

Virtual Reality Therapy for Reducing Anxiety in Patients with Drug-Resistant Tuberculosis

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Article Info

Article history:

Received: Apr 10, 2025

Revised: Jul 4, 2025

Accepted: Jul 21, 2025

DOI: [10.58418/ijni.v4i1.129](https://doi.org/10.58418/ijni.v4i1.129)

How to cite this article:

Abdillah, A. J., Ayu, W. D., & Rianzares, G. L. (2025). Virtual Reality Therapy for Reducing Anxiety in Patients with Drug-Resistant Tuberculosis. *International Journal of Nursing Information*, 4(1), 1–9.

<https://doi.org/10.58418/ijni.v4i1.129>

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ABSTRACT

Drug-resistant tuberculosis (DR-TB) presents both a biological challenge and a substantial psychological burden, particularly anxiety, which often disrupts treatment adherence and diminishes patients' quality of life. This study aimed to evaluate the effectiveness of Virtual Reality (VR) therapy as a non-pharmacological intervention for reducing anxiety levels among DR-TB patients. A quasi-experimental design with a pretest-posttest control group approach was employed. A total of 384 participants were recruited from Indonesia and Philippines. Anxiety levels were assessed using the validated Hamilton Anxiety Rating Scale. Data were analyzed using paired t-tests to assess within-group changes, and Analysis of Covariance (ANCOVA) was conducted to control for potential confounding variables and determine between-group differences. The results revealed a statistically significant reduction in anxiety scores in the VR group compared to the control group ($p < 0.001$), with participants reporting improved emotional regulation and reduced psychological distress. These findings suggested that VR therapy was an effective non-pharmacological strategy for managing anxiety in DR-TB patients. The study contributed to the digital mental health literature by offering culturally relevant evidence on the application of immersive therapy in two high-burden TB countries. Integrating VR therapy into TB care protocols may enhance holistic patient management, particularly in resource-constrained healthcare systems.

Keywords: Virtual Reality Therapy, Drug-Resistant Tuberculosis, Anxiety, Digital Mental Health



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1. INTRODUCTION

In the era of global digital transformation, the healthcare sector is facing increasingly complex challenges that involve not only physical illnesses but also the psychological conditions that accompany them. As the burden of chronic and infectious diseases rises, there is an urgent demand for innovative interventions that can address the psychological consequences of prolonged treatment processes. One of the most affected patient groups according to Wang et al. (2024) and Storvig et al. (2024), comprises individuals with drug-resistant tuberculosis (DR-TB), who experience both physical suffering and emotional distress. In this context, Virtual Reality (VR) emerges as a potential solution that extends beyond entertainment and offers an immersive psychological therapy. The use of VR in mental healthcare is gaining attention as an alternative strategy to mitigate anxiety (Bell et al., 2024; Riches et al., 2023), particularly among patients with serious chronic conditions such as DR-TB, who are often subjected to isolation, stigma, and uncertainty about their recovery.

DR-TB is a form of tuberculosis infection that does not respond to one or more first-line anti-TB drugs (Saktiawati et al., 2024; Tan et al., 2023). It typically requires a long treatment period, involves severe side effects, and has a lower success rate compared to drug-sensitive TB. In Southeast Asia, especially in Indonesia (Yani et al., 2022) and Philippines (Roxas et al., 2023), DR-TB remains a complex public health issue. This is due not only to the high prevalence rates but also to the social and economic consequences for patients. Many face persistent stigma, significant economic disruption due to loss of productivity, and long-term isolation, all of which contribute to elevated levels of anxiety and psychological burden (Adejumo et al., 2025; Liboon Aranas et al., 2023). To date, most TB programs have focused primarily on biomedical treatment, with limited implementation of psychosocial support services (Myburgh et al., 2023; Pasha et al., 2021). Addressing the emotional and mental dimensions of care is essential to improving treatment outcomes and overall patient well-being.

The fear experienced by DR-TB patients is not limited to physical pain or drug side effects. According to research by Nagarajan et al. (2022), what often happens to some DARI-TB patients is fear and despair. It often includes social isolation, a loss of self-worth, fear of infecting loved ones, and the uncertainty of survival. According to Mphothulo et al. (2025), these psychological challenges are exacerbated by hospital environments that are emotionally uninviting and by the lack of accessible mental health care. In many cases, such unaddressed anxiety leads to poor treatment adherence, ultimately compromising recovery.

