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REVIEW
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Effectiveness of virtual reality on pain and anxiety, in patients undergoing hemodialysis: a systematic review and meta-analysis

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ABSTRACT

Introduction: Patients undergoing hemodialysis frequently experience recurrent procedural pain and anxiety, particularly during arteriovenous fistula cannulation. Virtual reality (VR) is a non-pharmacological intervention that may reduce symptom burden during hemodialysis, but its effectiveness in this population has not been comprehensively synthesized specifically on pain and anxiety. The objective was to evaluate the effectiveness of VR interventions on pain and anxiety in patients receiving hemodialysis.

Methods: This systematic review and meta-analysis were conducted in accordance with PRISMA 2020. Risk of bias was assessed with Cochrane RoB2. Certainty of evidence was graded using GRADE.

Results: Four RCTs met eligibility criteria. Three RCTs contributed extractable quantitative data for pain. VR reduced procedural pain compared with controls (VR n = 93; standard care n = 91) with a statistically significant overall effect in favor of VR (MD = −2.04 (95% CI −2.62 to −1.46), and with a strong overall test of effect (Z = 6.92, p < 0.00001). There was substantial heterogeneity ($\tau^2 = 0.18$; $\chi^2 = 7.33$, df = 2, p = 0.03; $I^2 = 73\%$), and the certainty of evidence was "moderate". For anxiety, pooled across 79 participants in the VR group and 86 in the standard care group in two RCTs, the overall estimate remains in favour of VR but is not statistically significant (SMD = −3.43, 95% CI −9.25 to 2.39; Z = 1.16, p = 0.25).

Conclusions: In hemodialysis patients, VR appears to meaningfully reduce procedural pain, especially during arteriovenous fistula cannulation. Larger, rigorous RCTs are needed.

Keywords: Anxiety, Arteriovenous fistula, Cannulation pain, Hemodialysis, Meta-analysis, Systematic review, Virtual reality

Introduction

Hemodialysis (HD) remains the most widely used kidney replacement therapy worldwide and is characterized by a high symptom burden that frequently includes recurrent procedural pain and anticipatory distress during treatment sessions (1-3). Repeated vascular access cannulation, often performed multiple times per week, represents a major source of pain, with evidence suggesting that a substantial proportion of patients experience clinically relevant discomfort during arteriovenous fistula (AVF) needle insertion (1,2). Pain during cannulation is not only a transient, unpleasant sensation but a repeated noxious experience that may amplify psychological distress, reduce patients' sense of control, and negatively shape the overall dialysis experience (2-4).

Anxiety is highly prevalent among adults receiving maintenance HD and is commonly triggered or exacerbated by invasive procedures such as AVF puncture, machine alarms, and the chronic uncertainty associated with end-stage kidney disease (2-4). Anxiety and pain are bidirectionally linked because higher anxiety states can increase pain perception through attentional and affective mechanisms, while repeated pain episodes can reinforce anticipatory anxiety and avoidance behaviors (2-4). This interplay has relevant clinical implications because persistent anxiety symptoms in HD populations have been associated with impaired quality of life, reduced adherence to prescribed regimens, and poorer health outcomes (3,4).

Despite the availability of topical anesthetics, analgesics and anxiolytic drugs and behavioral strategies, pain and anxiety remain incompletely controlled in routine clinical practice, supporting the need for safe and scalable non-pharmacologic

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interventions (1-4). Contemporary frameworks for chronic care management emphasize patient-centered approaches and the integration of supportive technologies to improve experience and engagement, including within nephrology services (9). Immersive and semi-immersive virtual reality (VR) has emerged as a promising adjunctive modality in this context, as it can provide multisensory distraction, enhance perceived "presence" in an alternative environment, and reduce attentional resources available for processing nociceptive inputs (5-7).

Beyond mechanistic plausibility, growing evidence across medical procedures supports the analgesic potential of VR, showing meaningful reductions in pain intensity compared with standard care, although heterogeneity exists across settings and devices (6,7). Systematic reviews and meta-analyses in procedural contexts report overall beneficial effects of immersive VR for pain reduction, suggesting that clinical implementation is increasingly feasible with modern head-mounted displays and standardized content (6,7).

In nephrology-related digital innovation, VR has been discussed as part of a broader transition toward technology-enabled supportive care models (8,9). Within the HD setting, recent randomized controlled trials (RCTs) have evaluated VR distraction during AVF cannulation, reporting reductions in pain intensity and, in some studies, lower anxiety levels compared with standard or routine care (10-13). However, the magnitude and consistency of these effects remain uncertain due to variation in study designs, VR content and immersion level, measurement tools, and timing of outcome assessment (10-13). Therefore, an updated systematic review and meta-analysis focusing specifically on pain and anxiety outcomes in adult HD patients is warranted to synthesize current RCT evidence, estimate pooled effects, and inform clinical practice (10-14).

Objective

To assess the effectiveness of VR on anxiety and pain in patients undergoing HD, and to provide evidence for decision-making in clinical practice.

Methods

This systematic review was conducted and reported according to the PRISMA 2020 statement (15). To evaluate risk of bias, we used Cochrane RoB 2 (16). Cochrane guidance for reporting and the Grading of Recommendations Assessment, Development and Evaluation methodology (GRADE) was used to structure synthesis and evidence grading (17,18). Review Manager software (RevMan, version 7.12.0) (19) was used to perform the meta-analysis.

