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Systematic Review

Does immersive virtual reality reduce pain and anxiety in pediatric dentistry? A systematic review and meta-analysis

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Abstract – Introduction: There is a bidirectional relationship between anxiety and pain with mutual potentiation. We already have many treatments, pharmacological (anxiolytics, conscious sedation) or not (tell-show-do, hypnosis, music), to control anxiety and/or pain. Of all the digital approaches for the treatment of pain, virtual reality (VR) has for several years been the subject of studies and tests on different types of pain, with promising results. The objective of this meta-analysis is to determine the effects of VR on pain and anxiety in a pediatric population during dental care including minor oral surgery. **Materials and method:** Our research was carried out using different databases such as PubMed, Web of Science and Cochrane. Review Manager 5.4.1 software was used to perform the quantitative analysis. Randomised controlled trials evaluating pain and/or anxiety in children who received dental treatment and comparing immersive virtual reality to usual care were included. **Results:** 5 articles were finally selected. Anxiety was measured by the Children's Fear Survey Schedule-Dentale Subscale and by the heart rate which showed a significant reduction of anxiety thanks to the VR (SMD = −0,53, 95%CI = −0,77, −0,28, p<0,0001 and SMD = −0,91, 95% CI = −1,31, −0,51, p<0,00001 respectively). The pain was measured by the Wong-Baker Faces Scale which showed a significant reduction thanks to the VR (SMD = −0,99, 95%CI = −1,24, −0,74, p<0,00001). **Discussion:** There is a clinical heterogeneity between the studies as well as significant statistical heterogeneity in all the meta-analyses (≥65%). All studies are single-census, with a low number of subjects included (varying from 54 to 104) and a limited age range (from 4 to 12). The population within the studies can be considered heterogeneous since it includes young children and pre-adolescents. Last but not least, it exists a publication bias that decreases the credibility of the results of this review which might influence the validity of the evidence. **Conclusion:** This meta-analysis is therefore innovative since it is not only the first to carry out a quantitative analysis but also the first to include only VR headsets and to exclude all studies on audio-visual distraction. Our work confirms the very recent interest of immersive VR in reducing pain and anxiety in pediatric dentistry. Nevertheless, further studies are needed to reach a definitive conclusion.

Introduction

According to the International Association for the Study of Pain (IASP), pain is defined as an "unpleasant sensory and emotional experience associated with actual or potential tissue damage". On the other hand, according to the World Health Organization (WHO), anxiety can be defined by a state of psychic disorder caused by the fear of danger, uncertainty and expectation. There is a bidirectional relationship between anxiety and pain with mutual potentiation. Anxiety, directly linked to the apprehension of the painful stimulus, will reduce the threshold of perception of this pain [1]. In pediatric odontology, the management of pain and anxiety is a daily concern for dental surgeons [2]. It is essential to establish a reassuring climate conducive to care from the first consultation in order to establish a relationship of trust between the child, the parent and the practitioner. This is a real public health issue since a non-anxious patient will be more inclined to consult his dental surgeon and the dental surgeon will be more efficient in intercepting and preventing carious lesions [3]. There are many treatments, pharmacological (anxiolytics, conscious sedation) or not (tell-show-do, hypnosis, music), to control anxiety and/or pain. However, some treatments induce many side effects (confusion, sleepiness, nausea) or require time to build a relationship with the patient [4,5]. In addition, the use of conscious sedation, often effective in anxious patients, is regulated and requires specific training for which only 3.1% of practitioners are trained [5]. Digital technology opens new perspectives in the treatment of pain and anxiety. Digital therapies such as tablet, Virtual Reality (VR), music, laptop with earphones, television or smartphone offer high-quality software-driven therapeutic interventions to prevent,

