement, feel the warmth of support, stress from work environment, stress of being infected, extreme physical exhaustion, loneliness and concern for family
Muz et al. (12)/Turkey	Phenomenological approach; semi-structured interviews	19 nurses who took care of COVID-19 patients in pandemic wards and pandemic intensive care units in tertiary public hospitals in Turkey	To reveal the experiences of nurses who care for COVID-19 patients during this process	Five themes: first meeting and getting caught unprepared, social isolation and loneliness, dilemma and conflict in professional roles, nursing: power born from difficulties and organizational expectations
Su et al. (30)/China	Phenomenological approach; semi-structured interviews	14 first-line nurses from a hospital in Beijing who had been dispatched to Wuhan, Hubei province, to fight COVID-19	To learn more about the true experience of first-line nurses caring for critically ill patients in remote emergency response to COVID-19	Four themes: heavy physical and mental burden, difficult observation of illness, psychological fluctuations, growth and harvest
Jiang et al. (31)/China	Phenomenological approach; semi-structured interviews	12 first-line nurses who had participated in the rescue of severe COVID-19 patients in Shanghai, China	To explore the experiences of nurses supporting the care of severe COVID-19 patient, to provide information and basis for nursing emergency rescue of public health emergencies	Four themes: strong sense of professional honor, heavy pressure, professional technology as support, support from all parties as motivation
Gordon et al. (32)/USA	Descriptive qualitative research; semi-structured interviews	11 ICU nurses who had cared for COVID-19 patients in the United States	To explore the experiences of critical care nurses working in central Texas amidst the pandemic	Five themes: emotions experienced, physical symptoms, care environment challenges, social effects, and short term coping strategies
Moradi et al. (33)/Iran	Descriptive qualitative research; semi-structured interviews	17 nurses worked in medical ICUs of a coronavirus (COVID-19) centre, Urmia, Iran	To explore the challenges experienced by ICU nurses throughout the provision of care for COVID-19 patients	Four themes: organization's inefficiency in supporting nurses, physical exhaustion, living with uncertainty and psychological burden of the disease

(Continued)

TABLE 2 | Continued

References/ Country	Research method	Participants	Aim	Results
Chegini et al. (34)/Iran	Phenomenological approach; semi-structured interviews	15 nurses who provided care for patients infected by COVID-19 in critical care units of Iran's public hospitals	To describe the experiences of critical care nurses caring for patients infected by coronavirus disease 2019 (COVID-19)	Four themes: psychological challenges; organizational challenges; social challenges; professional challenges
Ozdemir et al. (35)/Turkey	Phenomenological approach; semi-structured interviews	10 cardiovascular nurses who were assigned to COVID-19 intensive care unit during the pandemic in Turkey	To explore the experiences of cardiovascular nurses working in a COVID-19 intensive care unit during the pandemic	Six themes: the duties and responsibilities in a COVID-19 intensive care unit; the differences of COVID-19 intensive care unit practices from cardiovascular practices; the transferrable skills of cardiovascular nurses in a COVID-19 intensive care unit; the difficulties encountered working in a COVID-19 intensive care unit; the difficulty of working with personal protective equipment; and the psychosocial effects of working in a COVID-19 intensive care unit
Fernandez-Castillo et al. (36)/Spain	Descriptive qualitative research; semi-structured interviews	17 ICU nurses from a tertiary teaching hospital in Spain	To explore and describe the experiences and perceptions of nurses working in an ICU during the COVID-19 global pandemic	Four themes: providing nursing care, psychosocial aspects and emotional lability, resources management and safety, professional relationships and fellowship

brother" (33); *"The number of bowel movements has increased in the last few days. The first symptom of novel coronavirus patients is diarrhea. Am I infected?"* (26).

Pressure to Get Into Work

While working in an isolated ICU was difficult, the repressive work environment made the nurses uncomfortable. "*The working environment is closed, and doctors are seldom in the ward. We have to communicate with the outside world through the pager. Sometimes in the face of emergency, nurses need to make independent decisions, which brings me great pressure*" (29). Specific protective equipment, such as screen filters and face masks, are required in the ICU, which could cause pressure injuries in nurses and be troubling. "*Deep indentations on my face after wearing the goggles for a day, I developed a pressure injury... My face suffered from severe eczema due to protective equipment, which was very itchy and uncomfortable. Fortunately, I had prepared medicine with me*" (31). The condition of severe patients changed quickly and the course of the disease was uncertain, which gave nurses great psychological pressure. *"At the beginning, patients often asked me about my illness, and I didn't know how to answer. For previous patients, I was very confident to tell him"* (30). Some of the nurses stated that they hesitated while providing care to the patients because of the fear of contamination and felt guilty because they believed that they were unable to provide adequate care. *"I was suffering from extreme remorse for shortening the duration of the patient's care. We were experiencing fear for ourselves even while taking the patient's meal to his room as his nutrition was dependent on us"* (12). Faced with deterioration or even death of severe COVID-19 patients, nurses felt overwhelmed and helpless, especially those who had little experience of death. *"If the patient is critically ill and cannot contact his family members, there is little hope for rescue, which will increase her discomfort. However, if do not do something, I will feel uncomfortable, and that feeling is especially helpless (Sigh)"* (30).

TABLE 3 | Thematic synthesis findings.

Descriptive themes:	Sub-themes:
Physical reactions and psychological changes	Physical symptoms caused by work characteristics
	Life-threatening pandemic induced anxiety
	Pressure to get into work
	Emotional reactions related to family
The need for support from multiple sources	Support and attention from the organization
	Longing for support outside of work
Increased adaptation and resilience	Gradual adaptation toward work
	Build trust with the patient
	Inspired professional values

Emotional Reactions Related to Family

Similar to the medical team that helped Hubei in early 2020 in China, some nurses would be separated from their families for long periods. The prevalence of the disease and providing care for COVID-19 patients meant the loss of peace in life, and not being able to care for families made them worry about their familie's safety. *"The fear is that they will get infected, after all, other parts of Hubei are also seriously affected"* (29). Some nurses felt guilty and blamed themselves for the lack of care for their families. *"I have a 3-and-a-half-year-old son, I was feeling guilty when kissing him. In a way, I was blamed as a mom when I kissed my child, that*

affected me very bad" (35). On the other hand, the long isolation made the nurses feel lonely and miss their families. *"It was fine when I first came here, but now I miss my children and parents when I have video calls with them (eyes red)"* (27).

Theme 2: The Need for Support From Multiple Sources

Support and Attention From the Organization

Some nurses reported dissatisfaction with organizational support with respect to inadequate employee rights, poor planning, and a shortage of staff and protective equipment. *"There was no mask in the early days of the disease. We saw that disinfectant solutions were not in the ward and could not be found. The supply of gloves was reduced. Equipment was scarce"* (34); *"As a nurse, you are in an important place. You are always in contact with the patient, but you are always in the background in the system. I want my retirement rights and social rights"* (12); *"Since the outbreak of Coronavirus, no university deputies or hospital managers have come to ask "What are you doing here? What kinds of problems are you facing?" This shows that the system is not much concerned about personnel"* (33). However, many nurses also expressed that they received good organizational support that was helpful to their work. The common goal made the team cohesive, emphasizing the importance of organizational support. *"With professional training every two days, we are more confident in winning the battle against the epidemic"* (27). *"Your co-workers, they're along with you during this same crazy time… they are a huge support"* (32).

Longing for Support Outside of Work

Nurses believe that they need care and support from other people outside, for example, their families and friends, which could be a great spiritual boost during tough times. *"I was inspired by the fact that my family was proud of me"* (34). However, to the distress of some nurses, their families feared infection, and the lack of family support troubled the nurse. *"Our family are afraid that we might take the virus home and they could be infected. Their mentality is that we are all infected and could infect them all. It seems they fear us"* (33). Moreover, some nurses felt alienated and isolated from society because they were hospital workers. *"When we went to common areas in the hospital, there were complaints saying that we should not be there because we cared for COVID-positive patients. This type of social pressure wore us down a little"* (12). Strikingly, some nurses are stigmatized in life. *"You almost feel like the bubonic plague just walking around… that if someone touches you that they're gonna die instantly."* (32). Some participants with sufficient social support thought building confidence is a great motivation. *"We are encouraged by the outpouring of support and donations from the public, we are not alone in fighting the epidemic"* (31). *"Over time, healthcare professionals were highly praised. In the first days, we were under a lot of pressure, but little by little, we were supported by the people and the government, and the healthcare professionals were introduced as heroes in the society, and this motivated us"* (34).

Theme 3: Increased Adaptation and Resilience

Gradual Adaptation Toward Work

Facing COVID-19 for the first time was a big challenge for everyone. Many of the participants reported that over time, they adjusted to the work environment of the ICU and entered a treating state, their ability had been greatly improved (26–29, 35). *"I did have fear and anxiety in the early stage, but through psychological counseling and the help of my colleagues, I became calm and felt that I had changed from a medical nurse to an ICU specialist nurse"* (27). *"I have gained a lot here. I have not only learned a lot of professional knowledge, but also reflected on it. This is a process of positive motivation"* (30).

Build Trust With the Patient

The trust between the nurse and the patient was built during the nursing process, and the nurse's emotional temperature rose gradually. *"In the beginning, I also thought that I should contact with patients as little as possible. But gradually, I would no longer reject these patients and want to communicate with them more"* (30). The change in patient's attitudes toward nurses proved that they had done a good job. *"An old man did not cooperate with us at the beginning, but later he was moved by our behavior. From distrust at the beginning, to improvement later, he was very grateful to us"* (30).

Inspired Professional Values

The participants stated that the nursing profession had become stronger in this difficult period, and their motivation was strengthened when society understood the importance and meaning of nursing. *"During the pandemic, we proved to the society that the nursing profession is very important. At the moment, I think the society knows very well what we know, what training we have received, and our value"* (12). Participants and successfully treated critically ill patients by nurses, a heartfelt sense of responsibility, and mission were very critical, which could inspire professional values. *"I think it's a great honor for me to be selected by so many nurses, which is a full trust of the department, so I must fulfill my mission"* (30). Moreover, their professional maturity had increased, and the professional perception had changed through treatment work. *"We were the biggest part, namely nurses; while everyone shouldered responsibility, we put ourselves fully under that load. I realized that I was really a nurse"* (12).

DISCUSSION

A systematic review of 12 qualitative studies about the experiences of nurses who have treated of severe COVID-19 patients in ICUs, followed by a meta-synthesis, was performed on various databases after a manual search. The main findings indicated that the nurses face abundant physical and emotional stress while treating severe COVID-19 patients. These stressors arose from work burden, risk of infection, and public opinion. Nurse's coping strategies and external support improved their coping abilities under pressure, which improved the nursing work. Finally, through participation in the treatment of severe

COVID-19 patients, nurses had improved their coping ability, including professional competence, communication skills, and the sense of professional value, which increased their levels of resilience and positive emotional experiences.

COVID-19 is easily spread through droplet transmission. For those with serious complications, the onset is rapid, causing surges in admissions that stretch the capacity of the health care systems, and if not properly addressed, endanger the patients and the hospital staff (39). According to a study in *The Lancet*, public health measures and supportive care (interventions developed and delivered largely by nurses) were the first and the only unequivocally effective defense against COVID-19 with no disease-specific prevention, treatment, or cure for COVID-19 (40). Therefore, nurses have earned well-deserved recognition for their essential roles in providing skilled, compassionate care for patients throughout this pandemic. ICUs are the main battleground for treating patients with severe COVID-19. The critical nursing team has a precise and skilled professional level in the treatment and care of critically ill patients and can grasp the operation skills of various rescue and life support equipment proficiently (41). During the pandemic, nurses gained positive and negative psychological experiences but always prioritized the patient's treatment. The professional quality of nurses, good cooperation of the team, and active guidance of nursing managers guaranteed the goal.

The results of the process of patient care in the ICUs showed that fear, worry, anxiety, depression, and other negative psychological experiences were common among nurses fighting COVID-19 in a critical situation, which affected their physical and mental health; the workload and intensity were the primary reasons. Similarly, at the beginning of the epidemic, several studies reported that nurses experienced emotions, such as fear and anxiety, because of the lack of up-to-date information on the causes of infectious diseases, their management, and ways of protection or continuously updating information (42, 43).

Since the nurses worked in a closed working environment, mental stress also arose from the pain of isolation. Measures, such as quarantine and social distancing, were applied to control the pandemic and reduce mortality and morbidity levels, causing social isolation and stigmatization (44). Social distancing and quarantine increased the nurse's fears and negatively affected their professional performance and psychological health (45). This influence was not conducive to nurse's family and social relations, which posed them with the psychological burden of being away from their families, children, and spouses and changing their habits.

The physical and mental pressure on the nurses effectuated by protective equipment could not be ignored, and special equipment added to the burden. The results showed that they experienced physical symptoms, such as dyspnea, headache, muscle pain, and excessive sweating, because of the use of personal protective equipment, which consequently increased their stress. The accuracy of nursing operations was reduced and communication with patients or colleagues was obstructed, resulting in anxiety and frustration among nurses. In addition, wearing face screens, goggles, and masks for long periods caused pressure injury to their faces. However, to control contagious diseases, protective equipment and training of healthcare workers are critical for maintaining a safe working environment (46). These findings highlighted that providing adequate ergonomic protective equipment is essential.

Social support refers to the social resources provided by formal or informal support groups that individuals perceive subjectively and/or receive objectively (47). This review demonstrated that the nurses need support from multiple sources. Organizational support should be based on the interests of nurses. Importantly, nurses working in the event of an epidemic should be made to feel valuable. Their safety should be a priority, and they should be appropriately rewarded to provide positive support when a similar situation occurs in the future (48, 49). Notably, at the beginning of the pandemic, the uncertainty of assigning tasks and measures was exhausting for the nurses. This finding suggested that healthcare facilities, such as hospitals providing wards during disasters and emerging infectious diseases, need to plan for crisis management, including epidemic prevention, preparedness, and response processes (12). External support includes religious beliefs, friends, information from the environment, and support from colleagues, family, or social circle (47). When colleagues encounter difficulties, team cooperation and mutual support are critical to improving the state of mind. Family members and friends are often able to understand the nurse's situation, and their persuasion and comfort are focused and effective.

A systematic review revealed that insufficient social support was one of the risk factors for developing negative psychological consequences among healthcare professionals and providers during disasters (50). Outside the workplace, while mainstream media extolled nurses as heroes, some nurses endured stigmatizing attitudes by those viewing them as virus carriers. Therefore, community support for nurses is crucial during an epidemic (51), and policy-makers should address the barriers that create ethical challenges for nurses fighting COVID-19 (52). The study showed that a high level of social support and recognition for healthcare workers in public health emergencies could be shealing (53). In view of the external pressure, the relevant departments should actively guide the media, avoid the emergence of untrue reports, establish a good public image of medical staff, and consider outstanding medical staff as examples to promote positive energy.

Along with the negative psychological impact of COVID 19, positive emotions, such as confidence, inner satisfaction, professional pride, and commitment to the profession, are also reported in the results. Positive psychology mainly studies personality traits such as wisdom, courage, enthusiasm, and gratitude. Resilience means the ability to bounce back or recover easily when confronted by adversity, trauma, misfortune, or change (54). Thus, cultivating the positive strength of personality ensures that individuals acquire good resilience (55). Also, there is a need for self-actualization in everyone's heart, which stimulates people's positive power and excellent qualities. The key point of resilience is to adapt to various environments. Positive psychological strength and excellent psychological qualities improve adaptability (56). Therefore, positive psychological quality and resilience are interrelated. As described by Jnah

and Robinson (57), the positive emotions and self-efficacy of nurses exert a positive effect on the improvement of their resilience, indicating a high degree of confidence in the face of difficulties. Hence, psychological interventions are essential to increase the mindfulness and resilience of the nurses and their families (58, 59).

Furthermore, the resilience of nurses is a positive psychological quality, which plays a critical role in response to public health emergencies. High resilience makes the nurses competent and increases their patriotism and reverence for life (60). While saving lives, they gain a sense of self-worth as well as professional benefits. Several effective strategies have been proposed to help nurses improve their organizational support, cope with negative emotions, and improve resilience. A multimodal resilience training program improves individual resilience and psychological outcomes, such as symptoms of anxiety, depression, burnout syndrome, and posttraumatic stress disorder (PTSD). The strategies include a two-day educational workshop, written exposure sessions, event-triggered counseling sessions, mindfulness-based stress reduction exercises, and a protocol-based aerobic exercise regimen (61). The Stress Management and Resiliency Training (SMART) program encompass attention training and practice of gratitude, empathy, higher meaning, and forgiveness (62). Moreover, music therapy and online mind-body skill training are effective in improving nurse's resilience (63). Nursing managers focus on the psychological status of nurses in order to establish organizational strategies.

CONCLUSION

The findings of this review suggested that nurses working in critical care units during the COVID-19 pandemic experience psychological and physical distress as they cope with their work, social relationships, and personal lives. Thus, the active involvement of governments, policymakers, nursing groups, and healthcare organizations in supporting nurses during and after a pandemic or epidemic is essential to improve professional satisfaction and ensure the sustainability of the nursing workforce. Future studies will focus on the long-term psychological experience of nurses treating patients with severe COVID-19 and on strategies that can provide a better work experience. It is speculated that these results can act as a guide to understanding nurse's real feelings and needs that would contribute to further studies to be better prepared and improve the quality of nursing when responding to future public health emergencies.

LIMITATIONS

This meta-synthesis has several limitations. According to the inclusion criteria, only primary qualitative studies published in indexed journals in English or Chinese were selected. Therefore, gray literature and dissertations were not searched, which might have introduced an information bias. The response to the pandemic in different countries may lead to various protocols and policies that might influence the nurse's attitudes and work experiences. Finally, this meta-synthesis represents the authors and other researchers with different interests, which might provide varied results.

DATA AVAILABILITY STATEMENT

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

AUTHOR CONTRIBUTIONS

PH: conceptualization, methodology, formal analysis, writing—original draft, and writing—review and editing. XD: conceptualization, methodology, writing—original draft, and writing—review and editing. SZ: conceptualization, methodology, formal analysis, and writing—review and editing. XZ and JJ: methodology, formal analysis, and writing—review and editing. All authors contributed to the article and approved the submitted version.

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Association Between Loneliness and Sleep-Related Problems Among Japanese Workers During the COVID-19 Pandemic

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Background: The coronavirus disease 2019 (COVID-19) pandemic has been linked to a rise in loneliness. Loneliness is associated with sleep-related problems, which in turn can be a risk factor for various psychiatric disorders. However, it is unclear whether loneliness is linked to sleep-related problems during the pandemic. Here, we studied the association between loneliness and sleep-related problems during the COVID-19 pandemic in Japan.

Methods: A total of 33,302 individuals who indicated they were employed were surveyed online. The survey responses of 27,036 participants were analyzed. Odds ratios (ORs) were estimated using univariate and multiple logistic regression analyses.

Results: Of those analyzed, 2,750 (10.2%) experienced feelings of loneliness. Further, sleep-related problems were significantly more common among those who felt lonely both in the short term (more than 3 days) and the long term (more than 3 months). The ORs were much weaker after adjusting for factors related to interpersonal connections, such as family and friendships, than after adjusting for factors related to socioeconomic status.

Conclusion: Loneliness may be a risk factor for sleep-related problems in the COVID-19 pandemic. Having connections with family and friends may have a moderating effect on the occurrence of sleep-related problems.

Keywords: COVID-19, loneliness, sleep, workers, Japan

INTRODUCTION

Since the first confirmed cases of coronavirus disease 2019 (COVID-19), the disease has become a major infection risk around the world. Additionally, the associated pandemic has posed numerous other public health challenges such as loneliness (1, 2). Physical distancing and curtailing outings and opportunities for socializing are some of the recommended measures for preventing infection. Specifically, governing bodies around the world have requested the public to refrain from going out as much as possible, conduct work and leisure activities at home, and refrain from socializing with those other than family members as much as possible. These recommendations are being linked to increased loneliness. One study reported that 35% of residents who experienced lockdown in China had psychological distress, while another demonstrated that 45% of adults in the US had anxiety and stress (3, 4). The circumstances of those who experience loneliness have been worsened by the pandemic (5). Further, individuals with heightened stress of anxiety and loneliness have poorer sleep quality (6).

Even before COVID-19, loneliness was an emerging public health issue. Researchers had begun to explore the possibility that loneliness may be a trigger for public health intervention for all generations (7). According to previous studies, 10–40% of the population experienced loneliness and isolation (8, 9). While isolation refers to a lack of social interaction, loneliness is linked to subjective feelings. Although different, they are related, with isolation and loneliness shown to adversely affect health through both common and different pathways (10). Loneliness is associated with lower subjective health and lower quality of life, and exacerbates signs of depression (11). It is also a risk factor for suicide and dementia (12–14).

In particularly, loneliness is associated with sleep-related problems, which in turn can be a risk factor, precursor, or accompanying symptom of various psychiatric disorders. In the COVID-19 pandemic, loneliness has been identified as a major risk factor for insomnia (15). A study in Japan on patients who visited a psychiatric clinic during the pandemic demonstrated a link between loneliness and earlier bedtime and increased sleep duration (16). Other reports suggest that sleep disorders are on the rise during the pandemic (17).

Despite reports of an increase in people experiencing loneliness and isolation during the COVID-19 pandemic, the relationship between loneliness and sleep-related problems is unclear. Here, we studied the relationship between loneliness and sleep-related problems during the COVID-19 pandemic in Japan.

METHODS

Study Design and Participants

The present analysis forms part of the Collaborative Online Research on the Novel-Coronavirus and Work (CoroNaWork) Project, a cross-sectional study conducted between December 22 and 26, 2020, that used Internet-based surveys to probe the health of Japanese employees during the COVID-19 pandemic. A full description of the protocol is provided elsewhere (18). The survey was performed on individuals with an employment contract. Individuals whose response time was extremely short, height was below 140 cm, weight was below 30 kg, or provided conflicting answers to the same question were excluded. We excluded those with a response time of <6 min because this was considered the minimum time required to read and respond to the pre-checked text; a response time less than this was considered fraudulent. Out of 33,302 participants, responses from 27,036 were analyzed.

This study was conducted with the approval of the Ethics Committee of the University of Occupational and Environmental Health (Approval Number R2-079). Informed consent was obtained through a form on the survey website.

Assessment of Loneliness

We used a survey item to assess participants' loneliness. The survey item asked how often the participants had felt lonely during the last 30 days. Those who answered "never" or "a little" were grouped as feeling no loneliness. In contrast, those who answered "sometimes," "usually," or "always" were grouped as feeling loneliness.

Assessment of Sleep

We used a questionnaire to assess participants' sleep status. The questionnaire asked three questions. The first asked whether participants were getting enough sleep. The second asked whether they had experienced any trouble sleeping for more than 3 days. The third asked whether they had experienced any trouble sleeping for more than 3 months. Participants answered yes or no to these questions.

Other Covariates

For analysis, we treated the following as confounding factors: age, sex, marital status, equivalent income, education smoking, alcohol consumption (demographic variables); job type, number of employees at the workplace (occupational variable); cumulative incidence rate of COVID-19 in the prefecture of residence (infection-related variable); and lack of friends to talk to, lack of acquaintances to ask for favors, lack of people to communicate with through social network sites, family time and solitary eating (social variables).

Additionally, we used the cumulative incidence of COVID-19 in the prefecture of residence in the month prior to the survey as a community-level variable. These data were taken from the websites of public institutions.

Statistical Analysis

We identified a number of potential confounding factors in the relationship between loneliness and sleep. Multivariate analysis was used to adjust for confounding factors related to demographic background, occupational environment, and social background. Odds ratios (ORs) were estimated using univariate and multiple logistic regression analyses. Loneliness was treated as an independent variable and the presence of sleep-related problems as a dependent variable. To determine the association between loneliness and sleep problems, we constructed two multivariate models. In model 1, we adjusted for age, sex, marital status, equivalent income, education, smoking, alcohol consumption, job type, number of employees in the workplace

TABLE 1 | The characteristics of participants who have experienced loneliness.

Characteristics	Non-loneliness	Loneliness
	n = 24,286 (%)	*n* = 2,750 (%)
Age (years), mean (SD)	47.3 (10.5)	44.5 (10.1)
Age group		
20–29	1,659 (87.1%)	246 (12.9%)
30–39	4,223 (86.9%)	635 (13.1%)
40–49	7,090 (88.5%)	921 (11.5%)
50–59	8,219 (91.2%)	793 (8.8%)
60–65	3,095 (95.2%)	155 (4.8%)
Sex, male	12,601 (51.9%)	1,213 (44.1%)
Area (cumulative COVID-19 incidence rate per million population)		
97–356	4,767 (19.6%)	575 (20.9%)
438–490	4,903 (20.2%)	547 (19.9%)
535–911	4,765 (19.6%)	569 (20.7%)
1,168–3,496 (non-Kanto)	4,929 (20.3%)	521 (18.9%)
1,168–3,496 (Kanto)	4,922 (20.3%)	538 (19.6%)
Marriage status		
Married	14,077 (58.0%)	952 (34.6%)
Divorce/bereavement	2,445 (10.1%)	398 (14.5%)
Never married	7,764 (32.0%)	1,400 (50.9%)
Job type		
Mainly desk work	12,132 (50.0%)	1,336 (48.6%)
Mainly work involving communicating with people	6,243 (25.7%)	684 (24.9%)
Mainly labor	5,911 (24.3%)	730 (26.5%)
Equivalent income (million JPY)		
40–249	4,910 (20.2%)	800 (29.1%)
250–375	6,714 (27.6%)	836 (30.4%)
376–499	6,046 (24.9%)	579 (21.1%)
≥500	6,616 (27.2%)	535 (19.5%)
Educational background		
Junior high school	306 (1.3%)	62 (2.3%)
High school	6,190 (25.5%)	763 (27.7%)
University, graduate school, vocational school, junior college	17,790 (73.3%)	1,925 (70.0%)
Current smoke	6,274 (25.8%)	730 (26.5%)
Alcohol consumption		
6–7 days a week	5,179 (21.3%)	495 (18.0%)
4–5 days a week	1,910 (7.9%)	167 (6.1%)
2–3 days a week	2,935 (12.1%)	331 (12.0%)
<1 day a week	4,071 (16.8%)	476 (17.3%)
hardly ever	10,191 (42.0%)	1,281 (46.6%)
Number of employees in the workplace		
<10	5,619 (23.1%)	546 (19.9%)
<100	6,183 (25.5%)	757 (27.5%)
<1,000	6,379 (26.3%)	774 (28.1%)
>1,000	6,105 (25.1%)	673 (24.5%)
Do you have friends or neighbors with whom you can easily engage in small talk or daily conversation?	17,029 (70.1%)	1,057 (38.4%)
Do you have someone you can ask for help?	16,901 (69.6%)	932 (33.9%)
Do you have a partner with whom you can communicate closely using SNSs?	15,032 (61.9%)	1,136 (41.3%)
Time spent with family having a meal or at home		
More than 2 h	4,103 (16.9%)	272 (9.9%)
More than 1 h	5,922 (24.4%)	390 (14.2%)
More than 30 min	5,160 (21.2%)	451 (16.4%)
<30 min	3,185 (13.1%)	368 (13.4%)
Almost never	5,916 (24.4%)	1,269 (46.1%)
How often do you eat all meals of the day alone?		
6–7 days a week	4,276 (17.6%)	1,026 (37.3%)
4–5 days a week	2,064 (8.5%)	270 (9.8%)
2–3 days a week	2,501 (10.3%)	327 (11.9%)
<1 day a week	2,496 (10.3%)	234 (8.5%)
hardly ever	12,949 (53.3%)	893 (32.5%)
Sleep status		
Is your time of sleeping enough?	9,712 (40.0%)	1,766 (64.2%)
Do you have any troubles about sleep for more than 3 days?	6,469 (26.6%)	1,582 (57.5%)
Do you have any troubles about sleep for more than 3 months?	5,437 (22.4%)	1,405 (51.5%)

and cumulative incidence rate of COVID-19 in the prefecture of residence. In model 2, we additionally adjusted for lack of friends to talk to, lack of acquaintances to ask for favors, lack of people to communicate with through social networking sites, family time and solitary eating.

Dummy variables were as follows: age, sex (male = 0, female = 2), marital status (married = 1, divorce/bereavement = 2, never married = 3), equivalent income (million JPY: 40–249 = 0, 250–357 = 1, 376–499 = 2, ≥500 = 3), education (junior high school = 1, high school = 2, university, graduate school, vocational school, junior college = 3), current smoke (no = 0, yes = 1), alcohol consumption (6–7 days a week = 1, 4–5 days a week = 2, 2–3 days a week = 3, <1 day a week = 4, hardly ever = 5) (demographic variables); job type (mainly desk work = 1, mainly work involving communicating with people = 2, mainly labor = 3), number of employees in the workplace (<10 = 1, <100 = 2, <1,000 = 3, >1,000 = 4) (occupational variable); cumulative incidence rate of COVID-19 in the prefecture of residence [incidence rate per million population: 97–356 = 1, 438–490 = 2, 535–911 = 3, 1,168–3,496 (non-Kanto) = 4, 1168–3,496 (Kanto) = 5] (infection-related variables); lack of friends to talk to (0 or 1), lack of acquaintances to ask for favors (0 or 1), lack

of people to communicate with through social network sites (0 or 1), family time (more than 2 h = 1, more than 1 h = 2, more than 30 min = 3, <30 min = 4, almost never = 5) and solitary eating (eat alone: 6–7 days a week = 1, 4–5 days a week = 2, 2–3 days a week = 3, <1 day a week = 4, hardly ever = 5) (social variables).

All analyses were conducted using Stata (Stata Statistical Software: Release 16. College Station, TX: StataCorp LLC, United States.), with $p < 0.05$ indicating statistical significance.

RESULTS

Table 1 summarizes the general characteristics of the 27,036 participants included in the study. Of those analyzed, 2,750 (10.2%) experienced feelings of loneliness. Age (years), mean (SD) for non-loneliness was "47.3 (10.5)," and that for loneliness was "44.5 (10.1)," respectively. Age, region, occupation, and income were comparable between those who felt lonely and those who did not. On the other hand, those who reported feeling lonely were more likely to be unmarried, divorced or bereaved.

Table 2 summarizes the ORs of loneliness associated with sleep-related problems as estimated by the logistic model. We found a significant association between loneliness and the presence of sleep-related problems evaluated using the question "Do you get enough sleep?" The age-sex adjusted OR was 2.64 (95% CI 2.43–2.87). The association remained significant after adjusting for confounders in model 1 (OR = 2.58, 95% CI 2.37–2.80) and model 2 (OR = 2.05, 95% CI 1.89–2.24). A significant association was also observed between loneliness and the presence of short-term sleep-related problems based on the question "Have you had any trouble sleeping for more than 3 days?" The age-sex adjusted OR that participants who felt lonely had sleep-related problems was 3.63 (95% CI 3.35–3.94). The association was likewise significant in model 1 (OR = 3.53, 95% CI 3.25–3.83) and model 2 (OR = 2.95, 95% CI 2.71–3.22). Further, we also observed a significant association between loneliness and the presence of long-term sleep-related problems based on the question "Have you had any trouble sleeping for more than 3 months?" Among those who reported feeling lonely, the age-sex adjusted OR for sleep-related problems was 3.59 (95% CI 3.31–3.90). Similarly, the association was significant in model 1 (OR = 3.50, 95%CI 3.23–3.80) and model 2 (OR = 2.87, 95%CI 2.64–3.13).

DISCUSSION

We found that, during the COVID-19 pandemic, sleep-related problems were significantly more common among those who felt lonely both in the short term (more than 3 days) and the long term (more than 3 months). The OR of loneliness associated with sleep-related problems was much weaker when adjusted for factors related to interpersonal connections, such as family and friendships, than when adjusted for factors related to socioeconomic status. This suggests that having connections with family and friends has a moderating effect on the occurrence of sleep-related problems.

About 10% of participants in this study felt lonely. To our knowledge, this is the first large-scale study to investigate loneliness in a working population in Japan. A previous study based on 15,530 ordinary people in the UK also reported an association of similar risk factors with loneliness and mental illness (19). Our study is significant in that it examined an even larger number of employees (n = 27,036) in Japan. Further, in contrast to the finding that having a job is a protective factor against loneliness and mental illness in the UK study, we found that a marked number of people in Japan felt lonely despite having a job. We also examined additional risk factors. According to a previous Japanese study, the percentage of individuals experiencing loneliness among those aged 65 and above who were living with a spouse only, living with children, and living alone was 17.7, 18.5, and 37.3%, respectively (20). The lower incidence of loneliness in the present study may reflect the fact that working-age individuals more actively participate in society through work, and are in the early stages of marriage and raising children. However, we found that workers who were unmarried, divorced, or had lost a partner; had no neighbors or friends to talk, ask for favors, or communicate with on social networking sites; had little time to spend with family, or ate meals alone tended to feel lonely despite working.

Our analyses showed that those who felt lonely typically had sleep-related problems. These results are consistent with those of previous studies. One report found that pandemic-related loneliness, anxiety, and depression led to insomnia, which is more pronounced among women and inner-city residents. The study examined the association between loneliness and insomnia in 2,427 ordinary people in Greece (17). Our study is novel in its large-scale nature, investigating loneliness and sleep-related problems in 27,036 workers in Japan, who are considered to be socially engaged on a regular basis. A report on 556 members of the general public in France also showed that pandemic-related loneliness and anxiety were associated with insomnia (15), with 19.1% reporting insomnia. This figure is half that reported in Greece, but comparable to that reported in China and Italy (21, 22). In our study, we found that 10.2% of Japanese workers felt lonely. Loneliness has been shown to be associated with sleep fragmentation and poor sleep quality (23). A study that adjusted for the effects of depressive symptoms suggested that the relationship between loneliness and insomnia cannot be explained by the comorbidity of depressive symptoms alone (24). When individuals experience loneliness and threats to the safety of the social environment, vigilance against social threats is enhanced and the brain remains alert during sleep (25). Those who maintain good relationships with others tend to choose healthy behavioral actions (26). Having social relationships and choosing healthy behaviors has been suggested to lead to good sleep quality (27).

Our study investigated the relationship between loneliness and sleep-related problems in the context of the COVID-19 pandemic, where people are being asked to refrain from unnecessary movement and physical interaction. A study of 34,484 workers in the UK reported that a flexible schedule and telework improve work-family balance, increase job satisfaction, especially among women, and have mental health benefits (28).

TABLE 2 | The association between loneliness and sleep.

	Age-sex adjusted				Multivariate* (model 1)				Multivariate** (model 2)			
	OR	**95% CI**		***p***	**OR**	**95% CI**		***p***	**OR**	**95% CI**		***p***
slp1												
Loneliness	2.64	2.43	2.87	<0.001	2.58	2.37	2.80	<0.001	2.05	1.89	2.24	<0.001
slp2												
Loneliness	3.63	3.35	3.94	<0.001	3.53	3.25	3.83	<0.001	2.95	2.71	3.22	<0.001
slp3												
Loneliness	3.59	3.31	3.90	<0.001	3.50	3.23	3.80	<0.001	2.87	2.64	3.13	<0.001

**Multivariate model further adjusted for marital status, equivalent income, educational level, smoking, alcohol consumption, job type, number of employee at the workplace and cumulative incidence rate of COVID-19 at prefecture.*

***Multivariate model further adjusted for lack of friends to talk to, lack of acquaintances to ask for favors, lack of people to communicate with through social networking sites, family time and solitary eating.*

slp1: Is your time of sleeping enough?

slp2: Do you have any troubles about sleep for more than 3 days?

slp3: Do you have any troubles about sleep for more than 3 months?

However, it is also possible there is evidence that telework may be associated with loneliness, and as a consequence, sleep-related problems. This needs further study.

We found that having interpersonal connections with family and friends was effective in alleviating sleep-related problems in workers who felt lonely during the COVID-19 pandemic. The significant association of loneliness with sleep problems was true even after accounting for socioeconomic factors such as sex, age, and marriage. However, further adjusting for interpersonal connections with family and friends in model 2 led to a marked attenuation of the OR of sleep-related problems, indicating that the relationship between loneliness and sleep-related problems can be partially explained by the adjusted factors. To prevent spread of COVID-19 in Japan, the government has requested that people engage in physical distancing and refrain from going out. Self-isolation has been encouraged, for example, by performing work and leisure activities at home and refraining from interacting with those outside the family as much as possible. These requests may have brought the problem of loneliness to the surface for some workers. For those who live with their families, self-isolation allows them to spend more time and strengthen relationships with their kin. However, for workers who live alone or have no community ties outside of work, self-isolation may enhance the negative effects of loneliness.

Our study has several limitations. First, because this study was conducted on Internet users, the degree to which the results are generalizable is unclear. To reduce bias, we sampled based on region, job type and prefecture according to the rate of infection. We also considered the common-method variance bias, because internet surveys frequently use standardized question options. However, we judged that any common-method variance bias would be small because the Harman's one-factor test on all self-reported outcome measures used, namely, the Kessler 6 scale, Work Functioning Impairment Scale, and Job Content Questionnaire, explained 25% of the variance, which is lower than 50%. We also tried to reduce desirability bias by blinding the researchers to the results to ensure anonymity and confidentiality. The survey was also computer-controlled. Further, desirability bias is generally a problem in reports of ability, personality, sexual behavior, and drug use (29), and thus was unlikely to be a significant issue in our study. Meanwhile, recall bias is especially problematic in retrospective studies that aim to explore the etiology of mental states. There may have been recall bias in our study because it examined varying degrees of loneliness and sleep-related problems. As we were unable to determine causality, it is possible that those with sleep-related problems complain of loneliness. Second, whether or not participants felt lonely was determined using one question: "During the last 30 days, how often did you feel the following emotions?" There are variety ways to evaluate loneliness; in this study, we assessed loneliness by asking participants how often they felt lonely in the past 30 days. This method was adapted from a previous study that assessed loneliness using a single question (30). We feel that the question is appropriate as it briefly asks about participants' subjective experience. Further studies using less subjective assessments of loneliness are needed to confirm our findings. Third, we were unable to assess the severity of sleep problems as we did not use the insomnia rating scale. We used three questions to assess sleep problems, the reliability and validity of which are uncertain. However, the three questions inquired about participants' symptoms over 3 days and 3 months based on the Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM-5), for insomnia, and the alpha coefficient was relatively high at 0.78. In addition to DSM-5, the three questions were also developed with reference to the Athens Insomnia Scale, both of which are widely used around the world. We made the questions simple but appropriate for understanding sleep-related problems. Finally, because this was a cross-sectional study, we could not determine the temporal or causal link between loneliness and sleep-related problems; the results are purely correlational.

In conclusion, loneliness was found to be a risk factor for sleep-related problems during the COVID-19 pandemic. Our findings suggest that having connections with family

and friends has a moderating effect on the occurrence of sleep-related problems. However, it is not yet clear whether family and friendship-related interventions will be effective. Further studies are needed to provide causal evidence for the relationship and confirm the effectiveness of such interventions. Further, as workers who have no connections with family and friends are at high risk of sleep problems, identifying workers who feel lonely and have reduced opportunities for direct communication during the pandemic may prevent adverse downstream effects. Given the pandemic is still ongoing, strategies are needed to manage loneliness and sleep-related problems.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethics Committee of the University of Occupational and Environmental Health (Approval Number R2-079). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

YF was the chairperson of the study group. YK conceived the research questions. HT conducted the statistical analysis with YF and YK. HT drafted the initial manuscript. All the authors designed the research protocol, developed the questionnaire, revised, and approved the final manuscript.

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The Experiences of Nurses in Care Provision to COVID-19 Patients: A Qualitative Study

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Introduction: Nurses are key fighters in the forefront of care provision to COVID-19 patients. Due to the diversity of nurses' experiences in different countries because of variable nursing resources, health care systems, and cultural contexts, the present study aimed to divulge a deep understanding of the essence of health system problems based on nurses' experiences of care provision to COVID-19 patients in Iran.

Methods: The present study was conducted based on the conventional content analysis method and Graneheim & Lundman approach. The participants included the nurses working in the COVID-19 wards and were recruited by purposeful sampling and based on inclusion criteria. The data were collected by conducting semi-structured, one-to-one interviews, and taking field notes, until reaching data saturation.

Results: In-depth interviews with 12 nurses. represented four main categories and six subcategories. Sudden exposure to an unknown threat (nurses' feelings and concerns and nurses' reactions), being involved in an unequal war (a vicious virus and weary nurses), stressful working conditions, and efforts to confine the threat (seeking for new and adequate information and gathering all forces) were among the emerged data.

Conclusion: The nurses' experiences showed that despite passing a while since the coronavirus pandemic, there are still individual and professional concerns that all root in organizational and governmental factors.

Keywords: qualitative study, COVID-19, nursing, patients, pandemic (COVID19)

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INTRODUCTION

Nurses are key players at the forefront of providing care to COVID-19 patients, and their coordinated efforts are essential to put an end to the spread of the disease (1, 2). During the COVID-19 pandemic, nurses should be equipped with special skills to provide quality care to the patients who need their expertise, knowledge, attitudes, and skills, as well as their supportive care. So, health care workers should be skilled and accurate to be able to treat patients, and if nurses, as pioneers, lack the required expertise in inpatient care, they will impose major challenges on the health system (3, 4).

The rapid spread and high mortality of the COVID-19 disease have caused not only the public but also health care providers, especially nurses who are in close contact with infected people, the fear and anxiety about the impacts of the virus on themselves and their families (5, 6). In fact, nurses

have expressed their great fear of either themselves or their family members being infected with the virus, and due to this risk, many of them are reluctant to work during the pandemic (7). Therefore, it is important to identify the complications and consequences of the pandemic on nurses and recognize the worries and concerns that can accentuate these problems (8). Various studies have been performed on the care provided by nurses to COVID-19 patients, noting that ethical issues and the lack of adequate information about emerging diseases (9) can significantly affect the health status of nurses and the quality of the care provided by them. In this regard, two studies showed that the nurses caring for patients with a new infectious disease such as SARS and H1N1 lacked precise information and instructions on how to provide patient care and utilize personal protective equipment (10, 11). Moreover, post-traumatic stress after witnessing the death of patients was another experience reported by the nurses providing care to patients with emerging respiratory infections (12–14). If these psychological problems are not effectively addressed, they may not only weaken nurses' immunity, which increases the risk of the COVID-19 infection, but may adversely affect the quality and safety of the health care system (15).

Due to variable nursing resources, differences in the structure of health care systems, and various cultural backgrounds, the experiences of nurses in various countries vary in terms of care provision to COVID-19 patients (5). The International Council of Nurses has recognized the key role of nurses in the treatment and care of patients with COVID-19 (16). Therefore, it seems necessary to acquire a deep understanding of nurses' experiences to establish a safe and efficient network in which health staff can be prepared for facing possible outbreaks of new infectious diseases in the future. Moreover, facing such a crisis and life-threatening conditions make patients to be completely or partially depend on the nurses who have to provide a physical needs, and their psychosocial (wellbeing and mental health) needs (17, 18). Also, some studies have shown that there some institutional and personal barriers that have determinant role in providing the suitable care for these kinds of patients (19, 20). Furthermore, our cultural views and morals about health/illness/treatment, and those of our patients, may not bring into line. Nurses must find shared ground in order to offer culturally sensitive care. During this pandemic we can make a difference by considering chances and tools to alleviate and lessen hidden prejudice. In addition to providing quality healthcare, we can accept our patient's cultural opinions related to health and illness and incorporate this information into the plan of care (21, 22). So, it seems to be important to care for patients' cultural belief and values in every stages of their treatment. To obtain a deep understanding of a certain phenomenon, it is required to perform qualitative research that makes it possible for decision makers to become aware of the phenomenon by knowing stakeholders' perceptions and insights and the factors that affect their performance (5). Despite the key role of nurses and their experiences on the quality of care, this issue has been neglected in Iran amid the COVID-19 pandemic. Due to the lack of studies on the experiences of nurses on care provision to COVID-19 patients, this study aimed to scrutinize an in-depth understanding of the essence of the health system's problems experienced by the nurses involved in care provision to these patients using a conventional content analysis approach.

METHODS

A qualitative content analysis approach was adopted for this study. Qualitative content analysis has been described as a "systematic and objective means of describing and quantifying phenomena" [(23), p. 1] Content analysis involves reducing data to concepts that describe a phenomenon like care provision. By creating "categories, concepts, a model, conceptual system, or conceptual map" [(23), p. 2], content analysis has been shown to help clarify and explain a given phenomenon because it reveals in-depth information about the participants' views.

Participants

The participants in this study were 12 individuals with the mean age of 28.58 ± 3.9. To be included, participants needed to be working in the hospitals affiliated with Arak University of Medical Sciences, willingness to participate in the study, ability to communicate properly to convey rich and complete information, and having a bachelor's degree. The participants were therefore selected using a purposeful and criterion-based sampling approach. It has been argued that a sample size of between ten and twenty is appropriate for qualitative studies of this kind because they allow the researchers to discuss a sufficient breadth of responses in the appropriate depth (24). This sample size was also considered to be appropriate as the data analysis reached the point of saturation (25). All of the participants were from Arak city, Arak. They consented to taking part in the study verbally, and also using written consent forms.

Data Collection

After the approval of the research protocol by the Ethics Committee of the School of Nursing, the researcher started to collect and analyze the data. Initially, participants were recruited and explained about the aims of the study, and then were requested to sign an informed consent form. Once the participants gave their consent to take part in the study, physical face-to-face interviews were arranged which took place in the participants' wards that they worked or the place that they felt comfortable, but generally 12 interviews were done during the shifts of the participants and four of them were done before or after the shift in the participants' rest room in the units that they worked. It needs to mention that no one was allowed to come to the room during the interviewing. The whole interviews were conducted by one of the researchers (MJ) with training in interview procedures and each interview was checked by MS. Semi-structured interviews were the preferred method of data collection because they offered the researchers flexibility to pursue, probe and clarify responses as they occurred, but also to make comparisons between participants. Sandelowski (26) purports that one-to-one interviews are the most commonly used data collection tools in qualitative research. Specifically, the authors used the one-to-one Semi-structured interviews due to the following reasons: (1) it is appreciated method of collecting rich in-depth data about participants' experiences and outlooks;

(2) it suggests the researcher the chance to understand non-verbal indications through observation of body language, facial expression and eye contact and therefore may be seen to improve the interviewers consideration of what is being said; (3) it allows the researcher to investigate and discover unseen meanings and understanding; and (4) it provides valuable evidence about the public situation in which people exist (27).

Before starting the interview, the researcher aimed to build a rapport with the participants (28). Thereafter, the aims of the study were repeated. Participants were also informed that their responses would be confidential, and the process of recording the interview was also outlined. Data were grouped to ensure anonymity and confidentiality. Moreover, the author dedicated a number as a code to each participant in order to assure the confidentiality. After obtaining written consent, the interviewer began the interview using open questions.

Initially, four unstructured interviews were conducted to recognize the relevant questions needed to be asked, and then semi-structured interviews were held to gather information on the participants' positive and negative experiences and their opinions about priorities, strategies, and procedures in caring for COVID-19 patients.

In order to obtain maximum information, the highest diversity was tried to be fulfilled by recruiting nurses with variable working experiences (long and short) from different shifts (morning, evening, and night) and wards (intensive care units and general, etc.). An open question was initially asked, such as "What are your experiences in caring for COVID-19 patients?". Other questions were asked based on the interview guide and the responses provided by the participants, including "What are your suggestions for caring for COVID-19 patients?", "What are the impacts of the disease on your professional life and personality?", and other similar questions. Based on the answers to these questions, follow-up questions were asked to explore the participants' responses. Examples of follow-up questions included: "What did you mean by this?" and "Can you explain this in more detail?" The duration of the interviews varied depending on the participants' responses and willingness to continue. Interviews lasted for approximately 20 to 70 minutes, with a mean interview length of 45 minutes. In all, 16 interviews were carried out with 12 participants. However, four interviews (No. 2, 4, 7, and 11) were repeated in order to clarify information from the first interview. After listening to the interviews' voices over and over for several times, their texts were transcribed verbatim on paper and then analyzed. All of the interviews were recorded with a digital voice recorder, conducted in Persian and translated to English. In order to record observations and the events and interactions occurring in the field, the researcher took field notes whenever necessary, which was guided by one of the researchers (MJ).

After collecting the required data using interviews, they were accurately analyzed using the conventional content analysis method based on the Graneheim & Lundman approach, which included five steps as follows:

1. Transcription of the Entire Interview Immediately After Its Conductance;
2. Reading the Entire Text to Acquire a General Understanding of Its Content;
3. Extracting the Units of Meaning and the Initial Codes;
4. Classifying Similar Primary Codes Into More Comprehensive Categories;
5. Determining the Main Themes of the Categories (29).

Having transcribed the data, the text was reviewed by one researcher, and notes were made based on her first impressions. As this process continued, the researcher began to identify code labels which reflected a wider range of the participants' thoughts and ideas. These codes made up the initial coding scheme, and often came directly from the text. Codes that were conceptually similar were placed in one cluster, and these semantically related clusters were then organized into themes. To ensure the reliability of the data analysis, two additional researchers reviewed the established codes and themes to ensure that they were an accurate reflection of the data. A fourth researcher was introduced to resolve disagreements and opposing interpretations among the first three researchers. A final version of the coding scheme was then agreed upon by all four researchers. The interviews continued until saturation of the data. Saturation in this study meant that no new code was created in the coding process and the generated codes were duplicates. Data saturation in the present study was obtained from the tenth interview and two other interviews were conducted to ensure the adequacy of sampling. After the sixteen interviews, all subsequent data could be coded using the final coding scheme.

DATA ACCURACY AND RIGOR

Lincoln and Guba's method was also used in the current study. The assessed items of this method were as follows: credibility, dependability, transferability, and confirmability (30, 31). To assess the validity of the research, a trusted relationship was established with the participants. Each interview was provided to the participants after analyzing it, and their comments were sought to settle the data. Also, quotes reported were recorded verbatim. This study was conducted seeking expert colleagues' opinions on the extracted codes and categories for possible modifications. Moreover, the reviewers' suggestions were used throughout the research process. An external audit was used to assess the trustworthiness of the study. Finally, the audit process attested to the dependability of the study from a methodological standpoint, and the confirmability of the study by reviewing the data, analysis and interpretations, and assessing whether or not the findings accurately show the data. In essence, the audit observes both the process and product of the survey to control its trustworthiness. In this study, other advisors/supervisors and evaluators who were experts in qualitative research evaluate each phase of the research and provided ideas as needed.

One of the important subjects in qualitative research is the role of the researcher in eliciting data. The researcher as an instrument suggests opportunity to understand and discover an individual's experiences and insights of the phenomena in question. In order to suitably conduct qualitative research, the

TABLE 1 | Demographic information of the nurses participating in the study.

Demographic variables		Number (*n*)	Percentage (%)
Gender	Female	11	91.66
	Male	1	8.33
Marital status	Married	8	66.66
	Single	4	33.33
Employment	Permanent	3	25
	Temporary to permanent	4	33.33
	Contract	5	41.66
Age (year), mean ± SD		28.58 ± 3.98	
Work experience (year), mean ± SD		5.25 ± 2.89	

researcher should have the necessary experience and skills, and the ability to communicate (23).

RESULTS

Twelve nurses working in teaching hospitals affiliated with Arak University of Medical Sciences (Valiasr, Amir Al-Momenin, and Ayatollah Khansari) participated in this study and were subjected to in-depth interviews. The mean age of the participants was 28.58 (SD: 3.98) years, and the mean work experience was 5.5 (SD: 2.89) years. Most of the participants were married (66.6%). The participants' demographic information has been provided in **Table 1**.

The experiences of the participants in this study are presented in four main categories: sudden exposure to an unknown threat, being involved in an unequal war, stressful working conditions, and efforts to confine the threat.

Sudden Exposure to an Unknown Threat

The nurses participating in this study clarified that they were encountered with the disease suddenly, a disease that was unknown, had a rapid spreading rate, affecting people's lungs and causing serious and even life-threatening respiratory problems. The disease also would rapidly infect other family members. In addition to these problems, there was insufficient information about its symptoms and transmission ways, as well as its preventive and therapeutic measures. The nurses suddenly encountered this problem without prior preparedness, which changed their routine work rapidly. This type of confrontation caused panic, fear, and shock in many of them. Data analysis revealed two subcategories of nurses' feelings and concerns and nurses' reactions to the COVID-19 disease.

Nurses' Feelings and Concerns

The data showed that many nurses experienced feelings such as incompetency, inefficiency, sadness, grief, unhappiness, indecision, inability to make decisions, fear of becoming infected and transmitting the disease to family members, and stress, anxiety, and worry about the complications of the disease or even their possible death. A number of nurses had even thought of quitting the profession due to these feelings, tensions, and difficult conditions. In this regard, a nurse stated:

> "My biggest concern was the transmission of the disease to my family. I feared what if I was a carrier and transmit it to my family. What if my mom and dad would be unable to cope with the disease, and I be the reason of their death?". The nurse continued:
>
> "The first few months were very difficult. Stress was at the highest level. My colleagues were becoming infected one after the other. Even one of them was hospitalized here and constantly had hypoxia and dyspnea. I really was afraid of becoming infected myself." (Participant No. 4)

Nurses' Reactions

The data showed that a number of nurses sometimes expressed reactions such as oversensitivity to the disease, obsessive-compulsive behaviors, anger, crying, self-absorption, and irritability. In this regard, a nurse mentioned:

> "This was our first experience. I was on a shift with my colleague, and we were so worried. We did not know what would happen? We thought we would die soon. We went into a room, hugged each other and cried...". Another participant noted: "Every day, after taking off our protective clothing, we would spray each other's bodies with alcohol all over from the head to the toe to disinfect".

Another Nurse Expressed:

> "One of my colleagues was becoming very irritable and was always angry. The other one developed an obsession saying that she, after taking her child from the kindergarten, would spray him all over, change all his clothes and wash them with bleach, but still was thinking that he was contaminated, leaving her desperate." (Participant No. 1)

Being Involved in an Unequal War

Most of the participants in this study believed that they were dragged into an unequal war and did not know when it was going to end. A war in which, on one front, it was the COVID causative virus that seemed to be strong and designed for invading lungs, and on the other side, a small number of weary nurses. The nurses believed that on one hand, people would cause the disease to spread and consequently an increase in the number of referrals to hospitals by not observing health protocols; and on the other hand, there was this ever-changing virus with its vicious nature and the lack of a definite treatment. This type of fighting left nurses exhausted and depleted of energy and strength without seeing a clear vision ahead.

Stressful Working Condition

Nurses expressed that they were working in a stressful condition due to factors including the large number of hospitalized people, the bad behaviors of patients' companions, the presence of severely ill patients in the ward, constantly hearing coughing and seeing people struggling for their breath, patients' intense fear, anxiety, and begging and their sudden and rapid death, seeing some patients being abandoned in the hospital and not having companions due to the fear of contracting the infection, as well as difficult working conditions such as wearing protective

clothes, hats, and several layers of gloves, and not being able to drink fluids and water during work shifts, in addition to some organizational shortages such as insufficient number of nurses. A nurse stated:

> "We were dressed like astronauts, wearing face masks and other protective clothes. It was very hot in them, and I was very helpless. I was thirsty and would like to drink some water, but I couldn't. I was afraid of getting infected." (Participant No. 8)

Seeing patients' deaths was heartbreaking, and this was addressed by a nurse as:

> "Patients were becoming perished in front of our eyes very rapidly. It was heartbreaking. A woman came to the hospital on her own in the morning. She was fine, but when they took a CT scan, her lungs were completely white. During the night shift, she developed dyspnea and died." (Participant No. 5)

One of the nurses, addressing issues such as the lack of a proper patient management policy, the confusion of officials, and the lack of an appropriate system for rewarding and encouraging nurses (such as appreciating committed nurses by appropriate methods, stated:

> "Nobody pays attention to us nurses here. We have compact work shifts. Managers do not care for proper disease management. One day, Ayatollah Khansari hospital becomes the center of Coronavirus, and the next day, Amir Al-Momenin hospital. Committed nurses do not get promotions or rewards, and because of this, they lose their motivation." (Participant No. 1)

Efforts to Confine the Threat

Most of the participants reiterated the necessity of continuous efforts to control the disease and confine the virus. According to the participants, nurses would do their maximum effort to bring the patient to the best health condition. This is fulfilled by providing either direct care to the patient or via appropriately training the families of patients and individuals with milder symptoms. By keeping themselves up to date and seeking new knowledge about the disease, nurses not only boost their own awareness, but also can provide the best care to patients. In this regard, one of the participants highlighted:

> "In the ward where I work, all the colleagues are working beyond their capacity and abilities and try to provide patients with the best care so that they can recover as soon as possible." (Participant No. 10)

Another Participant Noted:

> "Nursing is a very hard profession. Anyway, from the beginning when we chose this field, we knew that we might face such a situation. So, even now, when we are under tremendous pressure, we are doing our best and even sacrificing ourselves, trying to get back to normal." (Participant No. 6)

TABLE 2 | The categories and subcategories extracted from the experiences of the nurses providing care to COVID-19 patients.

Categories	Subcategories	Examples of codes
Sudden exposure to an unknown threat	Nurses' feelings and concerns	Sadness and grief
		Incompetency and
	Nurses' reactions	Oversensitivity to the disease
		Irritability
Being involved in an unequal war	A vicious virus	A virus designed to invade lungs
		The vicious nature of the virus
	Weary nurses	Nurses' exhaustion
		Medical staff severe fatigue
Stressful working condition		High workload
		Patients' sudden and rapid death
		The lack of adequate nurses
Efforts to confine the threat	Seeking for new and adequate information	Efforts to disclose the truth about the disease
	Gathering all forces	Implementing all skills

DISCUSSION

This study aimed to investigate the experiences of the nurses providing care to COVID-19 patients in Iran. Our results were categorized into four main categories, which will be discussed in two main areas in the following sections (**Table 2**).

An Unknown Threat, Exaggerated Stress, and Efforts to Control the Disease

According to studies on COVID-19, this disease, as a pandemic, has caused a severe shock to the health care system of most countries around the world (32, 33). The nurses participating in this study perceived the COVID-19 disease as a life-threatening condition. In fact, epidemic diseases can have a significant psychological impact on nurses whose presence is necessary for providing health care services (34). According to previous studies, pandemic diseases exacerbate nurses' stress as they are faced with severe emotional, physical, and cognitive demands and must adapt to them (35, 36). In the frontline of care provision, nurses face pain, death, and moral dilemmas. In addition, the shortage of human resources and lack of equipment make their work even more exhausting due to imposing a high workload and exposing them to potentially health threatening conditions (37). Consistently, Koh et al. and Lam et al. stated that poor control on the patient's condition, incompetent management, and poor planning would increase nurses' burnout during epidemics (38, 39). Based on our results, the impacts of the COVID-19 disease on nurses' health status bring them fear and panic that can significantly accentuate the job burnout syndrome among them. Such a scenario means that nurses are faced with a significant increase in physical and psychological demands in their profession, and this occupational threat can

affect their personal and professional perceptions of existing demands and resources (34). Considering the job burnout caused by the perceived stress due to a shortage in available resources, it is important to evaluate the direct impacts of this perceived fear and its modifiers on job burnout and its relationship with occupational demands and resources. It is important to note that social, cultural, intrinsic, extrinsic, and personal factors can influence nurses' experiences and professional decisions. The results of various studies have shown that in dealing with the COVID-19 pandemic, it is required to make hard ethical and clinical decisions, and these two parameters are essential entities in order to provide quality, fair, and patient-oriented care services and greatly control the risk of harm to patients (40, 41). Therefore, the decisions made in this uncertain situation can have significant short-term and mid-term impacts on patients, their families, and health care providers. Therefore, incorrect decisions at this critical time can seriously inflict patients with consequences that may be even more devastating than the disease itself.

An Unequal War and the Role of Nurses

In the present study, facing a dreadful disease was likened to presence in a battlefield, reminiscing an unfair fight against an invincible enemy such as the COVID-19 disease. Seshadri et al. provided an example to draw this unequal battle as: "Our weapon in this war is stone while the enemy (COVID) is equipped with a gun" (42). Also, Perron and Gagnon (43) described nurses as "foot soldiers" who are sent to a war without proper equipment (or even with no equipment), sufficient information, and adequate human forces and physical resources, and even without adequate support and compensation. Other studies have also referred to nurses as "war heroes" (44, 45). Likewise, in the present study, the nurses used the same drawings to describe their experiences and transfer their emotions, as well as to describe the difficulties they have faced and the impacts of these stressful situations on their physical and emotional well-being. It is obvious that such conditions can have no positive effects in the long-term. In fact, although appreciation may be psychologically supportive, the long-term shortage of equipment and facilities will have negative psychological consequences on various aspects of nurses' personal and professional lives. A study noted that nurses should criticize only in the favor and interests of the state but not otherwise (43).

On the other hand, not observing health protocols by the public has led to the establishment of the disease and its victory in this battle, a notion that was also mentioned by the participants of the present study. Accordingly, a study in Iran stated that the biggest challenges in fighting against and controlling the COVID-19 disease from the perspectives of physicians and nurses were the general public not taking the disease seriously and quarantine regulations not being strictly implemented for contaminated cities (46). A number of combat strategies have been proposed by various studies, including the quarantine of cities and self-quarantine, implementing travel bans and controlling the entry and exit of cities, observing personal hygiene, the provision of adequate health and protective equipment, helping people with their primary needs and livelihood, identification of those suspected to have the disease, and providing sufficient medical staff (47–49). Therefore, proper policymaking and planning, adopting coherent strategies for crisis and information management, and boosting public awareness can be substantially helpful in controlling the disease and preventing its adverse consequences on the society and nurses.

Generally, the importance of cultural perceptions in times of crisis is highlighted. Moreover, cultural sensitivity during a pandemic doesn't sound like an accolade-winning idea (50); that means although cultural beliefs and values seem to be an important factor, it could be considered as an unimportant agent in the life-threatening conditions when the humans' health has the priority. In this regard, Foster (51) stated that "all of the efforts to maintain a culture of safety and prevent harm have a common denominator: They're dependent on the hands, hearts, and minds of the staff". So, during the life-threatening conditions, nurses feel more responsible to provide the suitable care, but it can vary based on cultural outlooks. This can make difference between nations. Iran is a country with an Islamic culture and a healthcare system that is unique from other countries. Iranian healthcare system is managed by pillars supported by religious and cultural sights. In Iran, patient care standards are controlled by Iranian beliefs in Islamic moral and ethical. Therefore, nurses from different social and cultural bases have diverse ethical and religious knowledge which may impact their care that they provide to the patients (52, 53). So, due to the importance of the cultural belief and values effectiveness, the nurses' outlooks considered as the main agent in doing the research especially the qualitative ones which reflects the individuals' point of views.

CONCLUSION

The experiences of the nurses participating in the present study showed that despite passing a while since the onset of the coronavirus pandemic, there are still individual and professional concerns that mainly root in organizational and governmental issues. In fact, establishing appropriate national and cultural contexts with an emphasis on maintaining public health not only improves community health and causes a better and more effective disease management process, but also greatly reduces the workload of health care workers, including nurses.

IMPLICATIONS FOR PRACTICE AND LIMITATIONS

Tackling with serious conditions like that of the COVID-19 pandemic which is reflected as an international threat, personnel of the health care organizations, and specially nurses, face serious challenges. Yet, if crisis is managed properly by getting enough information about all the aspects, environmentally and individually, nurses are more able to adopt with the current situation.

Due to the characteristics of qualitative research, the sample size of this study was limited. Moreover, all participants may not have revealed all their experiences due to worries about possible consequences. However, an effort was made to handle this limitation as much as possible by assuring the participants of the confidentiality and anonymity of their information.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Arak University of Medical Sciences. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

RM conceptualized the study with support from MG, AY, MJ, and MS. RM, KA, MS, and MG extracted the data for this study. RM cleaned and analyzed the data with support from MS. MG, AY, and MJ wrote the first draft of the manuscript. All authors contributed to writing and finalizing the manuscript. All authors have read and agreed to the published version of the manuscript.

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The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the COVID-19 Research Center (3624) and the Research Ethics Committee (IR.ARAKMU.REC.1399.063) of Arak University of Medical Sciences.

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Risk of SARS-CoV-2 Infection Among Essential Workers in a Community-Based Cohort in the United States

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Objectives: The objective of this paper is to identify the risk factors for SARS-CoV-2 infection that are related to occupation type as well as workplace conditions. Identifying such risk factors could have noteworthy implications in workplace safety enhancement and emergency preparedness planning for essential workers.

Methods: We conducted a retrospective analysis of visits at a community-based SARS-CoV-2 testing site in the greater Boston area between March 18th and June 19th, 2020, for individuals between 14 and 65 years of age. Nasopharyngeal swab specimen, medical review, and self-administered questionnaire were obtained, and SARS-CoV-2 infection was determined with real-time, reverse transcriptase-polymerase chain reaction (RT-PCR). Medical record-verified job classification, customer-facing, and work patterns were extracted from each individual's response through chart review and validated by licensed clinicians. The occupational patterns were coded by occupational medicine physicians with pre-specified criteria and were analyzed with logistic regression and inverse probability weighting.

Results: Among the 780 individuals included in the final analysis, working in healthcare-related jobs was associated with a four-fold increase in risk of SARS-CoV-2 infection (Adjusted OR: 4.00, 95% CI: 1.45–11.02). Individuals with customer-facing jobs had a two times risk increase (Adjusted OR: 1.97, 95% CI: 1.12–3.45) in having a positive SARS-CoV-2 RT-PCR assay result compared to participants with non-customer facing positions.

Conclusions: In this U.S. community-based population during the initial wave of the pandemic, a significant increase in risk of SARS-CoV-2 infection was observed in those

employed in the healthcare sector or with customer-facing positions. Further research is warranted to determine if these correlations continued with the buildup of population immunity together with the attenuation of SARS-CoV-2 virulence.

Keywords: COVID-19, communicable diseases, occupational health, healthcare workers, Public Health Surveillance

INTRODUCTION

The Coronavirus disease 2019 (COVID-19) pandemic has become one of the worst pandemics in this century which has affected billions of people around the world since late 2019 (1, 2). Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus causing the COVID-19 pandemic, is transmitted via aerosol and droplets (3, 4) and has a longer survival duration that potentiated the transmission capacity (5). Several drastic public health interventions were implemented around the world during the initial phase of the pandemic, such as business closures, city-wide lockdowns, and stay-at-home orders, which created significant socioeconomic impact on the society (6–8). Meanwhile, population health measures such as universal masking and social distancing were effective interventions to slow down the spread of COVID-19. The development and availability of the COVID-19 vaccines and pharmacological treatments further reduced the risk of severe illnesses and deaths while the virus continues to attenuate to less virulent variants (9).

Throughout the pandemic, workers are subjected to these constant, often drastic, societal changes as continued commerce activities are indispensable to our society. Therefore, occupational health has been an integral part of the disease prevention discussions since the onset of this pandemic. The discussion ranged from the early days of protecting essential workers to ensure the continuance of critical operations during the first wave, to the recent concerns of reopening businesses safely under this "new normal" (10–13). Understanding the associations between work conditions, work-related exposure risks and SARS-CoV-2 infection may support guidance and recommendations ranging from workplace environment modifications to targeted surveillance among workers with higher infection risk (14). Workplace preventive interventions could significantly impact the society, reduce the transmission of pathogen at work, and protect the population at large (12, 15–20).

Healthcare workers (HCWs) have historically been the research focus for occupational health as they work within an environment with significantly higher and uncertain exposure risks (21). Study in 11 Midwestern U.S. states found healthcare workers had a four-fold increase in risk of filing COVID-19 related Workers' compensation claims (22). Various studies throughout the pandemic have focused on the work conditions for healthcare workers, such as the proper use of personal protective equipment (PPE) was frequently associated with a decreased risk in SARS-CoV-2 infection among HCWs (23–25).

At the same time, work-related risks for SARS-CoV-2 infection among non-healthcare essential workers in the community continue to remain unclear even as businesses have largely reopened and as the society continued to adjust to different phases of this pandemic (12, 18–20, 26). Our study published early in the pandemic observed significant work-related transmission in service workers and drivers with COVID-19 exposure history in six Asian countries (19). In the U.S., only limited, industry-specific reports and studies provided some insights on non-HCW occupational exposure risks, such as the outbreak in meat-processing factories that identified congregated work and residential locations as risk factors, and the grocery store outbreak in Massachusetts that suggested customer contact as a risk factor for retail workers (12, 18, 20, 26). No study to-date has examined how job categories, occupations and customer-facing conditions influence SARS-CoV-2 infection risk at a community level in the U.S. Therefore, in this study we aim to examine the associations between job categories, occupational exposure, and SARS-CoV-2 test results among a cohort of community residents during the initial wave of the pandemic by utilizing occupational health physician-verified job categories, customer-facing conditions, and SARS-CoV-2 real-time, reverse transcriptase-polymerase chain reaction (RT-PCR) assay results, adjusting for known socio-behavioral confounders (27). We hypothesized that both job categories and customer-facing conditions impact a worker's risk of contracting SARS-CoV-2 infection after controlling for covariates.

MATERIALS AND METHODS

Study Population Selection and Setting

The study population was based on data from a city-supported COVID-19 testing clinic in Quincy, Massachusetts, which provided no-cost clinical evaluation and testing for the general population in the community with suspected COVID-19 related symptoms, contact, or travel exposure.

Our study included individuals aged 18 and above who presented for a clinical evaluation and received SARS-CoV-2 RT-PCR testing during the study period between March 18 and June 19 in 2020. Additionally, we included individuals between the age of 14–18 who indicated a current employment status to capture minors working part-time during the pandemic. We excluded patients tested for (1) State-sponsored post-mass-gathering/ protest testing initiative, (2) mandatory contact tracing testing events for homeless shelters and private institutions, and (3) retests after SARS-CoV-2 infection. We particularly selected the study period between March 18, 2020, and June 19, 2020, which reflected the first wave of coronavirus pandemic in the study region (28, 29).

Data Collection and Quality Control

We extracted baseline demographic information (name, age, gender, and race/ethnicity), day of the clinic visit, and SARS-CoV-2 RT-PCR test results from a database established by the clinic's data analyst. At the time the participants got COVID-19 testing, their information (sociodemographic and occupational history) was recorded by the clinic's staff. We then cross-referenced the list with the clinic's electronic medical record system, reviewed and extracted relevant information from the templated telemedicine clinical notes recorded by licensed clinicians and electronic intake forms from patients entered on an iPad prior to receiving SARS-CoV-2 testing. We also reviewed and validated medical charts for the individual's presenting clinical symptoms, date of symptom onset (if with symptoms), SARS-CoV-2 exposure history (if any), current occupation/ job title and last day of work, recent travel history, household population, and smoking status. The clinical symptoms in this study included fever, headache, cough, shortness of breath, sore throat, myalgia, fatigue, nausea/vomiting, diarrhea, and anosmia. The chart review process was equally and randomly assigned to three licensed clinicians (NL, LD, and RA) by their clinic visit date. The chart reviewers discussed any unclear or uncertain situations within the group and with JY, and final extraction decisions were then made by JY after discussions. To ensure chart review quality, a total of 20 charts were selected randomly and reviewed by JY from each chart reviewer. The database was then deidentified prior to further review and statistical analysis.

