

**Evaluation of Emerging Technologies in Augmenting Treatment for Serious  
Mental Illness**

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## **Introduction**

Mental health disorders affect Americans at an alarming rate; nearly 1 in 5 adults experience mental illness, and 1 in 25 adults experience serious mental illness at some point in their life. Serious mental illness (SMI) is defined as a mental, behavioral, or emotional disorder resulting in serious functional impairment, and includes disorders such as schizophrenia, severe bipolar disorder, posttraumatic stress disorder (PTSD), and severe depression and anxiety (National Institute of Mental Health, 2017). Traditional medical and therapeutic methods to treat mental illness have improved over the years, but often they do not lessen or eliminate the symptoms of mental illness. As a result, patients often seek out alternative methods to help with recovery. Recent advancements in both technology and healthcare have opened up a new frontier in digital mental health treatment and support. Within the past few years, thousands of mobile applications and online platforms have been introduced to help individuals who suffer from mental illness perform a variety of tasks at their own convenience, such as assessing symptoms, locating available resources, and tracking the treatment process (Luxton et al., 2011).

Since many of these platforms are emerging technologies, the extent to which such technologies can be used to help treat individuals with SMI is largely unknown. However, early testing and research indicates the potential for such technologies to supplement current treatment options. Without adequate treatment, individuals with mental illness often suffer from reduced quality of life and worsening mental health problems, which ultimately increases their potential to engage in self-harm or harm to others. Not only this, but timing is key; research has found stark differences in outcomes depending on how quickly an individual begins treatment (Giliberti, 2017). These issues become further exacerbated as individuals with SMI are more likely to face barriers to receiving mental health services, including the inability to afford care

and limited access to transportation (Dickerson et al., 2003). The combination of these issues has justified the need for more innovative approaches to illness self-management, symptom tracking, and overall treatment of mental illness. The goal of this research is to better understand the universe of treatment for people diagnosed with SMI in order to determine if there is a potential for technology to augment treatment for individuals diagnosed with SMI. This will be done by analyzing the range of technologies that currently exist, discussing their use, the regulatory environment, and then focusing specifically on evaluating how one technology, virtual reality (VR), has been used within the treatment process for SMI.

### **How the Treatment of Mental Illness has Developed Over Time**

Early attempts to treat mental illness date back as far as 5000 BCE, where early civilization believed mental illness to be a part of some supernatural phenomenon such as a demonic or spiritual possession, and thus responded with equally brutal treatments. It wasn't until centuries later that people believed mental illness stemmed from natural occurrences in the human body rather than from supernatural forces. From this point on, the clergy began to play a significant role in treating the mentally-ill, and was a desirable alternative as the treatment provided was considered relatively humane. However, as the mentally-ill population started to grow in number, the clergy-run facilities could not treat the whole of the mentally-ill. In order to accommodate the burgeoning number of individuals suffering from mental illness, asylums were established around the world. For years, asylums were not facilities aimed at treating mentally-ill individuals, but rather acted as institutions where individuals were abandoned by their family and faced a life of inhumane treatment. As people began to realize the true purpose of the asylums, emphasis was placed on finding alternative treatment options. In development during this time were somatic treatments for mental illness such as electroconvulsive therapy and psychosurgery.

These treatment options were based on the biological model of psychiatric disorders, and were designed to restore an individual's mental health by correcting the biochemical imbalance in their brain. The introduction of psychopharmacology came shortly after, and the advent of psychoactive drugs convinced many individuals that mental illness could be properly treated through the use of medication (Foerschner, 2010).

Currently, mental illness is most often treated through a combination of various treatment options, both conventional and unconventional. Choosing the right mix of treatments is an important step in the recovery process, as there is not a "one-size fits all" approach to treating mental illness. Psychiatric medications are often prescribed to patients and have been scientifically proven to significantly improve symptoms (National Institute of Mental Health, 2016). Psychotherapy is a common form of treatment and includes an in-person visit with a mental health specialist, and can be conducted individually or within a group setting. While mental illness is typically treated using one of the aforementioned strategies, several alternative treatment options exist that patients can seek out. Existing alternatives include standard telemedicine services, which provide users with the option of receiving remote support services from a mental health professional. However, this form of treatment is limited by the need for health providers on the other end of the phone, as well as the high price often charged. This has prompted the rapid development of mobile health solutions, as these technologies offer a wider range of services spanning more than just one-on-one consulting sessions, with the hope that individuals with a wider range and severity of mental illnesses can benefit.

