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Virtual Reality for Health Care Professionals During a Pandemic: A Pilot Program

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Abstract

Objective: The purpose of this pilot study was to evaluate the safety and use of a nature-based virtual reality (VR) experience among health care providers (HCP) during a pandemic. **Methods:** Twenty-four frontline HCP participated in this crossover pilot where the viewing order of the experiences were randomized. All participants attended in-person consent, baseline, and end-of-study visits. The intervention consisted of viewing 2 nature-based scenes ("walk in the woods" and "forest of focus") through 3-D VR and with computer 4K graphic imagery. Randomization took place with regards to the viewing order (VR vs 4K computer video, scene 1 and 2). Outcomes measured were safety, acceptability and changes in intensity of anxiety feelings, resilience, emotional distress, cognitive function, and self-efficacy. **Results:** Among the 26 HCP expressing interest in the study, 24 enrolled in this study. The majority were male (58.3%), white (66.7%) and of an average age of 46.3 ± 10.5 years (standard deviation (SD)). End of the study survey showed that almost all participants (96%) would participate in the study again and recommend it to others. Twenty-three of the 24 participants also felt relaxed after seeing the imagery. With respect to anxiety (as measured by the STAI Y1), the VR "walk in the woods" had the greatest reduction from pre to post (6.4 points, SD = 5.98) followed by VR "forest of focus" (5.8 points, SD = 9.29), computer screen "forest of focus" (5.0 points, SD = 8.89), and computer screen "walk in the woods" (4.1 points, SD = 6.22). All 4 sessions had a significant decrease in score from pre to post (P-values ≤.005), but there was no significant difference in the change from pre- to post-session between the 4 groups (P-value = .5835). **Conclusion:** The use of the VR among HCP has promise for reducing stress among health care providers during a high stress period, such as a pandemic but much larger studies are needed.

Keywords

virtual reality, pandemic, first responders, wearable technology

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Introduction

According to large population-based surveys, up to 33.7% of the population is or will be affected by an anxiety disorder during their lifetime.[1] In the workplace, millennials and people who fall into the "Gen Z" category (born in the mid 1990s to the early 2010s) are especially vulnerable,[2] where 54% of workers under 23 years of age have indicated they felt anxious or nervous due to stress in the preceding month.[3] The total cost of anxiety disorders has been estimated to be approximately $40 Billion in the US in the 1990s[4] and € 74.4 billion for 30 European EU countries in 2010.[5] The current costs are estimated to be much higher and are predicted to reach $3 Trillion Globally by 2030.[6]

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While some anxiety may improve job performance[7] by motivating people, many studies now document the detrimental impact of anxiety on job performance. Impostor syndrome,[8] burnout,[9] and decreased satisfaction with work[10] are just some of the negative impacts of anxiety. In addition, research indicates that the greater the anxiety, the lower degree of hope and sense of possibility,[11,12] with a subsequent sense of demoralization.

During the current COVID-19 pandemic, frontline health care providers have experienced significant anxiety, leading to increasing worry and a feeling of medical vulnerability[13]; as well as high susceptibility to burnout.[14] In fact, 1 meta-analysis demonstrated that the overall prevalence of anxiety and depression was close to 25%[15] with the state-and-trait anxiety levels being in the "severe" and "moderate" categories respectively,[16] while an additional meta-analysis showed that 25% of nurses, 17% of medical doctors, and 43% of frontline workers all experienced significant levels of anxiety.[17]

Aside from anxiety, insomnia and emotional distress are also common amongst healthcare workers.[18] Cognition may also be impaired due to the high-cognitive load of dealing with overcrowded emergency rooms, learning new protective equipment protocols, and the added burden of threat from the pandemic.[19,20]

There are few existing solutions for the cognitive and emotional sequelae of working as a healthcare worker during the pandemic. Most interventions offered to healthcare workers have been psychoeducational or supportive[21-23] with data supporting the usefulness of online cognitive-behavioral therapy (CBT).[24-26] Traditional measures such as the use of alprazolam to address state anxiety[27,28] may not be safe or feasible for healthcare workers. Several studies have indicated that nature-based guided imagery in a two-dimensional (D) format may be helpful for state- and trait-anxiety.[29,30] Additional studies have indicated similar reductions in anxiety and negative affect for nature-based imagery delivered through virtual reality (VR).[31-34]

VR, in essence, is the creation of a fully immersive simulation environment using a 3-D head mounted display which allows for limited interaction with experiences that appear to be real. VR has been used 2 different ways, depending on the goals. One is for training purposes and the other to create calm environments which can aid in stress/anxiety management. One approach, is referred to as "exposure therapy" is used for systematic desensitization, where VR allows for the ability to reproduce the stressful/anxious environment and through repeated experiences it allows the individual to improve their response thereby reducing the stress and anxiety.[35-41] The other VR approach, let us call it "immersion therapy," is with actual immersion therapy in calm environments with the goal in mind of reducing stress and anxiety. Whereas a number of trials have been reported using "exposure therapy," little work has been done with actual "immersion therapy" in calm environments.[42]

The purpose of this pilot study was to investigate whether VR "immersion therapy" with guided nature-based imagery, undertaken in the midst of a working day, might be a safe and feasible option for healthcare workers. An exploratory aim for this pilot was also to look for any signal signifying that the VR experience would reduce anxiety and emotional distress, as well as improve focus among health care providers (HCP).

Methods

Study Overview

The primary aim of this single-blinded randomized pilot study was to evaluate the feasibility and acceptability of a VR experience by HCP during a time of high stress. In this pilot, participants were asked to partake in 2 nature-based paradigm experiences by viewing them through Oculus VR goggles or on a computer screen. The order of the viewing experiences was randomly selected by a computer system (REDCap). In accordance with the Declaration of Helsinki, this study was reviewed and approved (ID 20-009579) by our Institutional Review Board (IRB). IRB approved written informed consent to be obtained for all study participants prior to study participation.

