

VIRTUAL REALITY FOR MAINTAINING THE MENTAL HEALTH OF END-STAGE KIDNEY DISEASE PATIENTS: A LITERATURE REVIEW

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ABSTRACT

Background: Hemodialysis patients are prone to significant psychological distress, particularly anxiety related to routine dialysis procedures and arteriovenous fistula (AVF) puncture. The high prevalence of anxiety in this population, ranging from 32% to 76%, underscores the urgent need for effective therapeutic interventions. Objective: This systematic literature review aims to analyze the effectiveness of Virtual Reality (VR) interventions as a non-pharmacological therapy for reducing anxiety levels in hemodialysis patients. Methods: This study employed a systematic literature review design. Seven studies meeting the inclusion criteria were comprehensively analyzed. These studies spanned various countries (Egypt, Spain, Iran, Poland, and Taiwan) and included a total sample of 405 participants. Results: The results of the data synthesis showed that VR interventions whether in the form of passive distraction using 360° nature videos or VR-based physical activities consistently resulted in a significant reduction in anxiety scores with moderate to large effect sizes. Conclusion: These findings support the integration of VR as a safe, effective, and cost-efficient adjunctive therapeutic modality in the routine care of hemodialysis patients. VR is a promising technological innovation in the field of nephrology with great potential to improve patients' quality of life and psychological well-being. Moving forward, the development of standardized implementation protocols and further research are needed so that VR can become an integral component of patient-centered, holistic care.

KEYWORDS

virtual reality, hemodialysis, anxiety, non-pharmacological



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INTRODUCTION

End-stage kidney disease is a chronic condition that requires long-term renal replacement therapy, with hemodialysis (HD) being the most commonly used modality. HD therapy is routinely performed three times a week for 3–4 hours per session via repeated cannulation of a vascular access site, primarily an arteriovenous fistula (AVF). This repeated invasive procedure not only causes physical pain but also imposes a significant psychological burden, particularly anxiety, on patients.

Epidemiological evidence indicates a high prevalence of anxiety disorders among hemodialysis patients in various countries, ranging from 32% to 76%. These anxiety rates have been documented in various studies, including those in Egypt (75.8%) (Nagy et al., 2023), Greece (47.8%) (Theofilou et al., 2015), China (36.9%) (Ye et al., 2022) and Brazil (32.3%) (de Brito et al., 2019). These findings confirm that anxiety is a universal problem among hemodialysis patients. Clinically, anxiety in hemodialysis patients negatively impacts quality of life and clinical outcomes, including a decline in mental health status (Durán-Gómez et al., 2025) and an increased risk of vascular access failure (OR = 3.672; $p = 0.04$) (de Brito et al., 2019). Given its detrimental effects, addressing anxiety is a crucial aspect of patient management. Based on a recent meta-analysis, psychosocial interventions have been shown to be effective and capable of significantly reducing levels of anxiety (SMD = -0.99) and depression (SMD = -0.85) in this population (Barello et al., 2023). This effectiveness underscores the need to integrate psychological therapy modalities as part of a comprehensive care approach for hemodialysis patients.

Traditionally, the management of anxiety in hemodialysis patients has relied on anxiolytic agents such as benzodiazepines. However, this pharmacological approach has significant limitations in the end-stage renal disease (ESRD) population. In addition to failing to address the root psychological issues, pharmacotherapy carries the risk of triggering the accumulation of active metabolites, polypharmacy interactions, sedation-related side effects and the risk of falls in geriatric patients, as well as long-term dependence. This has prompted a shift toward safer, nonpharmacological interventions that can be easily integrated into the dialysis routine, such as music therapy, progressive muscle relaxation, mindfulness, cognitive behavioral therapy, and visual distraction. Unfortunately, the clinical application of these modalities is often hindered by the need for specialized training, patients' inability to actively participate during procedures, and an insufficient level of immersion to divert patients' attention from aversive stimuli. Virtual Reality (VR) is an immersive, three-dimensional technology-based modality used as a nonpharmacological distraction therapy to reduce pain and anxiety during invasive procedures. Based on gate control theory and the limited attention capacity model, multisensory VR stimuli effectively divert patients' cognitive resources away from processing pain signals and anxiety (Indovina et al., 2018). Compared to other modalities, VR offers the advantages of high immersion, content flexibility, ease of application, cost-effectiveness, and freedom from the risks of side effects, tolerance, or drug dependence.

Empirical evidence demonstrates the effectiveness of VR in reducing pain and procedural anxiety, both in pediatric populations (Smith et al., 2022) and in hospitalized patients (Spiegel et al., 2019). However, the use of VR in the hemodialysis population remains limited and requires a systematic synthesis of evidence to support evidence-based practice. This literature review aims to comprehensively analyze the effectiveness of VR interventions in reducing anxiety in hemodialysis patients.

