Mental Health and Innovative Technologies: The Use of Virtual Reality to Address Post-Traumatic Stress Disorder and Anxiety Disorders

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Commented [dhl1]: Is this initial section the abstract? If so, label it? Or maybe it’s an intro to the collection of 2 papers? Or to the “thesis” (which is in turn a collection of 2 papers)?
Thesis Motivation and Structure

This paper focuses on how to leverage technology to provide critical mental health support. The World Health Organization identifies that mental health is a major influencing factor on global development (Mental Health, n.d.). Mental health illnesses are debilitating, correlated with an increased risk of disabilities and premature death (Mental Health, n.d.). Recognizing the impact of isolation and stress from the COVID-19 pandemic, the press, government, and healthcare organizations are acknowledging the need for more mental health support. The U.S. Surgeon General Vivek Murthy stated that “this is the right time for our country to have a conversation about mental health” (Owens, 2021). Murthy mentions that there is “a powerful and important lesson from this pandemic, which is [that] we have to invest in our mental well-being” (Owens, 2021). The World Health Organization agrees that “[i]ncreased investment is required on all fronts… [including] for research to identify new treatments and improve existing treatments for all mental disorders” (Mental Health, n.d.). This paper focuses on how to leverage technology to provide this critical mental health support.

Specifically, this paper focuses on the use of virtual reality technology. The immersive platform creates the potential to deliver effective exposure therapy, especially for patients struggling with PTSD and anxiety disorders. Many scientific studies have validated that virtual reality treatment can be efficacious. Virtual reality’s success in addressing the mental health crisis depends on patients indicating a preference and willingness to try this treatment approach. Thus, this paper explores the patient perspective of in-person versus virtual reality therapy and identifies a demographic of potential users that are struggling from PTSD. The first part of the paper is a research study. The goal of the study is to gather quantitative and qualitative insights on patients’ opinions toward different treatment approaches and the use of virtual reality in
exposure therapy. The second part of the paper examines how to bring this technology to market. It shifts from a research paper to a business market analysis. I focus on a subpopulation of people struggling with PTSD to identify a customer base, create a value proposition for the technology, and consider the market composition. When considering the current market offerings for PTSD treatment, I realized that most of the treatments focus on wartime PTSD. Participant responses in my research study revealed that there are many overlooked instances of PTSD cases. Given the intense stress and traumatic exposures that doctors experienced during the COVID-19, I was interested to learn about physician mental health statistics.

There is a business opportunity for a virtual reality healthcare company to enter the market and provide PTSD support to physicians. The second part of this thesis will analyze that opportunity. I learned that medical residents experience PTSD almost as much as veterans do. One in ten medical residents develop PTSD, whereas one in seven veterans develop PTSD (Vance, et al., 2021; PTSD: National Center for PTSD, 2023). Additionally, although there is a strong need for PTSD support tailored to physicians, in-person exposures are logistically infeasible, and no companies have developed virtual reality exposures focused on physician trauma. Thus, physicians are an overlooked but enticing target market for virtual reality treatment.
Research Study on Patients’ Perspectives Of Exposure Therapy and Virtual Reality

Exposure Therapy

Introduction

Anxiety disorders are pervasive conditions, impacting an estimated 31.1% of U.S. adults at some point in their lifetimes (Any Anxiety Disorder). Anxiety disorders affect individuals across age, income, education level, gender, and sexuality, and the anxiety intensity varies from mild to serious. Licensed professional mental health counselors diagnose a variety of anxiety disorders, among the most common are specific phobia (an estimated 8-12% of U.S. adults), social anxiety disorder (7%), and generalized anxiety disorder (2%) (What are Anxiety Disorders?, 2021). In the United States, analysis from the 2009 and 2010 Medical Expenditure Panel Survey, the Bureau of Labor Statistics, and the National Vital Statistics System revealed that in 2010, anxiety disorders were responsible for an estimated 3,497 suicides (Shirneshan, 2013). Additionally, the estimated annual direct healthcare costs resulting from anxiety disorders were $33.71 billion, and the estimated indirect costs from morbidity and mortality were $15.06 billion (Shirneshan, 2013). Thus, for both economic and health reasons, it is critical that society focuses on increasing the effectiveness and adoption of anxiety disorder treatment.

Across anxiety disorders, numerous scientific studies have identified that psychotherapy has a large positive impact as a treatment approach (American Psychological Association, 2012). Moreover, in these studies, patients noted that after completing psychotherapy, its positive impact persisted and grew (American Psychological Association, 2012; Norr, et al., 2019). Not only do psychotherapy patients experience improvements in their anxiety disorders, but also studies have identified that psychotherapy has broad benefits for individuals and society.
Psychotherapy is cost-efficient; boosts productivity; reduces psychiatric hospitalizations; decreases mortality, morbidity, and disability; and frees up medical resources in the over-demanded healthcare system (American Psychological Association, 2012).

Almost all effective psychotherapy approaches for anxiety disorders incorporate some exposure component (Gunter & Whittal, 2010). Studies have reported that these exposures are likely driving psychotherapy’s clinical success (Gould et al., 1997; Woody & Ollendick, 2006). Exposure therapy is an evidence-based “treatment that encourages the systematic confrontation of feared stimuli, with the aim of reducing a fearful reaction” (Kaplan & Tolin, 2011). Specifically, the psychological theories of “habituation, extinction, emotional processing, and self-efficacy” elucidate exposure therapy’s efficacy (Kaplan & Tolin, 2011). There are two main types of exposure therapies: in vivo and imaginal. With in vivo exposures, counselors create tangible experiences surrounding the feared stimuli that patients physically confront in-person. With imaginal exposures, clients lead patients through a visualization process to imagine and discuss precisely the controlled exposure (Kaplan & Tolin, 2011). Although both types of exposure are effective at reducing anxiety symptoms, several studies have revealed that in vivo exposures are generally more effective than imaginal exposures (Norr, et al., 2019).

