INPLASY

INPLASY202610030

doi: 10.37766/inplasy2026.1.0030

Received: 8 January 2026

Published: 8 January 2026

# Virtual Reality Versus Conventional Care for Relieving Perioperative Pain and Anxiety in Pediatric Patients: A Systematic Review and Meta-Analysis of Randomized Controlled Trials

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**ADMINISTRATIVE INFORMATION**

**Support -** No financial support was received for this study.

**Review Stage at time of this submission -** The review has not yet started.

**Conflicts of interest -** None declared.

**INPLASY registration number:** INPLASY202610030

**Amendments -** This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 8 January 2026 and was last updated on 8 January 2026.

## INTRODUCTION

**Review question / Objective** (1)Participants: Pediatric patients aged 2 to 18 years undergoing elective surgical procedures, regardless of gender, ethnicity, or socioeconomic status. Participants must be able to provide assent, and parents or guardians must provide informed consent.
(2)Interventions: The experimental group must receive virtual reality interventions designed to relieve perioperative pain and anxiety. These interventions should be immersive and interactive, utilizing head-mounted displays or similar technology, and must be administered during the preoperative and/or intraoperative period.
(3)Comparator: The control group must receive conventional care, which may include standard preoperative education, pharmacological interventions (e.g., anxiolytics), or other non-virtual reality-based methods for pain and anxiety management.
(4)Outcomes: Studies must report at least one of the following outcomes: perioperative pain levels measured using validated scales (e.g., Wong-Baker FACES Pain Rating Scale, Numeric Rating Scale), anxiety levels assessed using standardized tools (e.g., State-Trait Anxiety Inventory for Children), and any adverse events related to the interventions. Outcomes should be measured at baseline, immediately post-intervention, and at defined postoperative time points (e.g., 24 hours, 48 hours).
(5)Study Design: Only randomized controlled trials (RCTs) will be included in the meta-analysis, with a minimum follow-up duration of 24 hours post-surgery to assess the effectiveness of the interventions. Studies must report on blinding methods used for outcome assessment and provide clear randomization procedures

**Rationale** The management of perioperative pain and anxiety in pediatric patients has emerged as a critical concern within clinical practice. These patients often experience heightened levels of anxiety and discomfort surrounding surgical interventions, leading to adverse outcomes such as prolonged recovery, increased pain perception,

and even long-term psychological effects. The prevalence of anxiety and pain in pediatric surgical populations is significant, with studies indicating that a substantial proportion of children undergoing surgery report moderate to severe pain postoperatively [1]. This issue not only impacts the individual child's health but also poses broader implications for healthcare systems, exacerbating resource utilization and complicating care pathways.

Current therapeutic approaches primarily rely on pharmacological interventions, including opioids and anxiolytics, which, despite their efficacy, carry risks of adverse effects, dependency, and inadequate pain control in some cases. Additionally, the reliance on traditional methods often overlooks the unique emotional and psychological needs of pediatric patients. This gap in the management of perioperative anxiety and pain underscores the necessity for innovative interventions that can provide effective relief with minimal side effects.

Recent advancements in technology have introduced virtual reality (VR) as a potential adjunctive tool in the management of perioperative pain and anxiety. Preliminary studies suggest that VR interventions can significantly reduce anxiety and pain levels in children undergoing surgical procedures, positioning VR as a promising alternative to traditional methods . However, the evidence remains fragmented, with inconsistencies in study methodologies, patient populations, and outcomes measured. Furthermore, existing meta-analyses have not sufficiently addressed the comparative effectiveness of VR interventions relative to conventional care practices in pediatric settings, highlighting a crucial gap in the literature.

This meta-analysis aims to systematically evaluate and synthesize the available evidence regarding the efficacy of VR interventions in reducing perioperative pain and anxiety in pediatric patients compared to standard care. By employing rigorous statistical methodologies and quality assessment tools, this study seeks to provide a comprehensive overview of the current state of research, identify key factors influencing outcomes, and offer insights into the practical application of VR technology in clinical settings. The findings are anticipated to not only enhance understanding of VR's role in pediatric perioperative care but also to inform clinical practice guidelines and contribute to the development of more effective, child-centered pain management strategies.