RESEARCH METHOD

This literature review employs a systematic approach to identify, evaluate, and synthesize scientific evidence regarding the effectiveness of virtual reality in reducing anxiety in hemodialysis patients. This approach follows the principles of systematic literature reviews, with a focus on comprehensive data extraction and narrative synthesis of findings. The purpose of this paper is to review published research on the effects of virtual reality on anxiety in hemodialysis patients. The literature search utilized relevant databases, namely PubMed, ScienceDirect, and the Google Scholar search engine, using the following keywords: “virtual reality,” “VR,” “hemodialysis,” “haemodialysis,” “dialysis,” “anxiety,” “psychological distress,” and “mental health.”

Literature search conducted from 2021 through 2026; inclusion criteria: 1) English language; 2) Use of virtual reality as an intervention; 4) Presence of primary or secondary outcomes related to anxiety; 4) Study designs including randomized controlled trials (RCTs), quasi-experimental studies, or pilot studies; 5) Articles must be available in full text. Exclusion criteria: 1) Studies reporting only pain outcomes without anxiety measurements; 2) Peritoneal dialysis populations; 3) Protocol studies, case reports, or editorials without empirical data; 4) Studies with very low methodological quality or incomplete data. This study used the PRISMA guidelines for analysis and the Joanna Briggs Institute (JBI) Critical Appraisal for article eligibility assessment.

RESULT AND DISCUSSION

The seven studies that met the inclusion criteria included research from various countries: Egypt (n=2), Spain (n=1), Iran (n=1), Poland (n=2), and Taiwan (n=1). A total of 405 hemodialysis patients participated in the seven studies. Study designs varied, including randomized controlled trials (RCTs), quasi-experimental studies, and pilot studies. The duration of the VR intervention ranged from a single session to multi-session programs lasting several weeks.

Table 1. Identification of studies through databases and registries



The anxiety measurement instruments used in these studies include: the State-Trait Anxiety Inventory (STAI), the Visual Analog Scale for Anxiety (VAS-A), the Hospital Anxiety and Depression Scale (HADS), the Beck Anxiety Inventory (BAI), and the Depression Anxiety Stress Scale (DASS-21). This variety of instruments reflects different approaches to measuring anxiety, both as situational anxiety and as a personality trait.

Tabel 2. Characteristics of included studies

Author & Year	Study Design	Sample Size	VR Interventions	Results/Conclusions
(Elzaky et al., 2024) Egypt	Randomized Controlled Trial (RCT)	60	360° video of natural scenery (beaches, forests) during AVF surgery; Duration: single session ~10 minutes	Significant reduction in state anxiety (mean difference: -12.4 STAI points, $p < 0.001$). Reduction in procedural pain. VR is safe and well-tolerated.
(de Galvis et al., 2025) Spain	Pilot Study (without a control group)	30	360° videos of natural scenery and relaxation; 3 sessions over 3 consecutive weeks	Decrease in VAS-A from 5.2 to 3.1 ($p = 0.012$). 83% of patients reported a positive experience. Increased satisfaction with dialysis care.
(Arezoomand et al., 2025) Iran	Quasi-Experimental Study	50	VR videos of natural scenery + relaxing music; A single 20-minute session during dialysis	A significant decrease in state anxiety (STAI pre: 48.2, post: 38.6, $p < 0.001$) and trait anxiety (pre: 46.8, post: 42.1, $p = 0.003$). A decrease in blood pressure.
(Turoń-Skrzypińska et al., 2023) Poland	Randomized Controlled Trial (RCT)	80	VR Exercise: virtual physical activity (cycling, walking); 12 sessions, 2 times per week, 6 weeks, 30 minutes per session	Significant reduction in HADS-A scores (pre: 9.2, post: 5.8, $p < 0.001$) compared to the control group ($p = 0.23$). Improved physical capacity. Reduced depression.
(Rogowski et al., 2026) Poland	Quasi-Experimental Study	45	VR Exercise: virtual physical activity; 8 sessions, 2 times per week, 4 weeks	Decrease in HADS-A from 8.6 to 6.2 ($p = 0.002$). Greater effect in patients with high baseline anxiety. Decrease in depression.
(Hsieh & Li, 2022) Taiwan	Cross-Sectional	80	360° VR video of natural scenery; A single 15-minute session during dialysis	A significant decrease in VAS-A (pre: 4.8, post: 2.9, $p < 0.001$). A negative correlation between immersion level and anxiety ($r = -0.52$, $p < 0.001$). A decrease in blood pressure and heart rate.
(Elghoul & Younes, 2025) Egypt	Randomized Controlled Trial (RCT)	60	Cartoon VR videos + interactive games for children; 4 sessions over 4 weeks	Significant reduction in STAI-C state anxiety (mean difference: -10.8 points, $p < 0.001$) compared to the control group. Effective in the pediatric ESRD population.