Definition of Job and Work-Related Conditions

We included job classification, customer-facing, interval since last day at work, and work patterns (not at work, work from home, or in person) in this study. We extracted the individual's current work status directly from the medical records as a three-leveled response ("no," "yes", and "yes but work from home"). We further extracted their last date at work if a date was given by the individual during intake. Meanwhile, we categorized job classification and customer-facing conditions by independent clinician review followed by a panel discussion for all individuals who provided their job information during the initial intake. Specifically, three occupational medicine physicians (CFW, FYL, YTH) independently reviewed the job titles from the deidentified database and determined the initial coding for job category and customer-facing conditions. The job family of each patient was defined by matching each individual's self-reported job to the closest job families listed in O*NET OnLine, a U.S. Department of Labor-sponsored database (30). The three physicians coded customer-facing conditions at work as "yes" or "no", based on their likelihood of customer facing conditions for given job titles as determined by the reviewer. Then, a consensus of job classification and customer exposure was reached for each patient by combining and comparing independent category coding conducted by CFW, FYL, YTH. Any discrepancies were discussed together was a group and with JY for a final decision. For individuals with uncertain job category or customer exposure status after discussions, JY would conduct follow-up telephone for further clarification by the patients. Final coding for each patient was reexamined by all the discussants in the final discussion round, after resolving any residual discrepancy or possible misspecification (CFW, FYL, YTH, and JY).

SARS-CoV-2 Testing and Specimen Collection

Trained clinician obtained nasopharyngeal specimens from individuals and stored them in a 3 ml vial with viral transport media (VTM). The samples were transported on ice to Quest Diagnostic laboratory in Marlborough, Massachusetts for RT-PCR analysis. The collection process followed guidelines published by the U.S. Center for Disease Control and Prevention (CDC) (31). Patients' SARS-CoV-2 assay result was reported as positive, negative, or indeterminate (32).

Definition of Confounders

The confounders were selected based upon available literature on SARS-CoV-2 infection and COVID-19 (18, 23, 24, 27, 33–39). We manually extracted age, gender, race, smoking status, household population size, travel history, and self-reported contact from each medical record. Race and ethnicity were grouped into non-Hispanic white, non-Hispanic black, Asian, Hispanic, and others. Smoking condition and travel history were dichotomized into binary variables (yes or no). Self-reported contact history was categorized as no, yes (with family members or friends), and yes (with colleagues or customers). We defined an interval indicator as to the date of testing eligibility expansion at the study site (April 19, 2020) and the initiation of Phase 1 reopening in Massachusetts (May 18, 2020) (28).

Statistical Analysis

Continuous variables were inspected for normality with a Q-Q plot first. Then, these continuous variables were presented in their means and standard deviations among the population with positive and negative results, respectively. Meanwhile, categorical variables were presented in count and percentage. *P*-values were tested with independent *t*-test for continuous variables and were tested using χ^2 or Fisher exact test for categorical ones. The percentages were presented in rows to highlight the proportion of positive and negative tests for each level of the variables. We applied multivariable logistic regression models to examine the association between the primary outcome of positive SARS-CoV-2 RT-PCR assays and different work conditions. We demonstrated both unadjusted, adjusted odds ratio (OR) and 95% confidence intervals (CI) adjusted for all confounders listed above. We let people not currently working or working from home be the reference group for the association between job categories, and we set the non-exposed individuals as the reference group for the association of customer-facing, contact the source and work from home status.

The dataset was extracted and reviewed in Microsoft Excel, and analyses were performed using the R software, version 4.0.4. All *p*-values are two-tailed and without adjustment for multiple testing, and we used a significance level of 0.05 in this study.

Sensitivity Analysis

We tested the associations in the multivariable regression model adjusting for all other non-occupational factors, which captures the association between known risk factors and the risk of SARS-CoV-2 infection. Then, we examined the association between SARS-CoV-2 assay results and job categories, work status, and customer-facing exposure for patients presented before the date of Massachusetts Phase 1 reopening. This subpopulation is more reflective of essential workers and is indicative of the population at risk during the first wave of the pandemic (28). Furthermore, we applied inverse probability weighting to balance the covariate distribution in the whole population, in which we balanced the probability of being in each work groups with their symptoms at presentation. So, the association between different job categories was not confounded by indication of testing. We presented demographic characteristics in different work statuses, and clinical symptoms at their baseline visits. Lastly, we demonstrated the clinical and household conditions for work-from-home individuals who tested positive for SARS-CoV-2.

Human Subjects

All medical records and test results were de-identified at the primary clinical site. The de-identified database was then transferred by secure email system to Harvard TH Chan School of Public Health for analysis. The study of de-identified data received a non-human research exempt determination by the Institutional Review Board of Boston University (IRB H-40496).

RESULTS

Characteristics of the Study Population

A total of 2,257 patients received testing at this clinic location during the study period between March 18 and June 19 in 2020. We included 780 individuals that met our selection criteria in the final analyses, with 95 of them (12.2%) testing positive for SARS-CoV-2 by RT-PCR assay. The mean age of the study population was 42.0 years old (SD: 12.7 years); the majority of the participants were female (56.9%) and non-Hispanic Caucasians (63.7%) (**Table 1**). There were 190 current smokers (24.4%) in the study population. Self-reported COVID-19 exposure history were mentioned among 313 individuals (147 from families and friends, and 166 from colleague and customer), and only 44 subjects in the study population reported travel history during the study period.

There was no evident difference in the distribution of age and gender by SARS-CoV-2 assay result. Those with positive assay results were more likely to report COVID-19 exposure history (56.8 vs. 38.0%), live in a higher populated household, and reside in higher COVID-19 cumulative rate areas. Meanwhile, patients with negative results were more likely to be non-Hispanic Caucasian and current smokers. We further compared work status, job category, and work exposure between patients with positive and negative SARS-CoV-2 RT-PCR assay results. Overall, 456 of 780 (58.5%) individuals were remained at work upon presentation, and there were more HCWs in the case group (12 in 95 cases, and 51 in 685 negative individuals, p-value = 0.124). Meanwhile, the distribution of work patterns and the

TABLE 1 | Comparison of baseline sociodemographic, job category, and work condition in study population between March 18,2020 and June 19, 2020, stratified by SARS-CoV-2 RT-PCR assay results[a].

	Overall	Positive	Negative	*p*-value
N (%)	780 (100.0%)	95 (12.2%)	685 (87.8%)	
Age (mean (SD))	42.0 (12.7)	40.7 (14.2)	42.1 (12.4)	0.288
Gender (%)				0.782
Female	443 (100.0%)	52 (11.7%)	391 (88.3%)	
Male	335 (100.0%)	43 (12.8%)	292 (87.2%)	
Race (%)				<0.001
Non-Hispanic white	443 (100.0%)	30 (6.8%)	413 (93.2%)	
Black	56 (100.0%)	16 (28.6%)	40 (71.4%)	
Asian	77 (100.0%)	13 (16.9%)	64 (83.1%)	
Hispanics	44 (100.0%)	10 (22.7%)	34 (77.3%)	
Others	75 (100.0%)	16 (21.3%)	59 (78.7%)	
Smoking (%)				< 0.001
No	589 (100.0%)	87 (14.8%)	502 (85.2%)	
Yes	190 (100.0%)	8 (4.2%)	182 (95.8%)	
Household population size (mean (SD))	3.1 (1.8)	3.5 (1.9)	3.0 (1.8)	0.012
Contact history (%)				< 0.001
No	464 (100.0%)	41 (8.8%)	423 (91.2%)	
Family/Friend	147 (100.0%)	37 (25.2%)	110 (74.8%)	
Colleague/Customer	166 (100.0%)	17 (10.2%)	149 (89.8%)	
Travel history (%)				0.012
No	734 (100.0%)	93 (12.7%)	641 (87.3%)	
Yes	44 (100.0%)	0 (0.0%)	44 (100.0%)	
Job families (%)				0.749
Not working	324 (100.0%)	41 (12.7%)	283 (87.3%)	
Architecture and engineering	3 (100.0%)	0 (0.0%)	3 (100.0%)	
Building and grounds cleaning and maintenance	15 (100.0%)	2 (13.3%)	13 (86.7%)	
Business and financial operations	5 (100.0%)	0 (0.0%)	5 (100.0%)	
Community and social service	29 (100.0%)	3 (10.3%)	26 (89.7%)	
Computer and mathematical	1 (100.0%)	0 (0.0%)	1 (100.0%)	
Construction and extraction	34 (100.0%)	2 (5.9%)	32 (94.1%)	
Education, training, and library	4 (100.0%)	0 (0.0%)	4 (100.0%)	
Food preparation and serving	44 (100.0%)	7 (15.9%)	37 (84.1%)	
Healthcare practitioners and technical	40 (100.0%)	10 (25.0%)	30 (75.0%)	
Healthcare support	23 (100.0%)	2 (8.7%)	21 (91.3%)	
Installation, maintenance, and repair	12 (100.0%)	0 (0.0%)	12 (100.0%)	
Legal	4 (100.0%)	0 (0.0%)	4 (100.0%)	
Life, physical, and social science	2 (100.0%)	0 (0.0%)	2 (100.0%)	
Management	38 (100.0%)	3 (7.9%)	35 (92.1%)	

(Continued)

TABLE 1 | Continued

	Overall	Positive	Negative	*p*-value
Office and administrative support	33 (100.0%)	4 (12.1%)	29 (87.9%)	
Personal care and service	35 (100.0%)	6 (17.1%)	29 (82.9%)	
Production	10 (100.0%)	1 (10.0%)	9 (90.0%)	
Protective service	33 (100.0%)	2 (6.1%)	31 (93.9%)	
Sales and related	60 (100.0%)	8 (13.3%)	52 (86.7%)	
Transportation and material moving	31 (100.0%)	4 (12.9%)	27 (87.1%)	
Customer-facing (%)				0.166
No	473 (100.0%)	51 (10.8%)	422 (89.2%)	
Yes	305 (100.0%)	43 (14.1%)	262 (85.9%)	
Work patterns (%)				0.497
No	279 (100.0%)	33 (11.8%)	246 (88.2%)	
Work from home	45 (100.0%)	8 (17.8%)	37 (82.2%)	
Yes	456 (100.0%)	54 (11.8%)	402 (88.2%)	
Days since last work (mean (SD))	4.0 (5.3)	5.0 (5.4)	3.8 (5.3)	0.159

[a]*Continuous variables were presented in their means and standard deviations among the population with positive and negative results, and categorical variables were presented in count and percentage. p-values were tested with independent t-test for continuous variables and were tested using χ^2 or Fisher exact test for categorical variables. All missing values are omitted in this analysis.*
COVID-19, the Coronavirus disease 2019; SD, standard variations; RT-PCR, reverse transcriptase-polymerase chain reaction.

TABLE 2 | Clinical characteristics and symptoms reported by individuals in the study population during clinical intake, stratified by SARS-CoV-2 RT-PCR assay results[a].

	Overall	Positive	Negative	*p*-value
N (%)	780	95 (12.2)	685 (87.8)	
Days since onset (Mean (SD))	7.2 (10.1)	5.7 (5.2)	7.5 (10.7)	0.127
Count for symptoms (Mean (SD))	3.5 (2.5)	4.3 (2.2)	3.4 (2.6)	0.003
Symptomatic (%)	634 (100.0%)	88 (13.9%)	546 (86.1%)	0.002
Fever/chill	326 (100.0%)	60 (18.4%)	266 (81.6%)	<0.001
Headache	268 (100.0%)	41 (15.3%)	227 (84.7%)	0.054
Cough	429 (100.0%)	69 (16.1%)	360 (83.9%)	< 0.001
Shortness of breath	285 (100.0%)	30 (10.5%)	255 (89.5%)	0.284
Sore throat	302 (100.0%)	38 (12.6%)	264 (87.4%)	0.784
Myalgia	307 (100.0%)	52 (16.9%)	255 (83.1%)	0.001
Fatigue	405 (100.0%)	51 (12.6%)	354 (87.4%)	0.714
Nausea/vomiting	164 (100.0%)	20 (12.2%)	144 (87.8%)	0.995
Diarrhea	189 (100.0%)	24 (12.7%)	165 (87.3%)	0.802
Anosmia	80 (100.0%)	20 (25.0%)	60 (75.0%)	< 0.001

[a]*Continuous variables were presented in their means and standard deviations among the population with positive and negative results, and categorical variables were presented in counts and percentages. P-values were tested with independent t-test for continuous variables and were tested using χ^2 or Fisher exact test for categorical variables.*
RT-PCR, reverse transcriptase-polymerase chain reaction.

mean time since the last day at work was not different between the two groups.

Clinical Presentations of the Study Population

Clinical characteristics among the study population were demonstrated in **Table 2**. The majority of the positive cases were symptomatic upon presentation (88 of 95 individuals). Patients with positive SARS-CoV-2 RT-PCR assay results had more clinical symptoms at presentations (4.3 vs. 3.4 symptoms upon the visit, $p = 0.003$). Fever/chill, cough, myalgia, and anosmia were more likely to present among positive cases than their negative counterparts.

Associations Between SARS-CoV-2 Infection and Work-Related Conditions

We conducted multivariable logistic regression to examine the association between work conditions and the likelihood of positive the SARS-CoV-2 RT-PCR assay results in **Table 3**. HCWs were associated with an increased odd for SARS-CoV-2 infection than those who were not working or working from home (unadjusted OR 2.30, 95% CI: 1.05–5.06; adjusted OR 4.00, 95% CI: 1.45–11.02).

We also employed multivariable logistic regression to examine the association between job characteristics and the likelihood of positive SARS-CoV-2 RT-PCR assay (**Table 4**). Workers at jobs with customer-facing conditions had higher odds for SARS-CoV-2 infection compared to the rest of the population (unadjusted OR 1.36, 95% CI: 0.88–2.10; adjusted OR 1.97, 95% CI: 1.12–3.45). Meanwhile, workers who worked from home were associated with an increased likelihood of testing positive for SARS-CoV-2 than non-working individuals after adjusting for age, gender, race, smoking status, household population size, travel history, self-reported contact, and interval indicator (unadjusted OR 1.61, 95% CI: 0.69–3.76; adjusted OR 3.07, 95% CI: 1.13–8.34).

Sensitivity Analysis

The multivariable regression model showed associations for contact history, and race, and decreased risk for smoking after phase I reopening (**Supplementary Table 1**). Meanwhile, the associations were similar after restricting the analysis to individuals tested prior to phased reopening (**Supplementary Tables 2, 3**). The associations for HCWs remained significant after using inverse probability weighting to balance the distribution of covariates, and we did not identify other evident associations for other job families (**Supplementary Table 4**). We found that individuals reporting work status as in-person were more likely to report exposure to suspected/confirmed COVID-19 customers or colleagues, and they were more likely to have a shorter interval between symptom onset and clinic visit than those who were not working or working from home (**Supplementary Tables 5, 6**). Lastly, we examined the demographic and clinical presentations for

TABLE 3 | Associations between job families and the risk of testing positive for SARS-CoV-2 by RT-PCR assay among the study population.

Job family	Unadjusted OR	95% CI		Adjusted OR[a]	95% CI	
Building and grounds cleaning and maintenance	1.06	0.23	4.89	0.93	0.16	5.32
Community and social service	0.80	0.23	2.76	0.61	0.11	3.32
Construction and extraction	0.43	0.10	1.87	0.23	0.03	1.92
Food preparation and serving related	1.31	0.55	3.13	2.43	0.86	6.87
Healthcare practitioners and technical	2.30	1.05	5.06	4.00	1.45	11.02
Healthcare support	0.66	0.15	2.91	0.78	0.15	3.95
Management	0.59	0.17	2.02	0.57	0.14	2.32
Office and administrative support	0.95	0.32	2.85	2.48	0.72	8.59
Personal care and service	1.43	0.56	3.65	2.28	0.76	6.85
Production	0.77	0.09	6.23	0.77	0.07	8.75
Protective service	0.45	0.10	1.94	0.75	0.14	4.13
Sales and related	1.06	0.47	2.40	1.45	0.55	3.78
Transportation and material moving	1.02	0.34	3.08	0.79	0.21	3.04

[a]*Adjusted for age, gender, race, smoking status, household population size, travel history, self-reported contact, and interval indicator, and the reference group included individuals that reported a work-from-home status or not currently working.*

CI, confidence interval; OR, odds ratio; RT-PCR, reverse transcriptase-polymerase chain reaction.

TABLE 4 | Associations between customer facing, shift work, work pattern, and risk of testing positive for SARS-CoV-2 by RT-PCR assays among the study population.

Job characteristics	Unadjusted OR	95% CI		Adjusted OR[a]	95% CI	
Customer-facing	1.36	0.88	2.10	1.97	1.12	3.45
Shift work	1.29	0.79	2.09	1.63	0.91	2.94
Work pattern[b]						
Work from home	1.61	0.69	3.76	3.07	1.13	8.34
In person	1.00	0.63	1.59	1.47	0.80	2.69

[a]*Adjusted for age, gender, race, smoking status, household population size, travel history, self-reported contact, and interval indicator.*

[b]*The reference group was individuals with self-reported non-working status.*

CI, confidence interval; OR, odds ratio; RT-PCR, reverse transcriptase-polymerase chain reaction.

patients tested positive by SARS-CoV-2 RT-PCR assay and worked from home. These patients were mostly diagnosed in the first month of the study, and three out of eight subjects reported COVID-19 exposure history with their families (**Table 5**).

DISCUSSION

Several occupation-related risk factors resulting in a positive SARS-CoV-2 assay result were identified in this cohort of community residents in the U.S. To begin with, healthcare workers were 4 times more likely to have a positive SARS-CoV-2 assay result. While not statistically significant, we also observed an increased risk among workers in the food preparation, office administration, and personal care professions. Furthermore, individuals with customer-facing jobs had a two-fold risk increase in testing positive on the SARS-CoV-2 assay. Individuals working from home were associated with a higher likelihood of testing positive for SARS-CoV-2 at the earlier phase (unadjusted OR 1.61, 95% CI: 0.69–3.76; adjusted OR 3.07, 95% CI: 1.13–8.34). Additionally, individuals with a positive SARS-CoV-2 assay result were more likely to live in households with higher resident counts, in communities with higher cumulative incidence rates, and/or reported COVID-19 exposure with family or friends. To the best of our knowledge, this study is the first to demonstrate these associations between an individual's occupation, customer exposure through jobs, and SARS-CoV-2 assay results in a cohort of community residents in the U.S.

The increased risks among healthcare workers were consistently observed in multiple analyses throughout this study, which is in concordance with results observed in previous studies (23–25, 40–42). At the same time, previous studies that observed similar presenting symptoms and/or elevated SARS-CoV-2 positivity risks were conducted among healthcare workers in hospital-based settings (23, 25). Our study examined the risk among HCWs from different healthcare facilities and settings in a community-based cohort, which extended the scope from previously published hospital-based, single-setting studies. Additionally, a panel of occupational medicine physicians reviewed and verified each HCW's job title and work-related exposure under a standardized protocol. This rigorous approach provides a more granular information for individual's occupation and work status, extending the HCW occupational risk findings and associations previously identified in studies that utilized aggregated U.S. and U.K. databases (24, 43).

In addition to healthcare workers, we identified increased odds of having a positive SARS-CoV-2 assay result among workers in customer-facing roles and those who reported they worked from home. Individuals with customer-facing jobs had a two-fold increase in risk of being tested positive for SARS-CoV-2.

TABLE 5 | Descriptions of detailed (a) demographics and (b) reported clinical symptoms of individuals with positive SARS-CoV-2 RT-PCR assay result who reported they worked from home during the initial intake evaluation.

a. Demographic conditions

No	Encounter Date	Age	Sex	Race	Job family	Travel history	Exposure source	Cohabitant number	Smoker	Days since symptom onset
1	3/19/2020	49	Female	Black or African American	Educational instruction and library	No	No	1	No	1
2	3/26/2020	55	Male	White	Business and financial operations	No	No	0	Yes	7
3	4/1/2020	53	Female	White	Healthcare support	No	Families	1	No	1
4	4/2/2020	32	Female	Asian	Computer and mathematical	No	No	3	No	6
5	4/11/2020	33	Male	White	Educational instruction and library	No	Families	1	Yes	4
6	4/14/2020	28	Female	Black or African American	Arts, design, entertainment, sports, and media	No	Families	4	No	6
7	4/20/2020	36	Female	Asian	Business and financial operations	No	Colleagues	1	No	8
8	5/8/2020	35	Female	Asian	Transportation and material moving	No	No	4	No	2

b. Clinical symptoms

No	Fever/chills	Headache	Cough	Shortness of breath	Sore throat	Myalgia	Fatigue	Nausea	Diarrhea	Anosmia	Other symptoms
1	Yes	No	Yes	No	Yes	No	No	No	No	No	No
2	Yes	No	Yes	No	Yes	Yes	Yes	No	Yes	Yes	No
3	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	No
4	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Vomiting, ageusia, nasal congestion, eye pain, sinus pressure
5	No	Yes	Yes	No	Yes	Yes	Yes	No	No	No	Sneezing, sinus pressure
6	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Wheezing
7	Yes	No	Yes	No	Yes	Yes	No	No	No	No	Nasal congestion
8	Yes	Yes	Yes	No	Yes	No	No	No	No	No	No

RT-PCR, Reverse transcription polymerase chain reaction.

This finding we observed among individuals with customer facing jobs may be associated with the increased risk of direct exposure to coronavirus infected customers at workplace (12, 17, 19, 33, 36). In a previous study summarizing work-related COVID-19 cases in six Asian countries, it was hypothesized that these workers contracted COVID-19 through contact exposure to their customers (19). Another study among retail workers in Massachusetts also identified an increased risk in testing positive for SARS-CoV-2 in store employees with customer-facing roles (12). In further examining specific job categories, we observed an increased risk of SARS-CoV-2 positivity among workers in the food preparation, office admin, and personal care job categories, albeit the increase was not statistically significant among our cohort. At the same time, this study provided detailed occupation information on the population at risk, which filled in the scientific gap in the limitation of previous research using aggregated information from the Workers' compensation database (27).

Surprisingly, in this study we observed an increased risk in having a positive SARS-CoV-2 assay result among workers who reported a work-from-home status at the time of COVID-19 exposure or symptom onset compared to those who were not at work. This finding may be due to household clustering, as three of the eight positive cases in the work-from-home group reported exposure to confirmed COVID-19 household contacts. Additionally, household population and exposure to confirmed COVID-19 family members were associated with increased risk of SARS-CoV-2 assay positivity in this study. This may be due to shared spaces (4, 5), frequent interaction with infectious individuals at home (3, 6, 35, 37), or less adherence to maintaining social distancing within a more congregated household (18, 34, 38, 44). Therefore, the high proportion of reported household transmission among these work-from-home workers provided a possible explanation for the increased likelihood of SARS-CoV-2 infection we observed in this study, as work-from-home individuals are less likely to wear personal protective equipment at home and may have significant exposure to SARS-CoV-2 from their infected family members (4, 34–36, 38). Additionally, lengthened work hours and increased occupational stress due to workplace transition among work-from-home workers during this first wave of the pandemic may have further increased their susceptibility to SARS-CoV-2 (45). Lastly, as we observed a wide confidence interval for the estimate, the possibility of unmeasured confounders and temporal ambiguity cannot be ruled out.

There are several strengths to this study. First, the job category, customer exposure and work status of each patient was examined and classified independently by three occupational medicine physicians in a rigorous, blinded approach as the evaluators were unaware of SARS-CoV-2 testing results during the classification process. The results have also been validated internally for test-retest consistency to provide a more accurate and granular information of an individual's occupational status. Our approach and study results filled in the knowledge gap of previous studies that used public health databases, as those studies do not have the detailed work history as we collected in this study. Second, data were collected by multiple experienced licensed clinicians before testing in a preset, templated format, which minimized information and recall bias. Third, the nasopharyngeal SARS-CoV-2 RT-PCR test was utilized in all patients in this study, which is among the most widely used and accurate testing methods for SARS-CoV-2 detection (32). Last not the least, we adjusted for personal risk factors in this community-based population to reduce the confounding from individual factors.

There are several limitations to this study as well. First, there were unmeasured socioeconomic status confounders, such as family income and education level, which may lead to non-differential bias. Second, while we utilized templated intake questions with clear questions and answer choices conducted by licensed clinicians, there is a chance that individuals may have mistakenly reported their work status or exposure history. These misclassifications are non-differential under the cohort design, but they may bias the results toward the null. Third, while we included a moderate cohort size in this study, the extensive job category list led to wider confidence intervals and less power to detect smaller differences. Therefore, we were not able to distinguish the differences between frontline and supporting healthcare workers, and there was a wide confidence interval for the association on shift workers. Lastly, this study included individual data from the first wave of the pandemic, with the Massachusetts state of emergency and the Order to shutdown non-essential services, we were only able to capture essential workers' work-related exposure risks during the first wave and the subsequent initial phase of reopening. Additionally, the Massachusetts testing guideline excluded asymptomatic individuals from obtaining a SARS-CoV-2 test during this period of the pandemic. With the increase in population immunity from both COVID-19 vaccine and natural infection, the results from our study therefore cannot be fully generalized to our present state in this pandemic. At the same time, this limitation caused by the state non-essential services shutdown order and the strict testing criteria created a unique environment with less confounders and allowed us to specifically examine the workplace exposure risks for non-HCW essential workers at the onset of this pandemic, providing valuable insights and lessons to workplace communicable disease emergency response planning for essential services that can be used for the future.

In conclusion, this study identified several significant correlations between individuals' occupational exposure and risk of SARS-CoV-2 infection during the first wave of the COVID-19 pandemic. Our study demonstrated a four-time increased risk of SARS-CoV-2 assay positivity among healthcare workers. Moreover, workers with customer-facing jobs were associated with a two-fold increased risk in testing positive for SARS-CoV-2, suggesting a higher COVID-19 occupational risk for workplaces with direct, face-to-face customer exposures. While further research is warranted to determine if the observed correlations continued in this current state of the pandemic due to population immunity and natural attenuation of SARS-CoV-2 virulence, correlations observed in this study for non-healthcare essential workers provide significant insights for workplace communicable disease emergency response planning in the future.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Institutional Review Board of Boston University (IRB H-40496). Written informed consent to participate in this study was provided by the participant, or participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

C-FW, F-YL, Y-TH, and JY contributed to conception and design of the study and wrote sections of the manuscript. NL, LD, RA, and JY organized the database. C-FW performed the statistical analysis and wrote the first draft of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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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.2022.878208/full#supplementary-material

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Association Between Dimensions of Professional Burnout and Turnover Intention Among Nurses Working in Hospitals During Coronavirus Disease (COVID-19) Pandemic in Iran Based on Structural Model

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Purpose: This study was done to assess the dimensions of professional burnout and turnover intention among nurses working in hospitals during the coronavirus disease 2019 (COVID-19) pandemic in Iran based on a structural model.

Methods: This cross-sectional study was performed among 170 nurses working in two referral hospitals of COVID-19 in Tehran Province, Iran, from September to December 2020. Data were collected using the sociodemographic form, Maslach Burnout Inventory (MBI), and Turnover Intention Questionnaire. Data were analyzed with SPSS and Amos software version 22 using independent *t*-test, ANOVA, and structural equation model.

Results: The mean scores for burnout in emotional fatigue, depersonalization, and personal accomplishment dimensions were 25.38 ± 7.55, 9.47 ± 4.40, and 34.94 ± 7.80, respectively, moreover for the turnover intention, the score was 6.51 ± 3.17. The reduced personal accomplishment was identified as a positive predictor of turnover intention ($p = 0.01$). Work position and interest in attending the organization were significantly correlated with the turnover intention ($p < 0.05$).

Conclusions: There is an immediate need to prepare nurses to cope better with the COVID-19 outbreak. Work-related stressors during the COVID-19 pandemic have led to an increase in nurses' burnout and turnover intention. Identifying and managing the factors related to professional burnout will make it possible to prevent the nurses' turnover intention in such critical situations.

Keywords: COVID-19, nurses, pandemics, professional burnout, psychological, workplace, personnel turnover

INTRODUCTION

In the twenty-first century, the coronavirus disease 2019 (COVID-19) pandemic and its negative consequences are a health threat to the people worldwide (1, 2). After a short time, COVID-19 has caused significant damage to public health while causing a financial and economic loss in many countries (3). Healthcare workers (HCWs), especially nurses worldwide, have played a significant role during disease outbreaks. Unpredicted stress exerted by the pandemic on every country's healthcare system has presented many difficulties for nurses (4). Additionally, the lack of personal protective equipment causes them to spread COVID-19 and distance from the workplace. Therefore, reducing the nursing staff increases the workload and extreme fatigue among other employees (5). In addition, healthcare providers are constantly dealing with the unpredictable sources of stress and situations that have many negative adverse on their physical and psychological health. These resources can include the nature of the job, high workload, high emotional load, the imbalance between demands and available resources, long working hours, long shifts, vague expectations, and weakness in supportive and effective management styles (6, 7). Viral threats, such as acute respiratory infections, also help exacerbate the health problems of nurses (8). Aprevious research had shown a variable level of nurses' intention to leave their profession across the globe. According to these studies, at the time of the outbreak of infectious diseases, such as severe acute respiratory syndrome (SARS), avian influenza (AV), and Middle East respiratory syndrome (MERS) (MERS-CoV), has shown that such outbreaks influence the interest of HCWs in their jobs (9). In addition, it affects attention, perception, and ability to make workplace decisions, productivity (8), dissatisfaction, reduced efficiency, burnout, turnover, burnout, and ultimately the tendency to leave the profession in nurses (10–12). Occupational burnout results from long-term exposure to certain job demand that a person is unable to bear (13). This syndrome is in the form of physical, mental, and emotional fatigue and a feeling of reduced personal success that leads to a variety of physical and mental illnesses, negative self-image, negative attitude toward the profession, lack of effective communication with the client, decreased patient safety, quality patient care, as well as turnover intention (14). The results of studies on burnout in nurses before and during the outbreak of coronavirus pandemic are reported to be moderate to high (15, 16). In Iran, the rate of stress and burnout is higher in nurses working in COVID-19 wards (13, 17). Turnover intention is one of the negative consequences of fatigue on HCWs. It is a common issue among nurses locally and internationally (18). In the last decade, the shortage of nurses has been a serious concern in most of the countries.

Intention to leave and subsequently leaving the job is one of the most important organizational factors that, if it occurs, can have devastating effects and financial burden, and high costs for the organization (19). Turnover intention means the departure of an organization's workforce over a certain period. Willingness to leave is a significant predictor of actual exit. It is also a cognitive stage that occurs before leaving the actual service and refers to a person's thought or mental decision about staying or leaving the job (20). Due to the heavy workload and stress, the rate of tendency to leave the nursing profession has the highest rank compared with other medical professions, and also the rate has varied from country to country, so that it has been reported in Asian countries 15 and 25%, respectively (21, 22), among western countries, such as the United States, 18% (23) and in Iran, 32.7%, respectively (24). However, the intention to leave during the COVID-19 outbreak was mentioned as one of the negative consequences and the reasons for it were anxiety, fear, and burnout of nurses (11, 12). According to previous studies, the high prevalence of psychological problems in COVID-19 has led to the tendency of employees to leave or reconsider their job choices or to help nurses exit (25–27). Therefore, the loss of experienced nurses has a negative impact on the provision and continuity of patient care services and may lead to more side effects, loss of nursing care, and patient mortality (28).

Given the widespread consequences of burnout and its impact on turnover intention in HCWs, particularly nurses, it is vital to understand and overcome this emerging problem (27). Because of an emerging infectious disease, such as COVID-19 can occur anywhere globally, health managers need to be aware of job stress, burnout, and its impact on employee propensity to leave. The results of previous studies have shown that positive organizational resources and work environment help reduce the tendency to leave the job. These resources have included providing opportunities for promotion and growth, increasing rewards, and emotional support for managers (29, 30).

Therefore, assessing the turnover intention of nurses is necessary to plan nurses' retention mechanisms in the Iranian context. This study is significant to add evidence for policy planners and program managers to improve such problems. Therefore, this study was conducted to investigate the dimensions of burnout and nurses' turnover intention who have experienced direct patient care in the first wave of COVID-19 in medical wards.

METHODS

Design/Participant

This cross-sectional study is based on the structural equation modeling performed 6 months after the COVID-19 pandemic in the period from September to December 2020 in Iran. The study population consisted of 400 nurses (nurses, assistant nurses, and nursing students) working in the front line of two referral hospitals for patients with COVID-19 in Tehran. At the onset of the outbreak in early 2020, more than 10 wards for patients with COVID-19 were opened in these two referral hospitals, such as intensive care units (ICUs), internal medicine, emergency department, and day clinic and outpatient wards. The capacity of hospitalized patients was estimated at more than 200 patients per day.

Inclusion criteria were nurses and assistant nurses working in departments related to the patients with COVID-19, no physical or mental illness based on self-report, willingness to participate in the study, and completing the questionnaire.

Procedure

In this study, due to the prevalence of the disease and the limitations related to the physical presence of researchers in medical centers, the questionnaires were converted into online versions, and its link was randomly shared for 200 nurses in nursing groups through social networks, such as WhatsApp, Telegram, or *via* email. Nurses formed these groups during the COVID-19 pandemic to meet the educational and scientific needs of treatment, care, and the latest guidelines issued by the Ministry of Health. After coordinating with the group administrators, the researchers sent a questionnaire link. The questionnaire was designed in Google Docs. The study samples were provided with explanations on the first page of the questionnaire, such as the title, purpose of the study, inclusion criteria, and ethical considerations.

Data Collection

Data collection tools include 3 questionnaires: job and demographic information questionnaire, such as work position (nurse, assistant nurse, and student), age, gender, work experience, marital status, education level, satisfaction with income level, interest in attending the organization, experience in caring for patients with COVID-19, and describing the quality of sleep in the past month. The second questionnaire, Maslach burnout inventory-human service survey (MBIHSS), which is an internationally known, validated, self-report questionnaire for measuring frequency and severity of workplace burnout. It was first designed and used by Maslach et al. (1981) in the form of a Likert scale to assess the frequency and severity of the three dimensions of burnout (31). This questionnaire consists of 22 questions in the three dimensions of burnout, which include 8 questions related to emotional fatigue, 5 questions related to depersonalization, and 9 questions related to individual achievement (self-efficacy). The frequency of these emotions is from zero to 6 (never, several times a year, once a month, several times a month, once a week, several times a week, and every day). So that higher scores in the dimensions of emotional fatigue and depersonalization and lower scores in individual achievement indicate more burnout. The levels of emotional exhaustion (<17 low, 18–29 medium, 30 or higher, severe), the later levels of depersonalization (<5 low, 6–11 moderate, 12 and above, severe), and the levels of personal accomplishment [33 and less low, 34–39 moderate, 40 and more, severe (32)].

The Persian version of the questionnaire has been validated in Iran, and its Cronbach's alpha was between 0.86 and 0.96 (32, 33).

The third questionnaire, The Michigan Organizational Assessment Questionnaire, the tendency to leave of Cammann et al., has 3 questions and is based on a Likert scale from 1 to 5 (strongly agree to strongly disagree) and is in the range of 3–15. The average score was 9, score 3 indicates the lowest, and score 15 indicates the highest tendency to leave the service (34). Its Cronbach's alpha value in this study was 0.80. The Persian version of the questionnaire has been validated in Iran, and its Cronbach's alpha was 0.82 (35).

Data Analysis

Data were analyzed with SPSS and AMOS statistical software version 16 using independent *t*-test, one-way analysis of variance (ANOVA), backward linear regression analysis, and structural equation modeling (**SEM**). The one-sample Kolmogorov–Smirnov test was performed to check the normality of data distribution, and the result showed normal data distribution ($p > 0.05$).

Bivariate Pearson's correlation coefficients and structural equation modeling were used to test the association between the dimensions of burnout and the nurses' turnover intention. The overall model fit was evaluated using P ratio, comparative fit index (CFI), Tucker–Lewis index (TLI), relative fit index (RFI), normal fit index (NFI), root mean square error of approximation (RMSEA), and relative chi square (CMIN/df).

Ethical Consideration

The ethics committee has approved the present study of Baqiyatallah University of Medical Sciences with No. IR.BMSU.REC.1399.074. In this study, the voluntary and informed participation of the subjects, satisfying the respondents regarding the research by committing to not disclose their personal information in any way, and designing the questionnaires anonymously so as not to reveal the identity of individuals (maintaining confidentiality and anonymity) and obtaining permission from the Ethics Committee has been considered.

RESULTS

Findings from the analysis of 170 participants (85% response rate) showed that the mean age was 35.15 ± 10.12 years (range 20–62 years). The mean scores of burnout dimensions included emotional fatigue, depersonalization, and personal accomplishment were 40.38 ± 7.55, 9.47± 4.25, and 34.94 ± 7.80, respectively. Moreover, among nurses, 135 (79.4%) had a moderate and low, and only 35 (20.6%) had a high tendency to leave the service. The mean score of turnover intention was 6.51 ± 3.17. There was no significant relationship between gender, marital status, the level of education, care of patient with COVID-19, clinical work experience, satisfaction with income level, and sleep quality with nurses' turnover intention ($p > 0.05$). However, the mean scores of job type and interest in the organization had a positive relationship with nurses' turnover intention. Least significant difference (LSD) *post-hoc* test showed that assistant nurses were significantly more likely to exit than nurses ($p = 0.02$) and students ($p = 0.009$). Furthermore, the mean score of turnover intention among nurses who were less interested in the organization was significantly higher than the other two groups ($p < 0.001$) (**Table 1**). Multiple regression analysis demonstrated that the work position and interest in attending the organization were significantly associated with the Turnover Intention score.

The findings of correlation coefficients between the different dimensions of burnout and the score of intention to leave showed that with increasing the three dimensions of burnout, scores related to the tendency to leave increases, but the relationship is not significant. As the individual's achievement decreases, the emotional fatigue and depersonalization dimensions' scores increase (**Tables 2**, **3**).

The results of the structural equation showed that although the effect of emotional fatigue and depersonalization dimensions

TABLE 1 | Socio-demographic information of participants.

Variable		Number	Percentage	Turnover Intention score Mean ± SD	*P*-value
Gender	Male	102	60	6.39 ± 3.12	0.52
	Female	68	40	6.70 ± 3.26	
Marital status	Single	52	30.6	6.67 ± 3.30	0.67
	Married	118	69.4	6.44 ± 3.12	
Educational status	Associate	53	31.2	6.47 ± 3.27	0.87
	Bachelor	81	47.6	6.44 ± 3.07	
	Master	24	14.1	7.00 ± 3.10	
	Ph.D.	12	7.1	6.25 ± 3.79	
Experience in caring of a patient with Covid-19	Yes	101	77.1	5.81 ± 3.13	0.52
	No	30	22.9	5.40 ± 3.02	
Work position	Nurse	119	70.4	6.40 ± 3.17	0.02
	Nurse assistant	23	13.6	8.04 ± 2.65	
	Student	27	16	5.70 ± 3.29	
Work experience	<6 year	65	38.7	6.44 ± 3.06	0.24
	6–10 year	28	16.7	6.78 ± 3.57	
	11–15 year	19	11.3	6.63 ± 3.02	
	16–20 year	18	10.7	5.00 ± 2.42	
	>20 years	38	22.6	7.07 ± 3.39	
Income satisfaction	Low	16	9.4	7.43 ± 2.87	0.23
	Moderate	92	54.1	6.17 ± 3.00	
	High	62	36.5	6.79 ± 3.46	
Interest in attending the organization	Low	21	16.2	8.85 ± 4.26	>0.001
	Moderate	57	43.8	5.85 ± 2.74	
	High	52	40	4.30 ± 1.73	
Sleep quality	Very bad	20	15.3	6.50 ± 3.56	0.07
	Fairly bad	40	30.5	6.47 ± 3.68	
	Fairly good	54	41.2	5.18 ± 2.65	
	Very good	17	13	4.70 ± 1.57	

TABLE 2 | Pearson correlation coefficients between different dimensions of burnout with each other and turnover intention.

	Emotional fatigue	Depersonalization	Personal accomplishment	Turnover intention
Emotional fatigue	1	–	–	–
Depersonalization	0.50 ($P < 0.001$)	1	–	–
Personal accomplishment	−0.13 ($P = 0.09$)	−0.28 ($P < 0.001$)	1	–
Turnover intention	0.12 ($P = 0.12$)	0.15 ($P = 0.05$)	−0.14 ($P = 0.06$)	1

on intention to leave was not statistically significant ($p > 0.05$), there was a statistically significant relationship between the personal accomplishment component and job leaving. Thus, it can be said that by increasing one unit in the individual accomplishment score, the average score of turnover intention will be 0.26 less (**Table 4** and **Figure 1**).

The model fit indices are given in **Table 4**. The calculated values indicate that the model's slight negligence fit is acceptable.

DISCUSSION

The present study aimed to assess the dimensions of professional burnout and turnover intention among nurses working in hospitals during the COVID-19 pandemic. The present study results revealed that nurses suffered moderate burnout during the coronavirus crisis. However, since only 6 months passed from the outbreak of COVID-19 until the present study, the rate of burnout was significant and might increase if not prevented. The spread of infectious diseases over the past two decades has been a severe threat to the health system worldwide. Healthcare providers are under a great deal of physical and psychological pressure to care for many potential infectious victims. Therefore, burnout is not a new phenomenon. In line with the present study, the results of other studies showed that the majority of nurses working in the front line of COVID-19 had experienced 19 degrees of mild to high levels of burnout (4, 21). In addition, the present results showed that the prevalence of burnout in

TABLE 3 | Regression coefficients related to the association between burnout dimensions and turnover intention.

	Standardized regression coefficient	Regression coefficient	S.E	Test statistics	*p*-value
Emotional fatigue	0.072	0.078	0.15	0.52	0.6
Depersonalization	0.201	0.299	0.22	1.32	0.18
Personal accomplishment	−0.263	−0.265	0.10	−2.58	0.01

TABLE 4 | Model fit indices in examining the relationship between the dimensions of burnout and turnover intention.

PRATIO	CFI	TLI	IFI	RFI	NFI	RMSEA	CMIN/DF
0.9	0.85	0.83	0.85	0.7	0.73	0.07	1.92

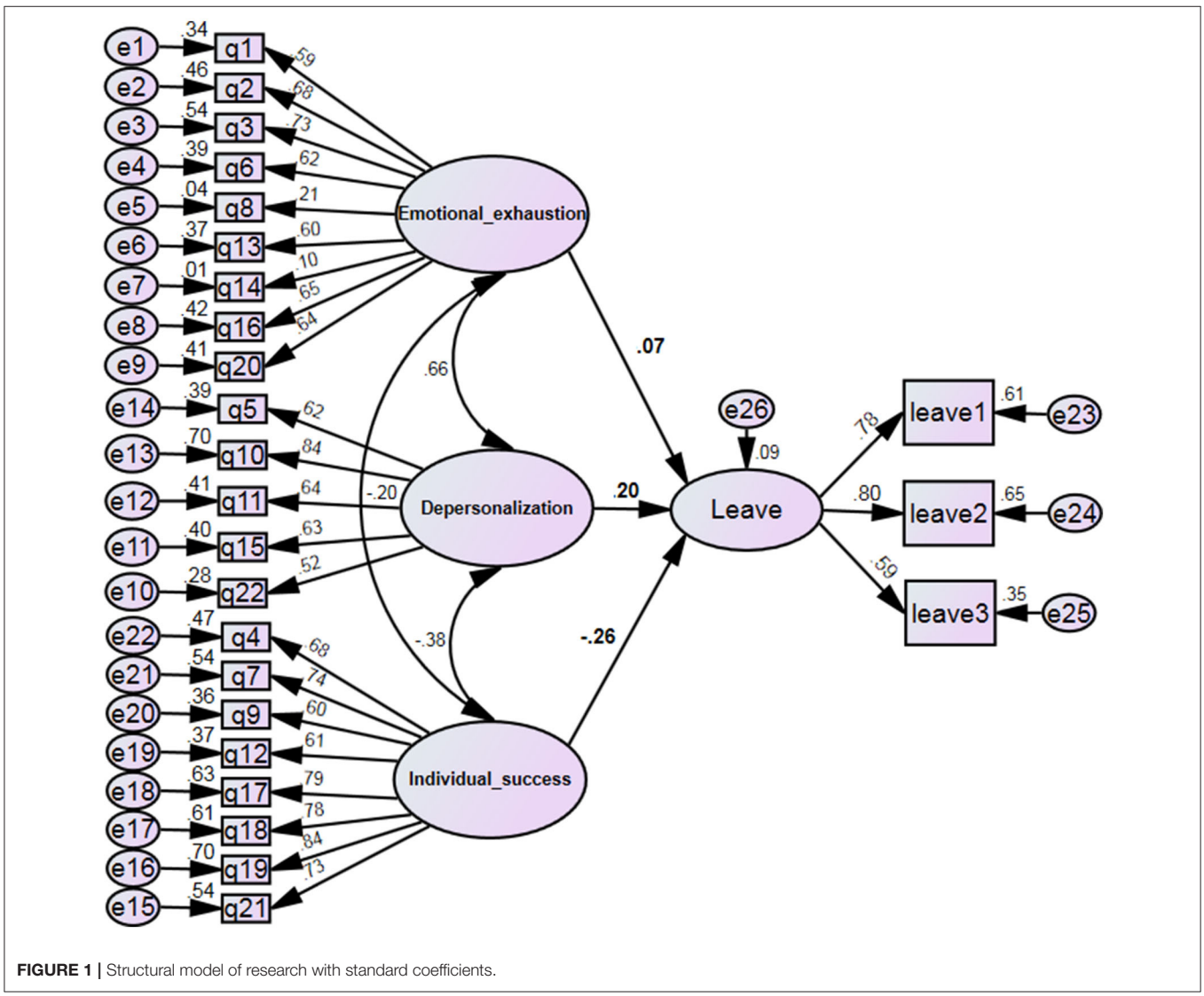

FIGURE 1 | Structural model of research with standard coefficients.

nurses, who were at the forefront of COVID-19, was much higher than the mean score of previous studies. Thus, immediate significant preventative considerations (36, 37) focused on the study objective, nurses' intention to live in the current area at the time of COVID-19 was low, in line with the results of other studies in Iran (19). Although the assessment tool in the present study was different from the above two studies, the tendency to leave among nurses was reported in the medium and low range. This finding is consistent with the Philippines study (11). However, in another study in Iran, the tendency to

leave service during the COVID-19 epidemic was reported to be higher (38).

Evidence suggests that the tendency to leave varies among nurses in different communities, depending on the severity of the viral disease outbreak. These differences may be attributed to the multiple definitions of the phenomenon of intent to leave due to differences in the research setting and even the duration of the COVID-19 outbreak. The direct contact of health workers with patients and observing their COVID-19 can increase the rate of intention to leave. According to previous studies, job stress, anxiety, and nurses' fear of coronavirus disease have increased the intention to leave among them (11). In addition, there is a positive relationship between the tendency to leave with job stress which predicts the tendency to leave among nurses (19). Moreover, according to the study results, with the increase in the dimensions of burnout, employees were more inclined to leave. So that burnout in the dimension of personal accomplishment had the greatest role in leaving intentions among nurses. In line with the present study, the highest prevalence of burnout has been reported about the decreased personal accomplishment (36, 39). The feelings of decreased personal accomplishment are described as decreased production capacity and individual ability, low morale, and inability to cope with problems (14).

Conversely, the feeling of personal success increases the job satisfaction, reduces the feeling of failure and disability, and consequently increases productivity (40). Additionally, a sense of personal success, desire to continue working, and professional presence is created among nurses when they see the improvement of patients due to their care efforts, which significantly reduces the work stress of nurses (38). Other reasons may have been the nurses' lack of previous exposure or experience in caring for patients with COVID-19 or similar pandemics, such as SARS or MERS, inadequate knowledge, frequent changes in the disease process, changes in guidelines have caused frequent worries, loss of confidence, feelings of inefficiency, and also the tendency of nurses to leave the service. The study results related no significant correlation between gender and the tendency to leave. These results were in line with other studies (22, 24, 38).

Conversely, the study conducted by Mirzaei (19) was significantly correlated with the variable of gender with a higher turnover intention. This difference may be attributed to the cultural context and setting of the study. It can also be said that this study was conducted in the first wave of COVID-19 in Iran, and this has probably affected the rate of intention to leave male and female nurses equally.

The results of the present study revealed that the mean turnover intention among nurses was not significantly correlated with the variables of marital status, level of education, experience in caring of a patient with COVID-19, clinical work experience, income satisfaction, and sleep quality, which was in line with other studies (38). A study showed that young and employed nurses in the private sector are more likely to leave (41). On the other hand, in another study, married and highly experienced nurses were more likely to leave due to fear of infection, burnout, and increased risk perception (27). The reason for such difference might be the tendency of nurses to leave is influenced by their care of patients and has less to do with their educational status. On the other hand, perhaps the nursing profession's critical conditions and altruistic nature have caused different degrees of non-difference of nurses. In the present study, the tendency to leave was not significantly associated with income satisfaction. Conversely, another study, low salaries reduced the quality of care and motivated nurses and increased the tendency to leave (42). Perhaps the organizational culture as well as the moral commitment to care in the times of crisis has been very prominent among healthcare providers. In addition, according to previous pieces of evidence and experiences, the commitment to work, love, and self-sacrifice of Iranian nurses in the current crisis is beyond material issues.

The study results showed that nursing assistants had more turnover intention than nurses. In the health system in Iran, nursing assistants are under more work pressure and stress due to their duties, job expectations, and type of care delivery. At the COVID-19 outbreak, they were more likely to be infected due to their high workload.

The present study results also showed that turnover intention had a positive and significant correlation with job satisfaction. These results align with those of the study conducted by Varasteh et al. (18). Job motivation, job satisfaction, and perceived organizational support are the predictors of nurses' tendency to leave their jobs (19). Organizations that provide more employee support are more likely to reduce stress and ultimately increase employee retention. Since managers in this organization can apply effective policies and methods to protect the human resources before employees leave. The present study in 6 months after the first COVID-19 wave in Iran and the study of various factors on the tendency of retention in HCWs can be an innovative aspect. Therefore, using the results of this study to assess the situation of employees in the current crisis and other various health crises in the future can be useful for planning the managers and policy makers of the health system.

LIMITATIONS

Small sample size is one of the limitation of study, so studies with higher sample sizes may offer different results. The use of self-report questionnaires may have created response biases. This study was performed in two COVID-19 reference hospitals in Tehran. Therefore, future studies can examine other hospitals according to the structure, culture, and organizational climate. The cross-sectional study design makes it difficult to explain the causal relationship between risk factors and turnover intention. The findings of this study may not be generalizable to the nurses' population in Iran as a whole. This study was conducted 6 months after the first wave of COVID-19. So, future research should be considered to assess the turnover intention and the level of burnout at different times of the COVID-19 epidemic. Finally, questionnaires were sent and completed online due to the limited access to research samples. So, we could not comply fully with our sampling schedule and plan. In future research, face-to-face questionnaires and interviews, observation of behavior in the workplace, and peer reporting are recommended.

CONCLUSION

Work-related stressors during the COVID-19 pandemic have led to an increase in the nurses' burnout and turnover intention. The present study results showed that nurses experience the moderate levels of burnout during the COVID-19 pandemic, while several sociodemographic and occupational factors affect this burnout and turnover intention. Reduced personal accomplishment is the most predictor for turnover intention. Thus, these factors should be identified and managed to prevent turnover intention in such critical situations. Most importantly, coping strategies to reduce stress during the outbreaks of infectious disease through the support of co-workers, caregivers, and supervisors should be actively used by nurses to reduce their turnover rates. To reduce the nurses' turnover intention and improve their mental health, healthcare managers and policymakers need to plan to prepare healthcare systems, individuals, and nurses for a better response to the COVID-19 outbreak.

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 present study was approved by the Ethics Committee of Baqiyatallah University of Medical Sciences, Tehran, Iran, with code IR.BMSU.REC.1399.074. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

LK: data collection and writing—review and editing. MR: methodology, data analyze, and writing—review and editing. AP: conceptualization, methodology, writing—review and editing, and supervision. All authors contributed to the article and approved the submitted version.

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Agility and Sustainability: A Qualitative Evaluation of COVID-19 Non-pharmaceutical Interventions in the UK Logistics Sector

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Background: The emergence of SARS-CoV-2 triggered a chain of public health responses that radically changed our way of living and working. Non-healthcare sectors, such as the logistics sector, play a key role in such responses. This research aims to qualitatively evaluate the non-pharmaceutical interventions (NPIs) implemented in the UK logistics sector during the COVID-19 pandemic.

Methods: We conducted nine semi-structured interviews in July-August 2020 and May-June 2021. In total 11 interviewees represented six companies occupying a range of positions in the UK's logistics sector, including takeaway food delivery, large and small goods delivery and home appliance installation, and logistics technology providers. Thematic analysis was completed using NVivo12. Codes relevant to NPIs were grouped into themes and mapped deductively onto an adapted Hierarchy of Control (HoC) framework, focusing on delivery workers. Codes relevant to the implementation process of NPIs were grouped into themes/subthemes to identify key characteristics of rapid responses, and barriers and facilitators.

Results: HoC analysis suggests the sector has implemented a wide range of risk mitigation measures, with each company developing their own portfolio of measures. Contact-free delivery was the most commonly implemented measure and perceived effective. The other implemented measures included social distancing, internal contact tracing, communication and collaboration with other key stakeholders of the sector. Process evaluation identified facilitators of rapid responses including capacity to develop interventions internally, localized government support, strong external mandates, effective communication, leadership support and financial support for self-isolation, while barriers included unclear government guidance, shortage of testing capacity and supply, high costs and diversified language and cultural backgrounds. Main sustainability issues included compliance fatigue, and the possible mental health impacts of a prolonged rapid response.

Conclusions: This research identified drivers and obstacles of rapid implementation of NPIs in response to a respiratory infection pandemic. Existing implementation process models do not consider speed to respond and the absence or lack of guidance in emergency situations such as the COVID-19. We recommend the development of a rapid response model to inform the design of effective and sustainable infection prevention and control policies and to focus future research priorities.

Keywords: COVID-19, rapid response, non-pharmaceutical interventions, logistics sector, delivery workers

INTRODUCTION

The novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus shocked the world in the last few days of 2019 and we still very much live in this Coronavirus disease 2019 (COVID-19) pandemic at the time of writing. In the UK, the logistics sector worked together to keep the workers and customers safe and increased capacity to cope with the sustained high level of demands. The sector employs and contracts a large number of workers to deliver a wide range products and goods to private and commercial addresses; many of them are self-employed. They could face both health and financial risks over a pandemic (1), and contribute to community transmissions (2–4). An analyses of COVID-19 mortality in England showed that, similar to other essential workers, van drivers had an increased risk of death from COVID-19, compared to non-essential workers (5). It is therefore important to introduce risk mitigation measures (RMMs) within this sector. Non-pharmaceutical interventions (NPIs) are often significant investments that require well-coordinated actions by multiple stakeholders across organizations and society (6, 7). To cope with imminent threats, such as a novel disease pandemic, interventions must be deployed rapidly to ensure behavioral and mindset changes occurring within a short time frame. In the case of COVID-19, mathematical models suggested that restrictive measures to reduce social mixing could reduce virus transmission and must take effect in a matter of days in order to save lives (8–10). While research about the health systems' response to public health emergencies has provided good quality evidence (11, 12), similar evidence on the contribution of control measures in non-healthcare sectors, such as the logistics sector, to control work-related transmission is so far lacking (13–15). Hence, it is imperative to learn more about what RMMs were implemented by the UK logistics companies, the barriers and facilitators of implementation and whether the control measures are sustainable in the long-term. The aim of this study was to answer these questions through interviews that explored the company representatives' opinions and experiences.

MATERIALS AND METHODS

As we aimed to understand what occurred in the face of a novel disease, it was deemed qualitative approach was appropriate. We have generally followed the Consolidated Criteria for Reporting Qualitative Studies (COREQ) to report the methods and findings (16). A checklist can be found in **Supplementary File 1**.

Data Collection

We approached 50 logistics companies and nine trade associations of this sector but only six companies agreed to participate. We recruited participants from most of the sub-sectors including food takeaway, small parcels and large items except grocery delivery, which we only managed to interview a technology developer for grocery chains. We recruited companies through a variety of approaches, such as direct contact, approaching trade and industry associations, via personal and professional networks and a social media campaign on LinkedIn. All recruitment activities were carried out using phones, emails or online facilities. We completed nine semi-structured interviews with six companies between July and August of 2020 (Round 1) and May and June of 2021 (Round 2), with three companies interviewed twice. Each of the interviews lasted between 60 and 90 min. There were in total 11 participants as four companies had two or three representatives.

All participants received a study scope and Participant Information Sheet and gave verbal consent before the interviews began. We used the Zoom teleconferencing facility to audio record the interviews. Three trained postdoctoral researchers (HW, SD, CW) carried out all the interviews, with attendance by other members of the study team. Interview schedules were developed in advance, with open ended questions which included inquiries on the type of RMMs implemented, facilitators and barriers of implementation, recommendations for possible future pandemics and potential health impacts of coping with a long pandemic. The interview schedules for both round 1 and 2 are available in **Supplementary File 2**. A summary report was emailed to each participating company for comments and corrections. One company returned written comments and another discussed feedback with us over Zoom.

Data Analysis

HW, SD and CW edited and anonymized the auto-transcripts generated by Zoom. One company supplied a detailed list of events from February 2020 to July 2020, which was also analyzed. Thematic analysis was carried out using NVivo12 software following the latent approach (17, 18). HW and SD studied the transcripts and events list and completed coding independently. The codes were combined to generate emerging themes and sub-themes. Codes that were relevant to RMMs for delivery workers were deductively matched, if appropriately, with the levels of the Hierarchy of Control (HoC) (19, 20). HoC ranks preventative measures according to their expected level of protectiveness against one particular hazard, moving from the most protective

measures that eliminate the hazard completely from the work environment, down to personal protective equipment (PPE), the last layer of protection for workers (see **Figure 1**). The mapping exercise was reviewed and discussed extensively within the team and with experts from the Health and Safety Executive (HSE) and Public Health England (PHE, now known as UK Health Security Agency). Codes, themes and subthemes that were relevant to the implementation process were reviewed and discussed among the coders. Themes were named and defined to develop a rapid response framework (see **Table 2**). Coding was conducted separately for the two rounds of interviews to allow for changes that occurred over the course of the pandemic. HW and SD's coding results were merged to assess inter-coder reliability. The percentage of agreement between the two coders was very high (>90%) and the average Kappa coefficient was 0.61 for the first round and 0.51 for the second round [0.41–0.75 is considered fair to good (21)]. Individual codes that showed higher discrepancy were discussed and consensus was reached.

The HoC analysis focused on the delivery workers who would collect deliveries from a workplace (i.e., warehouses or depots) and deliver them to customer premises, using a certain type of vehicle. For large items, they might also enter customer premises in order to drop the deliveries to a designated room (Room of Choice) or to complete the installation.

Characteristics of Participating Companies

Participants represented one takeaway food delivery platform, four logistics companies that delivered large and small items and one technology provider for food and grocery chain stores i.e., supermarkets and restaurant chains. Most of the representatives that we recruited were directly involved in the day-to-day running of the logistics business. However, for grocery store deliveries, we only managed to recruit a technology developer that served the food and grocery chains. All the delivery companies were large employers (500+) except the technology developer. The roles of the participants covered a range of functions in the companies, including health and safety, operation, operational support, communication, marketing and external affairs. Delivery of large items was normally fulfilled by two-person teams, while parcel and takeaway food deliveries were fulfilled by lone drivers or bicycle riders. Of the five delivery companies, delivery workers were engaged as self-employed in four, with one large items delivery company employing drivers directly.

RESULTS

What RMMs Were Implemented – HoC Analysis

HoC analysis focuses on the interventions. A wide range of RMMs were designed and implemented by the interviewed companies. Through the pandemic, they continued to do so to tackle newer challenges, such as the emergence of new variants, risks of increased transmission during the winter season, and adapting to new government measures, such as mass testing and vaccination. HoC analysis excluded the technology provider as they were not directly involved in delivery work. **Table 1** presented the results of thematic analysis of the RMMs that were discussed in the interviews. Food 1 refers to the takeaway platform, Parcel 1 and 2 refer to the two parcel delivery companies, and Large 1 and 2 refer to the two large items delivery companies. Food 1 engages couriers using an app and does not operate any physical sites, while the other four companies do, of which, Large 1 and 2 also provide company vehicles.

No measures taken by the companies fell within the definition of Elimination. For example, working from home (WFH) would eliminate risk of infection from workplaces but is not practical for delivery workers. "Other staff (i.e., office workers) WFH" is treated as an administrative control (AC) measure as it would help reduce workplace contacts for delivery workers.

Contact-free delivery was considered a Substitution measure and the most practical in the context of home deliveries. All five companies named it as the most important measure to reduce contacts for delivery workers and introduced it from a very early stage of the pandemic. It was achieved by drivers doing doorstep drop-off with no signature required. Proof of delivery that previously required customers to sign a paper document or the handheld unit with a pen, a finger or a wand was replaced by taking a photo at the doorstep or signed by the driver's colleague when it was two-person deliveries.

"The moment the UK went into lockdown and we moved to doorstep delivery only." [Large 1]

"As soon as lockdown was announced… we stopped (delivery to) room of choice as well." [Large 2]

"So quite quickly we had to establish a way of how could we achieve that without actually getting someone to touch our equipment or interact with the driver... And the way we achieved it is we took a photograph… It was accepted very quickly that that was the new form of signature." [Parcel 1]

"As well as asking drivers to knock on the door and then step back, we've also stopped getting signatures." [Parcel 2]

"We rolled out contact-free delivery across our entire network… so everybody was doing contract free delivery." [Food 1]

In terms of engineering controls (EC) measures, four of the companies that operated physical sites had installed physical barriers, changed workplace layout and restricted or suspended some services. One of them reported they erected temporary facilities such as portaloos and resting areas for visitors and third-party drivers. Companies took different measures to minimize contact for two-person deliveries. For example, Large 2 hired additional cars for the second delivery personnel so that the two-person team did not need to share the vehicle. They stopped the measure following publication of government guidance on sharing vehicles at work in June 2020. Large 1 suspended installation service immediately following the first lockdown and resumed it when the government guidance about working in customers' homes was introduced and they were able to establish safe work practice.

Most control measures reported were at the AC level. All five companies reported implementing self-isolation (if symptomatic, tested positive or close contact), hygiene measures, Information Instruction & Training (IIT), working with industry and authorities and compliance & data monitoring. Measures relevant to IIT or communication were described the most

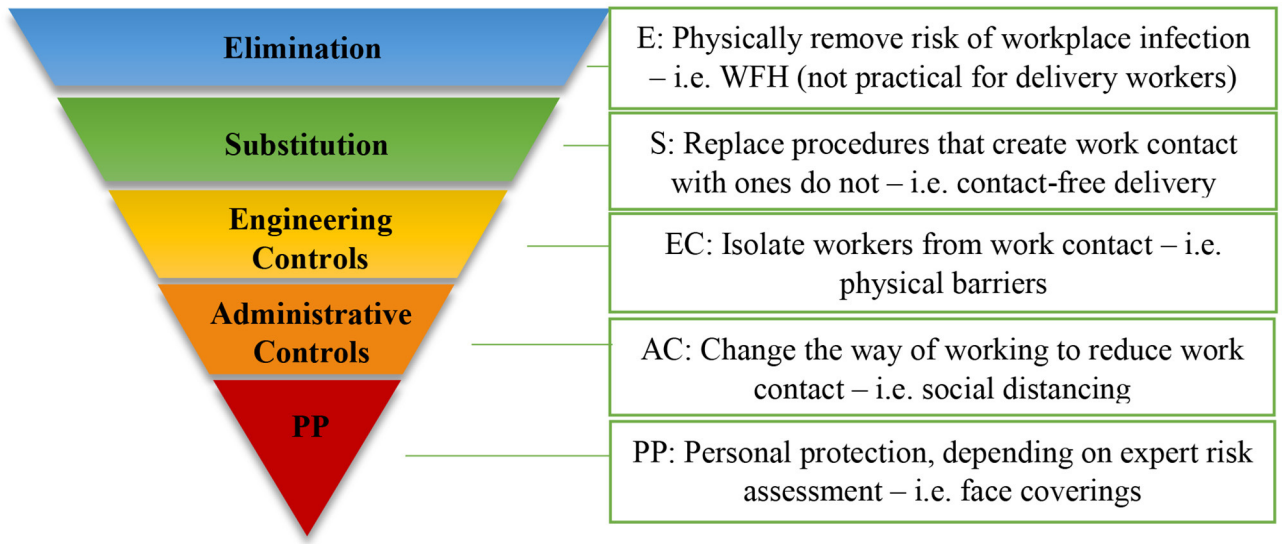

FIGURE 1 | HoC: COVID-19 – Delivery workers (adapted from HSE websites[1]).

frequently by the participants. All participants discussed how they communicated the guidance, instructions and the changes to their employed or self-employed drivers, employees and customers throughout the period. These included daily or weekly bulletins, virtual Town Hall meetings, emails, phone texts, messaging platforms such as Yammer, YouTube channels, face-to-face briefings (if workspace allowed social distancing) and educational phone calls when issues arose. They monitored COVID compliance by collecting information via staff surveys, customer feedback, observational monitoring by dedicated staff or CCTV and site audits. All of them reported thorough promotion of hand wash and enhanced cleaning routines.

All four companies that operated from distribution centers implemented pairs and bubbles, social distancing, workplace contact tracing and workplace infection monitoring. Pairing refers to fixing each two-person delivery team permanently. Before the pandemic these pairs would change every day or in some cases multiple times per day. Drivers and warehouse staff would be grouped by location to establish working group bubbles, with no rotation between sites. The key was to keep the same teams together as much as possible to reduce the number of contacts, and to make workplace contact tracing more effective. When a case was confirmed, the workers who had been in close contact with the infected individual would be notified immediately to go into self-isolation. The other AC measures reported included staggered working where breaks and beginning of shifts were staggered at intervals, i.e., 15 min to minimize contact. All of the interviewed companies demonstrated a strong capacity in workplace infection rate monitoring, especially in the second round of interviews. Four of them stated infection rates in the workforce merely reflected community infection rates, indicating limited workplace transmission. One reported they had outbreaks within workplaces when the Alpha variant emerged in winter 2020. They then immediately deployed third-party testing facilities to test the entire workforce at those sites.

For personal protection and personal hygiene, participants reported they provided drivers with face coverings, gloves and hand sanitizers.

Implementation – Process Evaluation

In this section, we investigate the process of implementation. Themes emerged from the thematic analysis included key characteristics of the implementation process, barriers and facilitators of rapid responses and issues that might affect sustainability. The process had prominent features, such as the speed to action, external pressure, improvised interventions, *ad hoc* approach, a fast-evolving situation and steep learning curves for all stakeholders. Based on the emerging themes of our thematic analysis, we summarized 15 key characteristics of rapid responses (subthemes) that can be categorized into five domains (themes), with relevant barriers and facilitators identified in **Table 2**.

Intervention Characteristics

Source of Interventions

The companies developed the interventions drawing from both external and internal sources. External sources were mostly government guidance such as social distancing, face covering and hand washing, which were relatively standardized. For companies that operate in multiple countries, signals from other countries also provided sources of intervention. For example, Parcel 1 mentioned they had secured a supply of facemasks (described as three-layer paper masks) for their UK workers, as colleagues from across the world recommended this as a preventative measure at the early stages of the pandemic.

[1]https://www.hse.gov.uk/coshh/detail/goodpractice.htm; https://www.hse.gov.uk/construction/lwit/assets/downloads/hierarchy-risk-controls.pdf

TABLE 1 | HoC analysis – COVID-19 RMMs implemented by the logistics companies for delivery workers.

HoC/Measures	Food 1	Parcel 1	Parcel 2	Large 1	Large 2
1. Elimination: Physically remove risk of workplace infection					
None practical					
2. Substitution: Replace work procedures that create work contact with ones that do not					
Contact-free delivery	+	+	+	+	+
3. Engineering Controls: Isolate workers from work contact					
Establish exclusion zones			+		
Extra car hiring				Discussed but not adopted	+ March-June 2020[a]
Install physical barriers		+	+	+	+
Re-layout workplace		+	+	+	+
Restricted or discontinued services		+ Temporarily suspended customer collection	+ Temporarily suspended customer collection	+ Installation service suspended March-May 2020	+ RoC[b] suspended March-May 2020; Initially failed deliveries if customers reported symptomatic or self-isolating
Ventilation in buildings		Believed lack of airflow in winter was a cause of outbreaks	Deemed sufficient	Deemed sufficient	+ Open windows
4. Administrative controls: Change the way of working to reduce work contact					
Pairs and bubbles (staff cohorts)		+	+	+	+
Social distancing		+	+	+	+
Self-isolation (if symptomatic, tested positive or close contact)	+	+	+	+	+
Staggered working			+	+	+
Ventilation in shared vehicles				+ Open windows	+ Instructed windows 1/3 down and recirculation turned off
Hygiene measures	+	+	+	+	+
Information Instruction & Training (IIT)	+	+	+	+	+
Working with industry and authorities	+	+	+	+	+
Mental health support		+		+	+
Compliance behavior monitoring	+	+	+	+	+
Workplace contact tracing		+	+	+	+
Workplace infection monitoring		+	+	+	+
Workplace testing		+ Deployed 3rd party testing at sites had outbreaks	Had concerns about regular workplace LFD[c] testing	Had concerns about regular workplace LFD testing	Some sites used LFD for warehouse staff
Disciplinary action		+		+	
5. Personal protection: Protect workers with certain equipment, depending on expert risk assessment[d]					
Face coverings	+	+	+	+	+
Gloves	+	+		+	

"+" indicates the measure was reported as implemented. This table is not a complete list of RMMs implemented by the companies. When some of the measures were not ticked by certain companies, it meant that this measure was neither applicable to the company's situation nor discussed during the interviews. [a]Time period was estimated by the interviewers during analysis. [b]RoC: room of choice. [c]Lateral Flow Device. [d]Neither face coverings nor normal gloves were considered PPE. They were issued to prevent transmission rather than protecting workers from getting infected.

Internally developed measures generally followed the principal of minimizing contact but with customized characteristics. Contact-free delivery is an example of an internally developed intervention with slightly different features designed by each company. Both Parcel 1 and 2 used photographs to replace customer signatures, while Large 1 required no signature and

TABLE 2 | Rapid response process: COVID-19 – Logistics sector, adapted for evaluating a range of RMMs.

