

# Perioperative virtual reality and neuropsychiatric outcomes: a scoping review

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# Perioperative virtual reality and neuropsychiatric outcomes: a scoping review

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## Abstract

**Background:** Surgical procedures in older populations carry significant risks, including increased perioperative complications such as anxiety and delirium, which adversely affect outcomes and patient satisfaction.

**Objective:** We sought to evaluate the efficacy and methods of virtual reality (VR) interventions in reducing perioperative anxiety and delirium in a scoping review.

**Methods:** Searches were performed in Embase and PubMed from 2020 to 2023 for studies involving VR in adult surgical patients, focusing on anxiety, pain, and delirium outcomes.

**Results:** Fifteen studies involving 1,313 patients were included, predominantly randomized controlled trials from various countries. No study directly evaluated VR's effect on delirium, but several showed VR's potential in reducing perioperative anxiety and pain, with mixed efficacy results. VR interventions varied in content, technological sophistication, frequency, and duration. Quality assessment indicated limitations due to unblinded designs.

**Conclusions:** VR shows promise in reducing perioperative anxiety, with potential implications for delirium prevention. However, the effectiveness varies, and further research is needed to refine VR interventions and explore their role in preventing delirium.

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## Original Manuscript

## Perioperative virtual reality and neuropsychiatric outcomes: a scoping review

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### Abstract

**Background:** Surgical procedures in older populations carry significant risks, including increased perioperative complications such as anxiety and delirium, which adversely affect outcomes and patient satisfaction. We sought to evaluate the efficacy and methods of virtual reality (VR) interventions in reducing perioperative anxiety and delirium in a scoping review.

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**Conclusions:** VR shows promise in reducing perioperative anxiety, with potential implications for delirium prevention. However, the effectiveness varies, and further research is needed to refine VR interventions and explore their role in preventing delirium.

**Keywords:** virtual reality, immersion therapy, perioperative, surgery, delirium, anxiety, pain

## Introduction

Surgical procedures carry many risks, especially in older populations. Major concerns include the increased risk of perioperative complications like anxiety and delirium. Anxiety occurs in 48% of surgical patients, and delirium incidence ranges from 9 to 87% based on patient risk factors, institutional protocols, and procedure type (1,2). These complications are associated with increased rates of 30-day readmission, postoperative nausea and vomiting, and prolonged length of stay (3,4). Pre- and postoperative anxiety and pain also adversely impact patient satisfaction and willingness to undergo elective procedures (5).

Pharmacologic interventions are effective in reducing these complications but are not without disadvantages, including adverse effects like mucosal membrane irritation, cardiopulmonary depression, and oversedation. Current nonpharmacologic methods to reduce perioperative anxiety include cognitive behavioral therapy (CBT), music therapy, audiovisual distraction tools, meditation, guided imagery relaxation therapy, and hypnosis (6). These interventions improve preoperative anxiety across multiple randomized clinical trials and procedure types (7–9). Music therapy has also been applied to prevent delirium, decreasing incidence through both music listening and credentialed music therapists (10). Audiovisual relaxation has been employed in agitated delirium to effectively decrease agitation (11). Multicomponent strategies incorporating physical training, reorientation protocol, early mobilization, geriatric consultation, medication monitoring, nutrition, regular circadian support, bright light therapy, and music therapy maintain the greatest efficacy in prevention and treatment of postoperative delirium (12).

A novel technology with potential applications for perioperative anxiolysis and delirium prevention is virtual reality (VR). Because of its capability for greater immersion in simulated environments, VR may augment the effectiveness of music and audiovisual relaxation therapies that have been previously utilized in anxiety and delirium prevention. Perioperative VR used to obtain informed consent improved patient satisfaction and objective understanding of their procedures and was well-tolerated (13). As an anxiolytic tool for pediatric patients, VR has few self-limited adverse effects and effectively attenuates anxiety and fear (14). VR has also shown the potential to reduce anxiety in minor procedures, including colonoscopies, dental procedures, burn wound dressing changes, and endoscopies (15).