Eligibility criteria

The inclusion criteria were: a) Population, adults (≥18 years) receiving haemodialysis; b) Study design, randomized controlled trials (parallel-group or cross-over RCTs); c) Intervention, any VR-based intervention (immersive or semi-immersive); d) Comparator, Standard care (SC); e) Outcomes, pain and anxiety; f) Language, English, Italian, French, Spanish, or Portuguese; g) Publication, Peer-reviewed journals. The exclusion criteria were: a) Articles without relevant descriptors in title or abstract; b) Studies with incomplete results or insufficient extractable quantitative data for synthesis; c) Trials in progress, protocols only, or registry-only records.

Search strategy

The search was performed in the following databases from January 2016 to January 2026: 1. PubMed/MEDLINE; 2. Web of Science; 3. Scopus; 4. CINAHL (EBSCO); 5. Cochrane Library. Search strategies were adapted for each database using controlled vocabulary (e.g., MeSH) and free-text terms. Reference lists of included studies and relevant reviews were also screened to identify additional eligible RCTs. The specific search strategies for the databases are illustrated in Table 1.

Selection process

Two reviewers independently screened titles and abstracts for eligibility. Potentially eligible articles underwent full-text review. Disagreements were resolved through consensus discussion. Data extracted included: Study characteristics (authors, year, country); Design (parallel or cross-over), setting; Sample size and participant demographics; VR intervention features (device, duration, session timing, content); Comparator details; Outcome measures and timepoints; Extractable outcome data for pain and anxiety (mean, SD, n).

Risk of bias assessment

We used Cochrane RoB 2 to evaluate risk of bias at the outcome level across five domains: randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of reported results (16). Judgments were "low risk", "some concerns", or "high risk".

Synthesis methods

All outcomes were continuous. Mean difference (MD) was used when the same scale assessed the outcome across trials. Standardized mean difference (SMD; Hedges g) was used when different scales assessed the outcome across trials. The fixed-effects model was used when heterogeneity was low (I^2 <50%). A random-effects model was used when heterogeneity was high ($I^2 \geq 50\%$). Heterogeneity was assessed with I^2 and Cochran Q. The pooled effect was presented by generating forest plots. Sensitivity analyses were planned but limited by the small number of trials per outcome. Funnel plots were planned for outcomes; however, the available evidence base was too small for meaningful asymmetry assessment.

Certainty of evidence

Certainty for each outcome was evaluated using the following GRADE domains: a. risk of bias; b. inconsistency; c. indirectness; d. imprecision; e. publication bias. Certainty for each outcome was rated as high, moderate, low, or very low, using current Cochrane guidance and contemporary GRADE methodological papers (17,18).

TABLE 1 - Search strategy

Database	Search strategy
PubMed/MEDLINE	((“Virtual Reality”[MeSH] OR “virtual reality”[tiab] OR VR[tiab] OR “immersive virtual reality”[tiab] OR “virtual reality headset*”[tiab] OR “head-mounted display*”[tiab]) AND (“Renal Dialysis”[MeSH] OR hemodialysis[tiab] OR haemodialysis[tiab] OR dialysis[tiab]) AND (randomized controlled trial[pt] OR controlled clinical trial[pt] OR random*[tiab] OR randomised[tiab] OR trial[tiab] OR RCT[tiab])) NOT (animals[mh] NOT humans[mh])
Web of Science Core Collection	TS= (“virtual reality” OR VR OR “immersive virtual reality” OR “virtual reality headset*” OR “head-mounted display*”) AND TS= (haemodialysis OR hemodialysis OR dialysis) AND TS= (random* OR randomized OR randomized OR trial OR “randomized controlled trial” OR RCT)
Scopus	TITLE-ABS-KEY (“virtual reality” OR VR OR “immersive virtual reality” OR “virtual reality headset*” OR “head mounted display*” OR “head-mounted display*” OR HMD) AND TITLE-ABS-KEY (hemodialysis OR haemodialysis OR dialysis) AND TITLE-ABS-KEY (random* OR randomized OR randomized OR trial OR rct OR “randomized controlled trial”)
CINAHL (EBSCOhost)	((MH “Virtual Reality+”) OR TI (“virtual reality” OR VR OR “immersive virtual reality” OR “virtual reality headset*” OR “head-mounted display*”) OR AB (“virtual reality” OR VR OR “immersive virtual reality” OR “virtual reality headset*” OR “head-mounted display*”)) AND ((MH “Hemodialysis+”) OR (MH “Renal Dialysis+”) OR TI (hemodialysis OR haemodialysis OR dialysis) OR AB (hemodialysis OR haemodialysis OR dialysis)) AND ((MH “Randomized Controlled Trials+”) OR TI (random* OR randomized OR randomized OR trial OR rct) OR AB (random* OR randomized OR randomized OR trial OR rct))
Cochrane Library (CENTRAL)	(MeSH descriptor: [Virtual Reality] explode all trees) AND (MeSH descriptor: [Renal Dialysis] explode all trees) OR ((“virtual reality” OR VR OR “immersive virtual reality” OR “head-mounted display*”):ti,ab,kw AND (hemodialysis OR haemodialysis OR dialysis):ti,ab,kw)

Results

Study selection

Across databases, a body of literature on VR in dialysis was identified, but most records were observational, qualitative, non-randomized, or focused on outcomes other than pain and anxiety. After full-text assessment, four RCTs met eligibility criteria for inclusion in the systematic review. Of these, three trials contributed extractable data for pain meta-analysis (11-13), and two trials contributed extractable data for anxiety meta-analysis (13,20). Figure 1 shows the flow diagram.