Setting

Potential participants were HCP in the frontline of the Covid-19 pandemic. They were recruited from a large health care facility in the Midwestern United States. Enrollment took place between January 22, 2021 and June 28, 2021. Study participation concluded on August 4, 2021.

Participants

Of the 26 HCP who expressed an interest in the study, 25 went on to be pre-screened and 24 were eventually enrolled (Figure 1). Eligibility criteria for this study included those currently employed at our health care facility as HCP, not pregnant at time of consent, and no contraindicated comorbid health conditions as deemed by the clinical investigator. They were excluded from the study if they were currently practicing mindfulness training on a weekly or regular basis; undergoing additional programs to improve quality of life (QOL); enrolled in another clinical or research program which intervenes on the patient's QOL, stress, or anxiety; or having an unstable medical or mental health condition such as existing eye strain, seizures, dizziness, or nausea. In addition, to be included in this study, participants needed to be able to tolerate VR experiences and not have photosensitivity.

All interested HCP underwent a 10-min phone pre-screen whereby the study details were discussed, and an interview took place for study eligibility. Those who passed the pre-screen interview were invited to attend an in-person

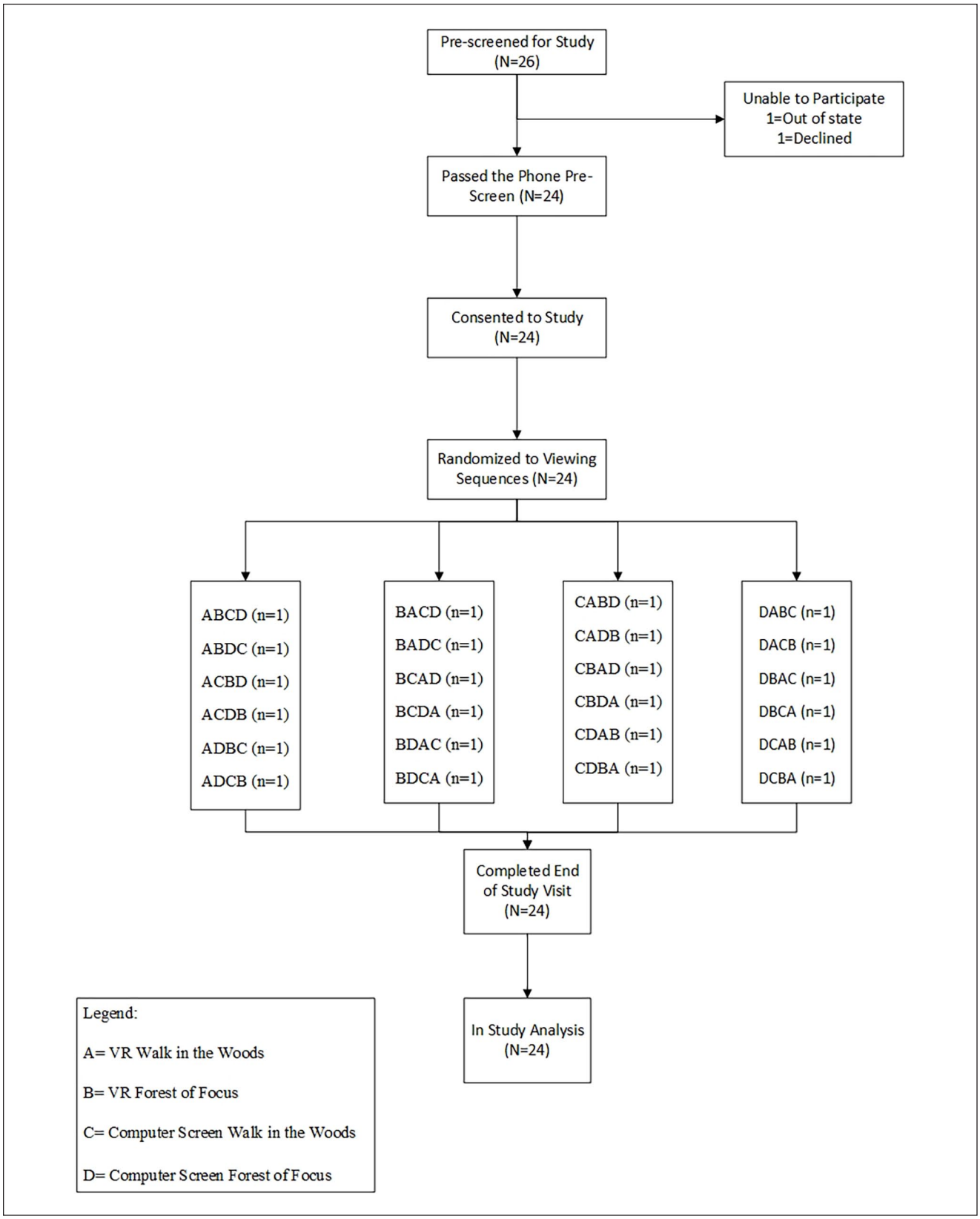

Figure 1. Participant study flow.

consent visit. After signing an informed consent, participants could either choose to start their first study viewing or could schedule that for a later date. Participation in the intervention phase was 2 to 3 weeks.

Intervention

Study participants were scheduled during the workday for four 30-min study visits within a 2 to 3-week time period to view the nature-based intervention. These visits needed to have at least 1 day in-between viewings. Participants were randomly assigned the order of the paradigms viewed in the R-VR or as videos on the computer (Figure 1). The randomization was through REDCap as programmed by the study statisticians. Prior to viewing the intervention and immediately following the viewing, participants were asked to complete study questionnaires pertaining to anxiety (*State-Trait Anxiety Inventory (STAI-Y1)*[43-47]), resilience (*Brief Resilience Scale (6 item) (BRS6)*[48]), emotional distress (Adapted from the *PROMIS Emotional Distress-short form* 7a *(7 items)*[49]), cognitive function (*PROMIS Cognitive Function short form* 6a *(6 items)*[49]), self-efficacy (*Self-efficacy (Short Form* 4a—*4 items)*[49]), and at the end of the study satisfaction form (adapted from *Was it Worth it Questionnaire (WIWI)*[50] and the *Reulay Qualitative Survey (RQS)*).

