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TECHNOLOGICAL CHARACTERISTICS, CLINICAL EFFECTIVENESS, FEASIBILITY, AND ACCEPTABILITY OF IMMERSIVE VIRTUAL REALITY DURING PEDIATRIC MEDICAL PROCEDURES: A SYSTEMATIC REVIEW

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ABSTRACT

Background: Pediatric medical procedures cause pain, anxiety, and distress, making non-pharmacological distraction strategies like immersive virtual reality (IVR) increasingly important. However, heterogeneity exists regarding hardware, immersion levels, clinical workflows, and implementation feasibility.
Aim: To evaluate the technological characteristics, clinical effectiveness, feasibility, acceptability, and tolerability of IVR interventions delivered during pediatric procedures.
Methods: A systematic review was conducted following PRISMA and PICOS criteria. Prospective interventional studies evaluating IVR (via headsets) in pediatric patients (<18 years) undergoing medical, diagnostic, surgical, or dental procedures were included. From 344 identified records, 327 unique articles were screened independently on the Rayyan platform, with consensus reached through discussion. Assessed outcomes included pain, anxiety, distress, cooperation, feasibility, acceptability, and adverse events.
Results: Included studies showed high technological heterogeneity (smartphone-based to standalone headsets) and content variation (passive viewing to interactive games). IVR effectively reduced pain, anxiety, and distress across various procedures (e.g., venipuncture, vaccinations, dental care), though efficacy compared to active controls or 2D screens varied. Feasibility was high, with strong acceptability and satisfaction among children, parents, and healthcare staff. Adverse events were rare, mild, and self-limiting, primarily involving slight cybersickness (dizziness, mild nausea).
Conclusions: Immersive virtual reality is a safe, highly acceptable, and effective non-pharmacological tool for reducing procedural pain and anxiety in children. Successful clinical implementation depends on age-appropriate ergonomics, procedure-compatible interactivity, proper infection control, and integration into routine workflows.

KEYWORDS

Immersive Virtual Reality, Pediatric Medical Procedures, Cybersickness, Anxiety

CITATION

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1. Introduction

Pediatric medical procedures are frequently associated with pain, fear, anxiety, and psychological distress. Needle related procedures, in particular, may be repeated throughout childhood and can contribute to anticipatory anxiety, avoidance behaviors, and negative experiences with healthcare. Effective management of procedural pain and distress therefore requires not only appropriate pharmacological treatment but also developmentally appropriate nonpharmacological strategies that can be integrated into routine clinical care. Clinical guidelines recommend distraction as an important component of multimodal approaches to reducing pain and distress during pediatric procedures [1].

Immersive virtual reality (IVR) has emerged as a promising technology-based approach to support children during medical procedures. By providing an interactive, multisensory digital environment that can capture and maintain the child's attention, IVR may reduce awareness of the procedure and consequently modify the perception of pain and anxiety. In addition to distraction, VR can be used for procedural preparation or exposure, allowing children to become familiar with aspects of a forthcoming medical intervention before it takes place. An integrative review of pediatric procedural pain and anxiety reported generally positive effects of VR across several clinical settings, including needle procedures, burn care, and dental interventions [2].

The growing body of clinical research has also been supported by systematic reviews and meta-analyses. A systematic review and meta-analysis update including 26 pediatric studies found that VR was associated with reductions in patient reported pain and anxiety, with the strongest evidence observed for VR used as a distraction intervention [3]. More recent evidence suggests that the effectiveness of VR may also depend on the characteristics of the technology itself. Different levels of immersion and different types of VR devices may produce different clinical effects, indicating that hardware characteristics should be considered when interpreting the evidence and selecting an intervention for clinical use [4].

Despite these promising findings, the implementation of IVR in pediatric healthcare involves factors extending beyond clinical effectiveness. The technological characteristics of the intervention including the type of device, degree of immersion, software and virtual environment, level of interactivity, and method of delivery may influence children's engagement and their ability to use VR during a procedure. Furthermore, practical aspects such as the timing and duration of the intervention, preparation of the child, compatibility with clinical workflow, and the need for assistance from healthcare professionals may determine whether an intervention can be successfully implemented in routine practice. Studies evaluating VR-based procedural education have demonstrated reductions in children's pain and anxiety, while also highlighting the potential relevance of procedural duration, feasibility, and satisfaction when assessing the intervention [5].

Feasibility and acceptability are particularly important in pediatric populations, where the child's age, developmental level, previous medical experiences, and individual preferences may influence engagement with immersive technologies. A mixed methods feasibility study in a pediatric orthopedic setting demonstrated that VR could be incorporated into clinical workflow and was generally considered easy to use and well tolerated [6]. Similarly, a recent quality improvement study involving children undergoing clinical procedures found high levels of acceptance, with most children indicating that they would choose VR again; parents and healthcare professionals also reported positive experiences regarding children's engagement and the practical value of the intervention [7].

Although the evidence supporting VR in pediatric procedural care is expanding, substantial heterogeneity remains across interventions and study designs. Differences in hardware, level of immersion, virtual content, interactivity, timing and duration of use, type of medical procedure, and outcome measures make it difficult to determine which technological and implementation characteristics are most relevant to successful clinical application. Moreover, clinical effectiveness is not necessarily sufficient to establish the usefulness of an intervention in practice; feasibility, acceptability, tolerability, technical difficulties, and potential adverse effects should also be considered.