Theme/Domain	Subtheme/Key characteristics	Illustrations	Barriers	Facilitators
Intervention characteristics	Source of interventions	Whether the interventions are perceived as externally or internally developed	Unclear or changing government guidance	Capacity to develop interventions internally
	Evidence Strength & Quality	Whether data are collected about the effectiveness of the interventions and how the quality and validity of evidence are perceived	Shortage of testing capacity and supply	
	Costs	Direct costs of the interventions and costs associated with implementing the interventions including investment, supply, and opportunity costs	High direct and associated costs	
External environment	Prioritization of safety	The extent to which workers and customers' safety are prioritized by the organization and other external actors, such as the government		
	Collaborations	The degree to which an organization is collaborating with other external organizations		Localized government support
	External pressure	External pressure to enact a rapid response, such as government mandates or peer pressure i.e., other organizations have already implemented interventions		Strong external mandates
Organizational setting	Effective communications	How the effectiveness and quality of communications are perceived	Diversified language and cultural backgrounds.	Effective communication
	Safety culture	Norms, values, and basic assumptions about safety in the organization		
	Implementation climate	The internal tension for change and the extent to which use of the interventions will be rewarded, supported, and expected within the organization		Financial support for self-isolation
	Leadership commitment	Commitment and involvement of leaders and managers with the implementation		Leadership support
Implementation process	Rapid response	The degree to which the interventions are rapidly developed and implemented without planning in advance		
	Full engagement	Engaging appropriate individuals in the implementation of the interventions through a combined strategy of social marketing, education, role modeling, training, and other similar activities		
	Strong execution	Carrying out or accomplishing the implementation according to plan		
	Continuous reflecting & evaluating	Continuous risk assessment and learning, accompanied with regular quantitative and qualitative feedback about the progress and quality of implementation		
Sustainability	Potential long-term effects	Any possible long-term effects when rapid responses have lasted longer than expected		

Large 2 asked the driver's "mate" (the other personnel in a two-person delivery team) to sign as a proof of delivery. Food 1 required no signature and strongly advised online payment. When cash payment was necessary, they then asked the money to be put into an envelope.

Barrier 1
Barriers to rapid development of interventions here appeared to be the lack of and changing government guidance.

Facilitator 1
The resourcefulness and capacity to design and develop interventions internally appeared to be a facilitator.

Strength and Quality of Evidence
The companies reported how they actively collected data to monitor the effectiveness of communication and infection rates. They mentioned customer and staff surveys, monitoring message click rate and dwelling time, and monitoring infection and self-isolation rates. Participants appeared to be more confident about the quality and validity of the evidence in round 2. During round 1, they generally reported a very low number of confirmed cases, while during round 2, participants provided more details about how they collected and analyzed data systematically. They were able to make clear statements about the perceived cause of the outbreaks. For example, Large 1 discussed how the Alpha variant, combined with lack of ventilation in the winter season, had a significant impact on transmission in the workplace. They were clear about timing, location and job roles that were the most affected. Parcel 2 showed to us over Zoom their COVID infection dashboard where data were systematically collected, analyzed and displayed for decision making.

Barrier 2
Limited testing capacity and shortage of supply at the beginning of the pandemic appeared to be major barriers. This capacity was visibly improved during the course of the pandemic as demonstrated by the round 2 interviews.

Costs
Barrier 3
NPIs implemented at speed appeared to be costly. The participants talked about direct and associated costs including investment, supply or equipment and the knock-on effect on efficiency. Interventions such as deploying more vehicles, providing equipment and furniture to allow office staff to WFH, and providing hand sanitizers and face coverings would obviously add to costs. Financial support, such as 14-day COVID sick leave pay for the self-employed and additional bonuses, were direct costs. There was also other investment such as communication systems, posters and markings, sanitary stations, physical barriers and alteration of workplaces.

External Environment
Prioritization of COVID Safety
The UK government imposed lockdown measures in March and November 2020 and January 2021 to stop non-essential contact and travel. Nevertheless, delivery of food and other essential supplies was recognized as essential work by the government. Hence worker and customer safety must be prioritized and the companies modified work procedures to reduce work contact, including suspension of services, such as installation or Room of Choice, and stopped procedures, such as signing on documents or equipment.

Unprecedented Collaboration Within the Industry
The level of collaboration within the industry was unprecedentedly high as reported by the participants. It included working with the sector including competitors, the government and international collaboration within the organizations.

Facilitator 2
Localized government support was a facilitator of the rapid response. Participants described working with the local police, Department for Environment, Food and Rural Affairs (DEFRA), HSE, PHE, National Health Service (NHS) and local authorities. When there was a high level of uncertainty, the companies appreciated the support from local authorities and local branches of HSE, PHE and unions. They would send their internal guidance and risk assessment to these bodies and obtain their opinions. The support was personalized to the companies, which then provided the companies with confidence to implement these measures.

Networking in this sector was strengthened especially at the beginning of the pandemic. Participants spoke highly about the industry forum organized by DEFRA that occurred weekly and then bi-weekly. It was unprecedented as all the main competitors of the industry joined. Participants reported that they shared best practices with an open mind and worked together to contribute to the development of government guidance. Email groups were set up to facilitate exchange of ideas and questions.

Strong External Mandates to Enact Rapid Responses
Facilitator 3
In addition to the networked collaborative activities, the numerous government recommendations, guidelines and updates, and that COVID-19 dominated the media and the Internet for a substantial period of time, all created strong incentives for the companies to respond rapidly.

Organizational Setting
Effective Communications
Facilitator 4
Effective communications were emphasized by many participants as an important facilitator of rapid responses. They reported that effective communications were highly valued by the staff because the situation had been a fast-evolving one. Uncertainties and lack of specific guidance at national level meant that workers needed the information provided by the companies or platforms to guide their everyday work.

Barrier 4
A number of participants reported that language and the complexity of the guidance could be a challenge as English is the second language for many workers within this sector. To tackle this issue, they simplified the language and added infographics to illustrate the meaning. A couple of participants mentioned the cultural background of the workforce could be a barrier to

enforce social distancing as certain cultures tend to socialize more and workers of that background were likely to share transport to work or accommodations.

Safety Culture

COVID-19 safety was discussed by the participants as a belief rather than something they reluctantly comply to. One participant articulated it particularly well.

"We have a culture in our leadership of putting safety first… we track our [COVID-19] numbers in [Large 2] but there's no incentive. You know I'm not bonused, my performance isn't measured on whether I achieve safety or not. We all do it because it's the right thing to do." [Large 2]

Facilitating Implementation Climate

The organizational climate for implementing interventions played a facilitating role. Key stakeholders felt the necessity to change in order to keep safe and contain the spread of the virus, as one of the participants described:

"The behavior change, the couriers, the restaurants, the customers was helped by the fact that every single aspect of life has changed. So people [were] kind of shocked into it." [Food 1]

Facilitator 5

Three of the companies mentioned they provided financial support such as sick leave pay to support the self-employed drivers to take COVID-related self-isolation. It can facilitate adherence among delivery workers as many of them were self-employed and did not enjoy statutory sick pay. They also mentioned that they promoted intangible incentives such as customers' appreciation messages and exemplar stories to be put on their websites and communication channels.

Leadership Commitment for Implementation

Facilitator 6

Key stakeholders' commitment for implementation appeared high. Leadership engagement was evident in all the interviews. Two participants particularly emphasized the influence from the leadership team that keeping workers safe from COVID-19 infection was the right thing to do and would reward the business in the long-term. This is then linked to resources dedicated for implementation. It appeared that the companies allocated adequate resources timely to support the interventions.

Implementation Process

The implementation process can be characterized as an unplanned rapid response, full engagement, strong execution and continuous reflecting & evaluating.

Unplanned Rapid Response, Full Engagement and Strong Execution

"Rapid response" was a prominent feature emphasized by all of the participants. From early March 2020, the volume of home deliveries "went through the roof". Participants mentioned figures such as:

"Our sales spiked… 202% year on year compared to previous March" [Large 1]

"Volume of orders have gone up, way up, absolutely unbelievable" [Logistics technology provider]

In response, the sector moved rapidly to increase the capacity, while ensuring worker and customer safety. Changes and interventions were obviously not planned in advance. Supply chain networks are underpinned by technology that help streamline the service. The technology provider participant described the chaos experienced by food and grocery chains during the first lockdown. Restaurants, cafes and small retailers were closed and hence the volume of that part of the supply chain went down to zero whilst supermarkets suddenly faced much higher demands which caused blockages and bottlenecks in their network. "It completely destroyed that (food) supply chain", the participant recalled. Nevertheless, their engineers rose to the challenge and developed solutions for the clients in just 6 days. The participant told us internally the grocery chains called it "the second Christmas" as they "turned on the Christmas protocols for everything" in a matter of days, whereas normally preparations for the Christmas peak would take a few months.

Other participants also passionately described the speed of implementation.

"We were able to react really quickly. And we were able to get, as I've said, sort of, PPE, standards, working from home, all of those things in really, really quickly. We even surprised ourselves… we really pride ourselves on how quickly… and we've done it really smoothly." [Parcel 1]

"And so lots and lots of shared facilities across all of our sites that we just had to change pretty much overnight and because we didn't stop operate so real big challenges." [Large 2]

There were many more examples that described deployment of interventions in a very short timeframe such as overnight, within a week, or in just a few days.

Continuous Reflecting and Evaluating

As an unplanned response, continuous risk assessment combined with an experimental approach were essential. There were measures that were considered but not adopted or were on hold for future review. This can be an important feature for learning when facing emergencies caused by novel threats in the future. Participants discussed these measures and reasons for not adopting them.

"We explored offering our people tests, we decided not to do that because there was a lot of uncertainty. This was around May [2020] time. There was a lot of uncertainty about which test, availability of tests… We wrestled with the ethics of if we take a big batch of tests. Does that take away from the NHS and care homes?" [Large 1]

"The key reason we didn't do that [ordering facemasks in bulks] immediately was because we wanted to ensure that what we were ordering wouldn't impact the NHS and care homes receiving it." [Food 1]

When mass testing became available later in the pandemic, it was not immediately adopted by the companies. Participants reasoned that regular lateral flow device testing could not be easily integrated into their daily operations. One participant expressed a strong view regarding the possible effect of workplace testing in undermining other existing measures.

"Workplace testing when you're dealing with certain members of society actually has a detrimental effect in terms of following COVID secure guidelines that we've put in place. So what we felt was that by introducing workplace testing people felt that was

a level of security that I didn't agree with, and that if they felt that they tested negative, then they didn't need to follow social distancing wear face coverings so. . . .my view is quite strong on this is that actually lateral flow testing undermines a lot of the measures that we really need people to be focusing on." [Parcel 2]

Sustainability

A rapid response mode may be effective in the short-term but can run into problems if it lasted longer than expected and hence introduce questions about sustainability.

As the pandemic continued into 2021, some workers developed compliance fatigue and this became a barrier to effective implementation. In round 2 interviews, we asked the participants whether they observed any relaxed attitudes toward the COVID measures. Participants agreed that to some extent attitudes had relaxed and described how they took actions to mitigate this. They highlighted the need to maintain effective communications by providing a "permanent alert" or "constant reminder" to workers. Two participants mentioned they added extra monitoring, that is, sending out staff to walk around the workplaces and giving colleagues a reminder whenever they observed behaviors not meeting the standard.

In round 2, all participants stated that high volume of home deliveries continued even when lockdown was lifted. They told us that the industry was used to working on full speed during the Christmas peak that was normally from late October to the end of December. As mentioned earlier, the industry immediately switched on the Christmas protocol from March 2020 and this continued into 2021. Mental health impacts of sustained high workload were mentioned by many of the participants. Participants expressed concerns about overwork, burnout and presentism.

"I've got a massive concern about burnout, about mental health, and you know the issues that overwork create. . . the level of additional work has just continued. . . it's not just the burnout because you can bring the extra people in, it's the prolonged on and on and on and on and no light at the end of the tunnel." [Parcel 1]

For office workers, while some appreciated the time saved from commuting by WFH, not all have an appropriate work environment in their homes and some reported feeling isolated. Participants also mentioned that the companies were surveying workers regarding to their mental wellbeing and trying to offer some support.

We have provided a schematic diagram to illustrate the important findings in **Figure 2**. This diagram summarizes the results section, our analysis of the UK logistics sectors in relation to the implemented NPIs and key characteristics of the rapid response. The implemented NPIs were matched with HoC to help understand the perceived level of protection.

DISCUSSION

This empirical research is responding to the call for knowledge and recommendations for preventive interventions to reduce the transmission of SARS-CoV-2. It offered an in-depth analysis for the UK logistics sector, with an occupational focus on delivery workers.

The process of implementation had prominent features, such as the speed to action, the external pressure, improvised interventions, and steep learning curves for all stakeholders. We scoped the literature to identify an appropriate theoretical model to inform the analysis. Multiple existing frameworks offered some useful insights, including the RE-AIM (Reach, Efficacy, Adoption, Implementation and Maintenance) (22, 23), CFIR (Consolidated Framework for Implementation Research) (24, 25), PRECEDE-PROCEED (26, 27) and other process evaluation models that generally included components such as recruitment, dose delivered, dose received, fidelity, satisfaction, maintenance and context (28). However, they generally assumed a systematically developed intervention program implemented with some extent of control, and none of them fully captured the characteristics of this sector's response to COVID-19. It suggests the urgency of developing a rapid response model that can first, analyze a collection of NPIs implemented in occupational settings. When responding to a pandemic, NPIs are likely to be implemented simultaneously with many other measures and a single measure would not be sufficient (20). Second, the model should take into account the barriers and facilitators of rapid responses to a public health emergency (29).

In addition to the well-known COVID-19 NPIs, such as face coverings, hand washing and social distancing (14), our HoC analysis identified measures that were important to the delivery work setting, including contact-free delivery, fixed pairing, effective communications/IIT and sectoral collaboration. Contact-free delivery and fixed pairing (for two-person deliveries) were new measures improvised by this sector during this COVID-19 pandemic and became established practices as the participants told us. Working collaboratively with key stakeholders of the sector, including the competitors and local and state authorities was considered an important measure and a facilitator in outer setting (25).

We identified important barriers and facilitators to rapid responses. Financial support for self-isolation was considered a facilitator for delivery workers especially the self-employed, as a previous study found sick leave pay was associated with adherence to infection, prevention and control measures among healthcare workers (30). In addition, COVID-19 infection rates among delivery and warehousing workers from the developed and developing countries varied significantly. For example, in Canada, it was as low as 0% (31), whilst in Ecuador it was 15.2% (32). Although the sample of the two studies may not be directly comparable, it is possible that financial conditions served a social determinant of COVID-19 related health outcome (33). The sector's capacity to design and develop interventions internally was also a key facilitator. As SARS-CoV-2 was a novel virus and the pandemic was fast-evolving, a response protocol or prevention guidance for the logistics sector was not available in the UK initially. Hence, internal knowledge and assessment was an important source of intervention development. Companies also used their judgement to decide not to adopt certain measures, such as workplace testing. This echoes the concern that people without COVID-19 self-isolating due to false-positive lateral flow test results

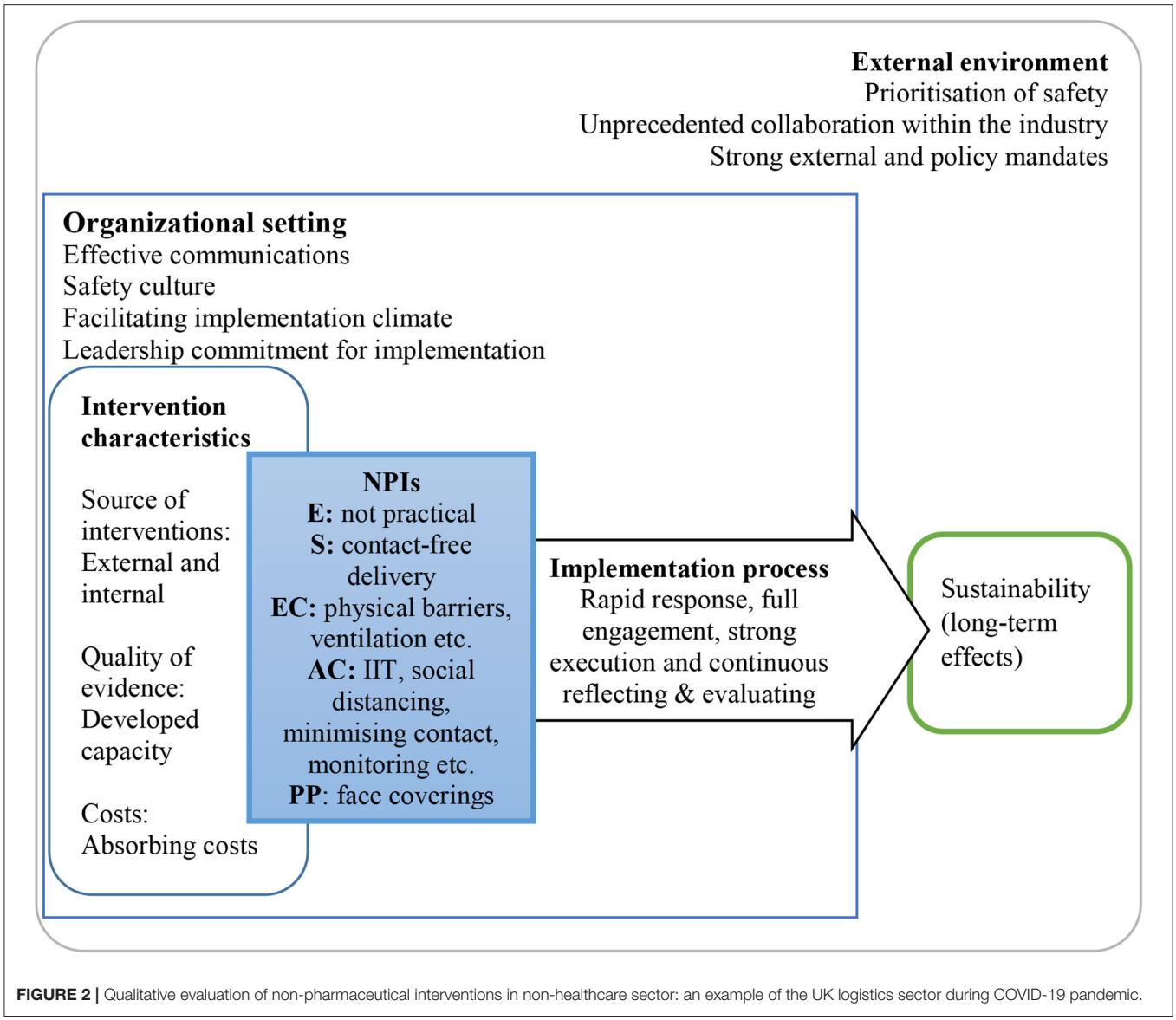

FIGURE 2 | Qualitative evaluation of non-pharmaceutical interventions in non-healthcare sector: an example of the UK logistics sector during COVID-19 pandemic.

could be a cost to the individual, their household, and their workplace (34). In addition, localized government support, effective communication and leadership support were considered facilitators. This is in line with findings from existing studies that evaluated the implementation of interventions programs (35, 36). Strong external mandates were probably prominent facilitators associated with the situation of a pandemic as few other health interventions received media attention like those for COVID-19.

Major barriers included unclear and changing government guidance, lack of testing capacity, shortage of facemasks, and diversified language and cultural backgrounds. Barriers associated with government guidance, testing capacity and supply of PPE mainly affected the rapid response at the early stages (37, 38). Language and cultural barriers were also identified by multiple intervention studies previously (36, 39). Carefully designed trainings were recommended, which were consistent with the measure took by the companies we interviewed. We identified compliance fatigue in the second interview round. Such behavioral changes reflected a response to adjustments in individuals' risk assessment (40, 41), especially when the government announced their Roadmap to lift restrictions. Our participants suggested adding more behavior monitoring measures and reminders to maintain the level of alert. Participants mentioned the high costs associated with these NPIs but also believed such costs were compensated by increased volume. Going forward, a more systematic approach should evaluate such costs from health economics perspective.

The prolonged WFH measure and sustained high workload both add to work stress (42). It highlighted a key sustainability issue associated with the current approach to dealing with the pandemic. The concern is consistent with findings from studies

that examined healthcare staff burnout during COVID-19 (43–45). It is not sustainable, and a more systematic approach and coherent sectoral strategy is urgently needed.

This paper is based on views expressed by those in managerial roles rather than the delivery drivers. We recognize that their views could differ significantly from the frontline workers' perspective. For example, surveys among app-based drivers reported concerns of infection risks from interactions with the public and insufficient workplace protections such as access to personal protective equipment (PPE) (31, 46). Delivery workers in the French gig economy also expressed concerns of financial precarity and lack of union support (1).

Another potential limitation of this study is the small sample size and the size of the participated companies. The sector was extremely busy throughout the pandemic and our invitations were declined by the majority of companies we approached. We were not able to directly assess the effectiveness of the interventions, but the perceived effectiveness of the participants.

CONCLUSION

This qualitative study provides a rich source of contextualized data to evaluate rapid implementation of COVID-19 NPIs in the UK logistics sector. We assessed the interventions against an occupational health and safety standard and identified barriers, facilitators and sustainability issues in the process of a rapid response. In conclusion, the UK's logistics sector rose to the challenge and rapidly developed and implemented a wide range of RMMs in a fast-evolving pandemic. They closely followed national and local guidelines available to them at the time and developed RMMs resourcefully when guidelines were lacking. Elimination of the risk was not practical for the delivery workers and most control measures were considered administrative controls. Contact-free delivery was commonly implemented and considered effective. Participants were confident that the RMMs played an important role in reducing workplace transmission risk for delivery workers. Further research is now needed to design and evaluate models and tools to apply sustainable respiratory infection prevention and control measures across work settings, as well as taking into account the more vulnerable work and social groups.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

The project was reviewed and approved by the University Research Ethics Committee at University of Manchester, Ref: 2020-9787-15953. Consent to participation was verbally obtained before the commencement of the interviews. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

Interview schedules and codebooks were developed by HW, SD, CW, and MT with extensive inputs from the rest of the team and collaborators at HSE and PHE. HW, SD, and CW carried out the interviews and completed the analysis. HW and SD drafted the manuscript. CW, MT, YH, DD, IH, MR, and AV commented and edited each version of the manuscript. All the authors reviewed and approved the final version.

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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.2022.864506/full#supplementary-material

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Worker Characteristics and Measures Associated With Patient and Visitor Violence in the COVID-19 Pandemic: A Multilevel Regression Analysis From China

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Objective: To analyze the patient and visitor workplace violence (PVV) toward health workers (HWs) and identify correlations between worker characteristics, measures against violence and exposure to PVV in COVID-19 pandemic.

Methods: A cross-sectional survey utilizing the international questionnaires in six public tertiary hospitals from Beijing in 2020 was conducted, and valid data from 754 respondents were collected. Multilevel logistic regression models were used to determine the association between independents and exposure to PVV.

Results: During COVID-19 pandemic and regular epidemic prevention and control, doctors were 5.3 times (95% CI = 1.59∼17.90) more likely to suffer from physical PVV than nurses. HWs most frequently work with infants were 7.2 times (95% CI = 2.24∼23.19) more likely to suffer from psychological PVV. More than four-fifth of HWs reported that their workplace had implemented security measures in 2020, and the cross-level interactions between the security measures and *profession* variable indicates that doctors in the workplace without security measures were 11.3 times (95% CI = 1.09∼116.39) more likely to suffer from physical PVV compared to nurses in the workplace with security measures.

Conclusion: Doctors have higher risk of physical PVV in COVID-19 containment, and the security measures are very important and effective to fight against the physical PVV. Comprehensive measures should be implemented to mitigate hazards and protect the health, safety, and well-being of health workers.

Keywords: COVID-19, health workers (HWs), patient and visitor violence, workplace violence, multilevel logistic regression

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INSTRUCTION

The COVID-19 pandemic has very clearly revealed the huge challenges and risks facing health workers (HWs) globally. Violence and harassment against health workers have been increasing during the COVID-19 pandemic (1–3). Experience shows that stress and fatigue, long patient waiting time, crowding, COVID-19-specific prevention, and control measures (such as placing

individuals in quarantine or isolation facilities), contact tracing etc., are most widespread risk factors for workplace violence in the health sector and can lead to acts of violence against healthcare professionals and others who directly care for patients and their visitors (3, 4). Violence, harassment, discrimination, and stigma from patients and their visitors against health workers should be prevented and eliminated as much as possible.

In China, proactive policies and measures were issued and implemented for HWs by the ministries and commissions of Chinese government, until the mid of March 2020, not only including the infection prevention and control (IPC) measures, but also measures of improving working condition and caring for physical and psychological health for HWs (5–7). In June 2020, COVID-19 broke out in Beijing, and 337 infected cases have been reported in 25 days. After that, all hospitals in Beijing have tightened IPC measures, and implemented proactive occupational health measures and preventive strategies against occupational hazards in hospitals. For example, a large number of public hospitals had set up security check system which was practically non-existent prior to the outbreak of COVID-19 (8). These policies and actions generally provide HWs qualified personal protective equipment, good work organization, and prevention strategy of violence and discrimination.

For many years, the prevalence and risk factors associated with PVV against HWs have been studied worldwide, previous studies discovered individual characteristics of perpetrator and victim (9–11), the HWs-patient and visitor interactions (12), the characteristics of the work environment (10, 13), and the official organizational hospital policies (14) seem important in the occurrence of PVV (15). Recently, several studies have investigated the occurrence of workplace violence (WPV) against HWs during COVID-19 pandemic in China, estimating that the percentage of experienced WPV against HWs was from 17.9 to 20.4% during the COVID-19 outbreak (<1 year), and risk factors have been identified for individual characteristics of HWs (16). What's more, public health studies indicate that individual health behavior and outcomes are jointly determined by individual and environmental factors (17). Risk factors of PVV may be associated with individual level factors, such as age, gender, profession, experience, as well as the hospital setting in which the HWs are imbedded, the contextual factors, such as the geographic location, institutional scale and type, and existing measures. However, to our knowledge, research on the causes and factors related to PVV during the epidemic is limited and fragmented, and there is little research which explores measures to deal with PVV and the effect of cross-level interactions between individual factors and the measures on PVV (18), by the questionnaire—*Workplace Violence in the Health Sector Country Case Studies Research Instrument-Survey Questionnaire* (hereafter referred to as "the international questionnaires"), which were jointly developed by ILO, the International Council of Nurses (ICN), the WHO and the Public Services International (PSI) (19). In addition, the literature reveals a lack of studies describing a coherent, non-fragmented analysis of the situations where PVV occurs and which is based on the experiences of different professions working in a variety of units from multiple hospitals.

The world is in the grip of the COVID-19 pandemic and the new mutation spreads more readily than the original, thus the health states of HWs should be valued, and violence, harassment, discrimination, and stigma from patients and their visitors against HWs should be prevented and eliminated as much as possible. In this study, 12-month prevalence of PVV in Beijing from 1 January to 31 December, including the period of COVID-19 pandemic, were described, correlations between worker characteristics, measures, the cross-level interactions, and exposed to PVV were examined. The findings may provide evidence on occupational health and safety measures for HWs and occupational health services in the context of the COVID-19 pandemic.

METHODS

A cross-sectional survey utilizing the international questionnaires was conducted in January 2021 and included HWs from six public tertiary hospitals in Beijing.

Sample

The sampling strategy was divided into two steps. Firstly, two hospitals were selected in east, west, and north of Beijing, respectively. We purposefully sampled general and specialized hospitals. Then we used convenience sampling to recruit participants. Under the coordination of the managerial department of each hospital, investigators first obtained permission from the departments where most of the HWs were willing to participate in the survey. At least two departments were investigated in each hospital, and the participating departments almost covered all major types of wards. All the HWs on duty were invited to fill in the questionnaire during the survey time from 8 a.m. to 5 p.m. in 1 day for each department. The inclusion criteria for HWs were those working in direct contact with patients/visitors and full-time employees of these public hospitals with qualification certificates. The sample included the following professions: physicians, nurses and midwives, pharmacists, physical therapists, occupational therapists, and dieticians, technical staff (e.g., laboratory/sterilization workers), and administrative staff.

The participating hospitals are all large, tertiary public hospitals. Five of them are general hospitals, and four general hospitals and one specialized hospital are university hospitals. The specialized hospital is a child hospital. The description of characteristics (number of beds, total workers) of each hospital is presented in **Table 1**. Eight hundred and fifty-nine HWs from the selected department of these hospitals met the inclusion criteria, and 760 of them participated in the survey voluntarily, of whom 754 returned valid questionnaires (total valid response rate 87.8%) (**Table 1**). 84.5 and 15.5% of the respondents were from general and specialized hospitals, respectively. The sample of HWs is typical for HWs in the health sectors of Beijing according to gender (87.4% vs. 74.3%

TABLE 1 | Description of hospital characteristics and the hospital-level prevalence of PVV.

	Beds	Total no. of workers	Valid respondents (%)	Included HWs(%)	No. of HWs experience PVV (%)		
					Overall	Psychological	Physical
General hospital	–	–	722 (84.1)	637 (84.5)	172 (27.0)	170 (26.7)	17 (2.7)
Hospital 1	1,600	3,389	138 (16.1)	121 (16.0)	41 (33.9)	41 (33.9)	7 (5.8)
Hospital 2	1,500	2,954	129 (15.0)	114 (15.1)	36 (31.6)	35 (30.7)	2 (1.8)
Hospital 3	1,500	2,498	186 (21.7)	166 (22.0)	48 (28.9)	48 (28.9)	7 (4.2)
Hospital 4	1,500	4,224	123 (14.3)	110 (14.6)	30 (27.3)	29 (26.4)	1 (0.9)
Hospital 5	800	1,653	146 (17.0)	126 (16.7)	17 (13.5)	17 (13.5)	0 (0.0)
Specialized hospital	–	–	137 (15.9)	117 (15.5)	48 (41.0)	47 (40.2)	14 (12.0)
Hospital 6	400	2,662	137 (15.9)	117 (15.5)	48 (41.0)	47 (40.2)	14 (12.0)
Total	–	–	859 (100.0)	754 (100.0)	220 (29.2)	217 (28.8)	31 (4.1)

PVV, patient and visitor violence.

female), age (about 60% vs. 50% over 35 years old), professional experience (about 65% over 6 years vs. 79.5% over 5 years), and department (20).

The cross-sectional survey was carried out in January 2021 and took 1 month to complete. The 12-month workplace violence before the investigation time points (from 1 January 2020 to 31 December 2020, covering the period of COVID-19 outbreak in Beijing) was investigated. HWs participating in the survey received written information about the study's aim, background, and voluntary nature of participation.

Instrument

Workplace Violence in the Health Sector Country Case Studies: Survey Questionnaire, Chinese Version-Revised (the international questionnaires-C-R) (21) was employed for data collection. The international questionnaires-C-R is based on the English version developed by ILO, ICN, WHO, and PSI, and was translated and tested for public hospitals by using in the Chinese language (22). The questionnaire includes the following four parts: personal and workplace data (individual characteristics), physical workplace violence, psychological workplace violence (verbal abuse, bullying/mobbing, sexual harassment, and racial harassment), and health sector employer information. The item of measures to deal with workplace violence existing in the workplace belongs to the part of health sector employer. The comprehensibility and validity of the international questionnaires-C-R was tested by some studies involving different health professions from different kinds of hospitals in China (21–25). The Cronbach's coefficient is 0.828 in this study, and our analysis suggested that the international questionnaires-C-R was comprehensible, comprehensive and meaningful for actual practice in China's public hospitals.

Variable Description

The multi-level data in this study includes two level variables: demographic variables (level-1) and contextual variables of the measures (level-2). Contextual variables are generated from original individual level data.

The analysis centers on two level-1 outcomes variables (dichotomous measures): Psychological PVV and Physical PVV. The covariates are all dummy variables: age, gender, profession, experience, department, and patients/clients most frequently work with variables. The level-2 contextual variable is *measure (n)*, which presents the 13 existing measures against violence and listed in **Table 4**. *Measure (n)* is a dummy variable (1—The measure (*n*) existed in HWs' workplace; 0—The measure (*n*) didn't exist in HWs' workplace), and $n = 1, 2, \ldots, 13$.

Statistical Analysis

Because of the hierarchical structure of the data and the discrete outcome, multilevel logistic regression analysis, a type of the Generalized Linear Mixed Model (26), was used to assess the association between the independents and PVV. Cross-level interactions in multilevel modeling enable us to assess the degree to which relationships between individual explanatory and outcome variables are moderated by group level variables. In addition, the assumption of observation independence is not required in multilevel modeling because multilevel models are designed to measure and thus account for ICC (Intra-class Correlation Coefficient) in hierarchically structured data (26). Therefore, this study established a Two-Level Logistic Regression Model, with the individual (including outcome measure and individual variables) as level-1 and the measures as level-2.

The results of empty model for psychological PVV and physical PVV showed that the variance of each intercept was statistically significant (ICC = 0.16, chibar2 (01) = 11.0, $P = 0.0005$) (ICC = 0.26, chibar2 (01) = 13.2, $P = 0.0001$). And the ICC showed a moderately large between-group heterogeneity or within-group heterogeneity. Thus, the multilevel modeling approach should be applied to this data. The basic two-level logistic model is

as follows:

$$\ln\left(\frac{P_{ij}}{1-P_{ij}}\right) = \beta_{0j} + \beta_{1j}Profession + \beta_2 Gender_{ij} + \beta_3 Age_{ij} + \beta_4 Experience_{ij} + \beta_5 Ward_{ij} + \beta_6 Patients_{ij}\ (I)$$

$$\beta_{0j} = \gamma_{00} + \gamma_{01} Measures\,(n)_j + \mu_{0j}\ (II)$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11} Measures\,(n)_j + \mu_{1j}\ (III)$$

$$\ln\left(\frac{P_{ij}}{1-P_{ij}}\right) = \gamma_{00} + \gamma_{01} Measure\,(n)_j + \gamma_{10} Profession_{ij} + \gamma_{11} Measures\,(n)_j{}^{*} Profession_{ij} + \beta_2 Gender_{ij} + \beta_3 Age_{ij} + \beta_4 Experience_{ij} + \beta_5 Ward_{ij} + \beta_6 Patients_{ij} + \left(\mu_{0j} + \mu_{1j}{}^{*} Profession_{ij}\right)\ (IV)$$

Equation (I) is the level-1 equation. Equation (II) and (III) illustrate the case of two level-2 equations. Where p_{ij} represents the probability of PVV occurring. The i represents the i^{th} individual (level-1 unit), and j presents the j^{th} hospital (level-2 unit); $i=1, 2,\ldots, N$ (N is the total sample size), and $j=1,2,\ldots,J$ (J is the number of hospitals). Equation (IV) is a combined model, and ($\mu_{0j}+\mu_{ij}^{*}Profession_{ij}$) is the composite error term. A new variable $Measure_j{}^{*}Profession_{ij}$ was created, which denotes the cross-level interaction between the contextual variable *Measure* and the level-1 variable *Profession*.

Descriptive statistics were used to describe demographic and frequency of psychological and physical PVV, and existing measures against violence (MAV) was evaluated. Associations between categorical variables were tested with chi-square tests. All data analyses were conducted using Stata 16.0. Statistical significance was defined as $p < 0.05$.

RESULTS

Prevalence and Distribution of PVV

Of the 754 respondents who completed valid questionnaires in the survey, 87.4% were women and 56.6% were between 35 and 45 years old (the mean age of total participants was 32.6 ± 6.8 years), 82.6% were nurses and 15.1% were doctors, and 32.8% had between 6 and 10 years of experience at the health sector (**Table 2**).

In 2020, a total of 220 (29.2%) HWs experienced the PVV. 217 (28.8%) and 31 (4.1%) respondents have witnessed incidents of psychological and physical PVV in their workplace, respectively. 10.2% of respondents reported the psychological PVV occurred 2–4 times in the 12 months of 2020. **Table 1** presents the hospital aggregates from the respondent data described in the text. The prevalence of psychological and physical PVV for specialized hospitals (40.2 and 12.0%) were both higher than that of general hospitals (26.7 and 2.7%) (all $p < 0.01$).

Across occupations, nurses had the highest exposure to PVV, followed by doctors and other HWs (technical and administrative staff) (31.9% vs. 16.7% vs. 11.8%) ($\chi^2 = 13.4$, $p = 0.001$). The doctor had the highest exposure to physical PVV (11.4%), while nurses had the highest exposure to psychological PVV (31.6%). When comparing the occurrence of PVV in different departments, the prevalence is highest in specialized unit (e.g., psychiatric, pediatrics, orthopedics, and radiology units), followed by general surgery and outpatient and emergency department (40.3% vs. 36.5% vs. 30.4%) ($\chi^2 = 22.9$, $p < 0.001$). In addition, the prevalence of PVV for HWs who frequently work with infants (73.1%) ($\chi^2 = 25.1$, $p < 0.001$), children (61.4%) ($\chi^2 = 50.0$, $p < 0.001$), and adolescents (51.6%) ($\chi^2 = 25.3$, $p < 0.001$) were higher than they frequently work with other patients/clients (**Table 2**). No significant between-group difference was found for age, work experiences, and night shift (all $p > 0.05$).

Multilevel Logistic Regression of Occupational Characteristics

Model 1.1 and 1.2 in **Table 3** shows the results of multilevel logistic regression to determine the association between demographic indicator variables and PVV, by a combined model of Equation (I) and empty model of level-2[1]. It indicates that after controlling for HWs characteristics, professions, department, and patients/clients most frequently work with are related to the occurrence of PVV. Nurses had a greater risk of psychological PVV than doctors who were 0.5 times (95% CI = 0.23∼0.99) less likely to suffer from psychological PVV than nurses, while doctors were 5.3 times (95% CI = 1.59∼17.90) more likely to suffer from physical violence than nurses. HWs in General surgery (OR = 2.3, 95% CI = 1.22∼4.40) and intensive care (OR = 22.9, 95% CI = 2.90∼181.23) had a greater risk of psychological PVV and physical PVV than in general medicine, respectively. Those who most frequently work with infants were 7.2 times (95% CI = 2.24∼23.19) more likely to suffer from psychological PVV than HWs most frequently work with other patients. No important association was found between having experienced PVV and gender, age, and length of experience in the health sector (**Table 3**).

Existing Measures Against Workplace Violence

The policies and measures against workplace violence implemented in the six hospitals in 2020, were reported by the respondents shown in **Table 4**. More than four-fifth (86.1%) of respondents reported that their workplace had implemented security measures, only 13.9% of them reported that their workplace had invested in human resource development, and 3.6% of them reported no measures at all. The prevalence of psychological and physical PVV for workplace where the measure against violence (MAV) existed and didn't exist are reported in **Table 4**, respectively. A combined multilevel regression model of Equation (I) and (II) was used to determine the association (the estimates of OR and 95% CI in **Table 4**) between each measure and PVV. The results indicate that after controlling for worker characteristics, the HWs in the workplace without measures of patient screening, increasing staff numbers, changing shifts or rotas, and investment in human resource development were found to be 2.6 (95% CI = 1.70∼4.00),

[1]Level-2 equation of empty model follows: $\beta_{0j} = \gamma_{00} + \mu_{0j}$.

TABLE 2 | Characteristics and frequency distributions for PVV among 754 HWs.

		No. of HWs(%)	Overall PVV		Psychological PVV		Physical PVV	
			No. of HWs (%)	X^2 (p)	No. of HWs(%)	X^2 (p)	No. of HWs (%)	X^2 (p)
Total		754 (100.0)	220 (29.2)		217 (28.8)		31 (4.1)	
Gender	Female	659 (87.4)	202 (30.7)	5.51	200 (30.3)	6.28	20 (3.0)	15.38
	Male	95 (12.6)	18 (18.9)	(0.019)	17 (17.9)	(0.012)	11 (11.6)	(0.000)
Age	Under 35	297 (39.4)	81 (27.3)	1.64	78 (26.3)	2.30	11 (3.7)	0.63
	35∼45	427 (56.6)	132 (30.9)	(0.44)	132 (30.9)	(0.317)	18 (4.2)	(0.728)
	46 and older	30 (4.0)	7 (23.3)		7 (23.3)		2 (6.7)	
Profession	Nurse	623 (82.6)	199 (31.9)	13.43	197 (31.6)	14.24	18 (2.9)	18.47
	Doctor	114 (15.1)	19 (16.7)	(0.001)	18 (15.8)	(0.001)	13 (11.4)	(0.000)
	Other HW	17 (2.3)	2 (11.8)		2 (11.8)		0 (0.0)	
Experience inhealthsector	<1 year	33 (4.4)	4 (12.1)	7.83	3 (9.1)	9.76	2 (6.1)	6.78
	1–5 year	227 (30.1)	66 (29.1)	(0.166)	64 (28.2)	(0.082)	14 (6.2)	(0.238)
	6–10 year	247 (32.8)	72 (29.1)		72 (29.1)		10 (4.0)	
	11–15 year	142 (18.8)	49 (34.5)		49 (34.5)		3 (2.1)	
	16–20 year	60 (8.0)	19 (31.7)		19 (31.7)		0 (0.0)	
	Over 20 years	45 (6.0)	10 (22.2)		10 (22.2)		2 (4.4)	
Department	OED	184 (24.4)	56 (30.4)	22.88	54 (29.3)	23.24	9 (4.9)	8.13
	General medicine	270 (35.8)	69 (25.6)	(0.000)	68 (25.2)	(0.000)	6 (2.2)	(0.149)
	General surgery	85 (11.3)	31 (36.5)		31 (36.5)		5 (5.9)	
	Intensive care	54 (7.2)	12 (22.2)		12 (22.2)		2 (3.7)	
	Specialized unit	124 (16.4)	50 (40.3)		50 (40.3)		9 (7.3)	
	Support services	37 (4.9)	2 (5.4)		2 (5.4)		0 (0.0)	
Work innights	Yes	352 (46.7)	108 (30.7)	0.72	107 (30.4)	0.84	18 (5.1)	1.68
	No	402 (53.3)	112 (27.9)	(0.395)	110 (27.4)	(0.359)	13 (3.2)	(0.195)
Patients/clients most frequently work with	Newborns	31 (4.1)	8 (25.8)	0.18	8 (25.8)	0.14	3 (9.7)	2.54
				(0.673)		(0.709)		(0.111)
	Infants	26 (3.4)	19 (73.1)	25.11	19 (73.1)	25.78	6 (23.1)	24.57
				(0.000)		(0.000)		(0.000)
	Children	88 (11.7)	54 (61.4)	49.95	54 (61.4)	51.61	8 (9.1)	6.27
				(0.000)		(0.000)		(0.012)
	Adolescents	91 (12.1)	47 (51.6)	25.29	45 (49.5)	21.57	7 (7.7)	3.37
				(0.000)		(0.000)		(0.067)
	Adults	466 (61.8)	153 (32.8)	7.89	151 (32.4)	7.82	18 (3.9)	0.19
				(0.005)		(0.005)		(0.662)
	Elderly	393 (52.1)	129 (32.8)	5.28	129 (32.8)	6.55	13 (3.3)	1.34
				(0.022)		(0.01)		(0.246)

PVV, patient and visitor violence.
OED, Outpatient and emergency department.
Doctor: physicians, pharmacists, physical therapists, occupational therapists, and dietitians.
Nurse: nurse and midwife.
Other HWs: technical staff (e.g., laboratory/sterilization workers) and administrative staff.
Specialized unit: psychiatric, pediatrics, orthopedics, radiology.

1.8 (95% CI = 1.16∼2.69), 1.8 (95% CI = 1.05∼2.99) and 4.5 (95% CI = 2.14∼9.38) times more likely to experience psychological PVV compared to HWs in the workplace with those measures, respectively. The HWs in the workplace without measures of security, improving surroundings, patient protocols, and investment in human resource development was found to be 7.9 (95% CI = 2.79∼22.58), 4.4 (95% CI = 1.82∼10.85), 4.7 (95% CI = 1.42∼15.52), and 13.8 (95% CI = 1.32∼143.21) times more likely to experience physical PVV compared to HWs in the workplace with the measures, respectively.

Model 2.1 and 2.2 in **Table 3** shows the significant results of cross-level interactions between the measures and professions examined by a combined multilevel regression model of Equation (IV). There were significant interactions between the contextual variable *measure (1)*, *measure (13)* and the individual level variable *profession*; in other words, the effect of *profession* does significantly vary for the workplace with and without the *measure*

TABLE 3 | Results of multilevel logistic regression models: worker characteristics, measures and cross-level interactions ($n = 754$).

Variable		Model 1.1 psychological PVV	Model 1.2 physical PVV	Model 2.1 psychological PVV	Model 2.2 physical PVV
		OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Level-1					
Gender	Male	0.86 (0.42∼1.77)	3.07 (0.94∼9.99)	0.97 (0.49∼1.92)	3.30 (0.97∼11.26)
	Female	1.0	1.0	1.0	1.0
Age	35∼45	1.21 (0.74∼1.98)	1.68 (0.56∼5.04)	1.17 (0.73∼1.87)	2.03 (0.69∼6.01)
	46∼	1.30 (0.38∼4.51)	4.37 (0.41∼46.15)	1.27 (0.4∼4.06)	4.34 (0.40∼47.62)
	Under 35	1.0	1.0	1.0	1.0
Profession	Doctor	0.48 (0.23∼0.99)[a]	5.34 (1.59∼17.90)[b]	0.31 (0.03∼2.86)	1.49 (0.35∼6.32)
	Other HWs	0.63 (0.12∼3.37)	–	15.64 (0.87∼282.37)	–
	Nurse	1.0	1.0	1.0	1.0
Experience in health sector	under 1 year	0.38 (0.07∼1.92)	2.28 (0.13∼39.06)	0.47 (0.1∼2.3)	1.74 (0.10∼30.94)
	1–5 year	1.92 (0.67∼5.49)	2.62 (0.29∼23.64)	1.73 (0.62∼4.83)	2.27 (0.24∼21.61)
	6–10 year	1.78 (0.68∼4.61)	1.11 (0.15∼8.49)	1.48 (0.58∼3.8)	0.74 (0.09∼6.37)
	11–15 year	2.09 (0.8∼5.49)	0.40 (0.04∼4.08)	1.91 (0.74∼4.96)	0.27 (0.03∼2.76)
	16–20 year	2.02 (0.7∼5.81)	–	1.99 (0.7∼5.7)	–
	Over 20 years	1.0	1.0	1.0	1.0
Department	OED	1.34 (0.73∼2.44)	2.25 (0.56∼9.11)	1.39 (0.81 ∼2.39)	2.73 (0.67∼11.15)
	General surgery	2.31 (1.22∼4.4)[a]	4.25 (0.93∼19.33)	2.69 (1.48 ∼4.89)[b]	2.71 (0.48∼15.15)
	Intensive care	1.09 (0.49∼2.45)	22.94 (2.9∼181.23)[b]	1.16 (0.52 ∼2.62)	30.21 (3.69∼247.22)[b]
	Specialized unit	1.95 (1.01∼3.76)[a]	9.34 (1.89∼46.21)[b]	2.67 (1.50 ∼4.78)[b]	15.68 (3.63∼67.75)[b]
	Support services	0.18 (0.03∼0.93)[a]	–	0.16 (0.03 ∼0.86)[a]	–
	General medicine	1.0	1.0	1.0	1.0
Patients/ clients most frequently work with	Newborns	0.62 (0.19∼2.08)	2.22 (0.44∼11.15)		
	Non-newborns	1.0	1.0		
	Infants	7.21 (2.24∼23.19)[b]	3.02 (0.58∼15.7)		
	Non-infants	1.0	1.0		
	Children	2.52 (1.34∼4.75)[b]	1.19 (0.32∼4.47)		
	Non- children	1.0	1.0		
	Adolescents	1.44 (0.77∼2.67)	2.06 (0.5∼8.49)		
	Non-adolescents	1.0	1.0		
	Adults	1.69 (1.11∼2.57)[a]	1.55 (0.53∼4.54)		
	Non-adults	1.0	1.0		
	Elderly	1.66 (1.03∼2.67)[a]	1.10 (0.3∼4.06)		
	Non-elderly	1.0	1.0		
Level-2					
Measure (*n*)	Without measure (1)				3.05 (0.67∼13.9)
	With measure (1)				1.0
	Without measure (13)			4.95 (2.16∼11.37) [b]	
	With measure (13)			1.0	
Cross-Level Interactions					
Measure (*n*) *Profession	Doctor*NO			1.31 (0.13∼12.73)	11.26 (1.09∼116.39)[a]
	Other HWs*NO			0.01 (0∼0.45) [a]	–
	Nurse*Yes			1.0	1.0

Column heading shows dependent variable.

[a,b]*denotes significance at the 5 percent and 1 percent level, respectively.*

Measure (1), Security measures; Measure (13), Investment in human resource development.

PVV, patient and visitor violence.

TABLE 4 | The correlation between 13 measures against violence and PVV.

Variables	Intervention measures	Respondents *n* (%)	Psychological PVV (%)			Physical PVV (%)		
			Yes	No	*OR (95% CI)*	Yes	No	*OR (95% CI)*
Measure (1)	Security measures	649 (86.1)	30.4	19.0	0.65 (0.37∼1.13)	2.9	11.4	7.93 (2.79∼22.58)[b]
Measure (2)	Improve surroundings	536 (71.1)	30.8	23.9	0.8 (0.54∼1.19)	2.6	7.8	4.44 (1.82∼10.85)[b]
Measure (3)	Restrict public access	328 (43.5)	27.1	30.0	1.37 (0.95∼1.97)	3.7	4.5	2.44 (0.99∼6.02)
Measure (4)	Patient screening	224 (29.7)	17.9	33.4	2.61 (1.7∼4.00)[b]	4.0	4.2	2.08 (0.81∼5.32)
Measure (5)	Patient protocols	204 (27.1)	24.0	30.5	1.41 (0.93∼2.12)	2.5	4.7	4.69 (1.42∼15.52)[a]
Measure (6)	Restrict exchange of money at the workplace	188 (24.9)	24.5	30.2	1.36 (0.91∼2.05)	2.7	4.6	2.05 (0.65∼6.46)
Measure (7)	Increased staff numbers	225 (29.8)	20.9	32.1	1.77 (1.16∼2.69)[b]	5.3	3.6	1.35 (0.52∼3.52)
Measure (8)	Check-in procedures for staff	152 (20.2)	23.7	30.1	1.48 (0.94∼2.33)	6.6	3.5	0.85 (0.34∼2.14)
Measure (9)	Special equipment or clothing	151 (20.0)	23.8	30.0	1.52 (0.96∼2.4)	4.0	4.1	1.35 (0.46∼4)
Measure (10)	Changed shifts or rotas	127 (16.8)	18.9	30.8	1.77 (1.05∼2.99)[a]	6.3	3.7	0.96 (0.34∼2.71)
Measure (11)	Reduced periods of working alone	195 (25.9)	24.6	30.2	1.13 (0.75∼1.7)	5.1	3.8	0.98 (0.39∼2.49)
Measure (12)	Training	258 (34.2)	25.2	30.6	1.21 (0.84∼1.75)	3.5	4.4	1.22 (0.49∼3.06)
Measure (13)	Investment in human resource development	105 (13.9)	8.6	32.0	4.49 (2.14∼9.38)[b]	1.0	4.6	13.77 (1.32∼143.21)[a]

[a,b]denotes significance at the 5 percent and 1 percent level, respectively.
OR (95% CI) were the results of multilevel logistic regression models.
PVV, patient and visitor violence.
Yes, The measure (n) existed in HWs' workplace; No, The measure (n) didn't exist in HWs' workplace.

(1), *measure (13)*. Specifically, doctors in the workplace without security measures were 11.3 times (95% CI = 1.09∼116.39) more likely to suffer from physical PVV compared to nurses in the workplace with security measures. And other HWs in the workplace without measures of investment in human resource development were less likely (OR = 0.01, 95% CI = 0.00∼0.45) to suffer from psychological PVV compared to nurses in the workplace with those measures. No cross-level interactions were found between other measures and professions (**Table 3**).

DISCUSSION

This study is an investigation of PVV against HWs in multiple hospitals during the COVID-19 epidemic in China and is one of the few studies relating individual and contextual factors to PVV by multilevel regression analysis. The results of the study reveal that in the year of 2020, 29.2% of HWs experienced PVV in tertiary public hospitals from Beijing. Doctors were more likely to suffer from physical PVV than nurses. HWs most frequently work with infants were more likely to suffer from psychological PVV. More than four-fifth of respondents reported that their workplace had implemented security measures. The effect of *profession* does significantly vary between the workplace with and without the security measures, and the measure of investment in human resource development.

The Situation of PVV in the Epidemic

This data set comes from a large representative sample of multiple hospitals. The findings confirm existing evidence that HWs in child hospitals were found to be about 1.5 times more likely to experience PVV compared to them in general hospitals (27). A recent published cross-sectional survey in China showed that the prevalence of WPV among mental health professionals in China during the COVID-19 pandemic (in 2 months) was 18.5% (16), which is higher than the occurrence rate of PVV (29.2% in a year) in this study from tertiary hospitals. However, the WPV from the former study not only includes the PVV, but also the horizontal violence in the workplace. Another study using the database of the Medical Quality and Safety Notification System showed that the overall prevalence of PVV for the 39 tertiary public hospitals in Beijing in 2015 was 16.6% (27), which is lower than the prevalence of PVV (29.2%) in this study that includes six tertiary public hospitals. In addition, the findings confirm existing evidence that HWs in some specialized hospitals (such as child hospital) had higher risk of PVV compared with general hospitals, and more attention should be paid to the workplace violence in child hospitals.

How to understand the prevalence of PVV in this study? In 2020, the COVID-19 pandemic ravaged all over the world. The COVID-19 broke out in Beijing from 11 June to 19 July with hundreds of people infected, and had been effectively controlled within a month. However, as the capital of China and international exchange center, Beijing is under great pressure to prevent and control the epidemic. Since February 2020, Beijing has issued a series of prevention and control measures. In the health sectors, different levels of COVID-19-specific IPC measures were implemented in hospitals, based on the local epidemiological situation, the specificity of the work setting and work tasks (28). For example, introduce measures for avoiding crowding and social mixing; restricting visitors; requirement of health pass codes and a negative nucleic acid certificate etc. Although these measures effectively protect HWs, patients and visitors from infection, the change of medical treatment process and visits regulation could also influence patients' intention to seek treatment from hospitals, and increase the risk of clinician-patient conflicts to some extent. According to the data

of the Health Statistical Yearbook from Beijing municipal health commission, the total number of outpatient visits of tertiary hospitals in 2020 was 32% lower than that in 2019 (20, 29). The study of Huang and Zhang (27) shows that the prevalence of PVV was significantly positively correlated with the outpatient workload of doctors ($\beta = 0.24$, $p < 0.01$) in China. This means the PVV should have decreased during the 2020 due to the decrease in workload of doctors. However, long patient waiting times, IPC measures, and contact tracing etc. may also increase the risk of PVV against HWs. Therefore, although the prevalence of PVV in this survey is lower than that in some studies, it cannot be simply concluded that the situation of PVV in Beijing in 2020 is more or less severe than that in other countries or before.

Worker Characteristics and PVV

The findings confirm existing evidence that HWs most frequently working with infants and children had a higher risk of psychological violence (15, 30–32). Patients and their relatives in pediatrics are more anxious and sensitive than other departments, thus increasing the possibility of conflicts and workplace violence. Previous studies found that HWs in pediatrics were at an increasing risk of PVV, because of the long labor shortage of pediatricians in China and the more vulnerable and sensitive patients there (27). In this study, the proportion of nurses who frequently worked with children (12.7%) was higher than other HWs, which means that nurses usually have a higher risk of psychological PVV.

Interestingly, doctors are more likely to suffer physical PVV than nurses (21), despite the latter having close contact with the patients more frequently, which is consistent with other studies from China (33). Indeed, doctors are often victims of physical PVV, especially the terrible violence in China. Why are doctors, not nurses? Previous studies suggested that the root cause of doctor-patient conflicts is the issue of trust between doctors and patients in China (34). The insufficient level of doctor-patient trust leads patients to blame the deterioration of their health directly on doctors rather than nurses (34, 35). During the outbreak of COVID-19, more and more patients went to hospital when they were in severe or critically ill condition, due to the risk of infection in epidemic. It's important to note that the severe patients and their relatives will become more anxious and sensitive than moderate patients, thus increasing the possibility of conflicts between doctors and patients, and the risk of physical PVV.

The Comprehensive Measures Against PVV

The workplace with measures of patient screening, increasing staff numbers, changing shifts or rotas, and investment in human resource development have a lower risk of psychological PVV. Meanwhile, the workplace with measures of security, improving surroundings, patient protocols, and investment in human resource development have a lower risk of physical PVV. It suggested that the measures in these hospitals could protect HWs from PVV to a certain extent. In 2020, a series of policies were timely issued and implemented by Beijing municipal government to protect the occupational health and safety of HWs, including the most comprehensive and rigorous prevention and control strategy against the epidemic, proactive measures of occupational health, and precaution strategies against occupational hazards (5, 6, 16, 36). Therefore, strict IPC measures and precaution strategies against WPV have been both strictly implemented. Our study showed that most of HWs reported the measures against workplace violence existed in their workplace, and 86.1% of them were security measures. What's more, the cross-level interactions between *profession* and *measure (1)* shows that without the security measures, doctors were 11.3 times more likely to suffer from physical PVV than nurses. Indeed, Beijing Municipal Public Security Bureau and Beijing Municipal Health Commission jointly issued the policies, *Regulations of Beijing Municipality on the administration of hospital safety*, and *List of prohibited and restricted items in hospitals of Beijing* in the year of 2020 (37). After that, 90% of the secondary and tertiary public hospitals in Beijing had set up a security check system, and more than 80% had installed devices which HWs can press the button to report to police, and 86 hospitals were equipped with face recognition system for patient screening (to record and be aware of previous aggressive behavior). And then, the number of hospital-related crimes was reduced by 10.8%, by August 2021 (8). According to the evidence from Italy, Ferorelli D et al. also confirm that comprehensive measures can reduce aggression to the detriment of HWs such as reporting events (38) which could activate the most suitable measures to prevent attacks (39). These demonstrated that the existing measures against WPV are still very important and effective to fight against the PVV during the pandemic, and comprehensive measures (measures of IPC and against WPV) should be implemented to mitigate hazards and protect the health, safety, and well-being of health workers.

LIMITATION AND STRENGTH

Firstly, due to the cross-sectional design, the causal associations between variables are still unknown. Second, recall bias cannot be excluded, especially in psychological PVV which is more likely to be under reported. Third, HWs participated voluntarily during the COVID-19 epidemic, which could lead to selection bias. It is possible that HWs who experienced the PVV or had sufficient time were more likely to participate in the survey. And for population studies in COVID-19 epidemic, it is difficult to interview all HWs by face-to-face investigation. Nevertheless, the total subjects recruited from six hospitals are typical for HWs in the health sectors of Beijing. What's more, the international definitions and questionnaire on workplace violence used in this survey enhances the validation of international comparison, and the multilevel logistic model provide an appropriate analytical framework to explore the nature and extent of relationships at both micro and macro level, which could provide evidence for further studies on the intervention with comprehensive measures. To our knowledge, the study is one of a limited

number of studies in China to verify the risk factors of PVV using the international technical tool based on multilevel regression analysis.

CONCLUSION

During COVID-19 pandemic, a series of policies were issued and implemented for HWs in China to protect the occupational health and safety of HWs, not only implementing strict IPC measures, but also the measures against violence. The security measures are very important and effective to fight against the physical PVV during the pandemic with widespread risk factors for workplace violence. Comprehensive measures (measures of IPC and against WPV) should be implemented to mitigate hazards and protect the health, safety and well-being of health workers.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

This study was approved by Ethical Review Committee of Chinese Academy of Medical Sciences (IMICAMS/8/22/HREC). Written informed consent was obtained from all participants before the survey. To ensure anonymity, no names, or other identifiers were used.

AUTHOR CONTRIBUTIONS

JH conceived and designed the study, performed the data analysis, and modified the manuscript. Y-qG conducted the literature search, interpreted the data, and wrote the first draft. N-nX and X-jM conducted surveillance, collected data, and had full access to all of the data in the study. All authors made important contributions to subsequent drafts and have seen and approved the final version.

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Different Impacts of COVID-19 on Quality of Therapy, Psychological Condition, and Work Life Among Occupational Therapists in Physical and Mental Health Fields

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Background: The negative impacts of the coronavirus disease 2019 (COVID-19) pandemic have worsened the quality of therapy, psychological condition, and work life of second-line healthcare workers and occupational therapists (OTs). However, no study has investigated whether the impact of COVID-19 varies among OTs working in different fields. This study aimed to investigate the differences on the impact of COVID-19 between OTs in the physical and mental health fields.

Methods: A cross-sectional online survey was conducted in Japan between January 20 and January 25, 2021. A total of 4,418 registered OTs who were members of the Japanese Association of Occupational Therapists volunteered for this study. After screening using the exclusion criteria, 1,383 participants were classified into two groups based on their field (mental health and physical health), and their quality of therapy, psychological condition, and work life were analyzed.

Results: OTs in the mental health field showed a greater decrease in therapy quality and increase in workload and a lower rate of decrease in working hours than those in the physical health field. In the multinomial logistic regression analysis, decreased and increased therapy quality and decreased therapy quality were significantly associated with depression in the physical health field, and decreased therapy quality was associated with insomnia in the mental health field. Furthermore, insomnia and anxiety were commonly associated with increased workload and working hours, respectively, in both fields, whereas anxiety and depression were associated with increased workload only in the physical health field.

Conclusions: These results demonstrate that COVID-19 differently impacted quality of treatment, workload, work time, and psychological condition in the physical and mental health fields; moreover, the relationships among these are different in these two fields. These results highlight the importance of investigating the field-specific negative

impacts of COVID-19 on OTs and may provide helpful information for devising tailored and effective prevention and intervention strategies to address these challenges.

Keywords: COVID-19, occupational therapy, healthcare worker, therapy quality, psychological condition, work life, mental health

INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic has had an unprecedented impact on society and led to a dramatic loss of human life worldwide, presenting a unique challenge to public health and socioeconomic welfare (1, 2). The repeated waves of COVID-19 outbreaks have resulted in social isolation (2), loss of accessibility (3), economic crises (4), substance abuse (5), and deterioration of the working environment (4, 6–8), which are reported to be closely related to the mental health of citizens and workers. In particular, many previous studies have reported on the relationship between the working environment and mental health, and significantly, concerns are increasing about the mental health, psychological adjustment, and recovery of healthcare workers treating and caring for patients with COVID-19 (9, 10). Several systematic reviews have revealed that frontline medical workers fighting the disease experience poor mental health, such as depression, anxiety, insomnia, and posttraumatic stress reactions (11–13). These negative impacts have also been reported among second-line healthcare professionals (6, 14, 15).

Occupational therapists (OTs) are healthcare workers who offer a broad variety of services to people of all age groups and are typically classified as second-line medical professionals who do not directly care for patients with COVID-19 during the acute phase (16). During the pandemic, occupational therapy has heightened the importance of enabling engagement in activities that provide meaning in life when participation in regular routines and activities is particularly challenging (17). However, contrary to this situation, their work life has changed due to the current pandemic, which has negatively affected their mental health (6, 16, 17). A global survey of individuals involved in the delivery of occupational therapy conducted by the World Federation of Occupational Therapists (WFOT) reported negative mental health impacts, overwork, and isolation in this group due to the COVID-19 pandemic and stated that practical support, reassurance, and prevention were vital to address these problems (17). In addition, for efficiency in work during the pandemic, respondents indicated that preparedness for ever-changing circumstances and needs was paramount. However, information on how such preparedness may be achieved is lacking.

Recently, although mental health problems have been associated with work-related stress, including long working hours and heavy workload on OTs, no study has investigated the differences in the impact of the COVID-19 pandemic on work life among OTs working in different fields. OTs work with all age groups in various fields of physical and psychosocial/mental health. They work in a wide variety of settings, including hospitals, clinics, daycare centers, rehabilitation centers, home care programs, special schools, industry (e.g., service industry, corporate sector), and the private sector, and the objectives and solutions required of OTs vary, depending on where they work (11). It is expected that the work changes and psychological impact of the recent pandemic will vary depending on the field in which they work, as previous studies of burnout syndrome

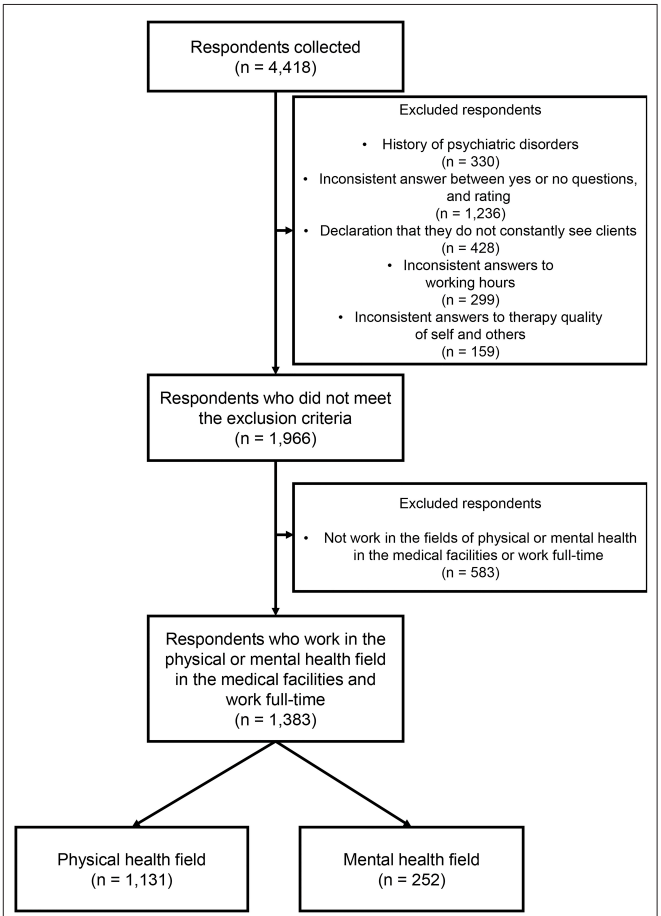

FIGURE 1 | Flow diagram for the respondents included in data analysis. Flow chart summarizing the number of respondents excluded with implementation of each eligibility criteria culminating in the final analytical data set (n = 1,383, OTs in the physical health field: n = 1,131; OTs in the mental health field: n = 252).

Abbreviations: AOR, Adjusted odds ratio; CI, Confidence interval; GLM, Generalized linear model; ISI–J, Japanese version of the Insomnia Severity Index; LS, Japanese version of the three-item loneliness scale; OECD, Organization for Economic Co-operation and Development; OR, Odds ratio; OTs, Occupational therapists; RC, Regression coefficient; SAS, Zung Self-Rating Anxiety Scale; SDS, Zung Self-Rating Depression Scale; WFOT, World Federation of Occupational Therapists; WHO, World Health Organization.

TABLE 1 | Sample characteristics and questionnaire results regarding daily life.

Characteristics	No./Total no. (%)			*p*
	Total sample (*n* = 1,383)	**OTs in the physical health field (*n* = 1,131)**	**OTs in the mental health field (*n* = 252)**	
Sample characteristics				
Mean age (year) (SD)	35.8 (8.7)	35.1 (8.6)	39.1 (8.3)	<0.001*
Sex				0.888†
Female	771 (55.7)	629 (55.6)	142 (56.3)	
Male	612 (44.3)	502 (44.4)	110 (43.7)	
Academic background				0.162†
< Bachelor	762 (55.1)	613 (54.2)	149 (59.1)	
≥ Bachelor	621 (44.9)	518 (45.8)	103 (40.9)	
Marital status				0.001†
Married	840 (60.7)	664 (58.7)	176 (69.8)	
Unmarried	543(39.3)	467 (41.3)	76 (30.2)	
Managerial position				0.001†
Yes	457 (33.0)	351 (31.0)	106 (42.1)	
No	926 (67.0)	780 (69.0)	146 (57.9)	
Service years, mean (SD)	12.1 (7.9)	11.5 (7.9)	14.8 (7.7)	<0.001*
Daily life				
Efforts to avoid being infected (1 = *never*, 7 = *frequent*)				0.870†
5–7	1,370 (99.1)	1,118 (98.9)	252 (100)	
1–3	0 (0.0)	0 (0.0)	0 (0.0)	
4	13 (0.9)	13 (1.1)	0 (0.0)	
Efforts to not transmit the virus to others (1 = *never*, 7 = *frequent*)				0.256†
5–7	1,363 (98.5)	1,116 (98.7)	247 (98.0)	
1–3	4 (0.3)	2 (0.2)	2 (0.8)	
4	16 (1.2)	13 (1.1)	3 (1.2)	
Frequency of contact with family (1 = *never*, 7 = *frequent*)				0.983†
5–7	940 (68.0)	768 (67.9)	172 (68.3)	
1–3	196 (14.2)	160 (14.1)	36 (14.3)	
4	247 (17.8)	203 (18.0)	44 (17.4)	
Frequency of contact with friends (1 = *never*, 7 = *frequent*)				0.324†
5–7	373 (26.8)	302 (26.7)	69 (27.4)	
1–3	637 (46.1)	513 (45.4)	124 (49.2)	
4	375 (27.1)	316 (27.9)	59 (23.4)	
Fewer outings				1.000†
Yes	1,365 (98.7)	1,116 (98.7)	249 (98.8)	
No	18 (1.3)	15 (1.3)	3 (1.2)	
Avoidance of face-to-face conversations				0.193†
Yes	1,275 (92.2)	1,048 (92.7)	227 (90.1)	
No	108 (7.8)	83 (7.3)	25 (9.9)	
Increased precautions at home				0.393†
Yes	1,323 (95.7)	1,079 (95.4)	244 (96.8)	
No	60 (4.3)	52 (4.6)	8 (3.2)	

(Continued)

TABLE 1 | Continued

Characteristics	No./Total no. (%)			*p*
	Total sample (n = 1,383)	OTs in the physical health field (n = 1,131)	OTs in the mental health field (n = 252)	
Increased mask-wearing				0.700†
Yes	1,373 (99.3)	1,122 (99.2)	251 (99.6)	
No	10 (0.7)	9 (0.8)	1 (0.4)	
Increased SNS usage				0.889†
Yes	709 (51.3)	581(51.4)	128 (50.8)	
No	674 (48.7)	550 (48.6)	124 (49.2)	
Free description about changes in life (fill-in-the-blank question)				0.634†
Yes	220 (15.9)	183 (16.2)	37 (14.7)	
No	1,163 (84.1)	948 (83.8)	215 (85.3)	

SNS, Social Networking Service.
**Two-sample t-test; †Fisher's exact test.*

among OTs reported a higher prevalence in the mental health field than in the physical health field (18, 19). Therefore, we focused on the differences in the negative impacts of the COVID-19 pandemic among occupational therapists between two representative fields from a macroscopic perspective: the mental health field and the physical health field.

OTs need to protect both clients and themselves from the COVID-19 virus when they undertake occupational therapy in hospitals. By avoiding closed spaces, crowded places, and closed-contact settings (3Cs), as proposed by the World Health Organization COVID-19 new normal guidelines, the WFOT has recommended telerehabilitation methods for providing treatment to clients. However, the introduction of telerehabilitation cannot be implemented uniformly due to differences in implementation methods such as group occupational therapy and one-on-one occupational therapy, as well as differences in clients' adaptability to new program delivery methods. If therapists and clients have no choice but to conduct the program in the same room, the degree of difficulty in conducting the program differs based on the client's understanding of infection prevention as well as of group and individual occupational therapy. In the physical health field, it is necessary to deal with the increased likelihood of therapists coming into physical contact with clients in the context of individual therapy. One is more likely to deal with programs that involve little body contact in group-based activities in the mental health field (20–22).