Data was also collected identifying if individual issues/needs were addressed by the experience (HUMAN survey—an unvalidated, exploratory tool). HUMAN is a 7-item instrument which was designed to reflect Reulay Virtual Reality (RVR) program's 7-pronged approach to anxiety with each of the VR experiences targeting one of the following phenomenological aspects of anxiety: Nervousness, Worry, Distraction, Somatic tension, Freezing/Stuckness, Sense of foreshortened future, Boredom. While the solutions were designed to target these phenomena with 1 specific focus (designed for inducing calmness, less worry, focus, relaxation, feeling free, enhancing a scene of possibility, and feeling a sense of awe), to the expectations is to learn which approaches anxiety fit specific individuals based on their demographics, biometrics, clinical presentation, and digital phenotypes. In essence, the HUMAN survey is simply a list of sentiments that were developed to correspond with 7 different experiences provided by Reulay Inc. Item 1 ("My future is amazing") was designed to correlate with *"walk in the woods"* VR experience, and item 3 ("My mind is still") was designed to correlate with *"forest of focus"* VR experience. Participants were asked to complete this survey before and after each session.

R-VR Experience and Computer Video (4K) Experience

For the intervention with the Reulay Occulus headgear VR experience, participants were seated in a swivel chair in the center of the research room and given instructions on the VR headgear and controllers. They then watched the 10-min nature scene through VR headgear. At any time if the participant felt dizzy or nauseous, they were instructed to stop the intervention. All participants completed both VR experiences without any side effects. The 10-min VR event involved 1 of 2 scenes: Scene 1 was designed for relaxation in nature with natural scenery such as trees, streams and deer. Scene 2 was designed to help the participant focus with natural scenery such as glowing embers and fireflies. Following the VR experience, the participant removed the headgear and completed the second round of questionnaires. These same 2 scenarios were also viewed on a 1920×1200 computer screen/monitor without any headgear.

The study randomized the order in which the experiences were viewed. Throughout the study, all study participants viewed the computer video experiences on the same computer. Surveys were completed before and after the computer video experiences as well.

Data Analysis

Descriptive characteristics and questions about their overall well-being were reported using frequencies for the categorical variables and mean, standard deviation (SD), and range for the continuous variable. The primary outcome was analyzed using the STAI Y1 survey score. The PROMIS emotional distress, cognitive function, and HUMAN survey were analyzed as secondary outcomes. Differences between the 4 session types were evaluated using a Kruskal-Wallis test, using an outcome of the difference in post-test minus pre-test score. Changes between pre-test and post-test within an individual session type were evaluated with a paired *t*-test. These tests were also conducted for all secondary analysis survey outcomes. Linear mixed models were conducted with participant ID as a random variable and after adjusting for whether a certain treatment was done before their screen/VR counterpart as a fixed effect. The outcome was the difference between post-test and pre-test scores. Estimates for the fixed effect of session type were reported with their 95% confidence intervals. Results from a satisfaction survey are reported. Post hoc tests were done between pre and post tests for the first VR STAI Y1 encountered and age, sex, race, and job type. Age was compared to the difference in STAI Y1 results using a Pearson Chi-Square test and Kruskal-Wallis tests for the categorical variables. All P-values $<.05$ were considered statistically significant. Analyses were performed using SAS (SAS 9.4).

Results

The average age of the participants was 46 (± 10.5) years; with 58% being male and 66.7% white. All participants ($N = 24$) answered a 5 or above when asked how motivated

Table 1. Participant Demographics.

Variables	Total (N = 24) N (%)
Age (in years)	
Mean (SD)	46.3 (10.46)
Median	43.8
Range (min, max)	32.4, 68.2
Sex	
Male	14 (58.3%)
Female	10 (41.7%)
Ethnicity	
Non-Hispanic nor Latino	23 (95.8%)
Hispanic or Latino	1 (4.2%)
Race	
Asian	6 (25.0%)
Black or African American	1 (4.2%)
White	16 (66.7%)
More than 1 race	1 (4.2%)
Current marital status	
Never married	1 (4.2%)
Married	23 (95.8%)
Job description	
Physician	16 (66.7%)
PA/NP	3 (12.5%)
Other*	5 (20.8%)
How would you describe your current level of activity	
Sedentary	3 (12.5%)
Moderately active	13 (54.2%)
Vigorously active	4 (16.7%)
Extremely active	4 (16.7%)
Rate your current level of stress (0 is no stress and 10 is the highest level of stress imaginable)	
0 = No stress at all	
1	1 (4.2%)
2	4 (16.7%)
3	2 (8.3%)
4	1 (4.2%)
5	4 (16.7%)
6	4 (16.7%)
7	2 (8.3%)
8	6 (25.0%)
9	0 (0.0%)
10 = highest level of stress imaginable	0 (0.0%)
Have you ever in your life had a period of time lasting several days or longer when most of the day you felt sad, empty, or depressed?	
No	16 (66.7%)
Yes	8 (33.3%)
Have you been ever diagnosed and/or treated for depression?	
No	20 (83.3%)
Yes	4 (16.7%)
Have you ever had a panic attack?	
No	19 (79.2%)
Yes	5 (20.8%)
On a scale of 0 to 10, with 0 being not concerned at all and 10 being very concerned, how concerned are you about your well-being?	
0 = not concerned at all	3 (12.5%)
1	2 (8.3%)
2	1 (4.2%)
3	0 (0.0%)
4	3 (12.5%)
5	6 (25.0%)
6	0 (0.0%)
7	5 (20.8%)
8	3 (12.5%)
9	0 (0.0%)
10 = very concerned	1 (4.2%)
On a scale of 0 to 10, with 0 being not motivated at all and 10 being very motivated, how motivated are you to make lifestyle changes to improve your overall well-being?	
0 = not motivated at all	0 (0.0%)
1	0 (0.0%)
2	0 (0.0%)
3	0 (0.0%)
4	0 (0.0%)
5	2 (8.3%)
6	1 (4.2%)
7	6 (25.0%)
8	6 (25.0%)
9	4 (16.7%)
10 = very motivated	5 (20.8%)
On a scale of 0 to 10, with 0 being not important at all and 10 being very important, how important it is for you to make lifestyle changes to improve your overall well-being?	
0 = not important at all	0 (0.0%)
1	0 (0.0%)
2	0 (0.0%)
3	0 (0.0%)
4	0 (0.0%)
5	3 (12.5%)
6	2 (8.3%)
7	2 (8.3%)
8	2 (8.3%)
9	7 (29.2%)
10 = very important	8 (33.3%)
On a scale of 0 to 10, with 0 being not confident at all and 10 being very confident, how confident are you in your ability to make lifestyle changes to improve your overall well-being?	
0 = not confident at all	1 (4.2%)
1	0 (0.0%)
2	0 (0.0%)
3	0 (0.0%)
4	1 (4.2%)
5	2 (8.3%)