Traditional approaches to anxiety management in TB care commonly rely on psychological counseling or pharmacological interventions, such as the use of anxiolytics. However, Papava et al. (2025) stated that these strategies face substantial limitations. These include a shortage of trained mental health professionals, persistent stigma surrounding mental illness, and inadequate infrastructure to support large-scale psychosocial interventions in TB clinics. Furthermore, one-directional methods such as verbal education or printed materials often fail to alleviate the complex emotional distress experienced by patients.

Considering the multifactorial physical and psychological stressors faced by DR-TB patients, the development of multidimensional and innovative therapeutic approaches is increasingly critical. VR technology is particularly relevant in this regard. According to Lv et al. (2025), it creates real-time, interactive three-dimensional environments that users can explore, making it a powerful tool for psychological intervention. In clinical settings, VR has already been employed successfully for surgical training, physical rehabilitation, and chronic pain relief (Goudman et al., 2022). Yet its application in managing anxiety among patients with communicable diseases like DR-TB remains underutilized, especially in low- and middle-income countries. This positions VR as a potentially transformative intervention that could bridge the emotional support gap left by conventional healthcare systems.

The mechanism behind VR's therapeutic value lies in its ability to distract and redirect perception (Appel et al., 2022; Bachelard et al., 2024; Cerritelli et al., 2021). Related to anxiety, according to research by Cawley & Tejeiro (2024), the immersive audio-visual experience can ease distress by shifting attention away from negative thoughts. Colombo et al. (2021), Zhang et al. (2021) and Drigas & Sideraki (2024) suggest that VR stimulates brain regions associated with relaxation through emotionally engaging content. Unlike traditional verbal therapies, VR allows patients to experience calmness firsthand rather than imagine it. This approach can be especially helpful for DR-TB patients who may have difficulty articulating emotions due to mental exhaustion.

Addressing psychological distress in the digital age, according to Ye (2021) and Abou Hashish (2025), requires approaches that combine technology with empathy, comfort, and repeated positive experiences. For patients with DR-TB, according to Liu et al. (2022), VR offers a bridge between biomedical treatment and the need for psychological comfort. As VR hardware becomes more affordable and culturally adaptable, it is increasingly viable for use even in resource-constrained healthcare facilities. This is particularly important for patients from low-income backgrounds who often lack access to formal psychological care.

VR also has the advantage of personalization (Marougkas et al., 2023). It can be tailored to the cultural and emotional contexts of patients in Southeast Asia, enhancing engagement and creating a sense of emotional safety. This cultural sensitivity adds value to VR compared to conventional psychological therapies, which are often too general and lack contextual relevance. As a result, VR is not just a distraction technique but also a potentially impactful therapeutic platform for integration into modern healthcare systems.

Although VR has been acknowledged in medical practice as a non-pharmacological strategy to alleviate anxiety (Gao et al., 2023; Jallad & Işık, 2022; Trusculescu et al., 2025), particularly among patients undergoing long-term (Zhai et al., 2021) or invasive procedures (Hosseini et al., 2024), limited research has explored its effectiveness in DR-TB populations. This research gap is especially relevant in Southeast Asia, where the intersection of cultural, social, and economic complexity with high DR-TB prevalence necessitates tailored mental health interventions. Rigorous evaluation is needed to determine how VR therapy can be adapted and deployed effectively in such settings.

This study presents an innovative therapeutic approach by applying culturally tailored virtual reality (VR) interventions to reduce anxiety among individuals with drug-resistant tuberculosis (DR-TB). Unlike conventional treatments that primarily focus on pharmacological or verbal psychological methods, this research explores an immersive digital therapy with the potential to be integrated into holistic TB care. The present study aims to assess the effectiveness of VR therapy in reducing anxiety levels among DR-TB patients in Indonesia and the Philippines. The findings are expected to contribute to the field of digital mental health by providing context-specific evidence on the feasibility and impact of immersive therapy in high-burden, low-resource TB settings.