Therefore, this systematic review aimed to comprehensively evaluate the **technological characteristics, clinical effectiveness, feasibility, and acceptability of immersive virtual reality during pediatric medical procedures**. Specifically, the review examined the characteristics of the VR technology and intervention, its effects on procedural pain, anxiety, fear, distress, and cooperation, as well as its feasibility, acceptability, tolerability, and practical implementation in pediatric clinical settings.

2. Methodology

To investigate the technological characteristics, clinical effectiveness, feasibility, and acceptability of immersive virtual reality during pediatric medical procedures, a systematic literature search was conducted. As a result of the search strategy, 344 records were identified. The results were exported to the Rayyan platform, which is dedicated to literature review management and analysis. Using this platform, 17 duplicates were identified and removed after manual verification by our research team. This process allowed for the identification of 327 unique articles that qualified for the next selection stage.

2.1. Participants

The research inclusion criteria were structured based on the PICOS framework (population, intervention, comparison, outcome, and study design) in accordance with the PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). The selected articles aimed to answer the following research question: "What are the technological characteristics, clinical effectiveness, feasibility, and acceptability of immersive virtual reality delivered during medical procedures in pediatric patients?".

The main inclusion criteria were as follows: (1) prospective primary interventional studies, including randomized controlled trials, non-randomized and quasi-experimental trials, controlled clinical trials, pilot studies, and feasibility and acceptability studies; (2) a pediatric population aged <18 years undergoing medical, diagnostic, nursing, surgical, or dental procedures, including venipuncture, blood sampling, vaccination, injection, cannulation, vascular port access, lumbar puncture, wound care, dressing changes, dental procedures, perioperative procedures, anesthesia induction, diagnostic imaging, MRI, and radiotherapy; (3) application of immersive virtual reality delivered through a head-mounted display, VR headset, or VR goggles immediately before or during a medical procedure, encompassing both interactive and passive VR interventions; (4) inclusion of a comparator group receiving standard care, no intervention, conventional distraction techniques, non-immersive virtual reality, or other pharmacological or non-pharmacological interventions, with a comparator not being strictly required for pilot, feasibility, or acceptability studies; and (5) reporting of at least one clinical or technological outcome, including pain, anxiety, fear, stress, procedural distress, discomfort, cooperation or successful procedure completion, feasibility, acceptability, satisfaction of children, parents, or healthcare professionals, adverse events, or technological characteristics.

The exclusion criteria were as follows: (1) systematic reviews, meta-analyses, scoping reviews, narrative reviews, study protocols, case reports, and conference abstracts without sufficient results; and (2) retrospective studies and purely observational studies.

2.2. Data collection and analysis

The literature selection process was carried out in multiple stages, strictly following PRISMA guidelines. Initially, independent reviewers assessed the titles and abstracts of 327 articles, examining their compliance with the main objective of the study. To ensure maximum objectivity and minimize systematic error, this stage was conducted independently on the Rayyan platform. Studies that failed to meet the basic assumptions of the PICOS protocol were excluded. The next step involved an independent full-text assessment of the remaining publications based on detailed inclusion and exclusion criteria. Potential disagreements and conflicting assessments were subjected to joint analysis and discussed until a final consensus was reached.

2.3. Data Extraction

The following data were extracted from the qualified publications: study type and design, first author's name, year of publication, characteristics and age of the pediatric population, type of medical procedure, details of the VR intervention (including head-mounted display model, software, content, interactivity level, duration, and timing of VR delivery), characteristics of the control intervention, evaluated outcomes regarding pain, anxiety, stress, fear, discomfort, procedural distress, cooperation, and procedure completion rates, measures of feasibility, acceptability, and satisfaction among children, parents, and healthcare staff, as well as the presence of adverse events, including nausea, dizziness, cybersickness, and intervention discontinuation.

3. Results

3.1. Technological characteristics of VR interventions

Considerable technological heterogeneity was observed across the included studies, encompassing hardware configurations, degree of immersion, software content, interaction methods, and intervention timing. Hardware ranged from smartphone-based head-mounted displays (HMDs) to standalone devices and tethered systems requiring an external computer. Smartphone-based configurations included Samsung Gear VR [11, 18], LG 360 VR [13], Cyber VR BOX 3.0 [9], ReTrak Utopia 360 VR [30], VR SHINECON [32], and headsets using Apple or Samsung smartphones [15, 22]. These systems offered portable configurations and were described in some studies as relatively inexpensive and straightforward to implement [8, 9].

Standalone HMDs included Oculus Go [16, 19, 27, 35], Pico Neo 3 [36], KindVR [25], and Smileyscope, which used a magnetically attached smartphone [28]. More technologically complex systems included HTC Vive [14], Oculus Rift connected to gaming laptops [21], and Sony HMZ-T2 combined with dedicated headphones [37]. Some studies also evaluated occlusive audiovisual headsets without 360-degree environments or head tracking, such as i-glasses 920HR [12]. Although these devices provided audiovisual distraction and reduced exposure to the surrounding clinical environment, they did not represent fully immersive VR. Other studies directly compared three-dimensional VR with two-dimensional content displayed on screens, tablets, or iPads [8, 13, 28, 35].