(continued)

Table 1. (continued)

(continued)

Table 1. (continued)

Variables	Total (N = 24) N (%)
6	3 (12.5%)
7	2 (8.3%)
8	7 (29.2%)
9	3 (12.5%)
10 = very confident	5 (20.8%)
Contemplation ladder	
0 = I am not ready to make lifestyle changes	0 (0.0%)
1	0 (0.0%)
2 = I think I need to consider making lifestyle change but I am not quite ready	0 (0.0%)
3	0 (0.0%)
4 = I think I should be making lifestyle changes but I am not quite ready	1 (4.2%)
5	1 (4.2%)
6 = I am thinking about making lifestyle changes	7 (9.2%)
7	2 (8.3%)
8 = I am seriously thinking of making lifestyle changes	0 (0.0%)
9	1 (4.2%)
10 = I am making lifestyle changes	12 (50.0%)

*Includes PhD, acupuncturist, and massage therapist.

(or how important it was) they were to improve their overall well-being on a scale of 0 to 10. In addition, 50% of the participants indicated that they were actively making lifestyle changes (using the Readiness to Change assessment tool "Contemplation Ladder"). Demographic characteristics are reported in Table 1.

Table 2 shows the Pearson correlation with resilience (BRS6), self-efficacy, emotional distress, anxiety (STAI Y1) for pre-test scores, at each time point. All scores are highly correlated. The average pre-test scores and post-test scores are reported in Table 3. For the STAI Y1 score, the lower the score the better the outcome. The VR walk in the woods had the greatest change from pre to post (6.4 points, SD = 5.98) followed by VR forest of focus (5.8 points, SD = 9.29), computer screen forest of focus (5.0 points, SD = 8.89), and computer screen walk in the woods (4.1 points, SD = 6.22). All 4 sessions had a significant decrease in score from pre to post (P-values $\leq$.005), but there was no significant differences in the change from pre- to post-session among the 4 groups (P-value = .5835). Similar results were seen in the mixed model analysis (Table 4). For the secondary analyses, the PROMIS emotional distress and cognitive function scores were analyzed. Both emotional distress and cognitive function scores improved within all 4 sessions, but there were no statistically significant differences among the 4 groups (Emotional distress P-value = .4114, Cognitive function P-value = .8923). No statistically significant differences were found in the mixed model analyses.

Findings from the analysis of the HUMAN questionnaire are summarized in Supplemental Table 1. For the VR "Walk in the Woods" experience significant improvements from pre to post were detected for 4 of the 7 HUMAN items.

The satisfaction survey at the end of the study showed that almost all participants (96%) would participate in the study again and recommend it to others. Twenty-three of the 24 participants also felt relaxed after seeing the imagery. The results of the survey are reported in Supplemental Table 2.

Tests were carried out post hoc to analyze if there was an association between some of the demographic factors and the score from the first VR experience. The correlation coefficient between age and the first VR experience difference was .28 (P-value = .18) suggesting that age was not a limiting factor in the response to the VR. The results from the Kruskal-Wallis test between the first VR score difference and sex (women vs men, P-value = .48), job type (physician vs PA/NP vs Other, P-value = .77), and race (non-white vs white, P-value = .60) also do not seem to implicate an association but larger studies are needed.

Discussion

This pilot study evaluated the acceptability and safety of nature-based imagery in 24 HCP during the COVID-19 pandemic. Acceptability was high, as evidenced by both the high completion rate and the favorable responses to queries about the value of participating in the study. This is a particularly significant finding, given the high baseline stress levels in this cohort heightened by the pandemic, and the very limited discretionary time available to the participants.

In terms of safety, no participants reported any adverse effects, either from the VR Headgear and experience or the computer (4K) program viewing and experience. This is an encouraging finding as some VR users of other studies have reported issues with nausea or other symptoms.[51-53] Although we did not collect any data pertaining to this, we suspect that the gentle scene changes and slow pace of the content used in the current VR experience helped to minimize potential negative effects.

Although the number of participants was small, we were able to detect statistically significant reductions in stress after each of the nature-based imagery interventions. We found a similarly significant reduction in emotional distress while also finding an increase in focus. Given the likelihood of persisting demand-resource imbalance across much of the medical profession for the foreseeable future, this study suggests that nature-based imagery could be part of an overall plan to help maintain HCP first-responders' mental health during the pandemic. An improvement in focus

Table 2. Pearson Correlation of Scores for Each Pre-Viewing Timeframe.