2. METHOD

This study employed a quasi-experimental design using a pretest–posttest control group approach to evaluate the effectiveness of Virtual Reality (VR) therapy in reducing anxiety levels among patients with Drug-Resistant Tuberculosis (DR-TB). A total of 384 participants were recruited from healthcare centers in Indonesia and the Philippines. The sample size was determined using the Lemeshow formula (Nurfikri et al., 2024), as the total population size was not precisely known. Prior to participation, all eligible individuals were provided with detailed information about the study’s purpose, procedures, risks, and benefits. Written informed consent was obtained in accordance with the Declaration of Helsinki and ethical research standards. Participants were proportionally assigned to either the intervention group, which received VR therapy, or the control group, which continued to receive standard TB care without additional psychological intervention. Inclusion criteria included being aged 18–60 years, undergoing active DR-TB treatment, and exhibiting at least mild anxiety symptoms based on a validated anxiety scale. Anxiety levels were assessed using the Hamilton Anxiety Rating Scale (HAM-A), a widely used and internationally validated clinical tool that measures both somatic and psychological aspects of anxiety (Parveen et al., 2025). The HAM-A consists of 14 items with a total score range of 0–56, where scores ≥ 18 indicate moderate to high anxiety. Pre- and post-intervention assessments were conducted by trained healthcare professionals who followed standardized HAM-A administration guidelines. Data were analyzed using paired t-tests to examine within-group differences and ANCOVA to assess between-group differences while adjusting for potential confounding variables. The research was guided by the following hypotheses: the null hypothesis (H_0) stated that there would be no significant difference in anxiety levels before and after the VR intervention, while the alternative hypothesis (H_1) posited that the intervention would significantly reduce anxiety levels among DR-TB patients compared to standard care.

The VR intervention was administered over a four-week period, with three sessions per week, each lasting approximately 15 minutes. The VR content featured immersive video experiences of calming natural environments such as waterfalls, fog-covered mountain valleys, and sunrise landscapes. These videos were delivered using standard VR headsets and accompanied by spatial audio elements including flowing water, birdsong, and soft breezes. Each session began with guided relaxation and deep-breathing instructions, followed by 10–12 minutes of immersive nature visualization and concluded with a 2–3 minute visual cool-down period to facilitate a smooth emotional transition back to the real-world environment. Sessions were conducted in private, quiet rooms under the supervision of trained healthcare personnel experienced in administering VR-based psychological interventions. Meanwhile, the control group adhered to the national TB treatment protocol without additional therapeutic support. Post-intervention evaluations were carried out at the end of week four to measure changes in anxiety scores and assess the overall effectiveness of the VR intervention.

3. RESULTS AND DISCUSSION

3.1. Results

A total of 384 participants successfully completed the study protocol, comprising 192 patients in the intervention group (VR therapy) and 192 in the control group. As shown in Table 1, the baseline mean anxiety scores, measured using the Hamilton Anxiety Rating Scale (HAM-A), were comparable between the two groups. The VR group had a mean pretest score of 26.45 (SD = 4.81), while the control group had a mean of 25.98 (SD = 5.12), indicating moderate anxiety levels in both groups with no statistically significant difference at baseline ($p > 0.05$).

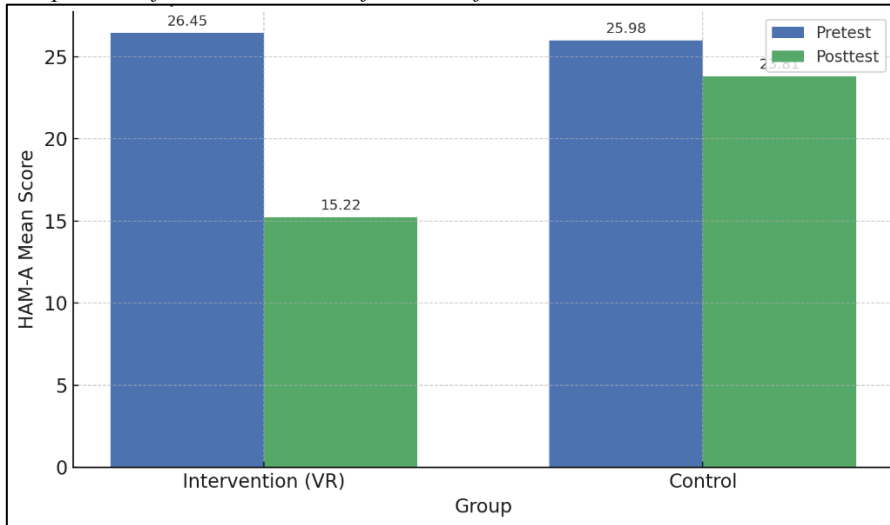
Table 1
Mean HAM-A Scores Before and After the Intervention

