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Virtual Reality in Treatment for Psychological Problems in First-Line Health Care Professionals Fighting COVID-19 Pandemic

A Case Series

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Abstract: Virtual reality therapy (VRT) is a new psychotherapeutic approach integrating virtual reality technology and psychotherapy. This case series aimed to study effectiveness of VRT in treating psychological problems. We described four cases of first-line health care professionals with emerging clinically significant early psychological problems during the COVID-19 outbreak, and specifically received the VRT treatment. We compared the Patient Health Questionnaire 9 items (PHQ-9), Generalized Anxiety Disorder-7 (GAD-7), PHQ-15, and Athens Insomnia Scale to evaluate psychological symptoms and sleep quality before and after sessions. All four cases showed a reduction in scale comparison. General scores of the PHQ-9 reduced 65%, GAD-7 reduced 52.17%, PHQ-15 decreased 38.17%, and scores of the Athens Insomnia Scale reduced 67.44%. Meanwhile, a reduction in depression, anxiety, psychosomatic, and sleeping symptoms was also found, which decreased 76.92% in general. These results are highly significant statistically. This case series demonstrated the effectiveness of VRT on psychological problems as a promising approach to apply on various psychological distress and disorders.

Key Words: Virtual reality therapy (VRT), mindfulness, COVID-19, health care professionals

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Health care professionals are practitioners of different highly specialized health care professions, including clinicians, nurses, and others, also referred to as health care workers. Because of their professionalism, health care professionals rarely respond to the call from local health care administration to address public health tasks, such as an infectious epidemic. Tasks may last from weeks to months, and the circumstances may be different but usually stressful: being far from home, abroad, long-time shift, wearing personal protective equipment (PPE) for a long time, or restriction of movement—leading to additional vulnerability to psychological problems. This vulnerability has been suggested again during the first COVID-19 outbreak in late 2019 in Wuhan, Hubei Province, China. During that time, a large number of health care professionals went to support the first line, fighting the pandemic. Many reported psychological problems that emerged at work, such as anxiety, sleep difficulty, depression, and psychosomatic symptoms.

"Psychological problem" is a broadly used term, which is defined as a psychological complaint or symptom that is perceived as an interference to the person, such as sleeping problems, depressive or anxiety symptoms, psychosomatic symptoms, and adjustment difficulties. These complaints may or may not construct the corresponding specific mental disorder. Usually, psychological problems are identified by self-report and appropriate self-rating scales (Grover et al., 2018) such as the Patient Health Questionnaire 9 items (PHQ-9) and Generalized Anxiety Disorder-7 (GAD-7), although these are not initially designed for this purpose. A Web-based multicentered survey by the Psychiatric Department of Southern Medical University Nanfang Hospital included 1563 health care professionals, who worked during the COVID-19 pandemic. Results found that 50.7% of the participants had depression (PHQ-9, >5), 44.7% had anxiety (GAD-7, >5), 36.1% of them were experiencing sleep disturbance (insomnia severity index, >8), and 73.4% were experiencing stress-accompanied symptoms (impact of event scale-revised, >9). Needs are real. However, there are no psychotherapeutic approaches for health care professionals in such situations. It is essential to develop effective, well-designed approaches to address where health care professionals fight—at the "front line."

The results from that survey, another survey (Du et al., 2020), and a previous study during the parallel situation of the 2003 SARS outbreak (Chong et al., 2004) discovered that health care professionals are vulnerable to psychological symptoms during task and attributed various factors for this vulnerability. From these results, we have noticed that these factors are basically two types: a) stress and b) restriction. Stress can be expressed differently, as reported: facing challenging situations including a newly emerged high-risk virus, increased severe or mortality cases, high-intensity off-site working conditions, fear of being infected, or fear of infecting others. Restriction, which is also a specified stress, could be a real restriction of places (environmental stressor), such as closed working environment and quarantine, and could be perceived restrictions, such as working in a PPE, following a strict working procedure to prevent infection, and collaborating with unfamiliar colleagues from other organizations. Addressing these two factors, two ever-existing evidence-based effective approaches separately targeting stress or restriction should be considered: mindfulness-based stress reduction (MBSR) and virtual reality therapy (VRT).