	Pre-viewing 1	Pre-viewing 2	Pre-viewing 3	Pre-viewing 4
Emotional distress vs Stai Y1	.86	.68	.66	.57
Emotional distress vs cognitive	−.68	−.77	−.71	−.85
Emotional distress vs self-efficacy	−.47	−.67	−.52	−.61
Emotional distress vs BRS6	−.49	−.63	−.59	−.38
Stai Y1 vs cognitive	−.67	−.42	−.40	−.47
Stai Y1 vs self-efficacy	−.57	−.26	−.32	−.40
Stai Y1 vs BRS6	−.64	−.42	−.31	−.40
Cognitive vs self-efficacy	.43	.50	.59	.54
Cognitive vs BRS6	.54	.31	.54	.35
BRS6 vs self-efficacy	.86	.77	.77	.52

Table 3. Pre/Post Average Scores.

	VR walk in woods (N = 24)	VR forest of focus (N = 24)	Computer screen walk in woods (N = 24)	Computer screen forest of focus (N = 24)
STAI Y1				
Average pre (SD)	33.8 (9.74)	34.1 (11.27)	34.8 (11.26)	34.2 (9.18)
Average post (SD)	27.4 (8.23)	28.3 (6.87)	30.7 (10.04)	29.3 (9.73)
Emotional distress				
Average pre (SD)	15.5 (4.96)	13.8 (5.69)	15.4 (4.66)	14.4 (4.30)
Average post (SD)	11.8 (5.47)	11.3 (5.21)	12.3 (5.29)	12.4 (5.12)
Cognitive function				
Average pre (SD)	33.5 (5.88)	33.2 (6.01)	33.3 (5.47)	33.6 (5.23)
Average post (SD)	35.1 (5.42)	34.6 (5.42)	34.3 (4.80)	34.9 (4.74)

might translate into better patient outcomes and needs to be evaluated in a larger future trial.

Both paradigms were designed to reduce anxiety, though the emphasis in the imagery of "walk in the woods" was to decrease anxiety, whereas the emphasis in "forest of focus" was to enhance focus. The findings that anxiety was reduced and focus was increased corroborates with the extensive literature connecting anxiety with impaired cognition and vice versa.[54-57] Furthermore, anxiety can decrease the ability of the prefrontal cortex to enable cognitive flexibility,[58] and a reduction in attentional bias to threat could also account for the reduction in anxiety.[59]

The "Walk in the Woods" experience, which was designed to reduce nervousness and induce calmness, did demonstrate some positive trends related to individual items. For example, for the item "every breath of air relaxes me," there was a statistically significant improvement which was not seen in the corresponding 4K computer video. Similar significant improvements were seen with VR with the items "I feel serene" and "I feel boundaryless and limitless." There was a trend toward significance for "my future is amazing," again not seen with the 4K computer video. Overall, these findings suggest that the VR experience specifically designed to reduce nervousness and enhance calmness did just that through a variety of mechanisms, and more than any of the other experiences evaluated in this study. For the experience designed to enhance focus, the 4K computer video impacted more anxiety-related variables than the VR designed to enhance focus. These findings may reflect the fact that certain people are able to reduce anxiety more effectively with first person immersion, while others prefer third person perspectives.[60]

In summary, study findings are consistent with studies that demonstrate that nature-based imagery can reduce state-anxiety and the associated autonomic hyperactivity.[29,30,61] While the study was not powered to detect these changes, we are encouraged by the potential for these interventions providing relief in HCP settings, especially given the preponderance of expressed opinion by the participants that the break was welcome during the stressful times of the pandemic.

Despite the numerically greater reductions in anxiety and improvements in focus with VR compared to 4K video in computer-based imagery, there were no statistically significant differences between paradigms across time. Other studies have demonstrated that VR is superior to biofeedback in reducing anxiety,[34] and that 360° videos may induce more awe than 2D imagery due to the immersive nature of the videos.[62] There are several reasons for why this might

Table 4. Average Difference by Group.

	VR walk in woods (N = 24)	VR forest of focus (N = 24)	Computer screen walk in woods (N = 24)	Computer screen forest of focus (N = 24)	*P*-value
STAI Y1 (post–pre)					.5835[a]
Mean (SD)	−6.4 (5.98)	−5.8 (9.29)	−4.1 (6.22)	−5.0 (6.89)	
Median	−7.0	−3.5	−2.5	−4.5	
Range	−18.0, 3.0	−28.0, 15.0	−20.0, 6.0	−17.0, 9.0	
Paired *T* (*P*-value)[b]	−5.2 (<.001)	−3.1 (.005)	−3.2 (.004)	−3.5 (.002)	
Paired *t*-test 95% CL[b]	−8.9, −3.9	−9.8, −1.9	−6.7, −1.5	−7.9, −2.0	
Emotional distress (post–pre)					.4114[a]
Mean (SD)	−3.7 (3.13)	−2.5 (3.16)	−3.1 (3.31)	−2.0 (3.49)	
Median	−3.0	−2.0	−2.5	−2.5	
Range	−9.0, 1.0	−14.0, 2.0	−11.0, 1.0	−11.0, 8.0	
Paired *T* (*P*-value)[b]	–5.8 (<.001)	−3.9 (.001)	−4.6 (<.001)	−2.8 (.010)	
Paired *t*-test CL[b]	−5.0, −2.4	−3.8, −1.2	−4.5, −1.7	−3.5, −0.5	
Cognitive function (post–pre)					.8923[a]
Mean (SD)	1.6 (2.50)	1.4 (2.41)	1.0 (1.53)	1.3 (2.35)	
Median	1.0	1.0	1.0	0.5	
Range	−2.0, 10.0	−3.0, 7.0	−1.0, 4.0	−3.0, 8.0	
Paired *T* (*P*-value)[b]	3.2 (.004)	2.9 (.009)	3.2 (.004)	2.6 (.016)	
Paired *t*-test CL[2]	0.6, 2.7	0.4, 2.4	0.4, 1.6	0.3, 2.2	