Comprehensive scientific studies have reported the success of exposure therapy in addressing anxiety disorders (Sars & van Minnen, 2015). Although there is strong evidence of its effectiveness, psychotherapists have not widely incorporated exposure therapy into their treatment approach. A study of 500 psychologists identified that over two-thirds of psychologists did not utilize exposure therapy on a regular basis, and two patient surveys revealed that 80% of patients had never received exposure therapy (Sars & van Minnen, 2015). Researchers have uncovered that therapists’ negative perceptions of exposure therapy dissuades implementation
(Pittig et al., 2019). Prohibitive concerns included that exposures would lead some patients to decompensate, a patient’s progress would regress, public exposures disrespect patient confidentiality, and the logistical complications of time required and access to exposure situations (Deacon & Farrell, 2013; Deacon et al., 2013; Pittig et al., 2019). As healthcare began to experience a digital transformation, researchers explored how to incorporate digital capabilities into traditional psychotherapy approaches. Researchers recognized the opportunity to leverage virtual reality (VR) in exposure therapy.

VR is a computer-generated experience in which users are immersed in a digital situation that mimics a real-world context and uses adjustments in the sound and display to provide realistic feedback (Penn & Hout, 2018). The technology is successfully convincing and can evoke feelings in users that allows them to believe they are in the virtual scenario (Riva et al., 2003). VR-assisted exposure therapy (VRET) introduces patients to a controlled, digitally-immersive situation where they face their fears with the same evidence-based approach utilized for in vivo and imaginal exposures. Using VRET is advantageous to therapists because it enables therapists to create exposures without much of the time and costs of in vivo and imaginal exposures. Moreover, in addressing specific phobias and PTSD, VR allows exposures to be easily customized to an individual’s triggers without logistical complications, such as being on a plane (for fear of flying) or entering a dangerous situation (for PTSD). As mentioned above, one of the concerns towards exposures is that they would prompt unmanageable distress that may dissuade patients from therapy and/or worsen the anxiety disorder. To combat therapists’ and patients’ concern of decompensation, VRET creates a highly controllable exposure that can be individually adjusted and gradually increased in intensity according to the patient’s reactions (Boeldt et al., 2019). Additionally, VRET addresses therapists’ and patients’ privacy concerns by
allowing patients to experience exposures that previously required being in public.

Numerous studies have reported that VRET has similar efficacy as in-person exposure therapies for specific phobias, PTSD, and social phobia (Carl et al., 2019; Deng et al., 2019; Horigome et al., 2020). For social phobia, in vivo exposures may have better long-term efficacy than VRET, but additional research is likely needed (Horigome et al., 2020).

Although VRET is similarly effective and could be easier to implement than in vivo exposures, very few therapists have used this approach so far. VRET adoption rates indicate that therapists and patients remain skeptical. Some studies have surveyed therapists’ concerns; however, few studies have researched patients’ perspective of exposure therapy. Even fewer studies have asked patients about VRET, and no studies to date have surveyed and compared perceptions of effectiveness, interest, comfortability, and enthusiasm across in vivo and VR exposures.

In this study, I surveyed individuals suffering from specific phobia, social phobia, PTSD, and/or acute stress disorder/reactions about their interest in, comfort with, and enthusiasm about in vivo and VR exposure therapy. After reporting basic information about their anxiety disorders and treatment history, I asked these individuals to watch an educational video about in vivo exposure therapy, and then asked them to rate their perceptions and concerns about in vivo exposures. I then asked participants to watch an educational video and asked them a similar set of questions focused on their perceptions and concerns about VRET. Results from this study can help inform therapists about the degree of patient interest in in vivo compared with VRET as well as the potential demand for VRET if offered as a treatment approach. Moreover, results could influence implementation strategies focused on increasing VRET adoption.

I created the survey and discussion analysis, but Tyler Wray, PhD helped with the overall
Overall study design and was an advisor throughout the process. Separately, a larger research team submitted the research findings to JMIR in a paper that is in-review (Levy, Nittas, & Wray, 2023).

**Methods**

**Participants**

Recruited a total of 184 participants through fliers, Reddit posts, and advertisements on Facebook and Instagram. Participants were located in Rhode Island, Massachusetts, and Connecticut. I emailed fliers to wellness centers within this region, and advertisements were targeted to display for users only in these locations. Additionally, I reviewed participants’ geoIP states to confirm their eligibility. Other eligibility requirements were (1) 18+ years old, (2) able to speak and read English fluently, (3) have been diagnosed with specific phobia, social phobia, posttraumatic stress disorder, or acute stress disorder/reaction by a person licensed to provide professional counseling for mental health conditions by a recognized licensing body, and (4) experience frequent anxiety (in the past week, felt anxious most of the time and found it very difficult to relax).

**Procedures**

The study consisted of three surveys: screening survey, contact information survey, and the main survey. The screening survey tested that participants satisfied the requirements listed in the above participants section. Upon completion of the screening survey, participants who were deemed eligible were automatically transitioned to the contact information survey to record personal information separate from the main survey responses (only linked through a screening...
ID). If the contact information did not match the screening responses, participants would be deemed ineligible. If participants completed the contact information survey and remained eligible, then they were automatically transitioned into the main survey.

The main survey first assessed basic information about participants’ anxiety disorders and experience with various forms of treatment, before showing them an educational video about *in vivo* exposures. To protect against fraudulent activity, the video page was locked for the video’s complete length to ensure that participants could not continue the survey until the time elapsed. Subsequently, there were two true/false questions to test if participants actively listened. Participants who responded incorrectly two or more times were not allowed to continue, and I removed their responses from our analysis. Participants who passed the quiz were then asked several questions about their interest in *in vivo* exposure. The survey then transitioned to a second round of educational videos, which consisted of two videos: the first video introduced VR technology and its application in therapy, and the second video discussed the use of VRET for phobias and PTSD. Like the first video, these two video pages were locked until the video’s time elapsed. In a replicating approach to the *in vivo* exposure section, to test active listening, participants answered five follow-up questions. If the participant incorrectly answered two or more times, then they were not allowed to continue with the survey, and I did not include their response in our analysis. Participants who passed answered questions that mirrored the interest questions on *in vivo* exposures, but these questions asked about VRET. The survey concluded with free response questions on participants’ concerns toward, perceived benefits of, and general comments about VRET.