Characteristics of included studies

All studies included were published between 2023 and 2026. Two trials were conducted in Türkiye, one in Poland, and one in Iran. All studies were parallel RCTs. Sample sizes ranged from 47 to 85 patients, and the total number of participants was 240. The mean sample age was 57.8 (SD = 16.1) years. Collectively, the trials demonstrate two clinically distinct VR interventions: 1. Procedural VR distraction targeting AVF cannulation pain and associated distress (20-22), and therapeutic VR exercise targeting broader psychosocial outcomes during the HD course (20). Table 2 shows the characteristics of the included studies.

Risk of bias

Using RoB2, trials generally showed adequate randomization procedures, but common limitations included: a. Limited blinding of participants and personnel due to the nature of the intervention; b. Possible performance bias from differential attention or expectancy effects; c. Potential measurement bias when outcomes were self-reported immediately after intervention without assessor blinding. Figure 2 shows the risk of bias.

Meta-analysis findings

Pain

Three RCTs reported pain using a 0–10 scale and provided extractable means and SD (11-13). Across all included trials, the effect estimates consistently favour VR, indicating lower pain scores in the VR groups: Güler et al. (13) (MD = −2.10 (95% CI −2.47 to −1.73), Namaznia et al. (10) (MD = −2.50 (95% CI −2.93 to −2.07), and Elmali and Aksoy (11) (MD = −1.11 (95% CI −2.04 to −0.18). Pooling the data (VR n = 93; standard care n = 91) yields a statistically significant overall effect in favor of VR (MD = −2.04 (95% CI −2.62 to −1.46), with a strong overall test of effect ($Z = 6.92$, $p < 0.00001$). This suggests that, on average, VR is associated, in the units of the original pain scale used across studies, with an approximately 2-point reduction in pain. There was substantial between-study heterogeneity ($\tau^2 = 0.18$; $\chi^2 = 7.33$, $df = 2$, $p = 0.03$; $I^2 = 73\%$), indicating that the magnitude of benefit varies meaningfully across trials. The smaller effect in Elmali and Aksoy (11) compared with the other two studies may reflect differences in patient populations, pain etiology, VR protocols, co-interventions, or the timing of outcome assessment. Figure 3 shows the forest plot for VR versus SC on pain.

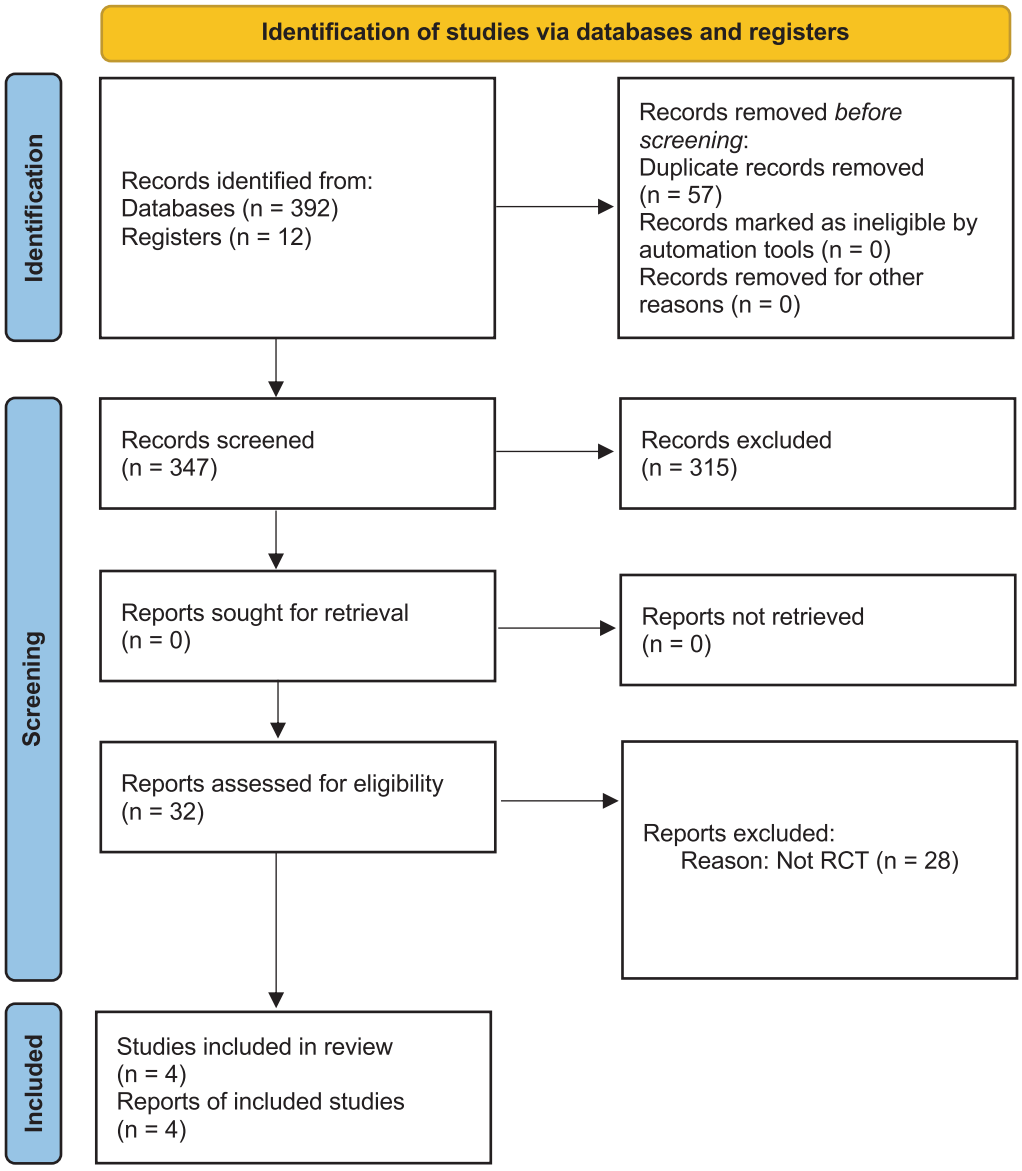

FIGURE 1 -Flow diagram.