[a]Kruskal-Wallis *P*-value across all 4 groups.
[b]Paired *t*-test from pre to post for each individual group.

be the case in this current study. The quality of imagery in the 4K video and VR was very high compared to current standards, potentially reducing the visual impact differences. Also, the VR experiences were not 360° immersive experiences, but rather 180° experiences, so that the degree of presence was far less than immersive video. It is also possible that this was a type II error that could be corrected by a larger sample size. However, given the large ranges of responses, and the sizeable standard deviations, we believe that it is more likely that the responses differ according to individual preferences.

As with any clinical trial, there are both strengths and weaknesses to this trial. A strength is that the study included the uniqueness of the application of a relatively novel technology in a setting where this intervention was welcomed. HCP who work in the medical frontlines are especially vulnerable to burnout and anxiety.[63-65] To our knowledge, this is the first study of a VR intervention among HCP working as first responders during the COVID-19 pandemic. Because this was designed as a pilot study, there are a number of weaknesses to the study. First and foremost is the small sample size which did not allow us to have any power to detect significant differences between the types of HCP. Sample Size for this pilot study was impacted by recruitment. This study took place at the height of the pandemic within our health care facility and study participation took place during a regular workday in order to reduce subject burden. A larger sample size would also allow for more explanatory variables to be included in the model. In our study we included Physicians, Physician Assistants/Nurse Practitioners, and other HCP such as massage therapists and acupuncturists, all of whom were on the frontlines during the pandemic but because of the small sample size, no significant differences were found. Next is the short amount of time between viewings. The study was designed to have all 4 viewings (in a computer-generated randomized order) within the span of 2 weeks. It would have been ideal to have had the participants randomized to 1 of the 4 experiences and use their assigned intervention for longer periods of time. Another limitation is that there was not an adequate option for a control group which could lead to some of the results being impacted by a placebo effect. The VR equipment used does not allow the participants to be blinded to treatment. Next is the use of 180° rather than 360° immersion might have skewed the impact of VR. Finally, because this was designed as a pilot where we assessed exposure to both paradigms ("walk in the woods" and "forest of focus") in both approaches (VR and computer), we have no data on how long-term use would have been impacted by adherence or choice by the participants.

Conclusion

This preliminary pilot study of nature-based guided imagery experiences has shown that a 10-min of VR experience has the potential to reduce anxiety and emotional distress as well as enhancing focus in HCP. For a first responder setting, such an intervention could provide the needed relief to

a vulnerable population. More research should be conducted to further define the role of VR in helping HCP reduce stress and anxiety during stressful situations as well as determine the impact of individualized VR scenarios.

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Authors' Contributions

All the authors participated in the study concept and design, analysis and interpretation of data, drafting and revising the paper, and have seen and approved the final version of the manuscript.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Ethical Standards

All authors assert that all procedures contributing to this work comply with the ethical standards of the Mayo Clinic.

Ethics and Consent to Participate

In accordance with the Declaration of Helsinki, this study was reviewed and approved by the Mayo Clinic Institutional Review Board (IRB). Mayo Clinic IRB approved written informed consent was obtained for all study participants prior to study participation.

Trial Registry Information

Trial registration: NCT04622527. Registered November 10, 2020.

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Supplemental Material

Supplemental material for this article is available online.

Availability of Data and Materials

All data supporting the study findings are contained within this manuscript and within file NCT04622527.

References

1. Bandelow B, Michaelis S. Epidemiology of anxiety disorders in the 21st century. *Dialogues Clin Neurosci*. 2015;17(3):327-335.
2. Brown RL, Richman JA, Rospenda KM. Economic stressors and psychological distress: exploring age cohort variation in the wake of the Great Recession. *Stress Health*. 2017;33(3):267-277.
3. Shellenbarger S. The most anxious generation goes to work. *Wall Street Journal*. Updated May 9, 2019. Accessed July 31, 2020. https://www.wsj.com/articles/the-most-anxious-generation-goes-to-work-11557418951
4. Greenberg PE, Sisitsky T, Kessler RC, et al. The economic burden of anxiety disorders in the 1990s. *J Clin Psychiatry*. 1999;60(7):427-435.
5. Gustavsson A, Svensson M, Jacobi F, et al. Cost of disorders of the brain in Europe 2010. *Eur Neuropsychopharmacol*. 2011;21(10):718-779.
6. The Lancet Global Health. Mental health matters. *Lancet Glob Health*. 2020;8(11):e1352.
7. Cheng BH, McCarthy JM. Understanding the dark and bright sides of anxiety: a theory of workplace anxiety. *J Appl Psychol*. 2018;103(5):537-560.
8. Bravata DM, Watts SA, Keefer AL, et al. Prevalence, predictors, and treatment of impostor syndrome: a systematic review. *J Gen Intern Med*. 2020;35(4):1252-1275.
9. Vîrgă D, Schaufeli WB, Taris TW, van Beek I, Sulea C. Attachment styles and employee performance: the mediating role of burnout. *J Psychol*. 2019;153(4):383-401.
10. Yilmaz A. Burnout, job satisfaction, and anxiety-depression among family physicians: a cross-sectional study. *J Fam Med Prim Care*. 2018;7(5):952-956.
11. Baryshnikov I, Rosenström T, Jylhä P, et al. State and trait hopelessness in a prospective five-year study of patients with depressive disorders. *J Affect Disord*. 2018;239:107-114.
12. Gozuyesil E, Karacay Yikar S, Nazik E. An analysis of the anxiety and hopelessness levels of women during IVF-ET treatment. *Perspect Psychiatr Care*. 2020;56(2):338-346.
13. Vujanovic AA, Lebeaut A, Leonard S. Exploring the impact of the COVID-19 pandemic on the mental health of first responders. *Cogn Behav Ther*. 2021;50(4):320-335.
14. Firew T, Sano ED, Lee JW, et al. Protecting the front line: a cross-sectional survey analysis of the occupational factors contributing to healthcare workers' infection and psychological distress during the COVID-19 pandemic in the USA. *BMJ Open*. 2020;10(10):e042752.
15. Sahebi A, Nejati-Zarnaqi B, Moayedi S, Yousefi K, Torres M, Golitaleb M. The prevalence of anxiety and depression among healthcare workers during the COVID-19 pandemic: an umbrella review of meta-analyses. *Prog Neuropsychopharmacol Biol Psychiatry*. 2021;107:110247.