Overall, the survey lasted 30-45 minutes. Upon completing the survey, eligible participants received a $15 Amazon gift card for compensation for their time.
The study’s procedure and participant recruitment received IRB approval.

Measures

**Anxiety Disorder Treatment**

Participants shared demographics and general information about their anxiety disorder diagnosis. Most notably, participants identified their disorder (specific phobia, social phobia, PTSD, and/or acute stress disorder/reaction), the date of their original diagnosis, and the intensity of their symptoms as measured by the Overall Anxiety Severity and Impairment Scale ("OASIS") published by the University of Washington and referenced in the Appendix. The OASIS scale quantitatively codes responses from 0 to 4.

**Experience with Treatment**

To further understand treatment history, the survey asked participants which types of treatments they had received (counseling, prescription medication, procedures [e.g., Transcranial Magnetic Stimulation, Eye Movement Desensitization & Reprocessing]), the length of any treatments, (if applicable) the reason for not receiving treatment, and their attitudes toward evidence-based practices in psychotherapy.

**Perceptions of In Vivo and VR exposures**

To assess participants’ perceptions of both in vivo and VRET, I asked participants to rate their perceived effectiveness of, willingness to use, comfortability with, interest in, and enthusiasm toward the exposure approach. Participants answered on a scale of “Not at all,” “Not very,” “Effective/Interested/Comfortable/Enthusiastic,” or “Very...
Effective/Interested/Comfortable/Enthusiastic.” These responses were coded as values 1 to 4 respectively to allow for quantitative analysis.

Data Analysis Plan

I computed basic descriptive and summary statistics of participants’ demographic and mental health characteristics (mean, standard deviation, and percentage). To compare participants’ perceptions of effectiveness, interest, comfort, and enthusiasm towards in vivo and VR exposure therapy, I estimated one-tailed two-sample t tests with unequal variances. I also reviewed participants’ responses to free text-entry questions about the concerns and perceived benefits of VRET and coded themes. I subsequently calculated the frequency of these themes and identified specific responses as examples of each category. Direct quotes are used in the Discussion section of this paper to prompt future research.

Results

Demographics

Participants were generally young adult females (57.07% female; age: M=29.95), largely non-Hispanic White (89.67% non-Hispanic; 61.41% white). About half were college educated, employed, and have income above $40K. See Table 1 for full demographics.

Anxiety Disorder History and Treatment Experience

Fifty-six percent of participants reported having more than one diagnosed anxiety disorder, and specific phobia was the most reported condition overall (59.8%) followed by PTSD (52.2%). On average, participants had been diagnosed with an anxiety condition just over 2 years ago (SD=1.79). Participants reported experiencing symptoms of anxiety frequently (M=3.13,
SD=0.52) with moderate to severe intensity ($M=2.72, SD=0.70$). Seventy-seven percent of participants had, at some point, received treatment for their anxiety disorder(s). Ninety-six percent of participants who had received treatment had received counseling, sixty-five percent had received prescription medication, and seven percent had received procedures (e.g., Biofeedback, Eye Movement Desensitization & Reprocessing, Transcranial Magnetic Stimulation). Among those who had never received treatment, the most common reasons participants cited included not believing it would help them or could make their anxiety worse and that they were ashamed of needing help.

**Exposure Therapy vs. VR Exposure Therapy**

Sixty-one percent of all participants had previously done exposure therapy. Of those who had undergone some kind of exposure therapy before, participants said they had received an average of 13.13 hours ($SD=13.79$) of *in vivo* exposure therapy and 10.53 hours ($SD=13.79$) of imaginal exposure therapy. All of the participants ranked concerns about engaging in in-person exposures (*in vivo* or imaginal), and the top three most important concerns were: that they would get too anxious during an exposure, would be embarrassed or ashamed about being seen in public engaging in exposure therapy, and doubt that it would improve participant’s anxiety or might exacerbate it.

Eighty-two percent of participants reported being willing to do *in vivo* exposures, versus 90.22% of participants would be willing to do VR exposures. Across all the factors I analyzed (perceived effectiveness, interest, comfort, enthusiasm), participants ranked VRET higher than their rankings for *in vivo* exposures. Additionally, for each factor, paired $t$-tests across *in vivo* and VRET showed that the differences in average ratings were all statistically significant. See Table 2 for descriptive statistics and $t$-tests.
**Perceived Benefits of VR exposure therapy**

By counting the frequency of common themes raised by participants in their free-text responses, I learned the following most common perceived benefits of VR exposure therapy: it can be done in private (11.4%); it is a safe, controlled, comfortable experience (10.9%); and that it addresses real-life situations but through digital situations detached from real-life consequences (6.5%). See Table 4 for statistics on all of the categorized perceived benefits.

**Concerns about VR Exposure Therapy**

Frequency coding common themes raised by participants in their free-text responses revealed the following most recurrent skepticism of VR exposure therapy: concerns about potential side effects (19.6%), concerns about the efficacy of the treatment for themselves (16.8%), and concerns about the cost (12.0%). Participants’ specific concerns related to side effects were eye/vision issues, migraines, motion sickness, and potentially becoming addicted to the digital world. Specific concerns about efficacy involved worries about the VR being realistic enough, the therapy’s effectiveness, and that the experience could make their anxiety disorder more severe. Concerns about cost seemed to relate more to general concerns about health insurance coverage than to the costs of VR itself. See Table 3 for statistics on all the categorized concerns.

