

A Pilot Study to Investigate the Role of Virtual Reality in the Preservice Training of Nursing Staff in Isolation Wards

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Healthcare providers without working experience in isolation wards experience enormous challenges. Traditional ward orientation is constrained by space, time, and even infection risk in particular periods (eg, the coronavirus disease 2019 pandemic). Virtual reality has been used widely, but rarely in wards. This study aimed to explore the experience of utilizing virtual reality for isolation ward training among nurses. In this study, nurses completed virtual reality training via an online platform and were then trained in isolation wards, after which their perceptions were explored by questionnaire and interviews. A total of 1868 participants completed the training. Most participants thought the preservice training was important and believed the virtual reality experience was consistent with the in-person training. Virtual reality was found not only to be convenient and valuable for training but also to have the benefits of occupational protection. However, whereas 50.48% of participants wanted to learn the ward via virtual reality, 87.21% of participants wanted to learn via in-person training before working in the wards. As a substitute for in-person training, virtual reality is a feasible and practical instrument to provide preservice training in particular periods. However, there is room for improvement due to general discomfort and technological problems.

KEY WORDS: Feasibility, Isolation wards, Training, Virtual reality

Coronavirus disease 2019 (COVID-19) has spread rapidly worldwide. The epidemic that broke out in Wuhan (Hubei, China) has since been controlled.¹ However, healthcare providers have suffered from enormous challenges due to the rapidly evolving epidemic.² Most healthcare staff

had no experience caring for clients in isolation wards.² Additionally, several studies reported that healthcare providers who worked in isolation wards had a higher risk of infection and emotional distress (anxiety, depression, insomnia, insecurity, and extraordinary stress) during the COVID-19 outbreak period.³⁻⁶ Studies have suggested that emotional distress and occupational safety may be correlated with unfamiliarity with isolation wards among healthcare providers. Liu et al² reported that healthcare staff had additional challenges when they adjusted to isolation wards, an entirely new working environment, during the stressful COVID-19 situation. Moreover, healthcare providers' health and safety are important for clients' safety.²

The technical guidelines for prevention and control of novel coronavirus infection in medical institutions⁷ issued by the National Health Commission of the People's Republic of China recommended that all medical and health institutions have an obligation to strengthen the training of professionals and conduct psychological training, theoretical lectures, and technical skills training related to COVID-19. The training included but is not limited to the spatial layout and partitioning of functional zones (three zones and two routes) of isolated wards; institutional processes (admission procedures, visit procedures, examination procedures, patient transfer, and discharge procedures); management of personnel (epidemiological investigations, close connection management); materials and equipment management; infection prevention and control (disinfection and isolation techniques); medical treatment (specimen collection and transmission, treatment of medical waste, laboratory testing); and health education (the work system, flow and job responsibilities, personal protection and protective techniques, occupational exposure handling process, and emergency plan).

One of the most important points was familiarity with the isolated wards' spatial layout and partitioning of functional zones. Therefore, it is necessary for healthcare providers to understand the interior structure and workflow of isolation wards. Healthcare providers are trained in on-site wards under normal circumstances, but in-person training is labor intensive and has substantial financial, space, and time limitations. Moreover, in-person training in isolation wards may increase the

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risk of infection for healthcare providers under COVID-19 outbreak circumstances if it is conducted improperly. Therefore, it is imperative to develop efficient methods to help healthcare providers adapt to isolation wards in advance of their work in them.