Note : STAI = State-Trait Anxiety Inventory; VAS-A = Visual Analog Scale for Anxiety; HADS-A = Hospital Anxiety and Depression Scale – Anxiety subscale; AVF = Arteriovenous Fistula; HD = Hemodialysis; ESRD = End-Stage Renal Disease; RCT = Randomized Controlled Trial

A comprehensive analysis of the seven studies revealed a consistent pattern of findings: Virtual Reality interventions significantly reduced anxiety in hemodialysis patients, both in adult and pediatric populations. The main findings can be summarized as follows.

The Effectiveness of VR in Reducing Anxiety

All seven studies reported a significant decrease in anxiety scores following the VR intervention. In studies with an RCT design, the difference between the intervention and control groups ranged from 10 to 12 points on the STAI scale, indicating a moderate to large effect size (Elghoul & Younes, 2025; Elzeky et al., 2024). Studies with multi-session interventions showed greater and more stable reductions compared to single-session interventions (Rogowski et al., 2026; Turoń-Skrzypińska et al., 2023).

Variations in Types of VR Interventions

Two main categories of VR interventions were identified: (a) Passive VR (Visual Distraction)—360° videos of natural landscapes with or without relaxing music, used in five studies (Arezoomand et al., 2025; de Galvis et al., 2025; Elghoul & Younes, 2025; Elzeky et al., 2024; Hsieh & Li, 2022) and shown to be effective in reducing procedural anxiety; (b) Active VR (VR-Based Exercise) — virtual physical activities such as cycling or walking in a virtual environment, used in two studies (Rogowski et al., 2026; Turoń-Skrzypińska et al., 2023) and demonstrating a dual effect: reducing anxiety while increasing physical activity.

Optimal Duration and Dosage

Studies with multi-session interventions (8–12 sessions over 4–6 weeks) showed greater and more stable reductions in anxiety compared to single-session interventions (Rogowski et al., 2026; Turoń-Skrzypińska et al., 2023). Even single-session interventions lasting 10–20 minutes demonstrated significant effects in reducing procedural anxiety (Arezoomand et al., 2025; Elghoul & Younes, 2025; Elzeky et al., 2024). These findings suggest that VR can be used both as an acute intervention and as a long-term therapy.

Moderators of VR Effectiveness

Several factors influencing the effectiveness of VR were identified: (a) Level of Immersion a study by (Hsieh & Li, 2022) found a significant negative correlation between the level of immersion and anxiety scores ($r = -0.52$, $p < 0.001$); (b) Baseline Anxiety (Rogowski et al., 2026) reported that patients with high baseline anxiety showed a greater response; (c) Content Preferences 83% of patients reported positive experiences with individual preferences for different types of natural scenery (de Galvis et al., 2025).

Safety and Tolerability

All studies reported that the VR intervention was safe and well-tolerated by the majority of patients. Side effects were minimal and mild, primarily mild nausea or dizziness in a small proportion of patients (<5%), which typically subsided after a few minutes (de Galvis et al., 2025; Turoń-Skrzypińska et al., 2023). In the pediatric population, 10% of children experienced difficulty tolerating the VR headset, particularly among younger children (Elghoul & Younes, 2025).

Secondary Outcomes

In addition to anxiety, several studies also reported positive secondary outcomes: reduced pain during AVF puncture (Elzeky et al., 2024); reduced blood pressure and heart rate (Arezoomand et al., 2025; Hsieh & Li, 2022); increased patient satisfaction with dialysis care (de Galvis et al., 2025); and reduced depression scores in studies with multi-session interventions (Rogowski et al., 2026; Turoń-Skrzypińska et al., 2023).

Discussion

The findings from the seven studies analyzed consistently confirm that Virtual Reality (VR) is an effective intervention for reducing anxiety in hemodialysis patients. The reduction in anxiety scores—ranging from 10 to 12 points on the State-Trait Anxiety Inventory (STAI) and 2 to 3 points on the Visual Analog Scale (VAS)—indicates substantial clinical significance. The magnitude of this reduction has the potential to positively impact quality of life, adherence to the treatment regimen, and long-term clinical outcomes. The effectiveness of VR in the hemodialysis population aligns with empirical evidence from various other clinical settings. (Indovina et al., 2018). confirm that VR effectively reduces pain and procedural distress through the gate control theory and the limited attention capacity model (Indovina et al., 2018). The level of immersion was shown to be directly proportional to the reduction in distress responses, reinforcing the findings of (Hsieh & Li, 2022) that immersion is a key moderator variable in the effectiveness of VR.