In summary, addressing the limitations of current treatment modalities through innovative approaches such as VR is imperative for improving perioperative experiences for children. This research endeavors to bridge existing gaps in the literature, ultimately enhancing the quality of care provided to this vulnerable patient population.

**Condition being studied** This systematic review focuses on the management of perioperative anxiety and pain in pediatric patients undergoing elective surgery.

Elective Surgery: This refers to planned, non-emergency surgical procedures. Common examples in children include tonsillectomy (removal of tonsils), adenoidectomy, hernia repair, orthopedic procedures (e.g., casting or pinning of broken bones), and other general surgical operations. While these procedures are essential for health, they are scheduled in advance.

Perioperative Anxiety: It is highly common for children to experience significant fear, worry, and psychological distress (anxiety) before, during, and after surgery. This anxiety can stem from fear of the unknown, separation from parents, or anticipation of pain.

Postoperative Pain: Despite advances in analgesia, managing pain after surgery remains a critical challenge. Inadequate pain control can lead to numerous negative outcomes.

The clinical significance of poorly managed perioperative anxiety and pain is substantial. It can:

Increase physiological stress responses.

Lead to negative behavioral changes (e.g., nightmares, bedwetting, separation anxiety).

Result in higher analgesic requirements.

Prolong recovery time and hospital stay.

Create traumatic memories that can lead to long-term medical phobias.

Traditional management often relies on pharmacological interventions (e.g., sedatives and opioids), which, while effective, can carry side effects like drowsiness, nausea, and respiratory depression. This highlights the critical need for effective, non-pharmacological adjuncts to improve the pediatric surgical experience, which is the gap this review aims to address by evaluating Virtual Reality interventions.

## METHODS

**Search strategy** To conduct a comprehensive meta-analysis on the effectiveness of Virtual Reality (VR) in relieving perioperative pain and anxiety in pediatric patients compared to conventional care, a systematic search strategy was implemented across multiple databases, including Web of Science, PubMed, EMBASE, and Cochrane Library. The search was conducted on January 4, 2026.

The keywords utilized in the search were derived from the PICOS framework: "Pediatric Patients,"

"Virtual Reality," "Conventional Care," "Perioperative Pain," "Anxiety," and "Randomized Controlled Trial." Boolean operators such as AND, OR, and NOT were employed to refine the search results. Specifically, the search string included terms like "pediatric OR children," "virtual reality OR VR," "conventional care OR standard treatment," "pain relief OR anxiety reduction," and "randomized controlled trial OR RCT."
Inclusion criteria were set to filter studies that specifically addressed the use of VR in pediatric populations undergoing surgical procedures, focusing on outcomes related to pain and anxiety management. Only studies published in English and those that met the randomized controlled trial design were considered for inclusion in the analysis. This systematic approach ensured a thorough examination of the existing literature on the topic, facilitating a robust synthesis of findings.

**Participant or population** In the present meta-analysis, we conducted a comprehensive literature screening process to ensure the inclusion of relevant studies. Initially, two experts independently screened the identified literature to assess their suitability based on predefined eligibility criteria. This initial screening categorized the studies into three distinct groups: "Yes," indicating clear relevance to the research question; "No," denoting studies that do not meet the inclusion criteria; and "Maybe," for those that require further evaluation due to ambiguity or insufficient information.
Following this first round of screening, we proceeded to a rigorous secondary review. This phase involved three additional experts who re-evaluated the literature categorized as "Maybe" and validated the initial conclusions drawn by the first two reviewers. This enhanced scrutiny was crucial in refining our selection, as it allowed for a more nuanced assessment of potentially pertinent studies that may have been overlooked in the initial analysis. By employing a systematic approach to the literature screening, we aimed to minimize bias and enhance the reliability and validity of our findings. Ultimately, this meticulous process ensured that the data included in our analysis would meaningfully contribute to the meta-analytic objectives.