Virtual reality (VR) is regarded as an innovative technology with three-dimensional spatial visualizations to generate immersive experiences by using multisensory stimulation (eg, visual, auditory, tactile).⁸ The stimulation promotes the recall of autobiographical memories and forms a sense of familiarity with the given scene,^{9,10} enhancing the experience.¹¹ The Hypothetical Model of Immersive Cognition provides an explanation for the learning process in a VR environment. Based on information processing theory, situated cognition theory, and embodied cognition theory, the model conjectures that VR can generate stimuli by activating visual and motor channels to form an illusion. As a result, the brain might mistakenly believe that a projected environment exists.¹² With the rapid development of information technology, VR has been widely used in procedural skills training, emergency response training, soft skills training, psychomotor skills training,¹³ and environment orientation.¹⁴ Many studies have shown that VR is a safe, cost-effective, efficacious, and acceptable instrument¹⁵ and has become an adaptive supplement for “real-world” experiences in particular situations.¹⁵ Virtual reality has recently been applied in the medical field.^{15,16} It enabled psychiatric patients to navigate around to gain an understanding of the ward, reducing patients' anxiety.¹⁴ Moro et al reported that VR is a feasible instrument for training in anatomy and promotes intrinsic benefits (such as enhanced learner immersion, engagement, and the generation of autobiographical memories).^{15,17} In addition, a survey showed that almost half of first-generation VR users wanted to continue using VR and were optimistic about the relationship between VR and education, especially for young people.¹⁵ However, few studies have demonstrated the feasibility of VR training aids for healthcare providers.

We propose that the implementation of VR preservice training in isolation wards may provide interactive and immersive experiences for nurses and may improve nurses' adaptation to the isolation ward. Therefore, this study aimed to explore the feasibility and experience of utilizing VR training in an isolation ward among nurses.

METHODS

Study Design and Participants

This research used a mixed methods design, including an online survey and contemporaneous semi-structured qualitative interviews. Self-administered questionnaires were used to understand the distribution of nurses' opinions, whereas qualitative interviews collected a wide range of opinions regarding the feasibility and experience of utilizing

VR training in an isolation ward among nurses. Between August 1 and September 6, 2020, we oversampled nurses using nonprobability, convenience, purposive sampling method in Tongji Hospital located in Wuhan (Hubei, China), which is one of the largest general hospitals in China and is responsible for providing medical care for critically ill patients. In line with the national policies and norms,^{7,18} the hospital provided COVID-19 training and assessment to all nurses regarding spatial layout; partitioning of functional zones; institutional processes; management of personnel, materials, and equipment; infection prevention and control; medical treatment; and health education on the hospital's learning platform. Registered nurses who worked at Tongji Hospital, were aged between 18 and 55 years, were able to read and understand Chinese, were willing to participate in the research, and signed the consent form were recruited. The exclusion criteria were intern nurses and refresher nurses (nurses commissioned by another hospital for further study), nurses not comfortable with using a smartphone or other computing devices or having a computer phobia, and nurses with a history of migraines.

First, the researchers invited nurses to participate in the research, providing study descriptions including research objectives, recruitment target, research processes, informed consent, VR instructions (user manual), and time to consider participation on the learning platform of the hospital. A total of 1912 nurses who were interested and met the inclusion criteria voluntarily contacted the researchers to sign informed consent forms and set up an appointment. Thirty-seven participants failed to participate in the study due to time conflicts, six participants withdrew because of personal circumstances, and one nurse resigned and withdrew. Therefore, a total of 1868 participants were included.

We provided VR training designed based on the spare isolation ward with quick response code and arranged in-person training on the learning platform identical to the VR training for these nurses. For the VR training, participants used VR and the audio narration synchronized with location freely under the guidance of the simplified user manual (the meanings and functions of the buttons, and the specific realization methods of the functions). They were encouraged to browse freely through the images. Participants were then trained on-site 2 weeks later. For the in-person training, the specialist nurse who worked in the isolation ward during the pandemic and provided the audio narration in the VR training acted as the guide, showed the participants around the ward, and provided identical audio narration. After the training, we conducted online surveys on the VR training experience (including the degree of necessity, impact, consistency, and feasibility) among the participants and asked about their willingness to participate in the interview. We collected the demographic characteristics and contact information of

the nurses willing to participate and selected the nurses with maximum variation sampling to ensure representativeness. The selection of interviewees was an ongoing, iterative process as nurses completed the survey. We recruited nurses with different combinations of the following variables: age (under 30 years vs over 30 years), sex (male vs female), level of education (bachelor's degree and below vs master's degree and above), and experience working in isolation wards (yes vs no).¹⁹ After each interview, the participant demographics were discussed by the researchers to identify the demographics missing from the selected samples. Individuals with identified missing demographics were sought in further sampling processes.²⁰ The interview was arranged within 2 days after the in-person training. The qualitative data collection and analysis occurred in a concurrent and iterative fashion. The number of nurses interviewed was based on the principle of data saturation, that is, when no new themes emerged from the participants.²¹ Saturation was assessed through preliminary data analysis and a discussion among the research team.²² In our study, data saturation was reached at the ninth interview. Two more interviews were conducted to ensure that data saturation had been achieved and no new themes emerged.