**TABLE 1**

<table>
<thead>
<tr>
<th>Variable</th>
<th>M (SD) or %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>29.95 (10.79)</td>
</tr>
<tr>
<td>Current gender</td>
<td></td>
</tr>
<tr>
<td>------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>Man</td>
<td>23.37</td>
</tr>
<tr>
<td>Woman</td>
<td>57.07</td>
</tr>
<tr>
<td>Trans/Other</td>
<td>19.56</td>
</tr>
<tr>
<td>Committed Relationship</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>44.02</td>
</tr>
<tr>
<td>No</td>
<td>54.89</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
</tr>
<tr>
<td>Hispanic or latino</td>
<td>10.33</td>
</tr>
<tr>
<td>Not hispanic or latino</td>
<td>89.67</td>
</tr>
<tr>
<td>Race</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>61.41</td>
</tr>
<tr>
<td>Black or African American</td>
<td>30.98</td>
</tr>
<tr>
<td>American Indian or Alaska Native</td>
<td>0.54</td>
</tr>
<tr>
<td>Asian</td>
<td>1.63</td>
</tr>
<tr>
<td>Multiracial</td>
<td>3.26</td>
</tr>
<tr>
<td>Education</td>
<td></td>
</tr>
<tr>
<td>College or higher degree</td>
<td>53.26</td>
</tr>
<tr>
<td>Lower than college degree</td>
<td>46.74</td>
</tr>
<tr>
<td>Income</td>
<td></td>
</tr>
<tr>
<td>Below $30K (poverty line)</td>
<td>42.93</td>
</tr>
<tr>
<td>Above $30K</td>
<td>57.07</td>
</tr>
<tr>
<td>Employment</td>
<td></td>
</tr>
<tr>
<td>Employed</td>
<td>52.72</td>
</tr>
<tr>
<td>----------</td>
<td>-------</td>
</tr>
<tr>
<td>Currently unemployed</td>
<td>46.74</td>
</tr>
</tbody>
</table>

1Note. Means and standard deviations were reported for continuous variables and percentages for categorical.

**TABLE 2**

<table>
<thead>
<tr>
<th>Perceptions of effectiveness</th>
<th>In-Vivo ($M$, $SD$)</th>
<th>VR ($M$, $SD$)</th>
<th>$t(2)$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceptions of effectiveness</td>
<td>2.95, 0.05</td>
<td>3.14, 0.06</td>
<td>-2.53</td>
<td>0.0059</td>
</tr>
<tr>
<td>Interest</td>
<td>3.06, 0.06</td>
<td>3.33, 0.06</td>
<td>-3.28</td>
<td>0.0006</td>
</tr>
<tr>
<td>Comfort</td>
<td>2.77, 0.07</td>
<td>3.24, 0.06</td>
<td>-5.17</td>
<td>0.0000</td>
</tr>
<tr>
<td>Enthusiasm</td>
<td>2.65, 0.07</td>
<td>3.16, 0.06</td>
<td>-5.74</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

2Note. Values reported from a one-tailed two-sample $t$ test with unequal variances.

**TABLE 3**

<table>
<thead>
<tr>
<th>Concern toward VR exposure therapy</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>User would experience side effects from using VR exposure therapy</td>
<td>19.60%</td>
</tr>
<tr>
<td>Users are concerned about the efficacy of VR exposure therapy efficacy for</td>
<td>16.80%</td>
</tr>
</tbody>
</table>
Levy 16

<table>
<thead>
<tr>
<th>Concern</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>VR exposure therapy would be costly</td>
<td>12.00%</td>
</tr>
<tr>
<td>● concerns about health insurance coverage</td>
<td></td>
</tr>
<tr>
<td>VR exposure therapy would heighten users’ anxiety and discomfort during therapy</td>
<td>9.80%</td>
</tr>
<tr>
<td>Users want more studies and to hear of other patients’ experiences with VR exposure therapy through publications</td>
<td>9.20%</td>
</tr>
<tr>
<td>VR would not help users with their specific type of anxiety disorder</td>
<td></td>
</tr>
<tr>
<td>● Childhood trauma and abuse</td>
<td></td>
</tr>
<tr>
<td>● Coping with death</td>
<td></td>
</tr>
<tr>
<td>● Domestic violence</td>
<td></td>
</tr>
<tr>
<td>● Sexual abuse</td>
<td>8.20%</td>
</tr>
<tr>
<td>VR exposure therapy is not accessible</td>
<td>4.90%</td>
</tr>
<tr>
<td>Users are concerned about the length of time until success for VR exposure therapy</td>
<td>3.30%</td>
</tr>
</tbody>
</table>

**TABLE 4**

<table>
<thead>
<tr>
<th>Perceived Benefits of VR exposure therapy</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>VR exposure therapy can be done in private</td>
<td>11.4%</td>
</tr>
<tr>
<td>VR exposure therapy feels like a safe, controlled, comfortable experience</td>
<td>10.9%</td>
</tr>
</tbody>
</table>
VR exposure therapy addresses real-life situations but through digital situations detached from real-life consequences 6.5%

VR exposure therapy is effective 6.0%

VR exposure therapy allows for a wider variety of exposures to address more anxiety disorders / it is customizable 4.9%

VR exposure therapy is easy-to-use, accessible 3.8%

VR exposure therapy is fun and enjoyable 3.8%

VR exposure therapy is a drug-free method 2.2%

VR exposure therapy is accessible for those with disability 1.1%

Discussion

In this study, I found that participants with anxiety disorders had a greater preference for VR-assisted exposures relative to *in vivo* exposures. Participants were generally more interested in, comfortable with, enthusiastic toward, and held more positive perceptions of effectiveness for VRET over *in vivo*. Results showed that with 90% of patients willing to try VRET and 82% of patients willing to try *in vivo*, VRET encourages an additional 8% of patients to try exposure therapy. Therefore, there is an opportunity to provide effective psychotherapy in a more palatable form. My results suggest that VRET could be particularly appealing to patients because it addresses the top two concerns identified by participants: that an *in vivo* exposure could cause anxiety that is too severe and that it could be embarrassing to do in public. The VRET benefits that participants shared largely addressed many of their concerns toward *in vivo* exposures: the
digital approach of facing real-life exposures allows patients who are hesitant to physically experience their triggers to still benefit from the evidence-based practice that scientific studies have validated as improving patients’ anxiety disorders, the ability to control and monitor the intensity of VRET exposures adds a level of safety, and the private environment of VRET addresses issues of shame.