Mobile devices such as cell phones, smartphones, smartwatches, and tablets are giving patients and medical professionals new ways to access treatment remotely. Additionally, patients can utilize desktop-based platforms to supplement their treatment, as well as newer forms of

technology such as virtual reality and augmented reality. These platforms offer a unique way to deliver mental health services to individuals, and include a wide range of services that the patient can benefit from. These mobile solutions and emerging technologies offer ways for patients to monitor and track symptoms, set up medication reminders, track body movement and breathing patterns, share stories and find support through internet-based support groups, and ultimately serve as a way to receive treatment at their own convenience without a medical professional being with them.

Virtual reality refers to an immersive, interactive, multi-sensory three-dimensional computer-generated environment, and the technology needed to build such environment. Virtual reality transmits these various sensations to users through a headset, enabling them to feel as though they are in a virtual environment. A new wave of psychological research is pioneering virtual reality to investigate, assess, and manage medical conditions such as mental illness. Most of the current VR content is designed to aid exposure therapy, a treatment option where patients are exposed to various stimuli in a safe, controlled environment. The ability to navigate through digitally created environments offers a unique way to alter anxiety, depression, cognition, and social functions in patients with mental illness (Freeman, 2019).

Literature on the topic of integrating digital technologies in behavioral healthcare exist, and these publications are a starting point for understanding the range of treatment options for individuals with mental illness. Publications such as the Treatment Improvement Protocol written by the Substance Abuse and Mental Health Services Administration (2015) detail the various levels of behavioral health technologies that exist currently. These publications draw on the knowledge of clinicians and researchers to develop best-practice guidelines for the treatment

of mental illness. However, current literature is heavily focused on the treatment of mental illness, and consolidated publications that deal with SMI specifically are lacking.

Health agencies have a long-standing tradition of regulating anyone and anything that claims to treat mental illness, including health professionals as well as the medications being prescribed by them. Mobile health solutions are a much more recent development currently facing much less regulatory oversight. In 2015, the FDA released its guidance describing the way it intends to regulate mobile medical applications and stated that it intends to apply its regulatory oversight only to technologies that are medical devices and which pose a serious risk to a patient's safety if the device were to malfunction (Armontrout et al., 2018). The FDA's discussion of the categories of health technologies currently being regulated helps clarify the blurred line that is drawn on regulatory oversight. Regardless, a considerable amount of ambiguity still exists, and as the FDA suggests in their report, a relatively wide range of technologies with useful applications are exempt from regulatory review. Overall, the question of how to adequately regulate mental health technology and the data it generates has not been definitively answered, and should be taken into consideration when analyzing potential emerging health technologies.

## **Methods**

In order to better understand the universe of treatment available for individuals diagnosed with SMI, I chose to focus my research on one specific technology, virtual reality, to evaluate its potential to augment treatment for individuals suffering from severe mental illness. In order to answer this question, I reviewed literature to evaluate the current state of knowledge about VR as an alternative treatment method. My research was focused on gathering articles describing the current use of VR and how the technology is used in the realm of mental health treatment.

I also reviewed studies that have been conducted to test the effects of using VR on patients with severe mental illness. I utilized the [clinicaltrials.gov](https://clinicaltrials.gov) search engine, a database of publicly and privately funded clinical studies and used the key word VR to systematically search for and analyze trustworthy studies. Within the search engine, I filtered for studies that had results posted as well as those that dealt with individuals suffering from mental illness. Five studies were identified that focused on individuals suffering from PTSD and schizophrenia, and one study pertaining to each mental illness was selected for further analysis. To supplement those studies, I researched Limbix, a startup that focuses on accessible mental health treatment and sells VR kits designed for clinical settings. The Limbix website links the peer reviewed studies the company used as their foundational research, and the studies are organized by type of disorder the VR technology was used to treat. Within the various studies and articles, I looked for evidence supporting VR as a treatment option, such as successful outcomes of the studies or articles outlining the evidence-based benefits of using VR treatment.

I categorized my research and findings initially on whether or not the literature supported using VR as an alternative treatment method. This included the entire article written in support or as a critique, as well as portions of the piece highlighting the benefits and/or drawbacks of the technology. I then analyzed the major ideas from the literature I gathered, and discussed the findings in two pieces: first looking at the potential for VR to be used as an alternative treatment option, and then addressing the critiques. In the latter section, I incorporated the theory of solutionism, highlighting the idea of VR and other emerging technologies as an unnecessary technological fix, and bringing up the argument of whether all problems, even social problems, require technological solutions.