16. Karasu F, Öztürk Çopur E, Ayar D. The impact of COVID-19 on healthcare workers' anxiety levels. *Z Gesundh Wiss*. 2021;2021:1-11.
17. Santabárbara J, Lasheras I, Lipnicki DM, et al. Prevalence of anxiety in the COVID-19 pandemic: an updated meta-analysis of community-based studies. *Prog Neuropsychopharmacol Biol Psychiatry*. 2021;109:110207.
18. Lai J, Ma S, Wang Y, et al. Factors associated with mental health outcomes among health care workers exposed to Coronavirus disease 2019. *JAMA Netw Open*. 2020;3(3):e203976.
19. Cai Z, Zheng S, Huang Y, et al. Emotional and cognitive responses and behavioral coping of Chinese medical workers and general population during the pandemic of COVID-19. *Int J Environ Res Public Health*. 2020;17(17):6198.
20. Díaz-Guio DA, Ricardo-Zapata A, Ospina-Velez J, Gómez-Candamil G, Mora-Martinez S, Rodriguez-Morales AJ. Cognitive load and performance of health care professionals in donning and doffing PPE before and after a simulation-based educational intervention and its implications during the COVID-19 pandemic for biosafety. *Infez Med*. 2020;28(suppl 1):111-117.
21. Muller AE, Hafstad EV, Himmels JPW, et al. The mental health impact of the covid-19 pandemic on healthcare workers, and interventions to help them: a rapid systematic review. *Psychiatry Res*. 2020;293:113441.
22. Viswanathan R, Myers MF, Fanous AH. Support groups and individual mental health care via video conferencing for frontline clinicians during the COVID-19 pandemic. *Psychosomatics*. 2020;61(5):538-543.
23. Vizheh M, Qorbani M, Arzaghi SM, Muhidin S, Javanmard Z, Esmaeili M. The mental health of healthcare workers in the COVID-19 pandemic: a systematic review. *J Diabetes Metab Disord*. 2020;19(2):1-12.
24. Song J, Jiang R, Chen N, et al. Self-help cognitive behavioral therapy application for COVID-19-related mental health problems: a longitudinal trial. *Asian J Psychiatr*. 2021;60:102656.
25. Weiner L, Berna F, Nourry N, Severac F, Vidailhet P, Mengin AC. Efficacy of an online cognitive behavioral therapy program developed for healthcare workers during the COVID-19 pandemic: the REduction of STress (REST) study protocol for a randomized controlled trial. *Trials*. 2020;21(1):870.
26. Benhamou K, Piedra A. CBT-informed interventions for essential workers during the COVID-19 pandemic. *J Contemp Psychother*. 2020;50:275-283.
27. Susman J, Klee B. The role of high-potency benzodiazepines in the treatment of panic disorder. *Prim Care Companion J Clin Psychiatry*. 2005;7(1):5-11.
28. Ait-Daoud N, Hamby AS, Sharma S, Blevins D. A review of alprazolam use, misuse, and withdrawal. *J Addict Med*. 2018;12(1):4-10.
29. Brown DK, Barton JL, Gladwell VF. Viewing nature scenes positively affects recovery of autonomic function following acute-mental stress. *Environ Sci Technol*. 2013;47(11):5562-5569.
30. Nguyen J, Brymer E. Nature-based guided imagery as an intervention for state anxiety. *Front Psychol*. 2018;9:1858.
31. Yeo NL, White MP, Alcock I, et al. What is the best way of delivering virtual nature for improving mood? An experimental comparison of high definition TV, 360° video, and computer generated virtual reality. *J Environ Psychol*. 2020;72:101500.
32. White MP, Yeo NL, Vassiljev P, et al. A prescription for "nature" – the potential of using virtual nature in therapeutics. *Neuropsychiatr Dis Treat*. 2018;14:3001-3013.
33. Browning MHEM, Mimnaugh KJ, van Riper CJ, Laurent HK, LaValle SM. Can simulated nature support mental health? Comparing short, single-doses of 360-degree nature videos in virtual reality with the outdoors. *Front Psychol*. 2019;10:2667.
34. Gorini A, Riva G. The potential of virtual reality as anxiety management tool: a randomized controlled study in a sample of patients affected by generalized anxiety disorder. *Trials*. 2008;9:25.
35. Arora S, Aggarwal R, Moran A, et al. Mental practice: effective stress management training for novice surgeons. *J Am Coll Surg*. 2011;212(2):225-233.
36. Frederiksen JG, Sørensen SMD, Konge L, et al. Cognitive load and performance in immersive virtual reality versus conventional virtual reality simulation training of laparoscopic surgery: a randomized trial. *Surg Endosc*. 2020;34(3):1244-1252.
37. Stetz MC, Folen RA, Horn SV, Ruseborn D, Samuel KM. Technology complementing military psychology programs and services in the Pacific Regional Medical Command. *Psychol Serv*. 2013;10(3):283-288.
38. Bajunaid K, Mullah MA, Winkler-Schwartz A, et al. Impact of acute stress on psychomotor bimanual performance during a simulated tumor resection task. *J Neurosurg*. 2017;126(1):71-80.
39. Chang TP, Beshay Y, Hollinger T, Sherman JM. Comparisons of stress physiology of providers in real-life resuscitations and virtual reality-simulated resuscitations. *Simul Healthc*. 2019;14(2):104-112.
40. Lee JY, Mucksavage P, Kerbl DC, et al. Laparoscopic warm-up exercises improve performance of senior-level trainees during laparoscopic renal surgery. *J Endourol*. 2012;26(5):545-550.
41. Barré J, Michelet D, Truchot J, et al. Virtual reality single-port sleeve gastrectomy training decreases physical and mental workload in novice surgeons: an exploratory study. *Obes Surg*. 2019;29(4):1309-1316.
42. Boeldt D, McMahon E, McFaul M, Greenleaf W. Using virtual reality exposure therapy to enhance treatment of anxiety disorders: identifying areas of clinical adoption and potential obstacles. *Front Psychiatry*. 2019;10:773-773.
43. Gaudry E, Vagg P, Spielberger CD. Validation of the state-trait distinction in anxiety research. *Multivariate Behav Res*. 1975;10(3):331-341.
44. Greene J, Cohen D, Siskowski C, Toyinbo P. The relationship between family caregiving and the mental health of emerging young adult caregivers. *J Behav Health Serv Res*. 2017;44(4):551-563.
45. Ugalde A, Krishnasamy M, Schofield P. The relationship between self-efficacy and anxiety and general distress in caregivers of people with advanced cancer. *J Palliat Med*. 2014;17(8):939-941.
46. State-Trait Anxiety Inventory. In: Weiner IB, Craighead WE (eds) *The Corsini Encyclopedia of Psychology*. https://doi.org/10.1002/9780470479216.corpsy0943