During the process of questionnaire collection and interviews, we emphasized the voluntary nature of participation. All participants provided informed consent prior to participation. Participants signed informed consent for surveys by clicking the "I agree" button after the study description before completing the questionnaires. Informed consents for interviews were obtained by signing the paper version of informed consents before interviews. We protected the anonymity and confidentiality of participants and the right to withdraw at any time. The data were kept and presented in a confidential manner, and only the researchers and the research team had access to the data. The researchers obtained the approval of the ethics committee of Tongji Hospital where the study was conducted.

DEVELOPMENT OF THE VIRTUAL REALITY SIMULATION

The VR isolation ward was designed by the nursing department of Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology with Internet visualization SaaS services of Weixiang Technology Co., Ltd. It was displayed on the hospital's learning platform of the smartphone app "WeChat" (a popular social media application compatible with the Apple and Android systems). From a technical perspective, the services provided through Weixiang Technology Co.'s Web site (www.720yun.com) were professional-grade and free to use for research and noncommercial applications. It is an emerging rich media technology that can load pictures, sounds, and videos. The Web site provided a variety of practical application scenarios for education, real es-

tate, enterprises, tourism, and other industries. The VR isolation ward was developed based on the operational pattern of the real isolation ward during the epidemic. A panoramic camera was used to take panoramic photos of the functional areas, and the free noncommercial Web site was used to edit the photos into the VR isolation ward panorama. The VR isolation ward showed 360° immersions and three-dimensional visualizations based on the real environment, as well as overall maps (Figure 1). A senior infectious disease specialist nurse who worked in the isolation ward during the pandemic was invited to narrate the attention points for each functional part.

The VR isolation ward was presented on the online platform of the hospital with a quick response code form. From August 1 to 10, 2020, participants could freely scan the quick response code via their smartphone or other computing device and learn about the isolation ward by swiping the screen. Participants could touch the screen at will to navigate the perspective of the VR isolation ward; they could move forward or backward by clicking on the arrow, as shown in Figure 2. Participants could highlight the view of the ward directly in front of them by double-clicking, and its name would be displayed on the screen. Participants could also zoom in and out on the VR isolation ward and change the scene focus. The regulations and precautions of the VR isolation ward were presented by audio narration. The audio narration synchronized with the location included the connotation and scope of the three zones (clean areas, semi-contaminated areas, and contaminated areas) and two routes (patient channels, staff channels), the flow line of medical staff and patients, wearing and removal procedures of protective clothing in different areas, item placement (eg, ultraviolet disinfection lightings, item transfer cabinets, rescue vehicles), and matters needing attention (eg, restrictions on personnel, door switch).^{7,18} From this narration, participants could follow the audio descriptions and completely navigate the VR isolation ward.

To better evaluate the feasibility of the VR isolation ward, we organized 78 rounds of in-person training from August 24 to September 6, 2020, in the spare isolation ward. Nurses who had experienced the VR training were recruited to complete the in-person training and the interpretation of the layout and regulations of the isolation ward.