## **Virtual Reality as an Emerging Technology for the Treatment of Serious Mental Illness**

The increasing power and convenience of digital technologies has created a revolution in healthcare, affecting the way we provide and access care. Virtual reality allows for the assessment of cognitions, emotions, and behaviors in a controlled, immersive environment. Distinct from other emerging technologies, VR offers users a unique sense of presence, allowing the user to feel as though they are experiencing what they can see in the headset (Slater, 2004). Several studies have been conducted that analyze VR as a potential treatment option, or supplemental treatment options, for patients with SMI. Within this research, I have highlighted 4 studies that offer insight into the effectiveness of VR to treat individuals with SMI.

Adery et al. (2018) tested the effectiveness of VR intervention for 47 participants diagnosed with schizophrenia in improving a targeted social cognitive function—social attention. The participants were split into two groups: one group did not undergo VR training and were used as a baseline comparison, and one group was administered the VR game for 1 hour per session over a total of 10 sessions. The participants played a VR game involving social interaction with various avatars at different virtual locations, and eye tracking patterns were recorded to observe the patterns of social attention. To start a new mission, a participant chose an avatar by fixating on a circle covering the avatar's face until that circle disappeared. The time it took for the circle to disappear was the Social Engagement Latency (SEL), a useful index that corresponds to one's readiness to initiate a social interaction. Individuals who participated in the VR therapy had a significantly lower mean SEL than the baseline group, and exhibited a significant reduction in overall clinical symptoms.

In a 2013 study, VR was used on 75 patients diagnosed with schizophrenia in order to better understand the efficacy and effectiveness of VR as a cognitive intervention to enhance



vocational outcomes (Tsang, 2013). This was done because employment was found to provide schizophrenic patients with an increased sense of hope and identity, ultimately aiding their mental health. Participants were randomly assigned to one of three groups: a VR-based vocational training group, a therapist-administered group, and a conventional group. All of the participants received similar prevocational skills training in work-simulated workshops. In the VR-based training group, participants were required to attend a VR-based vocational skills training in a virtual boutique. In the therapist-administered group, participants were required to attend therapist administered vocational skills training. Essentially, the training content of the two groups was the same, but the mode of training differed. Patients were required to complete some basic preparatory work, including sorting clothes and checking clothes, before solving some basic problem-solving questions. Their performance was evaluated using 5 different tests, and patients in the VR-based training group were found to perform better than patients in the other two groups in cognitive functioning, and had a higher self-efficacy score, which measures their self-perceived ability in performing sales-related activities.

In a 2011 study, a small group of active duty soldiers (N=24) were studied to determine the effectiveness of virtual reality exposure therapy in treating PTSD (Reger et al., 2011). Participants were considered for VR exposure therapy after failing to report any significant benefit from another form of psychotherapy, or when the patient specifically requested this type of therapy. During the therapy, patients articulated their trauma while immersed in a virtual environment customized in real time by the clinician operating the system. The environment was customized to resemble aspects of the patient's traumatic experience. On average, patients received 7.4 90-minute treatment sessions. Success of the VR therapy was evaluated using the patient's score on the PTSD checklist, 17-item self-report measure, which assesses symptoms of

PTSD in response to a stressful military experience (Bliese, 2008). Relative to their score on the PTSD checklist prior to receiving VR therapy, patients reported a significant reduction in PTSD symptoms post VR exposure therapy, and sixty-two percent reported a change of 11 points or more.

In 2001, a study was conducted on 10 male participants to test the effectiveness of using VR exposure therapy on Vietnam veterans suffering from PTSD. In a clinical environment and over 16 different sessions, participants were temporarily exposed to two different virtual environments: a helicopter flying over Vietnam, as well as a clearing surrounded by jungle. PTSD symptoms were measured using the Clinician Administered PTSD Scale before the study began, as well as 6-months after the completion of the study. All participants experienced a reduction in PTSD symptoms ranging from 15% to 67%. Additionally, participants saw a decrease in self-reported intrusion symptoms as measured by the Impact of Event Scale (IES), a set of 15 questions that measures the amount of distress individuals associate with a traumatic event (U.S. Department of Veteran Affairs, 1996).

These findings provide preliminary evidence for the effectiveness of VR therapy to be used to help treat disorders such as PTSD and schizophrenia. In the first two studies, individuals with schizophrenia who engaged in VR therapy saw significant reductions in their symptoms when compared to individuals who did not partake in the VR therapy. Additionally, those individuals experienced a higher level of cognitive functioning, a well-known indicator of maintaining independence and survival in adults. In the latter two studies, individuals diagnosed with PTSD claimed to have experienced a significant reduction in PTSD symptoms after engaging in VR therapy over the course of several different treatment sessions. However, sample sizes were small, which limits the external validity of the studies.