Group	Pretest (Mean \pm SD)	Posttest (Mean \pm SD)
Intervention (VR)	26.45 \pm 4.81	15.22 \pm 3.95
Control	25.98 \pm 5.12	23.81 \pm 4.77

Following four weeks of intervention, the VR group exhibited a substantial reduction in anxiety levels, with a posttest mean score of 15.22 (SD = 3.95). In contrast, the control group showed only a slight decrease to 23.81 (SD = 4.77). This change is visually depicted in Figure 1, which illustrates the pre- and post-intervention anxiety scores in both groups. The steep decline in the VR group underscores the therapeutic impact of immersive exposure, while the minimal change in the control group reflects the limited effect of standard care alone.

Figure 1

Comparison of HAM-A Scores Before and After the Intervention



Statistical analysis using paired t-tests confirmed a significant within-group reduction in anxiety scores for the VR group ($t = 18.28$, $p < 0.001$), whereas the change in the control group did not reach statistical significance ($t = 1.99$, $p = 0.064$). Further analysis using ANCOVA, with pretest scores as covariates, demonstrated a significant main effect of the intervention on posttest scores ($F(1,364) = 117.92$, $p < 0.001$), with a partial eta squared (η^2) of 0.236. This suggests that the VR intervention accounted for 24.1% of the variance in post-intervention anxiety outcomes. These findings are summarized in Table 2.

Table 2

Summary of Statistical Analyses

Statistical Test	Test Value	P-value	Interpretation
Paired t-test (VR)	$t = 18.28$	0.000	Significant reduction in anxiety
Paired t-test (Control)	$t = 1.99$	0.064	Not statistically significant
ANCOVA	$F(1,364) = 117.92$	0.000	Significant effect of intervention ($\eta^2 = 0.241$)

These findings support the alternative hypothesis (H_1), indicating a statistically significant difference in anxiety levels before and after the VR intervention among DR-TB patients. The null hypothesis (H_0) is therefore rejected. Virtual Reality therapy demonstrated a substantial therapeutic effect in reducing anxiety and presents a viable non-pharmacological strategy in DR-TB care settings, particularly in resource-limited environments.

3.2. Virtual Reality as a New Paradigm in Psychological Therapy for DR-TB Patients

The results of this study demonstrate that Virtual Reality (VR) therapy significantly reduces anxiety levels among patients diagnosed with Drug-Resistant Tuberculosis (DR-TB). Anxiety scores measured using the Hamilton Anxiety Rating Scale (HAM-A) showed substantial reductions in the intervention group across both study sites in Indonesia and Philippines. The potential role of VR as a transformative component in the psychosocial management of DR-TB patients. These findings support VR's role as an active psychological intervention rather than merely a relaxation aid, aligning with the theoretical framework of Polyvagal Theory (Haeyen, 2024), which posits that enhancing parasympathetic activation through calming stimuli promotes emotional regulation via the vagus nerve.

These observations are consistent with previous literature. A meta-analysis by van Loenen et al. (2022) highlighted VR's effectiveness in treating various anxiety disorders, with effect sizes analogous to traditional exposure therapies. Similarly, a recent meta-analysis covering over 3,000 individuals found a standardized mean difference of approximately -0.95 favoring VR interventions in anxiety reduction relative to conventional approaches (Zeng et al., 2025). According to Jemal (2024), clinical strategies

now acknowledge that healing extends beyond biological treatment and must also address emotional, cognitive, and social dimensions. VR therapy reflects this shift by offering a concrete and interactive form of psychological support. In the case of DR-TB patients, the use of VR represents more than just a technological advance; it embodies a humane and adaptive response to emotional suffering, including anxiety, fear of mortality, and the psychological impact of prolonged isolation.