Software content varied from passive or minimally interactive audiovisual materials to active games and procedural simulations. Passive content included dinosaur animations [9], underwater environments [10, 22, 28], nature-based scenarios [10, 16], and animated programs selected according to the child's age or preferences [12, 18, 27, 32, 36]. These modalities were commonly used during procedures requiring limited patient movement, including dental anesthesia, dental treatment, and otomicroscopy [12, 13, 18, 27, 32].

Active applications engaged children through goal-oriented tasks, virtual-object interaction, or motion tracking [11, 14, 15, 17, 19, 21, 23, 24, 26, 29, 31, 33, 35, 37]. Examples included *SnowWorld*, in which children threw snowballs at virtual objects [21, 37]; *Bear Blast*, based on target shooting [24]; *Virtual River Cruise* [15]; *Seagull Splash* [26]; and *Freddy-the-Frog* [35]. Other interventions used multiple-object-tracking tasks [23] or commercial games available on Oculus platforms [19, 29, 33]. Beyond intraprocedural distraction, VR was also used for procedural preparation. The PREVIEW application familiarized children with the operating room, hospital corridors, and recovery areas before surgery [14], while other applications provided structured information about venipuncture before or during the procedure [8, 17].

Interaction methods were adapted to the physical requirements of each procedure. Some interventions involved passive viewing without active user input [9, 12, 13, 16, 18, 22, 27, 28, 30, 32, 36], whereas others used handheld controllers or motion tracking [11, 14, 19, 21, 26, 35]. During vascular access, venipuncture, and laceration repair, gaze-based control triggered by head orientation was used to limit hand and arm movements and avoid interference with the procedure [15, 24, 31]. Thus, the level of interactivity depended not only on the software but also on the need to maintain an appropriate patient position and ensure access to the procedural site.

The timing and duration of VR exposure also varied according to the procedure. Short intraprocedural sessions, generally lasting approximately 1–15 minutes, were used during venipuncture [8, 9, 15, 22, 26, 37], vaccination [16, 34], port access [10, 19], and dental procedures [13, 18, 27, 32]. Longer exposures lasting approximately 30–45 minutes occurred during dental treatment, laceration repair, and cast-room procedures [12, 25, 30, 31]. Most interventions consisted of a single session, whereas repeated VR exposure was implemented during serial burn wound care and early rehabilitation [36].

Several studies explicitly addressed infection-control requirements. Reported strategies included removing absorbent foam components from headsets [22], using wipeable silicone face interfaces [28], applying disposable covers, and disinfecting equipment between patients [9, 15]. However, infection-control procedures were not consistently described across all studies. Overall, device portability, headset ergonomics, software content, interaction method, procedural compatibility, intervention duration, and ease of disinfection emerged as important considerations when selecting immersive VR technology for pediatric clinical use.

3.2. Clinical effectiveness

The effectiveness of immersive virtual reality (VR) in alleviating procedural pain in children yields inconclusive results and depends on the specific procedure, software interactivity level, and the control group used. A significant portion of analyzed studies indicates that VR intervention significantly reduces pain perception compared to standard care. A beneficial analgesic effect was observed, among others, during venipuncture [8, 9], subcutaneous intravenous port access [10], short invasive dental procedures including pulpotomy [12], and routine vaccinations [16, 34]. It was also noted that active (interactive) VR was more effective in alleviating pain during outpatient burn dressing changes than standard care and passive VR [15]. A significant reduction in pain sensations was also demonstrated during tooth extraction and cavity restoration [21], as well as during peripheral intravenous catheter placement [24]. In the case of vascular port access in pediatric oncology patients, a significant pain reduction emerged exclusively in the subgroup of younger children [19].

On the other hand, numerous studies did not confirm a statistically significant advantage of VR in reducing pain intensity. Such lack of differences (compared to standard care or active comparators) was demonstrated, among others, during local anesthesia administration in dentistry [13, 27], elective surgical procedures [14], venous cannulation [26], burn wound care [29], and surgical suturing of lacerations [30]. VR headsets also did not affect pain reduction during orthopedic procedures [31], primary molar extraction [32], and otomicroscopy [20]. It is worth noting that in studies including an active technological comparator—e.g., during blood sampling [23]—it was shown that while distraction significantly alleviated pain compared to standard care, immersive VR did not differ in efficacy from an identical game displayed on a standard mobile device (non-VR).

The use of VR technology shows promising results in reducing pre-procedural and procedural anxiety and fear. A significant reduction in these negative emotions in patients using VR was reported in studies on venipuncture [8, 9], intravenous port access [10, 19], dental anesthesia [18], intramuscular vaccinations [16], orthopedic procedures [31], wound suturing [25], and peripheral intravenous catheter placement [24]. Scientific reports also point to a reduction in behavioral signs of distress, such as crying and pain facial expressions during dental anesthesia [27], as well as a decrease in physiological indicators of anxiety in pediatric burn patients [15] and pediatric surgery ward patients [22]. Furthermore, some clinical trials demonstrate that preoperative exposure to VR software minimized anxiety during the preparation phase and improved cooperation during the induction of general anesthesia itself [11, 17].