A group-based occupational therapy program is a necessary and appropriate intervention for exploring and developing distinct knowledge and skills, including basic social interaction skills, tools for self-regulation, goal setting, and learning and skills acquisition across the lifespan (23), and these benefits are often highlighted in the mental health field (24, 25). Moreover, previous studies have reported that patients with mental illnesses have a higher risk of COVID-19 infection and worsening mental illness because of their symptom characteristics (26, 27). Worsened mental health in these patients can lead to a burden on therapists and even deterioration of therapists' own mental health and consequent lower quality of therapy. Furthermore, previous studies have reported a higher prevalence of burnout syndrome caused by work-related stress in the mental health field than in the physical health field (18, 19). Therefore, it is expected that different impacts of COVID-19 on mental health problems and lower therapy quality are likely in these two fields.

This study aimed to investigate the differences in the impact of COVID-19 on work life, psychological condition, and work quality among OTs in two representative fields of occupational therapy: physical and mental health. Moreover, we sought to identify the relationship between psychological measurements and therapy quality in therapists during the pandemic in each field. Clarifying the differences in the impact of COVID-19 on work life among OTs between the two fields and the psychological effects underlying them can contribute to developing preventive and intervention strategies for predictive field-specific occupational problems in occupational therapy and devising solutions and initiatives for current issues in this field.

MATERIALS AND METHODS

Research Protocol

A cross-sectional online survey was conducted in Japan from January 20 to 25, 2021, using Google Forms https://www.google.com/forms/about/. All respondents were occupational therapists who were members of the Japanese Association of Occupational Therapists, and an invitation for participation was sent to all registered members on January 20, 2021, *via* email.

The study protocol was approved by the Ethics Committee of Saitama Prefectural University (approval no. 20003) and was conducted in accordance with the latest version of the Declaration of Helsinki. Written informed consent was obtained from all the respondents, before and after answering the questionnaire.

Online Questionnaire

Sociodemographic Characteristics

Participants were asked to complete a questionnaire on their sociodemographic characteristics, including age, sex, academic background, marital status (married or unmarried), history of psychiatric disorders (yes or no), employment type (full-time or part-time), managerial position (yes or no), and years of service.

Therapy Quality

Participants were asked to assess their own therapy quality and colleagues' therapy quality (increased, decreased, or unchanged) compared to the period before COVID-19.

Effects of the Pandemic on Work Life

Participants were required to answer items concerning their work situation, which included the acceptance of patients with COVID-19 at their workplace ("yes" or "no"); provision of information on COVID-19 by the workplace (7-point rating scale ranging from "1 = insufficient" to "7 = sufficient"); changes to working hours, workload, and homework compared to the period before COVID-19 ("increased," "decreased," or "unchanged"); and a free description item (fill-in-the-blank question).

Effects of the Pandemic on Daily Life

Participants were required to respond to the following items concerning daily life: efforts to avoid being infected (7-point rating scale ranging from "1 = never" to "7 = frequent"), efforts to not transmit the virus to others (same 7-point scale), frequency of contact with family (same 7-point scale), frequency of contact with friends (same 7-point scale), fewer outings ("yes" or "no"), attempts to avoid face-to-face conversations (yes or no), increased standard precautions at home (handwashing and gargling; yes or no), increased mask-wearing frequency (yes or no), increased social network sites usage (yes or no), and free description (fill-in-the-blank question).

Psychological Measurement

Based on our previous study (6), we focused on differences in field-specific impacts on the psychological aspects of anxiety, depression, insomnia, and loneliness. To assess each psychological aspect, we used four validated questionnaires: the Zung Self-Rating Anxiety Scale (SAS) (28), Zung Self-Rating Depression Scale (SDS) (29), Japanese version of the Insomnia Severity Index (ISI–J) (30, 31) and Japanese version of the three-item loneliness scale (TILS) (32).

In this study, the cutoffs for detecting the presence of anxiety, depression, insomnia, and loneliness were set to 40 for the SAS (33), 50 for the SDS (34), 10 for the ISI–J (30, 31) and 6 for the TILS (32).

Data Recruitment Process

To determine the eligibility of the data, exclusion criteria were set as follows: (1) history of psychiatric disorders; (2) inconsistent responses between "yes" or "no" questions and rating (e.g., "yes" to the change in outing frequency but rated the frequency as "unchanged"); (3) declaration that they do not regularly see clients; and (4) inconsistent answers on items about working hours. Finally, the sample data that fulfilled the following inclusion criteria were recruited for data analysis in this study: (1) OTs who work in the field of physical or mental health in medical facilities and (2) OTs who work full-time.

Statistical Analysis

Analyses were conducted to characterize the differences between work life, daily life, and psychological impacts of the COVID-19 pandemic on OTs who work in the physical and mental health fields in medical facilities. Fisher's exact test and two-sample *t*-tests were performed on all items of the online questionnaire and psychological measurements in the fields of physical and mental health. If statistical significance was observed in Fisher's exact test for a questionnaire item with more than three selections, a *post hoc* residual analysis was applied to identify which selection contributed the most to the statistical significance.

In addition, a multinomial logistic regression model for each field was created with psychological measurement (anxiety, depression, insomnia, and loneliness) as independent variables to detect potential factors and subjective quality in one's own and colleagues' therapy services (increased, decreased, and unchanged as a reference variable) as dependent variables, and this model enabled us to test the impact of mental health on the quality of work. In the multinomial logistic regression model, sociodemographic data in each field were transformed into a generalized propensity score, which was used to adjust for potential confounding bias. Variance inflation factor (VIF) was used to check for multicollinearity. All independent variables were allowed places in a multinomial logistic regression model if their VIF values were less than five (35).

The formula is:

$$\text{Subjective therapy quality in one's own/colleagues' (increased, decreased, and unchanged)} \sim \text{SAS score} + \text{SDS score} + \text{ISI-J score} + \text{TILS score} + \text{generalized propensity score}.$$

Moreover, generalized linear models (GLMs) were created with the variables that showed statistically significant differences by the field comparison (mental and physical health) in work/daily life as the independent variables and the four psychological measurement scores (SAS, SDS, ISI-J, and TILS scores) as the dependent variables; this model enabled us to detect relationships between psychological impact and changes in work/daily life. The sociodemographic data in the two fields were transformed into a generalized propensity score, which was used to adjust for potential confounding bias in these models; VIF value ≤ 5 was also applied to avoid multicollinearity.

The formula is:

$$\text{Each psychological measurement score (SAS, SDS, ISI-J, or TILS scores)} \sim \text{work/daily life items differed between mental and physical health fields} + \text{generalized propensity score}.$$

The results were presented as odds ratios (ORs) or regression coefficients (RC) with 95% confidence intervals (CIs), and the

level of statistical significance was set at $p < 0.05$ (two-tailed). All statistical analyses were performed using SPSS (version 25.0; IBM Corp., Armonk, NY, USA).

RESULTS

Sample Characteristics and Questionnaire Results

Sample Characteristics and Daily Life

The total number of initial respondents was 4,418. To determine data eligibility, the following procedure was used to select the respondents in line with these criteria (**Figure 1**). First, data from respondents with a history of psychiatric disorders (n = 330), inconsistent answers between "yes" or "no" questions and rating (e.g., "yes" to the change in outing frequency but rated the frequency as "unchanged") (n = 1,236), declaration that they do not constantly see clients (n = 428), inconsistent answers to items about working hours (n = 299), and inconsistent answers to therapy quality of self and others (n = 159) were excluded (see **Figure 1**). The number of remaining respondents was 1,966. Of these respondents, 1,383 of whom worked full-time and in the fields of physical or mental health in medical facilities were identified and classified into two groups: OTs in the physical health field (n = 1,131) and OTs in the mental health field (n = 252).

Table 1 shows the characteristics and questionnaire results of all participants and those in each of the two health fields. In the sociodemographic data, OTs in the physical health field showed lower values in mean age and service years than OTs in the mental health field [mean age (SD): 35.1 (8.6) years vs. 39.1 (8.3) years, $t = -6.59$, $p < 0.001$; mean service years 11.5 (7.9) year vs. 14.8 (7.7) year, $t = -6.08$, $p < 0.001$]. In addition, a significant difference was observed regarding managerial position, indicating a lower rate of managerial position of OTs in the physical health field compared to those in the mental health field [Fisher's exact test: 351 (31.0%) vs. 106 (42.1%), $p = 0.001$, see **Table 1**].

No significant differences were observed between the two groups for any of the items about their daily lives.

Therapy Quality, Psychological Measurements, and Work Life

Table 2 shows the questionnaire results of therapy quality, psychological measurements, and work life in OTs who work in the two health fields. Regarding therapy quality, significantly higher ratios of decrease were shown in changes in one's own and colleagues' therapy quality in the mental health field than in the physical health field [*post hoc* residual analysis: 239 (21.1%) vs. 98 (38.9%), $p < 0.001$, and 231 (20.1%) and 94 (37.3%), $p < 0.001$, respectively].

In work life, a lower acceptance ratio was found in the mental health field than in the physical health field [Fisher's exact test: 451 (39.9%) vs. 50 (19.8%), p <0 0.001]. Additionally, a higher rate of increase and a lower rate of unchanged workload, and a lower ratio of decrease and a higher ratio of unchanged working hours were observed in the mental health field than in the physical health field [*post hoc* residual analysis: increased workload, 517 (45.7%) vs. 143 (56.7%), corrected $p = 0.005$; unchanged workload, 218 (19.3%) vs. 44 (17.5%), corrected $p = 0.015$]; decreased working hours, 121 (10.7%) vs. 12 (4.8%), corrected $p = 0.012$; unchanged working hours, 908 (80.3%) vs. 221 (87.7%), corrected $p = 0.017$.

In psychological measurements, no significant differences between these two fields were observed for any of the items.

Psychological Factors Impacting Therapy Quality in Each Field

Multinomial logistic regression analyses were performed to examine the psychological impact on changes in therapy quality (own and colleagues) in each field. In these analyses, all the values of VIF are less than five, showing that there is no multicollinearity among the four independent variables (SAS, SDS, ISI-J and TILS; all, VIF $\leq$ 2.561).

Table 3 shows the results of the multinomial logistic regression analysis for each field. Decrease and increase in therapy quality were significantly associated with SDS (decrease: OR = 1.03, 95% CI [1.00–1.06], $p = 0.033$; increase: OR = 0.96, 95% CI [0.92, 1.00], $p = 0.043$, respectively), and a decrease in colleagues' therapy quality was significantly associated with SDS (decrease: OR = 1.05, 95% CI [1.02–1.08], $p < 0.001$) in the physical health field. In the mental health field, only a decrease in colleagues' therapy quality was significantly associated with the ISI-J (OR = 1.22, 95% CI [1.04–1.44], $p = 0.015$). No significant differences were observed in any of the other psychological measurements that contributed to therapy quality in each field.

Influence of Work Life Problems on Psychological Measurements

GLM analyses were performed separately to examine the effects of changes in workload and working hours on psychological measurements (see **Table 4**). In these analyses, the values of VIF are less than five, showing that there is no multicollinearity between the two independent variables (workload and working hours; all, VIF $\leq$ 1.120). Increased workload was positively associated with anxiety (RC = 0.802, 95% CI [0.277–1.326], $p = 0.003$), depression (RC = 1.840, 95% CI [0.964–2.716], $p < 0.001$), and insomnia (RC = 2.330, 95% CI [1.180–3.481], $p < 0.001$) in OTs in the physical health field, and positively associated with insomnia (RC = 2.453, 95% CI [0.149–4.758], $p = 0.037$) in OTs in the mental health field. Moreover, increased working hours were commonly associated with anxiety in both fields (physical health: RC = 1.566, 95% CI [0.743–2.389], $p < 0.001$; mental health: RC = 3.184, 95% CI [1.342–5.026], $p < 0.001$, respectively).

DISCUSSION

To our knowledge, this is the first study to investigate the differences in work life problems between the physical and mental health fields in occupational therapy with a large sample size, and their psychological risk factors as affected by the COVID-19 outbreaks. Overall, 14.6, 17.5, 14.6, and 24.6% of the Japanese OTs involved in this study presented

TABLE 2 | Questionnaire results of therapy quality, psychological measurements, and work life.

Characteristics	No./Total no. (%)			*p*
	Total sample (*n* = 1,383)	OTs in the physical health field (*n* = 1,131)	OTs in the mental health field (*n* = 252)	
Therapy quality				
Changes in own therapy quality compared with early 2019 (before COVID-19)				<0.001†
Increased	91 (6.6)	75 (6.6)	16 (6.3)	1.000‡
Decreased	337 (24.4)	239 (21.1)	98 (38.9)	<0.001‡
Unchanged	955 (69.0)	817 (72.3)	138 (54.8)	<0.001‡
Changes in colleagues' therapy quality compared with early 2019 (before COVID-19)				<0.001†
Increased	81 (5.9)	65 (5.8)	16 (6.4)	1.000‡
Decreased	325 (23.5)	231 (20.4)	94 (37.3)	<0.001‡
Unchanged	977 (70.6)	835 (73.8)	142 (56.3)	<0.001‡
Psychologic measurements				
Presence of anxiety, depression, insomnia, and loneliness (cutoff score)				
SAS (≥ 40)	202 (14.6)	173 (15.3)	29 (11.5)	0.139†
SDS (≥ 50)	242 (17.5)	206 (18.2)	36 (14.3)	0.143†
ISI-J (≥ 10)	203 (14.6)	168 (14.9)	35 (13.9)	0.768†
TILS (≥ 6)	340 (24.6)	275 (24.3)	65 (25.8)	0.628†
Raw score on each questionnaire				
SAS	33.6 (6.5)	33.7 (6.6)	32.9 (6.2)	0.067*
SDS	40.6 (8.8)	40 0.7(8.9)	39.9 (8.0)	0.184*
ISI-J	5.3 (4.0)	5.4 (3.9)	5.2 (4.0)	0.652*
TILS	4.3 (1.5)	4.3 (1.5)	4.3 (4.5)	0.560*
Work life				
Accepting patients with COVID-19				<0.001†
Yes	501 (36.2)	451 (39.9)	50 (19.8)	
No	882 (63.8)	680 (60.1)	202 (80.2)	
Provision of information on COVID-19 by workplace (1 = *never,* 7 = *sufficient*)				0.257†
5–7 (above average level)	1,028 (74.3)	846 (74.8)	182 (72.2)	
1–3 (below average level)	132 (9.6)	101 (8.9)	31 (12.3)	
4	223 (16.1)	184 (16.3)	39 (15.5)	
Changes in workload compared with early 2019 (before COVID-19)				<0.001†
Increased	660 (47.7)	517 (45.7)	143 (56.7)	0.005‡
Decreased	262 (19.0)	218 (19.3)	44 (17.5)	1.000‡
Unchanged	461 (33.3)	396 (35.0)	65 (25.8)	0.015‡
Changes in working hours compared with early 2019 (before COVID-19)				<0.001†
Increased	121 (8.8)	102 (9.0)	19 (7.5)	1.000‡
Decreased	133 (9.6)	121 (10.7)	12 (4.8)	0.012‡
Unchanged	1,129 (81.6)	908 (80.3)	221 (87.7)	0.017‡
Change in homework compared with early 2019				0.491†
Increased	9 (0.7)	7 (0.6)	2 (0.8)	
Decreased	79 (5.7)	59 (5.2)	20 (7.9)	
Unchanged	1,295 (93.6)	1,065 (94.2)	230 (91.3)	
Free description about changes in work style (fill-in-the-blank question)				0.919†
Yes	233 (16.9)	190 (16.8)	43 (17.1)	
No	1,150 (83.1)	941 (83.2)	209 (82.9)	

*SAS, Zung Self-Rating Anxiety Scale; SDS, Zung Self-Rating Depression Scale; ISI-J, Japanese version of the Insomnia Severity Index; LS, TILS, Japanese version of the three-item loneliness scale. * Two-sample t-test; † Fisher's exact test; ‡ Post hoc residual analysis (corrected p-value).*

TABLE 3 | Multinominal logistic regression results predicting psychological impacts on quality of treatment among occupational therapists.

	Decrease					Increase				
			95% CI					95% CI		
Variables		**Odds ratio**	**Lower**	**Upper**	**p**		**Odds ratio**	**Lower**	**Upper**	**p**
Physical health field (*n* = 1,131)										
Therapy quality (self)	***n* = 239**					**n = 75**				
Psychological measurement	(Ref. *n* = 817)									
SAS		1.004	0.971	1.039	0.815		1.011	0.956	1.07	0.703
SDS		**1.030**	**1.002**	**1.058**	**0.033**		**0.956**	**0.916**	**0.999**	**0.043**
ISI		1.029	0.958	1.074	0.197		1.081	0.998	1.161	0.056
TILS		1.034	0.93	1.149	0.541		0.904	0.741	1.105	0.325
Therapy quality (colleague)	***n* = 231**					***n* = 65**				
Psychological measurement	(Ref. *n* = 835)									
SAS		0.971	0.938	1.006	0.105		0.993	0.935	1.054	0.806
SDS		**1.049**	**1.020**	**1.079**	**<0.001**		0.984	0.940	1.03	0.491
ISI		1.027	0.983	1.073	0.235		1.018	0.941	1.101	0.657
TILS		1.026	0.921	1.143	0.807		1.025	0.843	1.245	0.807
Mental health field (n = 252)										
Therapy quality (self)	***n* = 98**					**n = 16**				
Psychological measurement	(Ref. *n* = 138)									
SAS		0.902	0.783	1.038	0.815		1.005	0.946	1.068	0.867
SDS		0.983	0.886	1.089	0.149		0.999	0.952	1.048	0.953
ISI		**1.222**	**1.039**	**1.437**	**0.015**		1.024	0.944	1.111	0.571
TILS		0.797	0.476	1.337	0.390		1.119	0.910	1.376	0.285
Therapy quality (colleague)	***n* = 94**					***n* = 16**				
Psychological measurement	(Ref. *n* = 142)									
SAS		1.030	0.969	1.095	0.343		0.985	0.863	1.126	0.829
SDS		0.994	0.947	1.043	0.801		0.940	0.850	1.040	0.233
ISI		1.016	0.937	1.102	0.683		1.154	0.964	1.351	0.174
TILS		1.092	0.888	1.342	0.404		0.885	0.543	1.441	0.623

This model simultaneously entered psychological measurements as independent variables and standardized propensity scores as covariates. The reference variable as the dependent variable was "Unchanged". Bold values indicate statistical significance.

Ref., reference variable; SAS, Zung Self-Rating Anxiety Scale; SDS, Zung Self-Rating Depression Scale; ISI-J, Japanese version of the Insomnia Severity Index; TILS, Japanese version of the three-item loneliness scale; CI, Confidence Interval.

symptoms of anxiety, depression, insomnia, and loneliness, respectively (**Table 1**). An increase in negative psychological impacts was observed compared to the results of our previous survey conducted between May 28 to May 31, 2020 (6), especially with respect to anxiety and depression (11.3 and 10.6%, respectively, see **Table 2**). Additionally, in terms of work life, accepting patients with COVID-19 (36.2%) and increased workload (47.7%) and working hours demonstrated a substantial increase compared to our previous report (16.6, 28.5, and 3.4%, respectively). These results support the previous study that elevated psychological distress among healthcare workers was significantly greater during repeated outbreaks, and that longer exposure to psychological distress leads to poor functional outcomes at home and work, heightens the risk of mental health issues and its overt symptoms, and increases healthcare use (10). The results also suggest that OTs are continuously required to take prompt measures for mental health prevention and promotion at the workplace during repeated outbreaks of COVID-19, consistent with findings from a previous global survey by the WFOT (17).

Notably, the differences in work life between the two fields were mainly observed in therapy quality, increased workload, and work time. Despite a lower rate of accepting patients, a greater decrease in one's own and colleagues' therapy quality and increase in workload, and a lower rate of decrease in working hours were observed in the mental health field compared to the physical health field. One of the reasons for these results can be attributed to different work environments. In the mental health field, typical occupational therapy programs target the acquisition of psychosocial benefits through group-based interventions (20, 22). With repeated outbreaks of COVID-19 rendering group activities difficult, not only group therapy targeting multiple patients, but also recreational therapy formed by multidisciplinary cooperation has been severely limited. These factors may have obliged increased efforts among OTs to develop alternative interventions

TABLE 4 | Generalized linear model (GLM) for impact of workload and working hours on psychological measurements among occupational therapists.

	Physical health field ($n = 252$)						Mental health field ($n = 252$)					
				95% CI						95% CI		
Variables	***N***	**Coefficient**	**SE**	**Lower**	**Upper**	***p***	***N***	**Coefficient**	**SE**	**Lower**	**Upper**	***p***
Anxiety (SAS)												
Workload												
Increased	517	**0.802**	**0.268**	**0.277**	**1.326**	**0.003**	143	0.947	0.598	−0.225	2.119	0.113
Decreased	218	0.329	0.345	−0.347	1.004	0.341	44	−0.022	0.772	−1.536	1.492	0.977
Unchanged (Ref.)	396						65					
Working hours												
Increased	102	**1.566**	**0.420**	**0.743**	**2.389**	**<0.001**	19	**3.184**	**0.940**	**1.342**	**5.026**	**0.001**
Decreased	121	−0.169	0.396	−0.945	0.608	0.670	12	−0.627	1.172	−2.924	1.670	0.593
Unchanged (Ref.)	908						221					
Depression (SDS)												
Workload												
Increased	517	**1.840**	**0.447**	**0.964**	**2.716**	**<0.001**	143	1.062	0.912	−0.725	2.849	0.244
Decreased	218	0.996	0.577	−0.135	2.127	0.084	44	−1.241	1.203	−3.598	1.116	0.302
Unchanged (Ref.)	396						65					
Working hours												
Increased	102	0.791	0.701	−0.584	2.165	0.260	19	1.094	1.469	−1.785	3.972	0.457
Decreased	121	−0.561	0.663	−1.860	0.738	0.397	12	−2.421	1.840	−6.029	1.186	0.188
Unchanged (Ref.)	908						221					
Insomnia (LS)												
Workload												
Increased	517	**2.330**	**0.587**	**1.180**	**3.481**	**<0.001**	143	**2.453**	**1.176**	**0.149**	**4.758**	**0.037**
Decreased	218	0.839	0.757	−0.645	2.323	0.268	44	−0.229	1.545	−3.257	2.799	0.882
Unchanged (Ref.)	396						65					
Working hours												
Increased	102	0.516	0.922	−1.291	2.323	0.576	19	2.153	1.874	−1.519	5.825	0.251
Decreased	121	−0.150	0.869	−1.853	1.553	0.863	12	−1.564	2.352	−6.174	3.045	0.506
Unchanged (Ref.)	908						221					
Loneliness (TILS)												
Workload												
Increased	517	0.195	0.105	−0.011	0.401	0.064	143	0.167	0.221	−0.265	0.600	0.449
Decreased	218	0.153	0.136	−0.114	0.420	0.261	44	0.267	0.288	−0.297	0.831	0.353
Unchanged (Ref.)	396						65					
Working hours												
Increased	102	0.054	0.165	−0.270	0.378	0.743	19	0.208	0.348	−0.474	0.890	0.549
Decreased	121	0.232	0.156	−0.074	0.537	0.137	12	0.389	0.436	−0.465	1.243	0.372
Unchanged (Ref.)	908						221					

This model simultaneously entered workload and working hours as independent variables and standardized propensity scores as covariates. Bold values indicate statistical significance. SE, Standard error; Ref., Reference variable; SAS, Zung Self-Rating Anxiety Scale; SDS, Zung Self-Rating Depression Scale; ISI-J, Japanese version of the Insomnia Severity Index; TILS, Japanese version of the three-item loneliness scale; CI, Confidence Interval.

to promote continuity of service delivery for all users, in addition to basic infection prevention and control, resulting in decreased therapy quality and increased workload and work time. Another possible reason is the increased patient vulnerability to a higher risk of infection and mortality due to symptom characteristics of mental illness (e.g., cognitive impairment, limited awareness of risk, and inadequate/diminished efforts regarding personal protection among patients) (27, 36, 37). A previous study reported a seven-fold increase in infection risk of COVID-19 in patients with mental disorders than those without mental disorders (depression: adjusted odds ratio (AOR) controlling demographics, AOR = 10.43, 95% CI [10.10, 10.76]; schizophrenia: AOR = 9.89, 95% CI [8.68–11.26]); bipolar disorder: AOR = 7.69, 95% CI [7.05–8.40] (27). In addition, a previous study investigating the work environment of psychiatric healthcare workers reported a continuously worsening working environment and increased work-related stress during the COVID-19 pandemic in the psychiatric field (38). Another possible explanation is the long length of hospitalization of patients with mental disorders, which

is unique to Japan. Psychiatric care in Japan lags behind other countries in terms of deinstitutionalization (39, 40), and a lag of ∼266 days was reported in 2018 (41), which is conspicuously longer than that in other Organization for Economic Co-operation and Development (OECD) countries. Nevertheless, no significant difference was observed in any of the psychological measurements (presence rate of symptoms and raw scores).

Additionally, psychological factors in each field were extracted to investigate the impact of therapy quality using a multinomial logistic regression model. These results suggest that the different impacts of psychological conditions in the two domains did affect therapy quality; depression was the main cause of decreased therapy quality in the physical health field, and insomnia was the main cause of decreased therapy quality in the mental health field (**Table 3**). However, while the differences in therapy quality, workload, and working time between these two fields were expected to readily reveal more apparent psychological problems in the mental health field, these problems were not evident.

Furthermore, the GLM showed a relationship between mental health deterioration and work life, workload, and working hours (**Table 4**). As a result, increased workload was detected as an important factor in anxiety, depression, and insomnia, and increased working hours were detected in anxiety in the physical health field. In the mental health field, important factors identified were increased working hours for anxiety and increased workload in insomnia. Once again, the relationship between these variables in the mental health field was less pronounced than those in the physical health field.

The relationship between psychological measurements (including anxiety and depression) and workload was found to be significant only in the physical health field, perhaps because other factors might be influencing anxiety and depression in the mental health field. Another reason might be a specific form of social desirability bias. OTs in the mental health field routinely evaluate patients' mental health conditions using these psychological measurements. Therefore, it is possible that they may have estimated their own mental health assessment too high, to portray themselves as ideal therapists who care for patients with mental health problems (42). Another possibility is that they may have acquired effective preventive strategies such as self-care practices, mindsets and avoiding exposing themselves to negative information (9), to mitigate the deterioration of their mental states owing to their high expertise and skills exercised throughout their working lives. Future studies should clarify the coping skills of therapists in the mental health field.

Another possible factor that may cause the difference between the physical interpretation of these findings is that negative mental health conditions of OTs in the mental health field, which are not currently apparent, may gradually or rapidly deteriorate owing to the decreasing quality of treatment as well as increased workload and more working hours. This may be regarded as a finding that anticipates an OT crisis in the mental health and welfare field soon. If this is the case, it may be useful to examine the mental health condition of OTs in the mental health field, especially concerning depression symptoms, and to adapt the environmental setting; this would include facilitating increased staffing, reassignment, the effective use of telerehabilitation (enabling equal patient satisfaction and clinical improvement compared to conventional face-to-face rehabilitation programs) (43, 44), improvement of workplace infrastructure, the adoption of appropriate and shared anti-contagion measures (9). Reduced opportunities for resourcefulness have led to a burden on therapists, opportunities which could prevent the higher risk of anticipated depression symptoms.

This study has several limitations. First, it was conducted using a cross-sectional online questionnaire and focused only on OTs in the physical and mental health fields in Japan. As each of these two fields can have a different working style and healthcare systems can vary across nations, the generalization of the present findings should be carefully considered. Further studies should recruit OTs worldwide to determine whether these results are unique to OTs in Japan and examine whether the present results can be replicated among other second-line workers. Second, OTs in the mental health field could be affected by social desirability biases. In other words, they may overestimate their own mental health assessment. Adding welltrained interviewers and physiological indices that reflect psychological stress states which are less susceptible to these effects would give a clearer picture. Third, this study did not explore the details of each work life problem. Further research should focus on specific work life problems and collect detailed and specific information on aspects such as the type and degree of deterioration in therapy quality and increase in workload, to develop tailored preventive and intervention strategies for field-specific problems. Finally, it should be noted that the present study did not fully capture the influence of COVID-19 on OTs in the two fields examined. To address these issues, we believe that validation of free comments on individual mental health impacts and measures is needed, using the method of a recent study (14). Thus, we recommend that as much support as possible be rapidly afforded to the two groups of OTs.

In conclusion, this study demonstrated the differences in COVID-19 impacts between OTs in the physical and mental health fields, focusing on quality of treatment, psychological condition, and work life. Moreover, the relationships between psychological factors and treatment quality varied across fields. These results reveal the psychological impact of changes in work life due to COVID-19 differed by specialty, even among the same healthcare professionals; *depression* was the main cause of decreased therapy quality in the physical health field, and *insomnia* was the main cause of decreased therapy quality in the mental health field. Thus, we need to investigate the field-specific negative impacts of COVID-19 on OTs as an important step towards devising tailored and effective prevention and intervention strategies. Finally, we believe that the present study makes a significant contribution to the emerging literature on mental health management in the COVID-19 pandemic.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethics Committee of Saitama Prefectural University. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

DS, AI, HY, HN, and TI: study conception, design, and data acquisition. DS, AI, and TI: analysis, interpretation of data, and writing—review & editing. DS: writing—original draft. All authors approved final version of the article.

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Modeling the Behavioral Response of Dentists to COVID-19 and Assessing the Perceived Impacts of Pandemic on Operative Dentistry Practices in Pakistan

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COVID-19 pandemic has affected dentistry in unprecedented ways. This study investigates the perceived effects of the pandemic on operative dentistry procedures and dentistry profession in Pakistan and the factors that determine the behavioral changes among dentists to adapt to the "new normal." A Capability Opportunity Motivation-Behavioral model (COM-B) was utilized to investigate the factors that determine the behavior of dentists in Punjab, Pakistan to adhere to COVID-19 standard operating procedures (SOPs). Using social media, an online questionnaire was sent to operative dentistry professionals in Pakistan, and 312 responses were received. 81.4% of the respondents believed that the COVID-19 pandemic has severely affected the level of care provided to the patients, 66% were extremely worried about the risk of contagion during clinical practices, and more than 75% of the respondents opined that the pandemic has led to an increased emphasis on disinfection and oral hygiene instructions. The multiple regression model suggests that the behavior of Pakistani dentists to adhere to the COVID-19 SOPs is significantly affected by their Capabilities ($\beta = 0.358$) and Opportunities ($\beta = 0.494$). The study concluded that dentists in Punjab, Pakistan are concerned about the risk of contagion and report a serious concern about consequences such as financial loss and inappropriate care of patients. The current study results can feed the policymaking in Pakistan and other developing countries. Facilities and training to improve dentists' opportunities and capabilities can improve their ability to cope with the COVID-19 challenges.

Keywords: COVID-19, COM-B model, dentistry, operative dentistry, Pakistan

INTRODUCTION

Worldwide, healthcare professionals are on the first lines in fighting the COVID-19 pandemic. They have become highly vulnerable to COVID-19 transmission, constituting 9% of all the infected cases (1, 2). Dental practitioners are among high-risk healthcare professionals because of direct exposure to blood and saliva (3). The Occupational Safety and Health Administration (OSHA) devised an occupational risk pyramid which

shows the vulnerability of healthcare professionals based on their exposure to COVID-19 virus (https://www.osha.gov/Publications/OSHA3990.pdf; United States, Department of Labor). According to the OSHA (Department of Labor, USA), dentists are at "very high risk." Earlier studies confirmed that aerosol transmission and respiratory droplets are potential pathways of COVID-19 transmission (4).

Dental professionals are especially vulnerable when carrying out aerosol-generating procedures (AGPs) on infectious patients (5). Evidence suggests that while a dentist is treating a patient on a dental chair, the highest levels of aerosol contaminants are within 50–60 cm of the face of the patient. Furthermore, aerosols are highest on face masks of patients, and around their nose and eyes (6). The aerosol contaminants generated by ultrasonic devices can remain in the air for half an hour after the procedure (7). Thus, dentists are highly vulnerable to infection because of close proximity to the patient, contact with patients' blood and saliva as well as due to the use of instruments that generate aerosols (8, 9).

Evidence suggests that returning to work after the COVID-19 outbreak requires dentists and healthcare professionals to adopt a behavioral change to adhere to COVID-19 SOPs during clinical practices (5). The main SOPs include the use of personal protective equipment (PPE) in line with government advice, use of robust infection prevention and control procedures and use of high-power rubber suction and rubber dam where an aerosol generating procedure is necessary (5, 8, 9). This is especially true for operative dentistry professionals since several operative dentistry procedures involve AGPs, which makes dentists critically exposed to infection risk (5, 10, 11). Furthermore, COVID-19 also led to increased anxiety and practice modification as well as had economic consequences for dentists (12). Thus, it is critical to identify and understand the factors driving behavioral change in operative dentistry professionals.

Capability Opportunity Motivation-Behavior model (COM-B) has been used to study and understand the behavioral change in dentistry (5). The COM-B consists of three components that drive behavioral change: Capability, Opportunity, and Motivation (13, 14). In the proposed COM-B model, Capability is defined as the internal factors that enable an individual to engage in a given behavior. Opportunity is defined as the external variables or factors that allow an individual to engage in a given behavior. Motivation consists of a "conscious motivation" (intentional plans to engage in a given behavior) and "automatic motivation" (defined as an individual's habitual or instinctive response) (13). In another study (4), COM-B is utilized as a framework to understand the factors underpinning behavioral change for intervention.

Due to a high exposure to infection, wearing of PPE was made mandatory for healthcare professionals all around the world. PPE includes protective eyewear, N-95 mask, full-length gowns covering body from head to toe, air-purifying respirators, and surgical gloves. Compared to the countries such as New Zealand (15), Canada (9), and Saudi Arabia (16), dentists in developing countries have shown far less knowledge and compliance to the COVID-19 infection control SOP's (10). Although there is evidence of positive attitude toward the use of PPE by dentists in some developing countries including Iraq (6), in most developing countries, attitude toward the use of PPE during COVID-19 outbreak has not been encouraging.

In developing countries including Pakistan, the usage of PPE and adherence to the COVID-19 infection control SOP's is still quite challenging (17). Limited evidence is available which suggests that one of the key factors influencing the attitude of dentists toward the use of PPE are financial constraints and poor knowledge about the use of PPE among dentists in Pakistan (17). Studies in dental hospital in Rawalpindi and Karachi suggest that as low as 20 percent of the dental students complied to COVID-19 SOPs (18). This is an alarming situation for a country like Pakistan as dentists' lack of compliance of COVID-19 SOPs could lead to increased burden on scarce resources of the country. Therefore, it is vital to investigate how the COVID-19 pandemic has affected the dentistry profession in Pakistan and what factors underpin the behavioral change in the dentists of Pakistan.

This study aims to understand the perceived impacts of the COVID-19 pandemic on the dental profession in the Punjab province of Pakistan and understand the factors that underpin the behavioral change in the dentists to adapt to the COVID-19 SOPs. Punjab is the most populous province of Pakistan, containing more than 110 million people. Also, Punjab is the most affected province of the country by COVID-19 pandemic. So far, 506,018 confirmed cases of COVID-19 have been reported in Punjab. Of these confirmed cases, 13,560 patients died (https://covid.gov.pk/stats/punjab). Dentists working in all departments are vulnerable to COVID-19 exposure. Current study focuses on dentists who specialize and work in operative dentistry departments. This study specifically concentrated on this group of dentists as these dentists are among the most affected professionals by the challenges and risks associated with treatments frequently requiring AGPs. Although this study could have involved other professionals such as periodontists and oral hygienists, limiting this study to operative dentists allowed a more comprehensive and in-depth survey of the perception of a specific department of dentistry.

The specific objectives of this study are (a) to identify the perceived effects of COVID-19 on dentistry practices in Pakistan, (b) to identify the perceived impacts of COVID-19 on operative dentistry procedures in Pakistan, and (c) to identify the drivers of behavioral change of adherence of COVID-19 SOPs among dentists of Pakistan using COM-B model.

METHODOLOGY

A survey-based cross-sectional study was conducted to collect data for this project. A structured questionnaire was prepared through review of literature and consultation with expert biostatisticians, operative dentists, and psychologists. The questionnaire was approved by the Institutional Research Board (IRB) of Bakhtawar Amin Dental College & Hospital Multan, Pakistan (reference BADC&H No. 300/21). The questionnaire was pre-tested once with a pilot survey of 25 respondents. The demographic profile of these 25 respondents was fairly similar to the profile of the respondents in the actual survey (i.e., of

the 25 respondents, 18 were female and six were male. Eighteen respondents aged between 20 and 30 years, five respondents 30–40 years old and two respondents were above 60 years age. In terms of type of workplace, 19 respondents worked in Government hospitals, three worked in private hospitals and three respondents worked in both Government and private hospitals). Informed consent of all respondents was obtained.

Sample Selection

According to Pakistan Medical Dental Council Islamabad, total number of registered dentists in Pakistan are approximately 25,000 (https://www.pbs.gov.pk/sites/default/files//tables/rename-as-per-table-type/Registered%20Dental%20Doctor.pdf). Of these, 9,000 dentists are registered in Punjab (https://tribune.com.pk/story/1975950/pakistan-facing-acute-shortage-doctors). The sample size for this survey was determined by the total number of dentists in Punjab province of Pakistan (i.e., 9,000), using the sample size calculation formula proposed by Yamane (19). The confidence interval was set to 6% and a 95% confidence level was used. With these parameters, the sample size derived was 260.

Questionnaire Development

An online questionnaire was created using Google Forms and cascaded to registered operative dentistry professionals in Punjab, Pakistan, through social media (WhatsApp groups of dentists). The survey started on May 20th, 2021. The online survey was kept open for 10 weeks. Four reminders were sent to the respondents, each after 2 weeks (through messages in the WhatsApp groups) to record their responses during this time.

The questionnaire for this study consisted of 32 questions which were divided into eight sections. A complete draft of the questionnaire is provided in the **Table 1**.

The first section recorded the demographic details of the respondents. The respondents were asked about their age, gender, location, years in dentistry professions, dental education/training, type of workplace and nature of their jobs.

The second section enquires about respondents' perceived impacts of COVID-19 pandemic on dentistry profession. All answers were recorded on a Likert scale of 1–5 where 1 = "Not at all" and 5 = "Extremely."

The purpose of the third section was to explore the perceived impacts of pandemic situation on various dental procedures. The respondents were asked to record their answers on Likert scale, ranging from 1 to 5 (Completely disagree to Completely agree).

In the fourth section, the questionnaire inquired the participants about the perceived impacts of COVID-19 on various procedures in operative dentistry. Operative dentistry procedures include aesthetic (e.g., tooth whitening, veneers, crowns etc.), endodontics (e.g., root canal treatment), implant, and restorative procedures (e.g., tooth restoration.). The respondents were asked to record their responses on a Likert scale. The sections 2–4 were used to assess the perceived effects of the pandemic on dentistry practice and operative dentistry procedures.

Sections 5 to 8 in the survey was used to assess the behavior of respondents to adhere to COVID-19 SOPs. COM-B model is utilized to predict the "behavior to adhere to COVID-19 SOPs" using opportunities, motivation, and capabilities as independent variables. Behavior was measured using three items: (i) On a scale of 1–10, how regularly do you wear PPE during your clinical practices? (ii) On a scale of 1–10, how often do you ensure that your patients follow SOPs during your clinical practices? (iii) On a scale of 1–10, how often do you follow infection control measures during clinical practice? Opportunities were measured using three items: (i) On a scale of 1–10, how confident you are that you have the required physical resources available to follow COVID-19 SOPs at your workplace? (ii) On a scale of 1–10, how confident you are that your colleagues support you to follow COVID-19 SOPs at your workplace? (iii) On a scale of 1–10, how confident you are that you have the required time available to follow COVID-19 SOPs at your clinic/hospital/workplace? Motivation was measured using three items: (i) I feel that it is my moral obligation to follow the COVID SOPs during practice. (ii) I follow COVID SOPs automatically/unconsciously without reminding myself (has become a habit for me) (iii) If I implement COVID-19 SOPs correctly and regularly, I will be a role model for my colleagues. All questions of COM-B constructs were recorded on a Likert scale (1–10).

Data Analysis

Descriptive statistics is used to report the frequency and percentages of the respondents in each category of the demographic variables. Stacked bar charts were used to report the proportions of the respondents who chose various levels of agreements to the questions asked in section 2–4.

In order to establish a relationship between COVID-19 SOPs adherence behavior and the opportunities, capabilities, and motivations of the respondents, a multiple linear regression analysis is utilized. The significance level was set at $p \leq 0.05$.

Before running the regression model, Cronbach's alpha test was used to test the internal consistency in each of the four constructs (Behavior, Opportunities, Motivation and Capabilities). All data analysis were carried out in SPSS v. 21 and R statistical software. The results were then collected and performed using Statistical Package 21 for the Social Sciences SPSS® (IBM®, SPSS® Statistics, Armonk, NY, USA).

RESULTS

Demographics

A total of 312 valid survey responses were received. There were no missing data on responses. Among the respondents, 74.36 % ($n = 232$) were female. Most of the respondents aged between 20 and 30 years ($n = 210$). The details of the demographics of the respondents are given in **Table 2**.

Perceived Impacts of COVID-19 Pandemic on Your Profession

The results suggest that a large proportion of the respondents (66%) were "Extremely" worried about the risk of contagion during their clinical practices

TABLE 1 | List of sections and questions included in the questionnaire for this study.

Section	Questions	
Demographic information	Age (Years)	20–30. 30–40. 40–60. Above 60
	Type of workplace	Government. Private. Work in both Government and Private workplaces simultaneously
	Gender	Male. Female
	Nature of Job	Clinical. Teaching. Both clinical and teaching.
	Clinical experience (years)	Less than 1. 1–3. 3–5. 5–10. 10–15. More than 15.
	Dental education	BDS (Or equivalent). Post-graduation (In progress). Post-graduation (Completed)
Impacts of COVID-19 pandemic on your profession	To what extent has COVID-19 pandemic affected the ability of dentists to provide appropriate levels of care to the patients?	
	To what extent do you think COVID-19 pandemic is likely to cause loss of clinical skills in dentists?	
	To what extent do you think COVID-19 pandemic has financially affected dentists?	
	To what extent COVID-19 pandemic causes risk of contagion in dentists due to unavailability of appropriate PPE?	
Impacts of COVID-19 pandemic on dental practices	COVID-19 pandemic has positively impacted dental practice because it has allowed better spaced appointments	
	COVID-19 pandemic has positively impacted dental practice because it has led to more emphasis on disinfection procedures	
	COVID-19 pandemic has positively impacted dental practice because it has led to more emphasis on Oral Health Instructions (OHI)	
	COVID-19 pandemic has negatively impacted dental practices by causing reduced number of patients	
	COVID-19 pandemic has negatively impacted dental practices by causing reduced number of follow-up visits	
Impacts of COVID-19 pandemic on procedures in operative dentistry	COVID-19 pandemic has affected restorative procedures	
	COVID-19 pandemic has affected endodontic procedures	
	COVID-19 pandemic has affected aesthetic procedures (veneers, bleaching, etc)	
	COVID-19 pandemic has affected implants procedures	
Opportunities to follow COVID-19 SOPs	On a scale of 1–10, how regularly do you wear PPE during your clinical practices?	
	On a scale of 1–10, how often do you ensure that your patients follow SOPs during your clinical practices?	
	On a scale of 1–10, how often do you follow infection control measures (high volume suction, rubber dam isolation, etc) during clinical practice?	
	On a scale of 1–10, how confident you are that you have the required physical resources available to follow COVID-19 SOPs at your workplace?	
	On a scale of 1–10, how confident you are that your colleagues support you to follow COVID-19 SOPs at your workplace?	
	On a scale of 1–10, how confident you are that you have the required time available to follow COVID-19 SOPs at your clinic/hospital/workplace?	
Motivation to follow COVID-19 SOPs	I feel that it is my moral obligation to follow the COVID SOPs during practice.	
	I follow COVID SOPs automatically/unconsciously without reminding myself (has become a habit for me)	
	If I implement COVID-19 SOPs correctly and regularly, I will be a role model for my colleagues	
Capability to follow COVID-19 SOPs	I have enough physical strength to follow COVID SOPs during clinical practice	
	I have sufficient knowledge/information about how to follow COVID SOPs during clinical practice	
	Even if I commit an error, I feel confident to implement COVID-19 SOPs correctly again	

(**Figure 1**). More than two-third of the respondents recorded their perceived level of impact as "Quite a lot" (59%) and "Extreme" (22.4%) when asked if the COVID-19 pandemic has affected the level of care provided to the patients.

Perceived Impacts of COVID-19 Pandemic on Dental Practices

The results suggest that more than two-third of the respondents were either "Completely Agree" or "Somewhat Agree" that the pandemic situation has reduced the number of patients and reduced the number of follow-up visits (**Figure 2**). Almost two-third of the respondents opined that the pandemic has led to an increased emphasis on the disinfection procedures and OHI in dental practices in Pakistan.

Perceived Impacts of COVID-19 Pandemic on Procedures in Operative Dentistry

More than 75% of the respondents agreed that the pandemic has affected the aesthetic, endodontics, implants and restorative dentistry procedures (**Figure 3**). The highest agreement was found in response to the question about aesthetic procedures followed by restorative dentistry procedures.

Regression Modeling (COM-B)

Internal Consistency and Computation of Variables

Cronbach's alpha is used to assess the internal consistency of the items in each construct (i.e., capability, opportunity, motivation, and behavior). Results suggested an acceptable degree of internal consistency for all four constructs: Capability (0.825), Opportunity (0.801), Motivation (0.707), and Behavior (0.695). Then, "Compute Variable" function in SPSS version

TABLE 2 | Demographic profile of the respondents ($n = 312$).

	Frequency (*n*)	Percentage (%)		Frequency (*n*)	Percentage (%)
Age (Years)			**Type of workplace**		
20–30	210	67.31	Govt.	148	47.43
30–40	70	22.44	Private	90	28.84
40–60	22	7.05	Both Govt. & Private	74	23.71
Above 60 years	10	3.21			
Gender			**Nature of job**		
Male	80	25.64	Clinical	252	80.76
Female	232	74.36	Teaching	12	3.20
			Both Clinical & Teaching	48	15.38
Clinical experience (years)			**Dental education/training**		
Less than a1	26	8.33	BDS (or equivalent)	138	44.23
1–3	106	33.97	Post-graduation (in-progress)	22	7.05
3–5	106	33.97	Post-graduation (completed)	152	48.71
5–10	54	17.31			
10–15	10	3.21			
More than 15	10	3.21			

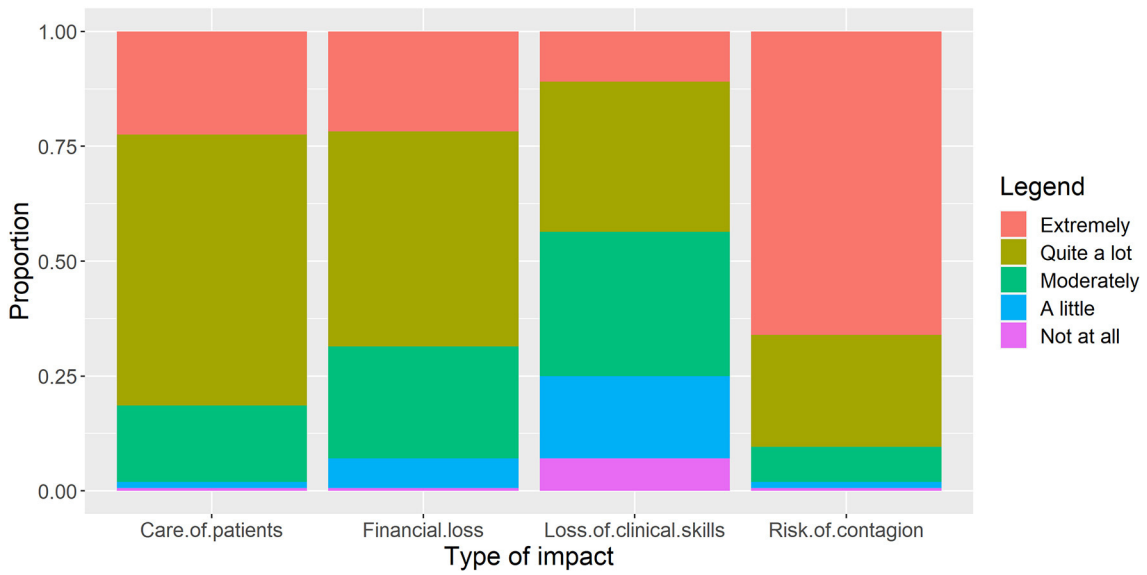

FIGURE 1 | Participant responses about "perceived impacts of COVID-19 on their profession" ($n = 312$). Proportions among respondents are reported.

21 (SPSS® (IBM®, SPSS® Statistics, Armonk, NY, USA) was used to compute four continuous variables from the items within each of the four constructs (i.e., the scores of all questions within a construct were averaged and the resulting score was used as a continuous variable). Thus, four continuous variables: Capability, Opportunity, Motivation, and Behavior were generated. **Figure 4** shows the response of participants.

Multiple Linear Regression Model

Table 3 shows that a significant regression equation was found ($F_{(3,303)} = 85.451$, $p < 0.0001$), with an adjusted R^2 of 0.453. The regression model shows that the dependent variable is significantly affected by the Opportunities and Capabilities of respondents. With increasing Opportunities, the respondents were significantly more likely to adhere to COVID-19 SOP's ($\beta = 0.494$). Similarly, with an increase in the Capabilities of the

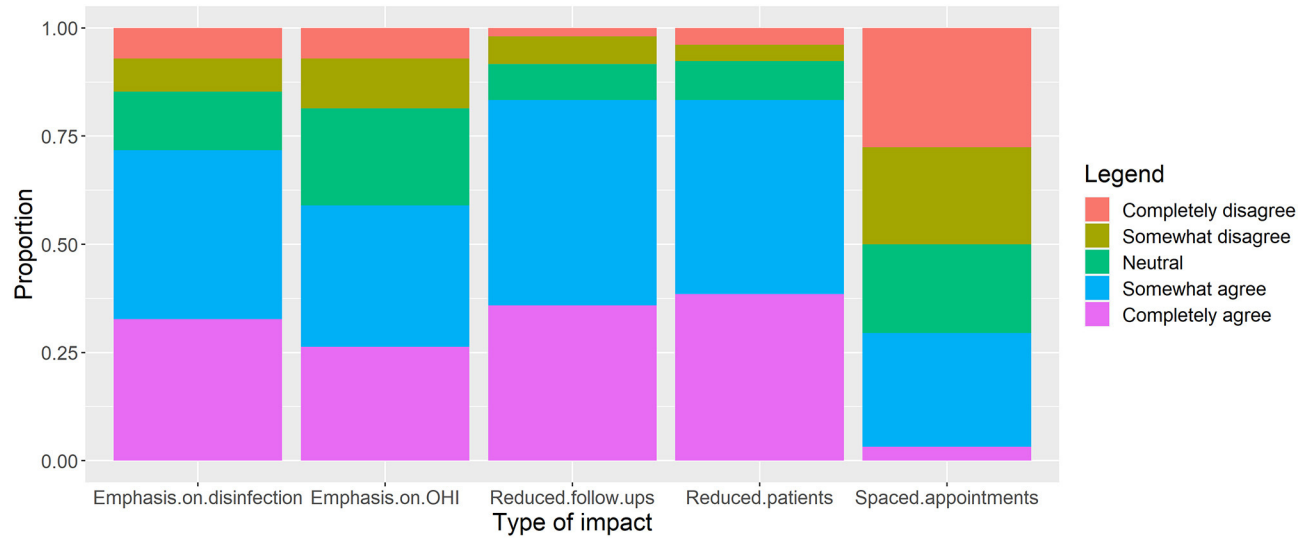

FIGURE 2 | Participant responses about "perceived impacts of COVID-19 on different practices in dentistry" ($n = 312$). Proportions among respondents are reported.

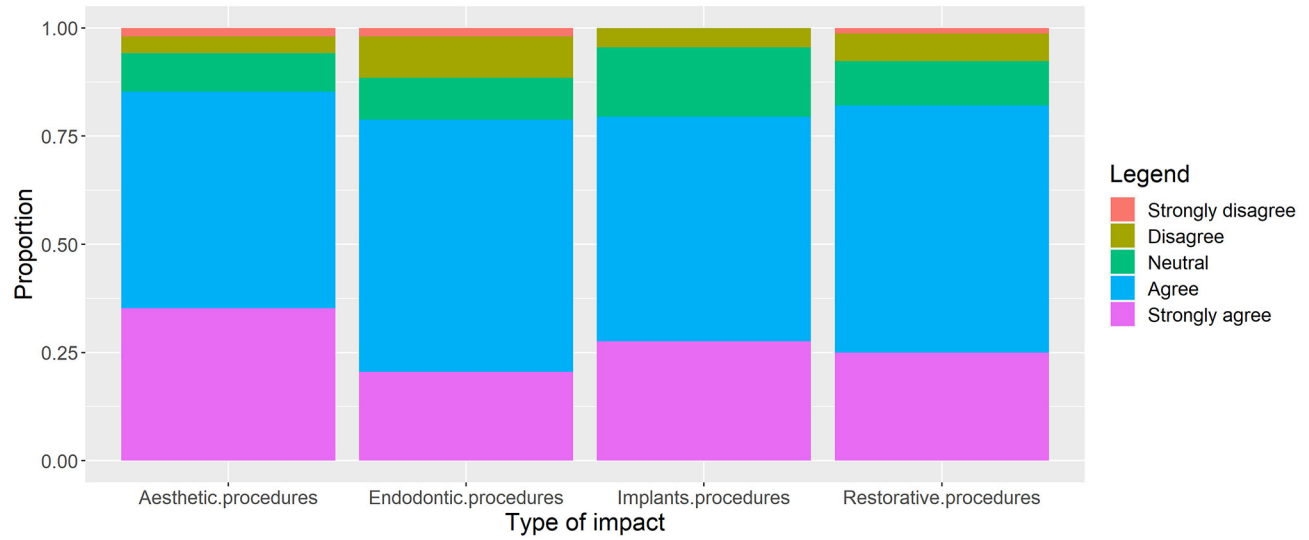

FIGURE 3 | Participant responses about "perceived impacts of COVID-19 on procedures in operative dentistry" ($n = 312$). Proportions among respondents are reported.

respondents, there was a significant increase in the Behavior to adhere to COVID-19 SOP's ($\beta = 0.358$).

DISCUSSION

Healthcare professionals around the world are the most vulnerable groups to COVID-19 exposure as they are most likely to be directly exposed to the infected patients. Healthcare professionals have reported mental stress and physical fatigue due to insufficient health care protection. This study was aimed to understand how the COVID-19 pandemic affected the dentistry professionals in Pakistan, taking a case study of Punjab province in the country. The study also aimed to understand the factors determining the dentists' behavior to adhere to the COVID-19 SOPs.

The results showed that the respondents are most concerned about the risk of contagion. This can be attributed to the fact that the contagious nature of COVID-19 has caused large-scale mortality among the healthcare professionals, especially in the developing countries of South Asia (20). A large number of operative dentistry procedures lead to generation of aerosols due to which dentists are at a high risk of infection (5, 9). Furthermore, scarcity of personal protective equipment also threatens safety of dentists, especially in the developing countries (21). Therefore, it is understandable why most of the respondents

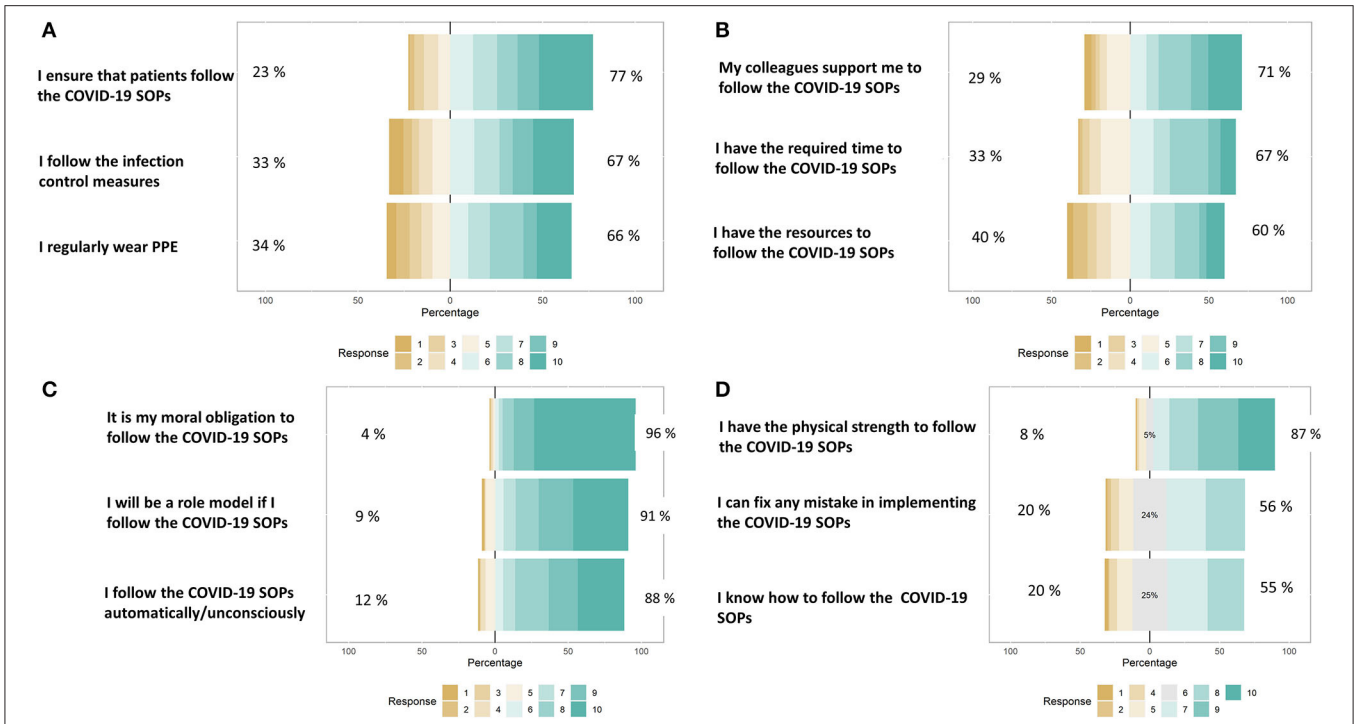

FIGURE 4 | Distribution of responses to the questions asked under the constructs: **(A)** Adherence to COVID-19 SOP's (Behavior), **(B)** Opportunities to follow COVID-19 SOP's, **(C)** Motivation to follow COVID-19 SOP's, and **(D)** Capabilities to follow COVID-19 SOP's. All responses were recorded on a Likert scale (0–10).

TABLE 3 | Multiple regression analysis results showing relationships between dependent variable (Behavior toward adherence to COVID-19 SOPs) and independent variables (Opportunities, Motivation and Capabilities to adhere to COVID-19 SOPs).

Model	Unstandardized coefficients		Standardized coefficients	*p*-Value
	B	Standard Error	*β*	
(Constant)	−0.977	0.674		0.148
Opportunities	0.516	0.047	0.494	0.000
Motivation	−0.091	0.087	−0.057	0.297
Capabilities	0.612	0.096	0.358	0.000

Constructs were created from questions in a survey administered to the dentists in Pakistan (n = 312).

in this survey showed highest concern about the risk of contagion.

After the risk of contagion, the respondents were most concerned about inappropriate levels of care provided to the patients. These results are in agreement with earlier reports where dentists in the UK reported a similar concern (5). This could be due to the fact that most of the operative dentistry treatments require a physical presence of the patients (22). However, due to the closure of clinics and dental hospitals, dentists were inaccessible for patients (23). Furthermore, most of the patients, especially those coming from remote rural areas do not have access to the internet for online appointments and follow-ups (24). Thus, it is expected that dentists would show concern about insufficient healthcare provision to their patients.

More than 60% of the respondents also showed high levels of concern about financial loss due to COVID-19 pandemic. The financial aspect of COVID-19 pandemic is not unheard of (25). Several studies have reported that the pandemic situations have caused financial insecurities among health professionals (26, 27). A study in the UK concluded that more than 75% of the dentists are worried about the financial losses caused by the pandemic (5). Similarly, in a large-scale survey of dentists in the Eastern Mediterranean, Europe, North America, and Western Pacific regions, 73.6% of the respondents strongly agreed that the pandemic situations has caused a substantial financial impact on their income (28). In Iraq, a study reported that 75% of dental practitioners believed their income had decreased by as much as 50% due to the pandemic situation (12). In case of developing countries like Pakistan where resources are limited, one could expect financial stress to be a major outcome of the pandemic.

About two-third of the respondents agreed that there has been an increased emphasis on the disinfection procedures and OHI. This could be attributed to the extraordinary awareness campaigns about disinfection procedures (29). Most people, including doctors and the patients, are extremely cautious about the risk of contagion and therefore an unusually high level of emphasis has been made on disinfection procedures in the dental hospitals (30–32). Similar results have been reported in several other studies. In Turkey, for example, dentists reported a significant decrease in the number of patient admitted to

dental hospitals (33). The researchers attributed this decrease in the number of patients to the measures taken by dentists and authorities against the COVID-19 pandemic in view of the growing number of cases (33).

In this study, the COM-B model was used to demonstrate how capabilities, opportunities and motivation of dentists predict their COVID-19 adherence behavior. Understanding human behavior in the era of pandemic is critical because behavioral adaptations play a key role in the spread and control of infection (34). Evidence suggests that behavioral science is pivotal to understanding the factors that encourage stakeholders to adopt behaviors that shape the progression of the outbreak (35). The British Psychological Society Behavioral Science and Disease Prevention Taskforce recommends understanding the behavioral adaptations regarding adherence to COVID-19 SOPs through COM-B model of behavior change. Application of the COM-B model to COVID-19 transmission-related behavior will provide a "behavioral diagnosis" that can help us identify the factors most likely to influence the behavior of individuals (13) and, thus, identify appropriate targets for behavior change interventions. The identified behavioral change interventions can then be designed and implemented to improve adherence to preventive behaviors during the period of social isolation.

The results of the regression model showed that the behavior is significantly affected by capabilities and opportunities. Various studies on this subject have reported contrasting results. For example, a study in the UK reported that motivation is the strongest predictor of an individual's behavior to adhere to COVID-19 SOPs (34). In this study, however, motivation was not a significant determinant of behavior. Instead, opportunities and capabilities were the strongest predictors in the regression model. This can be attributed to the fact that in countries with scarce resources, opportunities and capabilities of individuals are often more important than their motivation. Due to lack of resources and feasible environment, people fail to adopt or avoid a behavior despite motivation. The COM-B model gives a theoretical insight of the drivers of COVID-19 SOPs adherence behavior. In the recent past, COM-B model has been extensively used by researchers to model behavior to adhere to different COVID-19 SOPs (5, 34, 36).

This study makes an argument that the policymakers must emphasize more on improving the facilities, infrastructures, and resources for dentists to adopt COVID-19 SOPs. This is because the regression model in the study highlighted the fact that even though the respondents reported high levels of motivation, their behavior was not significantly affected by their motivation. Instead, better capabilities and opportunities lead to a more promising behavior change. Therefore, the scarce financial resources must be spent on providing PPE and other essential equipment and trainings to enable dentists to counter a pandemic situation.

Limitations of the Study

The study was conducted in the Punjab province of Pakistan. Therefore, the results of this study should not be generalized to other provinces of Pakistan, especially where socioeconomic profile of population is different and where severity of pandemic was different. Furthermore, most of the respondents in this study are under 40 years of age. Under ideal circumstances, a more representative sample of Pakistani dentists in terms of age and years of work experience would have been desirable. However, this study was conducted during periods of lock-down where meeting dentists in-person was not possible. The questionnaires were disseminated through WhatsApp groups and response was completely voluntary. However, the authors believe it did not affect the outcomes as this study did not include any hypothesis regarding the age, gender, or work experience of the dentists. Moreover, most of the dentists above 50 years of age did not attend clinics and hospitals because of being most vulnerable to COVID. Therefore, it is understandable that only younger dentists responded to this questionnaire as they were the ones who practiced dentistry during epidemic and were able to respond to the questions about the impacts of COVID-19 on dentistry profession in Pakistan.

CONCLUSION

This study concludes that COVID-19 pandemic has caused considerable worry to operative dentistry professionals in Pakistan. Dentists in the Punjab province of Pakistan reported financial loss, increased focus on disinfections procedures as major outcomes of the pandemic. The study further concludes that there is a need to spend more resources on providing opportunities and improving capabilities of dentists to allow them to successfully follow the COVID-19 guidelines during their clinical practices.

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 questionnaire was approved by the Institutional Research Board (IRB) of Bakhtawar Amin Dental College & Hospital Multan, Pakistan (reference BADC&H No. 300/21). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

SM: writing original draft, research, and analysis. A-HA: analysis, editing, review, and supervision. Both authors contributed to the article and approved the submitted version.

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The Perceived Impact of COVID-19 on Functional Activities Among Canadian Education Workers: A Cross-Sectional Study

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Objective: This cross-sectional study examined the self-perceived impact of the COVID-19 pandemic on 2,378 education workers in Ontario, Canada, during the second wave.

Methods: We examined six domains of functioning as per the short version of the World Health Organization Disability Assessment Schedule-2.0. Participants selected if their functioning had improved, remained unchanged or worsened during the pandemic for each item.

Results: Educational workers described a general worsening of functional activities since the beginning of the pandemic. Moderate-to-extreme challenges were reported for all six functional domains. These challenges appeared to aggravate functional challenges for workers with disability, as indicated by pre-existing work accommodations. Older participants reported worse mobility than younger participants; however, they appeared to have better coping skills in learning new tasks and maintaining friendships. Women were more likely to report difficulties in maintaining household responsibilities.

Conclusions: We consider the role of mental health challenges and pre-existing inequality as predictors of pandemic-related difficulties. Recommendations include more longitudinal research in this population and policymakers to incorporate a health promotion lens to support their education workers more proactively.

Keywords: COVID-19, functional activities, perceived impact, education workers, cross-sectional

INTRODUCTION

Education workers, including teachers, educational assistants, and other support staff, have highly demanding jobs characterized by long working hours, heavy workloads, and emotional demands (1). These working conditions take a toll, and as a profession, teachers are known to have comparatively poor physical health and psychological wellbeing (2, 3). This matters in several

ways. The health challenges of education workers may be difficult to navigate in themselves, potentially leading to high levels of absenteeism (4) and leaving the profession. Employers may find it challenging to meet their responsibilities for workplace health when the general level of distress is high. Finally, educational workers are central in the care of children. The difficulties faced by education workers may, in turn pose greater challenges to meet their needs.

The Impact of COVID-19

The COVID-19 pandemic had a significant impact on people worldwide (5). In most areas, significant public health measures were imposed to reduce the spread of the virus, such as closures of various businesses, including fitness centers and limits on the number of visitors in a household (6). These measures reduced the amount and quality of social interactions and added challenges in maintaining quality of life (7). The restrictions and their indirect consequences disrupted daily functions such as socialization, exercise, sleep, and healthy eating behaviors. In addition, recent studies have highlighted the pandemic's adverse impact on the general population's mental health, resulting in frustration, stress, and depression (5, 8). These undesirable outcomes may have been exacerbated in individuals with pre-existing disabilities due to reduced access to care, physical activities, and mood changes (9). These general results raise a concern about education workers since their background levels of stress and functional impairments may interact with the challenges generated by our response to COVID-19.

Canadian education workers may differ from those in other countries in several ways, for example, due to differences in their work environments and stability of employment. However, like those in other countries, Canadian education workers made rapid and significant changes in how they provided services. Moreover, given their pre-existing high prevalence of psychological distress and impaired functional activities the impact of COVID-19 is of particular concern.

To our knowledge, this is the first Canadian study that assessed the perceived impact of the pandemic and associated public health measures on the level of disability and functional challenges faced by education works in the province of Ontario, Canada.

MATERIALS AND METHODS

The study was approved by the University of Guelph's Research Ethics Board (REB# 20-06-002). This prospective cross-sectional study is a part of a larger undertaking that examined the impacts of the pandemic on Ontarian education workers. We used the STROBE checklist to ensure quality and accuracy when preparing this study (10). We examined the functional activities of education workers across Ontario, Canada, during the second pandemic wave, which began in in Ontario in the fall of 2020. The survey was disseminated between October 2020 and January 2021 *via* Qualtrics (11), with one follow-up email sent in December 2020. At the time of this study, Ontarian education workers were asked to return physically to the workplace following school closures in the spring of 2020 until the summer holidays. In some schools, teachers used a hybrid teaching model where they simultaneously taught students in person and others virtually.

We define education workers as unionized employees in the public education sector ranging from kindergarten to secondary. They include teachers, educational assistants, supply teachers, early childhood educators, administrative staff, and support workers who provide specialized services, including psychology, social work, and communicative supports. Eligible participants included those employed during the first wave of the pandemic and have returned to work during the second wave. We partnered with provincial unions, who agreed to disseminate the questionnaire on our behalf. Specifically, the survey links were disseminated from the executive to the district levels. Next, district leaders disseminated the survey links to their local members.

Participation was purely voluntary, and our anonymous survey could be completed in either English or French. Informed consent was obtained at the beginning of the survey. We collected demographic information, including age, gender, marital status, occupational groups, and employment status (i.e., permeant vs. contract, part-time vs. full-time). Participants also identified if they received accommodations from their employer due to physical or psychological disability.

Questionnaire

The World Health Organization Disability Assessment Schedule 2.0 (WHODAS 2.0 SF) is a 12-item self-rated health questionnaire that assesses the behavioral limitations and restrictions to participation experienced by individuals independent of a medical diagnosis in the past 30 days (12, 13). Items are scored on a 5-point Likert-type scale ranging from "none" to "extreme or cannot do." The WHODAS 2.0 SF has shown robust psychometric properties (9, 13). It has a test-retest reliability of 0.93–0.96 at the domain level and good internal consistency (Cronbach's alpha ≥ 0.81). Papadopoulou et al. (12) found strong intraclass correlation (ICC $= 0.99$; $p < 0.001$), suggesting excellent reliability. Their results also suggest strong construct and convergent validity (12).

The WHODAS 2.0 was recently used to assess the psychosocial wellbeing in the workplace during the pandemic (14). We used the WHODAS 2.0 to guide our survey of changes to functions during the period of accommodating the work changes and stresses imposed by COVID-19 and associated health measures. Specifically, we asked about participants' (1) cognition, (2) mobility, (3) self-care, (4) getting along, (5) life activities, and (6) participation. Each domain consists of two items. The cognition domain asks about learning new tasks and concentration. Mobility explores one's ability to stand for longer than 30 min and walking long distances. Self-care includes items on body washing and the ability to get dressed. Getting along focuses on how people deal with others and their ability in maintaining friendships. Life activities explores the ability to complete household responsibilities and day-to-day work. Finally, participation explores the ability to join group activities and how one is emotionally affected by health problems. In addition, for each question, a follow-up asked participants to rate

whether, since COVID-19, their response has improved, stayed the same or worsened.