MBSR is the one of the evidence-based psychotherapeutic approaches for various mental health challenges, particularly for stress. MBSR was developed based on the technique of mindfulness and broadly used in both clinical individuals and nonclinical populations (Simkin and Black, 2014). The first MBSR outpatient clinic was established in Massachusetts University Hospital by US professor J. Kabat-Zinn, who designed and proved the clinical procedure and the effectiveness of MBSR (Kabat-Zinn, 1982). Research suggests that the effect of MBSR is significant, even in short-term sessions (Goodman and Schorling, 2012). With the advancement of research, MBSR is gradually used as adjuvant treatment in many chronic conditions, including malignant tumors, chronic pain, insomnia, stress, and depression. Recently, some

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articles suggested the effectiveness of MBSR in health care workers during the COVID-19 pandemic (Janeway, 2020); however, it still requires further research among first-line workers.

Virtual reality (VR) is a modern simulation technology based on computer technology. It establishes a highly simulated experience in visual, auditory, and tactile sensations to the real world via digital three-dimensional (3D) environment modeling approaches. Through human-computer interaction, users can further interact with the digital simulation virtual environment and make cognitive and behavioral feedback similar to that in the real world; thus, they are able to have the subjective experience of being in a real environment, avoiding stressful environment (*e.g.*, a restriction of place). VR technology has three major characteristics: it is imaginative, immersive, and interactive. VR technology was used by the US military in psychotherapy for veterans in the Iraq War as early as the 1990s (Freeman et al., 2017). In recent years, with the rapid development of hardware technology, VR is also increasingly applied to health care, education, and other civil fields. Many researchers in different countries attempt to apply the VR technology to psychological experiments (Glennon et al., 2018), psychometrics (Glennon et al., 2018), and clinical psychotherapies (Maples-Keller et al., 2017), which results in VRT. This new therapy approach integrated VR and psychotherapy. Immersive and imaginative advantages make VRT express the specific psychotherapy content in the form of virtual scenes. At present, published case reports of VRT involves acrophobia, claustrophobia, posttraumatic stress disorder (PTSD), autism, social phobia, and other psychological disorders. Previous evidence suggested that VR could decrease the thresholds for patients to achieve self-calmness. With these advantages, it is recently believed that VR technology is helpful for restriction, both the real restriction of place and perceived restriction such as loss of sense of community (Riva and Wiederhold, 2020). However, the application of VRT combined with MBSR on first-line health care professionals is still unstudied.

To address the needs of first-line professionals and develop an effective approach, we innovatively combined the advantage of VR technology for restriction and the advantage of MBSR for stress, virtual reality mindfulness–based stress reduction (VR-MBSR), and applied it at the front line during the COVID-19 Wuhan outbreak. This article is a case series that includes four individuals with significant psychological symptoms identified by self-report and self-rating scales. The PHQ-9, GAD-7, Patient Health Questionnaire-15 (PHQ-15), and Athens Insomnia Scale (AIS) were compared before and after sessions.