Furthermore, these concerns and corresponding benefits are especially applicable regarding exposure therapy and VRET for domestic violence and sexual abuse. In free response answers on VRET, participants noted that if exposure therapy could be applied to sexual assault PTSD, “they don’t understand how ‘exposing’ themselves to that in VR exposure therapy could be helpful”, and that it “would be highly distressing.” This reflects the previously mentioned and common hesitancy that an anxiety-inducing psychotherapy method that triggers negative emotions is a detrimental approach. The psychotherapy foundations of exposure therapy, however, relies on habituation, extinction, emotional processing, and self-efficacy, which depend on repeated exposure to stimuli to decrease the fear response, develop a new association, shift the faulty processing of stimuli from fear to excitement, and validate a patient’s mental strength to accept fears. Facing distressing situations is the evidence-backed mechanism of exposure therapy that drives successful treatment. The reoccurring mention of this common misconception indicates that it may be helpful for VRET software to include an explanation of the psychotherapy foundation.

Moreover, participants’ comments exemplified an insufficient information dissemination as participants noted that they “don’t think there is any solution” for their sexual PTSD and are unsure if “there [is] even VR for DV [domestic violence].” Scientific studies, however, have validated that exposure therapy is applicable to sexual assault and domestic violence PTSD.
Orang, Tahereh, et al. (2018) studied PTSD from intimate partner violence and found that patients who used narrative exposure therapy experienced a significantly greater reduction in PTSD, depression, and perceived stress symptoms than patients with treatment-as-usual. Multiple studies have found that prolonged exposures are effective at reducing PTSD symptoms for rape victims (Foa et al., 1991; Resick et al., 2002; Rothbaum et al., 2005). Thus, exposure therapy is applicable, and VRET will provide the treatment benefits in a method that patients are more interested in, find more comfortable, are more enthusiastic about, and are more willing to try. The next steps are to increase the availability of out-of-the-box VRET software that addresses a wider variety of anxiety disorders. Patients are concerned that VRET would not be able to address anxiety from childhood trauma and abuse, coping with death, domestic violence, and sexual abuse, so software developers should code and publicize VR software that shifts treatment for these anxieties from in-vivo to VRET.

**Limitations**

It is important to note that there are a few limitations to this study. The participants were limited to those residing in RI, MA, and CT. Thus, the findings may not generalize to other geographic areas. Furthermore, many fraudulent accounts tried to complete the survey, and our research team had to manually check the user location and whether the free response questions were coherent. Participants were deemed ineligible if the free responses did not form logical, complete sentences that answered the question being asked. Although I decided strictly based on grammatical composition, this could have potentially introduced bias. Lastly, in accordance with the institutional review board, I had to specify that the survey would take 45 minutes. Due to the time commitment, I may have recruited participants who were especially motivated to complete research on anxiety disorders or receive an incentive.
Conclusion

In conclusion, this study found that there is likely demand for exposure therapy among patients, with even greater demand for virtual reality exposure therapy (VRET). Patients were statistically significantly more interested in, comfortable with, and enthusiastic toward VRET than in vivo exposure therapy. Additionally, patients perceived VRET to have higher effectiveness than in vivo exposures. Although patients had concerns about exposures triggering their anxiety and experiencing embarrassment in public, participants identified benefits of VRET that could successfully address these barriers.

The findings show that patients believe that VRET would address their concerns and indicate higher demand for VRET over in vivo. These findings could help persuade counselors that VRET is not only scientifically effective but also more acceptable to patients. With continued software development to code a variety of scientifically-validated exposures, therapists should have both the supply and demand to incorporate VRET as a treatment approach for patients struggling with social phobia, specific phobia, and PTSD.
Case Study on Implementing Virtual Reality Exposure Therapy for PTSD

Identification of Focus Area

From analysis of patients’ free response comments in my study, I realized that although patients suffer PTSD from a variety of traumatic experiences, the current commercialized offerings of VRET focus on wartime PTSD.

While physicians diagnose and treat patients struggling with PTSD, the physicians’ own mental health is not being adequately addressed. Doctors often see horrendous traumas inflicted on the human body through disease and calamities. They work relentlessly to provide care. Medical errors and complications as well as potentially deadly exposures also cause mental distress. Moreover, the “[r]isk for traumatic exposure is particularly pronounced for resident physicians, who typically have the greatest responsibility for frontline clinical care with high patient volumes, and lack the training and experience of more seasoned physicians” (Vance, et al., 2021) A 2018 nationwide study found that during residency programs, more than half of the interns experienced a traumatic exposure and one in ten residents developed PTSD, a rate three times that of the general population (Vance, et al., 2021).

The mental health impacts of the traumatic exposures in residency are devastating. A prospective study of 740 medical residents at 13 institutions revealed that within the first three months of residency, there was a 370% increase in suicidal ideation (Yaghmour, et al., 2017). Unfortunately, the traumatic exposures can have fatal effects. In the United States, about 300-400 physicians die from suicide every year (American Foundation for Suicide Prevention, 2018). Compared to the general female population, female physicians are 2.27 times more likely to commit suicide (American Foundation for Suicide Prevention, 2018).

Commented [dhl6]: This is a pretty major shift from the first paper. I’m not sure that the opinions you gathered there really say much about a population of physicians. That’s not really a problem for two independent papers, but it does reduce the logical connections between them.