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manage, or treat a medical condition or disease [6]. These digital solutions can be used alone or combined with a drug, a medical device, or a therapy in order to optimize the effects of the treatment. Of all the digital approaches for the treatment of pain, virtual reality (VR) has for several years been the subject of studies and tests on different types of pain, with promising results [7]. An official definition of VR was published in France in 2007 in the Official Journal: "It is an environment created using a computer and giving the user the sensation of being immersed in an artificial universe". VR is a computer technology that creates a simulated artificial environment in three dimensions. It immerses the patient in a "virtual universe", audio and visual, and encourages him to interact with this world. The ability of VR to reduce not only anxiety, but also pain, is believed to be due to our limited attention span. This is because pain demands attention, and if some of that attention is diverted, the patient will react more slowly to painful stimuli. VR does not interrupt painful messages, but acts on their perception through attention, emotion, concentration and/or memory. A brain imaging study [8] of patients using VR while exposed to a painful stimulus demonstrated a reduction of more than 50% in pain-related brain activity in several regions of the brain (anterior cingulate cortex, anterior insular cortex, primary and secondary somatosensory cortex, and thalamus) involved in the sensory and emotional aspects of pain.

The objective of this meta-analysis is to determine the effects of VR on pain and anxiety in pediatric dentistry compared to usual care (tell-show-do technique, communication or positive verbal reinforcement).

Materials and method

We conducted a systematic review and a meta-analysis of randomised controlled trials (RCTs) according to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines. The proposed review was registered in PROSPERO under registration number CRD42024512193.

Search strategy

Our research was carried out using different databases. These databases were PubMed, Web of Science and Cochrane.

The search equation on the PubMed website was: "(virtual reality or audiovisual distraction) and (anxiety and pain) and (oral or dental)". On the Cochrane website, it was: "(virtual reality) and (anxiety and pain) and (oral or dental)". On the Web of Science website, we used the filter « dentistry, oral surgery and medicine » and the keywords "virtual reality and (pain or anxiety)". The bibliographic search was carried out by two authors who compared the selected articles.

Bottom-up searches were performed to identify unreferenced studies in the cited databases. The final search was performed on January, 2024.

Eligibility criteria

Inclusion criteria:

- Population: pediatric patients (age $<$ 18 yr old) who received dental treatment.
- Intervention: immersive VR during dental treatment.
- Comparisons: usual care (Tell-show-do technique, communication or positive verbal reinforcement, since they are considered essential to the smooth running of the treatment) and no intervention.
- Outcomes: Related to anxiety and/or pain.
- Study design: Randomized controlled trials published in English or French, including parallel-arm and crossover design (only the first period of the crossover study was considered in order to best approximate a study with parallel arms).

Exclusion criteria:

- Patients with disabilities such as mental illness, visual or auditory deficits.
- Uncontrolled or non-randomized clinical trials, meta-analyses, dissertations and abstracts, case studies and narrative reviews.
- Studies using glasses or a helmet that does not meet the definition of immersive VR.
- Studies that included adult and pediatric patients without distinction.

Study selection

The first part of the search strategy was to make a selection based on the title and abstract of the various articles resulting from the search equation. After eliminating duplicates, only those meeting the inclusion criteria were retained. Potentially eligible studies were then subjected to a full-text reading.

Data collection

The studies identified as a result of the bibliographic search were reported in a table specifying for each article: general information (first author, country, publication year), the study design (parallel-arm design or crossover design, characteristics of control intervention, numbers of participants allocated to intervention or control group), characteristics of the participants (the average age of the subjects and the standard deviation), number of participants included in the study, characteristics of dental treatments (treatment type, treatment duration, VR application time duration), characteristics of VR distraction (devices and manufacturers of VR equipment and the type of VR content), outcomes and their measurements methods.

As a reminder, only the first period of the crossover study was considered in order to best approximate a study with parallel arms. For multiarm parallel studies only the data who correspond to the inclusion and exclusion criteria were considered.

Risk of bias in the evaluation

Case selection was deemed adequate when patients received dental cares with an immersive VR headset.

Selection of controls was appropriate when they were sampled from the same population as the cases. Comparability between cases and controls was assessed according to sex and age.

Outcomes

The different outcomes taken into account were:
- For pain:
- Visual Analog Scale: VAS.
- Wong-Baker Faces Scale: W-BFS. The latter is considered to be similar to the Faces Pain Scale-Revised (FPS-R).
- Face Legs Activity Cry Consolability Scale: FLACC.
- For anxiety:
- Heart rate: HR.
- Oxygen saturation
- Modified Corah's Dental Anxiety Scale score: MCDAS.
- Children's Fear Survey Schedule-Dentale Subscale: CFSS-DS.
- Facial Image Scale: FIS.
- Franckl Behaviour Rating Scale: FBRS.
- Venham Picture Test: VPT.