**Intervention** This systematic review aims to evaluate the effectiveness of virtual reality (VR) interventions for managing perioperative pain and anxiety in pediatric patients aged 2 to 18 years undergoing elective surgery. Below is a structured overview of the intervention group:
Core Intervention: Virtual Reality (VR) Technology
Type and Format: The interventions consist of immersive, interactive VR experiences delivered through head-mounted displays (HMDs) or similar devices (e.g., VR goggles or screens). These are designed to engage children in virtual environments, such as games, calming landscapes, or interactive stories, which distract from surgical procedures and reduce stress.
Timing and Administration: VR is administered during the preoperative period (e.g., in waiting areas or pre-op rooms to alleviate anxiety before surgery) and/or the intraoperative period (e.g., during induction of anesthesia or minor procedures to minimize pain and distress). The duration and frequency may vary but typically align with clinical routines (e.g., 10–30 minute sessions).
Content Characteristics: The VR content is age-appropriate, customizable, and often includes elements like:
Distraction-based activities (e.g., exploring virtual worlds or playing games).
Relaxation techniques(e.g., guided breathing exercises or peaceful scenarios).
Interactive feedback to enhance engagement and sense of control.
Rationale for Focus on VR Interventions
VR is chosen for its evidence-based potential to provide non-pharmacological relief by leveraging principles of cognitive distraction and immersion, which can modulate pain perception and reduce anxiety. This aligns with modern pediatric care trends emphasizing patient-centered, minimally invasive approaches to improve outcomes and reduce reliance on medications (e.g., anxiolytics or analgesics).
Context within the Review
This intervention group will be compared to conventional care (e.g., standard education or pharmacological methods) in randomized controlled trials (RCTs) to assess efficacy and safety. The review will explore variations in VR implementation (e.g., hardware types, content diversity) to identify best practices.

**Comparator** This control condition encompasses the standard, non-Virtual Reality methods currently used in clinical practice for managing perioperative anxiety and pain in pediatric surgical patients. The defining feature of this group is the absence of an immersive VR experience.
Conventional care typically includes one or a combination of the following elements:
Standard Preoperative Care: This involves routine psychological preparation, such as verbal explanations of the procedure, age-appropriate play therapy, reading books, watching standard (non-immersive) videos, or the presence of a parent during anesthesia induction.

Pharmacological Interventions: This represents a core component of standard practice and includes the administration of preoperative anxiolytics (e.g., midazolam) and/or intraoperative and postoperative analgesics (e.g., opioids like fentanyl, or non-opioids like acetaminophen).
Other Non-VR, Non-Pharmacological Methods: This category covers other evidence-based techniques like guided breathing exercises, listening to music, or receiving comfort and distraction from nursing staff.
The rationale for selecting "conventional care" as the comparator is that it provides a clinically relevant benchmark. It allows the review to determine whether the VR intervention offers a significant added benefit over the existing standard of care already implemented in hospitals and clinics.

**Study designs to be included** Study Design to Be Included The review will exclusively include Randomized Controlled Trials (RCTs).

**Eligibility criteria** To ensure transparency, reproducibility, and a clear understanding of the study selection process, authors should explicitly report any additional inclusion or exclusion criteria applied during the screening of studies for the systematic review. These are criteria that go beyond the core PICOS (Population, Intervention, Comparator, Outcomes, Study design) framework already defined.
Why Report Additional Criteria?
The PICOS framework outlines the primary eligibility questions. However, practical and methodological decisions made during the review process often necessitate supplementary filters. Reporting these is crucial for readers to understand the exact scope of the evidence synthesized and to assess potential limitations, such as publication bias or geographic generalizability.
Common Examples of Additional Criteria
Based on standard systematic review practice, such additional criteria might include:
1. Language of Publication: Specifying if the review was limited to studies published in certain languages (e.g., English only) and the rationale for this limitation.
2. Publication Status and Date: Defining the publication timeframe (e.g., studies from 2010 onwards) and whether grey literature (theses, conference abstracts) or unpublished studies were sought and included.
3. Setting/Context: Limiting studies to specific healthcare settings (e.g., only inpatient hospital surgeries, excluding outpatient or dental clinics) if relevant to the research question.
4. Specific Patient Subgroups: Excluding studies focused on patients with specific comorbidities (e.g., severe cognitive impairment, chronic pain conditions) that could confound the primary outcomes of perioperative anxiety and pain.
5. Intervention Specifications: Applying filters related to the technical delivery of VR, such as a minimum intervention duration, the exclusion of non-immersive VR (e.g., 2D screen-based games), or the requirement for head-mounted display use.
Reporting Recommendation
In the Methods section of the review protocol or manuscript, typically under a subheading like "Eligibility Criteria" or "Study Selection," authors should first present the PICOS criteria. This should be followed by a statement such as:
"In addition to the PICOS criteria, the following exclusion criteria were applied: [list criteria, e.g., studies not reporting quantitative outcome data, studies where the VR intervention was used solely postoperatively, articles not available in full text]."
This practice completes the methodological picture and strengthens the rigor of the review.