From a neurophysiological perspective, the immersive sensory experiences provided by VR have been shown to activate the limbic system, which is associated with emotional regulation. This activation leads to a reduction in sympathetic nervous system responses, resulting in measurable physiological changes such as decreased heart rate, lower blood pressure, and muscle relaxation. These changes correlate with reduced anxiety levels. At the same time, the parasympathetic nervous system becomes more active, allowing the body and mind to enter a state conducive to healing. Structures such as the amygdala and hippocampus are also involved, supporting the processing of soothing stimuli and the formation of calming emotional associations. This aligned with pilot EEG studies by Tarrant et al. (2018), which showed shifts from high-frequency Beta activity toward lower Beta in the anterior cingulate cortex, indicating a reduction in anxiety. A broader review combining VR and brain-computer interfaces (BCI) also suggested that immersive virtual environments can modulate neuroplasticity, enabling the formation of adaptive neural pathways in emotional regulation (Wankhede et al., 2025).

Therapeutically, repeated VR sessions foster learning and habituation, gradually building new coping strategies within the brain's plastic neural architecture. This concept is supported by Failla et al. (2022) and Wieczorek et al. (2024) showing greater state mindfulness and reduced anxiety following VR-based mindfulness interventions compared to audio-only controls. Within the framework of neuroplasticity, VR offers a valuable stimulus for reprogramming emotional pathways in the brain. This process has the potential to help patients reduce psychological distress without relying solely on pharmacological interventions. Given that many DR-TB patients experience treatment fatigue and limited access to mental health care, VR presents a promising solution for improving their emotional resilience and overall quality of life.

3.3. Contextual Sensitivity: The Role of Virtual Reality in Sociocultural Settings and Global Health Policy

The findings from both Indonesia and Philippines confirm that Virtual Reality (VR) therapy effectively reduces anxiety among DR-TB patients across different sociocultural and healthcare contexts. This aligns with cultural adaptation theory (Naderbagi et al., 2024), which emphasizes that intervention effectiveness improves when content is tailored to the values, symbols, and norms of the target population. A systematic review on VR relaxation for mental health reported that culturally inclusive design significantly enhances engagement and outcomes in diverse population (Ma et al., 2023; Riches et al., 2023). VR emerges as a promising tool for global implementation when delivered with cultural sensitivity in mind.

Southeast Asian patients with DR-TB often experience intense psychological distress exacerbated by social stigma, economic hardship, and fear of discrimination. For instance, qualitative research by Kumar Panda et al. (2024) documented pervasive stigma and isolation among TB patients, worsening anxiety and reducing treatment adherence. Through immersive simulations of calming natural environments such as valleys or waterfalls, VR creates a safe space that aligns with the patient's cultural background. This space allows them to temporarily escape the psychological stress caused by social stigma and isolation.

Studies in other clinical settings support these findings. Study by Kukharuk et al., (2025), a randomized controlled trial of immersive 360° video-based VR therapy among Ukrainian veterans treated for anxiety and depression showed significant reductions in both symptoms following user-centered content adaptation (14.5% anxiety reduction). Similarly, a meta-analysis of VR exposure therapy for anxiety disorders demonstrates its effectiveness across different cultural groups when sessions are culturally appropriate and user-informed (Shahid et al., 2024; Wray et al., 2023). Unlike traditional psychological interventions that often require trained professionals and private settings, VR sessions can be conducted in a compact and structured manner even in public healthcare environments. Patients exposed to calming digital scenes, including mountain landscapes, flowing rivers, or peaceful sunrises, are given the opportunity to relax, regulate their breathing, and reconnect with positive emotional experiences. Such simulated environments function as emotional sanctuaries where patients may begin to rebuild coping mechanisms that have been eroded by long-term illness and isolation. In this way, VR acts as a supplementary therapy that restores emotional equilibrium and supports mental recovery.