By definition, immersive VR is an interactive 3D computer simulation that totally immerse a person in a virtual environment, giving them a sense of real presence in the virtual world. Only immersive VR headsets *stricto sensu* were included in this study.

Among the VR headsets available on the market, we can mention (non-exhaustive list):
- HTC® Vive (Vive Focus 3, XR Elite Pro, Vive Flow, Vive focus, Vive Pro).
- Sony® PlayStation VR.
- Meta® (Quest, Oculus Rift, Oculus Go).
- Microsoft® (Hololens).
- Pico® (Pico G3, Neo 3, Pico 4).

Quantitative analysis

We chose a fixed-effect model based on the assumption that all studies come from the same population and produce estimates of the same and unique effect size. Inter-sample variation (between studies) is considered to be due to sampling fluctuations only. The weighting of the studies is then based solely on the intra-sample variance. We applied the Mantel-Haenzel (MH) calculation method, recommended as first-line in this type of model by the Cochrane Collaboration [9].

The meta-analysis was performed using Review Manager 5.4.1 software (Cochrane Community Software, 2014).

The Standardized mean difference (SMD) is used as a statistical tool in meta-analysis when all selected studies assess the same outcome but measure it in different ways. In these circumstances, it is necessary to standardize the results of the studies on a uniform scale before they can be grouped. The SMD expresses the size of the intervention effect in each study compared to the variability observed in that study.

$$\mathrm{SMD} = \frac{\text{difference in meanscore between groups}}{\text{the standard deviation of the results between the participants.}}$$

Thus, studies for which the difference in mean between groups is the same proportion as the standard deviation between participants, will have the same SMD, regardless of the actual scales used to perform the measurements.

Assessment of heterogeneity: Inevitably, the studies selected for a systematic review will not be perfectly identical and all forms of variability within these studies will be considered under the umbrella term of heterogeneity. The differences observed in the studies concerning the base population studied, the precise nature of the therapeutic intervention or the endpoints constitute the clinical variability. Methodological variability concerns the design and risk of bias of each study. The variability concerning the measurement of the effect in the various studies results from these clinical and methodological variabilities and can be quantified by the measurement of statistical heterogeneity or heterogeneity [9].

The Chi-square test proposed by Review Manager assesses whether the observed difference between studies is attributable to chance alone. The null hypothesis postulates that the studies are not heterogeneous. A low P or high Chi^2 value indicates the existence of heterogeneity in the estimation of the effect of an intervention. The interpretation of these figures must be cautious because it is highly dependent on the number of studies selected and the sample size of each. Small or few studies expose to under-screening for heterogeneity. Therefore, while a statistically significant result may indicate a problem of heterogeneity, a non-significant result should not be considered evidence of the absence of heterogeneity. This is also the reason why a P-value of 0.10 is sometimes used rather than the conventional level of 0.05 to determine statistical significance.

Thus, another method, the measurement of inconsistency was developed to measure, not the existence of heterogeneity, but its impact on the result of the meta-analysis.

$$\mathrm{I}^2 = \left(\frac{\mathrm{Q} - \mathrm{df}}{Q}\right) \times 100\%$$

Q = result of the Chi^2 et df = number of degrees of freedom of the Chi^2.

I^2 would represent the percentage of variability in the effect measure attributable to heterogeneity rather than sampling fluctuations.

The Cochrane Handbook for Systematic Review proposes to interpret the value of I2 as follows:
- 0% to 40%: probably low heterogeneity.
- 30% to 60%: moderately large heterogeneity.
- 50% to 90%: heterogeneity to be considered.
- 75% to 100%: very important heterogeneity.