Despite these positive reports, anxiety reduction was not a universal phenomenon. In some trials, VR did not reduce anxiety more effectively than standard video display [13, 28]. A similar lack of difference in anxiety or distress within study groups was demonstrated during venous cannulation [26] or wound care in children in the emergency department [30]. In a study involving preoperative preparation, no effect of 3D headsets on the occurrence of anxiety or postoperative emergence delirium was observed [14], while other analyses even suggest that the use of VR could technically hinder achieving optimal conditions for anesthesia induction [28]. Finally, in patients with special health care needs (SHCN), VR implementation did not result in lower anxiety prior to dental procedures compared to standard television distraction [33].

3.3. Feasibility and implementation

Overall, immersive VR appeared to be feasible for use during a wide range of pediatric medical procedures, although its practical implementation varied according to the clinical setting, procedure, age of the child, and characteristics of the VR equipment. Several studies reported that VR could be integrated into routine clinical workflow without substantially interfering with the procedure. In particular, VR was considered easily implementable and clinically useful during venipuncture and other procedures, with healthcare professionals reporting high ease of use and minimal disruption to their work [9, 13, 15, 19, 21, 25, 26, 27, 30, 31, 34, 35, 37]. In the orthopedic setting, VR did not interfere with the completion of medical procedures in the majority of cases and was compatible with communication between children and healthcare professionals [31]. Similarly, in dental care, the use of VR did not create obstacles for the dentist, although maintaining the child's head in a stable position was necessary [21]. In some studies, the intervention was particularly practical because of the relatively low cost, repeated usability, or smartphone based delivery [8, 9].

Nevertheless, several implementation barriers were identified. The physical characteristics of the headset, including its size, weight, fit, and comfort, were important determinants of feasibility, particularly among younger children. Difficulties related to headset size or discomfort were reported in children undergoing prolonged dental procedures [12], oncology related procedures [14], and other clinical interventions [22, 32]. In one study, younger children were more likely to discontinue VR exposure, with 71.4% of those who interrupted the intervention being 4–5 years old; the authors also noted that the relatively large and heavy headset reduced comfort in this age group [14]. Similarly, some children were unable to tolerate the headset for the entire procedure, resulting in discontinuation of VR in 33.3% of participants in one study [22], whereas

another study reported that 77% of children tolerated the headset throughout the procedure [33]. These findings suggest that headset ergonomics and age-appropriate equipment are important considerations for successful implementation.

Technical and organizational issues were also reported. Although several studies did not identify technical problems [8, 9, 10, 13, 21], isolated equipment failures or application related problems occurred in others. These included battery failure [11], application problems [15], malfunctioning headsets [16], and difficulties related to VR content or controller visibility [19]. In addition, the need for additional personnel and time for equipment preparation and disinfection was identified as a potential implementation burden [9]. In one study, interruptions by healthcare professionals represented an important barrier to maintaining VR exposure during the clinical process [28]. Furthermore, the physical configuration of the clinical procedure could limit VR use, particularly when an anesthetic mask had to be applied or when the child was positioned supine [28].

The feasibility of VR was generally accompanied by positive evaluations from children, parents, and healthcare professionals. High willingness to reuse VR was reported among children in several studies [19, 26, 27, 31, 35], while healthcare professionals generally perceived the intervention as useful and easy to implement [15, 19, 25, 31]. However, formal assessment of feasibility and acceptability was not consistently performed across studies. In several trials, feasibility was inferred from successful completion of the procedure or the absence of reported problems rather than measured using predefined implementation outcomes [10, 13, 17, 20, 23]. Overall, the available evidence indicates that immersive VR can generally be implemented in pediatric clinical settings, but successful implementation depends on appropriate headset design, age and procedure specific content, adequate preparation of the child, compatibility with the clinical workflow, and management of technical and organizational barriers.

3.4. Acceptability and safety

The implementation of virtual reality (VR) headsets in pediatric populations demonstrates high rates of acceptability and overall satisfaction among children, parents, and healthcare staff. Several studies indicate strong enthusiasm, with children reporting that the VR experience was engaging, enjoyable, and helpful during medical interventions [10, 13, 15, 19, 20, 28]. For instance, a majority of pediatric patients expressed a desire to use VR again in future procedures [17], with specific findings showing that 97.8% of children preferred using VR and 12.8% noted it completely alleviated their stress [17]. Satisfaction scores among pediatric patients consistently favor immersive VR interventions compared to standard care or traditional distraction methods such as 2D screen viewing [14, 15, 16, 18, 25]. Furthermore, high acceptability extends to parents and medical personnel, who rated VR as a valuable and highly recommended tool for procedural management [21, 25, 27, 28, 30, 32].

While positive feedback predominates, formal assessments of acceptability vary across the literature. A subset of studies noted high subjective acceptance despite not conducting formal scale evaluations [9, 11, 12, 18, 24, 31]. In studies utilizing structured tools, such as the Child Satisfaction Questionnaire (CSQ) or numeric rating scales, VR consistently scored higher than non-VR control setups [14, 20, 21, 25]. Additionally, the interactive nature of VR environments, such as playing games during procedures, significantly contributed to higher enjoyment levels [18].

3.4.1 Safety and Adverse Events

Across all reviewed trials, immersive VR demonstrated a strong safety profile in pediatric settings, with minimal and predominantly mild side effects. A substantial portion of the included studies reported zero adverse events during or following the VR intervention [8, 9, 15, 16, 20, 21, 22, 23, 24, 27, 28].