Statistical Analyses

Descriptive statistics and cross-tabulations for the WHODAS 2.0 SF items were used to describe the background level of functioning in this sample and investigate the overall level of perceived impact of COVID-19.

To investigate the relationships between pre-existing functional difficulties, demographic predictors, and the perceived impact of COVID-19, we conducted stepwise binary logistic regressions at the item level.

Goodness of fit was assessed using Hosmer-Lemeshow for each analysis. Additionally, multicollinearity was assessed using the tolerance threshold and Variance Inflation Factor (VIF). The models are expressed in odds ratios (OR) and corresponding 95% confidence intervals (CI).

We dichotomized the WHODAS items into two categories (1 = "none to mild"; 2 = "moderate to extreme"). Deciding on this split was determined by the research team's clinicians (occupational therapist and psychologist) in consultations with the team's statistician. Superficially, we believe that participants experiencing moderate severity levels or higher on any of the WHODAS items is of clinical concern. Furthermore, we dichotomized age as a predictor variable since the sample was evenly split between those below and above the mean age (<45 and ≥45). As a *post-hoc* analysis, we also examined age as a continuous variable to determine if there is a linear relationship. For the regression models, we included only binary gender responses ("man" or "woman"). Approximately 0.5% (n = 13) identified as "non-binary" or "other," and only 1% (n = 25) chose not to respond. The need for accommodations was also conceptualized in two levels ("no" or "yes"). Finally, the perceived impact of COVID-19 on each WHODAS item had three levels ('better than," "the same as," or "worse than" before the pandemic). The first level of each variable served as the referent group except for the perceived impact of COVID-19 on the WHODAS items where "the same as" served as the referent group. All statistical tests were performed using SPSS 28.0 for Mac (15). Statistical significance was determined at the 0.05 level.

RESULTS

Study Respondents

A total of 4,394 education workers completed the survey. Of those, 2,378 (54.1%) had sufficient information for data interpretation. The sample ranged from 18 to 81 years old (M = 44.82; SD = 9.163). Most participants identified as women (81.1%; n = 1,928), married, common law or in a committed relationship (75.4%; n = 1,794). Almost 87% of the sample comprised teachers, and over 85% were permanent, full-time employees. Approximately 8.4% (n = 199) required accommodations at work. Please see **Table 1**. The sample's characteristics are consistent with the population's characteristics.

Results from the cross-tabulation suggest a perceived decline in functional activities since the pandemic (**Table 2**). For instance, over 54% of the sample indicated moderate-to-extreme difficulties in their abilities to complete day-to-day work, with almost 69% reporting that this has worsened since the pandemic. Similar concerns were seen with joining community activities, being affected by other health problems, and concentrating on tasks for 10 min.

TABLE 1 | Demographic and job characteristics of the sample.

Characteristic	*n*	%
Age (*min.* = 18.0, *max.* = 81.0; *M* = 44.82; *SD* = 9.163)		
Below 45	1,131	47.6
45 or older	1,195	50.3
Missing	52	2.2
Identified gender		
Man	413	17.4
Woman	1,928	81.1
Non-binary or other	9	0.5
Choose not to answer	25	1.1
Missing	3	0.1
Marital status		
Married/common law/committed relationship	1,794	75.4
Separated/divorced	172	7.2
Single	333	14.0
Widowed	24	1.0
Choose not to answer	49	2.1
Missing	6	0.3
Requiring accommodations		
No	2,100	88.3
Yes	199	8.4
Missing	79	3.3
Job classification		
Teacher (including special education)	1,995	83.9
Occasional teacher/substitute teacher	63	2.6
Computer/technician/IT	4	0.2
Clerical/office	43	1.8
Education assistant	105	4.4
Maintenance/custodial	2	0.1
Early childhood educator/child and youth counselors	87	3.7
Psychological staff/social worker/speech and language pathologist/occupational therapist	31	1.3
Other	44	1.9
Missing	4	0.2
Work schedule		
Permanent full-time	2,131	89.6
Permanent part-time	94	4.0
Temporary full-time	105	4.4
Temporary part-time	47	2.0
Missing	1	0.04

n, number of respondents per characteristic.

Predictors of Functional Activities

The Hosmer-Lemeshow test revealed a good fit with the logistic regression models ($p > 0.05$). Also, the assumption of linearity was not violated, and there was no presence of multicollinearity

TABLE 2 | Cross-tabulation of dichotomized WHODAS 2.0 scores and COVID-19 indicator.

WHODAS items *In the past 30 days, how much difficulty did you have in…*	**WHODAS score**	**Since COVID-19, my response is _____ before**		
		Better than ***n*** **(%)**	**The same as** ***n*** **(%)**	**Worse than** ***n*** **(%)**
1. Standing for long periods such as 30 min	*N* = 2,228	60 (2.7)	1,618 (72.6)	550 (24.7)
	None-to-mild	54	1,491	267
	Moderate-to-extreme	6	127	283
2. Taking care of household responsibilities?	*N* = 2,229	61 (2.7)	744 (33.4)	1,426 (63.9)
	None-to-mild	43	593	352
	Moderate-to-extreme	18	151	1,074
3. Learning a new task (e.g., how to get to a new place)?	*N* = 2,216	34 (1.5)	1,271 (57.4)	911 (41.1)
	None-to-mild	27	1,179	387
	Moderate-to-extreme	7	92	524
4. Joining in community activities?	*N* = 2,224	21 (.9)	755 (34)	1,449 (65.1)
	None-to-mild	13	650	490
	Moderate-to-extreme	8	105	959
5. Emotionally affected by other health problems?	*N* = 2,222	29 (1.3)	753 (33.9)	1,440 (64.8)
	None-to-mild	20	656	1,102
	Moderate-to-extreme	9	97	1,120
6. Concentrating on doing something for 10 min?	*N* = 2,216	42 (1.9)	1,085 (49)	1,089 (49.1)
	None-to-mild	36	1,007	465
	Moderate-to-extreme	6	78	624
7. Walking long distance such as a kilometer (or equivalent)?	*N* = 2,214	132 (6)	1,570 (70.9)	512 (23.1)
	None-to-mild	13	1,473	1,848
	Moderate-to-extreme	132	1,570	366
8. Washing your whole body?	*N* = 2,209	49 (2)	1,848 (84)	312 (14)
	None-to-mild	47	1,824	199
	Moderate-to-extreme	2	24	113
9. Difficulty getting dressed?	*N* = 2,202	51 (2.3)	1,789 (81.3)	362 (16.4)
	None-to-mild	51	1,764	265
	Moderate-to-extreme	0	25	97
10. Dealing with people you don't know?	*N* = 2,212	50 (2.3)	1,128 (51)	1,034 (46.7)
	None-to-mild	45	1,057	478
	Moderate-to-extreme	5	71	556
11. Maintaining friendship?	*N* = 2,212	47 (2.1)	1,009 (45.6)	1,156 (52.3)
	None-to-mild	42	942	564
	Moderate-to-extreme	5	67	592
12. Your day-to-day work?	*N* = 2,214	41 (1.9)	532 (24)	1,641 (74.1)
	None to mild	30	466	515
	Moderate-to-extreme	11	66	1,126

N, Total number of respondents per item; n, number of respondents based on COVID-19 Indicator per item.

between variables (Tolerance > 0.1; VIF < 10). **Table 3** depicts the adjusted ORs for each item.

Domain 1: Cognition

Participants who felt that the pandemic had worsened their ability to learn new tasks were 17.46 times more likely to report pre-existing difficulties with learning ($p < 0.001$, 95% CI: 13.46–22.62). Those requiring physical or psychological accommodations had greater odds of reporting difficulties concentrating (OR = 2.10; $p < 0.001$, 95% CI: 1.44–3.07). Likewise, those who perceive that their concentration has worsened since the pandemic were 18.5 times more likely to have a pre-existing poor concentration ($p < 0.001$, 95% CI: 14.03–24.27). Participants older than 45 had significantly lower odds of reporting difficulties learning new tasks (OR = 0.76; $p = 0.02$, 95% CI: 0.60–0.96). *Post-hoc* analysis revealed that increased age slightly decreased the odds of reporting difficulties learning new tasks (OR = 0.98; $p < 0.05$, 95% CI: 0.97–0.996).

Domain 2: Mobility

Participants over the age of 45 had greater odds of reporting difficulties standing for long periods (OR = 1.55; $p = 0.001$,

TABLE 3 | Logistic regressions for reporting worsened WHODAS 2.0 domains with explanatory variables of age, gender, and requiring accommodations during COVID-19.

Variable	OR	95% CI (lower-upper)	*P*-value
Domain 1: cognition			
Learning new tasks			
Age	0.76	0.60–0.96	0.019*
Gender	1.24	0.91–1.71	0.177
Accommodations	1.29	0.87–1.91	0.211
Perception: better since COVID	2.71	1.09–6.76	0.032*
Perception: worse since COVID	17.46	13.46–22.62	<0.001***
Concentration			
Age	0.90	0.72–1.12	0.325
Gender	1.01	0.76–1.135	0.942
Accommodations	2.10	1.44–3.07	<0.001***
Perception: better since COVID	2.27	0.92–5.61	0.08
Perception: worse since COVID	18.45	14.03–24.27	<0.001***
Domain 2: mobility			
Standing for long periods			
Age	1.55	1.19–2.00	0.001***
Gender	1.40	0.98–1.99	0.062
Accommodations	2.32	1.56–3.44	<0.001***
Perception: better since COVID	1.33	0.56–3.19	0.522
Perception: worse since COVID	12.69	9.78–16.48	<0.001***
Walking long distances			
Age	1.59	1.20–2.09	0.001***
Gender	1.16	0.80–1.67	0.429
Accommodations	3.33	2.24–4.95	<0.001***
Perception: better since COVID	1.69	0.91–3.14	0.099
Perception: worse since COVID	14.48	10.90–19.23	<0.001***
Domain 3: self-care			
Washing the whole body			
Age	0.96	0.63–1.47	0.848
Gender	1.44	0.80–2.59	0.226
Accommodations	1.97	1.10–3.55	0.024*
Perception: better since COVID	3.94	0.89–17.42	0.071
Perception: worse since COVID	47.82	28.83–79.32	<0.001***
Getting dressed			
Age	1.41	0.92–2.17	0.118
Gender	1.13	0.62–2.06	0.683
Accommodations	1.75	0.97–3.16	0.063
Perception: better since COVID	N/A	0.00	0.998
Perception: worse since COVID	29.25	17.78–48.13	<0.001***
Domain 4: getting along			
Dealing with people don't know			
Age	0.96	0.76–1.20	0.714
Gender	1.00	0.75–1.34	0.995
Accommodations	1.88	1.28 –2.75	0.001***
Perception: better since COVID	1.77	0.68–4.62	0.245
Perception: worse since COVID	17.46	13.19–23.12	<0.001***
Maintaining friendships			
Age	0.67	0.54–0.84	<0.001***
Gender	1.18	0.89–1.56	0.257
Accommodations	1.34	0.92–1.94	0.125
Perception: better since COVID	1.88	0.71–4.96	0.202
Perception: worse since COVID	14.35	10.81–19.04	<0.001***
Domain 5: life activities			
Household responsibilities			
Age	0.76	0.62–0.94	0.10
Gender	1.68	1.29–2.19	<0.001***
Accommodations	1.67	1.14–2.43	0.008**
Perception: better since COVID	1.59	0.88–2.90	0.127
Perception: worse since COVID	11.67	9.33–14.6	<0.001***
Day-to-day work			
Age	0.75	0.61–0.91	0.004**
Gender	0.82	0.63–1.07	0.137
Accommodations	1.57	1.09–2.26	0.017*
Perception: better since COVID	2.49	1.15–5.39	0.020*
Perception: worse since COVID	15.61	11.68–20.85	<0.001***
Domain 6: participation			
Joining community activities			
Age	0.86	0.70–1.04	0.125
Gender	1.20	0.93–1.55	0.169
Accommodations	1.66	1.16–2.38	0.006**
Perception: better since COVID	3.73	1.50–9.25	0.005**
Perception: worse since COVID	12.16	9.57–15.51	<0.001**
Emotionally affected			
Age	0.95	0.77–1.17	0.639
Gender	1.27	0.97–1.67	0.089
Accommodations	3.15	2.08–4.77	<0.001***
Perception: better since COVID	2.99	1.30–6.90	0.010**
Perception: worse since COVID	15.49	12.05–19.91	<0.001***

OR, Odds Ratio; CI, Confidence Interval.
**Statistical significance (P-value < 0.05).*
***Statistical significance (P-value < 0.01).*
****Statistical significance (P-value < 0.001).*

95% CI: 1.19–2.00) and walking long distances (OR = 1.59, $p = 0.001$; 95% CI: 1.20–2.09), respectively. *Post-hoc* analysis also revealed that increased age slightly increased the odds of reporting difficulties for these variables (OR = 1.04; $p < 0.001$, 95% CI: 1.02–1.05 and OR = 1.04; $p < 0.001$, 95% CI: 1.02–1.05). Respondents requiring accommodations had greater odds of reporting difficulties standing up (OR = 2.32, $p < 0.001$; 95% CI: 1.56–3.44) and walking long distances (OR = 3.33; $p < 0.001$, 95% CI: 2.24–4.95). Participants who reported that their response has worsened since the pandemic were 12.69 times more likely to have difficulties standing up ($p < 0.001$, 95% CI: 9.78–16.48) and 14.5 times more likely to have difficulties walking long distances ($p < 0.001$, 95% CI: 10.90–19.23).

Domain 3: Self-Care

Participants requiring accommodations had greater odds of reporting difficulties washing their body (OR = 1.97, $p = 0.02$;

95% CI: 1.10–3.55). Also, participants who perceived that the pandemic has worsened their symptoms reported 47.82 times more likely to have difficulties washing their bodies ($p < 0.001$; 95% CI: 28.83–79.32) and 29.24 times more likely to have difficulties getting dressed ($p < 0.001$; 95% CI: 17.78–48.13).

Domain 4: Getting Along

Respondents requiring accommodations had significantly greater odds of reporting difficulties dealing with others (OR = 1.88; $p = 0.001$, 95% CI: 1.28–2.75). Those who had felt the pandemic worsened their response was 17.46 times more likely to have difficulties dealing with people they did not know ($p < 0.001$, 95% CI: 13.19–23.12). Furthermore, participants who were older than 45 years had significantly lower odds of reporting difficulties maintaining friendships (OR = 0.67, $p = < 0.001$; 95% CI: 0.54–0.84). *Post-hoc* analysis revealed that increased age mildly decreased the odds of reporting difficulties in maintaining friendships (OR = 0.98; $p < 0.05$, 95% CI: 0.97–0.99). Those perceiving that the pandemic has worsened their symptoms had greater odds of difficulties maintaining friendships (OR = 14.35; $p < 0.001$; 95% CI: 10.81–19.04).

Domain 5: Life Activities

There was no statistical difference between those above or below the age of 45. Exploring age as a continuous variable, we discovered a modest correlation suggesting that increased age decreased the risk of having challenges in terms of taking care of household responsibilities (OR = 0.98, $p < 0.05$, 95% CI: 0.97–0.99). Furthermore, participants over the age of 45 had significantly lower odds of reporting difficulties performing day-to-day work (OR = 0.75; $p = 0.004$, 95% CI: 0.61–0.91). *Post-hoc* analysis revealed that increased age mildly decreased the odds of reporting difficulties performing day-to-day work (OR = 0.98; $p < 0.05$, 95% CI: 0.97–0.99). Women had significantly greater odds of reporting difficulties taking care of household responsibilities (OR = 1.68; $p < 0.001$, 95% CI: 1.29–2.19). Participants who required accommodations had significantly greater odds reporting difficulties taking care of household responsibilities (OR = 1.67; $p = 0.008$, 95% CI: 1.143–2.43) and performing day-to-day work (OR = 1.57; $p = 0.017$, 95% CI: 1.09–2.26). Perceiving that COVID-19 has worsened their symptoms increased the odds of having difficulties in taking care of household responsibilities (OR = 11.67; $p < 0.001$, 95% CI: 9.33–14.60) and completing day-to-day work (OR = 15.61; $p < 0.001$; 95% CI: 11.68–20.85).

Domain 6: Participation

Respondents who perceived more difficulties since the pandemic were more likely to have challenges in joining community activities (OR: 12.16; $p = 0.005$, 95% CI: 9.57–15.51) and were 15.49 times more likely to be affected by other health problems ($p < 0.001$, 95% CI: 12.05–19.91). Furthermore, participants who required accommodations had significantly odds of reporting difficulties participating in community activities (OR: 1.66; $p = 0.006$, 95% CI: 1.16–2.38) and being emotionally affected by other health problems (OR = 3.15; $p < 0.001$; 95% CI = 2.08–4.77).

DISCUSSION

We examined the perceived impact of the pandemic on functional activities of education workers in Ontario, Canada using the WHODAS 2.0 SF. The WHODAS 2.0 SF addresses difficulties due to health conditions; it provides a measure of disability under the ICIDH-2 framework in which disabilities arise when difficulties with form or function prevent desired levels of participation in society. Disability measured in this way reflects both relatively objective and reliable difficulties workers face. It also provides some guidance as to the levels of accommodation, which could potentially be required as a matter of policy.

To our knowledge, this is the first study to explore this area among education workers. Cross-sectional surveys are inherently limited in their capacity to investigate cause and effect. However, the salience of COVID-19 and related public health measures gives confidence that participants can generally attribute changes in their functional capacity to this period. Overall, education workers perceived that their capacities for functional activities have worsened since the pandemic.

A key finding in the present study is that there are associations between how individuals perceived the impact of COVID-19 and functional activity ratings. These associations were evident across all six domains, an essential consideration for school employers, policymakers, and rehabilitation researchers. Several reasons could explain how the pandemic influenced functional activities. For instance, it could be due to the challenges of setting boundaries between work and home life (16). While most Ontario workers were physically at work, there is naturally more reliance on technology to complete day-to-day tasks, including meetings and the stress of the hybrid model. Thus, we suspect that establishing boundaries between work and home duties is a contributor. Furthermore, with the COVID restrictions, it is unsurprising to find challenges in domains such as participation and getting along. However, what is critical from a policy and employment perspective is that the impact of COVID-19 falls most strongly on people who have pre-existing functional limitations. Therefore, planning for these difficulties and review of accommodations should be given some priority in the future.

The pandemic restrictions might have reduced mobility among some participants, especially older adults. Specifically, with prolonged inactivity and increased stress, mobility could be affected due to reduced muscle activity (17). Furthermore, factors such as fear of contamination, limited in-person socialization, and closures of fitness facilities could have affected education workers' mental wellbeing. Poor mental health and functional limitations potentially reinforce each other. This is concerning since depression and anxiety symptoms have negative implications across all six domains (6), and teachers' mental health is clearly at risk. These are important considerations and contribute to our understanding of the impact of COVID-19 on education workers' physical and mental wellbeing. It is also important to consider the potential long-term impact of the restriction measures on functional activities, including physical and cognitive impairments, because

functional difficulties that are not addressed may in turn lead to difficulty managing disability and increased health care costs (18).

Older employees (i.e., ≥45) were more likely to have difficulties in mobility than younger employees. However, older age decreased the odds of adverse outcomes for some WHODAS domains. They were less likely to report difficulties learning new tasks (cognition) and maintaining friendships (getting along). While evidence suggests that older education workers had more difficulties adapting to some aspects of their jobs, such as technology, they were more eager to advance their knowledge than younger employees (19). Notably, younger participants were more likely to be impacted by COVID-19. This could be due to poorer coping abilities to deal with the consequences of the pandemic despite having more access to social support (6).

Age as a continuous variable produced relatively similar results as dichotomizing age, although the correlations were relatively weak. This is because increased or decreased risk is not entirely linear. Specifically, significant changes in scores changes were more visible in older age groups instead of a steady change in score year by year.

Our results revealed that women were more likely to have difficulties taking care of household responsibilities than men. Some evidence suggests that women tend to be more involved in household chores than men (20). However, a recent meta-analysis revealed that gender differences in work-life conflict are generally small (21). Another possible explanation could be the gender difference in the likelihood of reporting physical or psychosocial symptoms. Specifically, while men and women could exhibit similar symptoms, women were more likely to report their symptoms than men (22).

Individuals requiring accommodations were more likely to have difficulties in all functional areas. This could be due to difficulties managing their health and are often affected by work-related aspects such as stress, high workload, hostile interpersonal relationships, and dealing with strangers (23). While Ontario schools are compliant with the Accessibility for Ontarians with Disabilities Act (24), these workers are particularly vulnerable to negative treatment in the workplace, while issues around adequate resources and accessibility remain problematic pre-pandemic (25). We also found that employees requiring accommodations were more likely to be affected by their health problems. We suspect that the pandemic has likely exacerbated these concerns due to limited training or sufficient resources.

Limitations

There were some limitations in this study. First, the cross-sectional nature of the questionnaire only examines a point in time and cannot be used to establish causal relationships. While we attempted to understand how workers fared before the pandemic, longitudinal research is needed to examine the impact of COVID-19 on activity limitations over extended periods. A second limitation was our inability to calculate an accurate response rate. Specifically, we could not confirm that all district leaders disseminated the survey links or if the members received the links. Other factors that may have reduced participation rates include the survey length since, as previously noted, the survey contained other outcomes beyond the scope of this study. Naturally, longer surveys have lower completion rates than shorter surveys. Furthermore, education workers could likely be experiencing research and pandemic fatigue (26, 27). Finally, despite our inability to accurately calculate a response rate, one must consider the challenging climate some employees faced during that period. Thus, they could be less inclined to participate in COVID-related studies. Nevertheless, this study offers how participants perceived how the pandemic has impacted their functional activities. Accordingly, we believe these results remain essential for occupational, research, and policy considerations.

Recommendations

Our findings support the argument that education workers face challenges during the pandemic. Accordingly, improving working conditions in educational settings is essential. To mitigate the harmful effects of COVID-19 and associated public health measures, school policies must focus on promoting employees' wellbeing. Policymakers should consider the impact of COVID-19, including provincial restrictions on education workers with a health promotion lens. This is a complex undertaking as safety (i.e., infections) must remain a priority, as they play a significant role in supporting a vulnerable population, including disadvantaged children, students with special needs, and poor mental health.

Individuals suffering from poorer mental health, affecting their daily functions due to the pandemic restrictions, may benefit from telehealth services without requiring face-to-face contact. Overall, telehealth services help maintain patients' physical and psychosocial health while without the risk of contagion (28). Typically, permanent employees in Ontario receive employee and family assistance programs from their employers. Thus, employers should remind employees of these services and offer support on accessing such services.

School administrators should provide adequate training for education workers to improve their technological skills and virtual competence. Müller et al. (29) found that educators perceived less stress after receiving training in online teaching platforms. From a social perspective, online social events were shown to reduce stress among educators (16). Therefore, virtual social events when in-person social gatherings are not feasible could be helpful.

Recognizing the possible obstacles employees with accommodations could be facing during the pandemic, employers should offer a more tailored approach to address their needs. These employees should also be involved in implementing policies affecting their work, as previous research suggests limited involvement pre-pandemic (30). Finally, from a research perspective, researchers should examine employees' experiences with various disabilities during the pandemic to better understand their needs.

CONCLUSIONS

This study offers insight into the perceived impact of COVID-19 on functional activities in educational workers in Ontario, Canada. Overall, employees perceived worse functional activities since the pandemic. Furthermore, those requiring accommodations have worse functional outcomes. Despite provincial mandates to support those with disabilities, more research is required to understand the needs of education workers requiring accommodations within the context of the pandemic. Older participants had poorer mobility outcomes; however, they appeared to have better coping skills in learning new tasks and maintaining friendships. Furthermore, women had greater odds of experiencing difficulties in maintaining household responsibilities. Based on the results, we suspect that restrictions to reduce the spread of the virus have contributed to mobility, getting along, participation, and life activities. Also, due to the restrictions, we suspect that poorer mental health outcomes also affect one's abilities in all six domains. Based on these findings, we suggest that policymakers incorporate a health promotion lens to support their employees, including tailored support for employees requiring accommodations.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because of ethical restrictions. Requests to access the datasets should be directed to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Stephen P. Lewis, University of Guelph. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

Material preparation and data collection were performed by FS, BG, BN-K, RB, and JC. Analysis was performed by BG, FS, and BO. The first draft of the manuscript was written by FS. All authors edited subsequent versions of the manuscript. All authors contributed to the study's conception and design, read, and approved the final manuscript.

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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.2022.879141/full#supplementary-material

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The Prevalence and the Associated Sociodemographic-Occupational Factors of Professional Burnout Among Health Professionals During COVID-19 Pandemic in Malang, Indonesia: A Cross-Sectional Study

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Background: Since 2020, Indonesian health professionals have been affected by burnout as the physiological impact due to the COVID-19 pandemic. Malang has contributed to a substantial number of new daily cases and death rates in East Java, an epicenter of COVID-19 in Indonesia. However, a study about how burnout affected Malang health professionals was never conducted.

Objectives: This research aimed to assess the prevalence and factors associated with burnout among health professionals during the COVID-19 pandemic in Malang, Indonesia.

Materials and Methods: A cross-sectional study was carried out with an online survey conducted in 5 major hospitals in Malang. We conducted a study about the prevalence rate of burnout in Malang and the association between sociodemographic factors, occupational hazards, and the Maslach Burnout Inventory-Human Services Survey (MBI-HSS). The associations were presented as odds ratio (*OR*) and 95% confidence interval (*CI*).

Results: We analyzed 1,077 health professionals in Malang. Our result showed that the prevalence of burnout among health professionals in Malang is 22.0%. Respondents under the age of 30 tend to experience a higher level of burnout by 3.4-fold ($OR = 3.43$, p-value < 0.001), compared with those over the age of 40 years. Our data showed that respondents working longer than 100 h/week tend to experience burnout by 3.8-fold ($OR = 3.83$, p-value < 0.001).

Conclusion: Approximately one-fifth of the health professionals in Malang suffered from burnout during the COVID-19 pandemic, and MBI-HSS subscales are strongly associated with age and work hours.

Keywords: professional burnout, COVID-19, health occupations, prevalence studies, Indonesia

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INTRODUCTION

The World Health Organization (WHO) declared coronavirus disease 2019 (COVID-19) a pandemic on March 11, 2020. By April 9, 2020, COVID-19 had spread across all 34 provinces in Indonesia and subsequently reached 56,757 cases in a day on July 15, 2021, the largest of new COVID-19 cases in the world on that day. During this period, half of Indonesia's provinces had a more than 50% increase in COVID-19 cases, and East Java has the highest death rate of all provinces. In August 2021, the overall number of patients with COVID-19 in Malang, as the most populated area in East Java, remained high even after a local lockdown was held (1–3). This condition led to an overwhelming impact on Malang health professionals who are at the greatest risk of being infected. Health professionals had to continue their services in the hospital with constrained resources and precarious infrastructure. They must wear personal protective equipment (PPE), which leads to physical discomfort and breathing difficulty. In addition, they also need to be more cautious about the possibility of transmitting the virus to their family (4–7). These behavioral changes in daily life have been identified as factors that have a detrimental psychological influence on health professionals (8). A recent systematic review showed that one-third of Asian health providers suffered from psychological distress and other psychiatric disorders during the pandemic (9). These conditions may put health professionals in a burnout condition.

Burnout is a work-related psychological syndrome characterized by emotional exhaustion (EE), depersonalization (DP), and reduced sense of personal accomplishment (PA) (10). Burnout among health professionals has been linked to a greater risk of depression, anxiety, drug abuse, medical errors, and poor clinical decision-making leading to compromised personal wellbeing and patient safety (11–13). Amid the outbreaks of severe acute respiratory syndrome (SARS), H1N1, and Ebola, several studies showed that psychological sequelae were more likely to be found in frontline health professionals (13). However, when compared with the previous multinational endemics, the consequence of the COVID-19 pandemic was more serious.

Although burnout has increased among health professionals during the COVID-19 pandemic, a study about burnout in Malang has not been done yet. The primary objectives of this study were to evaluate the prevalence of burnout among health professionals and to identify the factors that contributed to burnout during the COVID-19 pandemic. We hypothesized that health professionals in Malang may have burnout during COVID-19 pandemic as in other countries, and sociodemographic factors and occupational hazards may contribute to those condition. A better understanding of the associated factors may improve how health professionals and health organizations face the horror of the COVID-19 pandemic.

MATERIALS AND METHODS

Study Design

We conducted a cross-sectional study to determine the prevalence rate and factors associated with burnout among health professionals during the COVID-19 pandemic in Malang. The definition of healthcare professionals in our study was a person that applies scientific knowledge relating to medicine as follows: (1) medical doctors; (2) nurses; and (3) other health professionals (14). To assess the prevalence rate, the definition of burnout used in our study was based on the Maslach Burnout Inventory for Human Service and its three subscales (EE, DP, and PA) (15). The correlation among sociodemographic factors, work-related factors, and each of the Maslach Burnout Inventory-Human Services Survey (MBI-HSS) subscale categories was calculated as odds ratio (*OR*) and 95% confidence interval (*CI*). Strengthening The Reporting of Observational Studies in Epidemiology (STROBE) checklist was used to ensure our study quality (16).

Data Collection

A survey questionnaire was used to collect data from health professionals from 5 COVID-19 referral hospitals in Malang, Indonesia. The health professionals from public hospitals were selected from Saiful Anwar Hospital and Kanjuruhan Hospital. Meanwhile health professionals participating from private hospitals in this study were selected from Persada Hospital, Panti Waluya Hospital, and Wava Husada Hospital. Those hospitals were chosen based on the similarity of bed occupancy rate of COVID-19 services. Furthermore, the survey was conducted from August 1 to 31, 2021 using the Google Form platform, which was distributed to the representatives of each hospital together with information about the study procedures, ethical issues, and data collection. The required sample size was calculated using Cochran's formula estimating a 56.67% burnout prevalence in Saiful Anwar Hospital (17). Power was set at 80% and significance at 0.05. A minimal sample size was calculated at $n = 377$ for burnout healthcare professionals. Sample size was obtained using non-probability convenient sampling technique and adequate sample sizes were obtained according to sample size calculation. Larger numbers have been included to increase power for sub-analyses. Afterward, the results of the data gathering process were processed by 2 independent authors (JK and MI) to ensure its validity and confidentiality.

Eligibility Criteria

From the obtained responses, we only included samples that met the following inclusion criteria: (1) working as a health professional; (2) agreeing to participate; and (3) participating in COVID-19 services. However, exclusion criteria in our study were (1) healthcare professional who are currently not working in the designated hospital and (2) duplicate response.

Instruments

A questionnaire survey consisting of 34 questions was used in this study, including 1 question about identity, 2 questions about survey agreement, 4 questions about sociodemographic characteristics, 5 questions about occupational characteristics, and 22 questions of MBI-HSS in Indonesian language (18). The questions about identity, agreement, sociodemographic characteristics, and occupational characteristics were the combination of the open and close question models. While on

MBI-HSS questions, the 7-point Likert scale was used ranging from 0 for "never" to 7 for "every day." MBI-HSS questions have 3 subscales consisting of 9 questions about EE, 5 questions about DP, and 8 questions about PA, and each subscale has its unique level categories sorted from "low" (EE $\leq$ 16; DP $\leq$ 6; and PA $\leq$ 31), "moderate" (EE = 17–26; DP = 7–12; PA = 32–38), and "high" (EE $\geq$ 27; DP $\geq$ 13; and PA $\geq$ 39). The definitions of burnout were still not having consensus yet, we agreed to defined a burnout condition in our study as people who experienced "exhaustion" with a high level of EE or "cynicism" with a high level of DP based on several previous studies (19–21). EE was a condition described as an individual with depleted emotional resources and no longer able to care for themselves at a psychological level, and cynicism was described as the development of negative and cynical attitudes and feelings toward people (15).

Ethical Considerations

All participants have been given informed consent and agreement in the early section of the online questionnaire survey. Our study was conducted according to the Declaration of Helsinki, and ethical approval was obtained from the Ethics Committee of Saiful Anwar General Hospital (Ref 400/083/K.3/302/2021 on April 19, 2021). Voluntary participation and data confidentiality were emphasized.

Statistical Analyses

Our study calculated the correlation between sociodemographic, occupational characteristics, and burnout depending on each subscale using statistical analysis. Sociodemographic factors, occupational hazards, and burnout categories were processed as nominal data and the MBI subscale was processed as ordinal data. The relationship between burnout category and the independent variables were calculated using binomial logistic regression, and ordinal logistic regression was used to calculate the relationship between MBI subscales and the associated factors. The results of the statistical calculation shown as *OR* and *OR*95% *CI*. The test used above is two-sided and the *p*-value is considered significant if it is <0.05. In addition, Cronbach's alpha (α) was calculated in our statistical analysis to see the reliability of the Indonesian version of the MBI-HSS questionnaire. All statistical tests in our study were conducted using SPSS version 23 (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp).

RESULTS

Baseline Characteristics

Our study involved 1,077 health professionals who worked during the COVID-19 pandemic in Malang. All respondents agreed to participate, but 15 pieces of data from our respondents cannot be used because of duplicate responses. Therefore, sociodemographic characteristics of the respondents showed that our study involved more women (65.6%) than men (34.4%) with an average age of 34 years old. Most of the respondents were married (75.5%) and lived with their families (52.5%). While from occupational characteristics, the professions included in our study were the nurses (51.0%), doctors (39.6%), and others (9.4%) who worked in public hospitals (59.0%) and private hospitals (41.0%). Most of the respondents worked <70 h/week and they work on non-emergency (72.3%) and emergency service (55.2%), only if one person could work on more than 1 duty. Furthermore, the information about sociodemographic and occupational characteristics used in our study is shown in **Table 1**.

TABLE 1 | Sociodemographic and occupational characteristics of the study sample (*N* = 1,077).

Characteristics	*N* (%)
Sex	
Male	371 (34.4)
Female	706 (65.6)
Age (year)[‡]	33.8 (8.2)
<30	398 (37.0)
30–40	477 (44.3)
>40	202 (18.8)
Marital status	
Married	813 (75.5)
Not married	264 (24.5)
Living	
Alone (home)	310 (28.8)
Alone (rent)	202 (18.8)
With family/parents	565 (52.5)
Profession	
Doctor	427 (39.6)
Nurse	549 (51.0)
Others	101 (9.4)
Hospital sector	
Public	635 (59.0)
Private	442 (41.0)
Work hours (hour/week)	
<70	777 (72.1)
70–100	266 (24.7)
>100	34 (3.2)
Workload	
Emergency service	
Yes	595 (55.2)
No	482 (44.8)
Non-emergency service	
Yes	779 (72.3)
No	298(27.7)
Administrative	
Yes	61 (5.7)
No	1,016 (94.3)

[‡]*Mean (standard deviation).*

Burnout Prevalence Based on MBI-HSS Subscales

Our result showed that the prevalence of burnout among health professionals in 5 major hospitals in Malang is 22.0%. That result

TABLE 2 | Distribution of the Maslach Burnout Inventory-Human Services Survey (MBI-HSS) subscale scores and the prevalence of burnout.

Indicators	*N* (%)	Mean	SD	Cronbach's α
Burnout (high EE or DP)	237 (22.0)			
EE				0.881
Low (0–16)	577 (53.6)	9.1	4.629	
Moderate (17–26)	278 (25.8)	21	2.778	
High (≥27)	222 (20.6)	34.67	5.999	
DP				0.807
Low (0–6)	808 (75.0)	4.39	5.258	
Moderate (7–12)	163 (15.1)	8.9	1.605	
High (≥13)	106 (9.8)	16.79	3.685	
PA				0.783
Low (0–31)	53 (4.9)	50.42	9.887	
Moderate (32–38)	83 (7.7)	35.4	1.944	
High (≥39)	941 (0.9)	53.12	7.006	

EE, Emotional exhaustion; DP, depersonalization; PA, Personal accomplishment.

is accumulated from 9.8% of respondents with a high level of DP and 20.6% of respondents with a high level of EE. Therefore, a low level of PA is shown on 4.9% of our respondents. Moreover, our results also showed that the internal consistency of the MBI-HSS Indonesian version is more than 0.7 that is interpreted as adequate for subscales EE ($\alpha = 0.881$), DP ($\alpha = 0.807$), and PA ($\alpha = 0.783$). Detailed information on the prevalence of burnout for each subscale is presented in **Table 2**.

The Factors Associated With Burnout

Several factors from sociodemographic and occupational hazards associated with burnout on health professionals during the COVID-19 pandemic were presented in our result. Our result showed that the associated sociodemographic factors of burnout were male gender, younger age, and not in marital commitment ($OR = 1.47$, p-value $= 0.015$; $OR = 3.43$, p-value < 0.001; and $OR = 1.50$, p-value $= 0.042$). The Associated occupational hazards of burnout were medical professionals, working in a private hospital, and long work hours ($OR = 2.78$, p-value < 0.001; $OR = 2.92$, p-value < 0.001; and $OR = 3.83$, p-value < 0.001). The detailed results of burnout associated factors are presented in **Table 3**.

Exhaustion and cynicism can be observed in respondents who have younger age, male gender, medical profession, worked in private hospital, and long work hours. Respondents with an age of under 30 years and those aged from 30 to 40 years tend to experience a higher level of both exhaustion by 2-fold and cynicism by 3-fold compared with respondents more than the age of 40 years (p-value < 0.001). Being male health professionals in Malang may also contribute to the higher level of EE by 1.3-fold (p-value $= 0.022$) and DP by 1.6-fold (p-value $= 0.001$) compared with the female health professional. Moreover, an association was observed on longer work hours increasing exhaustion risk by 3-fold (p-value $= 0.001$) and cynicism risk by 2-fold (p-value $= 0.015$) on respondents who worked more than 100 h/week. For hospital sector, our observation showed health professionals who worked in private hospitals tend to have a high-level of EE and DP (p-value < 0.001). Furthermore, doctors as a medical profession have an increasing score in all burnout subscales concurrently, such as higher EE, higher DP, and lower PA (p-value < 0.001). Compared with a nurse, others health professions also showed similar results with higher EE, higher DP, and lower PA ($OR = 2.20$, p-value $= 0.002$; $OR = 2.82$, p-value $= 0.001$; and $OR = 3.07$, p-value $= 0.003$). Those results are presented in **Table 3** and are visualized with a forest plot in **Figure 1**.

DISCUSSION

During the COVID-19 pandemic, ∼22.0% of health professionals in Malang suffered from burnout. Those numbers were smaller compared with burnout global prevalence due to the COVID-19 pandemic presenting 51.4% of health professionals from 60 countries around the world using one subjective question about burnout (22). Moreover, a similar result from Italy and Egypt showed that the prevalence rate of health professional burnout was 24.7–37.0% and 28.2–31.8%, respectively, if EE or DP score was used to determine burnout (23, 24). Similarly, in several Asian countries, such as China and Malaysia, there is a prevalence of burnout of 12.0–37.0% and 22.0–38.4%, respectively (25, 26). In Indonesia, Sunjaya et al. observed the prevalence rate of emotional fatigue due to COVID-19 was 26.8% during the early period of the COVID-19 pandemic (27). However, the differences between the prevalence rates given above were caused by several factors, such as differences in time of the survey, type of the respondents, and how the country handled the pandemic (28).

Our study has shown that the sociodemographic and occupational hazards that were associated with burnout were age, work hours, profession, and hospital sector. This finding was supported by several previous studies. Spanish and Argentinian studies showed health professionals with an age ranging from 31 to 40 years old and age >40 years have lower MBI-HSS score compared with younger health professionals ($OR = 0.56$, p-value $= 0.019$ and $OR = 0.43$, p-value $= 0.040$) (29, 30). However, work hours as a burnout factor in the study by Giusti et al. showed that there were increasing MBI-HSS scores associated with longer work hours although the respondents worked shorter, with an average of 25.8 (±16.8) h weekly than our respondents (31). Moreover, the number of studies about hospital sectors associated with burnout during the COVID-19 pandemic is still low but the evidence showed that the burnout rate of health professional in a private hospital in Indonesia was higher than in a public hospital (32). While for the profession, the weight of our data is still skewed toward 2 respondent types, doctors and nurses. The most prominent association of low PA in our study was found in the doctors, and similar results were also shown by the study conducted by Sevinc et al. by comparing the PA of anesthesiologists and nurses in the ICU during the COVID-19 pandemic (33). Eventually, the definition of health professionals in our study has a broad definition. Our result may show evidence between burnout conditions and other health professions, such as pharmacist, dietitian, and lab assistants, but it is not specifically divided and must be interpreted cautiously.

TABLE 3 | The logistic regression odds ratio (*OR*) and 95% confidence interval (*CI*) of burnout and each of the MBI subscale scores compared by sociodemographic and occupational hazards.

	Burnout				EE				DP				PA			
	OR	**Lower OR 95% CI**	**Upper OR 95% CI**	***p*-value**	**OR**	**Lower OR 95% CI**	**Upper OR 95% CI**	***p*-value**	**OR**	**Lower OR 95% CI**	**Upper OR 95% CI**	***p*-value**	**OR**	**Lower OR 95% CI**	**Upper OR 95% CI**	***p*-value**
Sociodemographic factors																
Male vs. female	1.47	1.08	2.00	**0.015***	1.33	1.04	1.7	**0.022***	1.60	1.20	2.14	**0.001***	1.15	0.78	1.68	0.481
Age (year)																
<30 vs. >40	3.43	1.90	6.21	**<0.001***	2.17	1.48	3.18	**<0.001***	3.14	1.82	5.42	**<0.001***	1.15	0.62	2.15	0.654
30–40 vs. >40	3.51	2.01	6.14	**<0.001***	2.11	1.49	2.99	**<0.001***	3.74	2.25	6.23	**<0.001***	1.56	0.89	2.71	0.118
Living companion:																
Alone (rent) vs. alone (home)	1.21	0.76	1.94	0.418	1.07	0.82	1.41	0.615	0.84	0.60	1.18	0.316	0.86	0.56	1.34	0.510
With family vs. alone (home)	1.04	0.72	1.49	0.848	1.23	0.84	1.79	0.286	1.05	0.68	1.64	0.813	1.34	0.77	2.36	0.302
Not married vs. married	1.50	1.02	2.22	**0.042***	1.39	1.01	1.92	0.045	1.41	0.97	2.06	0.073	1.31	0.79	2.15	0.294
Occupational hazards																
Profession:																
Others vs. nurse	2.97	1.55	5.67	**0.001***	2.20	1.33	3.63	**0.002***	2.82	1.52	5.24	**0.001***	3.07	1.48	6.37	**0.003***
Doctor vs. nurse	2.78	1.70	4.55	**<0.001***	2.12	1.48	3.04	**<0.001***	3.45	2.18	5.46	**<0.001***	3.44	1.94	6.10	**<0.001***
Private vs. public hospital	2.92	1.88	4.54	**<0.001***	2.30	1.68	3.16	**<0.001***	2.64	1.74	3.99	**<0.001***	1.07	0.64	1.80	0.787
Work hours (hour/week):																
70–100 vs. <70	1.89	1.32	2.72	**0.001***	1.74	1.29	2.33	**<0.001***	1.64	1.17	2.29	**0.004***	1.21	0.77	1.89	0.407
>100 vs. <70	3.83	1.86	7.90	**<0.001***	3.17	1.65	6.09	**0.001***	2.38	1.19	4.76	**0.015***	0.75	0.25	2.28	0.611
Emergency service	1.11	0.75	1.66	0.598	1.15	0.84	1.57	0.379	1.28	0.89	1.85	0.189	0.78	0.49	1.24	0.291
Non-emergency service	0.82	0.54	1.24	0.351	1.22	0.88	1.70	0.232	1.24	0.85	1.81	0.271	1.18	0.72	1.94	0.505
Administrative	0.39	0.16	0.94	**0.035***	0.73	0.39	1.35	0.315	0.41	0.18	0.92	**0.032***	1.54	0.70	3.43	0.285

EE, Emotional exhaustion; DP, depersonalization; Personal accomplishment; OR, Odds ratio; 95% CI, 95% Confidence interval.

**Significant p-value at < 0.05 (bold).*

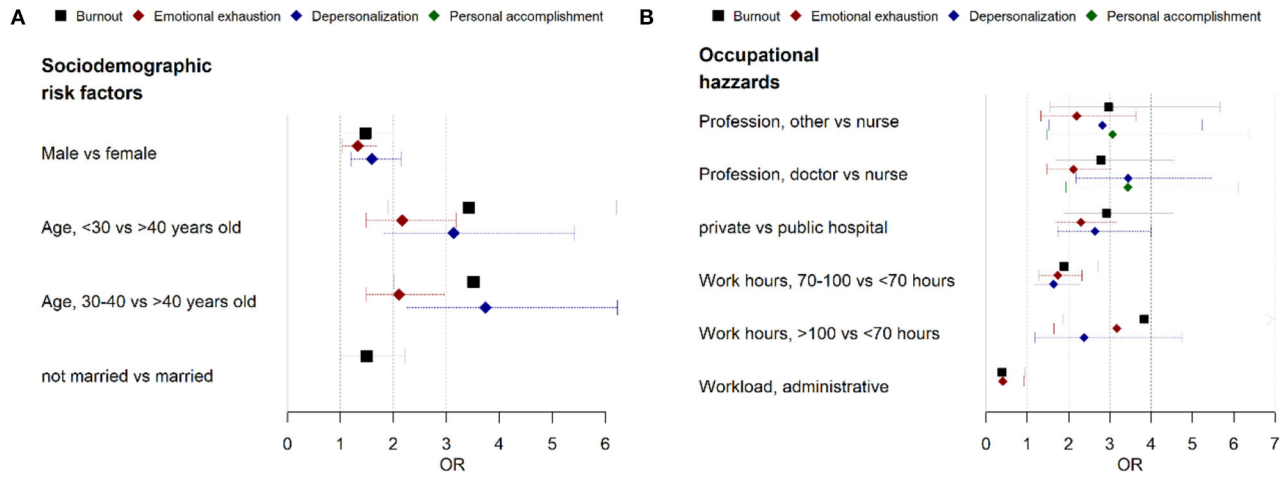

FIGURE 1 | A logistic regression plot of odds ratio (*OR*) and 95% confidence interval (*CI*) of the burnout subscale and the associated factors. **(A)** Sociodemographic factors and **(B)** occupational hazards.

Our results showed that the other factors, such as marital status, gender, and workloads associated with burnout, but they still have inconsistent results. Our results and the result of the study conducted by Patel et al. show an increase in burnout conditions for unmarried health professionals, whereas Hu et al. and Duarte et al. studies show that married health professionals are less susceptible to burnout (34–36). However, when we compared the data about gender, more studies showed female health professionals were more susceptible to burnout, but our result showed the opposite (29, 30, 36). In Indonesia, our data suggest that male gender was more susceptible to burnout, and it was similar with the result from the study conducted on Jordanian Health professionals (37). We believe the diversity of work culture among countries may have affected this result. The Indonesian government regulates healthcare professionals to work 40 h/week, but more resources were needed when COVID 19 emerged. Patients with COVID-19 that came to hospital in Malang exceed the capacity of the COVID-19 emergency room and isolation wards until they were willing to spend the night in front of the hospitals. The number of patients had forced hospital management to deploy more manpower to the COVID-19 services. Unfortunately some health workers still had to continue their daily routine services after working in the COVID-19 ward. Meanwhile, Indonesian health professionals may also have long work hours because of multiple workloads. For example, a doctor may work on the emergency service, provide non-emergency care, and participate in the hospital management at the same time. Our result presented the data about how the COVID-19 pandemic may expose all types of healthcare services, but front-liners who work intensely with direct interactions with patients, in an emergency or non-emergency service, clearly show burnout clinically but not statistically. New evidence in our result shows that health professionals with the administrative task may decrease the odd of burnout with low EE and DP score in an uncertain way, and further observation must be made.

It is worth debating how each of the MBI-HSS subscales involves the burnout in our respondent during the COVID-19 pandemic. EE is the most important subscale to determine the burnout condition, and aging has a negative correlation with the EE subscale. The explanation behind this phenomenon may be affected by how younger health professionals thought toward the fairness in a workplace (38). Younger health professionals may be more susceptible to EE than the older adults because they are more influenced by the outcome they receive, such as benefit and compensation. Furthermore, another factor associated with burnout that we found was long work hours. Earlier studies have shown how long work hours can make health professionals have limited time to rest (39). Meanwhile, a high DP subscale from the health professionals often associated with physiological distress (40). Although the causes of distress in our respondents cannot be observed clearly, a previous study conducted by Babore et al. has shown that the COVID-19 pandemic has increased distress for health professionals (41). This condition may affect the decline in professionalism and empathy of health professionals, especially doctors (40). The phenomenon above is also supported by the low level of professional accomplishment in this group. Earlier studies have shown that a high PA score may be affected by a person's knowledge and the skills contributing to their work (42). Hereafter, the reason behind the associations above still cannot be explained clearly, and further exploration must be made.

Indonesian health professionals have been struggling to fight against the COVID-19 pandemic for almost 2 years when this study was written. The second wave of pandemic peaked on July 2021 with the highest COVID-19 incident rate of 50,000 people in a day and, in August 2021, Indonesia mourned over 1,777 deaths in a day (28). Those numbers gave burden to the Malang's health professionals psychologically and were recorded in our study. Our results showed a considerable portion of health professionals suffered from EE due to occupational hazards. However, the explanation behind this phenomenon is still obscure, but no one will be prepared with the fear of a disease that can spread

and kill people in time, and it will affect the people working in the sectors (41). The results of our study confirm that burnout does occur among health professionals. If the numbers in our study continue to grow due to predictable factors, then things may get worse. Directly, burnout will increase the error rate made by a health professional (21). Coping stress mechanism by individuals is mandatory to fight the physiological burden among health professionals, but it usually depends on their unprotected free time. To treat the fear and horror, it will take more than just the readiness of the individuals. The larger groups, such as hospitals, an organization that provide health services, and locals or national government will also need to be prepared. The lack of supervision on current work regulations should be fixed to ensure that health professionals may use their rights in COVID-19 services. The providers must be able to protect the vulnerable individuals and may also give an access to healthcare workers who are exhausted from their work in a pandemic situation to have psychological support and intervention without discrimination and stigma (43).

There are several limitations that we found in our study. First, our study has not been able to show the prevalence of burnout without excluding the confounders because burnout may arise from many underlying factors, such as depression, anxiety, and an excessive level of fear of COVID-19 (11). Second, the prevalence of burnout in our study may differ from the prevalence in other studies. We believe this is caused by the diversity of hospital work culture and the various definitions of burnout that do not have global consensus definition yet (44). Burnout is associated with psychological conditions, so a direct diagnosis from a psychiatrist or clinical psychologist will provide enhancement in this field of research (45). Third, long work hour is an important factor associated with burnout in our study, yet the definition of long work hours associated with burnout remains unclear. Our previous study in Malang and other similar studies used 70 h/week as a cut-off point, but several studies showed that working >55 h/week was associated with medical conditions (17, 46–49). Those gaps made our result may differ in studies with a different work hour classification, and a standardized work hour classification was needed in future studies to assess the true effect of the association between work hours and burnout. Finally, we are aware that the factors that can be associated with burnout are still broad, such as income levels, interaction time with COVID-19 patients, compensation provided by the government, and other factors (50).

CONCLUSION

Our study showed that approximately one-fifth of health professionals in Malang suffered by the COVID-19 pandemic burnout. Many factors may increase the burnout condition, but the factors of age and long work hours show a strong association if compared with other factors. In our study, other factors, such as male gender, younger age, not in marital commitment, medical profession, and working in a private hospital also associated with burnout condition. These factors need to be examined and discussed further to prevent burnout among health professionals and increase the success rate of COVID-19 management.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethics Committee of Saiful Anwar General Hospital. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

Idea and concept: BD and FP. Design, control, supervision, and critical review: BD, FP, and JF. Data collection and processing: BD, MI, and JK. Analysis and interpretation: BD, MI, JK, and JF. Literature review: BD, FP, and JK. Writing the article: BD, FP, and MI. All authors contributed to the article and approved the submitted version.

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Improving Patient Safety Culture During the COVID-19 Pandemic in Taiwan

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Background and Aim: Patient safety culture attitude is strongly linked to patient safety outcomes. Since the onset of the COVID-19 pandemic in early 2020, pandemic prevention has become the priority of hospital staff. However, few studies have explored the changes in patient safety culture among hospital staff that have occurred during the pandemic. The present study compared the safety attitudes, emotional exhaustion (EE), and work–life balance (WLB) of hospital staff in the early (2020) and late (2021) stages of the COVID-19 pandemic and explored the effects of EE and WLB on patient safety attitudes in Taiwan.

Materials and Methods: In this cross-sectional study, the Joint Commission of Taiwan Patient Safety Culture Survey, including the six-dimension Safety Attitudes Questionnaire (SAQ) and EE and WLB scales, were used for data collection.

Results: This study included a total of 706 hospital employees from a district hospital in Taipei City. The respondents' scores in each SAQ sub-dimension (except for stress recognition) increased non-significantly from 2020 to 2021, whereas their EE and WLB scores improved significantly ($P < 0.05$ and $P < 0.01$, respectively). The results of hierarchical regression analysis indicated that although a respondent's WLB score could predict their scores in each SAQ sub-dimension (except for stress recognition), EE was the most important factor affecting the respondents' attitudes toward patient safety culture during the later stage of the COVID-19 pandemic.

Conclusion: In the post-pandemic, employees' attitudes toward safety climate, job satisfaction, and perception of Management changed from negative to positive. Additionally, both EE and WLB are key factors influencing patient safety culture. The present study can be used as a reference for hospital managers to formulate crisis response strategies.

Keywords: patient safety culture, COVID-19, emotional exhaustion, work life balance, patient safety

INTRODUCTION

The challenges to patient safety due to the COVID-19 outbreak, such as an imbalance in the supply and demand of protective equipment, rapid changes in policies, lack of evidence-based treatment guidelines for COVID-19, and inadequate supervision of procedures due to lack of personnel, make it easy to make mistakes (1). In response to this crisis, workers are on guard to improve safety behaviors (2). However, risk perception can increase anxiety and negatively affect safety performance. Research has Indicated that a team safety climate can alleviate this negative psychological impact (3). Safety climate is often used interchangeably with safety culture, with the difference being that the former refers to the stable characteristics of the organization. At the same time, the latter is the state of the environment at a given time (4). The favorable safety climate during SARS 2003 was also an organizational factor in protecting hospital staff from infectious diseases (5).

Adverse events during hospitalization affect one in 10 hospitalized patients (6). These events are associated with surgery (27%), medication errors (18.3%), and nosocomial infections (12.2%). Approximately 53.2% of these events are preventable (7). Ensuring patient safety and optimizing the provision of medical care by health-care professionals are essential to promoting high-quality health care. Patient safety and risk management training enhances staff adherence to patient safety, thus building a safety culture (8). Making efforts to foster a culture of safety is key to improving patient safety and the quality of care in nursing settings (9). The significance of the culture of safety as the sustainable approach to fostering safety has been emphasized by most health organizations such as the World Health Organization and Joint Commission International (JCI), which are international authorization associations (10). A system of patient safety culture can be constructed by drawing on the shared values, beliefs, norms, and patient safety procedures among the members of a health-care organization, unit, or team (11, 12). Safety culture can established from the effective interaction of three components: (a) environmental structures and processes within an organization, (b) worker attitudes and perceptions, and (c) individual behaviors related to safety (13).

Effective patient safety culture can decrease mortality to 44,000 and can reduce economic loss to US$2.9 billion (14, 15). In addition, it can facilitate the implementation of improved safety measures, promote effective communication, and encourage individuals to learn from their mistakes (16). Accordingly, it can reduce fatigue and psychological and work-related stress among employees and can promote their health and job performance. Overall, studies have demonstrated that positive patient safety culture contributes positively to patient satisfaction, family satisfaction, and the wellbeing of hospital staff and can even decrease hospital admissions (17, 18).

Organizational safety culture signifies "the outcome of the values, attitudes, competencies, and behavioral patterns of individuals and groups that ascertain commitment, style and efficiency in the management of an organization's health and safety. The features of a positive safety culture are communications based on mutual trust, a shared understanding of the importance of safety, and confidence in the effectiveness of precautionary measure" (19).

Due to the increasing awareness of the importance of hospital-wide patient safety culture, tools have been developed to assess the safety attitudes of hospital staff. Among the numerous cognitive tools to evaluate employee attitudes toward safety in health-care facilities, the most frequently used is the Safety Attitudes Questionnaire (SAQ) (20). The SAQ has undergone numerous revisions to improve its precision and ability to meet the needs of different units within a health-care organization (21).

The Joint Commission of Taiwan (JCT; https://www.jct.org.tw/cp-21-1155-4a85d-1.html), founded in 1999, is a professional assessment institute accredited by the International Society for Quality in Health Care (ISQua). In Taiwan, the SAQ is used to conduct an annual national survey to monitor long-term trends in patient safety culture (22, 23). The questionnaire accounts for six aspects of patient safety culture (namely teamwork ethos, safety ethos, job satisfaction, stress recognition, perception of management, and work conditions) and exhibits high internal consistency (Cronbach's $\alpha = 0.78$) (24). The JCT incorporated scales evaluating work–life balance (WLB) and emotional exhaustion (EE) into its annual patient safety culture survey in 2014 to detect burnout and work–life imbalance among hospital staff to eliminate their negative effects on patient safety culture.

Health-care workers, including nurses and those working in non-emergency wards of hospitals, are under great pressure as they are more vulnerable to COVID-19 (25). Throughout the COVID-19 pandemic, health-care professionals have experienced problems in terms of limited hospital resources, the threat of exposure to SARS-CoV-2 as an additional occupational hazard, increased workloads, fear of transmitting COVID-19 to family members, and disrupted sleep patterns, leading some to become agitated or even commit suicide (26). Although the death toll of COVID-19 in Taiwan (a total of 850 deaths as of December 29, 2021) has remained low relative to that in other countries. As a frontline medical worker, employment must deal with patient emotions and do related coordination under the epidemic's limited social contact policy, including restricting elective surgery or hospitalization and patient visits, which are likely ethical issues affecting patient autonomy (27). Meanwhile, because they must have close interaction with infected patients, may result in psychological and emotional trauma, acute stress disorder, and post-traumatic stress disorder (26). In addition, significant correlations have been identified among the work environment, EE, depersonalization (an alienated or apathetic attitude toward work), personal achievement, and organizational patient safety culture (28).

Work–life balance is based on the allocation of available personal resources. WLB is achieved when an individual's personal resources are sufficient for their professional and familial roles, thereby enabling them to effectively participate in each area (29). During the COVID-19 pandemic, a long-term work–life imbalance has resulted in high rates of burnout among medical staff. An individual's WLB affects not only the quality of professional life and family life but also affects the overall quality of life (30). The relationships between

WLB, resilience, and patient safety culture have not been thoroughly explored.

Senior leadership accountability (31), teamwork within a hospital, and organizational learning strongly affect organizational safety culture (32). The impact of COVID-19 on patient safety culture has been previously studied (22, 33); as of 2022, the COVID-19 pandemic has extended into its third year, and how the patient safety culture has adapted from various problems over time, such as personal protective equipment shortage, insufficient resources, increased costs and reduced revenue, and often-changing central policies in the early days of the outbreak (34), especially in district hospitals with relatively. However, no study has explored patient safety culture in district hospitals. For addressing this research gap, the study evaluated the differences in patient safety culture between the early (2020) and late (2021) stages of the COVID-19 pandemic in a district hospital in Taiwan and explored the effects of WLB and EE on SAQ subdimension scores.

MATERIALS AND METHODS

Study Design

This study employed a cross-sectional design. The original file (Microsoft Excel file) containing the results of the 2020 and 2021 patient safety culture surveys of a hospital in Taipei (2020, $N = 363$; 2021, $N = 343$) was used as the data source. The data were collected from a district hospital with fewer than 200 beds. Every August, the hospital administration conducts routine patient safety culture surveys for employees who have worked at the hospital for more than 3 months.

Data Collection

The test schedule was announced before the survey. During the test period, the supervisor was requested through the hospital Line group or at a hospital executive meeting) to encourage eligible employees to fill out the questionnaire. Employees could fill out the questionnaire online by clicking a link sent to them over email. Employees without email addresses were provided with a separate account and password on paper to access the online questionnaire. Some staff filled the questionnaire in paper form, which was sent to the undertaker in an official document and keyed into the file. All the questionnaires were anonymous; no identifiable personal information (such as account numbers or personal emails) was included in the data imported from the questionnaire. In this way, the survey answers go directly to an external system (JCT Patient Safety Culture Platform), eliminating the stress on supervisors when filling out the questionnaires. Therefore, colleagues are better able to respond to the survey based on their accurate perceptions and awareness.

Instruments

Demographic

We collected the following baseline demographic and professional information for each respondent: age, gender, educational level, tenure, profession, division, managerial status, number of incidents submitted in the past 12 months, and whether they have contact with patients at work.

SAQ

The SAQ (21) was translated into Chinese by Dr. Lee Wai-keung in Taiwan (with the permission of Dr. Sexton JB of the University of Texas), and it has been incorporated into the national surveys which was conducted annually by JCI. The questionnaire contains 30 items across six sub-dimensions: teamwork climate, safety climate, job satisfaction, stress recognition, perception of management, and working conditions. Each item on the questionnaire is rated on a 5-point Likert-scale (1 = strongly disagree, 2 = slightly disagree, 3 = neutral, 4 = slightly agree, and 5 = agree). Not applicable responses are scored as 0 points. A respondent's SAQ sub-dimension score is calculated as (dimension mean score -1) $\times$ 25 and is regarded as a positive attitude if it is $\geq$75. The SAQ is widely used in many countries, with Cronbach's α values ranging from 0.85 (35) to 0.88 (36), indicating its high internal consistency and reliability. In the present study, the Cronbach's α values of the sub-dimensions ranged from 0.83 to 0.91, indicating the scale's high internal consistency and reliability (**Table 1**).

EE Questionnaire

In addition to the SAQ, this study used the EE component of the Maslach Burnout Inventory developed by Maslach et al. in 1976 (37). The scoring of the EE scale is the same as that of the SAQ. The Cronbach's alpha values for the 2020 and 2021 questionnaires were 0.90 and 0.91, respectively.

WLB Questionnaire

The 7-item College Activities and Behavior Questionnaire by Sexton et al. (21)was adapted for use in health-care professionals as the WLB questionnaire in this study. Each item on the WLB questionnaire is rated on a 4-point Likert-scale almost never, less than 1 day per week), 4 points; sometimes (1–2 days per week), 3 points; most of the time (3–4days per week), 2 points; and always (5–7 days per week), 1 point. Not applicable responses are scored as 0 points. A respondent's total WLB score is calculated as (dimension mean score -1) $\times$ 33.3 and is regarded as positive if it is $\geq$63.3. The Cronbach's alpha values for the 2020 and 2021 questionnaires were 0.83 and 0.82, respectively.

Data Analysis

Statistical analyses were used the SPSS 25.0 software package, and the distribution of basic employee data was obtained from descriptive statistics (means, standard deviations, frequencies, and percentages). One-way analysis of variance (ANOVA) and independent t-tests were used for bivariable analysis of demographic and professional variables and SAQ score, EE, and WLB. Spearman's correlation co-efficient was used to identify the correlations among the SAQ subdimension, EE, and WLB scores. Hierarchical regression analysis was performed to predict the power of demographic and professional variables and EE and WLB scores for patient safety culture (SAQ sub-dimensions).

Compliance With Ethical Standards

Although no personal information was included in the study data, the data were still treated as confidential and will not be disclosed. All the identifiable information in our data has been

TABLE 1 | Internal consistency reliability of the SAQ.

Dimension	Sub-dimension	Definition (21)	Item	Cronbach's α	
				2020	2021
SAQ	Teamwork climate	Perceived quality of collaboration between personnel	6	0.85	0.85
	Safety climate	Perceptions of a strong and proactive organizational commitment to safety	7	0.88	0.90
	Job satisfaction	Positivity about the work experience	5	0.93	0.95
	Stress recognition	Acknowledgment of how performance is influenced by stressors	4	0.88	0.86
	Perception of management	Approval of managerial action	4	0.83	0.91
	Working condition	Perceived quality of the work environment and logistical support (staffing, equipment etc.)	4	0.87	0.84

replaced with codes and all the electronic files and documents related to the study are protected and encrypted. Only the research team members can access the research-related materials, and all the research-related materials will be destroyed after the research results are published.

RESULTS

Demographics and Characteristics

A total of 343 valid 2021 questionnaires were collected. Most (80.2%) of the respondents were women, most of whom were nurses. Nearly 70% of the respondents were over 40 years old, and 18.7% were managers. Most of the respondents had a college degree or above (87.8%), and nearly 50% (45.5%) had worked in the hospital for more than 10 years. A total of 79.3% of the respondents reported that they have contact with patients during their daily work, and 19% described that they had reported an incident within the preceding 12 months. The respondents' basic information in the 2021 questionnaire was the same as their information in the 2020 questionnaire, with no significant differences revealed by the chi-squared test (**Table 2**).

Comparison of SAQ, EE, and WLB Scores in 2020 and 2021

As shown in **Table 3**, the average EE and WLB scores in 2021 were significantly higher than those in 2020 ($P < 0.05$ and $P < 0.001$, respectively). Among the SAQ, EE, and WLB scores, only the EE and WLB scores changed significantly from 2020 to 2021. The average stress recognition score in 2021 was slightly lower than that in 2020, but this change was not statistically significant ($P > 0.05$). Regarding the mean score, only the teamwork climate subdimension score was positive ($\geq$75 points) in 2020, and in 2021, the safety climate, job satisfaction, and perception of management subdimension scores were all positive, except for the average teamwork climate subdimension score.

Changes in SAQ, EE, and WLB Scores Across Demographic Variables

To understand the factors affecting the respondents' SAQ, EE, and WLB scores in 2021, a bivariate analysis including demographic and professional variables, patient safety culture attitudes, EE, and WLB was conducted (see **Table 4**). The mean SAQ score differed across age groups ($P = 0.001$), and the mean total SAQ score of the $\geq$60 years age group was significantly higher than those of the other age groups.

Regarding division, the employees who worked in outpatient/inspection units had higher SAQ scores ($P < 0.001$) than did those who worked in high-risk units and administrative departments. Gender, educational level, tenure, profession, managerial status, number of incident reports, and whether they have contact with patients at work did not affect the overall SAQ score.

Regarding EE, the employees over 60 years old ($P < 0.001$) had the lowest mean EE score, and those 20–40 years old had the highest mean EE score. The men experienced less EE than did the women ($P = 0.010$). Regarding profession, the mean EE score of the nurses was significantly higher than those of the respondents in other professions. The physicians had the lowest mean EE score, but their mean EE score was not significantly different from those of the other medical technicians and administrative staff. As we had expected, the respondents who worked in high-risk units had the highest mean EE score, as we had expected. The average EE scores of the respondents employed in outpatient/inspection units and administrative units were not significantly different ($P = 0.958$).

The respondents who had reported at least one incident within the preceding 12 months had a higher mean EE score than did those who had not reported any incident ($P = 0.002$). The respondents who have no contact with patients in their daily work also had a lower mean EE score than did those who have contact with patients in their daily work ($P = 0.044$). Gender, educational level, tenure, and managerial status had no effect on the EE score.

The average WLB scores of most junior employees (those who had been employed for 3 months to 1 year) were significantly higher than those of most senior employees (those who had been employed for >10 years; $P = 0.006$). The mean WLB score of the nurses was lower than those of the other medical technicians ($P = 0.004$) and of the non-medical staff ($P < 0.001$), but the score of the nurses was comparable to that of the physicians ($P = 0.713$). The respondents who worked in outpatient/inspection units and administrative units had a higher average WLB score than did

TABLE 2 | Demographic and clinical characteristics.

Characteristics	2020 year ($n = 363$)		2021 year ($n = 343$)		χ^2	*p-value*
	n	%	*n*	%		
Age group						
20–40 years	126	34.7	115	33.5	0.450	0.799
40–60 years	165	45.5	153	44.6		
≥60 years	72	19.8	75	21.9		
Gender						
Male	84	23.1	68	19.8	1.147	0.314[a]
Female	279	76.9	275	80.2		
Educational level						
High school or less	54	14.9	42	12.2	1.471	0.479
Diploma or Bachelor	272	74.9	270	78.7		
Master or doctor degree	37	10.2	31	9.0		
Tenure						
3 months-1 year	41	11.3	29	8.5	3.311	0.346
1–4 years	94	25.9	104	30.3		
5–10 years	66	18.2	54	15.7		
>10 years	162	44.6	156	45.5		
Profession						
Physician	50	13.8	33	9.6	3.190	0.363
Nurse	141	38.8	135	39.4		
Technician	55	15.2	53	15.5		
Administrative	117	32.2	122	35.6		
Division						
High risk department	137	37.7	119	34.7	0.837	0.658
OPD/Inspection units	160	44.4	162	47.2		
Administration units and others	66	18.2	62	18.1		
Managerial position						
Yes	62	17.1	64	18.7	0.300	0.623[a]
No	301	82.9	279	81.3		
Incident reports						
None	283	78.0	278	81.0	1.031	0.351[a]
At least one	80	22.0	65	19.0		
Patient contact						
No	62	17.1	71	20.7	1.511	0.248[a]
Yes	301	82.9	272	79.3		

[a] *Fisher's exact test.*

TABLE 3 | SAQ, EE, and WLB (2020 vs. 2021).

Dimension	2020		2021		*t*	*p-value*
	N	Mean (SD)	*N*	Mean (SD)		
SAQ total score	363	71.41 (16.55)	343	72.44 (15.82)	0.846	0.398
Teamwork climate	344	76.18 (18.29)	325	78.50 (16.51)	1.719	0.086
Safety climate	356	74.38 (18.01)	334	76.37 (17.25)	1.483	0.138
Job satisfaction	362	74.28 (20.97)	343	76.00 (20.79)	1.095	0.274
Stress recognition	361	63.70 (24.44)	341	62.05 (22.37)	−0.933	0.351
Perception of management	361	74.64 (19.35)	342	75.43 (19.73)	0.532	0.595
Working condition	354	71.23 (20.60)	331	72.24 (19.12)	0.663	0.507
Emotional exhaustion	361	37.87 (19.48)	337	34.11 (20.47)	−2.488	0.013*
Work-life balance	337	54.80 (13.34)	343	57.56 (12.47)	2.846	0.005**

*$P < 0.05$, **$P < 0.01$.

TABLE 4 | Bivariable analysis of demographic and SAQ, EE, WLB.