TABLE 2 - Characteristics of included studies

Study	Country	Design	Sample	VR timing and content	Comparator	Measures
Elmali Şimşek & Aksoy 2024	Türkiye	Parallel RCT	n = 47	~5 min VR video during AVF cannulation	Standard care	Pain VAS 0-10
Namazinia et al. 2025	Iran	Parallel RCT	n = 60	VR distraction during AVF needle insertion	Standard care	Pain VAS 0-10
Güler et al. 2026	Türkiye	Parallel RCT	n = 48	VR video streaming during AVF cannulation	Standard care	Pain VAS 0-10 Anxiety STAI
Turoń-Skrzypińska et al. 2023	Poland	Parallel RCT	n = 85	VR-based intradialytic exercise program	Standard care	Anxiety GAD-7

Anxiety

Two RCTs contributed extractable anxiety data but differed substantially in both measurement instruments (STAI, GAD-7) (13, 10). Random-effects meta-analysis was used due to high heterogeneity. Both studies point in the direction of lower anxiety with VR. Güler et al. (13) reported an extremely large benefit (SMD = −6.42, 95% CI −7.53 to −5.31), whereas Turoń-Skrzypińska et al. (20) showed a small effect (SMD = −0.46, 95% CI −0.92 to −0.05). When pooled across 79 participants in the VR group and 86 in the SC group, the overall estimate remains in favour of VR but is not statistically significant (SMD = −3.43, 95% CI −9.25 to 2.39; Z = 1.16, p = 0.25), because the confidence interval crosses the null effect. Importantly, between-study inconsistency is extreme ($\tau^2 = 17.44$; $\chi^2 = 95.30$, df = 1, $p < 0.00001$; $I^2 = 99\%$), indicating that the study results are highly discordant and that the pooled effect is unstable. Figure 4 shows the forest plot for VR versus SC on anxiety.

Publication bias

For pain, all points lie on the negative side of the effect axis, indicating that all included trials favor the VR intervention. While this could reflect a true effect, it may also be compatible with selective non-publication of null or positive studies: the funnel plot alone cannot distinguish these explanations with so few studies. Figure 5 shows the funnel plot for pain.

For anxiety, the two points show marked dispersion, because one study is relatively precise with an effect near the null, whereas the less precise study shows a much larger negative effect. This configuration can be compatible with small-study effects. With so few studies, statistical tests for asymmetry (e.g., Egger's test) are not appropriate and would be unreliable; consequently, any statement about publication bias should be framed as speculative. Figure 6 shows the funnel plot for anxiety.

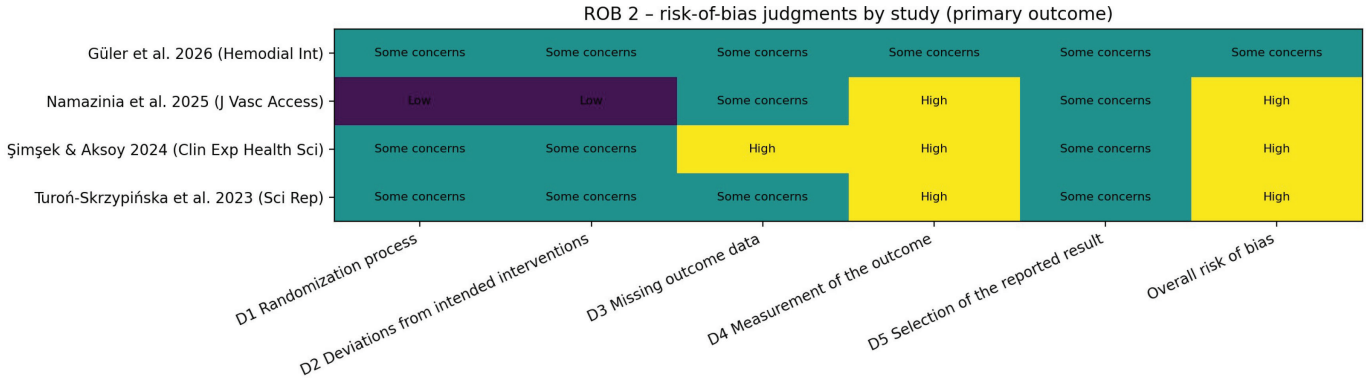

FIGURE 2 - Risk of bias.

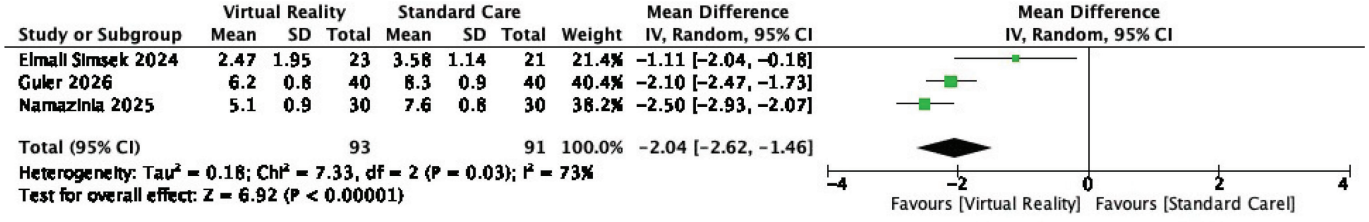

FIGURE 3 -Forest plot VR versus SC on pain.