When adverse reactions occurred, they were mild, transient, and self-limiting [32]. The most frequently reported side effects involved mild cybersickness symptoms, including mild dizziness, lightheadedness, nausea, or minor headache [9, 10, 11, 12, 13, 25, 29]. For example, minor symptoms such as mild dizziness were observed in a small fraction of participants (e.g., 2 out of 184 children in one cohort and isolated cases of transient discomfort in others) [10, 11]. Severe cybersickness or significant side effects—such as vomiting or disorientation—were explicitly absent or showed no statistically significant differences when compared to active 2D control groups [12, 25]. Overall, side effect scores remained consistently low (typically between 0 and 12 on standard scales) [24], confirming that VR is a safe, well-tolerated distraction tool for pediatric care.

4. Discussion

This systematic review indicates that immersive virtual reality is a promising nonpharmacological adjunct during pediatric medical procedures, although its clinical effects were not consistent across all procedures and outcomes. Considerable heterogeneity in hardware, software, interactivity, intervention timing, comparators, and outcome measures limits direct comparisons and makes it difficult to identify which characteristics contribute most strongly to clinical benefit.

The reviewed interventions ranged from smartphone-based headsets to standalone and computer-connected systems and included passive content, interactive games, and procedural simulations. Smartphone-based configurations offered portable and relatively simple solutions [8, 9, 15, 22], whereas computer-connected systems supported more technologically complex virtual environments but required additional equipment [14, 21, 37]. Some studies used occlusive audiovisual headsets without head tracking or interactive 360-degree environments [12]. These interventions should be distinguished from fully immersive VR when interpreting the findings.

The level of interactivity may influence effectiveness, although the available evidence does not allow definitive conclusions. In one study of pediatric burn wound care, active VR produced greater pain reduction than passive VR and standard care [15]. However, passive or gaze-controlled content may be more compatible with procedures requiring limited patient movement, including venipuncture, dental treatment, otomicroscopy, and laceration repair [12, 15, 20, 24, 27, 31]. The appropriate level of interactivity should therefore be selected according to the physical and organizational requirements of the procedure.

Evidence regarding procedural pain was mixed. Significant reductions were reported during venipuncture, port access, vaccination, dental treatment, burn wound care, and peripheral intravenous catheter placement [8-10, 12, 15, 16, 21, 24, 34]. Other studies found no significant advantage during dental anesthesia, surgery, venous cannulation, otomicroscopy, burn wound care, laceration repair, or orthopedic procedures [13, 14, 20, 26, 28–32]. These differences may be related to procedural intensity and duration, participant age, sample size, VR content, and the comparator. In one study, immersive VR was not more effective than the same game displayed on a mobile device, suggesting that part of the observed benefit may result from distraction rather than immersion itself [23].

Findings for anxiety, fear, and distress were generally favorable but similarly inconsistent. Reductions were observed during needle-related, dental, orthopedic, and emergency procedures [8-10, 16, 18, 19, 24, 25, 31]. Preprocedural VR also reduced anxiety or improved cooperation during preparation for anesthesia in some studies [11, 17]. Nevertheless, other trials found no advantage over standard video distraction or usual care [13, 14, 26, 28, 30, 33]. Moreover, the physical presence of the headset could complicate anesthesia induction when access to the child's face was required [28]. The usefulness of IVR therefore depends partly on whether its timing and configuration are compatible with the procedure.

IVR was generally feasible and well accepted. Healthcare professionals frequently reported that it caused minimal disruption to clinical workflow [15, 19, 25, 31], while many children indicated that they would use it again [19, 26, 27, 31, 35]. However, implementation barriers included headset discomfort, particularly among younger children, equipment or application failures, preparation and disinfection requirements, and incompatibility with certain patient positions [9, 11, 12, 14-16, 19, 22, 28, 32]. Feasibility was also often inferred from successful completion of the intervention rather than assessed using predefined implementation outcomes.

The reported short-term safety profile was generally favorable. When adverse effects occurred, they were usually mild and transient and included dizziness, nausea, lightheadedness, or headache [9-13, 25, 29, 32]. However, adverse events were not systematically assessed in every study, and most interventions involved a single, relatively short exposure. Consequently, the absence of reported adverse events should not be interpreted as evidence that they were actively monitored or that repeated exposure is free from risk.

This review is limited by substantial clinical and technological heterogeneity, relatively small samples, inconsistent outcome reporting, and the inclusion of both fully immersive VR and occlusive audiovisual distraction. Most studies evaluated a single procedure, limiting conclusions about repeated exposure, habituation, and sustained acceptability. Future studies should clearly define the degree of immersion, directly compare active and passive VR with equivalent non-VR content, and use standardized measures of effectiveness, feasibility, acceptability, and cybersickness. Larger studies conducted under routine clinical conditions are needed to determine which children, procedures, and technological configurations are most likely to benefit from IVR.

5. Conclusions

Immersive virtual reality represents a technologically diverse approach to supporting children during medical procedures. The reviewed interventions ranged from smartphone-based headsets to standalone and computer-connected systems and included passive audiovisual content, interactive games, and procedural simulations. This diversity enables IVR to be adapted to different procedures and clinical settings but limits direct comparisons between studies and prevents the identification of a single optimal technological configuration.