Although VR has been employed periprocedurally, trials evaluating its efficacy in adults to reduce anxiety and delirium are only just emerging. Further, VR technologies and the capabilities of hardware and audiovisual distraction software are ever evolving. A review of perioperative VR trials identified multiple different types of VR hardware, audiovisual immersive experiences, and implementation patterns. Given the rapidly evolving nature of this nascent field, we conducted a scoping review analyzing the methods of VR delivery, summarizing the efficacy of VR anxiolysis and delirium prevention, and examining the feasibility of VR implementation perioperatively.

## Methods

### Protocol

The protocol for search strategy, selection criteria, and data extraction was created prior to literature search and data extraction and is adherent to the Joanna Briggs Institute methodology for scoping reviews, as well as the Preferred Reporting Items for Systematic Reviews extension for Scoping Reviews (16). This review protocol was not registered. Because we reviewed existing literature, this study did not require institutional review board approval or written informed consent.

## Search strategy and selection criteria

We searched for studies in Embase and PubMed for articles published from January 1, 2020 to December 31, 2023. Each database was searched for keywords relating to virtual reality, surgical procedures, and neuropsychiatric outcomes including anxiety, pain, and delirium. For example, in PubMed, the full search criteria used were: ("Virtual Reality"[Mesh] OR "Virtual Reality" OR "VR") AND ("surger\*" OR "operat\*" OR "procedur\*" OR "postop\*") AND ("anxiety" OR "delirium" OR "pain") AND "Adult"[Mesh], and these search criteria were reformatted for Embase. The last search occurred on 12/5/2023.

## Eligibility criteria

Studies were required to meet the following criteria: published as a full paper in a peer-reviewed journal or as a preprint; be written in English; study population includes adults; be published in a journal accessible to the authors' institution; be an observational study or randomized controlled trial, and involve anxiety or delirium as a primary or secondary outcome. Case reports and series were excluded, as such studies are unsuited to measure efficacy. Conference abstracts/proceedings, literature reviews, comments, letters to the editor, simulation studies, studies not in English, and short communications were excluded. Articles that primarily occurred in specific patient populations (i.e. pediatric or racial constraints) or minor procedures only requiring local anesthesia, and not regional or general anesthesia, were excluded. Articles that investigated virtual reality in conjunction with interventions beyond routine care were excluded. Studies involving augmented reality (in which a headset provides audiovisual stimulation but the "real" environment is still visible) or other immersive interventions that do not involve full virtual reality immersion were excluded to keep the study reasonable in scope.

## Screening and abstraction process

One reviewer performed screening and abstraction using an online systematic review software tool (Covidence; Melbourne, Australia; [www.covidence.org](http://www.covidence.org)). Data were abstracted for the article's title, publication year, first author, start date, end date, patient age range, percentage male population, inclusion criteria, exclusion criteria, type of VR implemented, duration and frequency of the VR intervention, total number of participants, care received by the control group, types of surgeries and anesthesia, primary and secondary outcomes, key findings, and statistical significance of key findings. If age range was not available, then mean/median age of participants was extracted. Quality assessment for randomized controlled trials was performed using the Cochrane Risk of Bias 2 tool and the Newcastle-Ottawa Scale tool was used for observational studies (17,18)

## Results

### Study characteristics

*Figure 1* presents the study selection process. From an initial 440 records identified through database searches (305 from Embase, 135 from PubMed), 162 were removed after deduplication and eligibility checks, leaving 278 for screening. Out of these, 49 full-text articles were assessed for eligibility, with 34 subsequently excluded based on predefined criteria. One study was included manually after the search. The final review included 15 studies encompassing 1,313 patients (4,19–33).