Data Collection

After VR and in-person isolation ward training, from August 24 to September 6, 2020, participants were immediately invited to complete an online investigator-developed anonymous survey. The researchers explained the study's purpose and asked for approval for the data collection. Those who agreed to participate in the study were provided with online and oral instructions, and informed consent and questionnaires were completed on the spot. The survey was designed and collected with a stable, safe, and convenient online

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FIGURE 1. Overall map of the VR isolation ward.

questionnaire platform: <https://www.wjx.cn/>. Using the tools provided by the questionnaire platform, all questions were compulsory and had to be answered to access the next

question. The questionnaire could be submitted only after informed consent was obtained and all compulsory questions were completed. The nurses logged into the platform by

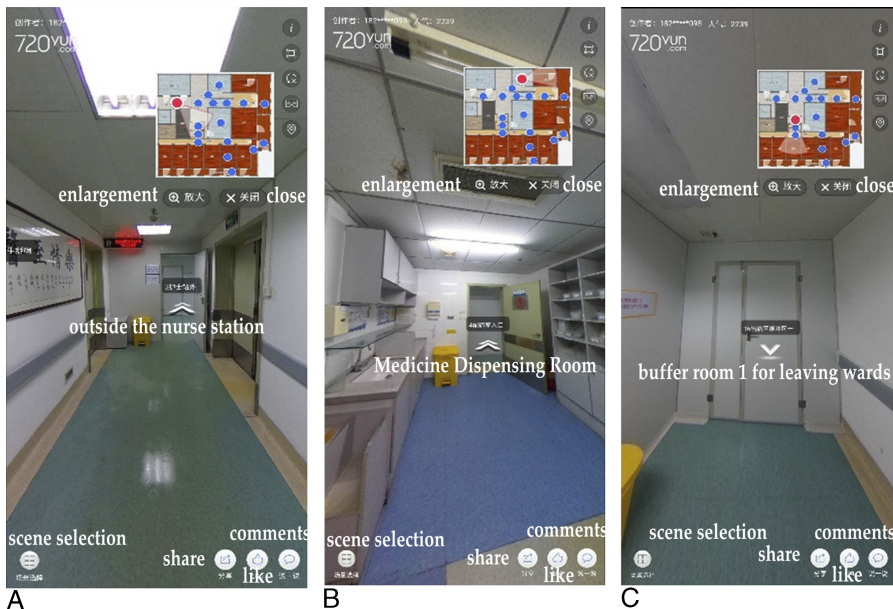


FIGURE 2. Illustration of the VR isolation ward: (A) outside the nurse station; (B) medicine dispensing room; and (C) buffer room 1 for leaving wards.

scanning a quick response code provided by the investigators and responded to the surveys. Data were then collected and extracted through the questionnaire platform background. The survey consisted of demographic characteristics (age, sex, educational background, work experience in isolation wards) and five questions. The questionnaire was sent to nine experts for face validation before this study. It was then pilot-tested among 50 nurses and refined further in readability, comprehension, and content based on their feedback, showing a good level of performance. The questions are listed in Table 1.

In addition, semi-structured interviews were conducted to explore participants' experience with VR training. The interviews were conducted in an independent, quiet private room equipped with a table, a chair, tea or coffee, biscuits, and water by two researchers trained in qualitative methods. The two researchers arrived 15 minutes before the appointed time with the research manual, informed consent, demographic characteristics document, recorder and batteries, interview guide, watch, pen, and papers. After the interviewee arrived, the researchers turned off the mobile phone and explained the purpose of the study and the interview precautions. Written and verbal informed consent, together with authorization for the public release of the data, was obtained from all participants before the interviews. Participants were initially encouraged to describe their experiences in their own words, and then, the researchers followed the interview guide to explore the experience with VR isolation ward training. The interview guide, as listed in Table 2, was developed by literature reviews^{15,23} and discussions of seven experts prior to the interviews. At the end of the interview, researchers and participants reviewed and confirmed the interview process and the topic discussed, and the interviewer thanked the interviewees for their cooperation. The interviews lasted 10-30 minutes. All interviews were digitally recorded and transcribed verbatim, and the transcripts were reviewed for accuracy.