IVR demonstrated the potential to reduce procedural pain, anxiety, fear, and distress, particularly during needle-related procedures, vaccination, dental treatment, and burn wound care [8-10, 12, 15, 16, 18, 21, 24, 31, 34]. Nevertheless, these benefits were not consistently observed across all procedures and outcomes. Several studies found no significant advantage over standard care or active distraction methods [13, 14, 20, 23, 26, 27, 29, 30, 32, 33]. The clinical effectiveness of IVR may therefore depend on the type and duration of the procedure, the characteristics of the virtual content, the degree of interactivity, the comparator, and the child's age and individual preferences.

IVR was generally feasible and well accepted by children, parents, and healthcare professionals, with many participants reporting satisfaction and willingness to use it again [15, 19, 25–28, 31, 35]. However, implementation barriers included inadequate headset fit or comfort, technical failures, equipment preparation and disinfection, the possible need for additional personnel, and interference with patient positioning or clinical workflow [9, 11, 14-16, 19, 22, 28, 32]. Reported adverse effects were uncommon and predominantly mild and transient, including dizziness, nausea, headache, and other symptoms of cybersickness [9-13, 25, 29, 32]. Because adverse events and acceptability were not evaluated systematically in all studies, definitive conclusions regarding safety and tolerability remain limited.

Overall, IVR appears to be a promising and generally well-tolerated adjunct to pediatric procedural care rather than a universally effective replacement for established pain- and anxiety-management strategies. Future studies should use standardized definitions and outcome measures, directly compare different levels of immersion and interactivity, and evaluate clinical effectiveness alongside feasibility, acceptability, safety, costs, infection-control requirements, and integration into routine clinical practice.

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REFERENCES

1. Loeffen, E. A. H., Mulder, R. L., Font-Gonzalez, A., Leroy, P. L. J. M., Dick, B. D., Taddio, A., Ljungman, G., Jibb, L. A., Tutelman, P. R., Liossi, C., Twycross, A., Positano, K., Knops, R. R., Wijnen, M., van de Wetering, M. D., Kremer, L. C. M., Dupuis, L. L., Campbell, F., & Tissing, W. J. E. (2020). Reducing pain and distress related to needle procedures in children with cancer: A clinical practice guideline. *European journal of cancer (Oxford, England : 1990), 131*, 53–67. https://doi.org/10.1016/j.ejca.2020.02.039
2. Addab, S., Hamdy, R., Thorstad, K., Le May, S., & Tsimicalis, A. (2022). Use of virtual reality in managing paediatric procedural pain and anxiety: An integrative literature review. *Journal of clinical nursing, 31*(21-22), 3032–3059. https://doi.org/10.1111/jocn.16217
3. Tas, F. Q., van Eijk, C. A. M., Staals, L. M., Legerstee, J. S., & Dierckx, B. (2022). Virtual reality in pediatrics, effects on pain and anxiety: A systematic review and meta-analysis update. *Paediatric anaesthesia, 32*(12), 1292–1304. https://doi.org/10.1111/pan.14546
4. Shi, C., Qiao, S., & Cao, X. (2026). The influence of different immersive virtual reality devices on children's pain during needle-based procedures: A network meta-analysis and systematic review. *Journal of pediatric nursing, 88*, 532–541. https://doi.org/10.1016/j.pedn.2026.03.022
5. Ryu, J. H., Han, S. H., Hwang, S. M., Lee, J., Do, S. H., Kim, J. H., & Park, J. W. (2022). Effects of virtual reality education on procedural pain and anxiety during venipuncture in children: A randomized clinical trial. *Frontiers in medicine, 9*, 849541. https://doi.org/10.3389/fmed.2022.849541
6. Addab, S., Hamdy, R., Le May, S., Thorstad, K., & Tsimicalis, A. (2022). The use of virtual reality during medical procedures in a pediatric orthopedic setting: A mixed-methods pilot feasibility study. *Paediatric & neonatal pain, 6*(3), 45–59. https://doi.org/10.1002/pne2.12078
7. Samnakay, S., Bell, E., Evans, D., Sommerfield, D., Sommerfield, A., Hauser, N., & von Ungern-Sternberg, B. S. (2025). Assessing the use and acceptability of virtual reality to assist coping in children undergoing clinical procedures. *Journal for specialists in pediatric nursing : JSPN, 30*(1), e70002. https://doi.org/10.1111/jspn.70002
8. Wong, C. L., & Choi, K. C. (2023). Effects of an immersive virtual reality intervention on pain and anxiety among pediatric patients undergoing venipuncture: A randomized clinical trial. *JAMA network open, 6*(2), e230001. https://doi.org/10.1001/jamanetworkopen.2023.0001
9. Erdogan, B., & Aytekin Ozdemir, A. (2021). The effect of three different methods on venipuncture pain and anxiety in children: Distraction cards, virtual reality, and buzzy® (randomized controlled trial). *Journal of pediatric nursing, 58*, e54–e62. https://doi.org/10.1016/j.pedn.2021.01.001
10. Gerçeker, G. Ö., Bektaş, M., Aydınok, Y., Ören, H., Ellidokuz, H., & Olgun, N. (2021). The effect of virtual reality on pain, fear, and anxiety during access of a port with huber needle in pediatric hematology-oncology patients: Randomized controlled trial. *European journal of oncology nursing : the official journal of European Oncology Nursing Society, 50*, 101886. https://doi.org/10.1016/j.ejon.2020.101886
11. Jung, M. J., Libaw, J. S., Ma, K., Whitlock, E. L., Feiner, J. R., & Sinskey, J. L. (2021). Pediatric distraction on induction of anesthesia with virtual reality and perioperative anxiolysis: A randomized controlled trial. *Anesthesia and analgesia, 132*(3), 798–806. https://doi.org/10.1213/ANE.0000000000005004
12. Shetty, V., Suresh, L. R., & Hegde, A. M. (2019). Effect of virtual reality distraction on pain and anxiety during dental treatment in 5 to 8 year old children. *The Journal of clinical pediatric dentistry, 43*(2), 97–102. https://doi.org/10.17796/1053-4625-43.2.5
13. Felemban, O. M., Alshamrani, R. M., Aljeddawi, D. H., & Bagher, S. M. (2021). Effect of virtual reality distraction on pain and anxiety during infiltration anesthesia in pediatric patients: A randomized clinical trial. *BMC oral health, 21*(1), 321. https://doi.org/10.1186/s12903-021-01678-x
14. Eijlers, R., Dierckx, B., Staals, L. M., Berghmans, J. M., van der Schroeff, M. P., Strabbing, E. M., Wijnen, R. M. H., Hillegers, M. H. J., Legerstee, J. S., & Utens, E. M. W. J. (2019). Virtual reality exposure before elective day care surgery to reduce anxiety and pain in children: A randomised controlled trial. *European journal of anaesthesiology, 36*(10), 728–737. https://doi.org/10.1097/EJA.0000000000001059
15. Xiang, H., Shen, J., Wheeler, K. K., Patterson, J., Lever, K., Armstrong, M., Shi, J., Thakkar, R. K., Groner, J. I., Noffsinger, D., Giles, S. A., & Fabia, R. B. (2021). Efficacy of smartphone active and passive virtual reality distraction vs standard care on burn pain among pediatric patients: A randomized clinical trial. *JAMA network open, 4*(6), e2112082. https://doi.org/10.1001/jamanetworkopen.2021.12082