## **Limitations to using Virtual Reality to Augment Treatment for Serious Mental Illness**

Journals and articles highlight some of the major concerns associated with introducing this technology into the healthcare field. First, not everyone is able to experience the benefits of VR-based therapy, as VR technology can bring on nausea or motion sickness for some individuals. Additionally, accessibility remains an issue, as obtaining and learning how to properly use VR technology still acts as a barrier. While the price of VR headsets has gone down significantly over the past decade, affordability of this technology is still an issue for many individuals who suffer from serious mental illness. The startup Limbix has a lofty price point of \$1,999 for one medical grade VR system, which includes a VR headset, a tablet that connects to the headset via Bluetooth, and a docking station to hold both the headset and tablet. Research on the effectiveness of using VR to help treat SMI is largely focused on a few illnesses, specifically PTSD and schizophrenia. Thus, the ability of VR to treat individuals suffering from other severe mental illnesses is not as clearly defined.

Another argument against promoting this treatment method is that VR, as well as other forms of technology, are unnecessary and inappropriate ways to treat something such as mental illness. In 1967, Dr. Alvin Weinberg posed a provocative question: Can technology solve all social problems? He hinted that it could, and engineers would eventually supplant social scientists as the most effective problem-solvers for society (Weinberg, 1967). He pioneered the term technological fix, the idea that technology can be used as a “social cure-all” and that all problems, even social ones, have technological solutions. He noted the benefits of this way of thinking, specifically that reframing a social problem as a technological one reduces seemingly insurmountable social problems to manageable levels, as technological problems are easier to solve than social ones. But is technology always the answer?

Critics of Weinberg's theory argue that in solving one problem, technological fixes often generate others (Scott, 2011). These emerging health technologies introduce new issues related to ease of use and lack of current regulation that were not previously there. Others argue that "technological solutions only eliminate the surface manifestations of the problem and do not get at its roots" (Volti, 2006). Regardless, Weinberg's theory offers a new lens to analyze the potential benefits and drawbacks of introducing a technology such as VR as a means to solve a social problem.

### **How can VR and Other Emerging Technologies be used as a Treatment Option for Mental Illness?**

The documentation of these studies highlights the potential that VR offers when it comes to helping individuals better cope with various forms of serious mental illness. VR's ability to immerse users in a simulated environment offers a way to expose individuals to potentially uncomfortable stimuli in a controlled and safe space. However, limitations related to ease of use still exist, as well as criticisms of using technology such as VR to solve a social issue. Not only this, but very little is set in stone with regards to the regulatory environment, and because of this, there may exist products that have no scientific backing and have not been clinically proven to be successful during the treatment process.

While VR was used as a specific case study, similar ideas hold true when discussing other emerging technologies used to treat mental illness. There exist studies that prove the technology can be beneficial during the treatment process, but significant drawbacks, including the lack of regulation, still exist. The demand for telemedicine has spiked recently, shedding light on how crucial these forms of technology are during unprecedented times such as the COVID-19 crisis (Lovett, 2020). Future work should further examine how this pandemic has changed society's

view of telehealth as well as the development of alternative technologies to consult and treat patients remotely.

While generalizations can be made about individuals with mental illness, every individual diagnosed is unique and responds differently to different forms of treatment. VR offers one way to provide additional treatment to those suffering from SMI (specifically PTSD and schizophrenia), and has scientific backing that shows its potential to help individuals during the treatment process. As technology continues to advance, the regulatory environment becomes more stringent, and startups such as Limbix continue to expand their breadth of services, the reach of such emerging technologies has the potential to grow tremendously.