47. Arnau RC, Broman-Fulks JJ, Green BA, Berman ME. The Anxiety Sensitivity Index-revised: confirmatory factor analyses, structural invariance in Caucasian and African American samples, and score reliability and validity. *Assess*. 2009;16(2):165-180.
48. Smith BW, Dalen J, Wiggins K, Tooley E, Christopher P, Bernard J. The brief resilience scale: assessing the ability to bounce back. *Int J Behav Med*. 2008;15(3):194-200.
49. Northwestern University. Health measures: transforming how health is measured. Published 2020. Accessed June 15, 2020. https://www.healthmeasures.net/
50. Chauhan C, Atherton PJ, Satele D, et al. Patient satisfaction with participation in phase II/III NCCTG clinical trials: was it worth it? (N0392). *J Clin Oncol*. 2012;30(15_suppl): 6133-6133.
51. Park S, Lee G. Full-immersion virtual reality: adverse effects related to static balance. *Neurosci Lett*. 2020;733:134974.
52. Oh H, Lee G. Feasibility of full immersive virtual reality video game on balance and cybersickness of healthy adolescents. *Neurosci Lett*. 2021;760:136063.
53. Gallagher M, Ferrè ER. Cybersickness: a multisensory integration perspective. *Multisens Res*. 2018;31(7):645-674.
54. Birk JL, Opitz PC, Urry HL. Distractibility as a precursor to anxiety: preexisting attentional control deficits predict subsequent autonomic arousal during anxiety. *Biol Psychol*. 2017;122:59-68.
55. Stefanopoulou E, Hirsch CR, Hayes S, Adlam A, Coker S. Are attentional control resources reduced by worry in generalized anxiety disorder? *J Abnorm Psychol*. 2014;123(2):330-335.
56. Robinson OJ, Vytal K, Cornwell BR, Grillon C. The impact of anxiety upon cognition: perspectives from human threat of shock studies. *Front Hum Neurosci*. 2013;7:203.
57. Vytal KE, Overstreet C, Charney DR, Robinson OJ, Grillon C. Sustained anxiety increases amygdala–dorsomedial prefrontal coupling: a mechanism for maintaining an anxious state in healthy adults. *J Psychiatry Neurosci*. 2014;39(5):321-329.
58. Park J, Moghaddam B. Impact of anxiety on prefrontal cortex encoding of cognitive flexibility. *Neuroscience*. 2017;345:193-202.
59. Hur J, Stockbridge MD, Fox AS, Shackman AJ. Dispositional negativity, cognition, and anxiety disorders: an integrative translational neuroscience framework. *Prog Brain Res*. 2019;247:375-436.
60. Wallace-Hadrill SM, Kamboj SK. The impact of perspective change as a cognitive reappraisal strategy on affect: a systematic review. *Front Psychol*. 2016;7:1715-1715.
61. Jo H, Song C, Miyazaki Y. Physiological benefits of viewing nature: a systematic review of indoor experiments. *Int J Environ Res Public Health*. 2019;16(23):4739.
62. Chirico A, Cipresso P, Yaden DB, Biassoni F, Riva G, Gaggioli A. Effectiveness of immersive videos in inducing awe: an experimental study. *Sci Rep*. 2017;7(1):1218.
63. Gualano MR, Sinigaglia T, Lo Moro G, et al. The burden of burnout among healthcare professionals of Intensive Care Units and emergency departments during the COVID-19 pandemic: a systematic review. *Int J Environ Res Public Health*. 2021;18(15):8172.
64. Amanullah S, Ramesh Shankar R. The impact of COVID-19 on physician burnout globally: a review. *Healthcare*. 2020;8(4):421.
65. Moukarzel A, Michelet P, Durand AC, et al. Burnout syndrome among emergency department staff: prevalence and associated factors. *Biomed Res Int*. 2019;2019:6462472.