As I read through, this seems very analogous to the VR class poster – 2 projects reported on a poster. So that is probably a decent model for how to present it as a poster.
Providing accessible and effective mental health support would help lower the rates of suicide and suicide ideation by addressing PTSD and depression symptoms. Studies of physicians struggling with depression show that “[p]hysicians who took their lives were less likely to be receiving mental health treatment compared with non-physicians who took their lives even though depression was found to be a significant risk factor at approximately the same rate in both groups” (American Foundation for Suicide Prevention, 2018).

**An Attractive and Effective Solution**

In my interview with a University of Utah cardio-thoracic resident, she revealed that a physician would feel more comfortable if their therapist worked outside of their hospital. Doctors are incredibly busy, however, and they do not have much time to travel to another healthcare location for therapy. Additionally, Sonia Mehta, MD, a physician executive with more than 25 years of experience in healthcare management, noted that successful resources must be accessible when and where doctors need them the most, at the hospital. Dr. Mehta pointed out that for a physical medical problem, there is easy and effective on-demand help. You can walk into an Urgent Care or Minute Clinic and get help any time of the day. There is no comparable resource for mental health. Crisis workers run emergency mental health facilities, and the care provided is not therapy but crisis intervention.

It is important to acknowledge that gaining access to mental health professionals can be a challenge. Sixty percent of therapists reported that their appointment schedule does not have room for new patients (Bethune, 2022). Dr. Mehta recognized this and recommended that the most effective tool to leverage is telemedicine. As a CEO and CMO of a hospital system, she rarely has time during the week to be a practicing physician. She leverages telemedicine, however, to add a 4-hour shift on weekend mornings. She shared how this analogy can be
applied to therapists, many of whom are young mothers who would be able to add patients if seen through telemedicine.

Looking at the problems facing both physicians (as prospective patients) and mental health professionals (as prospective providers) reveals that physicians would feel more comfortable if they could talk with a therapist through telemedicine, which also would make therapy more easily accessible for both patients and providers. Thus, telemedicine appears to be an attractive care delivery mechanism. It is not only appealing, however, but also effective. The American Psychological Association’s 2021 Practitioner Survey reported that 96% of psychologists feel that telemedicine is an effective method of delivering therapy, and 50% of clinicians are utilizing virtual care (Clay, 2022).

Telemedicine creates an effective platform to connect physicians to mental health professionals. Once physicians gain access to care, it is crucial to determine an efficacious treatment approach. Although traditional exposure therapy is highly effective at treating PTSD, the logistics of creating exposures can be an implementation barrier. In traditional exposure therapy, therapists often ask patients to imagine or experience an in-person replication of the traumatic exposure. With this approach, patients can find it challenging to feel re-enveloped in the traumatic situation, and, as a result, almost 50% of patients stop the treatment (Deng, et al., 2019). Exposure therapy experts have realized that patients find traditional exposures difficult and a successful approach to treating PTSD “calls for the innovation and dissemination of alternative or augmented treatments” (Deng, et al., 2019).

Virtual reality exposure therapy makes effective treatment accessible to doctors. The University of Utah resident noted that providing a telemedicine option may make residents willing to seek mental health help, but they need an incentive to devote their time. Residency is a
rigorous training program in which residents are consistently seeking to improve. They are continuously evaluated and competing for post-residency jobs. Their training process is very similar to that of elite athletes. Both residents and athletes are training for elite performance. Athletes have a team of coaches, with the top athletes meeting regularly with a mental coach. The same approach can be taken with doctors. Virtual reality therapy can be marketed as a performance-enhancing tool. Struggling with the effects of traumatic exposures has an impact on physicians’ performance. Cross-sectional studies recognize that if a physician is experiencing burnout, then there’s a correlation to lower performance, which can be quantified as twice the risk of medical error and a 17% increase in the likelihood of a malpractice lawsuit (West, Dyrbye, & Shanafelt, 2018). With proper mental health support, physicians will perform better, be less at risk for mistakes that can further worsen PTSD, and be more prepared for the next potentially traumatic exposure. Moreover, VRET allows medical exposures to be recreated in a safe and controlled virtual environment, which addresses the complications that arise from traditional exposure therapy.

**Shortcomings of Current Options in the Market**

The current resources marketed to physicians are insufficient. Support comes from two areas: mental health programs and training programs. The current mental health programs focus on risk identification as well as peer and emotional support. For example, the University of Chicago Pritzker School of Medicine created “a shareable resilience training curricula for residents” (Paturel, 2019). Additionally, the ACGME created the AWARE program, which includes workshops and podcasts to help develop well-being skills (Paturel, Healing the very youngest healers, 2020). Emphasizing the importance of resilience and well-being is important, but it is not a rigorous treatment approach. The University of California San Diego (UCSD) also
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launched a program, but its focus is on identifying individuals at risk (Paturel, Healing the very youngest healers, 2020). It provides referrals, but not treatment. UCSD’s Healer Education Assessment and Referral Program (HEAR) uses “an online, anonymous interactive screening program, or ISP, created by the American Foundation for Suicide Prevention (AFSP)... The ISP is now being utilized by 33 hospitals and medical schools” (Paturel, Healing the very youngest healers, 2020). The success of ISP illustrates that hospitals are willing to implement mental health programs, but current programs stop at risk identification and basic peer and emotional support. For physician well-being and mental health programs to be successful, the next step must be providing effective therapy that physicians will utilize. This is where VRET is an advantageous treatment offering.

Other competition to VRET software may come from virtual reality medical training programs. There are numerous platforms and institutions using VR technology to train medical students and residents in surgery and patient interaction techniques in a low-stakes environment. For example, the Hospital for Special Surgery (HSS) partnered with Osso VR to provide virtual reality surgical preparation to over 20 teaching hospitals (Raths, 2022). The focus of the software is training and assessment. These programs demonstrate that hospitals and physicians are willing to use VR as an important component of physician development. In addition to the very different training purposes for these programs, the user experience also differs considerably from a therapy approach. For medical training, the software is focused on “the key steps of a procedure and technical skill development” (Raths, 2022). VRET, however, is built on a psychological foundation. From discussions with psychologists specializing in PTSD, I learned that to address the trauma effectively, VRET must start by establishing a calm environment without any triggers associated with the traumatic patient event. Then, through controls driven by the therapist, not
the physician, the intensity of traumatic characteristics gradually increases. Physicians suffering with diagnosed or undiagnosed PTSD need therapists to slowly identify and work through triggers and address the emotional component affecting performance. Mentors and more senior physicians can lead doctors through feedback sessions that revisit the surgery techniques, but VRET is needed for proper mental health treatment.