Three studies were published in 2023, 5 in 2022, 3 in 2021, and 4 in 2020 (*Table 1*). The most common country of study completion was the United States (4 articles), while the remainder were conducted across multiple other countries. Fourteen studies were randomized controlled trials, and

one was a cohort study (22). Importantly, none of the articles evaluated VR's effects on delirium. Twelve articles examined VR for anxiolysis, and the remaining 3 evaluated VR for rehabilitation and pain reduction (22,25,31). Because of the absence of articles directly assessing VR for delirium prevention, these three articles were included despite their misalignment with the initial inclusion criteria for the potential for reducing delirium risk factors (pain and early mobility) (12). Age ranges were similar across studies, with all but 2 articles demonstrating a mean age in the 50s or 60s. Gender distribution varied amongst articles, with some populations comprising almost entirely males and others entirely females (21,28,31). The VR interventions comprised a single session in 10 studies, 2 sessions in 1 study, and multiple sessions in 4 studies. VR session durations were < 30 minutes in 9 studies, with the longest period being 60 minutes. Control care comprised non-VR audiovisual distractions in 3 articles and routine care in 12 articles (24,28,31).

Ratings of article quality across 5 quality domains are shown in *Figure 2*. Articles were randomized with predetermined protocols that utilized appropriate outcome measures, but the nature of VR intervention prevented blinding. Furthermore, some articles reported significantly unbalanced deviations from the intended intervention, particularly experimental group attrition. Allocation concealment was sometimes not explicitly reported.

## VR as an anxiolytic

VR demonstrated mixed results in reducing anxiety in the perioperative period; 7 studies identified improvement (4,19,21,24,28,29,33), while 5 did not (*Table 2*) (20,26,27,30,32). Anxiety was measured with multiple scales, including the State-Trait Operation Anxiety inventory (STOA), State-Trait Anxiety Inventory (STAI), Brief Measure of Emotional Preoperative Stress, and the Hospital Anxiety and Depression Scale, Amsterdam Preoperative Anxiety and Information Scale, and Anxiety Specific to Surgery Questionnaire. There were no qualitative differences between studies that did and did not demonstrate efficacy in terms of VR intervention (type, duration, frequency), surgery type, control group (routine care or non-VR audiovisual distraction), patient demographics, or anesthesia type.

## VR to reduce pain and facilitate rehabilitation

Barry et al. evaluated VR as a pain relief measure in the immediate perioperative period in patients undergoing total hip and total knee arthroplasty by measuring both functional postoperative (ambulation distance, length of stay, and 30-day readmission/complication/reoperation) and pain (propofol and fentanyl utilization) outcomes in a retrospective study (22). They found that VR use was associated with reduced propofol dosing but not functional postoperative outcomes. Gianola et al. compared 60-minute daily VR rehabilitation sessions to traditional rehabilitation in the immediate postoperative period and identified no differences in pain or functional outcomes except for an improvement in proprioception in the VR group. However, this difference was not corrected for multiple testing (25). Pandrangi et al. evaluated a single 15-minute session of postoperative VR distraction compared to mobile device distraction and demonstrated improved pain control up to 3 hours following VR application (31).

## Discussion

### Principal Results

This scoping review assessed the methods and results of VR interventions to reduce anxiety and delirium in the perioperative period. Compared to traditional audiovisual distraction, VR provides a



more immersive environment to engage patients' attention than traditional audio or visual distraction techniques, suggesting the potential to attenuate patients' subjective fear of procedures by diverting attention from the stimulus (34). Impaired sustained attention also forms a core pathogenic pathway in delirium, and VR's audiovisual immersion may provide benefit in refocusing patient attention and orientation (35).

Several systematic and scoping reviews have been performed evaluating the feasibility of perioperative VR (36–38). However, these reviews address VR in different settings and indications than the present work. For example, Yu et al. and Shepherd et al. assessed the impact of a VR operating room tour or anatomical modeling discussion to alleviate anxiety and improve patient understanding (36,37). Gao et al. performed a systematic review and meta-analysis evaluating general VR use to reduce anxiety, but did not consistently capture the duration, frequency, or type of VR use (38). Minor operations utilizing local anesthesia were also included, limiting the generalizability of the findings to major operations requiring general or regional anesthesia. This scoping review focuses on the methods of prior studies implementing VR in major operations, highlighting points of improvement for future works seeking to use VR for anxiety and delirium prevention.