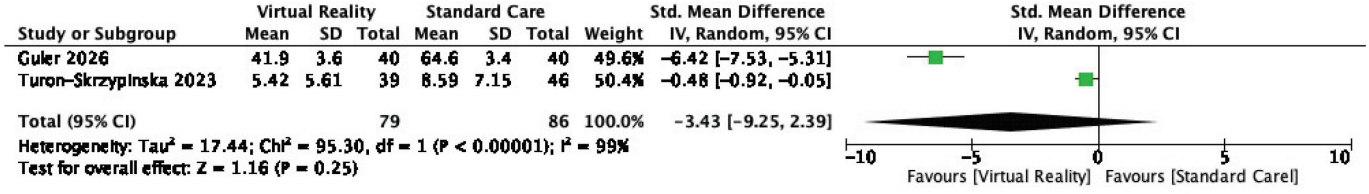

FIGURE 4 - Forest plot VR versus SC on anxiety.

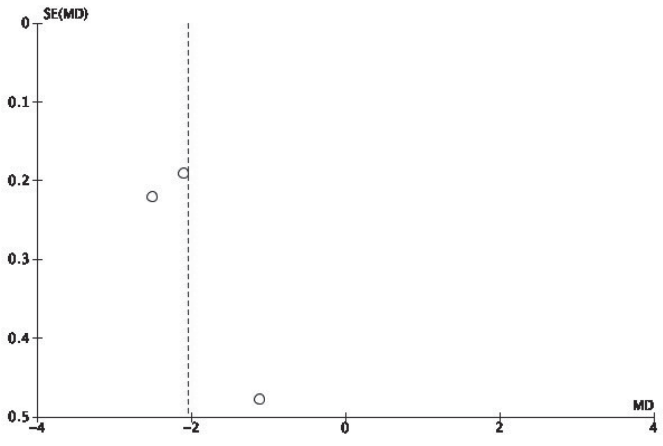

FIGURE 5 - Funnel plot for pain.

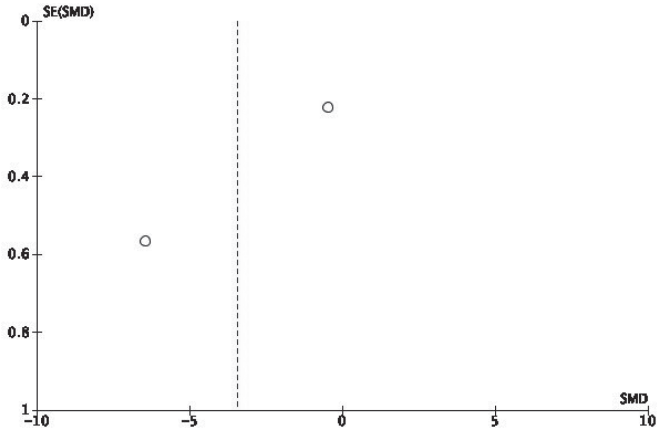

FIGURE 6 - Funnel plot for anxiety.

Certainty of evidence

For the outcome pain, the certainty of evidence was "moderate". Downgraded for inconsistency (I^2 > 50%) and some concerns in risk of bias, but supported by consistent direction of effect and clinically meaningful magnitude. For the outcome anxiety, the certainty of evidence was "very low." Downgraded for inconsistency due to very high heterogeneity, indirectness due to different constructs and instruments, and imprecision due to wide CI and small number of trials. Table 3 shows the GRADE Evidence Profile.

Discussion

This systematic review and meta-analysis aimed to assess the effectiveness of VR on anxiety and pain in patients undergoing HD, and to provide evidence for decision-making in clinical practice. Our findings showed that VR was associated with a statistically significant reduction in cannulation-related pain compared with standard care, with an average decrease of approximately two points on a 0-10 scale. This magnitude is consistent with the broader procedural literature in which immersive VR provides clinically relevant analgesia, although pooled effects commonly show substantial heterogeneity across indications and protocols (21-23). The observed pain reduction is likely to be clinically meaningful in routine dialysis practice. Data-driven thresholds suggest that a 1-2 point change on an 11-point numerical rating scale may correspond to a patient-perceived important improvement, and consensus recommendations emphasize interpreting analgesic effects using both statistical and clinical benchmarks (24-26). Accordingly, VR may represent a non-pharmacological integrative intervention that could be added to standard care during arteriovenous fistula cannulation, especially in patients with recurrent needle-related pain (25,26). Heterogeneity in pain effects across trials is expected and mirrors findings from umbrella reviews and meta-regression analyses, which identify VR characteristics, such as immersion level, interactivity, content, and clinical context, as key modifiers of analgesic benefit (22,23). Experimental studies also support a mechanistic role of "presence," showing that greater immersion can increase the magnitude of VR analgesia, which may partly explain variability between devices and audiovisual content used during cannulation (24). These considerations suggest that standardizing the VR dose, duration, timing relative to puncture, content, and level of interactivity may improve reproducibility and optimize clinical effects (23,24).