16. Sánchez-López, M. I., Lluesma-Vidal, M., Ruiz-Zaldibar, C., Tomás-Saura, I., Martínez-Fleta, M. I., Gutiérrez-Alonso, G., & García-Garcés, L. (2025). The effect of virtual reality versus standard-of-care treatment on pain perception during paediatric vaccination: A randomised controlled trial. *Journal of clinical nursing, 34*(3), 1045–1062. https://doi.org/10.1111/jocn.17287

17. Wu, Y., Chen, J., Ma, W., Guo, L., & Feng, H. (2022). Virtual reality in preoperative preparation of children undergoing general anesthesia: A randomized controlled study. Virtuelle Realität in der präoperativen Vorbereitung von Kindern unter Vollnarkose: eine randomisierte kontrollierte Studie. *Die Anaesthesiologie, 71*(Suppl 2), 204–211. https://doi.org/10.1007/s00101-022-01177-w

18. Hamdy, S. F., Farag, M. S. M. S., Helmy, Y. S., & Abo-Elsoud, A. A. (2024). Enhancing pediatric dental care: The influence of virtual reality. *European journal of dentistry, 18*(4), 1030–1039. https://doi.org/10.1055/s-0044-1782193

19. Rygh, L., Johal, S., Johnson, H., & Karlson, C. W. (2023). Virtual reality for pediatric oncology port-a-cath access: A pilot effectiveness study. *Journal of pediatric hematology/oncology nursing, 40*(6), 379–385. https://doi.org/10.1177/27527530221147875

20. Galst, I. M., Høxbro Knudsen, M., & Hjuler, T. (2024). Distracting children with virtual reality during otomicroscopy: A randomised control trial. *International journal of pediatric otorhinolaryngology, 184*, 112045. https://doi.org/10.1016/j.ijporl.2024.112045

21. Atzori, B., Lauro Grotto, R., Giugni, A., Calabrò, M., Alhalabi, W., & Hoffman, H. G. (2018). Virtual reality analgesia for pediatric dental patients. *Frontiers in psychology, 9*, 2265. https://doi.org/10.3389/fpsyg.2018.02265

22. Gilboa Pras, Y., Indursky, A., Gilboa Pras, S., Schaffer, O., Niazov, E., & Zmora, O. (2024). Infectious diseases-approved virtual reality goggles for common procedures in pediatric surgical patients. *Journal of clinical medicine, 13*(18), 5572. https://doi.org/10.3390/jcm13185572

23. Czub, M., Serrano-Ibáñez, E. R., Piskorz, J., Esteve, R., Lydon, H. K., López-Martínez, A. E., Mullen, B., Ramírez-Maestre, C., Heary, C., O'Neill, C., Sainero, G., Ruiz Escalera, J. F., Caes, L., Morales Murcia, S., McDarby, V., & McGuire, B. E. (2024). Virtual reality distraction for needle-related pain and distress in children: A multicenter randomized controlled trial. *Cyberpsychology, behavior and social networking, 27*(6), 409–419. https://doi.org/10.1089/cyber.2023.0454