Dimension Variable	*n*	SAQ total Mean (SD)	EE Mean (SD)	WLB Mean (SD)
Age group				
[1] 20–40 years	115	69.94 (15.46)	40.63 (18.50)	57.55 (11.04)
[2] 40–60 years	153	71.93 (17.05)	32.74 (19.69)	57.24 (12.79)
[3] ≥60 years	75	77.32 (12.56)	26.98 (22.22)	58.24 (13.94)
P-value		0.001**	<0.001***	0.851
post-hoc		3>1, 2	1>2, 3	
Gender				
Male	68	75.15 (13.72)	28.32 (19.44)	59.77 (11.70)
Female	275	71.77 (16.25)	35.52 (20.50)	57.01 (12.61)
P-value		0.115	0.010*	0.103
Educational level				
High school or less	42	72.48 (16.90)	32.40 (21.80)	60.29 (11.84)
Diploma or Bachelor	270	72.36 (15.69)	35.11 (20.58)	56.92 (12.54)
Master or doctor degree	31	73.07 (16.02)	27.69 (16.77)	59.45 (12.39)
P-value		0.973	0.138	0.179
Tenure				
[1] 3 months-1 year	29	76.42 (17.48)	27.50 (21.97)	62.81 (11.51)
[2] 1–4 years	104	72.17 (16.67)	31.78 (20.70)	59.65 (12.44)
[3] 5–10 years	54	72.04 (13.43)	34.76 (19.48)	56.22 (13.51)
[4] >10 years	156	72.03 (15.73)	36.66 (20.12)	55.65 (11.90)
P-value		0.573	0.082	0.006**
post-hoc				1>4
Profession				
[1] Physician	33	75.26 (12.35)	27.00 (20.51)	56.28 (13.03)
[2] Nurse	135	71.55 (15.32)	41.00 (18.24)	53.54 (12.57)
[3] Technician	53	76.16 (14.38)	28.67 (17.98)	60.78 (9.67)
[4] Administrative	122	71.05 (17.54)	30.66 (21.83)	60.95 (12.04)
P-value		0.108	<0.001***	<0.001***
post-hoc			2>1, 3, 4	3, 4>2
Division				
[1] High risk department	119	69.30 (14.26)	41.14 (18.07)	51.89 (12.05)
[2] OPD/inspection units	162	76.36 (14.54)	30.57 (19.62)	59.74 (12.28)
[3] Administration units	62	68.24 (19.34)	29.70 (23.52)	62.73 (9.52)
P-value		<0.001***	<0.001***	<0.001***
post-hoc		2>1, 3	1>2, 3	2, 3>1
Managerial position				
Yes	64	73.34 (13.72)	37.19 (17.90)	51.95 (13.44)
No	279	72.24 (16.28)	33.41 (20.98)	58.85 (11.90)
P-value		0.576	0.187	<0.001***
Incident reports				
None	278	72.46 (16.07)	32.48 (19.67)	58.98 (12.14)
At least one	65	72.37 (14.83)	41.08 (22.44)	51.48 (12.11)
P-value		0.965	0.002**	<0.001***
Patient contact				
Yes	272	73.03 (15.14)	35.26 (20.34)	56.01 (12.56)
No	71	70.18 (18.15)	29.74 (20.53)	63.48 (10.21)
P-value		0.225	0.044*	<0.001***

EE, emotional exhaustion; WLB, work-life balance.
** P <0.05, ** P <0.01, *** P <0.001.*

those employed in high-risk units ($P < 0.001$), and the managers had a lower average WLB score than did the employees without managerial positions ($P < 0.001$). The respondents who had not reported an incident within the preceding 12 months had a higher average WLB score than did those who had reported at least one incident ($P < 0.001$), and those who had no contact with patients had a higher mean WLB score than did those who have contact with patients ($P < 0.001$). Age, gender, and educational level did not affect WLB score.

Correlations Between SAQ, EE, and WLB

As shown in **Table 5**, the correlation co-efficients for the SAQ subdimensions (except stress recognition) ranged from 0.65 to 0.85. The stress recognition subdimension did not exhibit a linear relationship with any of the other SAQ subdimensions. The total SAQ score was negatively correlated with the EE score and positively correlated with the WLB score. Except for the stress recognition subdimension, all the SAQ subdimensions exhibited significant negative and positive linear relationships with EE and WLB, respectively, indicating that staff members with a lower degrees of EE or greater WLB have more positive attitudes toward patient safety. The stress recognition subdimension was not significantly correlated with WLB ($r = -0.082$, $P = 0.131$) and was negatively correlated with EE ($r = -0.230$, $P < 0.001$). When an individual has low EE, their awareness of their work performance under stress will also be low. EE and WLB were not highly correlated ($r = -0.525$); therefore, when the two were simultaneously input into the regression model as independent variables, the problem of multicollinearity did not arise.

Effect of EE and WLB on SAQ

The hierarchical regression analysis results identify the factors affecting the respondents' attitudes toward patient safety culture in 2021 (see **Table 6**). EE and WLB were used as predictors, and demographic and professional variables (age, gender, educational level, tenure, job role, division, managerial status, number of incident reports, and whether they have contact with patients at work) served as control variables. SAQ subdimension scores were the dependent variables. WLB affects the safety climate (38), and individuals with greater WLB are less likely to experience personal burnout (39), so for the time being, low WLB occurs before burnout. Therefore, demographic and professional variables were input into the model in the first step, and WLB and EE were input into the model in the second and third steps, respectively.

The results of the hierarchical regression model (M1), in which teamwork climate was used as the dependent variable, indicate that demographic and professional variables input in the first step could jointly predict 9% of the variation in teamwork climate, and In the first model (M1), the regression model was significant. When WLB was input in the second step, it accounted for 5% of the variation in teamwork climate [$\Delta R^2 = 0.05$; F (1, 301) = 18.84, $P < 0.001$], and the result of the model (M2) was again significant. When EE was input in the third step, both WLB and EE served as predictors of teamwork climate. As a result, the explanatory power of the full model (M3) increased significantly [$\Delta R^2 = 0.16$; F (1, 300) = 72.77, $P < 0.001$], and only EE was identified as a significant predictor of teamwork climate ($\beta = 0.51$, $P < 0.001$), whereas WLB was not a predictor of teamwork climate in M3 ($\beta = 0.01$, $P = 0.86$). Other full model such as M6, M9, and M14 full models were also only EE was identified as a significant predictor, and WLB was identified as a non-significant predictor of safety climate ($\beta = 0.10$, $P = 0.08$), job satisfaction ($\beta = 0.05$, $P = 0.38$), and perception of management ($\beta = 0.06$, $P = 0.29$). M17 is the only exception, when EE was introduced in the third step, both EE and WLB exerted significant effects on working conditions ($\beta = 0.45$, $P < 0.001$ and $\beta = 0.18$, $P = 0.001$; respectively), but the effect of WLB in M17 was smaller than that in M16 ($\beta = 0.39$, $P < 0.001$).

In the full model, managerial status was a significant predictor of teamwork climate and safety climate. The managers scored higher in these two subdimensions than did the respondents without managerial positions. The respondents who had reported incidents in the preceding 12 months had higher average scores in the safety climate, perception of management, and working conditions subdimensions than did those who did not reported any incident. In addition, to account for the effects of the COVID-19 pandemic, we stratified analysis by division. According to M3, M6, M9, M14, and M17, the respondents who worked in outpatient clinics and inspection units, which tend to have high numbers of patients and short average lengths of stay, scored higher in each SAQ subdimension than did the respondents who were employed in high-risk units such as the ED, inpatient wards, and ORs (Show on M3,6,9,14,17). The respondents who were 60 years old or older had higher job satisfaction (M9), perception of management, and working conditions (M17) scores than did those who were 20–40 years old. Because no significant linear relationship was observed between stress recognition and WLB (**Table 5**), only EE was included in the regression model for stress recognition (M11). M11 indicated that EE was a significant predictor of stress recognition [adjusted $R^2 = 0.10$, $\Delta R^2 = 0.04$; F (1, 318) = 16.00, $P < 0.001$]. To summarize, higher EE is associated with greater stress recognition.

DISCUSSION

By 2021, a year after the onset of the COVID-19 pandemic, the respondents' EE and WLB scores had improved significantly. WLB positively affected scores in the SAQ subdimensions of teamwork climate, safety climate, job satisfaction, perception of management, and working conditions, and EE exerted the strongest effect on the SAQ all subdimension during the COVID-19 Pandemic.

Changes in Patient Safety Culture During the Epidemic

No significant difference was identified between the respondents' 2020 and 2021 average patient safety attitude scores. Effective communication was determined to affect patient safety culture in previous studies (32, 35, 40). From the beginning of the COVID-19 pandemic in 2020 to the present, the implementation of comprehensive infection control interventions mandating the

TABLE 5 | Correlations matrix among dimensions of SAQ, EE, and WLB.

Measurement	1	2	3	4	5	6	7	8	9
1.Teamwork climate	1								
2.Safety climate	0.845**	1							
3.Job satisfaction	0.755**	0.809**	1						
4.Stress recognition	0.019	0.039	–0.016	1					
5.Perception of management	0.732**	0.796**	0.756**	0.021	1				
6.Working condition	0.645**	0.738**	0.706**	–0.072	0.782**	1			
7.Total SAQ score	0.861**	0.909**	0.807**	0.171**	0.826**	0.780**	1		
8.Emotional exhaustion	–0.525**	–0.548**	–0.602**	–0.230**	–0.543**	–0.569**	–0.519**	1	
9.Work-life balance	0.267**	0.317**	0.313**	–0.082	0.307**	0.418**	0.289**	–0.525**	1

** *P < 0.01.*

use of personal protective equipment that covers most of the face has increased the complexity of interpersonal communication (41). In addition, Strict regulations related to infection control undermine mutual support among hospital staff by preventing staff members from helping each other with certain tasks (42).

However, the COVID-19 pandemic has cultivated positive opportunities for interprofessional interactions and teamwork among hospital staff (43), including interdepartmental support and collaboration on tasks in response to policy or outbreak developments, such as the construction of quarantine sites at the entrance of the hospital in 2020 and the implementation of vaccination programs in 2021, both of which were resource-intensive projects (especially for small hospitals).

None of the average SAQ subdimension scores differed significantly between 2020 and 2021. However, according to the cut-off point of 75 points stipulated by the JCT, the attitudes of the employees toward safety climate, job satisfaction, and perception of management changed from negative to positive from 2020 to 2021. The COVID-19 pandemic has forced hospital workers to acknowledge their workplace as a high-risk environment and to abide by various pandemic prevention measures, thereby improving safety awareness and, in turn, patient safety culture.

Sreeramoju et al. (44) adopted a positive deviance approach in their study exploring the social aspects of infection prevention practices, which demonstrated the importance of identifying local role models for accelerating change and developing actionable solutions, which, in turn, strongly affect patient safety climate. Such approaches consistently emphasize strengthening the awareness of patient safety within the hospital, learning through interaction with exemplary role models, and promoting stress management among peers, thereby having positivity about the work experience; these positive attitudes may be reflected in employees' job satisfaction subdimension scores becoming positive These positive attitudes about work experience result from the accumulation of knowledge of and practical experience in dealing with COVID-19, allowing staff to feel autonomous in organizing patient care in the best possible way (42). In this study, because WLB affects safety climate, the positive shift in attitudes regarding safety climate may also be the attributable to an improvement in WLB in 2021.

The respondents' WLB and EE scores improved from 2020 to 2021. EE is the core element of burnout, and it reflects individuals' stress levels (45).At the onset of the COVID-19 pandemic in 2020, medical professionals were under increased pressure from multiple sources, including increased workload, fear of bringing the virus home, possible infection, inability to deal with patients refusing to cooperate with medical procedures, and fear of dealing with patients' emotional issues (such as anxiety and panic), fear of protective equipment shortages putting them at risk when treating critical patients, the need to adapt to frequently changing policies, and obligations to family members and others outside the hospital (22, 41).

Among the problems mentioned above, shortages of personal protective equipment are of particular concern to hospital staff (46), and the difficulty in purchasing protective equipment and the rising prices of such equipment were major challenges faced by hospital managers in the early stages of the pandemic (34). However, with the unified procurement and regulation of masks implemented by the Taiwanese government on January 30, 2020, stress from the Acquisition of materials was slightly alleviated despite the continuing supply shortage. More time could be spent on epidemic prevention. The average workload had decreased due to the cancellation of non-essential surgeries, which resulted from patients' fear of being infected at a hospital (47).

May 2021 was the peak of the COVID-19 pandemic in Taiwan. The Taiwan Centers for Disease Control regulated medical institutions to reduce the workload and instructed such institutions to suspend medical treatments that could be post-poned. In addition, because the hospital in our study was a district hospital, but not a hospital dedicated to COVID-19 patients, the stress of the staff was low, possibly resulting in lower EE scores in August 2021. Furthermore, with continuous education, training, and public awareness efforts regarding the transmission routes and pathogenic mechanisms of COVID-19 and with the provision of infection prevention-related information, medical staff became more familiar with emerging infectious diseases and related treatment procedures. The staff tended to have a higher degree of positive WLB because of the lower workload and fewer shifts in May 2021. Some of the hospital staff had begun dividing their work between home and hospital, which enabled them to manage their work and their

TABLE 6 | Hierarchical models of SAQ.

Variables beta	Teamwork climate				Safety climate		Job satisfaction			Stress recognition		Perception of management			Working condition		
Model	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**	**M12**	**M13**	**M14**	**M15**	**M16**	**M17**
Control variable																	
Age																	
20–40 years [ref]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
40–60 years	0.08	0.10	−0.03	0.12	0.14*	0.01	0.15*	0.17**	0.03	−0.11	−0.06	0.12	0.14*	0.02	0.14*	0.17	0.06
>60 years	0.24**	0.25**	0.10	0.27***	0.27***	0.12	0.38***	0.38***	0.21**	−0.14	−0.06	0.33***	0.33***	0.18**	0.30***	0.30	0.16*
Gender (male)	0.07	0.06	0.05	0.01	−0.01	−0.01	0.03	0.01	0.00	−0.01	0.00	0.05	0.03	0.02	0.05	0.03	0.02
Education level																	
High school or below [ref]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Diploma or college	0.03	0.03	−0.00	0.02	0.02	−0.00	0.04	0.04	0.01	−0.05	−0.03	0.07	0.07	0.04	0.06	0.07	0.05
Graduate	−0.08	−0.08	−0.11	−0.04	−0.05	−0.07	0.02	0.02	−0.01	−0.01	0.00	0.02	0.01	−0.01	0.00	0.01	−0.01
Tenure																	
3 months-1 year	0.16**	0.14**	0.07	0.22**	0.18**	0.10	0.17**	0.14**	0.05	−0.01	0.04	0.20**	0.17**	0.09	0.19**	0.15**	0.08
1–4 years	0.07	0.05	−0.01	0.07	0.04	−0.03	−0.03	−0.06	−0.14	0.14*	0.18**	0.05	0.03	−0.04	0.02	0.01	−0.06
5–10 years	−0.01	−0.01	−0.07	0.04	0.04	−0.02	−0.01	−0.01	−0.08	0.06	0.09	0.00	0.01	−0.05	−0.06	−0.05	−0.10
>10 years [ref]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Profession																	
Nurse [ref]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Physician	0.05	0.03	−0.02	0.04	0.01	−0.04	0.06	0.03	−0.01	−0.14	−0.12	0.03	0.01	−0.03	0.03	0.00	−0.05
Technician	0.01	−0.03	−0.05	0.01	−0.03	−0.05	−0.04	−0.08	−0.10	−0.08	−0.06	−0.01	−0.05	−0.07	0.02	−0.03	−0.05
Administrative	0.03	0.03	−0.01	0.04	0.04	0.01	0.05	0.05	0.01	−0.19*	−0.17	0.02	0.02	−0.01	0.02	0.02	−0.02
Division																	
High risk units [ref]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Opd/inspection units	0.29***	0.24**	0.17*	0.28***	0.21**	0.16*	0.27***	0.20**	0.13*	0.09	0.15	0.31***	0.25**	0.19**	0.28***	0.20**	0.14*
Adm. unit or other	0.04	−0.04	−0.04	0.03	−0.06	−0.07	0.05	−0.04	−0.05	0.15	−0.17*	0.13	0.04	0.04	0.17*	0.04	0.01
Manager (yes)	0.08	0.12*	0.11*	0.07	0.13*	0.11*	0.03	0.09	0.07	0.01	−0.00	0.00	0.04	0.03	−0.06	0.01	−0.11
Incidient report (yes)	0.01	0.05	0.05	0.06	0.11	0.11*	0.02	0.06	0.05	0.02	0.00	0.10	0.14*	0.14**	0.10	0.12*	0.14**
Patient contact (yes)	0.04	0.07	0.06	0.02	0.06	0.03	−0.02	0.01	−0.02	0.00	0.00	0.01	0.04	0.02	−0.03	−0.04	−0.12
Predictive variable																	
WLB	–	0.26***	0.01	–	0.33***	0.10	–	0.31***	0.05	–	–	–	0.29***	0.06	–	0.39***	0.18**
EE	–	–	−0.51***	–	–	−0.49***	–	–	−0.55***	–	0.24***	–	–	−0.48***	–	–	−0.45***
R-square	0.13	0.18	0.34	0.13	0.22	0.37	0.19	0.26	0.45	0.10	0.14	0.15	0.22	0.36	0.16	0.28	0.40
Adjusted *R*-square	0.09	0.14	0.30	0.09	0.17	0.33	0.15	0.22	0.42	0.06	0.10	0.11	0.17	0.32	0.12	0.24	0.36
F	2.86***	3.95***	8.67***	2.94***	5.08***	9.99***	4.66***	6.68***	14.34***	2.23**	3.14***	3.57***	5.13***	9.81***	3.70***	6.96***	11.28***
ΔR-square		0.05	0.16		0.09	0.15		0.07	0.19		0.04		0.06	0.14		0.12	0.12
ΔF		18.84***	72.77***		34.36***	73.41***		31.84***	106.90***		16.00***		25.76***	70.33***		49.73***	61.45**

EE, emotional exhaustion; Ref, reference category; WLB, work-life balance.

** P < 0.05, ** P < 0.01, *** P < 0.001.*

family responsibilities, including children who may have been studying online at home due to the suspension of classes.

Predictors of Patient Safety Culture

Although the predictive value of demographic and professional variables for SAQ subdimension scores was not the focus of this study, the results showed that the respondents employed in outpatient and examination units, which tend to have the highest patient number, had the highest average scores for every SAQ subdimension, except stress recognition. The employees' sensitivity to patient safety had increased because the staff were under frequent exposure to asymptomatic patients and were therefore required to observe strict infection control measures.

Some of the demographic and professional variables exhibited significant predictive power for each SAQ subdimension in the full regression model, which differs from the results reported by Chen et al. (22). This is mainly attributable to the distinct sorting methods used for demographic variables. For example, this study had four categories for the age variable, with three dummy variables, whereas the study by Chen et al. had only two age groups, and the other categorical variables were also dichotomized.

Incident reporting is a critical component of patient safety culture (32). In the present study, the respondents who had reported incidents within the preceding 12 months had higher average scores in the perception of management and working conditions sub-dimensions than did those who had not reported any incident.

Stress recognition was the only subdimension of patient safety culture that did not exhibit a linear relationship with WLB. EE was determined to negatively affect stress recognition, which is consistent with the results of a study on community nurses, which considered high stress recognition scores to be a reflection of longer on-call hours (48), which may be associated with greater EE.

However, scholars using confirmatory factor analysis have reported that stress recognition was a strong one-factor model, and that it is only weakly correlated ($r = -0.15$ to 0.03) with the other five sub-dimensions of the SAQ, indicating that the stress recognition subscale does not fit into the overall safety climate construct in the SAQ, which was designed to reflect safety climate (49). In this study, the correlations between stress recognition and each of the other sub-dimensions ranged from −0.02 to 0.02 ($P > 0.05$), which is similar to the results reported by Taylor and Pandian (49). Stress recognition is the only subdimension of the SAQ that accounts for personal behavior and is affected by many confounding factors (35); therefore, it will not be discussed further the statistical test results related to them in this paper.

Finally, regarding the theoretical basis of the present study, the hierarchical regression test revealed that after demographic and professional variables were controlled for, WLB could predict all SAQ sub-dimensions (except for stress recognition). However, when EE was incorporated into the model, WLB lost its predictive power, which may be because some of the information accounted for by the WLB scale overlapped with that accounted for by the EE scale.

Although a large-scale study indicated that the effect of WLB on the safety climate is achieved entirely through the full mediation of EE and teamwork climate, district hospital staff accounted for only 3.2% of the sample of the study, and the study focused on ICUs, EDs, and ORs (38).

Limitations

Although this study adopted a robust research design, it still has some limitations. First, the study conducted an in-depth analysis of the changes in the patient safety culture as the COVID-19 pandemic progressed. However, it only used variables employed by the JCT and could not, therefore, evaluate the effects of patient safety culture, such as workforce load or employee engagement in patient safety culture. Prospective studies should be conducted in the future. Second, the generalizability of the study results is limited by the small sample of physicians serving as frontline caregivers during the pandemic and the collection of the study data from a single regional hospital in Taiwan.

CONCLUSIONS

This study investigated the changes in patient safety culture in a regional hospital during the COVID-19 pandemic. Health-care professionals employed at the hospital have faced numerous challenges related to the COVID-19 pandemic, such as those related to redeployment of district hospital operators. From 2020 to 2021, the employees' attitudes in three SAQ sub-dimensions—safety climate, job satisfaction, and perception of management—changed from negative to positive. In addition, to preserve medical capacity, the government reduced the workload of health-care professionals, reducing consultations with doctors for psychological conditions. With the decreased labor demand and diversion of workload, EE and WLB significantly improved, and the study results indicate that both EE and WLB are key factors affecting patient safety culture. The results of this study can serve as a reference for hospital managers to develop plans for responding to Crises, which integrate appropriate education, information transparency, and training to motivate staff to participate in learning from incident event, to actively promote patient safety, to exhibit concern for internal issues, and to engage in specific problem solving. A positive patient safety culture can be cultivated with reasonable working hours and effective communication.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by CMUH111-REC-001. Written informed consent for participation was not required for this study

in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

SJW, YCC, and WYH: study conception and design. SJW and YHS: data collection. All authors: data analysis and interpretation, drafting of the article, and critical revision of the article. All authors contributed to the article and approved the submitted version.

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The Effect of Regional Factors on the Mental Health Status of Frontline Nurses and Patients With COVID-19 During COVID-19: The Role of Depression and Anxiety

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At the end of 2019, Wuhan, Hubei Province, China, experienced the ravages of Coronavirus disease 2019 (COVID-19). In a few months, infected people rose to tens of thousands. This study aimed to explore the mental health status of military nurse personnel assisting (non-Hubei area) in the fight against COVID-19 and local nurse personnel (in the Wuhan area), as well as the differences in mental health status between nurses and COVID-19 patients that provide a reference basis for psychological crisis intervention. A convenience sampling method was used to select frontline nurses and COVID-19 patients (sample size 1,000+) from two mobile cabin hospitals from January to March 2020. The questionnaire consists of socio-demographic information, Patient Health Questionnaire 9 (PHQ-9), Generalized Anxiety Disorder 7 (GAD-7), General Mental Health Service Questionnaire and Work Intensity and Physical Status Questionnaire. The results showed that depression was present in 117 nurses (19.73%) and 101 patients (23.33%) with PHQ-9 scores >10; anxiety was present in 60 nurses (10.12%) and 54 patients (12.47%) with GAD-7 >10. The anxiety and depression levels of nurses in Wuhan area were higher than those in non-Hubei area. The differences in PHQ-9 and GAD-7 scores were also statistically significant ($p < 0.001$) when comparing patients from different regions, with anxiety and depression rates of 30.19 and 16.04% in local patients and 16.74 and 9.50% in foreign patients. The comparison between nurses and patients showed that the nurses were more depressed than the patients, while the patients were more anxious. Local nurses in Wuhan had a higher workload intensity than aid nurses (77.72 vs. 57.29%). Over 95% of frontline nurses and patients reported that they had not received any form of psychological counseling before the COVID-19 outbreak. 12.87% (26/194) of frontline nurses in Wuhan had a history of taking hypnotic drugs. However, fewer patients (16/212, 7.55%) took medication than frontline nurses. Anxiety and depression levels were far higher among local nurses and patients in Wuhan than in non-Hubei areas. The nurses had higher levels of depression, while the

patients had higher anxiety levels. Providing targeted mental health services to healthcare professionals and patients is necessary when experiencing the impact of a major event.

Keywords: nurses, patients, COVID-19, mental wellbeing, depression, anxiety

INTRODUCTION

When faced with major emergencies, the population involved in the event often has physical and psychological reactions and may even experience symptoms of post-traumatic stress disorder (1). Firefighters who were on duty during the 9/11 attacks in the United States suffered convulsions, nightmares, and sleep disturbances following their involvement in emergency care (2, 3). According to a World Health Organization (WHO) study, 9% of people who have experienced a crisis event in the past 10 years suffer from a moderate or severe mental disorder, 22% develop depression (4). On January 30th, 2020, the WHO convened an emergency committee on the novel coronavirus epidemic and identified the epidemic in Wuhan, Hubei Province, China, as an international public health emergency (5).

Coronavirus 2019 (COVID-19) is an emerging infectious disease caused by a novel coronavirus with strong infectiveness, high incidence, multiple transmission routes, and widespread epidemiological characteristics (6). There are about 19.8 million confirmed cases of patients with COVID-19 and 5,156,433 cumulative deaths worldwide to date, and few countries have been spared[1]. As the core force in public health emergencies, medical and nursing personnel not only have to face the anxiety and fear of a large number of patients with COVID-19 at the scene of the epidemic but also have to overcome their fear and nervousness of being infected by close contact with patients with COVID-19 (7). In addition, the increased workload and physical strain of wearing physical protective equipment threaten nurses' health (8). The huge workload and psychological pressure could easily lead to different degrees of anxiety, depression, and panic among health care workers. Studies show that 81.8%−92.68% of frontline nurses may have negative emotions due to high work intensity, low experience in responding to public emergencies and lack of protective materials (9). A study also revealed that nursing staff who had cared for suspected or confirmed cases of patients with COVID-19 had significantly higher rates of anxiety and depressive symptoms than the rest of the population (10). Negative emotions can lead to individual stress reactions, which can affect the physical and mental health of health care workers, as well as reduce the quality of work and job satisfaction of health care workers, thus affecting patient outcomes (11, 12).

Due to the severe shortage of medical personnel, medical teams were formed across the country to support Wuhan rapidly. By May 16, 2020, 42,000 medical workers have supported Wuhan, of which nurses account for 68%, far exceeding other medical personnel (13). In the face of the sudden onset and high infectivity of COVID-19, we hypothesize that front-line nurses who assist face greater psychological stress than local front-line nurses. They were more likely to suffer from psychological problems such as guilt, self-blame, insomnia, fear, frustration and powerlessness. In addition, the unfamiliar, high-intensity and high-risk work environment make them also exposed to intense work pressure, which is highly likely to produce negative emotional problems such as depression and anxiety, thus affecting the efficiency of work and causing a certain negative impact on the prevention and control of the epidemic. Chen et al. (14) found that nurses in Taiwan who worked during the outbreak of SARS experienced severe psychological distress. Chen et al. (15), who studied the SARS outbreak, concluded that doctors and nurses exposed to the psychological pressures associated with life-threatening infectious diseases experience high depression and anxiety. Although previous studies have examined the mental health status of frontline nurses, no study has yet described differences in mental health status between nurses in outbreak centers and aid nurses from other provinces.

People diagnosed with COVID-19 are also receiving attention for their mental health and physical pain. In the early stages of the outbreak, individuals with suspected COVID-19 symptoms experienced a variety of mental and psychiatric states (16–18). Wuhan's hospitals were overcrowded before the city's lockdown measures were taken on January 23, 2020. While waiting for diagnosis and treatment, patients are under much psychological stress. Many studies have shown that high psychological and physical stress levels can induce anxiety and depression-like behaviors (19, 20). Previous studies have mainly focused on depression and anxiety levels in patients after infection with infectious diseases (21). According to a study of patients suffering from Middle East Respiratory Syndrome, feelings of anger and anxiety were 16.6 and 7.6%, respectively, in 1,656 patients who were isolated. Part of the anxiety or anger resulted in isolation from family members and friends (22). It is suggested that stress levels of infected patients were raised immediately after infection. Many patients who survived contagious diseases experienced post-traumatic stress disorder (23). However, few studies have examined the emotional differences between patients and nurses. Only a few studies have compared emotional differences between patients and physicians suffering from SARS. Huang et al. (24) included that doctors/nurses infected by SARS experienced fewer emotional disorders than regular patients. Yet, this study's objects were infected medical workers rather than working with the patients, and the sample size is limited.

Therefore, the main purpose of this study was to investigate the influence of regional factors (Wuhan region and non-Hubei region) on the mental health status of nurses and patients, as well as differences in the mental health status of patients and nurses. The results of this study may provide useful information for frontline nurses and patients to develop supportive strategies to improve mental health during the epidemic and timely attention and intervention after the assistance mission.

[1]https://coronavirus.jhu.edu/

MATERIALS AND METHODS

Participants

A convenience sampling method was used to conduct the questionnaire survey in two square cabin hospitals (COVID-19) in Wuhan, Hubei Province, China. The survey was conducted from February 10 to March 10, 2020. Front line nurses (including the Wuhan and non-Hubei areas) and patients (including the Wuhan and non-Hubei areas) were invited to participate in the survey. All questionnaires were distributed and collected on-site at the hospital by doctors.

The Ethics Committee of the Air Force Medical University approved this study (CBA20200315). All procedures were performed in accordance with the ethical standards set by the Declaration of Helsinki.

Measures

Demographic Form

A self-developed questionnaire was used to investigate the demographic information of nurses, including gender, age, educational level, professional title, clinical experience, working duration as a frontline nurse, average working hours per shift, whether Wuhan is the original working place, whether the current department is intensive care unit (ICU). The demographic information of patients consisted of age, education background, occupation, and time of admission to the temporary shelter hospital.

Mental Health Assessment

The Patient Health Questionnaire 9 (PHQ-9) and Generalized Anxiety Disorder 7 (GAD-7) are the quantitative assessment criteria for mental health recommended by the Diagnostic Statistical Manual of Mental Disorders, fifth edition (DSM-V), published by the American Psychiatric Association and have good reliability and validity (25). The depression and anxiety status of participants were evaluated using PHQ-9 and GAD-7, a quick and easy-to-administer screening tool for depression and anxiety, respectively, that is widely used in clinical settings (26, 27).

The PHQ-9-Chinese version was used to assess depression, with nine items self-report instrument, divided into four grades, almost no = 0, some days = 1, more than half = 3, almost every day = 4. Each question is scored from 0 to 3 according to the frequency in the preceding 2 weeks, and a higher score reflects poorer conditions. The total score of PHQ-9 ranged from 0 to 27, in which 0 to 5 was not depressed, 6 to 9 were mild, 10 to 14 was moderate, 15 to 19 was severe, and 20 to 27 was very severe. The PHQ-9 uses a score of 10 as the cutoff value indicating depression (28), and Cronbach's α coefficient is between 0.8 and 0.9 (29).

The GAD-7-Chinese version is a brief self-rating scale of anxiety symptoms developed by Spitzer et al. (30) based on DSM-V to assess the frequency of anxiety symptoms in the past 2 weeks. The GAD-7 scale consists of 7 items on a 4-point scale, not at all = 0, a few days = 1, more than half of the days = 2, and almost every day = 3 (31). The reliability and validity of this scale can effectively reflect the anxiety and degree of the subjects (26).

General Mental Health Service Questionnaire

In order to avoid the participant's anxiety and depression survey results from being affected by the mental health wellbeing that may exist previously before being infected of COVID-19 or before the outbreak, and the possible existing psychological counseling relationship, this study also investigated the possible mental health service happening of the subjects. The survey contains seven questions. Have you received professional psychological assistance before? If so, is the consultation paid or free? What kind of practitioner is your consultant? Is the consultation face-to-face or online? Is the consultation accepted in Hubei or other provinces? And are you taking sleep aids or antidepressants or anxiety drugs?

Nurse's Work Intensity and Physical Status

Taking into account the work situation and physical health of the first-line nurses and the wellbeing of their family members have greatly affected their mental health. A set of questionnaires for these questions was also distributed to the nurses' group. This set of questionnaires investigated the subjects' physical health in detail, including whether or not there were symptoms of suspected infection in the past week. And the intensity of the nurse's work in the past week, including specific working hours and night shifts.

Procedure

For each subject who participated in the survey, their basic information was first collected using a demographic form. The PHQ-9 and GAD-7 were then completed. To avoid the influence of psychological counseling that may exist before the outbreak of COVID-19, the study also used unstructured questionnaires to investigate participants' mental health services before the outbreak. In addition, we also used unstructured questionnaires to investigate the working situation, physical health status and happiness of family members of front-line nurses, which may have an impact on their mental health. The two non-structured questionnaires were assessed and tested by six experts in the field, and the items with content validity index (CVI) >0.78 and Kappa value >0.74 were retained. The final questions are listed in Items in **Tables 5**, **6**.

Statistical Analysis

The Kolmogorov–Smirnov test was used to examine the normal distribution of continuous variables. The mean ± Standard error (Mean ± SE) was used for data with a normal distribution, whereas the median was used for data with non-normal distribution. Differences in demographic and clinical characteristics were tested using the Chi-square tests or two samples independent sample *t*-tests. All the data was performed and analyzed by SPSS 20.0 (IBM Corporation, New York, USA).

RESULTS

Demographic Characteristics

A total of 552 valid questionnaires were collected in the analyses with a recovery rate of 92%, including 195 questionnaires from

local nurses in Wuhan and 357 assisted nurses from non-Hubei regions. Of the 552 frontline nurses, 513 (93.11%) were female, of which 188 (96.53%) were from Wuhan, and 325 (91.3%) were from non-Hubei areas. The majority (89.31%) of nurses were aged between 20 and 40 years, and the number of young nurses from non-Hubei areas was approximately twice as many as in Wuhan. All of them have college-level or education or higher. Current work hours show that the number of nurses working in their current work unit for more than 8 weeks is the highest ($n = 118$, 21.38%). More than half of the nurses in Wuhan (58.91%) and non- Hubei regions (59.34%) have <10 years of experience. Eighty-nine frontline nurses reported that they were transferred from their former workplaces after the COVID-19 outbreak. The demographic information of the nurse is shown in **Table 1**.

A total of 450 questionnaires were distributed to patients, of which 433 (96.2%) valid questionnaires were returned, including 212 (48.96%) patients from Wuhan and 221 (51.04%) patients from non-Hubei regions (**Table 2**). More female patients than male patients from Wuhan (52.80%) and non-Hubei regions (55.70%). The age of these patients ranged from 18 to 60 years. The demographic information of the patients is shown in **Table 2**.

PHQ-9

The statistical results of the PHQ-9 questionnaire are shown in **Table 3**. The results of the PHQ-9 for the nurse population showed a significant difference between nurses from Wuhan and the non-Hubei region ($p < 0.001$). Both the total score and the scores of each question were significantly different. This result indicates that Wuhan nurses are more depressed than non-Hubei nurses. Moreover, the number of local nurses in Wuhan with PHQ-9 scores higher than 10, the threshold for depression, was higher than the number of nurses outside Hubei province.

The results of the PHQ-9 for the patient population showed significant differences in the total PHQ-9 scores between patients from Wuhan and non-Hubei regions ($p < 0.001$). For single items, the differences were significant for 2–8 questions except for the first question ($p = 0.679$), indicating that local patients in Wuhan were significantly more depressed than those in non-Hubei areas. The number of local patients with total PHQ-9 scores higher than 10 was higher than those in non-Hubei regions.

Our study also compared PHQ-9 score between nurses and patients in the Wuhan area (**Figure 1**). The results showed that the average depression score of nurses was 8.44, while that of patients was 8.31, showing no statistically significant difference ($p > 0.05$). In the non-Hubei region (**Figure 2**), the average depression score of nurses was 4.71, and that of patients was 5.6, and there was no statistically significant difference between them ($p > 0.05$).

GAD-7

The results of the GAD-7 for the nurse population showed a significant difference between nurses from the Wuhan area and nurses from non-Hubei areas ($p < 0.001$). Significant differences were demonstrated in both the total score and the score of each question. Moreover, the anxiety level of local nurses in Wuhan was higher than that of nurses in non-Hubei areas. The results

TABLE 1 | Demographics characteristics of nurses on admission.

Basic information	Wuhan *N*/(%)	Non-Hubei *N*/(%)
Gender (Female)	195 (96.53%)	357 (91.3)
Age		
20∼30	98 (48.51)	197 (50.38)
30∼40	72 (35.64)	126 (32.23)
40∼50	25 (12.38)	46 (11.76)
>50	7 (3.47)	22 (5.63)
Education		
College	78 (38.61)	116 (29.67)
Undergraduate	119 (58.91)	264 (67.52)
Master	5 (2.48)	11 (2.81)
Time participates the current work (weeks)		
1	4 (1.98)	52 (13.3)
2	34 (16.83)	31 (7.93)
3	20 (9.9)	24 (6.14)
4	23 (11.39)	85 (21.74)
5	23 (11.39)	66 (16.88)
6	23 (11.39)	37 (9.46)
7	21 (10.4)	10 (2.56)
8	9 (4.46)	13 (3.32)
>8	45 (22.28)	73 (18.67)
Professional qualifications		
Nurse practitioner	64 (31.68)	120 (30.69)
Nurse	72 (35.64)	110 (28.13)
Supervisor's career	54 (26.73)	132 (33.76)
Deputy director's nurse	10 (4.95)	25 (6.39)
Chief nurse	2 (0.99)	4 (1.02)
Years of work		
≤10 years	119 (58.91)	232 (59.34)
11∼20	50 (24.75)	87 (22.25)
21∼30	22 (10.89)	50 (12.79)
>30 years	11 (5.45)	22 (5.63)
Previous department		
Internal medicine	88 (43.56)	32 (8.18)
Men's section	0 (0)	1 (0.26)
Psychiatry	1 (0.5)	122 (31.2)
Emergency department	19 (9.41)	20 (5.12)
ICU	5 (2.48)	5 (1.28)
General branch	10 (4.95)	4 (1.02)
Imaging section	1 (0.5)	0 (0)
Laboratory section	0 (0)	1 (0.26)
Surgical department	37 (18.32)	15 (3.84)
Rehabilitation department	6 (2.97)	153 (39.13)
Logistics department	5 (2.48)	6 (1.53)
Gynecologic	6 (2.97)	3 (0.77)
Pediatric	9 (4.46)	9 (2.3)
Oncology	3 (1.49)	5 (1.28)
Infectious department	6 (2.97)	3 (0.77)
Chinese medicine	2 (0.99)	10 (2.56)
Five official sections	3 (1.49)	1 (0.26)
Dermatology	1 (0.5)	1 (0.26)

(Continued)

TABLE 1 | Continued

Basic information	Wuhan *N*/(%)	Non-Hubei *N*/(%)
Level the hospital		
3A	158 (78.22)	267 (68.29)
3B	3 (1.49)	67 (17.14)
2A	15 (7.43)	51 (13.04)
2B	26 (12.87)	6 (1.53)
Current department		
ICU	9 (4.46)	7 (1.79)
Non-ICU	193 (95.54)	384 (98.21)
Change the working place		
No	156 (77.23)	348 (89)
Yes	46 (22.77)	43 (11)

TABLE 2 | General information of interviewees on admission.

Basic information	Wuhan ($n = 212$)	Non-Hubei ($n = 221$)	p-Value
Gender (Female)	52.80%	55.70%	0.555
Age			
18–35	33.00%	50.70%	0.001
36–60	61.80%	45.20%	
>60	5.20%	4.10%	
Education			
Senior high school and below	21.70%	10.40%	<0.0001
Secondary	26.90%	10.40%	
College	23.10%	24.40%	
Undergraduate	24.50%	39.40%	
Master and above	3.80%	15.40%	
Occupation			
Family of medical staff	0.50%	14.50%	<0.0001
Retirement	17.50%	5.00%	
Student	2.40%	3.60%	
Individual businesses	11.80%	9.00%	
Employee	30.20%	21.70%	
Farmer	1.90%	2.30%	
Other	35.60%	43.90%	
Arrival time at the temporary shelter hospital (weeks, mean, SD)	2.36, 0.62	—	

of the GAD-7 for the patient population showed significant differences between patients in Wuhan and non-Hubei regions ($p < 0.001$). Significant differences were demonstrated in both the total score and the score of each question. Anxiety was significantly greater in local Wuhan patients than in non-Hubei regions.

Our study also compared the GAD-7 of nurses and patients in Wuhan (**Figure 3**), and the results showed that the average anxiety score of nurses and patients was 5.86 and 6.94, respectively, indicating that the anxiety of local patients was higher than that of local nurses. In non-Hubei region (**Figure 4**), the average anxiety score of nurses was 2.91, and that of patients was 3.91. The anxiety degree of non-Hubei patients was higher than that of non-Hubei nurses (**Table 4**).

Working Intensity and Physical Fitness Outcomes of the Frontline Nurses

The results showed that most nurses did not show fever and other symptoms of COVID-19 infection in the past 2 weeks, but they felt strong physical discomfort, including sore throat and dyspepsia. In terms of work intensity, both local nurses in Wuhan and nurses who assisted Hubei in the field experienced higher intensity work than before the outbreak. It is worth emphasizing that the local nurses in Wuhan felt a higher workload intensity than the nurses who assisted Hubei (77.72 vs. 57.29%). In terms of self-assessment, the obvious fatigue is statistically significant in Wuhan local nurses and the nurses who assisted Hubei. **Table 5** shows the frontline nurses' working intensity and physical fitness outcomes.

Previous Mental Health Condition

In this study, more than 95% of frontline nurses reported that they had not received any form of psychological counseling before the COVID-19 outbreak. But it is worth noting that 12.87% of the frontline nurse (26/194) have a history of taking hypnotic drugs in Wuhan. More than 95% of patients reported that they had not received any form of mental health counseling in the past. However, fewer patients were taking medication compared with the frontline nurses (16/212). From an objective point of view, this sudden outburst has become the main cause of their psychological problems. The results of the mental health history are shown in **Table 6**.

DISCUSSION

In this study, we investigated the characteristics of the influence of geographical factors on the mental health status of newly crowned patients and nurses; secondly, we compared the differences in the mental health status of nurses and patients. The results revealed that local nurses and patients in Wuhan had much higher levels of anxiety and depression than in non-Hubei areas; nurses and patients showed different characteristics, with reports indicating higher levels of depression among nurses and higher levels of anxiety among patients.

Previous studies of the SARS and Ebola epidemics have shown that sudden, immediately life-threatening illnesses result in significant stress for health care workers (32). Front-line nurses, who require close contact with patients, confront serious problems such as heavy workload, shortage of protective equipment, fear of infection from family and physical exhaustion, which have a major influence on their physical and mental health (33). A meta-analysis that included 13 cross-sectional studies with a total of 33,062 participants found that during the COVID-19 pandemic, a large proportion of h frontline nurses experienced severe levels of anxiety, depression, and insomnia (34). The prevalence of affective symptoms was higher for women and nurses than for men and physicians. The nurse population is mainly female, so the incidence of affective symptoms is higher

TABLE 3 | Outcomes of PHQ-9 for nurses and patients (Mean ± SE).

Items	Nurses		*p*-Value	Patients		*p*-Value
	Wuhan (*n* = 202)	Non-Hubei (*n* = 391)		Wuhan (*n* = 212)	Non-Hubei (*n* = 221)	
1. Little interest or pleasure in doing things	1.01 ± 0.06	0.64 ± 0.04	<0.0001	0.73 ± 0.04	0.76 ± 0.06	0.679
2. Feeling down, depressed, or hopeless	0.91 ± 0.06	0.48 ± 0.03	<0.0001	0.92 ± 0.05	0.56 ± 0.05	<0.0001
3. Trouble falling or staying asleep, or sleeping too much	1.35 ± 0.07	0.76 ± 0.04	<0.0001	1.24 ± 0.07	0.83 ± 0.06	<0.0001
4. Feeling tired or having little energy	1.23 ± 0.07	0.71 ± 0.04	<0.0001	1.17 ± 0.05	0.83 ± 0.06	<0.0001
5. Poor appetite or overeating	1.1 ± 0.06	0.66 ± 0.04	<0.0001	0.95 ± 0.05	0.65 ± 0.06	0.0001
6. Feeling bad about yourself or that you are a failure or have let yourself or your family down	0.75 ± 0.06	0.43 ± 0.04	<0.0001	0.92 ± 0.06	0.52 ± 0.05	<0.0001
7. Trouble concentrating on things, such as reading the newspaper or watching television	0.88 ± 0.06	0.46 ± 0.04	<0.0001	0.92 ± 0.06	0.65 ± 0.04	0.0007
8. Moving or speaking so slowly that others could have noticed, or being so fidgety/restless that you have been moving more than usual	0.73 ± 0.06	0.36 ± 0.03	<0.0001	0.87 ± 0.05	0.48 ± 0.05	<0.0001
9. Thoughts you would be better off dead, or of hurting yourself	0.49 ± 0.06	0.22 ± 0.03	<0.0001	0.60 ± 0.05	0.33 ± 0.04	<0.0001
Total score	8.44 ± 0.47	4.71 ± 0.26	<0.0001	8.31 ± 0.28	5.60 ± 0.39	<0.0001
	***N* (%)**	***N* (%)**		***N* (%)**	***N* (%)**	
Total PHQ ≥10	63 (31.19%)	54 (13.81%)	<0.0001	64 (30.19%)	37 (16.74%)	0.0009
Total PHQ 0–4	59 (29.21%)	229 (58.57%)	<0.001	33 (15.57%)	113 (51.13%)	<0.001
Total PHQ 5–9	80 (39.6%)	108 (27.62%)		115 (54.25%)	71 (32.13%)	
Total PHQ 10–14	3 3 (16.34%)	29 (7.42%)		43 (20.28%)	19 (8.60%)	
Total PHQ 15–19	15 (7.43%)	20 (5.12%)		19 (8.96%)	12 (5.43%)	
Total PHQ 20–27	15 (7.43%)	5 (1.28%)		2 (0.94%)	6 (2.71%)	

Clinically, the answers to these questions are assigned a score between 0 and 3 (from 0 for "not at all" to 3 for "nearly every day"). For a total range of 0–27. CUT-OFF 10.

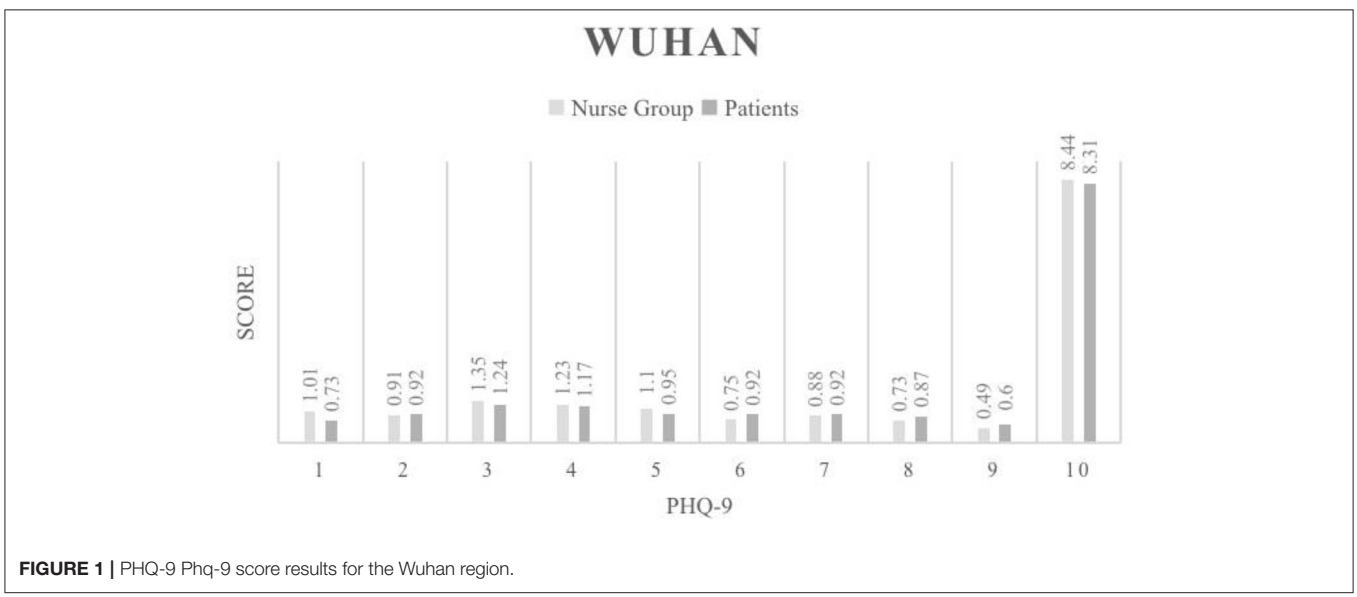

FIGURE 1 | PHQ-9 Phq-9 score results for the Wuhan region.

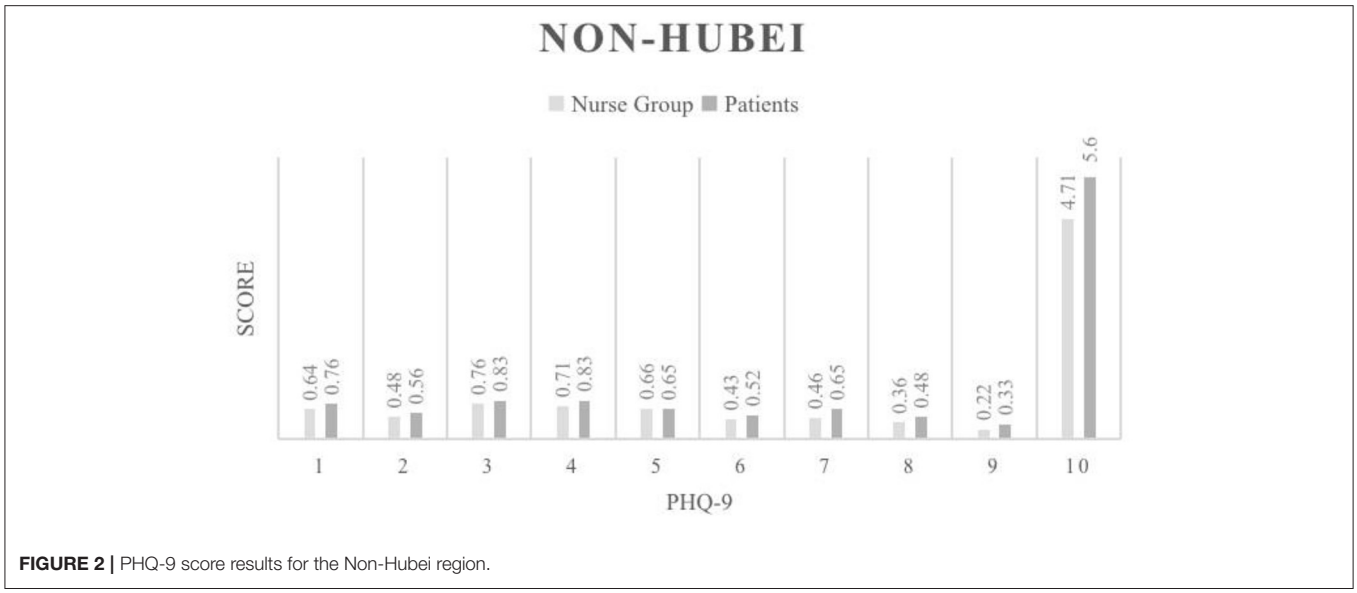

FIGURE 2 | PHQ-9 score results for the Non-Hubei region.

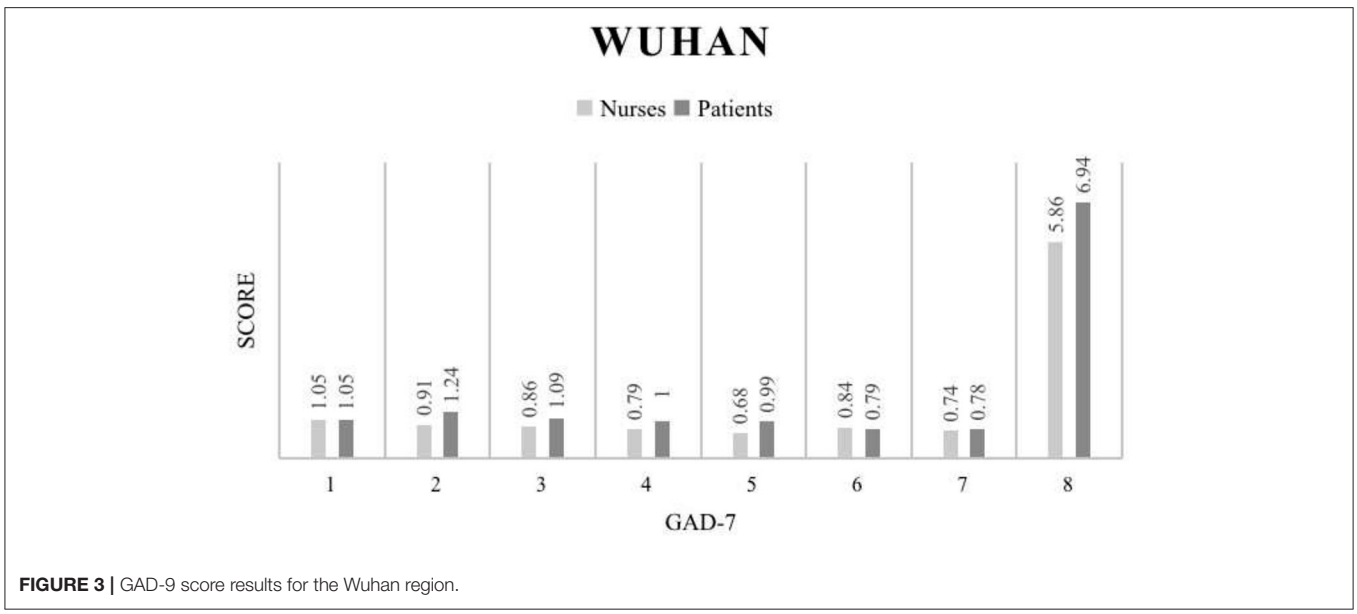

FIGURE 3 | GAD-9 score results for the Wuhan region.

than that of physicians. During a COVID-19 outbreak, nurses are often at greater risk of exposure.

Survey of Regional Factors on Nurses' and Patients' Mental Health

This study is the first comparative study on the psychological status of nurses supporting Hubei province and local nurses. According to the results of PHQ-9, Wuhan local nurses show a significantly higher degree of depression than all non-Hubei nurses in all nine items. The average score of the total has even nearly doubled in the local nurses, most likely because of the increasing number of patients, the shortage of medical resources and the shortage of medical staff in Wuhan before the arrival of foreign aid teams. The long and intensive work made the local nurse experience unprecedented pressure.

Similarly, compared with the record of zero infection in the foreign medical aid teams (34, 35), there was an infection in Wuhan local nurses who lacked protection early stage of the disease. The same similar conclusion is also reflected in the anxiety level of the frontline nurses. In all seven questions of GAD-7, the nurses in the Wuhan are more anxious than the nurses from outside Hubei province, and the total score of GAD-7 is also nearly doubled. These data indicate that anxiety and depression often coexist with health caregivers in high-intensity and high-risk work, coherent with previous studies (36–39).

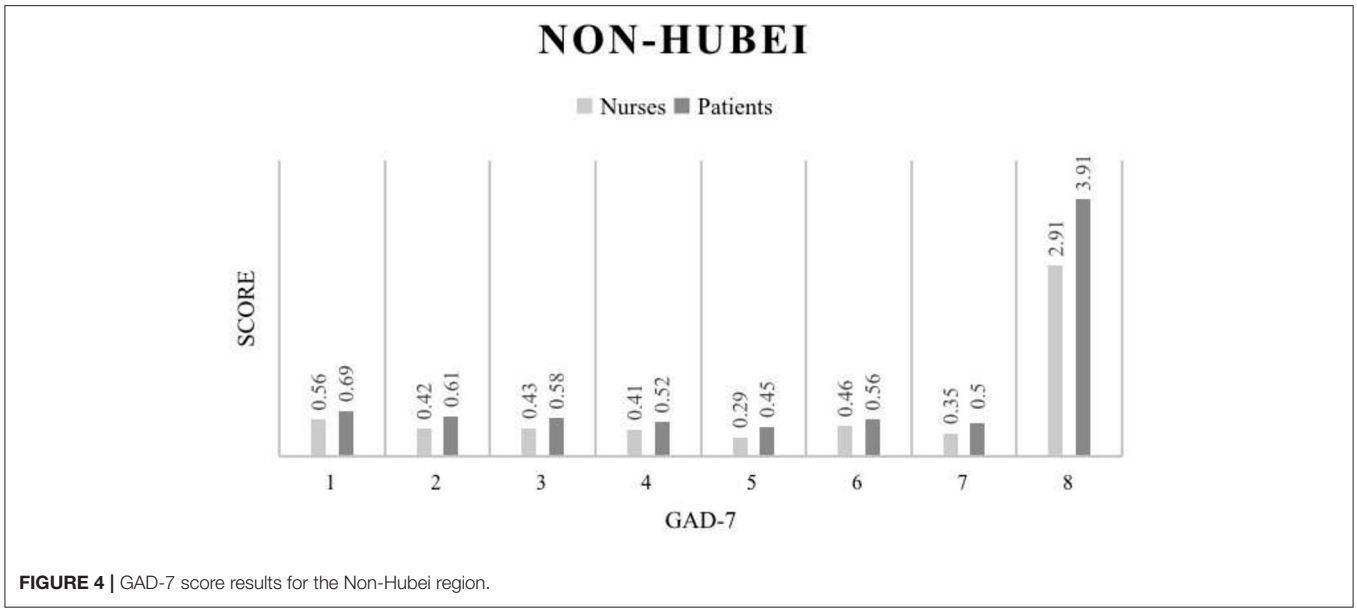

FIGURE 4 | GAD-7 score results for the Non-Hubei region.

TABLE 4 | Outcomes of GAD-7 for nurses and patients (Mean ± SE).

Items	Nurses		*p*-Value	Patients		*p*-Value
	Wuhan (*n* = 202)	Non-Hubei (*n* = 391)		Wuhan (*n* = 212)	Non-Hubei (*n* = 221)	
1. Feeling nervous, anxious, or on edge	1.05 ± 0.06	0.56 ± 0.03	<0.0001	1.05 ± 0.05	0.69 ± 0.05	<0.0001
2. Not being able to stop or control worrying	0.91 ± 0.06	0.42 ± 0.03	<0.0001	1.24 ± 0.06	0.61 ± 0.05	<0.0001
3. Worrying too much about different things	0.86 ± 0.06	0.43 ± 0.03	<0.0001	1.09 ± 0.06	0.58 ± 0.05	<0.0001
4. Trouble relaxing	0.79 ± 0.06	0.41 ± 0.03	<0.0001	1.00 ± 0.06	0.52 ± 0.05	<0.0001
5. Being so restless that it's hard to sit still	0.68 ± 0.06	0.29 ± 0.03	<0.0001	0.99 ± 0.06	0.45 ± 0.05	0.002
6. Becoming easily annoyed or irritable	0.84 ± 0.06	0.46 ± 0.03	<0.0001	0.79 ± 0.05	0.56 ± 0.05	0.0001
7. Feeling afraid as if something awful might happen	0.74 ± 0.06	0.35 ± 0.03	<0.0001	0.78 ± 0.06	0.50 ± 0.05	<0.0001
Total score	5.86 ± 0.40	2.91 ± 0.20	<0.0001	6.94 ± 0.22	3.91 ± 0.30	<0.0001
Total score ≥10	37 (18.32%)	23 (5.88%)		34 (16.04%)	20 (9.50%)	0.041
Total score 0–4	91 (45.05%)	277 (70.84%)		45 (21.23%)	134 (60.63%)	<0.0001
Total score 5–9	74 (36.63%)	91 (23.27%)		133 (62.74%)	65 (29.86%)	
Total score 10–13	9 (4.46%)	8 (2.05%)		24 (11.32%)	7 (3.17%)	
Total score 14–18	17 (8.42%)	12 (3.07%)		90 (4.25%)	11 (4.98%)	
Total score 19–21	11 (5.45%)	3 (0.77%)		10 (0.47%)	3 (1.36%)	

CUT-OFF 10.

According to the history of psychological counseling and medication use reported that nurses from other provinces have more experience with psychological counseling than nurses in Wuhan. Nevertheless, the vast majority of nurses have no experience with psychological counseling. The report also showed that in terms of drug use, more nurses in the Wuhan were more likely to choose sleep aids and antidepressants or anti-anxiety medications, suggesting that when faced with more intense stress, the Wuhan nurses preferred assistance with drugs rather than psychological counseling services. It is possible that nurses lacked time and availability for psychological counseling during the epidemic; therefore, this study recommends introducing online counseling services to field nurses.

The same number of male and female respondents were reported based on patient demographic information, with a wide

TABLE 5 | Work intensity and physical condition of nurses.

Items	Wuhan (%)/*N*	Non-Hubei (%)/*N*	*p*-Value
Do you have a fever in the last 2 weeks?			
No	195 (96.53)	388 (99.23)	0.0363
Yes	7 (3.47)	3 (0.77)	
Do you have respiratory symptoms in the last 2 weeks?			
No	164 (81.19)	386 (98.72)	<0.0001
Yes	38 (18.81)	5 (1.28)	
Do you have systemic symptoms in the last 2 weeks?			
No	179 (88.61)	387 (98.98)	<0.0001
Yes	23 (11.39)	4 (1.02)	
(A) (None)			
No	67 (33.17)	24 (6.14)	<0.0001
Yes	135 (66.83)	367 (93.86)	
(B) Sore throat			
No	154 (76.24)	375 (95.91)	<0.0001
Yes	48 (23.76)	16 (4.09)	
(C) Anti-acid reflux			
No	196 (97.03)	389 (99.49)	0.0213
Yes	6 (2.97)	2 (0.51)	
(D) Indigestion			
No	185 (91.58)	387 (98.98)	<0.0001
Yes	17 (8.42)	4 (1.02)	
(E) Diarrhea			
No	189 (93.56)	387 (98.98)	0.0004
Yes	13 (6.44)	4 (1.02)	
(F) Constipation			
No	182 (90.1)	382 (97.7)	0.0002
Yes	20 (9.9)	9 (2.3)	
(G) Bloated			
No	192 (95.05)	389 (99.49)	0.0006
Yes	10 (4.95)	2 (0.51)	
(H) Abdominal pain			
No	198 (98.02)	389 (99.49)	0.1875
Yes	4 (1.98)	2 (0.51)	
Other			
No	192 (95.05)	385 (98.47)	0.015
Yes	10 (4.95)	6 (1.53)	
In the last 2 weeks, did your lung CT show any signs of "ground glass shadow"?			
No	196 (97.03)	391 (100)	0.0015
Yes	6 (2.97)	0 (0)	
The last month, there has been change work position?			
No	44 (21.78)	151 (38.62)	<0.0001
Yes	158 (78.22)	240 (61.38)	
On average, how many day shifts are in a week?			
0–2	70 (34.65)	145 (37.08)	0.7223
3–5	99 (49.01)	178 (45.52)	
>5	33 (16.34)	68 (17.39)	
On average, how many night shifts are in a week?			
0–2	129 (63.86)	329 (84.14)	<0.0001
3–5	68 (33.66)	52 (13.3)	
>5	5 (2.48)	10 (2.56)	
What is the average length of work per shift?			
<8 h	142 (70.3)	157 (40.15)	<0.0001
8–16 h	59 (29.21)	228 (58.31)	
17–24 h	1 (0.5)	6 (1.53)	
Compared to the outbreak before, about the last 2 weeks of your work intensity, you think:			
It's not very different	45 (22.28)	167 (42.71)	<0.0001
It's harder than before	92 (45.54)	169 (43.22)	
Significantly harder than before	65 (32.18)	55 (14.07)	
Have you taken the following isolation measures?			
No	39 (19.31)	271 (69.31)	<0.0001
Self-isolation at home	22 (10.89)	68 (17.39)	
Separation from the family	141 (69.8)	52 (13.3)	
Are there any family members in your home who need to be cared for?			
No	80 (39.6)	196 (50.13)	0.0002
Older person	42 (20.79)	40 (10.23)	
Infants or children	66 (32.67)	143 (36.57)	
Pregnant women	0 (0)	2 (0.51)	
People with disabilities	1 (0.5)	0 (0)	
Other needs to be taken care of	13 (6.44)	10 (2.56)	
In the last 2 weeks, have your family had respiratory symptoms?			
No	187 (92.57)	385 (98.47)	0.0002
Yes	15 (7.43)	6 (1.53)	
No	200 (99.01)	391 (100)	0.1157
Yes	2 (0.99)	0 (0)	
According to your feelings and experience, how often does the following situation appear to you?			
Work makes me feel physically and mentally exhausted			
Never	12 (5.94)	95 (24.3)	<0.0001
Occasionally	89 (44.06)	226 (57.8)	
Regularly	52 (25.74)	49 (12.53)	
Frequently	16 (7.92)	13 (3.32)	
Daily	33 (16.34)	8 (2.05)	
I feel exhausted after work			
Never	12 (5.94)	89 (22.76)	<0.0001
Occasionally	82 (40.59)	209 (53.45)	
Regularly	54 (26.73)	68 (17.39)	
Frequently	19 (9.41)	15 (3.84)	
Daily	35 (17.33)	10 (2.56)	
I feel very tired when I wake up in the morning and have to face a day of work			
Never	30 (14.85)	165 (42.2)	<0.0001
Occasionally	78 (38.61)	179 (45.78)	
Regularly	52 (25.74)	28 (7.16)	
Frequently	11 (5.45)	12 (3.07)	
Daily	31 (15.35)	7 (1.79)	

(Continued)

TABLE 5 | Continued

Items	Wuhan (%)/*N*	Non-Hubei (%)/*N*	*p*-Value
I doubt the significance of the work I do			
Never	93 (46.04)	284 (72.63)	<0.0001
Occasionally	71 (35.15)	82 (20.97)	
Regularly	19 (9.41)	17 (4.35)	
Frequently	5 (2.48)	4 (1.02)	
Daily	14 (6.93)	4 (1.02)	
According to your feelings and experience, how often does the following situation appear to you?			
I can effectively solve problems at work			
Never	2 (0.99)	13 (3.32)	0.0424
Occasionally	19 (9.41)	27 (6.91)	
Regularly	94 (46.53)	144 (36.83)	
Frequently	25 (12.38)	54 (13.81)	
Daily	62 (30.69)	153 (39.13)	
I feel I am making contribution to the hospital			
Never	3 (1.49)	10 (2.56)	0.0252
Occasionally	28 (13.86)	27 (6.91)	
Regularly	73 (36.14)	129 (32.99)	
Frequently	20 (9.9)	34 (8.7)	
Daily	78 (38.61)	191 (48.85)	
In my opinion, I am good at my job			
Never	2 (0.99)	13 (3.32)	0.0034
Occasionally	25 (12.38)	21 (5.37)	
Regularly	79 (39.11)	137 (35.04)	
Frequently	28 (13.86)	47 (12.02)	
Daily	68 (33.66)	173 (44.25)	
I am confident that I can do all the work effectively			
Never	2 (0.99)	10 (2.56)	0.0088
Occasionally	17 (8.42)	15 (3.84)	
Regularly	79 (39.11)	127 (32.48)	
Frequently	29 (14.36)	46 (11.76)	
Daily	75 (37.13)	193 (49.36)	

age range. In general, however, relatively more middle-aged and older infected individuals participated in this study, which is consistent with this COVID-19 infection epidemiological survey (40–42). There were no significant differences in occupation or educational background in the infected population. The transmission characteristics of foreign outbreaks also reported no clear trend of virus infection for specific occupations and educational backgrounds (43, 44).

In terms of depression, Wuhan patients showed more obvious depression mood than eight non-Hubei patients in eight of the nine questions in the PHQ-9 survey, and the total score statistics also significantly surpassed the latter. This is related to the time of onset of Hubei patients and the time in line to wait for the hospital admission. In addition, it should also be noted that these local Wuhan patients lacked awareness of the COVID-19 at the early stage of the epidemic outbreak. When they developed symptoms, they received only normal fever or other treatments, and when the disease worsened, a series of physical and psychological changes occurred. The results of anxiety and depression show matching. But it is worth to be mentioned that the anxiety level of Wuhan patients is slightly lower than that of patients in other regions of China and slightly higher than the data of depression level of both. A reasonable explanation is that when a patient receives treatment, more emotions about their condition and the outside world are reflected in the level of anxiety rather than depression. To confirm this conclusion, more research needs to be done. According to the history of psychological counseling and drug use reported, there is no obvious difference between Wuhan patients and patients in other places of China. This also objectively shows that the COVID-19 virus does not tend to these aspects. And the mental health of patients in Wuhan is not different from patients in other parts of China.

Comparison of Differences in Mental Health Status Between Nurses and Patients

We first compared the results of frontline nurses and patients in Wuhan (**Figure 1**). The results of the PHQ-9 scores showed that frontline nurses in Wuhan had slightly higher levels of depression than patients. In particular, there was a statistically significant difference between the frontline nurses and patients in terms of loss of interest in other things, which objectively indicates a higher level of depression among both patients and health care workers in Wuhan, but the overall situation was worse for overworked nurses. From a psychological support perspective, both populations need counseling and encouragement, and these results provide a reference for countries with high epidemic prevalence, such as EU member states and the United States, which are experiencing a severe test of COVID-19. According to the statistical results of the non-Hubei area, both nurses and patients in the non-Hubei area had significantly lower PHQ-9 scores than the Wuhan (**Figure 2**). However, patients in the non-Hubei were more likely to be anxious than nurses. It is reasonable to explain that nurses in the non-North Lake group had better protection and peer nurses supported each other. But when a patient is infected, fear of the unknown disease develops. However, patients in the non-Lakeland group were more likely to be anxious than nurses, and a reasonable explanation is that nurses in the non-Lakeland group had better protection and peer nurses supported each other. When a patient is infected, there is fear of the unknown disease. **Figure 3** below shows the specific data.

Amusingly, the results for anxiety appear to be the opposite of the results for depression. According to the data of the Wuhan area, the patients have more obvious anxiety than the nurses. This emotion is particularly reflected in the inability to control anxiety, inability to sleep, and irritability. There was a statistically significant difference between patients and nurses on the total score. A reasonable guess at this set of figures is that nurses work hard and don't have much time to think about other things, whereas patients are unable to contact their family members in

TABLE 6 | Mental health service for nurses and patients.

Items	Nurses (Mean ± SE)		Patients	
	Wuhan (*N* = 202)	Non-Hubei (*N* = 391)	Wuhan (*N* = 212)	Non-Hubei (*N* = 221)
Have you received professional psychological assistance? (%):				
Yes	194 (96.04 %)	375 (95.91%)	11 (5.2%)	9 (4.1%)
No	8 (3.96%)	16 (4.09%)	201 (94.8%)	212 (95.9%)
What kind of professional psychological assistance have you received? (%):				
No	194 (96.04 %)	375 (95.91%)	/	/
Paid service	1 (0.5%)	10 (2.56%)		
Free service	7 (3.47%)	11 (02.81%)		
What kind of expert's assistance have you received? (%):				
No	194 (96.04%)	378 (96.68%)	/	/
Psychiatrist	0	2 (0.51%)		
Counselor	6 (2.97%)	8 (2.05%)		
Social worker	1 (0.5%)	2 (0.51%)		
Other	1 (0.5%)	1 (0.26%)		
What kind of psychological assistance has been received? (%)				
No	194 (96.04%)	378 (96.68%)	/	/
On-site consultation	3 (1.49%)	6 (1.53%)		
Online consultation	5 (2.48%)	7 (1.79%)		
What sources of psychological assistance have you received? (%)				
No	194 (96.04%)	80 (96.19%)	/	/
Doctors in Hubei Province	3 (1.49%)	1 (0.26%)		
Doctors outside Hubei Province	5 (2.48%)	10 (2.56%)		
Do you take a sedative or hypnotic drugs? (%):				
Yes	176 (87.13%)	374 (95.65%)	15 (7.08%)	8 (3.62%)
No	26 (12.87%)	17 (4.35%)	197 (92.92%)	213 (96.38%)
Do you take antidepressant and anxiety drugs? (%):				
Yes	195 (96.53%)	387 (98.98%)	8 (3.77%)	4 (1.81%)
No	7 (3.47%)	4 (1.02%)	204 (96.23%)	217 (98.19%)

/ Too few people to count.

the hospital, but seeing more and more patients enter the hospital makes them more restless.