**Information sources** Intended Information Sources for the Systematic Review
To ensure a comprehensive and unbiased search for relevant studies, the systematic review will utilize multiple information sources. These sources are selected to minimize publication bias and capture all eligible randomized controlled trials (RCTs) on virtual reality (VR) interventions for perioperative pain and anxiety in pediatric surgical patients. Below is a structured overview of the planned sources:
1. Electronic Databases:
• Primary databases include PubMed/MEDLINE, Cochrane Central Register of Controlled Trials (CENTRAL), EMBASE, PsycINFO, and CINAHL. These databases were chosen for their extensive coverage of medical, psychological, and nursing literature, aligning with the interdisciplinary nature of the review (e.g., pain management, pediatric surgery, and VR technology).
• Search strategies will use a combination of keywords and MeSH/Emtree terms related to "virtual reality," "pediatric surgery," "pain," "anxiety," and "randomized controlled trial."
2. Trial Registers:
• We will search ClinicalTrials.gov and the WHO International Clinical Trials Registry Platform (ICTRP) to identify ongoing, completed, or unpublished RCTs. This helps reduce publication bias by including studies that might not appear in traditional databases.
3. Grey Literature:
• Sources such as proQuest Dissertations & Theses Global, conference proceedings (e.g., from

pediatric anesthesiology or pain management conferences), and institutional repositorieswill be explored to access unpublished data, theses, and abstracts. This ensures that negative or neutral findings are not overlooked.
4. Contact with Authors and Experts:
• If necessary, we will contact corresponding authors of included studies or experts in the field to request missing data, clarify study details, or identify additional relevant studies. This approach aids in data completeness and accuracy.
5. Additional Sources:
• We will manually screen reference lists of included studies and related systematic reviews to identify any potentially eligible RCTs that might have been missed in electronic searches. This snowballing technique enhances the comprehensiveness of the search.

**Main outcome(s)** These are the most critical endpoints directly related to the core objectives of managing perioperative distress.
• a. Perioperative Anxiety:
• Measurement: Quantified using validated, age-appropriate self-report or observer-rated scales.
• Tools: Examples include the State-Trait Anxiety Inventory for Children (STAI-C), the Modified Yale Preoperative Anxiety Scale (m-YPAS), or visual analog scales (VAS) for anxiety.
• Timing: Assessed at key time points:
• Preoperative: Before the intervention (baseline) and immediately before surgery/anesthesia induction.
• Intraoperative: During procedures (e.g., during IV placement or anesthesia induction).
• Postoperative: In the post-anesthesia care unit (PACU) or on the ward.
• b. Postoperative Pain:
• Measurement: Quantified using validated, age-appropriate pain scales.
• Tools: Examples include the Wong-Baker FACES Pain Rating Scale, the Visual Analog Scale (VAS) or Numerical Rating Scale (NRS) for older children, and the FLACC (Face, Legs, Activity, Cry, Consolability) scale for younger or non-verbal children.
• Timing: Assessed postoperatively:
• Early: Immediately upon arrival in the PACU (e.g., 0-30 minutes).
• Short-term: At specified intervals (e.g., 1 hour, 2 hours, 4 hours, 24 hours post-surgery).