We find that studies implementing VR varied greatly in their content, technological sophistication, frequency, and duration of audiovisual distraction. For example, Huang et al.(26) utilized the Oculus Rift™ Development Kit 2, a headset with an “inbuilt” VR screen, while others used headsets that require a mobile device as the VR “screen”, such as the BoboVR Z4™. Further, studies applied different audiovisual distraction techniques, ranging from films to meditative environments to games, at different frequencies and durations. Variation exists in whether VR was trialed in the operating room, pre-, or postoperatively. Qualitatively, there appeared to be no relationship between any of these factors and efficacy in reducing anxiety.

## Limitations

A significant gap identified in this review is the lack of studies investigating the effects of VR on postoperative delirium. VR demonstrates potential to palliate pain and reduce sedation/opioid requirements in the immediate perioperative setting; but to our knowledge there are no direct trials assessing VR as an intervention to prevent postoperative delirium (22,31). The potential for VR interventions to mitigate this risk remains largely unexplored, indicating a crucial area for future research.

Although there have been significant strides made in VR applications for anxiety, we found mixed efficacy results in our study. No systematic methodological differences were identified between studies that did or did not show efficacy. Further studies of sufficient power will be necessary to elucidate the impact of VR on perioperative anxiety. Anxiety is complicated and can have multiple etiologies in a given patient. Patients may be able to relax with VR, but anxiety may not fully resolve unless they receive more comprehensive medication or psychotherapeutic intervention. Some patients may have reasons for their anxiety unrelated to the surgery which may need to be processed outside of VR. Though significant changes may be hard to appreciate, it may still be a useful relaxation tool for a carefully selected patient. Accordingly, VR appeared to be feasible to implement and well-tolerated in the inpatient setting, a promising outlook for future studies (26,27).

Overall, our findings suggest several directions to refine research for perioperative VR moving forward. Our recommendations include: 1) Utilize expanded sample sizes to identify effectiveness of VR interventions, given the heterogeneous results of current anxiolytic data, 2) Compare and pinpoint the most effective VR software regimens to reduce anxiety, given that current studies are highly variable in their approach to VR intervention, and 3) Expand the investigative indications of VR from anxiety reduction to delirium prevention and other neuropsychiatric outcomes which may benefit from VR's immersive environment.

This study is not without limitations. First, the date restrictions, limiting the search to studies published from 2020 to 2023, may have excluded earlier research that could provide additional insights into VR's applications in surgery. Second, per the nature of VR interventions, trials were unblinded, inherently limiting the quality of included articles. Some articles reported significant experimental group attrition, and some did not report allocation concealment methods. Most articles were also low-powered, which may explain the mixed efficacy of VR anxiolysis. Third, some papers that may have met inclusion criteria were ultimately excluded due to the inability to access or interpret the language of the article. Finally, this study does not examine augmented reality or other methods of enhanced immersion.

## Conclusions

The reviewed studies indicate a promising role of VR in reducing anxiety in the surgical preoperative period, although the effectiveness in preventing delirium deserves further investigation. These findings contribute to the growing body of evidence supporting the integration of VR in perioperative care.

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## Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Authors' contributions

HL performed the search, screening, data abstraction, and data synthesis and was a major contributor in writing the manuscript. ML and PS designed the study protocol and was a major contributor in writing the manuscript. RV, JWM, NR, NKV, and KL substantially revised the work. NB conceived and supervised the work. All authors read and approved the final manuscript.