The results of the GAD-7 data comparison between non-Hubei patients and nurses reveal that more statistically significant differences can be observed (**Figure 3**), further confirming the reasonable speculation of anxiety mentioned above. Although the overall level of anxiety was not as pronounced as in Wuhan, the anxiety status of patients in non-Hubei areas was still a cause for concern. These results suggest that with limited resources for psychological support, priority is given to psychological support for people in the hardest-hit areas. For example, in the European Union region (45), Italy's Lombardy region (46), and New York City in the United States (47), this COVID-19 infection high-risk patients require anxiety relief work. **Figure 4** below shows the specific data of the non-Hubei class.

Sudden public events cause varying mood swings in those affected by them, and some symptoms of depression and anxiety disorders emerge. At the end of 2019, an outbreak of novel coronavirus pneumonia in Wuhan caused a huge shock on residents, healthcare professionals, families and patients in different areas. According to the findings of this survey, the intense workload and risk of infection following the outbreak caused both local and field nurses to experience significant depression and anxiety, with local nurses in Wuhan showing more pronounced depression and anxiety due to their long working hours and lack of protection in the early days. Although health care professionals did not face significant risks and other problems, patients admitted to the hospital also had significant anxiety and depression. According to the survey results, after the outbreak, local nurses in Wuhan showed more pronounced depression and anxiety than nurses in non-Hubei areas due to their long early working hours and lack of protection. Although medical workers and other issues face no major risks, the admitted COVID-19 patients also felt significant anxiety and depression. By comparing the nurses and patients in the high-risk and low-risk areas, it was clear that medical staff and patients in the high-risk area experienced more intense emotional distress. That can explain why some nurses in Italy chose to commit suicide after learning they were infected with the virus under stressful work conditions and lack of medical supplies (48). In addition, even in areas where the epidemic was not prominent, psychological changes occurred among medical staff

and patients, with patients exhibiting significant anxiety. These data support the development of future psychological work in public emergencies.

Limitation and Future Outlook

This study adopted a survey method and the sample size exceeded 1,000. However, Wuhan's COVID-19 patients and full-time nurses far exceed this number from a research perspective. Therefore, the sample size covers a small range. In addition, this study mainly focuses on the influence of regional factors on the mental health status of nurses and patients, as well as the differences between patients and nurses. However, in real life, not only regional factors may affect the anxiety and depression of these subjects. Although we have collected demographic variables such as age, education level and working years, we have not conducted further analysis on these variables in this paper. Future studies can comprehensively consider the impact of regional factors and other demographic factors on people's psychological status in the context of the epidemic.

In terms of clinical intervention, although research surveys show that both the nurse group and the patient group are suffering from depression and anxiety, the counseling interventions that can be done are very limited. One reason is that the nurses were very busy during the epidemic and did not have time to receive professional psychological counseling. Another reason is that the flow of nurses and patients is obvious, and it is difficult to track the follow-up status of subjects after a one-time questionnaire. Although various provinces in China have sent a certain number of psychological counseling workers to support Wuhan, the number of patients who can receive counseling is limited, and this number is even less for medical staff. The SARS that broke out in China in 2003 has put the country through a test. The lack of related psychological counseling services has prompted the investigation of psychological counseling services in this COVID-19 epidemic. Although it is not yet possible for everyone to receive psychological support, it is believed that more and more psychological support will be given to people fighting the disease on the road of human anti-epidemic. Up to now, more and more countries in the world have been violently impacted by the COVID-19, and China's successful anti-epidemic experience is worth promoting and learning. Hopefully, other countries will lead the way in terms of psychological support.

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 Ethics Committee of the Air Force Medical University approved this study (CBA20200315). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

Conceptualization: HW. Methodology: FL, XN, and SZ. Software: JT. Writing—original draft preparation: SZ. Writing—review and editing: XWei, XWang, FL, and SZ. Funding acquisition: XWang. All authors contributed to the article and approved the submitted version.

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Improving Recovery of Irritant Hand Dermatitis in Healthcare Workers With Workplace Interventions During the COVID-19 Pandemic

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Introduction: Occupational hand dermatitis is common among healthcare workers, with increased incidence during the COVID-19 pandemic. Irritant contact dermatitis accounts for the majority of occupational hand dermatitis and is largely due to frequent contact with hand hygiene products. Long-term prognosis of occupational contact dermatitis is often very poor. This study aims to identify and implement suitable workplace interventions to aid in the recovery of occupational irritant hand dermatitis among healthcare workers during the COVID-19 pandemic.

Methods: A quality improvement (QI) project was performed in a tertiary hospital using the Plan-Do-Study-Act model. Healthcare workers seen at the Occupational Dermatology Clinic from March 2020 to May 2021 for the first time for likely occupational irritant dermatitis were targeted for the project. Four workplace interventions were implemented: (a) substitute current alcohol-based hand rub (ABHR) with a different, gentler ABHR, (b) alternate ABHR with gentle hand wash products, (c) temporary job modification with less clinical work (d) switch latex gloves to nitrile gloves. The improvement was assessed after 2 months of workplace intervention using a visual analogue scale, based on changes seen on photographs taken at the baseline and monthly review. The target improvement was set at 70% after 2 months of workplace interventions.

Results: A total of 21 participants were included in the QI project. All participants were found to have significant improvement in their hand condition. The estimated mean reduction of signs and symptoms was 80% in comparison to their baseline hand condition before intervention.

Conclusion: Workplace interventions such as substituting irritant hand hygiene products with gentler alternatives and temporary reduction in clinical duties may be useful in improving the recovery rate of irritant hand dermatitis among healthcare workers. Areas with high hand hygiene workload or high incidences of hand dermatitis may opt to implement systemic workplace changes.

Keywords: COVID-19, healthcare workers, occupational dermatitis, workplace intervention, quality improvement

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INTRODUCTION

Hand dermatitis is common among healthcare workers with reported prevalence ranging from 21 to 55% across different studies (1–4). Hand dermatitis in healthcare workers can be largely attributed to repeated hand hygiene activities, such as hand washing and the use of hand sanitizers which are known irritants (5).

Irritant contact dermatitis (ICD) accounts for 80% of occupational contact dermatitis (5–7). Cumulative exposure to irritants from hand washing and hand hygiene products directly damages the skin surface, initiating a cascade of inflammatory changes (5, 7, 8). Allergic contact dermatitis (ACD) contributes to the remaining 20% of occupational dermatitis (6). Preservatives, fragrances, and antimicrobial agents found in hand hygiene products, as well as latex and rubber accelerators in latex gloves may cause allergic reactions (5, 9, 10). Prolonged use of gloves was also associated with adverse reactions of the hands (11, 12).

Infection prevention measures were enhanced across multiple settings during the COVID-19 pandemic. In the healthcare setting, the pandemic has resulted in increased hand hygiene activities and prolonged use of personal protective equipment among its workers from high patient load and heightened infection prevention activities. Combined with insufficient downtime for skin recovery and inadequate moisturising of hands, healthcare workers are at higher risk of developing occupational contact dermatitis during the pandemic (5, 13, 14).

The long-term prognosis of occupational contact dermatitis is often very poor due to continuous exposure and can negatively impact the workers (15). A study reported recovery of occupational skin disease in only 28% of healthcare workers 6 months after diagnosis (16). Prolonged dermatitis not only affects the quality of life and work productivity, it can also be a barrier to hand hygiene compliance (17). Colonisation of skin surfaces with microorganisms is also more common in damaged skin, posing a potential risk for nosocomial infection transmission (18).

We aim to identify and implement suitable workplace interventions to aid in the recovery of occupational irritant contact dermatitis among healthcare workers during the COVID-19 pandemic. Although principles of workplace management such as identification and avoidance of precipitants, workplace educational programmes, and use of hand protection with gloves and barrier creams have been widely suggested, the effects of direct workplace interventions have yet to be adequately researched (19). The findings of this study can aid healthcare institutions in implementing workplace changes as part of the management of occupational ICD among their workers.

METHODS

The study was performed as a quality improvement (QI) project at a tertiary hospital in Singapore during the COVID-19 pandemic. The QI project team comprised of an Occupational Medicine (OM) physician and OM trainees. The target population of the project was healthcare workers seen at the Occupational Dermatology Clinic for likely occupational ICD. All healthcare workers seen at the clinic for their first consultation from March 2020 to May 2021 were included in the QI project as part of the occupational management for their skin condition, with their consent.

The Plan-Do-Study-Act (PDSA) model was utilised for the conception and implementation of the project (20). During the "Plan" component of the PDSA cycle, a root cause analysis based on the 5 WHYs model, identified causes of slow recovery time for ICD amongst healthcare workers (**Figure 1**) (21). The identified root causes were: (i) frequent exposure to hand hygiene products, (ii) inadequate moisturising, (iii) high hand hygiene load, and (iv) others (e.g., allergic contact dermatitis). Healthcare workers were also asked about the presence of the identified root causes to further quantify the frequency of these factors.

During the "Do" phase of the PDSA cycle, the team proposed possible direct workplace interventions to tackle the identified root causes. These interventions were generated and scored by the team members based on four different criteria: effectiveness, feasibility, sustainability, and low cost (**Figure 2**, **Table 1**). Each criterion was scored between 1 and 5, with 1 for poorly meeting the criteria and 5 for meeting the criteria well. The effectiveness of control measures was considered based on the principles of the hierarchy of controls from the National Institute for Occupational Safety and Health (NIOSH) (22). Feasibility and sustainability were scored based on the relative ease of implementation for short-term and long-term periods. The cost of interventions was scored based on estimated expenditures or resources required to replace current products or manpower. Possible solutions scoring 15 and above were included in the programme.

Four workplace interventions were chosen for the programme:

(a) Substitute current alcohol-based hand rub (ABHR) with a different, gentler ABHR
(b) Alternate ABHR with gentle hand wash products
(c) Temporary job modification with less clinical work
(d) Switch latex gloves (potential allergen) to nitrile gloves

Workplace interventions (a), (b), and (d) were implemented for all participants while workplace intervention (c) was only implemented for participants with moderate-severity hand dermatitis, due to the reduced sustainability of the intervention. The participants were given medical letters addressed to their direct superiors for implementation of the workplace interventions.

All participants were advised on hand hygiene care, such as moisturising techniques and avoidance of household irritant products. All participants were prescribed similar topical creams including topical steroid cream and moisturisers as part of their standard care of treatment.

The hospital generally used one type of ABHR, which consists of 100% ethanol, 1-propanol, emollient, moisturiser, and fragrances. The proposed substitute ABHR consists of 70% ethanol, emollients, and moisturiser, and was readily available at the hospital. It was considered to be a gentler alternative based on lower alcohol concentration and positive response from other healthcare workers seen at the Occupational Dermatology Clinic

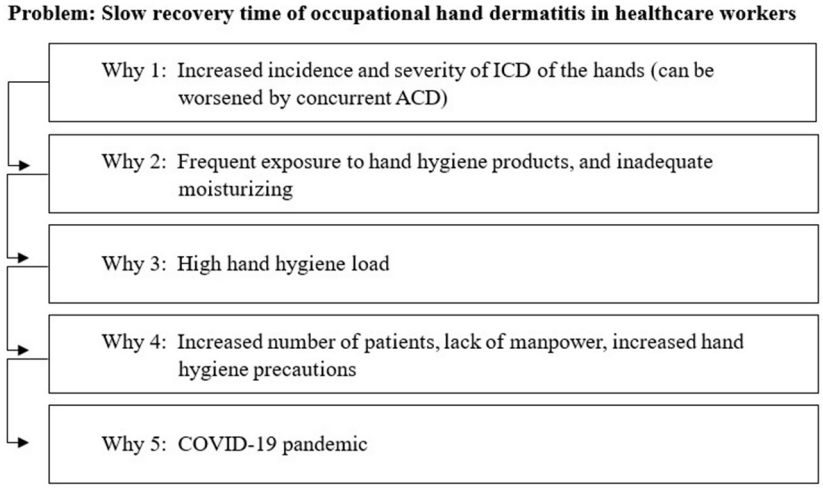

FIGURE 1 | Root-cause analysis using the 5 Whys technique.

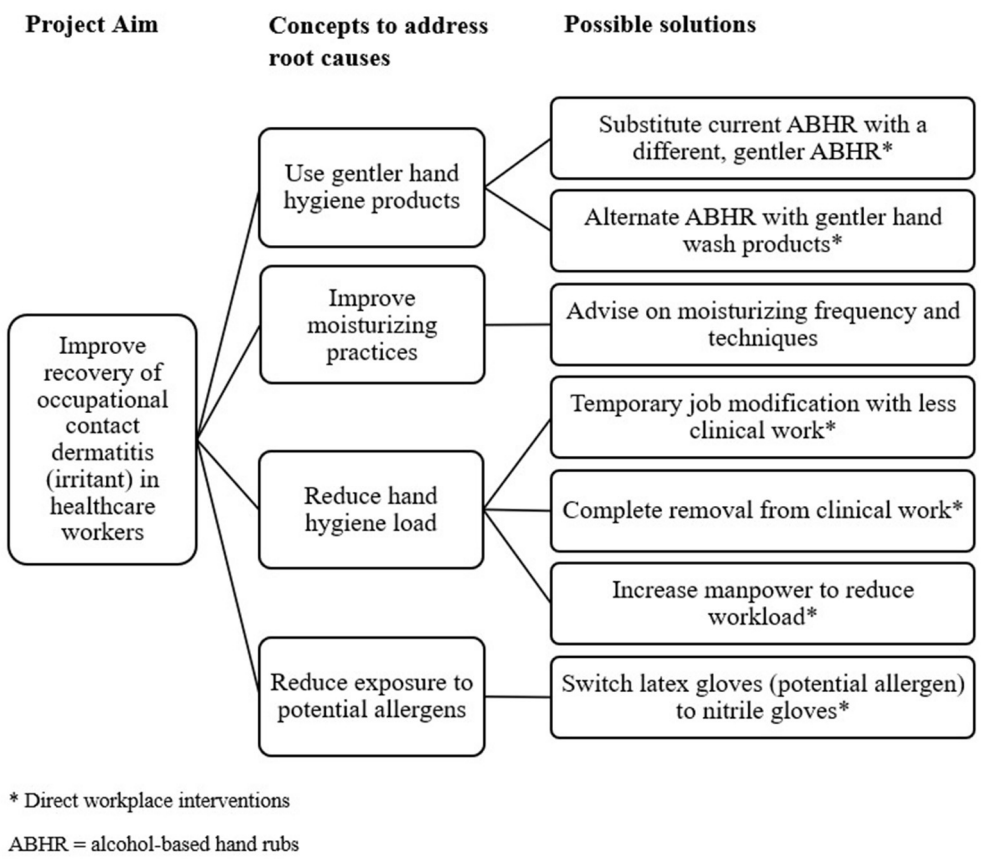

FIGURE 2 | Generating solutions with a tree diagram.

previously, before the COVID pandemic. A mild, germicidal wash lotion with added moisturiser was proposed for the hand wash alternative.

The team subsequently implemented the proposed interventions with the support of key stakeholders such as team supervisors and patients.

TABLE 1 | Prioritisation matrix for possible workplace interventions.

Possible workplace interventions	Effectiveness	Feasibility	Sustainability	Low cost	Total score
Substitute current ABHR with a different, gentler ABHR	4	5	5	5	19*
Alternate ABHR with gentler hand wash products	3	5	5	5	18*
Temporary job modification with less clinical work	4	4	3	4	15*
Complete removal from clinical work	5	2	1	2	10$^{\Delta}$
Increase manpower to reduce workload	4	1	2	1	8$^{\Delta}$
Switch latex gloves (potential allergen) to nitrile gloves	3	5	5	5	18*

Scoring: 1—meets criteria poorly. 5—meets criteria well.
ABHR = alcohol-based hand rubs.
**Included in the programme.*
$^{\Delta}$Excluded from the programme.

The results were analysed during the "Study" phase of the PDSA cycle. Photographs of the hands were taken at the first visit and during subsequent clinic reviews at one-monthly intervals. The same OM physician assessed the degree of improvement by comparing the hand condition during clinic reviews against photographs of the hands during the first visit. The percentage improvement is based on the change from a visual analogue scale (23). Zero percent constitutes no improvement, and 100% improvement meant complete recovery. All assessments of improvement were approximate in nature, in relation to the signs and symptoms of hand dermatitis in the participants.

The target improvement for the QI project was set at 70% after 2 months of workplace interventions. Baseline comparison was deemed as no improvement (0% improvement) in ICD without workplace interventions, which was based on previous reviews of healthcare workers seen at the Occupational Dermatology Clinic with ICD.

The effects of the workplace interventions, future plans, and possible impact were discussed in the "Act" phase of the PDSA cycle.

The workplace interventions were performed as part of the standard occupational management for the participants presented to the Occupational Dermatology Clinic. The interventions were implemented systematically as a QI project to improve the recovery of hand dermatitis among healthcare workers and were approved by the hospital's Quality Improvement Committee. All the participants gave their verbal and written consent to be included in the QI project.

RESULTS

A total of 21 participants were included in the project, consisting of medical doctors, nurses and allied healthcare workers (**Table 2**). The majority of participants were female nurses, in the age range of 21–30 years old.

Frequent use of hand hygiene products was identified in all the participants, with 12 of them reported to have a high daily hand hygiene count of 50 times or more approximately. More than half were also found to moisturise their hands infrequently. Other factors that might contribute to the prolonged recovery time of ICD were found in only 4 participants (**Figure 3**).

TABLE 2 | Demographics of participants.

Characteristics	Number, *n* (%)
Job	
Medical doctor/medical student	2 (9%)
Nurse/nursing student	13 (62%)
Allied healthcare worker	6 (29%)
Age (years)	
≤20	5 (24%)
21–30	11 (52%)
31–39	4 (19%)
≥40	1 (5%)
Gender	
Male	4 (19%)
Female	17 (81%)

During the first visit, 6 participants were found to have mild dermatitis and were not required to have temporary job modification. All participants were given medical letters detailing the intervention recommendations to pass to their superiors. At the 2-month post-intervention review, all participants were found to have a clinical improvement in their hand condition. Based on the visual analogue score, the estimated mean reduction of signs and symptoms was 80% in comparison to their baseline hand condition before intervention. The participants reported that their workplace supervisors were accommodating to the interventions by supplying the participants with the proposed hand hygiene products and making adjustments to reduce their clinical duties temporarily.

All participants had an improvement rate of 70–90% from their baseline signs and symptoms, with a mean improvement of 80%. Out of the 6 participants without job modification intervention, one participant had 70% clinical improvement, 3 participants had 80% improvement and 2 participants had 90% improvement. Out of the 15 participants with job modification intervention, 6 participants had 70% clinical improvement, 7

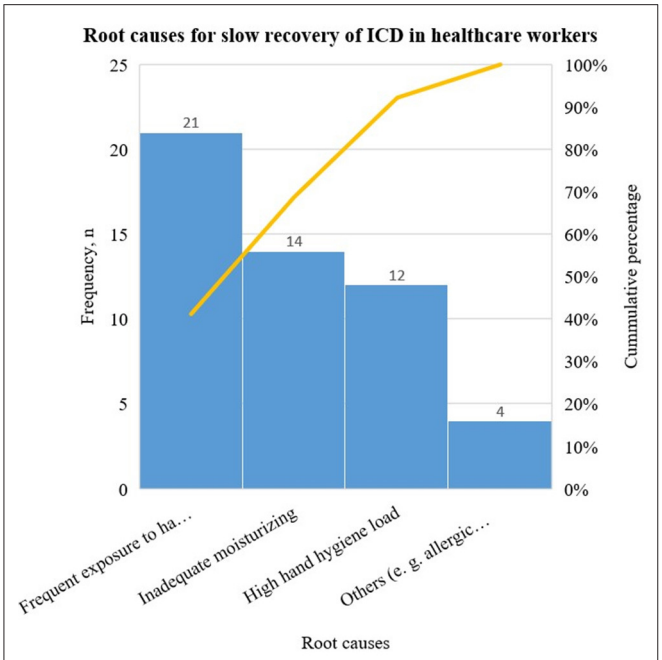

FIGURE 3 | Pareto chart of the different root causes. Root causes: frequent exposure to hand hygiene products, inadequate moisturising, high hand hygiene load and others (e.g., allergic contact dermatitis). High hygiene load denotes daily hand hygiene activities of fifty times and above.

participants had 80% improvement and 2 participants had 90% improvement.

Clinically significant improvement in the hand condition of all the participants was noted during the 2-month post-intervention review with most of the participants returning to their full clinical duties after the intervention period.

Although their hand condition improved, none of the participants recovered completely after 2 months. Subsequently, all participants were given follow-up reviews at different intervals and were managed individually based on their clinical condition.

DISCUSSION

The use of gentler hand hygiene products at the workplace and temporary reduction in hand hygiene activities may be useful to aid the recovery of hand dermatitis in healthcare workers.

Based on the hierarchy of controls from the National Institute for Occupational Safety and Health (NIOSH), substitution of an irritant chemical with a less irritant alternative is the most effective control measure for managing a hazard at the workplace, after elimination (22). Elimination of hand hygiene activities is impossible for healthcare workers performing clinical duties due to the nature of their job.

Hand disinfection with an ABHR is the most common modality of infection control (24). However, while ABHRs are effective in preventing pathogenic transmission, the alcohol content in such formulations can be irritating and impair skin tolerability, which can result in reduced compliance to hand hygiene requirements (17, 24). A study found significant dryness and itching scores for workers using mixed gel which contains ethanol and isopropanol as compared to ethanol-only gel (25). Different ABHRs can have varying impacts on the skin depending on their composition. Emollients in ABHRs can also improve the skin condition and should be a factor when selecting ABHR for use (5, 25, 26).

Although ABHRs are generally better tolerated than hand washing with water and soap, considerations of their composition must be taken into account when deciding their tolerability (25). Hand washing remains an integral part of hand hygiene and is still recommended when hands are visibly soiled (17). Mild cleansers should be made available for healthcare workers at the workplace for hand washing purposes.

Temporary reduction of clinical workload with hand hygiene activities, while not curative, may aid in the recovery of irritant dermatitis by reducing exposure to the irritants and allowing a period of rest. It is considered a type of administrative control and may be less effective than the substitution of irritant products because the worker will still be continuously exposed to the irritant, albeit at a reduced rate. While implementation of temporary reduction in workload is feasible for a small number of affected healthcare workers, it is less sustainable in the long run, since the additional workload might be transferred onto other colleagues in the same unit. The additional hand hygiene load might put other colleagues at increased risk of developing hand dermatitis.

The use of protective items such as barrier cream and moisturiser can be considered the least effective method based on the hierarchy of control as it does not remove or reduce the hazard itself and can be affected by human behaviour. For example, the lack of accessibility to moisturisers or the additional time required to moisturise can be potential barriers.

While substitution with a less irritant ABHR and reduction in workload are beneficial for the recovery of ICD of the hands, complete avoidance of allergens is the treatment for ACD. Healthcare workers with ACD will need to be removed from further exposure to the offending allergen. Patch testing is often used to identify the offending allergen for individuals with ACD (27). However, patch testing is time-consuming and referral for patch testing will require an appointment with a dermatologist. At the height of the COVID-19 pandemic, resources were diverted to manage COVID-19 infections, and all non-urgent appointments were delayed. Referrals for patch testing were delayed beyond the 2 months' timeline set in the QI project. Since ICD accounts for a majority of hand dermatitis, workplace interventions targeting ICD and substitution of latex gloves; a common allergen, with other alternatives may be useful in improving hand dermatitis among healthcare workers while awaiting patch testing.

The strength of this study includes the assessment of the effects of workplace interventions based on principles of substitution and administrative controls to improve the recovery rate of occupational ICD. While previous studies done on healthcare workers focused on educational programmes and the use of moisturisers, they did not evaluate the effects of workplace interventions (28). A systemic approach including work-based

changes is vital to prevent occupational hand dermatitis amongst healthcare workers while protecting the safety of patients.

Substituting highly irritant hand hygiene products with gentler alternatives may reduce the intensity of irritant exposure during hand hygiene activities. Furthermore, it can be implemented at a department level without incurring high expenditures.

There were several limitations in the study. The study lacks objective scoring of the hand dermatitis condition, such as the hand eczema severity index (HECSI) (29). Although a scoring index might be more useful in measuring objective changes, the process itself may be laborious and require input from a dermatologist. Photographic documentation for outcome assessment was performed to reduce the biases and the assessment was performed by the same OM physician to reduce inconsistency. The study also had a small sample size. A larger sample size would be beneficial in future studies to evaluate the effectiveness of different workplace interventions.

The workplace interventions were implemented through the participants' superiors *via* a medical letter. Although the superiors were generally supportive, the rate of implementation on the ground may vary: substitution with alternative ABHR or hand wash products might be affected by the supplies at the ward level, while temporary work adjustment will require time to implement due to manpower arrangement. The recovery from ICD might also be affected by factors outside of work, such as wet work activities from household chores.

Prevention and enhanced recovery from occupational dermatitis require disease awareness and early management. As part of primary prevention, appropriate control measures at the workplace can be implemented to reduce occurrences of hand dermatitis among healthcare workers at high risk of developing occupational dermatitis. Surveillance for early detection of the disease and individualised occupational management for affected healthcare workers can be performed to improve rate of recovery. To ensure a systemic and permanent workplace changes, support and collaboration with various stakeholders such as the hospital's management and the Safety and Health department on suitable workplace interventions will be necessary.

CONCLUSION

Chronic occupational contact dermatitis can result in impaired quality of life and loss of work productivity. With increased incidences of ICD among healthcare workers, effective preventive measures should be implemented at the workplace.

Workplace interventions such as substituting highly irritant hand hygiene products with gentler alternatives and temporary reduction in clinical duties may be useful in improving the recovery rate of ICD among healthcare workers. Specific high-risk areas with high hand hygiene workload or high incidences of ICD may opt to implement systemic workplace changes to improve recovery and prevent new occurrences of ICD.

Further studies on the clinical effectiveness, sustainability and cost-benefits of different workplace interventions at a larger scale can be considered in the future. Effective systemic workplace changes can have significant positive impact on the worker and the workplace. Engagement and support from relevant stakeholders will be essential for sustained and effective change.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because they contain clinical details of the cases reviewed. Requests to access the datasets should be directed to AL, alicia.loi@mohh.com.sg.

ETHICS STATEMENT

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

AUTHOR CONTRIBUTIONS

AL is the primary author responsible for the original draught and subsequent revision of the manuscript. She was involved in the design, implementation, and analysis of the study. ZA was also involved in the design and implementation of the study. She assisted in the analysis of the results and provided inputs during the revision of the manuscript. YF provided guidance and was involved in the design, implementation, and interpretation of the result. She reviewed the manuscript and provided direction on the drafting and revision of the manuscript. All authors have read and agreed to the final version of the manuscript.

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Compliance to Infection Prevention and Control Practices Among Healthcare Workers During COVID-19 Pandemic in Malaysia

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Healthcare workers (HCWs) are at risk of contracting coronavirus disease-2019 (COVID-19) in their workplace. Infection prevention guidelines and standard operating procedures were introduced to reduce risk of exposure and prevent transmission. Safe practices during interaction with patients with COVID-19 are crucial for infection prevention and control (IPC). This study aimed to assess HCWs' compliance to IPC and to determine its association with sociodemographic and organizational factors. A cross-sectional study was conducted between March and April 2021 at public healthcare facilities in the east coast of Peninsular Malaysia. HCWs who were involved with COVID-19-related works were invited to participate in the online survey. The questionnaire was adapted from the World Health Organization (WHO) Interim Guidance: WHO Risk Assessment and Management of Exposure of Healthcare Workers in the Context of COVID-19. Respondents were categorized as compliant or non-compliant to IPC. A total of 600 HCWs involved in COVID-19-related works participated in the survey. Most of them (63.7%) were compliant to IPC as they responded to all items as "always, as recommended" during interaction with patients with COVID-19. The multivariate analysis showed that non-compliance was significantly associated with working in the emergency department (AOR = 3.16; 95% CI = 1.07–9.31), working as laboratory personnel (AOR = 15.13; 95% CI = 1.36–168.44), health attendant (AOR = 4.42; 95% CI = 1.74–11.24), and others (AOR = 3.63; 95% CI = 1.1–12.01), as well as work experience of more than 10 years (AOR = 4.71; 95% CI = 1.28–17.27). The odds of non-compliance among respondents without adequate new norms and personal protective equipment training were 2.02 (95% CI = 1.08–3.81) more than those with adequate training. Although most of the respondents complied to IPC protocols, compliance status differed according to department, work category, and years of service. Ensuring adequate training that will hopefully lead to behavioral change is crucial to prevent breach in IPC and thus minimize the risk of exposure to and transmission of COVID-19 in healthcare facilities.

Keywords: healthcare workers, infection control practices, risk, pandemic, COVID-19

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INTRODUCTION

The World Health Organization (WHO) declared coronavirus disease-2019 (COVID-19), which is caused by novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), a pandemic in March 2020. At that time, COVID-19 had spread rapidly in 114 countries with more than 118,000 confirmed cases, causing 4,291 deaths (1). After more than a year, the disease showed no sign of mitigation. Up until 6 July 2021, cumulative cases globally were more than 183 million with almost 4 million total deaths and over 2.6 million new cases being reported in a week (2). The overwhelming number of cases increased the burden for frontline healthcare workers (HCWs) in patient-facing roles and placed them at greater risk as their work require close contact with patients with COVID-19 (3).

The main mode of transmission for COVID-19 is human to human with respiratory droplets as the primary route of transmission. The SARS-CoV-2 route of entry to the respiratory systems are either *via* inhalation or deposition of droplets to mucous membrane or touching mucous membrane with SARS-CoV-2 contaminated objects (4). Available prevention guidelines on how to prevent COVID-19 transmission has remained unchanged from the early phase of the pandemic (4). Generally, physical distancing, face mask usage, frequent hand washing, good indoor ventilation, and avoidance of crowded places have been recommended (5). Additional implementation of personal protective equipment such as usage of gloves, gowns, face or eye protections and N95 masks, along with other standard practices, had been recommended for HCWs who are involved or in contact with patients with COVID-19 as part of infection prevention and control (IPC) during the pandemic (6, 7).

Despite the availability of infection prevention guidelines to protect HCWs, they are not immune to the disease. Previous evidence had shown that during the SARS-CoV-1 outbreak in 2003, a total of 1,706 HCWs were infected globally, contributing to 21% of total SARS cases (8). The current pandemic has shown a similar situation with HCWs comprising 14% of all reported cases (9). Nearly 570,000 HCWs in America were reported positive for COVID-19, and more than 2,500 of them were deceased by September 2020 (10). The WHO had estimated that the number of HCW deaths globally could be more than 115,000 within 18 months of COVID-19 emergence, and this was derived by population-based estimations (11).

By February 2021, Malaysia had recorded a total of 4,756 confirmed COVID-19 cases among HCWs prior to the national COVID-19 vaccination program (12). Despite preventive measures and completed 2 doses of vaccination, 2,341 confirmed COVID-19 cases were detected among HCWs within 3 months post-vaccination (13). Public healthcare system is the main healthcare provider in Malaysia, and the system is overwhelmed with the surge of cases during COVID-19 waves (14). Quarantine centers were established, and some government hospitals were redesigned into full or partial COVID-19 hospitals (15). Similar studies on compliance of HCWs to IPC during care of patients with COVID-19 and their associated factors have been carried out (16–22). However, they were confined mostly to HCWs working in hospitals. In Malaysia, management of and exposure to patients with COVID-19 involved HCWs from various types of healthcare facilities including hospitals, health clinics, and state and district health offices. The HCWs had different job scopes and level of exposure to or interaction with patients with COVID-19. Furthermore, there were limited studies that looked at the impact of organizational support to IPC compliance among HCWs. Thus, it is crucial to understand the role of organizational support and how exposure to SARS-CoV-2 and safe practices could reduce the risk of COVID-19 among HCWs in different types of healthcare facilities. A comparison of similar studies on compliance to IPC is available in **Supplementary Table S1.**

This study aimed to assess HCWs' compliance to IPC and to identify the associated sociodemographic and organizational factors that contributed to their compliance. The findings are expected to assist in investigating the trends of COVID-19 infection among HCWs and to assist in developing mitigation strategies to reduce COVID-19 transmission and protect our HCWs in their workplace. The tools from this study could be used by stakeholders in assessing adequacy of control and preventive measures among HCWs to other contagious outbreaks in the future.

MATERIALS AND METHODS

This was a cross-sectional study conducted at public healthcare facilities in a state in the east coast of Peninsular Malaysia involving 9 hospitals, 56 health clinics, and 10 district health offices. The online survey was emailed between March and April 2021 to all HCWs who were involved in COVID-19-related works including medical doctors, nurses, assistant medical officers, medical assistants, environmental health assistant officers, health attendants, laboratory personnel, and others (e.g., clerks, cleaners, and drivers). The survey link was sent through the occupational health unit of each facility. The link introduced briefly the study and approval that was obtained from the ethics committee and the state health department prior to commencement of this study. A detailed description of the study including objectives and participants' rights were explained in the first part after clicking the link, followed by informed consent. Respondents will be able to proceed to the questionnaire after providing their consent. A reminder for HCWs to fill up the questionnaire was sent by the occupational health unit at a 2-weeks interval throughout the 2-months study duration. Out of the 618 HCWs who responded to the questionnaire, 600 (97%) answered the questionnaire completely and met the criteria for involvement with COVID-19-related works. These included those who were directly involved in treating, managing or handling, and screening patients with COVID-19, conducting

Abbreviations: COVID-19, coronavirus disease-2019; HCWs, healthcare workers; IPC, infection prevention and control; MOH, Ministry of Health; PPE, personal protective equipment; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; SPSS, Statistical Package for the Social Sciences; WHO, World Health Organization.

TABLE 1 | HCW adherence to infection prevention and control practices during interaction with patients with COVID-19.

Variables	Always, as recommended *n* (%)	Most of the time *n* (%)	Occasionally *n* (%)	Rarely *n* (%)
PPE				
Single-use gloves	503 (83.8)	57 (9.5)	35 (5.8)	5 (0.8)
Medical mask	585 (97.5)	14 (2.3)	1 (0.2)	0 (0)
Face shield or goggles	523 (87.2)	53 (8.8)	21 (3.5)	3 (0.5)
Disposable gown	502 (83.7)	64 (10.7)	27 (4.5)	7 (1.2)
Remove and replace PPE as protocol*	539 (89.8)	48 (8.0)	10 (1.7)	3 (0.5)
Hand hygiene				
After touching patient	565 (94.2)	33 (5.5)	0 (0)	2 (0.3)
Before and after clean or aseptic procedures performed	570 (95.0)	27 (4.5)	1 (0.2)	2 (0.3)
After exposure to body fluid	578 (96.3)	16 (2.7)	4 (0.7)	2 (0.3)
After touching patient's surrounding	537 (89.5)	57 (9.5)	5 (0.8)	1 (0.2)

**Remove and replace PPE as protocol—refer to the WHO interim guidance (e.g., when a medical mask became wet, dispose the wet PPE in the waste bin, perform hand hygiene, etc.).*

SAR-CoV-2 laboratory tests, transporting patients with COVID-19 and samples, cleaning COVID-19 facilities, and conducting epidemiological investigation on confirmed COVID-19 cases.

This study was approved by the Medical Research and Ethics Committee (MREC), Ministry of Health Malaysia [KKM/NIHSEC/P21–109(12)]. All participations were anonymous, and personal identifiers would not appear in any report.

Study Tool and Variables

The questionnaire was adapted from the WHO Risk Assessment and Management of Exposure of Healthcare Workers in the Context of COVID-19 (23), which was structured in 4 parts. The first part was for gathering sociodemographic and occupational profiles consisting of variables such as age, gender, marital status, medical and medication history, workplace, job category, and years of service. The second part was about HCWs' activities related to COVID-19 exposure in the workplace and their COVID-19 status such as tested for COVID-19 and the result. The third part was about adherence to IPC during interaction with possible, probable or confirmed COVID-19 cases, which included assessment of PPE usage (5 items) and hand hygiene (4 items). Scoring for compliance status was similar to the WHO tool with a 4-point Likert scale: "always as recommended," "most of the time," "occasionally," and "rarely." While the terms used in this study for "high-risk exposure" were "noncompliance" and "low risk exposure" were identified as "compliance." Those who responded to all items with "Always, as recommended" were categorized as compliant to IPC, whereas those with response other than that were categorized as non-compliant to IPC. Another modification was in scoring, which did not include adherence to IPC while doing aerosol-generating procedures. The last part was about organizational support. It consisted of 7 items to assess whether higher management in health facilities provided their workers with adequate instruments, items, training, or enforcement needed to ensure a safe work environment during the pandemic.

The survey forms were made available bilingually, in English and in Malay. The questions were translated into Malay language by 2 native Malaysians with good English proficiency, and back-translations were conducted by another two bilingual individuals to verify accuracy. The questions were modified according to local circumstances and were validated by five panels with occupational and public health background. Each panel indicated its comment or decision to remove, keep, or modify each item. After modification, content validation was conducted by another five public health specialists working at Ministry of Health's headquarters and the State Health Department. All of them were managing the occupational health program, including HCWs' well-being during the pandemic. Prior to the study, the questionnaire was tested on 50 HCWs in the Ministry of Health (MOH) who had an experience with COVID-19-related works. This was performed to ensure the readability, understanding and comprehensiveness of this tool and accuracy in reflecting the factors. The Cronbach's alpha was 0.748, which signified acceptable reliability.

Data Analysis

Data from the questionnaires were transferred to Microsoft Excel, and Statistical Package for the Social Sciences (SPSS) version 21 (IBM, United States) was used for analysis. The data were initially analyzed descriptively to determine the representativeness of the respondents in this study. Categorical data were presented as frequencies and percentages, whereas means and standard deviations were expressed for continuous data. Pearson chi-square or Fisher's exact test was carried out to analyze activities with high exposure to SARS-CoV-2 and COVID-19 status with IPC compliance status. Next, univariate and multivariate analyses were conducted by binary logistic regression to identify a sociodemographic association with IPC as well as organizational support and IPC. Then, multicollinearity terms were checked, and the Hosmer-Lemeshow test and classification table were applied to check for model fitness. Statistically significant result was set at $p < 0.05$.

TABLE 2 | Activities with high exposure to SARS-CoV-2 and COVID-19 status according to IPC compliance status.

Variables	Compliance status		*p*-value[a]
	Yes *n* (%)	No *n* (%)	
Activitieswith high exposure to SARS-CoV-2			
Provide direct care to COVID-19 patients			
Yes	327 (64.2)	182 (35.8)	0.487
No	55 (60.4)	36 (39.6)	
Mobilized to carry out COVID-19 works			
Yes	158 (61.7)	98 (38.3)	0.392
No	224 (65.1)	120 (34.9)	
Face to face contact with COVID-19 patients			
Yes	103 (64.8)	56 (35.2)	0.734
No	279 (63.3)	162 (36.7)	
Direct contact with environment where COVID-19 patients were cared for			
Yes	251 (64.4)	139 (35.6)	0.631
No	131 (62.4)	79 (37.6)	
Present during aerosol-generating procedures			
Yes	54 (62.1)	33 (37.9)	0.738
No	328 (63.9)	185 (36.1)	
Involved in COVID-19 biological accident			
Yes	9 (52.9)	8 (47.1)	0.351
No	373 (64.0)	210 (36.0)	
HCW's COVID-19 status			
History of testing for COVID-19			
Yes	178 (58.4)	127 (41.6)	0.006*
No	204 (69.2)	91 (30.8)	
Positive by PCR for COVID-19			
Yes	11 (84.6)	2 (15.4)	0.148[b]
No	371 (63.2)	216 (36.8)	

[a]*Pearson* χ^2 *test;* [b]*Fisher's exact test; *p-value < 0.05.*

RESULTS

A total of 600 HCWs who were involved in COVID-19-related works were included in the survey. They were predominantly women (73.8%), married (90.3%), diploma or certificate holder (60.8%), without pre-existing medical condition (59.0%), and not on regular medication (75.0%). Mean age was 39.9 ± 7.4 years old, and mean household number was 5 ± 1.8. Nearly half of the respondents worked in hospitals (49.0%) and were nurses (52.0%). More than two-thirds of them had work experience of more than 10 years (69.5%) with mean work duration of 15.3 ± 7.3 years.

Table 1 shows the reported adherence to IPC practices. Adherence to type of PPE used and hand hygiene practices ranged from 83.7 to 97.5%; the highest adherence was for using medical masks and the lowest adherence was for using disposable gowns and single-use gloves. Overall, 382 (63.7%) of the respondents were compliant and adhered fully to all PPE and hand hygiene items (answered "always, as recommended"), making 218 (36.3%) of the respondents non-compliant.

Majority of the HCWs in this study provided direct care to patients (84.8%), but only 26.5% had face-to-face contact with patients with COVID-19, and 14.5% were present during aerosol-generating procedures (**Table 2**). Nearly two-thirds of the respondents (65%) had direct contact with contaminated objects or environmental exposure (bed, linen, medical equipment, bathroom, etc.) while caring for patients with COVID-19, and 2.8% were exposed to splash accidents (6 cases to eyes, 6 cases to mouth, and 10 cases to non-intact skin) and sharps injuries (2 cases) involving patients with COVID-19. However, no significant difference was found ($p > 0.05$) between their involvement in activities with high exposure to SARS-CoV-2 and compliance status.

Based on their COVID-19 status, **Table 2** shows that out of 600 respondents, 305 (50.8%) had a history of taking a COVID-19 swab test either by procedural or asymptomatic screening or because they were in close contact to positive COVID-19 cases. Only 4.3% were positive for COVID-19. There was a significant difference in compliance status among respondents with history of swab testing, whereas compliance status was higher among those who had not undergone a swab test for COVID-19 ($p = 0.006$). However, there was no difference in compliance seen by positivity status to COVID-19.

Univariate and multivariate regression analysis were conducted to determine the association between sociodemographic and occupational factors, as well as organizational support and compliance status as shown in **Tables 3**, **4**. The final model was checked for multicollinearity, and the variance inflation factor (VIF) for the variables was < 5, indicating no strong correlation between the variables. The Hosmer and Lemeshow tests were not significant ($p > 0.05$), which indicated that the model was fit. The overall correctly classified percentage is acceptable by the classification table.

Age, educational level, number of households, preexisting medical condition, and taking regular medication showed no association with breach in IPC. There were five factors that were statistically significant for compliance status. Those who worked in the emergency department (AOR = 3.16; 95% CI = 1.07–9.31) had higher odds of non-compliance to IPC than those based in non-clinical departments. The odds of non-compliance to IPC were 15 times higher among laboratory personnel (AOR = 15.13; 95% CI = 1.36–168.44), 4.4 times higher among health attendants (AOR = 4.42; 95% CI = 1.74–11.24), and 3.6 times higher among other job categories (AOR = 3.63; 95% CI = 1.1–12.01) than nurses, whereas those who have a work experience of more than 10 years (AOR = 4.71; 95% CI = 1.28–17.27) had higher odds of non-compliance than those with < 1 year of work experience.

Table 4 describes the association between organizational support and compliance status among the respondents. It was found that the odds of non-compliance to IPC was 2 times higher among HCWs who lacked training than those who received adequate training. It was also found that the odds of non-compliance to IPC was 3 times higher if there were inadequate enforcement reminders for wearing a mask and physical distancing ($p = 0.05$).

TABLE 3 | Demographic and occupational factors associated with compliance status among healthcare workers.

Variables	Compliance status		Univariate		Multivariate	
	No *n* (%)	Yes*n* (%)	OR (CI = 95%)	*p*-value	OR (CI = 95%)	*p*-value
Gender						
Female	144 (32.5)	299 (67.5)	1		1	
Male	74 (47.1)	83 (52.9)	1.851 (1.277–2.683)	0.001*	0.830 (0.440–1.565)	0.565
Workplace						
Hospital	87 (29.6)	207 (70.4)	1		1	
Health clinics	111 (40.7)	162 (59.3)	1.630 (1.151–2.309)	0.006*	1.663 (0.698–3.962)	0.251
District Health Office	20 (60.6)	13 (39.4)	3.660 (1.743–7.686)	0.001*	1.124 (0.196–6.441)	0.896
Department						
Laboratory based	8 (40.0)	12 (60.0)	1.481 (0.450–4.876)	0.518	0.173 (0.013–2.298)	0.184
Medical based	22 (22.4)	76 (77.6)	0.643 (0.257–1.612)	0.347	1.154 (0.389–3.419)	0.797
Surgical based	13 (22.8)	44 (77.2)	0.657 (0.241–1.786)	0.410	1.195 (0.378–3.777)	0.762
Outpatient	87 (38.2)	141 (61.8)	1.371 (0.597–3.147)	0.456	1.447 (0.427–4.904)	0.553
Emergency	36 (50.0)	36 (50.0)	2.222 (0.892–5.534)	0.086	3.159 (1.072–9.312)	0.037*
Anesthesiology/ Intensive care	3 (14.3)	18 (85.7)	0.370 (0.087–1.585)	0.180	0.656 (0.137–3.131)	0.596
Public health	40 (53.3)	35 (46.7)	2.540 (1.024–6.298)	0.044*	1.598 (0.414–6.169)	0.497
Non-clinical based	9 (31.0)	20 (69.0)	1		1	
Job description						
Nurse/ Midwife	84 (26.9)	228 (73.1)	1		1	
Medical Doctor	42 (39.6)	64 (60.4)	1.781 (1.121–2.829)	0.014*	1.148 (0.409–3.222)	0.794
Assistant Medical Officer	32 (43.8)	41 (56.2)	2.118 (1.252–3.584)	0.005*	1.957 (0.862–4.443)	0.108
Assistant Environmental Health Officer	20 (64.5)	11 (35.5)	4.935 (2.269–10.734)	<0.001*	5.352 (0.883–32.455)	0.068
Laboratory Personnel	11 (47.8)	12 (52.2)	2.488 (1.058–5.854)	0.037*	15.133 (1.360–168.438)	0.027*
Health attendant	19 (55.9)	15 (44.1)	3.438 (1.671–7.075)	0.001*	4.420 (1.738–11.242)	0.002*
Others	10 (47.6)	11 (52.4)	2.468 (1.011–6.022)	0.047*	3.632 (1.099–12.009)	0.034*
Duration of employment						
Less 1 year	6 (30.0)	14 (70.0)	1		1	
1 to 10 years	62 (38.0)	101 (62.0)	1.432 (0.523–3.922)	0.484	2.505 (0.714–8.790)	0.152
More than 10 years	150 (36.0)	267 (64.0)	1.311 (0.493–3.482)	0.587	4.708 (1.283–17.274)	0.019*

*Only significant odds ratio was presented in Table 3; *p-value < 0.05.*

DISCUSSION

The existing IPC standard in Malaysia is applied in healthcare settings to minimize the risk of infection for both patients and HCWs, and this is supported by the Occupational Safety and Health (OSH) program (24). During the pandemic, the Annex 21 Management of HCWs During the COVID-19 Pandemic has been developed and regularly updated to address standard operating procedures (SOP) (25). It includes awareness and training, IPC practices, PPE usage, vaccination, surveillance, and management of HCWs contracting the disease. The implementation of SOPs including IPC is regularly monitored and audited by the OSH or IPC committee in respective healthcare facilities.

Compliance status is important in identifying breach in IPC among HCWs. This is especially because since the start of the pandemic up to February 2021, more than half of infected HCWs in Malaysia contracted the disease at work (26). Preventing infections among HCWs is crucial to ensure there are no disruption of healthcare delivery during the pandemic. Staff shortage occurred not only because HCWs are positive and need to be isolated or treated but also because their colleagues become close contacts and need to be quarantined as well to prevent further transmission to others as mentioned before. In this study, 4.3% of respondents who underwent testing for COVID-19 were confirmed positive. This was consistent with findings from other studies in Italy (3.5%), Germany (3.5%), and the United States (4.5%) (27–29), while another review showed a higher percentage from HCWs tested by RT-PCR and detection of antibodies, with the pool prevalence of SARS-CoV-2 reported as 11 and 7%, respectively (30).

Compliance to IPC in other studies showed mixed findings from low to high practices (16–19). The majority of HCWs in this study showed good adherence to single items in IPC practices. Use of disposable gowns (83.7%) scored the lowest compliance among all personal protective equipment (PPE) used, while items under hand hygiene showed better results except for hand hygiene after touching patient's surrounding (89.5%), which was the only item that scored below 90%. The result was probably due to the illusion of safety, as there was

TABLE 4 | Organizational support provided by management in healthcare facilities.

Variable	Compliance status		Univariate		Multivariate	
	Yes	No	OR (CI = 95%)	*p*-value	OR (CI = 95%)	*p*-value
Provide adequate temperature screening upon entering facility						
Yes	367 (64.7)	200 (35.3)	1		1	
No	15 (45.5)	18 (54.5)	2.202 (1.086–4.463)	0.029*	0.437 (0.138–1.385)	0.160
Provide adequate hand washing facility or hand sanitizer						
Yes	377 (65.0)	203 (35.0)	1		1	
No	5 (25.0)	15 (75.0)	5.571 (1.996–15.550)	0.001*	2.470 (0.547–11.156)	0.240
Provide adequate training for PPE and new norms						
Yes	351 (67.1)	172 (32.9)	1		1	
No	31 (40.3)	46 (59.7)	3.028 (1.854–4.946)	<0.001*	2.023 (1.075-3.809)	0.029*
Enforce adequate wearing mask and physical distancing reminder						
Yes	375 (65.6)	197 (34.4)	1		1	
No	7 (25.0)	21 (75.0)	5.711 (2.386–13.666)	<0.001*	3.120 (1.000–9.729)	0.050
Enforce adequate physical distancing markings (line, square, cross etc.)						
Yes	369 (65.4)	195 (34.6)	1		1	
No	13 (36.1)	23 (63.9)	3.348 (1.659–6.755)	0.001*	0.745 (0.250–2.220)	0.597
Enforce adequate limitation the number of people in one area or room						
Yes	354 (65.8)	184 (34.2)	1		1	
No	28 (45.2)	34 (54.8)	2.336 (1.374–3.973)	0.002*	1.175 (0.536–2.574)	0.687
Enforce at least 1 metre spacing between seats						
Yes	365 (65.9)	189 (34.1)	1		1	
No	17 (37.0)	29 (63.0)	3.294 (1.765–6.142)	<0.001*	1.648 (0.645–4.209)	0.296

*p-value < 0.05.

no direct contact with patients. However, it is important to take precaution as the virus could also be transmitted from contaminated surfaces (31). In our study, there was no significant difference in compliance to IPC among HCWs based on their work during management of patients with COVID-19. Most of the respondents complied to IPC practices regardless of involvement in activities with high risk of exposure to SARS-CoV-2 or not. This is a commendable practice, as adherence to IPC is important in other daily activities, considering they can be exposed and contract COVID-19 infection even from the community (32). However, it is quite worrying that there was non-compliance to IPC practices even among HCWs who were involved in high-risk works, as they could get infected and increase the risk of nosocomial transmission to others (33).

The univariate analysis showed a significant association among status of compliance by gender, profession, type of facility and department where HCWs worked. Non-compliance was higher among men (47.1%) than women (32.5%), with the odds among men being 1.9 times higher than those among women. This could be contributed by their profession, as most of the women involved in the study were nurses, and they were also found to be more compliant than those with other types of profession in this study. Other studies also found that nurses were better in utilizing PPE than those with other professions (16, 20, 34, 35), while a seroconversion study in Egypt reported that the odds of hazard in women were 1.63 times higher than the odds in men (36). The medical doctors in this study had lower compliance than the nurses. Gilbert and Kerridge (37) reported reasons for lower compliance among medical doctors as they tend to rely on clinical judgment and experience rather than follow rules and ignorance, and some chose to disregard IPC practices despite recognizing their importance (37). Atnafie et al. (22) found that the rate of HCWs infected with COVID-19 among hospital staff was lower than that of HCWs working in other health facilities. However, they did not find any significant association (22). In our study, the odds of non-compliance were higher in HCWs working in health clinics and district health offices than in HCW working in hospitals. This is probably because hospitals have established IPC guidelines and have been practicing standard operating procedures on IPC even before the pandemic (24) compared to other types of health facilities. Moreover, infectious disease physicians and nurses are also posted in hospitals, and they have regular training and monitoring of IPC practices there (38). Similarly, HCWs who worked in public health departments had a significant association with non-compliance. This might be because common infectious diseases in community were tropical diseases like dengue and other diseases that are not spread by air or droplets, which have different protocols for IPC (39, 40).

After adjusting for other demographic and occupational factors, it was found working in emergency department (ED), worked for more than 10 years, HCWs who were laboratory personnel, health attendant and occupation grouped as others had significant risk of noncompliance. Non-compliance among

HCWs in the ED could be contributed by the hectic and busy nature of work in the ED where there are many varied patients with different severity, with some requiring emergency procedures, making it difficult for them to keep changing their PPE each time for different patients (35, 41). A study by Ezike et al. found that preventive measures were not strictly adhered to in medical wards, children wards, and clinic and maternity complexes (21). The finding of significant non-compliance among HCWS who had worked for more than 10 years was consistent with the findings by Osborne (42). Greater non-compliance was found to be associated with longer years of working experience and habit as they could lead to disinclination to changes (42). However, our findings contradicted with another study in Canada that reported experienced nurses were more compliant than new nurses (43). Non-compliance was also seen among health attendants, laboratory personnel, and non-clinical staff compared to nurses. This category of HCWs usually does not have a direct contact with patients and this could probably influence their IPC practices. Nevertheless, they are still at risk, and IPC training should include them to improve their compliance (16).

Organizational support had been associated with compliance with using PPE in preventing respiratory diseases (43). This study demonstrated that all the organizational support provided had a significant association with compliance in the univariate analysis but after adjusting for confounders, only lack of adequate training was associated with non-compliance. Other studies had reported the importance of training and its influence on compliance with using PPE (44, 45). Inadequate training will lead to low knowledge of the importance and need for adherence to IPC among HCWs. Therefore, effective training in IPC should be endorsed to all medical staff (44) especially during this pandemic. Based on the findings, the questionnaire is able to assess IPC compliance among HCWs and would be useful to be incorporated in occupational health surveillance programs. Follow-up surveys should be carried out to observe whether there is improvement over time and to evaluate the effectiveness of intervention programs.

Among the limitations of this study was the use of self-administered questionnaire, which could lead to over- or under-reporting as compared to the real situation. Respondents will have to recall their practices when answering the question, which may contribute to recall bias. The IPC practices and compliance included in this study may also need to be revised in future studies with the emergence of new COVID-19 variants of concerns that are more transmissible (46–48).

CONCLUSION

Generally, most of the HCWs in this study complied with IPC. The compliance status differed among HCW location, profession, and their years of service. However, it is a cause of concern that more than a quarter of the respondents were non-compliant to IPC practices during interactions with patients with COVID-19, which may expose them to SARS-CoV-2 infection in their workplace, especially when there are new emerging variants that are more transmissible. As this study has identified HCWs who are more likely to be less compliant, it is imperative that administrators of these health facilities look into ways to improve IPC compliance, which should include an infection control committee and an occupational safety and health committee. They could plan intervention programs to target non-compliant workers by sending reminders at regular intervals or conducting regular training, nudging strategies, and rewarding those who comply. They should also review the effectiveness of their intervention program by conducting regular monitoring of compliance.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Medical Research and Ethics Committee (MREC), Ministry of Health Malaysia [KKM/NIHSEC/P21-109(12)]. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

All the authors were involved in the conception and design of the investigation. YO, HT, NMu, ZM, and AM participated in the acquisition of the data. NMo, RS, and RI analyzed the data and interpreted the results. NMo, MP, RS, and RI wrote the manuscript, and all the other authors critically revised it. All the authors approved the final version of the manuscript. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

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Factors and optimizations of healthcare workers' perception in alternative care facilities

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Background: Diverse measures have been carried out worldwide to establish Alternative Care Facilities (ACFs) for different ends, such as receiving, curing or isolating patients, aiming to cope with tremendous shock in the urban medical system during the early passage of the COVID-19 epidemic. Healthcare workers always felt anxious and stressed during multiple major public health emergencies in medical facilities. Some active measures to improve healthcare workers' perceptions, such as temporary training, workflow improvement, and supplementary facilities, were proved insufficient in several past public health emergencies. Therefore, this study aims to analyze the contributing factors of the healthcare workers' perceptions of the ACFs in this pandemic, which can help find an innovative path to ensure their health, well-being and work efficiency.

Method: This paper conducted semi-structured in-depth interviews with the world's first batch of healthcare workers who have worked in ACFs through a qualitative study based on Grounded Theory. The healthcare workers interviewed from Heilongjiang, Shandong, Fujian, and Hubei provinces, have worked in one of the four different ACFs built in Wuhan. The results are obtained through the three-level codes and analyses of the interview recordings.

Results: The factors affecting the perception of healthcare workers in ACFs during the epidemic situation can be summarized into five major categories: individual characteristics, organization management, facilities and equipment, space design, and internal environment. The five major categories affecting the composition of perception can be further divided into endogenous and exogenous factors, which jointly affect the perception of healthcare workers in ACFs. Among them, individual characteristics belong to endogenous factors, which are the primary conditions, while other categories belong to exogenous factors, which are the decisive conditions.

Conclusion: This paper clarifies factors affecting the perception of healthcare workers in ACFs and analyzes the mechanism of each factor. It is posited that the passive strategies are a promising solution to protect healthcare workers' health, improve their work efficiency, and help reduce the operation stress of ACFs. We should train multidisciplinary professionals for future healthcare and

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enhance collaborations between healthcare workers and engineers. To sum up, this paper broadens new horizons for future research on the optimization of ACFs and finds new paths for alleviating healthcare workers' adverse perceptions of ACFs.

KEYWORDS

alternative care facility (ACF), healthcare workers' perception, grounded theory, nurse-engineer partnership, active and passive strategies

Introduction

The scarcity of medical resources is ubiquitous worldwide, resulting from the large number of patients caused by the COVID-19 pandemic (1–5). Alternative Care Facilities (ACFs) are temporary facilities that can meet the emergency needs of medical treatment in public health emergencies to alleviate the burden of medical conditions of existing medical facilities (6, 7). Lam C, Waldhorn R, and others believe that there are several uses for ACFs: as overflow hospitals providing a full range of care; for limited supportive care for noncritical patients; as primary triage and rapid patient screening centers; for quarantine; etc. (8, 9). ACFs have played various roles in different countries and regions according to their medical system in this epidemic (10–15). For example, NHS Nightingale Hospital in the UK provides comprehensive care for patients (16), and Fangcang shelter hospitals in China mainly focus on isolation and provide limited supportive treatment (17–19). In general, ACFs are a common way for many countries to solve the shortage of medical facilities.

Perception is the human body's organization, identification, and interpretation of acquired information through the sensory system to present the information or environment (20). Relevant studies show that although people's perceived risk in a dangerous environment is not necessarily the same as the actual risk, the individual's perception will still affect their behavior (21, 22). Specifically, although healthcare workers are unrecognized in their nosocomial surroundings, their stress perception also impacts their health and work performances. For example, the sound and light in the hospitals will also affect the workers' stress and job satisfaction (23–26). Healthcare workers play critical roles in public health emergencies and provide emergency medical services to people in need (27–32). However, previous studies have shown that healthcare workers might have poor physical and mental health due to lack of support, increasing workload, fear of infection, and insufficient training, during public health emergencies like SARS and MERS (33–39). Moreover, there are also studies showing that healthcare workers in various countries face similar situations during the COVID-19 epidemic (40–45). And specific relevant researches on healthcare workers in ACFs show that their adverse perception may be exacerbated due to their maladjustment to the new environment, the limited medical resources and open space for activities, and the imbalance between the ratio of healthcare workers to patients (46–49).

Healthcare workers' perception of ACFs is the overall presentation of information generated in the working process through a series of their sensory systems. Traditionally, the point of view of medical staff has been measured by using questionnaires that monitor the satisfaction with the care received. However, the exclusive use of surveys to study overall health care quality has some weaknesses, including framing the protagonists' subjective experiences into rigid categories imposed by the researchers based on preconceived ideas (50). Thus, Grounded Theory constructs symbolic codes based on categories emerging from recorded qualitative data, which is quite different from the traditional scientific research model (51–53). Some practice researches understood nurses' experience with nursing consultations in the context of the Family Health Strategy and proposed a representative model with the open, axial and selective coding (54). There is also research into nurses' changing perceptions regarding the efforts in preparation for working in a COVID-19 ward in the rural Japanese context (55). Moreover, other researches explored the perception of entrepreneurship among nurses and developed a mid-range theory that explains the meaning and practices of entrepreneurship among nurses (56). The above researches fully show that the Grounded Theory method is feasible to comprehensively explain the factors affecting the perception of healthcare workers under specific conditions. Thus, to improve the adverse perception affecting healthcare workers' health, well-being and work efficiency during the epidemic, this paper clarifies the contributing factors to healthcare workers' perception of ACFs through the method of Grounded Theory, to find innovative improvement measures and alleviate their adverse perception.

Methods

Research method

Grounded Theory is based on investigations and analyses by returning to the phenomenon itself and avoiding presupposition by the researchers. Categories are divided *via* concept extraction,

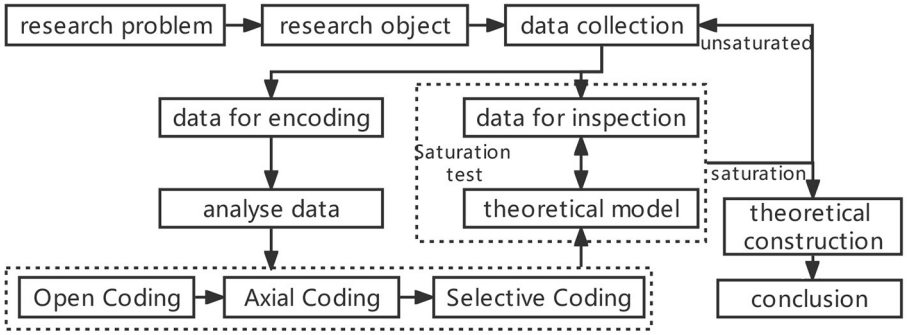

FIGURE 1
Grounded theory research process.

induction, and summary in a bottom-up way based on data collected and the relationship between various categories is further explored to establish a theoretical model to solve the research questions. Specifically speaking, research processes of the Grounded Theory can be divided into four steps: research question–data collection–data analysis–theoretical construction, among which data analysis, as the core link, is usually categorized by the three-level codes, namely open coding–axial coding–selective coding (57, 58) (Figure 1).

Participants

The selected participants were the first ones who worked in ACFs in the world during the epidemic in Wuhan, and thus there were no referential experiences for them. Hence, later policies and improvement measures did not affect their behaviors and perceptions.

The participants were eight healthcare workers who come from Hubei (2 participants), Heilongjiang (3 participants), Shandong (2 participants), and Fujian Provinces (1 participant) in China with an average age of 38.9 (SD = 6.9; min = 27; max = 50), including four men and four women. These participants included five nurses and three doctors with an average working seniority of 15.6 (SD = 9.0; min = 4; max = 30) with bachelor's degree (Table 1). To ensure the objectivity of the research results, the selection of participants in this study were from the four ACFs in Wuhan named Shipailing Fangcang shelter hospital (2 participants), Zhuankou Fangcang shelter hospital(3 participants), Guobo Fangcang shelter hospital (2 participants), Guanggu Fangcang shelter hospital (1 participant) with the same functions and ends in the same period.

Informed consent was obtained from all participants before the interview began. Participants were informed about the goals and contents of the study, privacy, and data protection and that their participation in the study was voluntary. Biological samples were not collected.

TABLE 1 Demographic characteristics of respondents.

	n	%
Gender (*N* = 8)		
Male	4	50%
Female	4	50%
Age (*N* = 8)		
20–29	1	12.5%
30–39	3	37.5%
40–49	3	37.5%
50–60	1	12.5%
Occupation (*N* = 8)		
Nurse	5	62.5%
Doctor	3	37.5%
Position titles (*N* = 8)		
Associate Professor	3	37.5
Head Nurse	1	12.5%
Associate Chief of Nursing	1	12.5%
Nurse–in–charge	1	12.5%
Nurse	2	25%
Working seniority (year) (*N* = 8)		
0–9	1	12.5%
10–14	3	37.5%
15–19	2	25%
20–24	1	12.5%
>25	1	12.5%
Province (*N* = 8)		
Heilongjiang	3	37.5%
Shandong	2	25%
Fujian	1	12.5%
Hubei	2	25%
Educational background (*N* = 8)		
Undergraduate	8	100%

Data collection

This study draws up an outline for the interview as follows. There are four parts of the interview, which are not conducted in a fixed order to avoid interrupting the interviewees.

TABLE 2 Open coding process.

a_n Label	aa_n Conceptualization	A_n Categorization
a_1 We got up at 8 a.m. on the 16th. A group of people from the National Health Commission trained us to wear protective clothing, prevent infection and wear masks.	aa_1 training before entry	A_1 business training
a_2 I started working on the 17th, and I didn't have enough protective clothing at that time.	aa_2 insufficient initial protective materials	A_2 material reserve
a_3 We stipulated six hours for each person, but at first, some people worked at least eight hours or even ten hours.	aa_3 work overtime	A_3 working strength
a_4 In the beginning, I was pretty unfamiliar with my work and environment. The first two groups of workers were not as smooth as expected.	aa_4 unfamiliarity	A_4 individual mentality
a_5 I went in on the 17th in protective clothing with the high psychological pressure since the mood of rehearsal and practice in the hotel is entirely different.	aa_5 tension	A_5 medical passage
a_6 We entered through the gate, and the staff had a password.	aa_6 the room with protective clothing is not divided	A_6 medical auxiliary facilities
a_7 Before entering, it is a container. We must first put on our protective clothing in a sterile environment.	aa_7 mirrors for healthcare workers	A_7 working pressure
……	aa_8 process of wearing protective clothing	A_8 work content
	aa_9 medical passage is equipped with a password	A_9 walkway layout
	aa_{10} large number of patients admitted internally	A_{10} work division
	aa_{11} a large number of patients to be cared for by each medical care provider	A_{11} coordination and organization
	aa_{12}daily work content of medical care	A_{12} peripheral medical facilities
	aa_{13} trouble caused by protective clothing	A_{13} physiological differences
	aa_{14} proportional collocation, grouped action	A_{14} previous experience
	aa_{15} long walking path	A_{15} bed space
	aa_{16} auxiliary facilities	A_{16} nurse station space
	aa_{17} interaction with patients to alleviate patients' psychological problems	A_{17} medical auxiliary space
	……	A_{18} patient participation
		A_{19} patient passage
		A_{20} activity space
		A_{21} internal ventilation
		A_{22} night lighting
		A_{23} communication
		A_{24} somatosensory temperature
		A_{25} peripheral living facilities
		A_{26} monitoring facilities
		A_{27} shared facilities

(1) *Basic information: the name of ACF, the stationed time of the healthcare workers, the number of patients, etc.;*
(2) *Work contents: the respondents' work division, organization and process, as well as the problems they encountered in ACFs, etc.;*
(3) *Perception: recognition of the respondents in different positions and at other times in ACFs from the beginning to the end;*
(4) *Improvement suggestions: the management, operation and layout design of the ideal ACFs from respondents' perspectives.*

This study has conducted interviews either online or offline because, on the one hand, interviewees are from various medical care teams in different provinces; on the other hand, it can avoid the interactions between respondents. The critical information was recorded during the 1h to 1.5h interview. Furthermore, the respondents' personal information was not mentioned so that they could tell their actual perceptions. After the interview, the interviewers analyzed the recordings.

According to the Grounded Theory, researchers will not be able to obtain new information from the research data when the research results reach saturation (51). After analyzing the interview recordings of 8 healthcare workers, the researchers found that the interview contents of the other three could not provide any new concept, and hence results are considered saturated.

Results

Concept and category

Open coding is a process of the label, conceptualizing and categorizing the similar or relevant information from the recordings of the interviews. This study is in accordance with the following procedures: labeling (analyze the recordings, sift essential information out, and label as "a_n")—conceptualization (combine similar and relevant labels, and conceptualize as "aa_n")–categorization (classify the conception and categorize as "A_n")—open coding. In all, there are 406 labels, 53 concepts, and 27 categories after the process of open coding (Table 2).

TABLE 3 Main category and corresponding category.

Number	AA_n Main category	A_n corresponding category
1	AA_1 Individual characteristics	A_4 individual mentality
		A_{13} physiological differences
		A_{14} previous experience
2	AA_2 Organization management	A_1 business training
		A_2 material reserve
		A_3 working strength
		A_7 working pressure
		A_8 work content
		A_{10} work division
		A_{11} coordination and organization
		A_{18} patient participation
3	AA_3 Space design	A_5 medical passage
		A_9 walkway layout
		A_{15} bed space
		A_{16} nurse station space
		A_{17} medical auxiliary space
		A_{19} patient passage
		A_{20} activity space
4	AA_4 Internal environment	A_{21} internal ventilation
		A_{22} night lighting
		A_{23} communication
		A_{24} somatosensory temperature
5	AA_5 Facilities and equipment	A_6 medical auxiliary facilities
		A_{12} peripheral medical facilities
		A_{25} peripheral living facilities
		A_{26} monitoring facilities
		A_{27} shared facilities

Main category

Axial coding aims to merge correlated categories, find the links among all categories, then simplify and differentiate them. In this study, the major categories are sifted out to better specify the themes of the interview recordings by merging the minor categories together. Thus, there are five major categories after axial coding, namely "individual characteristics," "organization and management," "space design," "internal environment" and "facilities and equipment" (Table 3).

Core category

Selective coding aims to sift core categories from the major categories. Core categories are used to clarify the interrelation of the major ones for an integral logic to better clarify the interrelation among the major categories. It is posited that "space design" should be selected as the core category. Specifically, based on the perception of the healthcare workers in ACFs, this study takes the five major categories and other minor ones and some related conceptions into consideration, which shows that "space design" can be used to explain the correlation among the major categories. The integral logic among the five categories is as follows: because of the COVID-19 epidemic, healthcare workers with distinguishing "individual characteristics" had to work in ACFs that were not well-equipped. While the original building structures constrained the "space design" of the ACFs, the "internal environment" was relatively deficient. The inadequacies of the "space design" of the ACFs were balanced mainly through "organization management" and together with some "facilities and equipment" to improve the health, well-being and work efficiency of the healthcare workers (Figure 2).