METHODS

Psychometric Scales

1) The PHQ-9 is suggested by *Diagnostic and Statistical Manual of Mental Disorders, 5th Edition* (*DSM-5*) and is used as a measurement of depression. The PHQ-9 contains nine items or questions to determine the following: level of interest in doing things, feeling down or depressed, difficulty with sleeping, energy levels, eating habits, self-perception, ability to concentrate, speed of functioning, and thoughts of suicide. Responses range from "0" (not at all) to "3" (nearly every day). The total sum of the scores suggests the levels of depression: 0 to 4, no depression; 5 to 9, mild depression; 10 to 14, moderate depression; 15 to 19, moderately severe depression; and 20 to 27, severe depression (Liu et al., 2020). Reliability was indicated by Cronbach's alpha of about .815. Score of 5 or higher indicates the presence of depression (Table 1).
2) The GAD-7 is also used as an instrument measuring anxiety, which is also suggested by the *DSM-5*. GAD-7 is a self-report questionnaire that contains seven items: feeling nervous, anxious, or on edge; not being able to stop or control worrying; worrying too much about different things; trouble relaxing; being so restless that it is hard to sit still; becoming easily annoyed or irritable; and feeling afraid as if something awful might happen. Each item is rated from 0 (not at all) to 3 (nearly every day). The total sum of the scores suggests the levels of anxiety: 0 to 4, absence of anxiety; 5 to 9, mild anxiety; 10 to 14, moderate anxiety; and 15 to 21, severe anxiety. Reliability was indicated by Cronbach's alpha of about .896. Score of 5 or higher indicates the existence of anxiety.
3) The PHQ-15 is used to evaluate somatic symptoms of cases and is a 15-item self-reported questionnaire evaluating different somatic symptoms: stomach or bowel problems; back pain; pain in arms, legs, or joints; menstrual disturbance; headaches; chest pain; feeling shortness of breath; dizziness; feeling spells; feeling of heart pounding or racing; feeling tired or having low energy; trouble sleeping; pain or problems during sexual intercourse; constipation; loose bowels or diarrhea; and, nausea, vomiting, or indigestion. The total sum of the scores suggests the levels of somatic distress: 0 to 4, very mild somatic distress; 5 to 9, mild somatic symptoms; 10 to 14, moderate somatic distress; and 15 to 30, severe somatic problem. Score of 5 or higher indicates the presence of somatic distress. Reliability was indicated by Cronbach's alpha of about .833.

TABLE 1. Self-Rating Scales Involved in the Study

Name (Abbr.)	Targeted Symptoms	No. Items, Score for Each Item, and Total Scoring Range	Scoring Criteria	Reliability (Cronbach's α)
PHQ-9	Depression	9, 0–3, 0–27	0–4 absent; 5–9 mild; 10–14 moderate; 15–19 moderately severe; 20–27 severe	.815
GAD-7	Anxiety	7, 0–3, 0–21	0–4 absent; 5–9 mild; 10–14 moderate; 15–21 severe	.896
PHQ-15	Somatic symptoms	15, 0–2, 0–30	0–4 absent or very mild; 5–9 mild; 10–14 moderate; 15–30 severe	.833
AIS	Sleep disturbance	8, 0–3, 0–24	<4 absent; 4–6 suspicious; ≥7 presence	.862

4) The AIS was introduced to evaluate sleep disturbance. It contains eight items, which is rated from 0 to 3. The sum of the items is the total score, positively reflecting the severity of sleep disturbance. A total score less than 4 could be seen as the absence of sleep disturbance; 4 to 6, suspicious sleep disturbance; and 7 or higher, presence of insomnia (Zhao et al., 2019). Reliability was indicated by Cronbach's alpha of about 0.862.

Participants

This study was completed at the front line of Wuhan 2020 when health care professionals fought COVID-19. Inclusive criteria of participants were the following: a) first-line professionals directly work with patients with COVID-19 at the hospital; b) from different provinces outside Wuhan and were sent by the health administration; c) with self-perceived psychological symptoms, complaints or distress, and sought psychological intervention actively; d) symptoms firstly emerged after they arrived in Wuhan, soon or after a period of working at the front line; e) symptoms, complaints, or distress are suggested by corresponding self-rating scales; f) never diagnosed with mental disorders; g) never accepted any therapy including MBSR or VRT; and h) with informed consent of the study. Through the self-report and inclusion process, we found four health care workers with psychological problems meeting the full criteria (Table 2).

Case A is a 31-year-old woman who is a surgical nurse. Case A complained of experiencing work stress in Wuhan, with accompanying difficulty in falling asleep and insomnia. Before the session, she had scores of 4 for PHQ-9, 4 for GAD-7, 5 for PHQ-15, and 10 for AIS.

Case B is a 30-year-old woman who is an osteological specialist. She complained of depressed mood and a period of bad quality of sleep since she had arrived in Wuhan. Before the intervention, she had scores of 14 for AIS, 7 for PHQ-9, 5 for GAD-7, and 11 for PHQ-15.

Case C is a 37-year-old woman who is an emergency department (ED) nurse. She reported decreased sleep quality, easily wake up during sleep, and fatigue since she arrived in Wuhan. Before the intervention, she had scores of 5 for PHQ-9, 4 for GAD-7, 4 for GAD-7, 12 for PHQ-15, and 9 for AIS.