Table 1. Interview Guide for the Semi-structured Interviews

Main Topic	Question
Previous experiences	Have you ever worked in isolation wards before, or do you know about isolation wards?
Experiences regarding the VR training	<p>What do you think about the virtual isolation ward?</p> <p>a. Have you ever been exposed to similar training? If not, how did you feel when first came in contact with it?</p> <p>b. What are the advantages and disadvantages of the virtual isolation ward training?</p> <p>c. Did you have any concerns while you were experiencing the virtual isolation ward training? If so, what were they?</p> <p>d. Did you have any questions while you were experiencing the virtual isolation ward training? If so, what were they?</p> <p>e. What is the impact (possible benefit) of the virtual isolation ward training on later work (or participation in the fight against the epidemic)?</p>
Perspectives	<p>Do you think there are big differences between the virtual and in-person training? If so, what were they? Which one do you prefer? Why?</p> <p>Can virtual isolation ward training replace in-person training? Why?</p>

Table 2. The Specific Questions of the Survey

Number	Question
Q1	Do you think it is necessary to understand the layout and regulations of the isolation ward before working in it?
Q2	What do you think are the benefits of understanding the layout and regulations of the isolation ward before working in it?
Q3	How much do you think the experience of VR training is consistent with the in-person training?
Q4	Which type of training do you expect to adopt if you have an opportunity to work in an isolation ward?
Q5	Do you have any suggestions for the isolation ward training?

Q1 and Q3 were single select, Q2 and Q4 were multiple choice, and Q5 was an open-ended question.

The design of the survey and interview guide were based on the Kirkpatrick four-level training evaluation model, which suggests that the educational value of the curriculum includes reaction, learning, behavior, and results.²⁴ In our study, we assessed nurses' reactions to VR training.

Data Analysis

Questionnaires were checked for integrity before data entry and coded. All statistics were completed using IBM SPSS Statistics version 28.0 (IBM Inc., Armonk, NY, USA). For sociodemographic and clinical data, qualitative variables were described by percentages and frequencies. Quantitative variables were described by mean and SD.

The transcripts were analyzed with QSR NVivo (QSR International, Melbourne, Australia). Two researchers independently analyzed the transcripts by bracketing data on predominant themes (including both Q5 in the questionnaire and the transcription file) and strictly following the adapted Colaizzi's method. Disagreements (on themes, clusters, and categories) were discussed until a consensus was achieved.

Throughout the subsequent stages of the research, the first author continuously refined and examined the topic.

RESULTS

Survey Evaluation

A total of 1868 participants, with an average age of 34.5 years (SD, 10.7 years), participated in both the VR and in-person ward training and completed the post-VR questionnaire. The majority of participants (98.34%) were female, and almost half of the participants (40.95%) had more than 10 years of clinical working experience. A total of 92.50% of participants had no working experience in isolation wards. The characteristics are detailed in Table 3.

Table 4 shows the details of the participant responses. Most participants (99.84%) thought that having ward training in advance was important or very important. A total of 97.81% of nurses believed that isolation ward training before working in the ward was beneficial to quick adaptation to work, 89.99% of nurses held the view that it was beneficial for occupational protection, and 83.30% of nurses believed it helped alleviate anxiety. A total of 99.04% of nurses believed that the experience of the VR isolation ward was consistent or completely consistent with the in-person training. A total of 50.48% and 87.21% of nurses thought that if they would work in the isolation ward, they would like to learn the layout and regulations of the ward through VR training and in-person training, respectively.

Interview Evaluation

Eleven nurses were interviewed, and no nurses declined to participate. Thematic redundancy was achieved with the ninth interview, and two participants were then interviewed to confirm thematic redundancy. The majority of participants (n = 9, 81.82%) were female, and the average age was 32.7 years

Table 3. Demographic Characteristics of Participants

Characteristics	n (%)
Sex: female	1837 (98.34)
Clinical experience, y	
≤3	345 (18.47)
4-6	402 (21.52)
7-9	356 (19.06)
≥10	765 (40.95)
Department	
Medical wards	212 (11.35)
Surgical wards	475 (25.43)
Operating room	170 (9.10)
Infectious disease	41 (2.19)
ICU and emergency treatment room	92 (4.93)
Other departments	878 (47.00)
The experience of working in an isolation ward: no	1728 (92.50)

Table 4. Participant Responses for the VR Isolation Ward Training (N = 1868)