Relational structure

The "individual characteristics" are essential to all perceptions of the healthcare workers after clarifying the categories. While the facility and operation conditions of the ACFs were decisive factors for the final perception of healthcare workers. The "facility conditions", i.e. space and environment of the ACFs, affect the healthcare workers' perceptional system as soon as they begin to work in the ACFs. However, the "operation conditions", i.e. "organization management" and "facilities and equipment," plays decisive roles in the perception of the healthcare workers. The space of ACFs is essential to healthcare workers' activities, while the environment of the buildings is rather critical to their perception. Both of them had potential impacts on the healthcare workers, although they usually seemed to be unrecognized in the space and environment (17). However, despite the limited conditions during the epidemic, some counterbalanced measures were carried out to optimize the "operation conditions" of the ACFs, aiming to improve the workers' perceptions. Primary measures were to improve management capacity and secondary ones to strengthen support facilities (Table 4).

Theoretical model

The relational structure of the perception model for the healthcare workers in ACFs is developed based on the interactions among the categories. According to this structure, the factors affecting the healthcare workers' perceptions can be further divided into two groups that are endogenous factors (individual characteristics) and exogenous factors (organization management, space design, internal environment and facilities and equipment). As endogenous factors are composed of individual characteristics, it is regarded as the basis of the workers' perceptions and the exogenous ones play rather critical roles. Both of them are merged together by the sensory system of the healthcare workers and then the primary perception is

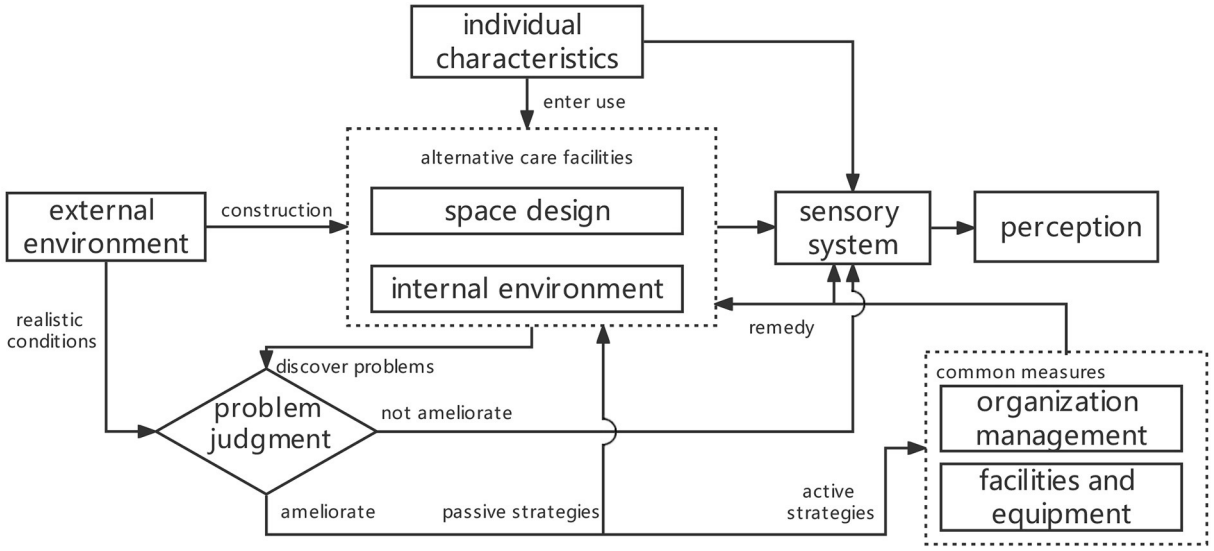

FIGURE 2
Interaction mechanism between main categories.

TABLE 4 Relational structure of the main category.

Relational structure				Intension
Individual characteristics		Essential conditions		Differences in experience, gender, and stress resistance are the primary factors leading to the different perception.
Space design	Decision condition	Facility conditions	Basic problems	The design of ACFs only meets basic user needs, which is the core reason for adverse perception.
Internal environment			Core problems	The internal environment of ACFs is mainly based on safety, and the importance of perception is relatively low.
Organization management		Operation conditions	Main measures	When external conditions are limited, and it is challenging to improve the building and environment facilities, strengthening operation conditions can effectively enhance the perception, such as business training, organization, and coordination.
Facilities and equipment			Auxiliary measures	Strengthening personal protective equipment, using existing facilities , taking mobile equipment and other feasible measures can effectively improve the specific perception.

produced. The improvement measures that counter healthcare workers' adverse perceptions can be further classified into two parts: active and passive strategies (Figure 3).

Discussion

The passive design strategy improves the performance of the building through the optimization of the building design, like the appearance and space design of the building and the selection of building materials. The active strategy aims to enhance building performance by artificial supplementary measures, such as air-conditioners and the operations of the buildings. The design of a hospital is usually improved by analyzing the workflow and needs of healthcare workers, by which the designer can ensure better user perception for the healthcare workers *via* promoting the design of space and environment of the buildings. ACFs are some of the most promising solutions to the pressing health care needs under disaster situations. During the COVID-19 epidemic, previous studies show that the environment of the ACFs not only has adverse impacts on the patients but requires healthcare workers to adjust themselves to the new surroundings (59). To improve healthcare workers' perceptions of ACFs during the epidemic,

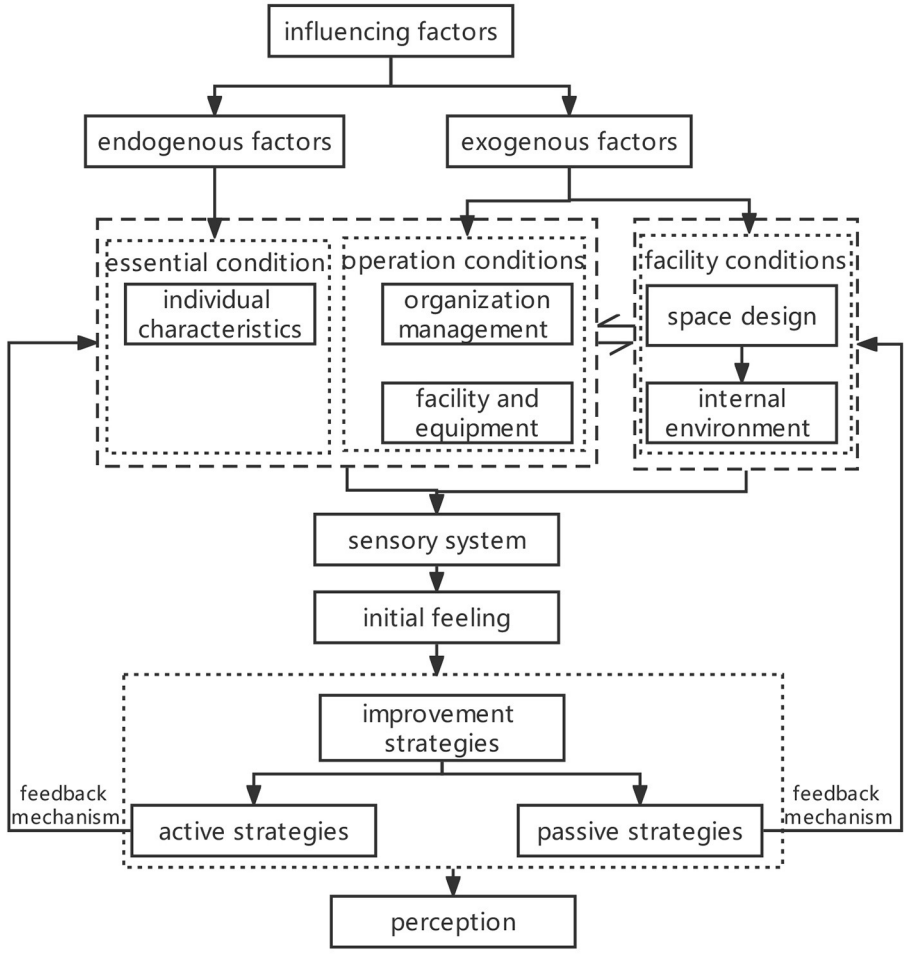

FIGURE 3
Perception models of healthcare workers in ACFs.

administrators of ACFs focus on active measures by a multi-tiered care model, PPE packs, emergency medical staff training, and psychological crisis intervention (49, 60–62). Recently, there have been studies on passive measures concerning more about the safety of the buildings' functional layout and internal environment (63–66). Although security is foremost in the ACFs, it is also essential to consider the healthcare workers' perceptions, which may reduce operating costs and active remedial measures. However, previous studies seldom explained the contributing factors of ACFs' design affecting the perception of healthcare workers. Only some showed that buildings, like residential living situations, impacted people's physical and mental well-being during the epidemic (67–69). Some analyzed the effect of housing built-environments on personal depression and anxieties (70, 71). Also, studies using multiple regression analyses show that the better the building design is, the fewer stress people may feel and the more active feedback the user will get (72). Passive design measures, such as function division, interior design, socialization approaches to design and positive distraction of light and sound can improve people's behaviors and emotions, reduce pressure and anxiety, and enhance users' perception and satisfaction (73).

Because healthcare environments are one of the most complex and demanding fields of work, an interdisciplinary solution is needed to achieve the goal of passively improving the healthcare environment. Giuliano K. K. and other researchers proposed that a nurse-engineer partnership is one of the most promising solutions to health care issues. Although the nurse-engineer partnership is faced with many barriers, it is encouraging to empower both nurses and engineers to create collaborations. According to Giuliano, finding a way for engineers to be trained in nursing and nurses to enter engineering are strategies helpful to developing infrastructure for health care innovation (74). For example, Brambilla and other researchers proposed the massive vaccination center layouts with the passive strategies, which is not only address safety by reducing cross-contamination risks, and improve the process efficiency but also ensure healthcare workers' well-being by the designs of resting spaces, short distances, and the correct sizing of space for the different activities (75). Meanwhile, they

developed an easy-to-use checklist divided into two sections containing general and specific structural requirements to ensure the different activities' quality, safety, and efficiency (76). In addition, relevant researches also show that it is necessary to strengthen the synergy between design and health and training multidisciplinary professionals for future healthcare (77, 78).

The above discussions show that building characteristics affect personal perceptions during the pandemic, and the optimization of the built facilities can improve healthcare workers' health and well-being. Therefore, it is necessary to strengthen the emerging multidisciplinary education, which can develop the nurse-engineer partnership, to excavate passive improvement strategies for seeking more optimization measures for the building design of the ACFs. Specifically, such passive measures include the number of beds in each care unit in the bed area, the layout of healthcare workers passage and patient passage, the openness and accessibility of nurse stations, and the position of medical apparatus and instruments. The optimization of the building design and environment of the ACFs can be realized by the passive strategies, reducing the healthcare workers' adverse perceptions and the operating costs and active measures.

Conclusion

The research aims to analyze the contributing factors to the healthcare workers' perceptions of the ACFs in this pandemic. Analyzing the actual narration of healthcare workers can avoid presupposition by the researchers through a qualitative study based on Grounded Theory. Eventually, there are five factors affecting the healthcare workers' perceptions which can be further divided into endogenous factors and exogenous factors. By interpreting the interactions among the factors and perception of healthcare workers, the passive strategies are realized to protect people's health and well-being in ACFs. In all, the research broadens new horizons for future research on the optimization of ACFs. It is also suggested that the emerging multidisciplinary education should be strengthened, especially the nurse-engineer partnership. Furthermore, exploring the measures of the rebuilding facilities as many as possible can help improve healthcare workers' perceptions and protect the health and well-being of people in ACFs.

Limitations

Although this paper proposed a way to optimize the healthcare workers' perception of ACFs based on passive design, it did not explore specific measures which need further research. In addition, the healthcare workers interviewed are all from China. As mentioned above, the ACFs have played various roles in different countries during the epidemic (14–16), which leads to the differences in the responsibilities and working environment of the healthcare workers. Meanwhile, the interviewees come from other provinces to fight the epidemic in Wuhan, which means that their adverse perceptions may not be influenced by the fear that their families could be infected by the virus, as shown by some studies (44). Limitations as such may constrain the feasibility of this research and lead to differences in some details of the factors of perception in ACFs in different regions.

Data availability statement

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

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

HW is responsible for interview data collection, article writing, and post revision. PL is responsible for interview design and article content inspection. YW is responsible for interview data collection and post revision. XZ is responsible for post revision. All authors contributed to the article and approved the submitted version.

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Conflict of interest

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

Publisher's note

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Strategies for screening, occupational prevention, and management of COVID-19 in outpatient clinics in Shandong

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Objective: We hope to analyze the information of outpatients in a tertiary care hospital during the epidemic of COVID-19, so as to formulate effective regulations for the prevention and control of COVID-19.

Methods: We collected information from outpatients from January 28, 2020 to March 2, 2020 and performed the statistical analysis.

Results: During the study period, there were more than 60,000 outpatients. Among them, 404 patients with a body temperature above 37.3°C who had not been to Wuhan and had no contact with people from Wuhan. There were 8 people who had contact with people from Wuhan, such as 4 people with fever, 3 people with normal body temperature but cough symptoms, and 1 person with normal body temperature and no other discomfort. There were 2 patients with high body temperature from the epidemic area in Wuhan, and one novel Coronavirus patient was confirmed as the final result.

Conclusion: During the COVID-19 pandemic, outpatient medical staff should enhance their awareness of protection, hospitals should standardize the outpatient COVID-19 prevention and control system, improve the prevention and emergency system, and reduce occupational exposure hazards and the occurrence of post-exposure infections.

KEYWORDS

COVID-19, occupational exposure, outpatient clinic, prevention, epidemiological investigations

Introduction

Since December 2019, pneumonia cases caused by an unknown pathogen have been observed in Wuhan, Hubei. The epidemiological investigations have revealed high contagiousness and potential of transmission among people. In January 2020, the pathogen was isolated and identified by scientists. Genome analysis showed that the pathogen was a novel coronavirus and named COVID-19 (1). The COVID-19 pandemic suggests the importance of infection prevention and control measures in

health facilities (2). The rigorous measure has been taken to prevent and control the spread of the COVID-19 in China. As the cases of COVID-19 have been reported nationwide, the outpatient clinics of hospitals in other provinces apart from Hubei are also exposed to the infected patients. Without sufficient awareness of occupational protection and appropriate regulation of outpatient activity, it is highly possible that nosocomial spread occurs (3). It has been required that infectious diseases be managed by different classifications and the healthcare providers are obliged to prevent, control, and eliminate the spread of infectious diseases according to the Infectious Disease Prevention Act in China (4). It is acknowledged that the outpatient clinics are the first guard to the potential virus infection. And due to the fact that long duration and great workload are common for medical staff in outpatient clinics, the possibility of occupational exposure for them is greatly increased. To propose better working protocols and strategies for the occupational prevention of COVID-19, we summarized the characteristics of the outpatients and testified the routine preventive measures.

Materials and methods

Subjects

From January 28, 2020 to March 2, 2020, all patients who attended the outpatient clinic of the Qilu Hospital of Shandong University were included. Prior to the information collection, informed consent was obtained from each participant and the study was approved by the local Ethical Committee of Qilu Hospital of Shandong University.

Epidemiological analysis

We detected body temperature and developed a questionnaire to collect relevant information on outpatients during the study period, such as the motion trail in hospital, history of travel to epidemic areas, and potential exposure to suspected patients. All registered information was entered into an Excel sheet and sorted and summarized.

Results

The daily outpatient amount

The total amount of outpatient visits from January 28, 2020 to March 1, 2020 was over 60, 000 (Figure 1). The maximum amount of daily outpatient visits was 4,727 on March 1, 2020. The daily outpatient amount was fluctuated and relatively low during the weekends. At the end of February, the daily outpatient amount was increased compared to the former part of the month.

Epidemiological analysis of outpatients with high risk of COVID-19

All outpatients were subjected to epidemiological investigations. A total of 404 patients had a body temperature above 37.3°C without a history of traveling to Wuhan or coming from the epidemic area of Wuhan (Table 1). A total of 8 patients had a history of traveling to Wuhan, of which 4 patients had a fever and 3 patients had a symptom of cough with a normal body temperature. A total of 2 patients came from the epidemic area of Wuhan with an abnormal temperature, of which one was diagnosed with COVID-19 (Table 2).

Prevention and management strategies

Strengthen the management of personnel

The patients and their companions are the major sources of the floating population at outpatient clinics. To help prepare the patients for the appointment and seeing the doctors, the visit procedure and notes were broadcasted by the Internet, WeChat, and electronic screens. These measures can shorten the stay time of patients and their companions in the department of outpatient. The patients and their companions are required to wear surgical masks or N95 masks and keep a distance of at least 1 meter from each other all along their visiting time. Before they enter the hospital, the patients and their companions should receive body temperature detection and show their ID cards. And epidemiological investigations help to learn about the purpose of the visit, history of travel to Hubei, potential exposure to COVID-19 diagnosed or suspected patients, and possible contact with clustering infection households.

The medical staffs are crucial to take part in the prevention of nosocomial COVID-19. The doctors and nurses should detect and report their body temperature every day. Once they had a fever or symptoms, such as cough or chest distress, they should not come to work. The working staff should obey the standard prevention rules, evaluate the potential risk of occupational exposure when they operate and pay much attention to hand hygiene (5). Furthermore, the working stall at outpatient clinics should be equipped with personal protection facilities, such as isolation gowns, medical hats surgical masks, latex gloves, protection suits, goggles, and face shields, if necessary. A three-level previewing and triaging system is applied and when the outpatients and their companions register and take the body temperature test, the doctors and nurses

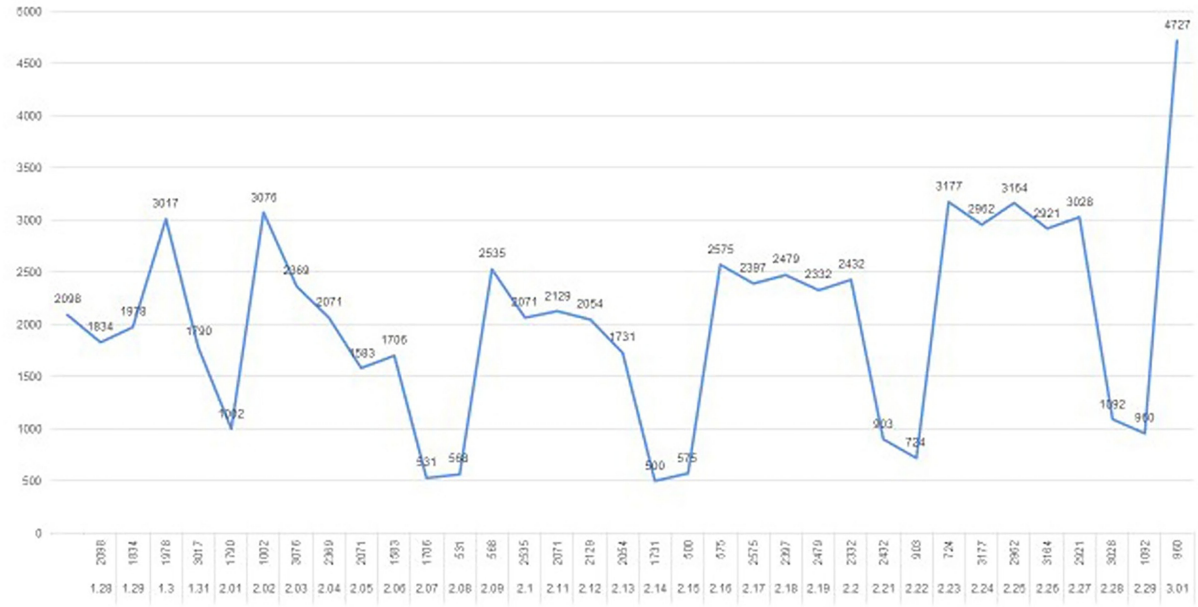

FIGURE 1
The daily amount of outpatient visit.

should keep a safe distance from them and use sanitizers to prevent contact infection. On the other hand, the amount of working staff can be adjusted according to the number of outpatient visits. Exquisite management of working shifts helps to ensure sufficient rest of healthcare providers and decreases the unnecessary consumption of protection facilities. A team for an emergency situation can be set up to cope with the unexpected inflow of large amounts of patients.

Apart from the doctors and nurses, other working staff, such as cleaners and security personnel, should also be trained for nosocomial infection prevention and personal protection. The cleaners should disinfect the working environment using chlorine-containing disinfectant twice daily. And the medical waste should be transported and disposed timely. Security patrols should be strengthened to maintain normal medical order and deal with emergency events.

TABLE 1 Fevered patients without history of coming from the epidemic area of Wuhan.

Department	Number	Direction
Department of pediatrics	274	Fever clinic
Department of internal medicine	85	Fever clinic
Department of obstetrics and gynecology	13	Fever clinic
Department of clinical laboratory	9	Fever clinic
Department of otorhinolaryngology	5	Fever clinic
Department of oncology	5	Fever clinic
Department of ultrasound	5	Fever clinic
Department of productive medicine	4	Fever clinic
Department of International medicine	2	Fever clinic
Department of hepatology	1	Fever clinic
Department of surgery	1	Fever clinic

Enhance the management of processing

A three-level defense system is applied to prevent the nosocomial COVID-19 spread. The first line of defense is the previewing and triaging station in the emergency room, the hall of the outpatient department, and the entrances of the hospital. Medical staff should guide the patients and their companions to sign the consent, check the identification, detect and record the body temperature and investigate the epidemiological background. If the patient has a fever or exposure history, he should be required to wear a medical mask appropriately and be guided to the fever clinic on the assigned route. And the environment should be disinfected at once. The second line of defense is the previewing and triaging station at different departments. The nurses should pay attention to personal protection and hand hygiene. They should recheck the identification and epidemiological information of the patients and retest their body temperature. Patients with a temperature above 37.3°C should also be guided to fever clinic in the assigned route. The third line of defense is the

TABLE 2 Patients with a history of traveling to Wuhan or coming from the epidemic area of Wuhan.

Department	Number	Symptom	Epidemiological background	Direction
Department of internal medicine	1	Body temperature above 37.3°C	From the epidemic area of Wuhan	Fever clinic, designated hospital (diagnosed with COVID-19)
Computerized tomography room	1	Body temperature above 37.3°C	From the epidemic area of Wuhan	Fever clinic, designated hospital
Department of pediatrics	7	4 had fever, 3 had cough	Travel to Wuhan	Fever clinic
Bronchoscope room	1	None	Travel to Wuhan	Fever clinic

doctors in the clinic rooms. The doctors at the department of outpatient should strengthen their personal protection and obey the rules of hand hygiene. They should detect the body temperature of the patient and inquire about the epidemiological information once again. And patients with high risk should be guided to the fever clinic by the nurses. More importantly, the process of the outpatient visit should obey the principle of unchangeableness, i.e., the requirement that only one patient can stay in the clinic room, the route of the outpatient visit, the place of patients registering, taking examinations, and getting the drugs, and the accompanying medical staff and companions should not be changed to avoid extra contact between patients and other people.

The nurses at the outpatient clinic can be subdivided into triage, service, and contact post. And flexible shifts are recommended. When the triage work is in need, nurses in triage posts should be sufficient to finish measuring body temperature, helping the patients get registered, and triaging quickly. After triaging, the nurses in the service post should guide the patients and their companions to take seats in a safe distance and wait for seeing the doctor. They should also monitor the patients and persuade them from close chatting. And the nurse in contact post should guide the patients to the clinic room, keep them in quiet, and in order, and make sure that only one patient can stay in the clinic room.

To better learn the situation, statistics on the fevered patients and their companions should be collected and analyzed daily. Also, the medical staff should report their exposure to the suspected patients to discover the unit with high risk and make corresponding responses. Senior nurses should survey and supervise the implementation of preventive measures.

Improve the management of environment

The accommodation capacity of the patients and their companions are evaluated based on the available space and facilities at the department of outpatient. And the amount of outpatients is accordingly limited to avoid personnel overload and increased risk of COVID-19 spread. The ventilation of the clinic area is ensured by opening the window twice daily for at least 30 min. The air is refreshed using an air purifier with a circulating fan when the clinic room is used. And the air is disinfected utilizing an ultraviolet radiator or peroxyacetic acid and chlorine-containing disinfectant spray. The air-conditioning system and exhaust fans are regularly checked to function well. The air conditioner filter is cleaned and the air outlets are disinfected regularly. The public areas such as nurse stations, the hall, corridors, waiting areas, clinic rooms, and toilets are disinfected twice daily using chlorine-containing disinfectant twice daily. The medical and non-medical waste is cleared timely and the dustbins are disinfected with 75% ethanol or chlorine-containing disinfectant.

Reinforce the management of emergency response

The three-level previewing and triaging system should be strictly executed. Once the patient with high risk who has fever or epidemiological hazards is identified, the patient should be immediately registered and reported. Specific staff in response to the emergencies is responsible for the patient transferring to the fever clinic. The space and materials which are exposed to the suspected patients should be disinfected sufficiently with chlorine-containing disinfectant or ultraviolet radiation.

Case

A 37-year-old male traveled to Chongqing in business on 17th, January and flew back on 20th, January. He had a fever during this time and saw a doctor in a community hospital. His symptoms were worsened on 25th, January and came to the department of outpatient, Qilu Hospital of Shandong University. The nurses at the first level previewing and triaging station collected his epidemiological information and detected his body temperature. The emergency response was initiated after the nurses judged that this patient is at high risk of COVID-19. The personal information of this patient was registered and reported. The patient was transferred to the fever clinic for further examination. In this process, the two nurses were in protection suits from the beginning and strictly cleaned their hands and changed their suits according to the protocols. At

the same time, the environment exposed to the patient was carefully disinfected. On 1st, February, the nucleic acid test of nasopharyngeal swab samples showed positive results, and the patient was diagnosed with COVID-19 after the expert consultation. The patent was then transferred to the designated hospital by ambulance. The two nurses were quarantined at home for 2 weeks and received medical observations. No discomforts or abnormal body temperatures were reported before the quarantine was relieved.

Discussion

COVID-19 is an infectious disease that is managed according to the national regulations in China. Outpatient clinics are the first to be affected and are crucial in the prevention and control of nosocomial spread. The systems of information registration, screening process, visiting management, and emergency response play important roles in the management of outpatients and help to build defense lines in the prevention of COVID-19 transmission at the department of outpatient. First of all, awareness of occupational protection should be emphasized to avoid epidemic among the medical staff. Furthermore, the department of outpatient is responsible for the identification of potentially infected patients quickly and accurately (6). Thus, working protocols and management regulations are needed (7). Trainings are necessary and the information should be updated timely. Moreover, measures to isolate and monitor the fevered and suspected patients are important to protect the medical staff and other patients. Meanwhile, sufficient preparation and rigorous execution of the management regulations are vital to make sure the situation is under control.

In this study, the department of outpatient admitted more than 60,000 patients in this period. The 2 suspected patients were identified and transferred to the designated hospitals and 1 patient was diagnosed with COVID-19 eventually. Owing to the strict measures, standardized regulations and great execution of the protocols in the daily working at the department of outpatient, none of the medical staff was found to be infected. Therefore, improving the strategies for screening, occupational prevention, and management is vital and effective in the control of the COVID-19 epidemic at the department of outpatient.

Data availability statement

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

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

YZ and X-MG: methodology, formal analysis, data curation, software, writing—original draft, and visualization. YL and YS: writing—review and editing and project administration. YL, JT, and Z-HZ: investigation. X-DJ, YZ, and X-MG: conceptualization, resources, supervision, and project administration. All authors contributed to the article and approved the submitted version.

Conflict of interest

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

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Comparison of different estimators of SARS-CoV-2 pandemic activity on geographical and temporal levels

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Background: Studies began investigating occupational exposures as a source of contamination to SARS-CoV-2, yet few considered the variation in SARS-Cov2 pandemic activity for these exposures. Several indicators were built to assess SARS-Cov2 activity though they usually serve a specific purpose and have limitations. The aim was to compare qualitatively different estimators of the SARS-CoV-2 pandemic activity and to create an estimator of pandemic activity level based on daily hospital admissions for job-exposure matrices (JEM) usage.

Methods: From publicly available French databases, we retrieved all data from March 19, 2020 (first day available) to March 25, 2021 (day of data collection) on four different estimators: percentage of intensive care bed occupied, reproductive number, tests' positive rate and number positive tests. An indicator based on new daily hospital admissions was created for a COVID JEM. Due to the heterogeneity of the estimators, a qualitative comparison was carried out.

Results: During the study period, three major outbreaks took place. Though the number of positive tests was the first indicator to worsen during the 2nd outbreak, it failed to identify variation during the outbreak. Though each indicators behaved differently during the study period, the indicator based on new daily hospital admissions and the positive rate seemed to be the closest to one another.

Conclusion: This study highlights the heterogeneity of the indicators used during the first and second SARS-Cov2 outbreaks in France. An indicator based on new daily hospital admissions seems to be a good candidate for estimating SARS-CoV-2 epidemic activity for COVID JEMs and is easily available in countries where usual indicators are not commonly accessible.

KEYWORDS

COVID-19, occupational health, public health, epidemiology, job-exposure matrices

Introduction

While the COVID-19 crisis is still underway, questions have risen regarding occupational exposures as a source of contamination. Though temporarily shutting down work activities was a measure frequently used at the beginning of the pandemic, prolonged lockdowns seem unreasonable because of their adverse effect on the economy and on health (1, 2). Work life is now regimented by the variation in SARS-CoV-2 pandemic activity, which often changes how strict preventive measures would be applied. Thus, companies, with the help of occupational health professionals, are constantly having to adapt their work organization to the ebbs and flows of the SARS-CoV-2 infection trends. Indeed, assessing biological hazards, including infectious diseases, and implementing adequate preventive measures has become fundamental, and the International Labor Organization has recently released guidelines to advice governments, employers, workers and their representatives (3). There are several methodology to assess the workplace risks and management them consequently, but most of them characterize biological hazard in relation to the probability of contact to a contagious source, whether there are contacts with colleagues at work or the general public, and the means of protection including how likely a close proximity is needed at work (4). In the case of a infectious diseases, especially with airborne transmission, the first part of this assessment requires to know the epidemic activity level which can influence the probability of a contact to be a contagious source. However, this factor is often eluded even if there are exposure indicators that could be used to optimize employer and occupational health professionals' responses to pandemics, especially in the case of SARS-CoV-2.

Governments and research teams have built many models with exposure indicators to assess SARS-CoV-2 activity. Each indicator serves a specific purpose and is used in public health decision-making that is often guided by whether or not health systems are overloaded. One of the most common indicators used for assessing the SARS-CoV-2 epidemic activity is the daily number of positive PCR tests. These tests may seem like decent indicators of epidemic activity since they have good sensitivity and specificity (5) and permit early detection (6). However, they have many limitations, including the time needed to develop, validate and make them broadly accessible as well as their dependence on the number of tests performed (7). The daily number of new hospital admissions is an indicator closely related to the circulation of the virus (8). It is easily accessed and quickly useable. It seems like a reliable indicator in countries where surveillance capabilities are limited, beyond confirmed deaths from COVID-19. Cumulative incidence on a set period (weekly, monthly) also could be a better choice than daily indicators since the latter are more susceptible to variability and errors. However, considering the singularities of workplaces, the best usable indicator for occupational health practitioners and stakeholders is not known.

The aim of this study was to qualitatively compare different estimators of the SARS-CoV-2 epidemic activity that are currently in use as pandemic indicators, as well as create an estimator of pandemic activity that would be based on daily hospital admissions. These indicators were compared across both time and geographical variations.

Method

Origin of data

Data on COVID-19 indicators such as incident cases or incident new hospitalization cases were retrieved from France's official government website (9). Launched in May 2020, SI-DEP, a screening information system, is a secure platform where the results of SARS-CoV-2 tests from all hospitals, laboratories, pharmacies, healthcare professionals, and screening campaigns are systematically recorded. The SI-DEP information system feeds various institutions with different objectives and needs: Public Health France and the Ministry of Health for monitoring the epidemic; the France compulsory health insurance and regional health agencies for contact tracing. The database variables are publicly available and accessible at the departmental level (equivalent to county). We included all data from March 19, 2020 (the first day available) to March 25, 2021 (day of data collection). Since we aimed to build an indicator that would show the spatial trends of the SARS-Cov2 circulation on a county level, the indicator needed to be standardized on the number of inhabitants per county. For this, we retrieved data from the latest national census available (2020) (10).

Estimators

Five different estimators were used in this study: four indicators provided by the French Government based on the daily cases of positive PCR, on the positivity rate of COVID tests, on the basic reproduction number and on the percentage of intensive care beds occupied), and a specific indicator made for Mat-O-Covid JEM based on the daily number of new hospital admission.

The first estimator is the number of people tested positive by a PCR or an antigen test for the first time in the last 60 days standardized by the number of inhabitants. The indicator is calculated for a moving week and categorized in three level of epidemic activity: <10 positive cases per 100.000 inhabitants (low epidemic activity), between 10 and 50 positives cases (moderate epidemic activity), ≥ 50 positive cases (high epidemic

activity). Due to the lack of tests during the first covid outbreak, this indicator is usable only from May 13, 2020.

The second estimator used is the positive rate of COVID test which is the percentage of number of PCR or an antigen test positive divided by the number of tests carried out on a set period. Three level of epidemic activity were calculated: positive rate <5% (low epidemic activity), positive rate between 5 and 10% (moderate epidemic activity) and positive rate ≥10% (high epidemic activity). Positive rate was available from May 19, 2020.

The third estimator is the basic reproduction number which is calculated once a week based on data from the previous week. Three level of epidemic activity were calculated: basic reproduction number <1 (low epidemic activity), basic reproduction number between 1 and 1.5 (moderate epidemic activity), and basic reproduction number ≥1.5 (high epidemic activity). This estimator was available from June 15, 2020.

The fourth estimator is the percentage of intensive care beds occupied which is the number of patients hospitalized in intensive care unit divided by the number of ICB available before the COVID-19 crisis. Three level of were defined: percentage of ICB occupied <30% (low epidemic activity), percentage of ICB occupied between 30 and 60% (moderate epidemic activity), and percentage of ICB occupied ≥60 (high epidemic activity). This estimator was available from the beginning.

The last estimator used was built specifically for the Mat-O-Covid project, a COVID JEM (11). The estimator is based on the cumulated number of new hospital admissions on a weekly basis and is calculated for each county, from March 19, 2020 to March 25, 2021. This distribution of all cumulated number of new hospital admissions for each week and each county considered is saturated to lower the effect of extreme observations. The threshold used for this saturation was identified as the value equal to the third quartile plus 1.5 times the interquartile range. Using this saturated distribution, the maximum for the entire population was identified, and three categories of epidemic activity were created: ratio of incident number of new hospital admissions divided by the maximum number of new hospital admissions <1/3 (low epidemic activity, i.e., 12.0/100,000), between 1/3 and 2/3 (moderate epidemic activity) and >2/3 (high epidemic activity, i.e., 24.0/100,000).

Three of the four government estimators assess epidemic activity daily. To allow comparison with our estimator which was chosen to be weekly, we created a weekly average of epidemic activity for these estimators. The epidemic activity variable was converted into a discrete quantitative variable: low epidemic activity being "1," moderate epidemic activity "2" and high epidemic activity "3." The weekly epidemic activity corresponded to the rounded mean on a week.

For the analysis of these indicators, we decided to take a qualitative approach to illustrate our hypothesis, which is that classical indictors used in epidemy activity level are heterogeneous. Indeed, there is no gold standard to compare these indicators and each of them estimate different aspect of an epidemy activity which makes the comparison complex. As such, no quantitative estimates were made in this study. Three representative counties and one oversea county were chosen: Paris (most populated), Bas-Rhin (high epidemic activity during the first outbreak), Ille-et-Villaine (low epidemic activity during the first outbreak) and La Guadeloupe (overseas county). A table presentation showing evolution of all five estimator was created and a table with all counties is available as Supplementary material. All analyses were run using R software version 4.0.4 (packages "tidyverse" and "ggsci"). The new hospital admission indicator that was constructed is at an early stage of development and further work will be needed to better analyze its statistical and epidemiological attributes.

Results

Between March 19, 2020 and March 25, 2021, data were collected for 371 days, i.e., 53 weeks. During this period, three major outbreaks took place: from March to April 2020 (first lockdown), from October to December 2020 (first curfew and second "soft lockdown") and from March to April 2021 (extended curfew and third "soft" lockdown) (12). The only indicators available during the first lockdown were the percentage of ICB occupied and the new hospital admission.

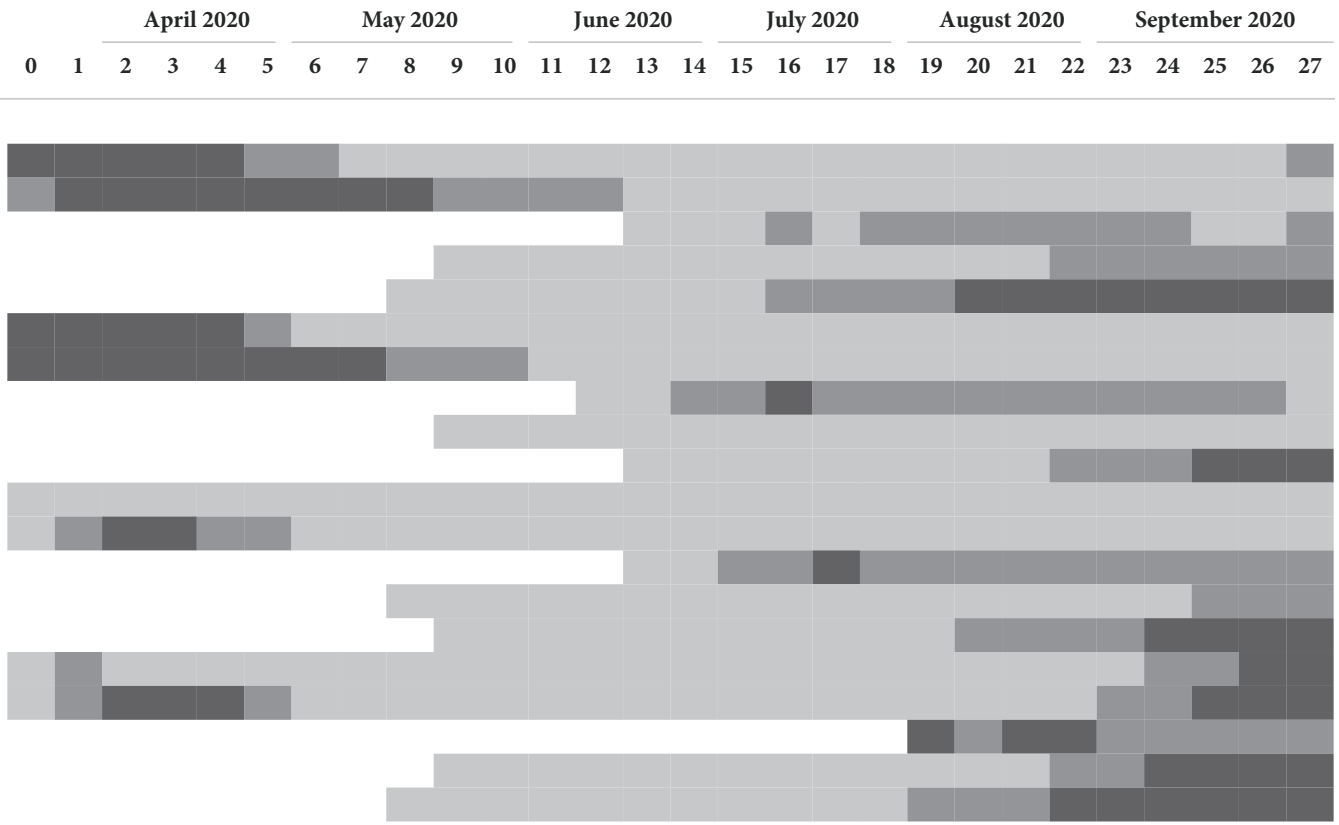
Though the number of positive tests was the first indicator to worsen during the 2nd outbreak, as early as September 2020, it classified weeks as high epidemic activity during the rest of the study period (until March 2021) for almost all counties (Table 1 and Supplementary Data). The percentage of intensive care beds occupied was the 2nd indicator that categorized the most weeks in high pandemic level activity, with more than 30% weeks classified as high epidemic activity (Figure 1). The reproduction number indicator classified the least weeks as high epidemic activity (6.4%) compared to the other indicator. Though each indicators behaved differently during the study period, the number of hospital admission indicator and the positive rate indicator seemed to be the closest to one another, though latest classified more weeks in moderate epidemic activity than low epidemic activity.

Discussion

This study highlights the heterogeneity of the indicators used during the first and second SARS-CoV-2 outbreaks in France.

There is no gold standard for assessing the epidemic level activity of a disease and finding a good indicator can be difficult. The European Center for Disease Prevention and Control (CDC) enumerates a number of qualities a good indicator should have (13). Some qualities are related to the inherent qualities of the indicator, such as its ability to measure adequately (e.g., sensitivity, reliability), others are

TABLE 1 Comparison of the different indicators according to time for four different types of counties.



(Continued)

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TABLE 1 (Continued)

	Month	October 2020				November 2020					December 2020				January 2021				February 2021				March 2021				
	Week	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53
Counties	**Indicator***																										
Paris	New hospital admission																										
Paris	Intensive care bed occupied																										
Paris	Reproductive number																										
Paris	Positive rate																										
Paris	Number positive tests																										
Bas-Rhin	New hospital admission																										
Bas-Rhin	Intensive care bed occupied																										
Bas-Rhin	Reproductive number																										
Bas-Rhin	Positive rate																										
Bas-Rhin	Number positive tests																										
Ille-et-Villaine	New hospital admission																										
Ille-et-Villaine	Intensive care bed occupied																										
Ille-et-Villaine	Reproductive number																										
Ille-et-Villaine	Positive rate																										
Ille-et-Villaine	Number positive tests																										
La Guadeloupe	New hospital admission																										
La Guadeloupe	Intensive care bed occupied																										
La Guadeloupe	Reproductive number																										
La Guadeloupe	Positive rate																										
La Guadeloupe	Number positive tests																										

*Black square = high pandemic activity, dark gray square = moderate pandemic activity, light gray square = low pandemic activity.

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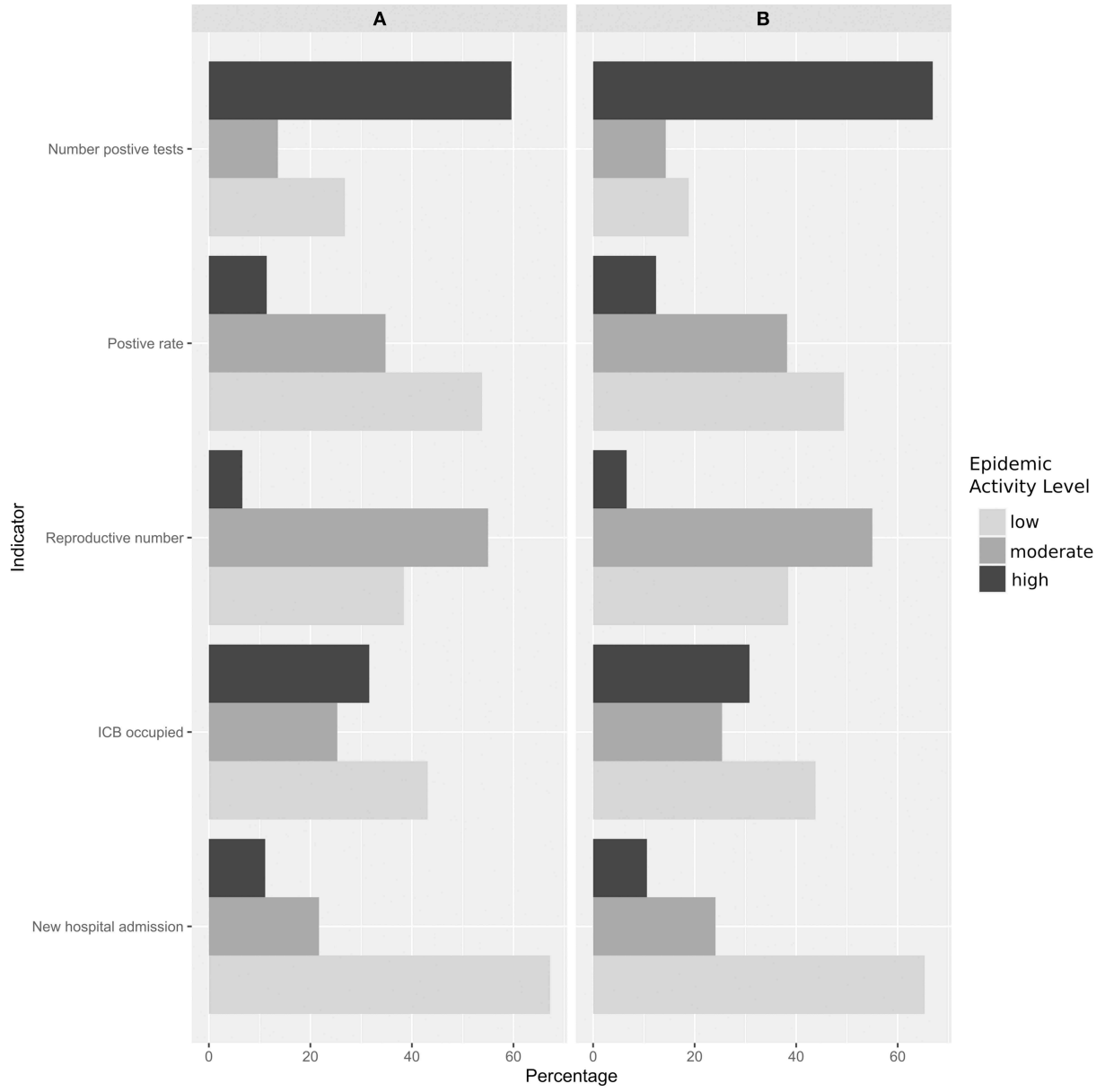

FIGURE 1
Percentage of weeks, for all counties, categorized as high, moderate, and low epidemic activity by the indicators considering **(A)** all the study period and **(B)** the date when all indicators were available (18 June 2020).

focused on the usage of the indicator, such as, its simplicity or its representativeness. The World Health Organization further develops these characteristics: an indicator should be relevant, scientifically sound and applicable to users (14). Though it seemed intuitive to use and easy to understand by everyone, the number of positive test as an indicator of epidemic activity did not seem to be sensitive to changes. Likely, the reproductive number worsened early during the 2nd outbreak but tended to underestimate peaks of epidemic activity.

The indicator based on the number of new hospital admission cases seems to be a good candidate for estimating SARS-CoV-2 epidemic activity. First, new hospital admission is a variable that can be easily obtained even at the beginning of a pandemic and in countries where PCR tests are not easily available since hospitalization data is now always collected. Second, it is also a simple and understandable indicator to use as it is not conceptual (number of cases) and as it also reflects the burden of SARS-CoV-2 on health systems. Lastly it is also more robust to differential bias as the criteria for hospital

admission is consistent to both time and geographical areas, contrary to the number of positive tests for example, which is dependent on the number of tests performed and its availability. The main limitation is that it seemed to underestimate epidemic activity in counties less populated (Supplementary material) and worsened later than some indicators. This may be due to how the indicator was constructed as the thresholds used are based on the total number of cases by week, which is a national data, and thus flatten the epidemic activity assessment in these counties. This potential new indicator is still in development and much research will be needed, notably to assess its statistical and epidemiological proprieties before considering a potential usage as indicator of epidemic activity.

As mentioned previously, management of occupational biological risk hazard is essential for preventing propagation of diseases. This assessment will allow to implement preventive measures that are proportionate to the intensity of the workplace risk and clinical vulnerability risk (4). Indeed, prevention measures that are too strict can lead to adverse health effect as shown by the SARS-Cov2 pandemic (2). A precise assessment of the risks is thus important and could need indicators of level of epidemic activity. This work suggest that some indicators are better suited for this assessment, and the reproductive number and new hospital admissions indicators could be used on a county level to help workplace adapt their prevention measures. For example, occupational health professionals could first assess the risk of contact with public and colleagues during their work. If this risk is high, they could next use local and open access data from public health agencies (like new hospital admission or positive rate) to incentivize broader teleworking or social distancing at work when these indicators begin to worsen or increase past a threshold. Other potential targets for mitigating risk could be promoting more frequent testing, enabling contact tracing, and incentivizing vaccination, if tests and vaccine are available. Likely, a decrease of these indicators would help alleviate preventive measure. This kind of approach would allow a flexibility in the implementation of safety measures and would also consider both the local trend of pandemics and the specificity of workplaces.

In addition, on a broader level, new hospital admission could be an interesting indicator to use for Covid-19 job-exposure matrices (JEM) for research and public health purposes. For example, The Mat-O-Covid project ("Matrix-Occupation-Covid") aims to build a job-exposure matrix (JEM) for SARS-CoV-2 exposure. JEM allow to have a mean estimate of exposure according to a job title. JEM have many strengths and weaknesses (15) and, while not being a good estimate on an individual level, the results of JEM are useful when working on a population level. While this indicator was developed for the French JEM Mat-O-Covid, it could be adapted for other covid JEM that are being constructed to further improve their estimations (16). Epidemic activity is an important factor to consider in these matrices due its variability according to time and geographic area, as illustrated in this study.

The descriptive analysis limits the results of this study, however, and a direct comparison between the indicators would not be relevant due to the difference in what they measure. The lack of gold standard also makes it difficult to validate the indicators. In many countries, the problem is about the availability of such indicators, and the indicator based on new hospital admission seems promising, though much statistical confirmation is needed before implementing it. Our work illustrates some strengths and limitations of each indicator though careful interpretation is warranted as they are not easily interchangeable and assessing the level of epidemic activity would require using more than one to be thorough.

To conclude, this study highlights the heterogeneity of the indicators used to assess SARS-CoV-2 epidemic activity. An indicator based on new hospital admission may be useful for workplace decision-making, future COVID JEM and in countries where usual indicators are not commonly accessible.

Data availability statement

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

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

RV, AD, and MF designed the study. RV and MF collected the data, carried out data analysis, and drafted the manuscript. GS and AD critically reviewed the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

Author AD is editor in chief of Archives des maladies professionnelles et de l'environnement (Elsevier).

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.

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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.2022.871010/full#supplementary-material

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Lessons from a crisis—opportunities for lasting public health change from the COVID-19 pandemic

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The coronavirus 2019 (COVID-19) global pandemic has wrought hardship and disrupted lives across all strata of humanity, giving rise to a variety of social, psychological, and medical challenges to individuals in almost every country in the world. Yet for all the difficulties the pandemic has inflicted, it has forced us to examine previously accepted practices at home, work, and society more broadly and has led to innovative changes in the way we communicate and collaborate. These novel approaches to contemporary challenges were devised primarily to allow continued productivity despite the need for social distancing, but have offered secondary advantages that could provide society with lasting benefits. In the following review, we outline three aspects of working life and public health which could experience lasting improvement on the back of lessons learnt from the current crisis.

KEYWORDS

COVID-19, vaccination, medical education, telemedicine, pandemic (COVID-19), collaboration

Introduction

The coronavirus 2019 (COVID-19) global pandemic has unambiguously wrought hardship and disrupted lives across all strata of humanity. In doing so, the pandemic has given rise to a bleak chapter not to be forgotten by any of us anytime soon. COVID-19 has spread to almost every country in the globe with almost 400 million cases and more than 5.5 million deaths worldwide (1). The highest number of confirmed cases and deaths in the United States was over 75 million and 890,000, respectively; at the time of this writing, numbers made all the more staggering when considering the fact that the first year of the pandemic saw the virus killing more people in the United States than stroke, influenza, suicides, and car crashes combined (1). Moreover, neither world economies nor individual businesses have been able to escape its grasp, with unemployment reaching 15% at the height of the first wave, prompting the government in the United States to enact six major relief bills amounting to more than $5 trillion (1). Undoubtedly, the pandemic has affected individuals at all levels of society across the world, bringing with it a host of stressors including job loss or job and income insecurity, illness and deaths of loved ones, and social isolation and loneliness. While the longer-term implications of the COVID-19 pandemic are yet to be realized, it is likely that the health and economic consequences faced by individuals and families across the world during this time will be vast.

So, naturally, who would not want to return to the "good old days"—a simpler, safer, and more familiar time. In many ways, the return leg of that journey is well underway. The vaccination campaign in the United States commenced in December 2020, with more than 50% of the population in the country fully vaccinated (1). Lockdown policies and social distancing restrictions have largely been lifted, and minds are concentrating on a potential return to a semblance of normalcy this year. This then begs the question whether our existing concept of "normal" henceforth should be revised. Are there some aspects of pandemic life that we should retain? Did any good come of this time, or was all our suffering for nothing? Winston Churchill was purported to say "never let a good crisis go to waste" in the early days of the Second World War. Indeed, the former British Prime Minister was referring to early events of what in its own right was a terrifying chapter of human history. For all the misfortunes the pandemic has inflicted, it has forced us to examine previously accepted practices at home, work, and society more broadly and has led to innovative changes in the way we communicate and collaborate. Outside the usual scope of workplace navigation, these changes were devised primarily to allow continued productivity despite the need for social distancing, but through serendipity have yielded secondary advantages that we should be cautious about disregarding in our eagerness to return to familiarity.

Tele-healthcare

The pandemic has led to an unparalleled shift from in-person care to remote visits (2), facilitated in part by changes in reimbursement policies. The use of telemedicine has increased gradually over recent years although there has been a sharp surge in its uptake during the pandemic, laying the basis for remote clinics forming a larger and more permanent aspect of healthcare delivery (3–5). Studies have shown the benefits of remotely delivered healthcare through event monitors, smart devices, and wearables on various disease processes including hypertension and heart failure (6, 7). Indeed, while traditional healthcare models require in-person evaluation with potentially lengthy visits and costly testing, telemedicine holds the promise of offering simple, inexpensive, and non-invasive methods of evaluation that are undertaken remotely from healthcare providers, which may therefore reduce risk of transmission of diseases between patients and providers. Further, studies have demonstrated that telemedicine has the potential to improve care for patients (7, 8). Nevertheless, the implications of such a large-scale transition to remote healthcare on real-life clinical practice patterns as well as patient care and outcomes are still to be determined. This would be particularly important given the lack of established guidelines outlining best practice for remote care, the potential for unintended consequences that include those created by the so-called digital divide whereby specific patient groups such as those who are older, from racial and ethnic minority groups, and with more comorbidities might be less able to use remote care through lack of access to the Internet and technology literacy or through a lack of physical examinations resulting in an excess use of unnecessary testing and overprescribing medications. Surprisingly, in a recent study looking at a large number of ambulatory cardiology visits the authors found a significantly higher use of remote cardiology clinic visits among Asian, Black, and Hispanic individuals and those with cardiovascular comorbidities (9). Less surprisingly, they found that patients with private insurance, a proxy for high socioeconomic status, made up a larger proportion of both video and telephone visits. This was consistent with another study of clinics serving low-income individuals that reported a decline in overall patient visits after switching to a telehealth model mainly due to a lack of access to video visits for low-income populations (2). They also demonstrated a stepwise reduction in the ordering frequency of both diagnostic tests and prescription medications when comparing pre-COVID with COVID-era in-person and COVID-era video and COVID-era telephone visits (9), which was all the more remarkable given patients seen by remote visits had more cardiovascular comorbidities and were therefore more likely to require guideline-recommended medical therapies. A variety of explanations may be postulated for these findings. First, studies in the press have focused attention on the increased risk of COVID-19 infection in the elderly, those from ethnic minority backgrounds, and those with cardiovascular comorbidities. This then has the potential for convincing such patients, as well as their clinicians, to differently perceive the risk of attending face-to-face visits and to instead elect to pursue telehealth options (10). Second, older patients, those from ethnic minority backgrounds, or those with more medical comorbidities may find remote visits more appealing because they are relatively less able to access in-person visits due to greater barriers to transportation or scheduling (11). Indeed, higher proportions of individuals from ethnic minority backgrounds work "essential jobs" and so may be less able to take time off from work to travel to in-person visits. Third, some of the decreased testing could similarly be explained by reduced access, as much medical testing is typically undertaken at the same facility and at the same time as in-person clinic visits. Fourth, differences in patterns of ordering tests and in turn prescribing medications may simply be associated with the inherent limitations in understanding each patient's clinical picture when using remote care due to a lack of physical examination and decreased clarity in communication. Prompting for testing is often cued by examination findings, while starting and titrating medication is often directed by the results of laboratory testing. What effects these changes have on longer-term patient outcomes as well as on the structure of clinical practices going forward remain to be seen and will require further follow-up studies after the pandemic has waned. Nonetheless, the fact that a substantial proportion of clinical care

in future will be delivered through telehealth provides numerous important opportunities in the efficacy, access, and cost of healthcare that may be best implemented when hybridized with and used as an adjunct to existing in-person practice models.

An important point worth highlighting is that by ensuring the timely and affordable provision of healthcare services, telemedicine is particularly advantageous for developing countries. That said, special consideration should be given to the challenges of making telemedicine an ethical and secure mode delivery of medical care that is accessible to all (12). This could include greater standardization in remote healthcare delivery protocols including the development of guidelines outlining best practices; systematic evaluation of telemedicine practice models to assess their feasibility, safety, and efficacy; large prospective clinical trials evaluating clinical protocols delivered using telemedicine that include diverse populations from high-, middle-, and low-income countries to ensure clinical outcomes are at least non-inferior to those provided by established in-person healthcare models with comparative cost–benefit analyses; establishing the role of and creating guidelines for regulatory agencies and insurance companies as well as private companies that may collaborate with healthcare groups to build telemedicine infrastructure; and instituting robust and standardized measures to safeguard individual privacy and data protection.

Remote working and education

Government mandates for social distancing and limiting the number of people attending in-person indoor public gatherings have led to a surge in the so-called working from home economy in which 42% of the labor force in the United States worked from home, while 26% worked on business premises, the majority of whom were essential service workers (13). Further, the greatly enlarged proportion of home workers accounts for more than two-thirds of the country's economic activity in terms of gross domestic product (13). Considering an essential part of the fight against COVID-19, working from home allowed the lockdown to endure without an ensuing collapse to the economy. As a necessary consequence, the stigma against remote workers has dissipated and many organizations are developing plans to allow for more work-from-home options beyond the duration of the pandemic, with the potential for the number of working days spent at home expected to increase to 20% compared with 5% prior to the pandemic levels (13). Although not available to everyone in all types of work, this shift has yielded enormous changes allowing individuals to save time and money previously spent on commuting. While the longer-term economic and social fallout of these modifications is still to be realized, and stakeholders and participants alike argue that there is indeed something uniquely human lost through digital interactions that may only be provided for through in-person meetings, the advantages are hard to ignore. Further, few would dispute the benefits that the dramatic fall in commuting traffic has provided for the environment. In addition to images in China's biggest cities showing scarcely before seen clean air and blue skies, and the iconic image of New Delhi's India Gate photographed without its usual ghostly polluted haze, studies have demonstrated significant reductions in air pollutants including nitrogen dioxide during the pandemic (14). Correspondingly, similar changes with day-to-day work meetings have opened our eyes to the redundancies and time lost that existed in our previous work schedules allowing for the potential of greater efficiency and work done in a given work week.

On March 17, 2020, the Association of American Medical Colleges recommended the suspension of medical student clinical rotations, with academic institutions migrating curricula to a virtual format to maintain social distancing among students (15), with evidence of similar or improved learning compared to prior years (16). The pandemic has also disrupted medical education for residents and fellows by imposing necessary limitations to in-person meetings forcing learners and educators to adapt to the "new normal" of remote learning. Such challenges can be transformed into opportunities through rapid innovation and exploitation of technological resources to ensure personal safety while maintaining and potentially improving medical education. Technology has already been playing an increasingly important role in teaching core clinical skills as simulation centers and computerized anatomy laboratories have become more prevalent over time (17). The forced adoption of virtual technologies during this pandemic, however, holds the potential to spur an unexpected yet likely beneficial wider embracing of these, and other, tools in the longer term. Various academic organizations have described successful experiences implementing virtual education programs for medical students in diagnostic radiology (18), surgery (19), and other specialties (20). In one published experience, students were exposed to electives in interventional radiology (21) that devised curricula utilizing a combination of synchronous and asynchronous learning and the "flipped" classroom educational model. Synchronous learning is when students and instructors engage in real time, typically utilizing videoconferencing and/or chat software to allow for live interaction, while asynchronous learning refers to learning that occurs at different times for each student, without real-time interaction, making use of resources such as assigned readings or prerecorded videos provided by the instructor (22, 23). A "flipped classroom" model is when students are provided asynchronous educational material to review to establish background knowledge prior to participating in a synchronous lecture on the same topic during which facilitators focus on clarifying concepts, sharing clinical pearls, and engaging with students with virtual lectures (22, 23). In one pilot study, the investigators showed that this "flipped classroom" strategy improved knowledge acquisition with no

increase in preparation time and was in fact widely preferred by trainees (24). In another example of the use of virtual technology, while prior to the pandemic medical students and residents attended in-person resident education conferences each morning, during the pandemic these conferences were held virtually to maintain education, a familiar experience in programs across the country. Given that residents and medical students work closely during clinical rotations, residents acting as teachers restored some semblance of normalcy for both groups and allowed residents the chance to refine their teaching skills (25). Key to the evolution of these educational strategies has been the development and sharp increase in the use of commercially available videoconferencing and remote sharing applications such as Zoom (Zoom Video Communications, San Jose, CA, USA), WebX WebEx (Cisco Webex, Milpitas, CA, USA), and Skype (Skype Technologies, Palo Alto, CA, USA). These formats allow trainees and staff to share slides, images, PowerPoint presentations, and other materials remotely while having a live video feed so that each person can see who is present and can engage in dialog in a manner that gives the feel of an in-person meeting. Users can log in from computers but have the flexibility of accessing meetings from smartphones and tablets as well. Other useful benefits include the fact that this format allows administrators to record conferences providing the option for later review, as well as a live chat and even polling functions to add to the learning experience. Such formats can be used to provide educational lectures internally and even to worldwide audiences in an open-access format.

While a return to an in-person education model seemed highly desirable in the early stages of the pandemic, many of the creative changes developed over this time are rightly here to stay having shown that aspects of virtual education are not only possible and of similar value to in-person education but in many ways offer important advantages. The waning of previous resistance to technology-enhanced learning is being increasingly accompanied by evidence of its ability to embellish educational opportunities.

Vaccine development

A further aspect of the pandemic chapter which must not be overlooked is the development, testing, and mass uptake of multiple effective and safe vaccinations against COVID-19. This impressive feat invoked an unprecedented level of international cooperation and government–private sector collaboration that could in fact form a novel framework for future vaccine development. Vaccinations are one of the world's most efficacious interventions against disease estimated to save 3 million lives each year (26). In 1796, Edward Jenner discovered that exposing individuals to small amounts of the cowpox virus, known as the "vaccine virus," was effective in preventing smallpox (27). While approximately 300 million people died due to smallpox in the twentieth century alone, the consistent application of global vaccination programs meant that by 1980 the World Health Assembly could officially declare the eradication of smallpox (28). Similar success stories include measles, diphtheria, and rubella whose vaccinations resulted in the >99% decrease in cases in 2019 with respect to the average annualized morbidity in the twentieth century. In fact, one dose of the measles, mumps, and rubella vaccine has an efficacy of 93% against measles, 78% against mumps, and 97% against rubella (29). It must, however, be recalled that for most diseases developing a vaccine takes more than 10 years, as part of an expensive and linear process in which each step is carried out sequentially. Specifically, five stages are involved: (i) discovery laboratory-based research, looking at ways to induce an immunologic response, normally requiring 2–5 years; (ii) preclinical stage, involving testing various compounds in animals to assess safety and appropriateness for use as a potential vaccine in humans, usually requiring 2 years; (iii) clinical development, testing potential vaccines in humans as part of phase I (testing for safety), phase II (further testing for safety, determining suitable dosages, and understanding the immune response), and phase III (assessing the vaccine for efficacy and safety in thousands of patients) trials that typically require 2, 2–3, and 5–10 years, respectively; (iv) regulatory approval, by submitting data to regulatory authorities for review, requiring up to 2 years; and (v) manufacturing and delivery, requiring specialized and expensive facilities. Regulatory authorities continue to monitor safety and efficacy after a vaccine has been licensed and made available. This process is further complicated by the fact that many candidate vaccines never progress beyond the preclinical stage as they fail to produce a desired immune response, fewer than 10% of drugs that enter clinical trials are ever approved by the Food and Drug Administration (30), and a vaccine for a coronavirus has never been developed before. Further, the fastest a vaccine has been developed previously is 4 years, which was against mumps in 1967. Meanwhile, the vaccine against varicella, released in 1995, took 28 years to develop, license, and distribute. While certain steps in the developmental timeline of a vaccine may be fast-tracked or bypassed, the approval step does not fall under this category, and previous incidents in which poorly produced batches of a vaccine that was approved hurriedly leading to individuals contracting and even dying of infections loom large.

Given how deadly and disruptive the pandemic has been, the development of a vaccine against COVID-19 necessitated a radical restructuring to traditional vaccine development. These involved several important adjustments. First, different stages of the development and production of the vaccine occurred at the same time, and multiple vaccine trials were being carried out in parallel around the world. In the United States, three vaccines are currently authorized and recommended, namely, Pfizer-BioNTech, Moderna, and Johnson & Johnson/Janssen. The Pfizer/BioNTech vaccine was the first mRNA vaccine,

followed by the Moderna vaccine, to be used in humans outside of clinical trials pioneering mRNA technology to deliver the coronavirus S protein's genetic material into target cells. All vaccines have been evaluated in randomized clinical trials and have been shown to be safe, effective, and capable of reducing the risk of severe illness (31). The Pfizer/BioNTech vaccine has reported the highest efficacy at 95% (32) although it has the disadvantage of requiring storage and shipping at around −70 degree Celsius. Second, multiple vaccine types were funded at the same time using different and often novel technologies providing not only the best chance of finding one that works, but also a diversity of vaccines capable of being effective across different populations. It was estimated that more than 100 vaccines were being developed across the world by June 2020 within exploratory, preclinical, and phase I studies using a broad range of technologies including an inactivated, non-replicating, or replicating viral vector, recombinant protein- or peptide-based vaccines, and viral DNA- or RNA-based vaccines (33). Third, manufacturing was started before vaccines were proven to be safe and effective to avoid delay while incurring significant risk to manufacturers. New manufacturing sites highly tailored to the production of the new vaccines were also built around the world. Fourth, existing technological progress further helped advance the rapid development of the vaccine. Using genomic sequencing, researchers successfully uncovered the viral sequence of COVID-19 by January 2020, 10 days after the first reported case of pneumonia in Wuhan, and the previously studied SARS virus is approximately 80% identical to COVID-19, both of which use the so-called spike protein to grab onto a specific receptor found on cells in human lungs (34). Similarly, early efforts by scientists at Oxford in creating an adenovirus-based vaccine against MERS provided important experimental groundwork in developing an adenovirus vaccine against COVID-19. Last, a new collaborative approach to science and global manufacturing and distribution has been established, without trivializing testing and safety measures, and ensuring the same ethical, scientific, and statistical standards are maintained as in traditional development programs. A study in 2018 estimated the cost of early development and initial clinical safety trials for a typical vaccine to be in the range of $31–68 million (35), which with large-scale trials and an accelerated timetable would likely be an underestimate for COVID-19. Yet, in the United States, Operation Warp Speed partnered with multiple institutions, including the National Institutes of Health and the Centers for Disease Control and Prevention, when developing, manufacturing, and distributing their target of 300 million doses by early 2021. Similarly, the UK government vaccine Taskforce was a significant contributor to a wide variety of vaccine research, with recipients of this funding helping to develop the Oxford/AstraZeneca vaccine (31). The rapid completion of clinical trials was also facilitated by a high interest in volunteers for vaccine studies further highlighting a collaborative spirit. Skeptics argue that the unprecedentedly accelerated timeline in approving and distributing the new vaccines generates legitimate causes for concern. Indeed, the sheer rapidity in the evolution of these vaccines, their approval for use, and the accompanying public health policies that facilitated their mass have been impressive feats, underscoring the benefits of well-organized and collaborative efforts in tackling global health challenges.

An important caveat that must be kept in mind, however, is that while vaccines are the best chance to control the pandemic, these efforts can be thwarted when world leaders succumb to vaccine nationalism. Indeed, vaccine equity is not just a theoretical slogan but above all protects people worldwide from new vaccine-resistant variants. Vaccine nationalism is already setting a foundation for itself and is socially and economically counterproductive, particularly in low-and-middle-income countries (36). We should, therefore, be prepared to enhance awareness of and employ counter measures against this trend to ensure that the success of vaccine development programs may be realized by all.

None of us will miss this pandemic or the trials it has imposed on us. Returning to a life and world glowing with nostalgia sounds appealing, and in many ways it will be. But too much has been sacrificed to the worst yet of this century's global pandemics for us to disregard the benefits and innovation acquired during this time. To quote Churchill again "never was so much owed by so many to so few." In innumerable ways, the Second World War formed an inflection point that shaped world affairs in ways we can see even today. So too will this pandemic have implications for years to come. The pre-pandemic ways of practicing healthcare, work, and education can be improved upon to create a new and potentially better "normal." We should be willing to acknowledge and retain useful changes that have been made to our working lives and embrace important lessons in how we collectively tackle our workplace, societal, and public health challenges—unique lessons offered to us from the current crisis.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

Conflict of interest

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

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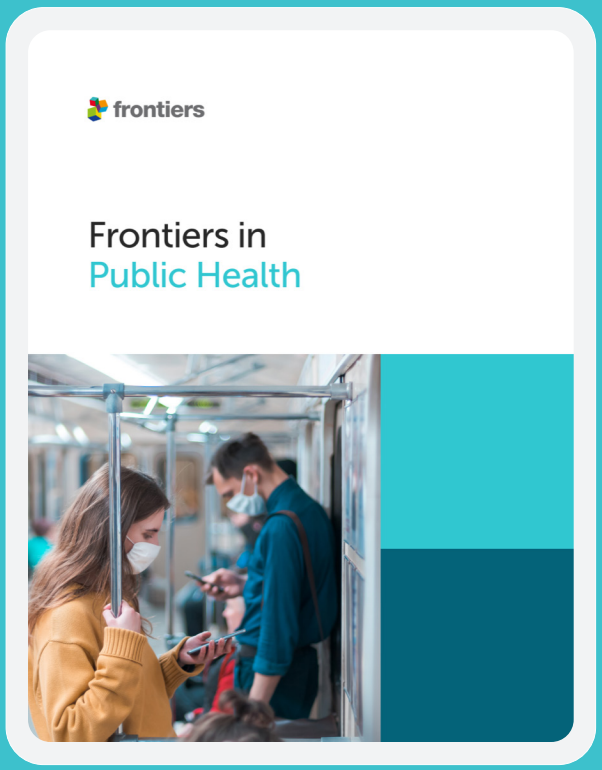

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