Case D is a 29-year-old woman who is a surgical nurse. She reported decreased sleep quality, easily wake up during sleep, and fatigue since she arrived in Wuhan. Before the intervention, she had scores of 6 for PHQ-9, 11 for GAD-7, 11 for PHQ-15, and 10 for AIS.

This survey was approved by the ethics panel of the Medical Association Changzheng Hospital (no. 2020SL010). All participants in this study provided informed consent to participate.

Virtual Reality Therapy

The VRT device used in this study was developed by the author's hospital, Department of Psychology, and Shanghai Zan Tong Med-tech Limited Co Ltd. The hardware used a China-made integrated VR machine with a binocular resolution of 2.5 K. Software was developed on 3D Unity, which contained a total 12 different virtual scenarios, including grassland, seabed, beach, forest, etc. Single or multiple MBSR sessions were delivered through these scenarios, combing instruction words played through the headset integrated with the device (Fig. 1).

FIGURE 1. VRT session for a first-line health care worker.

Intervention

All participants gave written informed consent. After the process of gathering information, obtaining informed consent, and scale evaluations, VRT was applied to these four participants, who have shown psychological problems. The participants had a heavy workload and more temporary changes in work content, which made them less likely to receive a complete 8 weeks of mindfulness stress reduction. The setting of therapy was designed to receive 30 minutes of VRT psychological intervention at a specific location, every day for a week, in total seven times (Fig. 2).

TABLE 2. Information of Participants

Case Information	Case A	Case B	Case C	Case D
Sex	Female	Female	Female	Female
Age	31	30	37	29
Marital status	Partnership	Partnership	Partnership	Partnership
Working years	10	2	16	8
Profession	Surgical nurse	Osteologist	ED nurse	Surgical nurse
Main complaint	Feeling of stress, sleep difficulty	Depressive mood, poor sleep quality	Poor sleep quality, fatigue	Poor sleep quality, fatigue
PHQ-9	4	7	5	6
PHQ-15	5	11	12	11
GAD-7	4	5	4	11
AIS	10	14	9	10

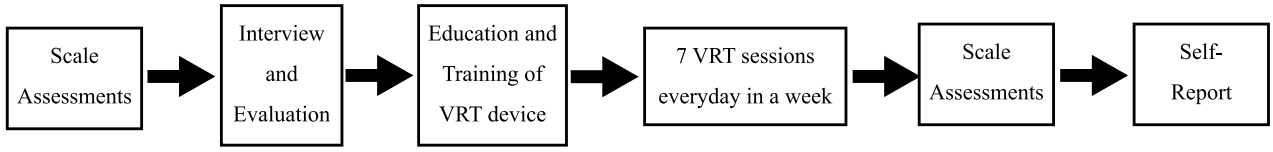

FIGURE 2. Study procedure.

In the total seven sessions, all participants followed according to the therapy setting of the sequential steps of the MBSR. Participants voluntarily chose VR scenarios, which were taken in the sitting or sleeping position. After each training session, the equipment was sterilized with alcohol and set aside for the next session. Scale ratings of AIS, PHQ-9, GAD-7, and PHQ-15 were performed again after the final session and after the end of the last session to evaluate the effect of the VRT. In addition, after the seven sessions, we invited all the participants to give an open-question comment about how they experienced and see the effect of the VRT.

RESULTS

Demographical characteristics are listed in Table 3. All individuals were female ($n = 4$, 100%). The age of the participants ranged from 29 to 37 years; mean (SD) is 31.75 (3.59) years. All of them were married or in a long-term stable partnership ($n = 4$, 100%). Working years as health care professionals were from 2 to 16 years; mean (SD) is 9 (5.77) years.

All four participants had significant psychological problems before the intervention. Case A had both psychosomatic and sleeping disturbance, which reflected by scores of 5 for PHQ-15 and 10 for AIS. Case B showed significance in symptoms of depression (7 for PHQ-9), anxiety (5 for GAD-7), somatic (11 for PHQ-15), and sleep difficulty (14 for AIS). Case C had depression (5 for PHQ-9), somatic (12 for PHQ-12), and sleeping problems (9 for AIS). Case D experienced depression (6 for PHQ-9), anxiety (11 for GAD-7), somatic (11 for PHQ-11), and sleeping problems (10 for AIS) (Table 3).