These benefits have also been documented in other medical populations. In pediatric patients, meta-analyses by Nordgard & Lag (Nordgård & Låg, 2021) and (Smith et al., 2022) (SMD = 0.60; 95% CI 0.28–0.93) (Smith et al., 2022) reported moderate to large effect sizes on anxiety and procedural pain. In an inpatient setting, (piegel et al., (2019). demonstrated the superiority of VR over active control in reducing pain scores (−1.72 vs. −0.46), with a greater effect in the severe pain subgroup (−3.04 vs. −0.93). In oncology patients undergoing chemotherapy, (Acosta Nuñez et al., 2025) observed a 25–45% reduction in anxiety (STAI and HADS-A) and a 20–50% reduction in pain (VAS). These comparable reductions indicate the consistent effectiveness of VR across medical contexts.

The mechanism by which virtual reality reduces anxiety and pain is based on the synergy of several neurophysiological and psychological mechanisms. Gate Control Theory: Multisensory stimulation (visual, auditory, and haptic) from VR competes with pain and anxiety signals for entry into the central nervous system. Intense multisensory input effectively “closes the gate” on the transmission of aversive signals at the level of the spinal cord and cerebral cortex (Indovina et al., 2018). Limited Attention Capacity Model: Human cognitive processing capacity is limited. When cognitive resources are focused on immersive VR stimulation, the allocation of attention to pain and anxiety signals is significantly reduced (Indovina et al., 2018). Findings by Hsieh & Li, (2022), which show a negative correlation between immersion levels and anxiety scores ($r = -0.52$), support this model. Neurophysiological Modulation (fMRI Study): Using functional magnetic resonance imaging (fMRI), Hoffman et al., (2019) demonstrated that VR distraction reduces neuronal activity in brain regions involved in pain processing, including the somatosensory cortex, the insula, and the anterior cingulate cortex (ACC).

These findings demonstrate that the effects of VR involve an objective modulation of the central nervous system, rather than merely a subjective perceptual response. Attention Restoration Theory and Autonomic Regulation: Nature-based VR content stimulates the parasympathetic response and suppresses sympathetic activity, thereby reducing heart rate, blood pressure, and cortisol levels. These physiological effects are supported by the findings of Arezoomand et al., (2025) and Hsieh & Li, (2022). Sense of Presence and Escapism: VR triggers a sense of presence the subjective feeling of being inside a virtual environment which facilitates psychological “escape” from the dialysis room. This mechanism reduces anticipatory anxiety, as reported by Rodriguez de Galvis et al. [2], in which 83% of patients felt “transported” to a calming environment.

The reviewed “Variations in VR Interventions and Clinical Implications” identified two main modalities of VR interventions for hemodialysis patients: passive VR (visual distraction) and active VR (VR-based physical exercise). Passive VR (Visual Distraction):

This involves using 360° videos of natural landscapes or relaxing environments in which the patient acts as an observer. This modality offers the following advantages: (1) ease of implementation; (2) applicability during invasive procedures such as AVF puncture; (3) suitability for patients with physical or cognitive limitations; and (4) a low risk of motion sickness. Studies on passive VR (Arezoomand et al., 2025; de Galvis et al., 2025; Elghoul & Younes, 2025; Elzeky et al., 2024; Hsieh & Li, 2022) have proven effective in reducing acute procedural anxiety. Active VR (VR-Based Physical Exercise): Involves virtual physical activities (such as cycling or walking) using sensors or controllers. Its advantages include: (1) reducing sedentary behavior during dialysis; (2) improving physical capacity; and (3) providing a greater sense of agency. (Rogowski et al., 2026; Turoń-Skrzypińska et al., 2023) confirmed that active VR effectively reduces anxiety while improving physical fitness

CONCLUSION

This systematic review confirms the effectiveness of Virtual Reality as a nonpharmacological intervention for reducing anxiety in the hemodialysis population. Supported by neurophysiological mechanisms proven to modulate the perception of distress at the central nervous system level, VR has proven to be superior because it is non-invasive, safe, cost-effective, and capable of enhancing patients' sense of control during dialysis procedures.

Overall, VR plays an innovative role in the field of nephrology to sustainably improve patients' quality of life and psychological well-being. To strengthen this scientific evidence, further research with more robust designs including multicenter studies, long-term impact evaluations, and cost-effectiveness analyses is essential as a basis for developing standardized clinical practice guidelines.

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