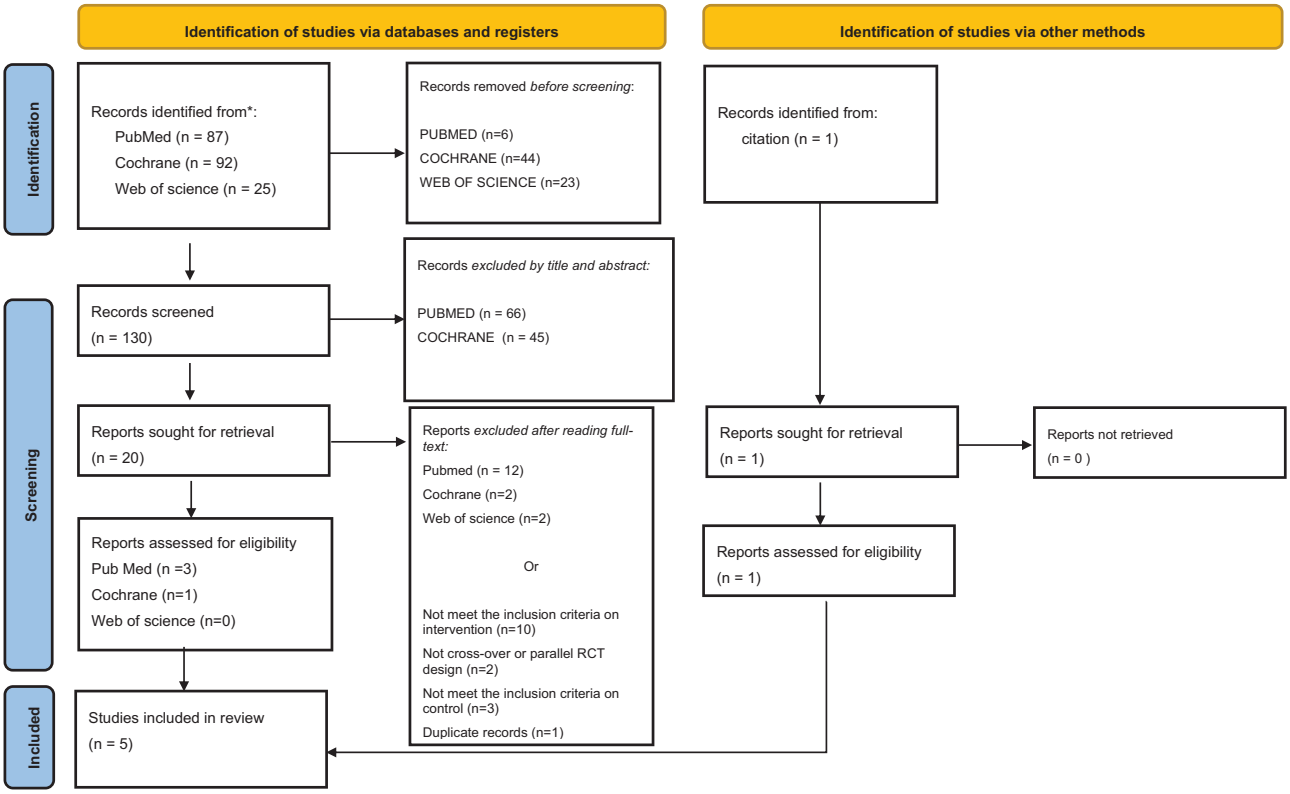


Fig. 1. PRISMA Flow diagram representing the bibliographic selection strategy.

Results

Study selection

In total, the search equation led to an initial selection of 204 articles, 20 of which were eligible after reading the title and abstract. After complete reading of the articles, 5 articles were finally selected for this study and represented in the flowchart (Fig. 1).

Study characteristics

The 5 studies included were published in the last 3 yr, which reflects the recent interest in virtual reality in dentistry. They were conducted in 4 countries: India (Aditya *et al.* [10]), Jordan (Alshatrat *et al.* [11]), Turkey (Buldur *et al.* [12]) and China (Du *et al.* [13], Ran *et al.* [14]). Three studies were published in 2021 [10,12,14] and two studies in 2022 [11,13] (Tab. I).

Four studies assessed both pain and anxiety while one study assessed only anxiety.

Regarding the study design, three studies used two-arm parallel trial, one study used multiarm parallel trial and one study used crossover design. The number of participants in the various studies ranged from 54 to 104. The age of patients varied from 4 to 12 yr. Three studies compared VR with "standard cares", one study compared VR with no distraction and one study compared VR with kaleidoscope, "fidget spinner" game and no distraction. For this last study, only the "no distraction" group was considered (Tab. I).