All participants completed a total of seven sessions. After the VRT sessions, scores in symptoms of depression, anxiety, somatic, and sleeping decreased. We found 10 out of 13 scales (76.92%) reduce to an underdelimitation level. For case A, the scores for PHQ-15 and AIS decreased to an underdelimitation level. For case B, PHQ-9, GAD-7, and AIS dropped to an underdelimitation level. PHQ-9, PHQ-15, and AIS of case C reduced under delimitation as well as. PHQ-9 and AIS for case D fell to a degree down below the delimitation. Total scores for PHQ-9 of four participants decreased 63.64% on average; for GAD-7, decreased 52.17% on average; for PHQ-15, decreased 38.46% on average; and for AIS, decreased 67.44% on average. The report of the participants was "significantly effective." See detailed score comparison and participant reports in Table 3 and Figure 3.

DISCUSSION

The MBSR-VRT showed effectiveness in all four individuals, improving symptoms of depression, anxiety, somatic, and sleeping difficulty with a total remission rate of 76.92%. It reduced PHQ-9 overall scores by 63.64%, 52.17% for GAD-7, 38.46% for PHQ-15, and 67.44% for AIS. In addition, in the comments after the sessions, all individuals spontaneously talked about how they see the effectiveness of the MBSR-VRT, using words such as "relax" (all four cases), "immersive" (cases A and C), and "scenario" (cases B and D). These comments generally suggested the effectiveness of the VRT sessions, also providing the suggestion of our previous assumption of stress and restriction.

TABLE 3. Scale Ratings Before and After VRT

Case	Scales	Before	After	Reduction Rate (%)	Self-Report and Comment
A	PHQ-9	4	1	75.00	"The VR scene gives a sense of peace of mind, and if you are immersed in it, you won't be able to think about other people or things. It gives me a relaxing effect. This week, I've especially enjoyed these short 30-minute sessions at a time. Now I do sleep better than before."
	GAD-7	3	3	0.00	
	PHQ-15	5[a]	4	20.00	
	AIS	10[a]	6	40.00	
B	PHQ-9	7[a]	2	71.43	"In the first session of VRT, scenarios, and instruction words brought me into a gradually relaxing state of mind and helped me find the ideal sense when falling asleep. My sleep quality is much improved over the course of a week compared to the earlier part of the week."
	GAD-7	5[a]	1	80.00	
	PHQ-15	11[a]	10[a]	9.09	
	AIS	14[a]	3	78.57	
C	PHQ-9	5[a]	1	80.00	"The full 360°C HD scenes of VRT and instruction words are immersive and completely relaxing. It made my body got calm. I was so relaxed that I fell asleep during the sessions several times! The VRT taught me how to have a sense of relaxation after work and improved the quality of sleeping!"
	GAD-7	4	1	75.00	
	PHQ-15	12[a]	3	75.00	
	AIS	9[a]	3	66.67	
D	PHQ-9	6[a]	4	33.33	"Putting myself briefly in a VR scenario was relaxing and comfortable. My sleep state and anxiety symptoms are now significantly better, and I have learned how to relax. When feeling anxious, I first allow myself to take three deep breaths, then recall and image scenarios taught by VRT. This process made my body seems to go into that same state it was in during my previous training. Slowly begin to shift your attention to your breathing and the sensations in your body, and gradually one can relax."
	GAD-7	11[a]	6[a]	45.45	
	PHQ-15	11[a]	7[a]	36.36	
	AIS	10[a]	2	80.00	
Total	PHQ-9	22	8	63.64	
	GAD-7	23	11	52.17	
	PHQ-15	39	24	38.46	
	AIS	43	14	67.44	

[a]Above cutoff score.