24. Gold, J. I., SooHoo, M., Laikin, A. M., Lane, A. S., & Klein, M. J. (2021). Effect of an immersive virtual reality intervention on pain and anxiety associated with peripheral intravenous catheter placement in the pediatric setting: A randomized clinical trial. *JAMA network open, 4*(8), e2122569. https://doi.org/10.1001/jamanetworkopen.2021.22569

25. Nemetski, S. M., Berman, D. I., Khine, H., & Fein, D. M. (2022). Virtual reality as anxiolysis during laceration repair in the pediatric emergency department. *The Journal of emergency medicine, 63*(1), 72–82. https://doi.org/10.1016/j.jemermed.2022.01.025

26. Walther-Larsen, S., Petersen, T., Friis, S. M., Aagaard, G., Drivenes, B., & Opstrup, P. (2019). Immersive virtual reality for pediatric procedural pain: A randomized clinical trial. *Hospital pediatrics, 9*(7), 501–507. https://doi.org/10.1542/hpeds.2018-0249

27. Zaidman, L., Lusky, G., Shmueli, A., Halperson, E., Moskovitz, M., Ram, D., & Fux-Noy, A. (2023). Distraction with virtual reality goggles in paediatric dental treatment: A randomised controlled trial. *International dental journal, 73*(1), 108–113. https://doi.org/10.1016/j.identj.2022.06.003

28. Samnakay, S., von Ungern-Sternberg, B. S., Evans, D., Sommerfield, A. C., Hauser, N. D., Bell, E., Khan, R. N., & Sommerfield, D. L. (2025). 3-dimensional virtual reality versus 2-dimensional video for distraction during the induction of anesthesia in children to reduce anxiety: A randomized controlled trial. *Anesthesia and analgesia, 141*(3), 629–638. https://doi.org/10.1213/ANE.0000000000007119

29. Jeffs, D. A., Spray, B. J., Baxley, L., Braden, E., Files, A., Marrero, E., Teague, T., Teo, E., & Yelvington, M. (2024). Comparing novel virtual reality and nursing standard care on burn wound care pain in adolescents: A randomized controlled trial. *Journal for specialists in pediatric nursing : JSPN, 29*(1), e12419. https://doi.org/10.1111/jspn.12419

30. Goldman, R. D., & Behboudi, A. (2021). Pilot randomized controlled trial of virtual reality vs. Standard-of-Care During Pediatric Laceration Repair. *Journal of child & adolescent trauma, 14*(2), 295–298. https://doi.org/10.1007/s40653-021-00350-4

31. Richey, A. E., Hastings, K. G., Karius, A., Segovia, N. A., Caruso, T. J., Frick, S., & Rodriguez, S. (2022). Virtual reality reduces fear and anxiety during pediatric orthopaedic cast room procedures: A randomized controlled trial. *Journal of pediatric orthopedics, 42*(10), 600–607. https://doi.org/10.1097/BPO.0000000000002250

32. Pathak, P. D., Lakade, L. S., Patil, K. V., Shah, P. P., Patel, A. R., & Davalbhakta, R. N. (2023). Clinical evaluation of feasibility and effectiveness using a virtual reality device during local anesthesia and extractions in pediatric patients. *European archives of paediatric dentistry : official journal of the European Academy of Paediatric Dentistry, 24*(3), 379–386. https://doi.org/10.1007/s40368-023-00801-6

33. Wu, W., Asselin, M. E., Hung, N., Ouimet, P., Fortin, O., Genest, C., Francoeur, M., Guingo, E., St-Arneault, K., Sylfra, A., Vu, A. K., Carmel, J., Lessard, L., Cara-Slavich, S., DeKoven, K., Paquette, J., Hoffman, H., & May, S. L. (2024). Effects of a virtual reality game on children's fear and anxiety during dental procedures (vr-tooth): A pilot randomized controlled trial. *Journal of medical extended reality, 1*(1), 137–146. https://doi.org/10.1089/jmxr.2024.0021

34. Vitor, M. Z., Silva, T. L., Bitencourt, A. S., da Rocha, P. F. A., Echevarría-Guanilo, M. E., Dos Santos, L. M., Pina, J. C., & Rocha, P. K. (2025). Virtual reality for pain relief in children during vaccination: Randomized pilot study. *Pain management nursing : official journal of the American Society of Pain Management Nurses, 26*(6), e530–e538. https://doi.org/10.1016/j.pmn.2025.06.014

35. Thybo, K. H., Friis, S. M., Aagaard, G., Jensen, C. S., Dyekjaer, C. D., Jørgensen, C. H., & Walther-Larsen, S. (2022). A randomized controlled trial on virtual reality distraction during venous cannulation in young children. *Acta anaesthesiologica Scandinavica, 66*(9), 1077–1082. https://doi.org/10.1111/aas.14120

36. Lu, L., Li, W., Ye, S., & Dai, P. (2026). Immersive virtual reality for pediatric burn pain and early rehabilitation. *Frontiers in pediatrics, 14*, 1876793. https://doi.org/10.3389/fped.2026.1876793

37. Atzori, B., Hoffman, H. G., Vagnoli, L., Patterson, D. R., Alhalabi, W., Messeri, A., & Lauro Grotto, R. (2018). Virtual reality analgesia during venipuncture in pediatric patients with onco-hematological diseases. *Frontiers in psychology, 9*, 2508. https://doi.org/10.3389/fpsyg.2018.02508