Question	Answer	n (%)
Q1	Very necessary	1730 (92.61)
	Necessary	135 (7.23)
	Not necessary	3 (0.16)
	Unnecessary	0 (0.00)
Q2	It facilitates rapid adaptation	1827 (97.81)
	It contributes to occupational protection	1681 (89.99)
	It helps relieve anxiety	1556 (83.30)
	No obvious help	1 (0.05)
	Others	14 (0.75)
Q3	Completely consistent	1046 (56.00)
	Mostly consistent	804 (43.04)
	A few consistent	18 (0.96)
	Totally inconsistent	0 (0.00)
Q4	In-person training	1629 (87.21)
	Live interactive training	767 (41.06)
	VR training	943 (50.48)
	Others	11 (0.59)

(SD, 8.2 years). Undergraduate and postgraduate nurses accounted for 72.7% and 27.3% of the sample, respectively. Nurses with working experience in isolation wards accounted for 27.3%. Overall, nine nurses (81.81%) were coded as positive for VR isolation ward training, and two nurses (18.18%) were neutral. We classified the findings into three thematic categories after analyzing the data.

Theme 1: Virtual Reality as an Alternative Training Mode

Eight participants expressed that VR was an innovative instrument and easy to learn. Furthermore, the only requirement for VR training was having a computing device; presence in the isolation ward and a fixed time were not required. Participants could voluntarily arrange their training. Ten participants stated that they were able to understand the layout of the isolation ward by utilizing VR, which reminded them of the regulations through the narration. Some participants emphasized that VR should be conducted before working in the isolation ward. Participants could not learn in an isolation ward during the pandemic due to the shortage of resources. Thus, participants who were unfamiliar with the isolation ward could experience immersive VR. Furthermore, VR created an independent and infection-free learning environment. Participants could also repeat the training indefinitely.

Theme 2: The Limitations of Virtual Reality Training

First, participants had to spend time adapting to VR. Four participants expressed that in-person training provided a

greater sense of reality, whereas VR could not. Two participants complained of a lack of timely interaction. In addition, two participants experienced mild side effects, such as dizziness.

Theme 3: Implications for Virtual Reality Integration

Participants also suggested that we could optimize the process or add details that could help them have a more realistic experience during VR training.

The answers to Q5 in the questionnaire (which were further reflected upon in the interview) and the interview results are presented in Table 5.

DISCUSSION

In-person training, as an essential conventional training method, requires substantial financial and time resources, which results in participants feeling nervous and increases the risk of infection.²⁵ Therefore, alternative methods for