**Additional outcome(s)** 1. Long-Term Behavioral Outcomes
• What to Measure: The incidence of negative postoperative behavioral changes (NPOBCs) beyond the immediate recovery period.
• Tools: Validated instruments like the Post Hospitalization Behavior Questionnaire (PHBQ).
• Timing: Assessed at follow-up intervals (e.g., 2 weeks, 1 month, and 3 months post-surgery).
• Rationale: A key goal of reducing perioperative distress is to prevent long-term trauma and maladaptive behaviors like separation anxiety, sleep disturbances, and eating problems.
2. Healthcare Process and Economic Outcomes
• What to Measure: Metrics related to healthcare efficiency and resource utilization.
• Examples:
• Time to discharge readiness from the Post-Anesthesia Care Unit (PACU).
• Total length of hospital stay.
• Cost-effectiveness analysis (if data is available), comparing the cost of VR implementation to savings from reduced medication use or shorter stays.
• Rationale: These outcomes are highly relevant to healthcare administrators and policymakers for assessing the practical implementation and economic viability of VR programs.

## Data management

1. Record Identification and Deduplication
• All records retrieved from the electronic database searches and other sources are imported into a reference management software (e.g., EndNote, Zotero, or Mendeley).
• The software's automatic deduplication function is used first, followed by a manual check to identify and remove any remaining duplicate records. The final, unique set of records is then exported for screening.
2. Study Screening and Selection
• The screening process is conducted in two phases (Title/Abstract, then Full-Text) using systematic review software (e.g., Covidence, Rayyan, or DistillerSR) or a shared spreadsheet (e.g., Excel or Google Sheets).
• At least two independent reviewers screen each record against the pre-defined eligibility criteria (PICOS and any additional criteria).
• Any disagreements between reviewers are resolved through discussion or, if necessary, by consulting a third reviewer. The software or spreadsheet tracks the reason for exclusion at the full-text stage.
3. Data Extraction and Management
• A standardized, pilot-tested data extraction form is created in the review software or a spreadsheet. This form captures all relevant data related to:
• Study characteristics (author, year, country, design, sample size).
• Participant details (PICOS).
• Intervention and comparator details (VR type, timing, control group specifics).

• Outcome data (means, standard deviations, effect estimates for all pre-specified outcomes at all reported time points).
• Data extraction is performed independently by two reviewers for each included study to ensure accuracy.
• The extracted data is compared, and any discrepancies are resolved by consensus or third-reviewer adjudication. The final, agreed-upon dataset is stored as the master file.
4. Risk of Bias (Quality) Assessment
• The risk of bias for each included RCT is assessed independently by two reviewers using a standardized tool, such as the Cochrane Risk of Bias 2 (RoB 2) tool.
• The judgments and supporting information are recorded in the review software or a dedicated template. Disagreements are resolved as described above.
5. Data Synthesis and Storage
• The cleaned and verified data from the extraction forms are imported into statistical software (e.g., RevMan, Stata, R) for meta-analysis, if applicable.

### Quality assessment / Risk of bias analysis

1. Assessment Tool
The Cochrane Risk of Bias 2 (RoB 2) tool will be used to evaluate the methodological quality of each included randomized controlled trial. This tool is the current gold standard for assessing bias in RCTs and aligns with your focus on high-quality evidence.
2. Domains of Assessment
The RoB 2 tool evaluates five critical domains:
• Randomization process: Was allocation sequence random and concealed?
• Deviations from intended interventions: Were participants/study personnel blinded?
• Missing outcome data: Were outcome data complete?
• Outcome measurement: Were assessors blinded?
• Selection of reported results: Were outcomes pre-specified and reported without bias?
Each domain is judged as "Low," "Some concerns," or "High" risk of bias.
3. Process
• Two independent reviewers will assess each study.
• Disagreements will be resolved through discussion or consultation with a third reviewer.
• Results will be summarized in a risk of bias table or figure (e.g., a traffic light plot) to visualize patterns across studies.
4. Integration with Findings
• The overall risk of bias for each study will inform the interpretation of results (e.g., sensitivity analyses excluding high-bias studies).
• Findings will be incorporated into the GRADE assessment to evaluate the certainty of evidence for key outcomes.