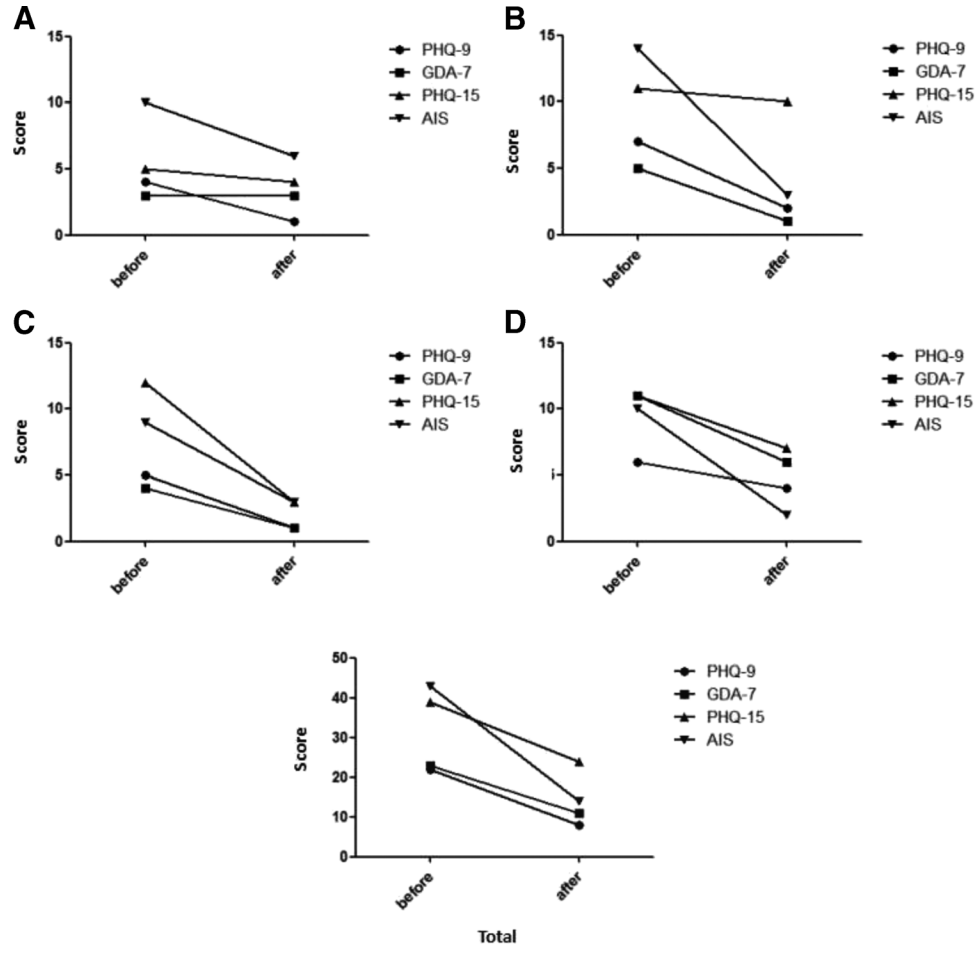

FIGURE 3. Scale ratings before and after VRT.

Results are consistent with most of the previous studies. First, VR combined with mindfulness-based approaches is effective, improving sleep quality (Lee and Kang, 2020), anxiety (Navarro-Haro et al., 2019) and perceived stress (Modrego-Alarcón et al., 2021). Second, although not solid, the study does suggest that VR improved mindfulness skill learning and adherence because no participants dropped or reported any difficulty in the sessions, which is consistent with previous studies (Modrego-Alarcón et al., 2021; Chandrasiri et al., 2020), but this must be further supported by randomized control trials with a control group simply using MBSR. Until now, there are only few studies on MBSR via VR for depression and somatic problems.

Stress is a complicated physiological and psychological process that a person responds to and interacts with stimulations or the environment. Stress is an important component during the onset of other various mental disorders (Corcoran et al., 2003). Although these symptoms of stress are characteristic and specified (*e.g.*, trauma event reexperience, avoiding behavior to reminders), most of the stress is manifested as nonspecific symptoms, such as depression, anxiety, and psychosomatic and sleep disturbances, and vary in a wide range of individuals. These nonspecific symptoms may meet the *DSM-5* criteria of "adjustment disorder," (pp 286) or may be notable but only can be considered as "normative stress reaction" (pp 289), "psychological problems," or "nonspecific stress-accompanied disorder" (pp 290). However, whether these symptoms meet the criteria, symptoms can still interfere with a person's life, with a possibility of exacerbation to a more severe disorder (*e.g.*, a mood disorder, an anxiety disorder). Nonspecific symptoms give a clue to the person and us, allowing us to track them early using self-rating scales and self-reporting and provide interventions for them.