**Market Analysis**

The virtual-reality-in-healthcare market is large enough to provide financial opportunities for a VRET startup. The market is valued globally at $459M in 2021 and growing (Virtual Reality (VR) in Healthcare Market, 2022). From $628M in 2022, the market is expected to experience a 38.7% CAGR to reach $6.20B in 2029 (Virtual Reality (VR) in Healthcare Market, 2022). Within North America, in 2021, the market was valued at $185M and is expected to experience tremendous growth (Virtual Reality (VR) in Healthcare Market, 2022).

Because the technology is new, there is increasing regulatory activity to ensure safety. The FDA created a patient engagement advisory committee that is considering how to distinguish between and regulate consumer and clinical applications of VR (Reuter, 2022). Products that combine applications (consumer headset with clinical software) may need to coordinate with the FDA and the CPSC or FTC to register products and comply with any safety compliance requirements (U.S. Food & Drug Administration, 2022).

Regarding insurance, there are anticipated updates to the Current Procedural Terminology (CPT) codes for virtual reality therapy. Ultimately, the Centers for Medicare & Medicaid Services (CMS) will determine public insurance coverage by pricing the CPT code (Louys & Hamon, n.d.).
The major competitors in the market include Amelia Virtual Care, Virtually Better, and BehaVR. The competitors mostly focus on phobias, addictions, relaxation, and war-time PTSD. Competitors’ intended usage is for use with healthcare providers’ patients, not for use by healthcare providers themselves. One exception is Virtually Better’s nurse resiliency program (Virtually Resilient, n.d.). An informational interview with an industry expert revealed that Amelia Virtual Care was started in Barcelona and has expanded to the United States. Amelia Virtual Care has ~2,000 therapists total, with about 300 in the U.S. Virtually Better uses USC Institute of Creative Technologies’s Bravemind software that focuses on war-time PTSD, specifically for traumas experienced in Iraq and Afghanistan (PTSD Suite, n.d.). BehaVR claims to be the biggest virtual reality healthcare delivery platform and was approved by the FDA with a FDA Breakthrough Device designation (Hagen, 2022). BehaVR offers exposure therapy for anxiety disorders, but they also provide VR programs for maternal health, pain management, and addiction recovery (Focus Areas, n.d.).

The barriers to entry for this market are the technical and medical expertise required. To gain credibility and an attractive user experience, companies need software engineers with virtual reality development experience as well as psychologists specializing in PTSD, cognitive behavioral therapy, and exposure therapy. Additionally, companies need team members with medical experience to validate the content accuracy. Moreover, scaling a company takes time because of the approval process for FDA designations and insurance coverage.

The high amount of investment money raised by the top market players exemplifies these barriers and indicates high costs to develop VR. BehaVR has raised 4 rounds of funding, cumulating with a Series B round that brought the total investment acquired to $21.2M.
Amelia Virtual Care has raised a total of $14M through five investment rounds (Amelia Virtual Care, n.d.).

The market consists of only a few major players. Recently, there has been consolidation through mergers and expansion within the U.S. market. Virtual behavioral health companies BehaVR and OxfordVR merged in December 2022 (Hagen, 2022). OxfordVR was a UK-based company, so it is extending its reach through the merger. In February 2022, Psious renamed itself Amelia Virtual Care, and Afsana Akhter became the new President and CEO (Business Wire, 2022). Both strategies are to help Amelia Virtual Care's expansion into the U.S. and global market (Business Wire, 2022).

BehaVR, Amelia Virtual Care, and Virtually Better do not offer tailored PTSD treatment focused on physician trauma, and the lack of personalization and accessibility of their VR treatments could be limiting their applicability to physician wellness. Moreover, BehaVR is a prescription software, which limits its usage (Hagen, 2022). Many physicians experience traumatic events but are not seeking a PTSD diagnosis that would grant them access to the software. Thus, there is opportunity for a new market entrant that could capture an overlooked customer segment.

Regarding pricing, Amelia Virtual Care offers subscriptions ranging from $279-$1250 per month. Thus, with a unique offering tailored to physician, a VRET company could reasonably charge $500 per month. To avoid deterring therapists, who are essential in the double-sided marketplace, this VRET company should sell to hospitals who can gift the subscription to therapists. Hospitals would be willing to pay this subscription cost because each medical resident costs approximately $1.5M to train (U.S. Department of Health and Human Services Health Resources and Services Administration; Medical Residency Timeline & Length
Thus, over the average 4.5 years of residency, the VRET subscription would cost hospitals $27,000, which is much less than the cost of retraining due to physician dropout (Medical Residency Timeline & Length (2022-2023), n.d.). It is cost-efficient and potentially extremely cost-saving for hospitals to implement VRET for physician mental health support.

Overall, there is an advantageous business opportunity for a company to create VRET software that focuses on physician trauma. There is an unmet need to create an efficacious mental health treatment approach for physicians; virtual reality addresses implementation barriers to in-person therapy or exposures; there are a limited number of market players, none of whom are focused on exposures for physicians themselves; and VRET is a relatively low-cost program that can help retain physicians, who are an expensive human capital investment.