Table 5. Nurses' Perspectives on VR Isolation Ward Training

Themes	Clusters	Exemplary Quotes
Alternative training	Innovative	<p>"It's an innovative method forwards orientation, and I liked trying it." (n10)</p> <p>"Before working there, I think you still need in-person training; that is, you may experience a more personal experience and then VR training may be used as a supplement and as an alternative method in emergencies." (n5)</p>
	Convenient	<p>"We do not need to waste commuting time." (n9)</p> <p>"I will choose VR training certainly. In-person training is troublesome and difficult to arrange." (n6)</p> <p>"I think VR is possible training for nurses to widely promote. Because nurses are still experiencing the VR ward voluntarily and actively everywhere.... We discuss it, even share it with my nurse friends outside the hospital." (n7)</p>
	Feasible and valuable	<p>"VR is an incredible and realistic experience, just like I was there." (n7)</p> <p>"I think it does help the nurses and...It has explained everything to us, and everyone is encouraged to use it, once they start using it, they will realize how easy it is." (n8)</p> <p>"I feel that there is no need to learn in the in-person ward anymore, and VR is quite effective." (n2)</p> <p>"Before you go to the isolation ward, you should conduct VR training first, which is very helpful to adapt to the isolation ward as soon as possible." (n4)</p>
	Occupational protection	<p>"The in-person training is unrealistic and has a high risk of infection." (n4)</p> <p>"VR training can prepare us mentally, giving a buffer time and alleviating fear and anxiety... Because I hurriedly went there (the isolation wards during the epidemic), and I didn't learn about it at all. No one introduced the ward, which was newly built, so I was at a loss." (n6)</p>
The limitations of VR training	Lacks a sense of reality or perception	<p>"The VR can make us more familiar, but it is still not as three-dimensional as the in-person training." (n3)</p> <p>"I think the in-person training is more concrete, but VR training would miss...if I didn't go to the wards, I wouldn't understand it. Not all directions have instructions." (n5)</p> <p>"When I experienced in-person training, I felt that I had a clear understanding. I knew different directions, regulations, and usage. It was so impressive that I can remember it completely after the training." (n4)</p> <p>"People with a bad sense of space may have a hard time imagining." (n6)</p> <p>"The process of changing scenes should be slowed down appropriately." (n11)</p>
	Timely interaction	<p>"And we will have an immediate interaction in the in-person training, which is not available in the VR training." (n1)</p> <p>"My suggestion is to give us a communication platform. If you have any questions, you can give us a way to consult. No need to answer right away; you can give us a reply when it is convenient." (n2)</p>
	Adverse effects	<p>"The location shift makes my dizzy; I could not enjoy it immersively." (n9)</p>
Implications for VR integration	Optimize the process	<p>"I think you could add test questions. This way, you may know if you have got relevant knowledge." (n3)</p>
	Additional details	<p>"You can add details in terms of the communication methods between people, the layout of personnel, and work processes; I think it can be specifically designed." (n5)</p> <p>"Move forwards and tell you where it is.... I think you can mark more important doors or places where the hall forks.... I just suggest that regardless of whether it is relevant or something you use frequently, write the name on it." (n6)</p> <p>"I think more details could be reflected and displayed, such as the use of item transfer cabinets and disinfection lamps." (n8)</p> <p>"When I went there, I could see the protection procedures, as well as how to use the equipment, disinfection equipment (for example, and the material transfer window). But it won't be so specific in the VR training mode." (n10)</p>

spatial training in the clinic are needed, especially in crisis periods. Our study aimed to explore the feasibility and experience of transitioning in-person training to VR training, and it showed that implementing VR training is acceptable among nurses in special periods.

In our study, almost all of the nurses stated that ward training in advance was important. Virtual reality training was perceived as highly consistent with the in-person training for the isolation ward, which confirmed the feasibility of VR training because there was “no need to visit the wards anymore.” The results showed that our research met the expectations for the implementation of VR training—realistic and practical.²⁶ Some of the participants preferred to use VR instead of in-person training. Participants described how easy the VR training was to complete and explained that “once they start using it, they will realize how easy it is.” Overall, VR training aids are convenient and feasible. Virtual reality offers an immersive experience with inherent benefits for participants (eg, increased immersion, quick adaptation, safe practice, alleviation of anxiety). Some possible explanations for the benefits might be the result of the “novelty effect,”²⁷ and the novel nature of VR increased their motivation and made learning more interesting.²⁸ The use of VR aids is therefore quite feasible and is a potential alternative method for in-person training in the medical field.

More importantly, VR has a uniquely immersive capability, is associated with improvements in many domains (eg, cognitive, psychological), and may not be limited by resource availability and time constraints.²⁹ Virtual reality aids could facilitate rapid adaptation, relieve stress, and save time.²⁷ Nurses newly sent to isolation wards were found to feel anxious and stressed if they had never been trained.³⁰ Studies have shown that sleep quality, depressive symptoms, and perceived stress deteriorate in the early stage of working in isolation wards due to adaptation to the new environment.³¹ However, it was reported that only 50.6% of new nurses had received structured orientation training for providing safe, competent, and feasibility care.³² Hence, nurses need to be familiar with the special work environment in a short time (eg, isolation wards). Our study showed that 97.81% of nurses thought VR aids provided nurses with an opportunity to be familiar with the new environment, which could facilitate rapid adaptation to the new environment. Implementing VR helped participants recognize the ward orientation rapidly, as the VR ward depicted realistic three-dimensional models and provided an immersive experience. The aids enabled nurses to deal with difficult situations in a risk-free environment without putting them at risk. In addition, participants could use VR as often as they needed. Compared with in-person training, VR had the advantages of simulating a real environment inside of the isolation ward, favorably impacting nurses, saving time, and reducing material