In contrast, evidence for anxiety reduction in hemodialysis remains uncertain in our pooled analysis, because of extreme inconsistency between studies and differences in constructs and measurement instruments. In other procedural contexts, meta-analyses generally report small-to-moderate reductions in preoperative or peri-procedural anxiety with VR, with more consistent benefits in pediatric populations and variable

TABLE 3 - Evidence Profile

Outcome	No. of studies (design)	Participants	Risk of Bias	Inconsistency	Indirectness	Imprecision	Publication bias	Relative effect	Absolute effect	Certainty
Pain	3 RCTs	187	Serious	Serious I^2 = 73%	Not serious	Not serious	Undetected/ uncertain (a few studies)	MD −2.04 (95% CI −2.62 to −1.45)	2.04 points lower on 0–10 VAS	MODERATE (⊕⊕⊕◯)
Anxiety	2 RCTs	165	Serious	Very serious I^2 = 99%	Serious different scales/ constructs	Serious Very wide CI	Undetected/ uncertain (a few studies)	SMD −3.43 (95% CI −9.25 to 2.39)	Not estimable (different instruments)	VERY LOW (⊕◯◯◯)

effects in adults (27,28). A review similarly concluded that VR could reduce distress-related outcomes in several procedural settings but highlighted major heterogeneity driven by population, comparator intensity, and outcome timing (22). For the hemodialysis setting, the discrepant anxiety effects observed across trials are plausibly explained by differences in intervention goals: a) acute distraction during cannulation versus longer-term intradialytic programs; b) timing of assessment, as anticipatory versus post-procedural, and c) outcome selection, as state anxiety versus generalized anxiety measures. These sources of indirectness align with prior meta-analytic observations that anxiety outcomes are particularly sensitive to measurement and timing, and that heterogeneity can obscure modest but clinically relevant effects (22,28). Future hemodialysis trials should therefore adopt standardized procedural anxiety measures and consistent timepoints, such as pre-cannulation anticipatory anxiety and immediate post-cannulation state anxiety, to support comparability and pooling (28).

Regarding the neurological mechanisms of the VR on outcome pain, a first aspect is the attentional competition and pain-matrix down-modulation. Pain is intrinsically attention-demanding and competes with ongoing cognitive goals, such that allocating limited attentional resources away from noxious input reduces the salience and interruptive function of pain (29). VR operationalizes this principle by imposing high perceptual and cognitive load as visual, auditory, vestibular and proprioceptive cues, and task demands, thereby diminishing central processing of nociceptive signals (30). Functional neuroimaging provides mechanistic support; in fact, during VR distraction, reduced pain ratings are accompanied by decreased activation in canonical pain-related regions, including anterior cingulate cortex, insula, thalamus, and primary/secondary somatosensory cortices, consistent with top–down modulation of nociceptive processing (31). A second factor is the presence and immersion as a dose-like determinant of analgesia. The magnitude of VR analgesia is not merely distraction, but scales with presence, the subjective sense of "being there", suggesting that stronger immersion more effectively recruits attentional and affective systems away from pain (24). Accordingly, manipulating immersive features as higher-quality head-mounted displays that enhance the field of view, resolution, and sensorimotor contingencies, increases VR analgesic effects, supporting a technology-dependent gradient in central modulation (32). Interactivity further augments analgesia, likely by increasing agency, engagement, and continuous sensorimotor prediction, thereby strengthening competition with pain processing (33).

Regarding the psychological mechanisms, threat appraisal, control, and affect regulation are important variables. Beyond attentional diversion, VR changes the meaning and emotional context of the dialysis procedure by reducing perceived threat and fostering a sense of situational control, two factors tightly coupled to pain unpleasantness and anxiety severity (34). In hemodialysis settings, immersive "escape" experiences have been associated with lower pain and anxiety ratings and higher satisfaction, consistent with affective buffering and improved tolerability of repeated procedures (10). VR can also deliver mindfulness-based content that trains nonjudgmental attention to internal states, which may reduce catastrophic interpretations of bodily sensations and attenuate distress amplification of pain and anxiety (35). In hemodialysis patients, mindfulness-oriented VR has been reported as acceptable and safe, supporting the feasibility of targeting experiential avoidance and distress reactivity in-session during dialysis (36).

Somatic and autonomic mechanisms are activated by VR through an autonomic down-regulation and stress physiology coupling. Pain and anxiety are partly embodied as sympathetic arousal characterized by tachycardia, blood pressure elevation and muscle tension, which can feed back to intensify subjective distress (37). VR relaxation environments have been linked to measurable autonomic shifts, often indexed by heart-rate variability, suggesting enhanced parasympathetic activity and reduced physiological stress load (38). In hemodialysis cannulation, VR distraction has been associated not only with lower pain and anxiety ratings but also with reduced systolic blood pressure and heart rate, consistent with central-to-peripheral stress attenuation during a repeated noxious event (12).

For anxiety-specific mechanisms, an evidence-based pathway is VR exposure therapy (VRET), where repeated, controlled exposure to feared cues promotes extinction learning and inhibitory updating of threat expectancies (39). Evidence across anxiety-related disorders supports clinically meaningful symptom reductions with VRET, consistent with fear network engagement under safe conditions (40). In hemodialysis, VR exposure-based educational simulation of peri-procedural contexts has been associated with reduced state and trait anxiety, plausibly by decreasing uncertainty, normalizing procedural cues, and strengthening coping expectancies (41).

Across included trials, serious VR-related adverse events were not reported. Transient cybersickness (e.g., dizziness or nausea) remains a recognized risk in immersive applications and warrants routine screening and monitoring (42,43). Implementation in dialysis units should include brief eligibility checks, as history of motion sickness, severe visual impairment, supervised use during needle insertion, and infection control protocols for shared headsets (22,23). From an implementation perspective, clarifying which VR components drive benefit, immersion, interactivity, and content, and aligning them with the cannulation workflow, may facilitate scalability without increasing staff workload (23).