## Availability of data and materials

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

## Abbreviations

VR: Virtual Reality; IVR: Immersive Virtual Reality; JBI: Joanna Briggs Institute; PRISMA-ScR: Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping

Reviews; PACU: Postanesthesia Care Unit.



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## Figures

**Figure 1. Flow Diagram of Study Selection.**

**Figure 2. Study Quality Diagram.**





## Tables

Table 1. Study characteristics.

Author, Year	Country	Dates	Age range	% male	Participants	Type of VR	Duration of VR	Frequency	Control group details	Type of surgery	Anesthesia type
Turan, 2021	Turkey	09/2017-01/2018	18-75	82	97	Bobo VR Z4, nature documentary	Intraoperative	Once	Routine care	Surgeries requiring spinal anesthesia	Spinal
Vogt 2021	Germany	N/A	20-81	51	84	Oculus Go Standalone VR, virtual tour of the operation room	6 minutes 28 seconds	Once	Routine care	Elective surgeries with general anesthesia	General
Almedhesh 2022	Saudi Arabia	2/2021-10/2021	mean 31.2 years	0	351	Oculus Rift S PC-Powered VR Headset, natural landscapes with relaxing audio	After anesthesia and until surgical closure	Once	Routine care	C-section	Spinal
Barry 2022	United States	N/A	74	33	54	Immersive Virtual Reality (IVR) with PICO G2 4K Enterprise goggles and Bose QuietComfort QC 35, noise-canceling headsets, 4 different relaxation environments	During surgery	Once	Routine care	Total hip arthroplasty (THA) and total knee arthroplasty (TKA).	Spinal
Amiri et al., 2023	Iran	N/A	56.1 mean age	63	60	TSCO virtual reality glasses (model TVR 568), virtual reality tour of the procedure	4 minute video	Once one day before operation	iPad video viewing	Open heart surgery	General
Gianola, 2020	Italy	11/2014-11/2017	Mean age 66.6	43.5	74	Virtual Reality Rehabilitation System	60 minutes sessions until discharge (around 10 days after surgery)	Once per day	Traditional rehabilitation	Total knee arthroplasty	N/A
Huang, 2020	Australia	2/2016-06/2016	Mean age 65	50	50	Immersive Virtual Reality (IVR) using Samsung Gear VR HMD or Oculus Rift Development Kit 2 HMDs, snow world virtual experience	VR was used throughout the surgical procedure	Once	Propofol patient-controlled sedation (PCS) alone	Elective total knee and total hip arthroplasty	Regional
Haisley 2020	United States	02/2019-07/2019	Median age 64.5	27	52	Wireless VR headset with mindfulness/meditation application ("Flow VR", "Meditation for Modern Life" - Oculus Go platform)	6 guided exercises, approximately 4-5 minutes each	First three exercises pre-operative, remaining three on post-operative day #1	Routine care	Minimally invasive foregut surgery (fundoplication, paraesophageal hernia repair, esophageal myotomy, pyloroplasty)	N/A
Hendricks 2020	United States	05/2017-01/2019	Median age 70	90	20	Samsung Gear VR headset with the game module Bear Blast (AppliedVR)	20 minutes	Once	Tablet-based game (Candy Crush)	Cardiac surgery via sternotomy	N/A
Turrado 2021	Spain	N/A	Median age 65	64	126	Bluebee Genuine VR3D Glasses viewing	Unlimited access	Unlimited access	Routine care	Colorectal cancer surgery	N/A