### Strategy of data synthesis

1. Preparation for Analysis
• Extracted data will be managed and organized using reference management and statistical software (e.g., RevMan, Stata, R).
• Prior to synthesis, the clinical and methodological characteristics of the included studies will be assessed to determine their suitability for meta-analysis. If studies are sufficiently homogeneous in terms of participants, interventions, comparators, and outcomes, a quantitative synthesis (meta-analysis) will be performed. If not, a narrative synthesis will be conducted.
2. Statistical Analysis and Synthesis
• Effect Measures: For continuous outcomes (e.g., pain/anxiety scores), the Mean Difference (MD) or Standardized Mean Difference (SMD) with 95% confidence intervals (CIs) will be calculated, depending on whether the same measurement scale was used across studies. For dichotomous outcomes (e.g., incidence of emergence delirium), the Risk Ratio (RR) or Odds Ratio (OR) with 95% CIs will be calculated.
• Assessment of Heterogeneity: Statistical heterogeneity among studies will be assessed using the $I^2$ statistic. An $I^2$ value greater than 50% will be considered to represent substantial heterogeneity.
• Model Selection: If low heterogeneity is present ($I^2 \leq 50\%$), a fixed-effect model will be used for meta-analysis. If substantial heterogeneity is present ($I^2 > 50\%$), a random-effects modelwill be employed, and potential sources of heterogeneity will be explored.
3. Investigation of Heterogeneity and Robustness
• If substantial heterogeneity is identified, pre-specified subgroup analyses will be conducted to explore possible causes. Potential subgroups may be based on factors such as the child's age, type of surgery, timing of the VR intervention (preoperative vs. intraoperative), or type of VR content (interactive vs. passive).
• Sensitivity analyses will be performed to test the robustness of the primary meta-analysis results. This may involve excluding studies with a high overall risk of bias or repeating the analysis using an alternative statistical model.
4. Presentation and Quality of Evidence
• Results from the meta-analyses will be presented visually using forest plots.
• The overall certainty of the evidence for each primary and key secondary outcome will be evaluated using the GRADE (Grading of Recommendations, Assessment, Development,

and Evaluations) approach and summarized in a 'Summary of Findings' table.

**Subgroup analysis** 1. Purpose and Rationale
The primary goal is to determine if the effect of VR on perioperative anxiety and pain differs meaningfully across distinct categories. This analysis helps identify which pediatric populations or under which conditions VR is most (or least) beneficial, thereby refining the clinical applicability of the review's conclusions.
2. Pre-specified Subgroup Variables
If substantial statistical heterogeneity ($I^2 > 50\%$) is identified in the primary meta-analyses, we will explore the following subgroups:
Age of Participants: Comparing effects in preschool children (2-5 years), school-aged children (6-12 years), and adolescents (13-18 years). Rationale: Developmental stage significantly impacts cognitive ability, coping mechanisms, and engagement with technology.
Type of Surgical Procedure: Comparing effects in minor/day surgeries (e.g., dental, minor orthopedic) versus major/inpatient surgeries (e.g., abdominal, spinal fusion). Rationale: The level of inherent surgical stress and pain may influence the relative benefit of a psychological intervention like VR.
Timing of VR Intervention: Comparing studies where VR was applied preoperatively (before anesthesia induction), intraoperatively (during procedure/induction), or postoperatively (in the PACU). Rationale: The phase of care may determine its primary role (anxiolysis vs. analgesia).
Type of VR Content/Interaction: Comparing interactive VR (active gaming, engagement) with passive VR (360° videos, relaxing scenes). Rationale: The level of immersion and cognitive distraction may differ.
3. Method of Analysis
For each primary outcome (anxiety and pain), subgroup analyses will be conducted within the meta-analysis software (e.g., RevMan).
The difference in effect estimates between subgroups will be tested for statistical significance using subgroup interaction tests.
Results will be presented visually in forest plots with studies grouped by their subgroup category.
Important Note: These analyses are exploratory and observational in nature. Any identified differences between subgroups will be interpreted with caution, as they may be due to other confounding factors rather than the subgroup variable itself. We will adhere to the PRISMA guideline of not over-interpreting subgroup findings, especially when the number of studies in a subgroup is small.