**Overall Conclusion**

There is a raging mental health crisis in the United States. At the same time, however, there has been technology developed with the potential to creating impactful improvements. Specifically, virtual reality provides an opportunity to make therapy more accessible. A treatment approach that is easily replicated in virtual reality is exposure therapy, which is considered “an effective first-line treatment for posttraumatic stress disorder” (Rauch, Erfekhari, & Ruzek, 2012). The use of virtual simulations for fear-provoking experiences offers a digital treatment approach that has an efficacy validated by multiple scientific studies (Carl et al., 2019; Deng et al., 2019; Horigome et al., 2020). To encourage therapists to incorporate exposures, especially virtual reality exposures, into their treatment approach, it is important to share patients’ demands for the treatment. Data from my research study revealed that a high percentage
of participants were willing to try in vivo exposure therapy, and even more participants were willing to try virtual reality exposure therapy (VRET). Moreover, on average, participants had higher perceived effectiveness of, interest in, comfortability with, and enthusiasm towards VRET, in comparison with in vivo exposure therapy. Therefore, my research study indicated that virtual reality exposure therapy has patient demand, revealing an impactful and attractive business opportunity for virtual reality developers.

When considering the business opportunity, physicians are a target customer who is currently being overlooked by the existing market players. Physicians experience devastatingly high rates of PTSD, but in-person exposures for medical traumas can be unethical and logistically infeasible. Moreover, VRET could be provided remotely via telemedicine platforms. This allows providers to add physicians’ therapy sessions more easily into their schedules and is more appealable to physicians who want to speak to a provider outside of their hospital but have little time to travel.

Not only are physicians an advantageous target customer because of their customer needs, but also because the market players do not offer virtual reality exposures that address physician trauma. Launching a software company to develop these tailored exposures will be resource-intensive, requiring human capital from software engineers, psychologists, and physicians. Although the current market players have not developed VR software for physicians, they have raised high amounts of investment funds, indicating an expensive development and sales process. This suggests that while there is a product-market fit, a VRET software company that targets physicians would likely face significant barriers to entry.

The COVID-19 pandemic not only revealed the importance of our physicians, but it also added crippling stress to their lives. We need healthy physicians, but they are experiencing
mental health conditions that are impeding their ability to provide healthcare and damaging their health. Thus, we need to leverage innovative technology to provide effective treatment options in an appealable approach. For physicians, virtual reality exposure therapy could have a positive psychological impact and be offered in an attractive and convenient delivery mechanism.

Physicians have sacrificed so much for society. Now, it is time for the technology community to reciprocate and provide support for physicians.
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Overall Anxiety Severity and Impairment Scale (OASIS)

The following items ask about anxiety and fear. These symptoms may include panic attacks, situational anxieties, worries, flashbacks hypervigilance of startle. Include all of your anxiety symptoms when answering these questions. For each item, circle the number for the answer that best describes your experience over the past week.

1. In the past week, how often have you felt anxious?
   0 = No anxiety in the past week.
   1 = Infrequent anxiety. Felt anxious a few times.
   2 = Occasional anxiety. Felt anxious as much of the time as not. It was hard to relax.
   3 = Frequent anxiety. Felt anxious most of the time. It was very difficult to relax.
   4 = Constant anxiety. Felt anxious all of the time and never really relaxed.

2. In the past week, when you have felt anxious, how intense or severe was your anxiety?
   0 = Little or None: Anxiety was absent or barely noticeable.
   1 = Mild: Anxiety was at a low level. It was possible to relax when I tried. Physical symptoms were only slightly uncomfortable.
   2 = Moderate: Anxiety was distressing at times. It was hard to relax or concentrate, but I could do it if I tried. Physical symptoms were uncomfortable.
   3 = Severe: Anxiety was intense much of the time. It was very difficult to relax or focus on anything else. Physical symptoms were extremely uncomfortable.
   4 = Extreme: Anxiety was overwhelming. It was impossible to relax at all. Physical symptoms were unbearable.

3. In the past week, how often did you avoid situations, places, objects, or activities because of anxiety or fear?
   0 = None: I do not avoid places, situations, activities, or things because of fear.
   1 = Infrequent: I avoid something once in a while, but will usually face the situation or confront the object. My lifestyle is not affected.
   2 = Occasional: I have some fear of certain situations, places, or objects, but it is still manageable. My lifestyle has only changed in minor ways. I always or almost always avoid the things I fear when I’m alone, but can handle them if someone comes with me.
   3 = Frequent: I have considerable fear and really try to avoid the things that frighten me. I have made significant changes in my life style to avoid the object, situation, activity, or place.
   4 = All the Time: Avoiding objects, situations, activities, or places has taken over my life. My lifestyle has been extensively affected and I no longer do things that I used to enjoy.

4. In the past week, how much did your anxiety interfere with your ability to do the things you needed to do at work, at school, or at home?
   0 = None: No interference at work/home/school from anxiety
   1 = Mild: My anxiety has caused some interference at work/home/school. Things are more difficult, but everything that needs to be done is still getting done.
   2 = Moderate: My anxiety definitely interferes with tasks. Most things are still getting done, but few things are being done as well as in the past.
   3 = Severe: My anxiety has really changed my ability to get things done. Some tasks are still being done, but many things are not. My performance has definitely suffered.
   4 = Extreme: My anxiety has become incapacitating. I am unable to complete tasks and have had to leave school, have quit or been fired from my job, or have been unable to complete tasks at home and have faced consequences like bill collectors, eviction, etc.

5. In the past week, how much has anxiety interfered with your social life and relationships?
   0 = None: My anxiety doesn’t affect my relationships.
   1 = Mild: My anxiety slightly interferes with my relationships. Some of my friendships and other relationships have suffered, but overall, my social life is still fulfilling.
   2 = Moderate: I have experienced some interference with my social life, but I still have a few close relationships. I don’t spend as much time with others as in the past, but I still socialize sometimes.
   3 = Severe: My friendships and other relationships have suffered a lot because of anxiety. I do not enjoy social activities. I socialize very little.
   4 = Extreme: My anxiety has completely disrupted my social activities. All of my relationships have suffered or ended. My family life is extremely strained.

Total Score: ___