MBSR is an effective mindfulness-based approach with strong clinical evidence (Rush and Sharma, 2017). It is designed for mitigating subthreshold (*i.e.*, not PTSD and acute stress disorder) stress-accompanied distress. Studies suggested that traditional MBSR is effective in depression, anxiety, sleeping disturbance, somatic symptoms, adjustment disorders, and even acute stress disorder and PTSD (Dutton et al., 2013). However, MBSR is not always successful. One of the barriers to successful MBSR is doing it in a stressful environment, such as a restrictive workplace. Another difficulty is the stressor management part of MBSR: it requires achieving awareness of stressors and managing them using skills; however, not every stressor can be managed or accepted quickly. If there is awareness of a stressor but it is unable to be managed, it may increase the discomfort (Baer et al., 2019). These disadvantages may be ignored in articles because studies usually do not count those who dropped from a mindfulness program. Therefore, these difficulties interfere with the MBSR practice in the front line, especially for individuals who never used it.

The combination with the immersive effect of VRT could be the solution. Previous studies suggested that immersive VR environments do change the response to the environmental stressor physiologically (Martens et al., 2019) and help people manage environmental stress (Soyka et al., 2016). A recent conference study reported that MBSR sessions via VR can improve the effectiveness in patients with chronic pain (Tong et al., 2015). This study suggested that VRT has many strengths compared with the traditional approach first, especially the immersion effect of VRT, which quickly separates the participant's perception from the stressful external environment (*e.g.*, a restricted place) or stressor, assisting participants in immersing themselves in the benign therapeutic circumstance. Another

advantage is that VRT less requires the condition of the therapeutic situation (space, place, and setting), which is strictly required in the traditional MBSR. The third is that the VRT provides a space of imagination, by different virtual circumstances and scenarios, which satisfies the individualized needs of every participant. These advantages ensure the quality and effectiveness of the MBSR under various special or severe environments (*e.g.*, the front line).

Although the PHQ-15 scores in cases B and D, and GAD-7 in case D, showed less significant decreasing, but still changed a lot compared to other scale scores. The result does not suggest the insufficiency of the effectiveness of the VRT for a particular symptom domain or some individuals. There are three reasons: a) the stress varies and manifests differently; b) it is also a possibility that effectiveness will be shown later or requires long-term sessions more than a single week; and c) the small size of this study hardly leads to a conclusion for a specific symptom domain, either positive or negative.

At present, most of the research on VRT relate to PTSD in wars (Mclay et al., 2011). However, there are few studies about the VRT intervention in PTSD related to natural disasters and public emergencies (such as the outbreak of a pandemic). In the existing VRT research, combined therapy with exposure techniques is mostly investigated (McLay et al., 2011), rather than others. There are no studies reported before on VRT combined with MBSR approaches. This report series suggests the effectiveness of mobile VRT as an innovational and convenient therapeutic approach, which has great potential in the assistance of mental health professionals with limited manpower to implement digital and large-scale stress psychological intervention for more personnel. It will play a role in promoting the means and ability of disaster psychological assistance in China in the future.

The main limitations, first, are the small number of participants and the number of therapy sessions, which hardly lead to a solid conclusion based on statistical significance. Another limitation is there are no control groups (either the typical VRT group or the traditional MBSR group). Next, we did not follow up for a sufficient period, because of the retreat from the front line of us and participants. In addition, although we have mentioned the role of restriction of place and stressors, it is still not theoretically deep and which parts of the MBSR and VRT really worked. Further research will be started focusing on VR-MBSR in frontline health care professionals, with a larger size and blinded randomized trial with control groups.

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DISCLOSURE

Ethical standards: This survey was approved by the ethics panel of the Medical Association Changzheng Hospital (No. 2020SL010). All participants in this study provided informed consent to participate.

Availability of data and materials: The datasets used or analyzed during the current study are available from the corresponding author on reasonable request.

The authors declare no conflict of interest.

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