Limitations

This systematic review has these limitations: 1) a small number of RCTs; 2) small sample sizes; 3) heterogeneity in VR content, modalities, dose, and delivery timing; 4) limited blinding feasibility and risk of expectancy effects; 5) no data are currently available to determine whether the effectiveness of VR may decrease with long-term use. Future dialysis VR research should prioritize: a) multicentre RCTs with robust allocation concealment and standardized reporting; b) common outcome sets for pain and procedural anxiety, including consistent timepoints; c) non-pharmacological control designs to minimize performance bias; d) evaluation of cost-effectiveness, staff workload impact, and sustained acceptability; and e) exploration of individual moderators.

Conclusions

In adults receiving hemodialysis, VR appears to provide a clinically meaningful reduction in arteriovenous fistula cannulation pain compared with standard care, supporting VR as a feasible, personalized, non-pharmacological adjunctive strategy for symptom control during repeated procedures. The certainty of evidence was "moderate". Evidence for anxiety reduction is promising but remains inconsistent in the current hemodialysis trials, likely due to substantial clinical and methodological heterogeneity and non-uniform anxiety constructs and measures. The certainty of evidence was "very low".

Disclosures

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Authors' contribution: Burrai F, Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Project Administration, Resources, Software, Supervision, Validation, Visualization, Writing – Original Draft, Writing – Review & Editing; Sotgia M, Supervision, Validation; Giaconi GL, Supervision, Validation; Senatore M, Supervision, Validation.

Data availability statement (DASs): Data sharing not applicable.

References

1. Sharifnia AM, Chu G, Manias E, et al. Comparative analysis of the effectiveness of pharmacological and non-pharmacological interventions on arteriovenous fistula cannulation-related pain in patients receiving hemodialysis: a systematic review and network meta-analysis. Int J Nurs Stud. 2025;169:105123. CrossRef PubMed
2. Ibrahim MB, Badawi SEAB, Alameri RA. Assessment of pain and anxiety during arteriovenous fistula cannulation among hemodialysis patients: a cross-sectional study in Saudi Arabia. J Multidiscip Healthc. 2022; 15:705-718. CrossRef
3. Semaan V, Noureddine S, Farhood L. Prevalence of depression and anxiety in end-stage renal disease: a cross-sectional study. J Psychosom Res. 2018;114:80-86. CrossRef
4. Bakhsh AM, Mahallawi WH. Psychological effects of hemodialysis on patients with chronic kidney disease: current evidence and clinical implications. J Clin Med. 2025;14(20):7136. CrossRef PubMed
5. Dreesmann NJ, Su H, Thompson HJ. A systematic review of virtual reality therapeutics for acute pain management. Pain Manag Nurs. 2022;23(5):672-681. CrossRef PubMed
6. Teh JJ, Pascoe DJ, Hafeji S, et al. Efficacy of virtual reality for pain relief in medical procedures: a systematic review and meta-analysis. BMC Med. 2024;22(1):64. CrossRef PubMed
7. Brown P, Powell W, Dansey N, et al. Virtual reality as a pain distraction modality for experimentally induced pain in a chronic pain population: an exploratory study. Cyberpsychol Behav Soc Netw. 2022;25(1):66-71. CrossRef PubMed
8. Burrai F, Micheluzzi V, Apuzzo L. Innovation governance: digital health, mobile health, big data, virtual reality. G Clin Nefrol Dial. 2021;33(1):42-50. CrossRef
9. Apuzzo L, Iodice M, Gambella M, et al. Chronic care model. G Clin Nefrol Dial. 2021;33(1):141-145. CrossRef
10. Namazinia M, Mohajer S, Abbaspour S, et al. Effects of virtual reality on pain induced by arteriovenous fistula needle insertion in patients undergoing hemodialysis: a randomized clinical trial. J Vasc Access. 2025;26(2):531-539. CrossRef PubMed
11. Elmalı Şimşek H, Aksoy M. The effect of using virtual reality glasses on pain during fistula cannulation in hemodialysis patients: a randomized controlled trial. Clin Exp Health Sci. 2024;14(3):821-826. CrossRef
12. Elzeky ME, Salameh B, Reshia FAA, et al. The effect of virtual reality distraction on haemodialysis patients' pain and anxiety during arteriovenous fistula puncture: a randomized controlled trial. J Res Nurs. 2024;29(6):421-434. CrossRef PubMed
13. Güler S, Öztürk S, Şahan S, et al. The effect of video streaming with virtual reality glasses during arteriovenous fistula needle insertion on pain and anxiety of individuals undergoing hemodialysis treatment. Hemodial Int. 2026;30(1):37-45. CrossRef PubMed
14. Anderson N. Commentary: the effect of virtual reality distraction on haemodialysis patients' pain and anxiety during arteriovenous fistula puncture: a randomized controlled trial. J Res Nurs. 2024;29(6):435-437. CrossRef PubMed
15. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372(71):n71. CrossRef PubMed
16. Sterne JAC, Savović J, Page MJ, et al. RoB 2: a revised tool for assessing risk of bias in randomized trials. BMJ. 2019;366: l4898. CrossRef
17. Higgins JPT, Thomas J, Chandler J, et al, eds. Cochrane Handbook for Systematic Reviews of Interventions. Version 6.5 (updated August 2024). Cochrane; 2024.
18. Brożek JL, Canelo-Aybar C, Akl EA, et al.; GRADE Working Group. GRADE Guidelines 30: the GRADE approach to assessing the certainty of modeled evidence—an overview in the context of health decision-making. J Clin Epidemiol. 2021;129: 138-150. CrossRef PubMed
19. Manager R. (RevMan). Version 7.12.0. The Cochrane Collaboration; 2024. Online revman.cochrane.org (Accessed February 2026)
20. Turoń-Skrzypińska A, Tomska N, Mosiejczuk H, et al. Impact of virtual reality exercises on anxiety and depression in hemodialysis. Sci Rep. 2023;13(1):12435. CrossRef PubMed
21. Davison SN. Mitigating pain in people undergoing hemodialysis. Clin J Am Soc Nephrol. 2022;17(9):1275-1277. CrossRef PubMed
22. Viderman D, Tapinova K, Dossov M, et al. Virtual reality for pain management: an umbrella review. Front Med (Lausanne). 2023;10:1203670. CrossRef PubMed
23. Lier EJ, de Vries M, Steggink EM, et al. Effect modifiers of virtual reality in pain management: a systematic review and meta-regression analysis. Pain. 2023;164(8):1658-1665. CrossRef PubMed
24. Hoffman HG, Sharar SR, Coda B, et al. Manipulating presence influences the magnitude of virtual reality analgesia. Pain. 2004;111(1-2):162-168. CrossRef PubMed
25. Farrar JT, Young JP Jr, LaMoreaux L, et al. Clinical importance of changes in chronic pain intensity measured on an 11-point numerical pain rating scale. Pain. 2001;94(2):149-158. CrossRef PubMed
26. Dworkin RH, Turk DC, Wyrwich KW, et al. Interpreting the clinical importance of treatment outcomes in chronic pain clinical trials: IMMPACT recommendations. J Pain. 2008;9(2): 105-121. CrossRef PubMed
27. Tas FQ, van Eijk CAM, Staals LM, et al. Virtual reality in pediatrics, effects on pain and anxiety: A systematic review and meta-analysis update. Paediatr Anaesth. 2022;32(12): 1292-1304. CrossRef PubMed