Beyond cultural adaptation, VR is increasingly recognized in global policy as an inclusive digital mental health tool. The World Health Organization has highlighted the potential of digital interventions to close the emotional support gap in TB care (Lee et al., 2023; Ridho et al., 2022), calling for evidence-based, patient-centered innovations. Our study contributes region-specific evidence that VR can fulfill this role by addressing psychosocial needs in high-burden TB settings. Implementing VR in such contexts

represents a shift from a disease-centric treatment model to one that integrates mental well-being into standard protocols. This study underscores that VR therapy, when designed with cultural sensitivity and local engagement, offers a scalable and contextually appropriate intervention. It bridges critical gaps in TB care by supporting emotional resilience, enhancing patient experience, and aligning with current global health priorities for inclusive and integrated digital mental health strategies.

3.4. Implementation Strategies and the Future of VR in Digital Mental Health Policy

The findings from this study not only contribute to the scientific understanding of the impact of Virtual Reality (VR) in reducing anxiety, but also provide a practical foundation for integrating such interventions within public healthcare systems. The significant reduction in HAM-A scores among DR-TB patients in both Indonesia and Philippines demonstrates that VR therapy can be effectively implemented beyond controlled laboratory settings. This highlights an opportunity for policymakers to consider VR not merely as a complementary digital tool, but as a primary therapeutic intervention within digital mental health strategies.

Effective integration of VR into clinical care requires a multi-level approach. At the institutional level, healthcare workers need to be trained in both the technical and clinical aspects of using VR in therapeutic settings. Successful implementation depends on both the technological readiness of the facility and the cultural acceptance among patients and staff. Therefore, VR programs must be participatory in design and culturally adaptive, as highlighted by Cushnan et al. (2024) showed that therapist training and perceptual familiarity significantly influence adoption rates. At the policy and funding level, governments and donors must allocate dedicated budgets for the procurement of VR equipment and the development of culturally appropriate content. Scenes such as waterfalls, mountains, and coastal landscapes, which were shown in this study to have a calming physiological and emotional effect, should be tailored to local cultural symbols and imagery to enhance emotional resonance.

On the national and international policy fronts, these findings align with the broader global health agenda to incorporate digital technologies into the treatment of chronic infectious diseases. The World Health Organization's Digital Health (Wilson et al., 2021) for TB initiative promotes the adoption of innovative tools that address not only clinical outcomes but also emotional well-being. VR therapy, within this framework, holds potential as a strategic element in healthcare transformation, supporting more inclusive and patient-centered models. Importantly, VR may improve treatment adherence among TB patients by alleviating psychological burdens such as anxiety and depression, which are known to hinder recovery and reduce compliance. In this sense, investing in VR is not only an investment in technology but also in human dignity and quality of life. This study reinforces the notion that the future of healthcare must prioritize both physical healing and emotional care in equal measure.

4. CONCLUSION

This study demonstrated that Virtual Reality (VR)-based therapy significantly reduced anxiety levels among patients with Drug-Resistant Tuberculosis (DR-TB) in Indonesia and the Philippines. Immersive exposure to natural environments through VR headsets led to meaningful reductions in anxiety, as measured by the Hamilton Anxiety Rating Scale (HAM-A). These findings highlighted the potential of non-pharmacological, technology-driven interventions to complement biomedical treatment by addressing psychological distress that was often overlooked in the management of chronic infectious diseases. Beyond short-term relaxation, VR provided a private and emotionally secure space that allowed patients to temporarily disengage from the psychological impact of stigma, social rejection, and treatment fatigue. By facilitating emotional regulation and supporting the development of adaptive coping mechanisms, VR proved particularly valuable in settings with limited access to conventional mental health services.

The limitations of this study include a brief intervention period, a focus solely on anxiety as the outcome, and the absence of exploration into patients' subjective experiences. Future research should adopt longitudinal designs and mixed-method approaches to assess the long-term effects of VR therapy and to gain deeper insight into patients' emotional and cognitive responses. This study contributes to the digital mental health literature by providing culturally grounded evidence on the use of immersive VR therapy in two high-burden TB countries. It demonstrates that integrating VR into TB care protocols can support more holistic patient management, particularly in resource-constrained healthcare systems.

ACKNOWLEDGEMENTS

The authors extend their deepest gratitude to all participants from Indonesia and Philippines who generously shared their time and experiences during this study.

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