						the perioperative environment					
Rousseaux 2022	Belgium	10/2018-01/2020	66	76	100	Oncomfort (head-mounted display with goggles) consisting of a tridimensional graphical landscape of a mountain cabin near a lake	20 minutes	2 sessions	20 minute hypnosis session by audio and video	Cardiac surgery	N/A
Pandrangi 2022	United States	07/2020-10/2021	Mean 58.3	90	30	Oculus Quest playing Angry Birds	15 minutes	Once	Angry Birds on a smartphone for 15 minute session	Head and neck surgery	N/A
Fuchs 2022	Israel	2019-2020	Mean age 70	42	55	Samsung Gear VR head-mounted display, either a nature or music film	15 minutes per session beginning on first postoperative day	Once per day	Conventional physiotherapy	Primary total knee arthroplasty	N/A
Chiu 2023	Hong Kong	07/2022-12/2022	46.3 mean age	51	74	8-minute immersive 360-VR video tour in the operating theater via a head-mounted display console	8 minutes	Once	Routine care	Various elective surgeries	General anesthesia
Ugras 2023	Turkey	06/2018-05/2019	18-65 years	67	86	5 3D relaxation videos on the VR Box 2	10 minutes	Once	Routine care	Colorectal and abdominal wall surgery	N/A

**Table 2.** Virtual Reality Effect on Perioperative Anxiety, Pain, and Rehabilitation

Author, Year	Primary outcome and measurement scale	Secondary outcomes	Secondary outcome scales	Key findings
Turan, 2021	Intraoperative anxiety, VAS	Hemodynamics	Vitals	VAS and relative risk values were significantly lower in the study group in all measurements.
Vogt 2021	Anxiety, STOA	Patient satisfaction	In-house questionnaire	No significant difference in perioperative state anxiety; however, VR was positively evaluated by patients.
Almedhesh 2022	Hemodynamic variables (vitals)	Anxiety, satisfaction	B-MEPS, NVFAS, BSS-R	VR group had improved postoperative anxiety and satisfaction. Some hemodynamic parameters were improved.
Barry 2022	Intraoperative sedation dosages	Pain, acute postoperative outcomes	Fentanyl dosing, antiemetics dosing, pain scores, ambulation distance, length of stay	VR group utilized significantly less intraoperative sedation; no significant differences in postoperative outcomes.
Amiri et al., 2023	Anxiety, STAI	Hemodynamics	Vitals	VR group showed a significant reduction in anxiety levels compared to the control group.
Gianola, 2020	Pain, VAS	Knee function, Quality of life, perceived effect	WOMAC, EQ-5D, GPE	VR-based rehabilitation is not superior to traditional rehabilitation in terms of pain relief but improved global proprioception.
Huang, 2020	Sedation requirement, Intraoperative propofol use	Pain, anxiety, satisfaction	Fentanyl Dosage, midazolam dosage, QoR-40	VR was well tolerated but did not significantly reduce overall sedation requirement compared to the control group.
Haisley 2020	Pain, scored 0-10	Pain, satisfaction, anxiety	Narcotic dosage in MME, PSQ-18, 10-point VAS	No significant differences in post-operative pain scores, total narcotic utilization, overall satisfaction scores.
Hendricks 2020	Anxiety, STAI			VR users experienced significant reductions in anxiety.
Turrado 2021	Anxiety, STAI-S and HADS			VR reduced anxiety on both the HADS and STAI-S
Rousseaux 2022	Anxiety, fatigue, pain - VAS	Pain, Hemodynamics	Opioid dose, vitals	There were no significant differences for fatigue, physiological measures, or opioid use.
Pandurangi 2022	Pain, NRS	Pain, satisfaction	opioid dosages, 2 question survey	VR reduced pain immediately after intervention, at 1 hour, 2 hours, and 3 hours compared and reduced opioid use at 4 and 8 hours postoperative.
Fuchs 2022	Pain and anxiety, STAI and VAS	Knee function, range of motion	WOMAC	VR intervention decreased pain and anxiety but was not more effective than conventional physiotherapy in long-term function or pain anxiety.
Chiu 2023	Preoperative anxiety, Amsterdam Preoperative Anxiety and Information Scale	Stress, length of stay, simulation sickness	VAS, length of stay, simulation sickness questionnaire	VR decreased anxiety.
Ugras 2023	Anxiety, ASSQ	Hemodynamics	Vitals	VR significantly reduced preoperative anxiety levels and physiological anxiety responses.