28. Koo CH, Park JW, Ryu JH, et al. The effect of virtual reality on preoperative anxiety: a meta-analysis of randomized controlled trials. J Clin Med. 2020;9(10):3151. CrossRef PubMed
29. Eccleston C, Crombez G. Pain demands attention: a cognitive-affective model of the interruptive function of pain. Psychol Bull. 1999;125(3):356-366. CrossRef PubMed
30. Li A, Montaño Z, Chen VJ, et al. Virtual reality and pain management: current trends and future directions. Pain Manag. 2011;1(2):147-157. CrossRef PubMed
31. Hoffman HG, Richards TL, Coda B, et al. Modulation of thermal pain-related brain activity with virtual reality: evidence from fMRI. Neuroreport. 2004;15(8):1245-1248. CrossRef PubMed
32. Hoffman HG, Seibel EJ, Richards TL, et al. Virtual reality helmet display quality influences the magnitude of virtual reality analgesia. J Pain. 2006;7(11):843-850. CrossRef PubMed
33. Dahlquist LM, McKenna KD, Jones KK, et al. Active and passive distraction using a head-mounted display helmet: effects on cold pressor pain in children. Health Psychol. 2007;26(6): 794-801. CrossRef PubMed
34. Löffler M, Kamping S, Brunner M, et al. Impact of controllability on pain and suffering. Pain Rep. 2018;3(6):e 694. CrossRef
35. Dorado K, Schreiber KL, Koulouris A, et al. Interactive effects of pain catastrophizing and mindfulness on pain intensity in women with fibromyalgia. Health Psychol Open. 2018;5(2):205 5102918807406. CrossRef PubMed
36. Hernandez R, Burrows B, Browning MHEM, et al. Mindfulness-based virtual reality intervention in hemodialysis patients: a pilot study on end-user perceptions and safety. Kidney360. 2021;2(3):435-444. CrossRef PubMed
37. Rhudy JL, Meagher MW. Fear and anxiety: divergent effects on human pain thresholds. Pain. 2000;84(1):65-75. CrossRef PubMed
38. Gaertner RJ, Kossmann KE, Benz ABE et al. Relaxing effects of virtual environments on the autonomic nervous system indicated by heart rate variability: a systematic review. J Environ Psychol. 2023;88:102035. CrossRef
39. Maples-Keller JL, Yasinski C, Manjin N, et al. Virtual reality-enhanced extinction of phobias and post-traumatic stress. Neurotherapeutics. 2017;14(3):554-563. CrossRef PubMed
40. Carl E, Stein AT, Levihn-Coon A, et al. Virtual reality exposure therapy for anxiety and related disorders: A meta-analysis of randomized controlled trials. J Anxiety Disord. 2019;61: 27-36. CrossRef PubMed
41. Hosseini T, Hooshmandja M, Noaparast M, et al. Virtual reality exposure therapy to decrease anxiety before surgical invasive procedures in hemodialysis patients: an interventional study. BMC Nephrol. 2024;25(1):30. CrossRef PubMed
42. Burrai F, Ortu S, Marinucci M, et al. Effectiveness of immersive virtual reality in people with cancer undergoing antiblastic therapy: a randomized controlled trial. Semin Oncol Nurs. 2023;39(4):151470. CrossRef PubMed
43. Burrai F, Othman S, Brioni E, et al. Virtual reality in dialysis: a new perspective on care. J Ren Care. 2018;44(4):195-196. CrossRef PubMed