**Sensitivity analysis** The following analyses are planned:
Risk of Bias Exclusion: The primary meta-analysis will be repeated after excluding studies judged to have a "High" overall risk of bias (as assessed by the Cochrane RoB 2 tool). This tests whether the pooled effect estimate is stable when only the most methodologically rigorous evidence is considered.
Statistical Model Variation: The analysis will be repeated using an alternative statistical model (e.g., switching from a random-effects to a fixed-effect model, or vice-versa, depending on the primary choice). This assesses the impact of the underlying statistical assumptions on the results.
Effect Measure and Data Handling:
For continuous outcomes, sensitivity analyses may explore using Standardized Mean Difference (SMD) versus Mean Difference (MD), or different correlation imputations for calculating change-from-baseline scores if needed.
For dichotomous outcomes, using Odds Ratio (OR) versus Risk Ratio (RR) will be compared.
The impact of studies with potentially outlying results will be examined by temporarily removing them from the analysis.
Analysis of Missing Data: If applicable, the impact of studies with high levels of missing outcome data will be assessed by excluding them, or by exploring different data imputation methods.
Interpretation: If the direction, magnitude, and statistical significance of the primary effect estimate remain consistent across these sensitivity analyses, confidence in the robustness of the review's conclusions will be strengthened. Any substantial change in results will be reported and discussed as a potential limitation.

**Language restriction** Search limited to English studies.

**Country(ies) involved** The present systematic review is being conducted by authors affiliated with institutions in.China. The geographic scope of the included evidence will not be restricted by country.

**Other relevant information**
1. Protocol Registration and Publication Plan
Protocol Registration: The protocol for this systematic review has been registered on an international prospective systematic review registration platform.
Publication Plan: The research findings are planned to be submitted to peer-reviewed academic journals and will follow the open access principle to promote knowledge dissemination.
2. Patient and Public Involvement

Involvement Status: This study does not directly involve patient participation (but can state whether clinical experts or parents of children were consulted to optimize the research design).
Dissemination of Results: The research findings will be disseminated to the public through academic conferences, medical institution bulletins, or science popularization platforms.
3. Data Sharing and Availability
Data Availability: The data extracted for this review all come from published studies, and the original data must be obtained by applying to the corresponding study authors.
Supplementary Materials: Detailed search strategies, data extraction tables, and analysis codes can be obtained by applying to the corresponding author.
4. Ethics and Approval
Ethics Approval: A systematic review does not require ethics approval, but all included studies must comply with ethical norms (such as obtaining informed consent, passing ethical committee review).

**Keywords** Virtual Reality、 Conventional Care 、 Perioperative Pain 、 Anxiety 、 Pediatric Patients、Systematic Review、 Meta-analysis、 Randomized Controlled Trials.

**Dissemination plans** The dissemination of findings from this systematic review will follow a multi-faceted strategy designed to reach academic, clinical, and public audiences to maximize impact and facilitate knowledge translation.
1. Academic Publication
The primary dissemination route will be submission of the completed systematic review and meta-analysis to a high-impact, peer-reviewed journal in the fields of pediatric anesthesia, pain medicine, digital health, or clinical psychology (e.g., Pediatric Anesthesia, The Clinical Journal of Pain, Journal of Medical Internet Research). We will prioritize an open-access publication modelto ensure unrestricted global access to the full findings.
2. Conference Presentations
Key results will be presented at relevant national and international scientific conferences, such as those held by the:
• Society for Pediatric Anesthesia (SPA)
• International Association for the Study of Pain (IASP)
• American Pain Society (APS)
• World Congress on Pain
3. Professional and Clinical Channels
To directly inform practice, we will:
• Disseminate a summary of key findings and clinical implications through professional society newsletters and networks.
• Develop a clinician-friendly evidence brief or infographic for distribution in hospital departments (anesthesiology, pediatrics, perioperative care).
• Offer to present the findings at hospital grand rounds or continuing medical education (CME) seminars.

## Contributions of each author

Author 1 - Yan Ling - Author 1: Conceptualized the review, designed the methodology, developed the search strategy, screened studies for eligibility, extracted and validated the data, performed the statistical analysis and meta-analysis, interpreted the results, created the data visualizations (e.g., forest plots), drafted the initial manuscript, and coordinated revisions from co-authors.
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Author 2 - Xueliang Xu - Provided overall supervision and mentorship throughout the project, secured funding and ethical approvals, contributed to the conceptualization and methodological design of the review, critically reviewed and revised the manuscript for important intellectual content, approved the final version to be published, and is responsible for all correspondence regarding the manuscript and.
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