## References

- Adery, L. H., Ichinose, M., Torregrossa, L. J., Wade, J., Nichols, H., Bekele, E., Bian, D., Gizdic, A., Granholm, E., Sarkar, N., & Park, S. (2018). *The acceptability and feasibility of a novel virtual reality based social skills training game for schizophrenia: Preliminary findings*. *Psychiatry Research*, 270, 496–502.  
<https://doi.org/10.1016/j.psychres.2018.10.014>
- Armontrout, J. A., Torous, J., Cohen, M., McNeil, D. E., & Binder, R. (2018). *Current Regulation of Mobile Mental Health Applications*. *Journal of the American Academy of Psychiatry and the Law Online*, 46(2), 204–211.  
<https://doi.org/10.29158/JAAPL.003748-18>
- Bliese, P. D., Wright, K. M., Adler, A. B., Castro, C. A., & Hoge, C. W. (2008). *Validating the Primary Care Posttraumatic Stress Disorder Screen and the Posttraumatic Stress Disorder Checklist with soldiers returning from combat*. *Journal of Consulting and Clinical Psychology*, 76, 272–281. doi: 10.1037/0022-006x.76.2.272.
- Dickerson, F., McNary, S., Brown, C., Kreyenbuhl, J., Goldberg, R., & Dixon, L. (2003). *Somatic Healthcare Utilization among Adults with Serious Mental Illness Who Are Receiving Community Psychiatric Services*. *Medical Care*, 41(4), 560-570.
- Foerschner, A. M. (2010). *The History of Mental Illness: From “Skull Drills” to “Happy Pills.”* *Inquiries Journal*, 2(09). <http://www.inquiriesjournal.com/articles/1673/the-history-of-mental-illness-from-skull-drills-to-happy-pills>
- Freeman, D. (2019, May 13). Five ways virtual reality is transforming mental health. Med-Tech Innovation | Latest News for the Medical Device Industry. <https://www.med->

technews.com/api/content/5f748e42-755f-11e9-b1a1-12f1225286c6/

Limbix. (n.d.). Limbix VR Kit for Therapy & Mental Health. Limbix. Retrieved April 2, 2020, from <https://vr.limbix.com/>

Lovett, L. (2020, March 30). GoodRx launches telemedicine price comparison service, amid growing demand during COVID-19 pandemic. MobiHealthNews.

<https://www.mobihealthnews.com/news/goodrx-launches-telemedicine-price-comparison-service-amid-growing-demand-during-covid-19>

Luxton, D. D., McCann, Russel A., Bush, Nigel E., Mishkind, Matthew C., & Reger, Greg M. (20111031). *mHealth for mental health: Integrating smartphone technology in behavioral healthcare*. Professional Psychology: Research and Practice.

<https://doi.org/10.1037/a0024485>

National Institute of Mental Health. (2017). Mental Illness [Report]. Retrieved November 1, 2019, from <https://www.nimh.nih.gov/health/statistics/mental-illness.shtml>

National Institute of Mental Health » Mental Health Medications. (2016). Retrieved April 2, 2020, from <https://www.nimh.nih.gov/health/topics/mental-health-medications/index.shtml>

Reger, G. M., Holloway, K. M., Candy, C., Rothbaum, B. O., Difede, J., Rizzo, A. A., & Gahm, G. A. (2011). *Effectiveness of virtual reality exposure therapy for active duty soldiers in a military mental health clinic*. Journal of Traumatic Stress, 24(1), 93–96.

<https://doi.org/10.1002/jts.20574>

Rothbaum, B. O., Hodges, L. F., Ready, D., & Alarcon, R. D. (2001). *Virtual Reality Exposure*

- Therapy for Vietnam Veterans With Posttraumatic Stress Disorder*. The Journal of Clinical Psychiatry, 62(8), 617–622.
- Scott, D. (2011). *The Technological Fix Criticisms and the Agricultural Biotechnology Debate*. Journal of Agricultural and Environmental Ethics, 24(3), 207–226.  
<https://doi.org/10.1007/s10806-010-9253-7>
- Slater, M. (2004). Presence and Emotions. CyberPsychology & Behavior, 7(1), 121–121.  
<https://doi.org/10.1089/109493104322820200>
- Substance Abuse and Mental Health Services Administration. (2015). *Using Technology-Based Therapeutic Tools in Behavioral Health Services*.
- Tsang, M. M. Y., & Man, D. W. K. (2013). *A virtual reality-based vocational training system (VRVTS) for people with schizophrenia in vocational rehabilitation*. Schizophrenia Research, 144(1), 51–62. <https://doi.org/10.1016/j.schres.2012.12.024>
- U.S. Department of Veteran Affairs. Impact of Event Scale - Revised (IES-R) for DSM-IV - PTSD: National Center for PTSD. (n.d.). Retrieved April 1, 2020, from <https://www.ptsd.va.gov/professional/assessment/adult-sr/ies-r.asp>
- Volti, R. (2006). *Society and Technological Change* (5th ed.). Macmillan.
- Weinberg, A. M. (1967). *Can technology replace social engineering?* American Behavioral Scientist, 10(9), 7–7.