consumption. Previous studies have shown that VR could better improve knowledge and skills than traditional training or other types of digital aids.^{8,33} Positive responses of participants to VR training were demonstrated in both quantitative and qualitative data. We found that the VR ward was acceptable and easy to use, suggesting that VR can provide a realistic method for primary ward orientation and might be a candidate during the epidemic, although it could not completely substitute for in-person training if it replaced opportunities to learn from experienced educators.³⁴ Therefore, it is necessary to implement ward orientation training to introduce the new environment and regulations to nurses.

However, some participants in our study complained they could not have timely interactions using VR aids. We need to improve the limitations of VR. In addition, participants also reported a lack of realism or perceptions in VR training due to discomfort. In our study, participants reported that they experienced mild health effect (cybersickness) because of the VR aids. One participant reported, “The location shift makes me dizzy; I could not enjoy it immersively.” A potential issue is that utilization of VR can result in cybersickness,³⁵ such as disorientation, discomfort, dizziness, difficulty concentrating, and problems with vision, especially for participants with poor orientation.¹⁷ Previous reports also showed that using VR aids was associated with cybersickness, and 40% of participants were found to have cybersickness the first time they used VR.³⁶ Potential improvement should be used to minimize the effects of VR aids. One possible solution was to use predictive models to eliminate nurses prone to cybersickness. The prediction cybersickness model took demographic factors (history of motion sickness, sex), hardware factors (screen, tracking), and software factors (stabilizing information, movement) as a whole to predict cybersickness.³⁷ Those with a history of severe motion sickness might not be the target population for VR. The next possible solution was to develop a tolerance and encourage habituation to cybersickness-inducing stimuli through shortened repeated training or playing three-dimensional video games with forward movement.^{37,38} Furthermore, making hardware and software more user-friendly for cybersickness participants was another solution, such as designing virtual content focused around the center to decrease unnecessary eye movements³⁹⁻⁴¹ and allowing participants to anticipate their movement.⁴¹ Some participants thought that we could optimize the process and add details; for example, some efforts will be needed to improve and optimize the experience of the VR isolation ward, including slowing down the process of scene switching, providing a communication platform, disclosing more specific details, and setting up test questions. We can also improve the communication platform. In this way, common and individualized problems might arise and be solved, such

as communication methods between people, the layout of personnel, concrete workflows, and instructions for specific equipment (eg, item transfer cabinets and disinfection lamps). In addition, the feasibility of the ward orientation would be further improved. Thus, further investigation would focus on the influence of VR aids for training other medical staff or its broader incorporation into other medical domains.

LIMITATIONS

Our study had several limitations. Virtual reality implementation requires financial investment or technical assistance, which can limit its application. In addition, due to the nature of the convenience sample, our study was conducted in one clinical environment, which may affect the generalizability of the findings. However, we used quantitative and qualitative methods to design our research reasonably and present reliable results. Furthermore, this study aimed to explore the feasibility and experience of utilizing VR for isolation ward training among nurses; thus, the evaluation of these results was relatively subjective. It was not clear whether participants completing VR training would achieve the same or even better objective results than those completing in-person training. The implementation of VR in emerging disciplines will inevitably encounter problems. How to take full advantage of the role of VR and how to continue to combine environmental orientation with VR are research areas that should be thoroughly pursued in the future.

CONCLUSION

In this study, we explored the feasibility and experience of utilizing VR training in an isolation ward among nurses. The analysis results of the quantitative and qualitative data showed that VR training was regarded as convenient and useful, and it provided additional intrinsic benefits, such as occupational protection. Virtual reality, as acceptable as in-person training, is a feasible training instrument for isolation ward training and might be considered an alternative method to familiarize oneself with the isolation ward under emergencies. Virtual reality holds great promise regarding the feasibility of future aids utilizing VR to supplement in-person training for participants' engagement. However, we should still be cautious regarding the adverse effects of VR. Furthermore, more improvements should be made to VR training, such as slowing down the process of site switching and providing more details.

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