The anxiety and pain levels were measured by: CFSS-DS, W-BFS, FBRS, FIS, FLACC, VAS, Oxygen saturation, VPT, HR (Tab. I).

No adverse effects were reported in any of the studies.

Characteristic of VR intervention

Two studies left the choice of cartoon to the patient. Of the three studies that imposed content, one showed an interactive underwater background, one showed a manga episode, and one showed a magical virtual world with nature scenes. Only one study clarified that the placement of the VR helmet was 5 min before the start of loco-regional anaesthesia (Tab. I).

Characteristic of dental treatment

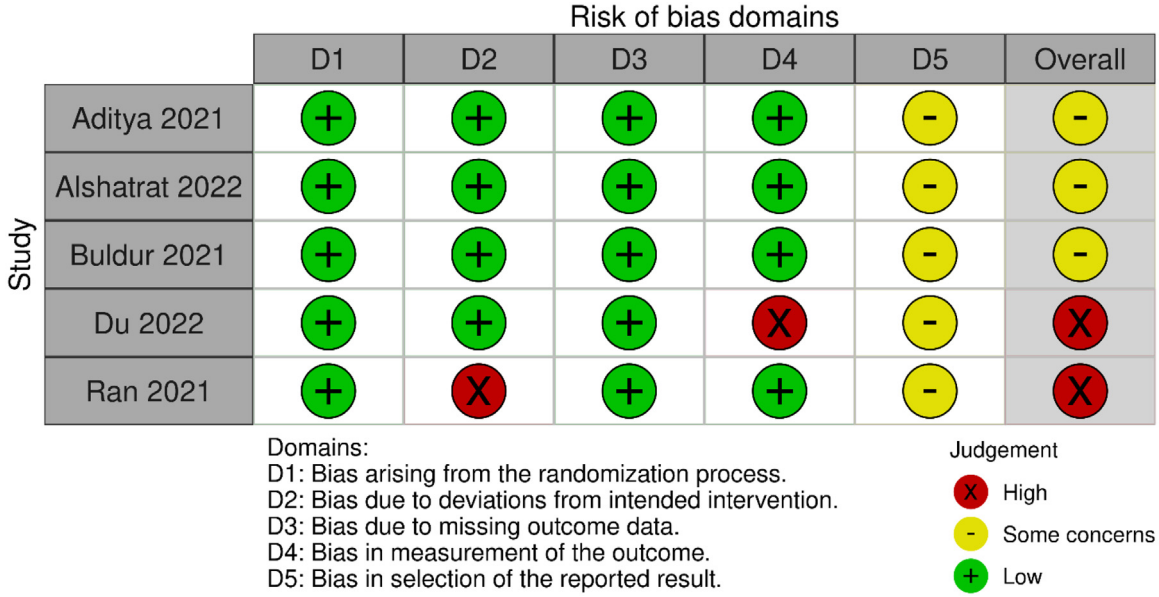
The five studies tested VR when performing anaesthesia (para-apical [11–14] or loco-regional [10]). Then 4 of them continued to assess the effect of VR during different types of

Table I. Characteristics of selected studies.

	Study design	Age: Mean +/− SD (min max) years old	Number of participants (n)	Dental treatment	System of VR	VR content	Measurements
Alshatrat *et al.* *Jordan* 2022 [11]	RCT Parallel arms Test group: VR (*n* = 28) Control group: standard care (n=26)	Ma = 8,39+/−2,05 (5–12)	54	Local anaesthesia and painful care (pulp therapy, restoration, avulsion or coronary preparations).	iWear Video Headphones, Vuzix, NY	Films such as Tom and Jerry, Mr Bean chosen by the child. Choice	VAS, W-BFS, FLACC
Buldur *et al.* *Turkey* 2021 [12]	RCT Crossover Group 1: AB (*n* = 38) Group 2: BA (*n* = 38) A: standard care B: RV	Ma = 9.02 ± 1.39 (7–12)	76	Local anaesthesia followed by carious removal and composite restoration of a mandibular first permanent molar with occlusal caries	PlayStation 4 VR, Sony Inc, Japan	Cartoon of the child's Choice	CFSS-DS, FIS, W-BFS, HR
Ran *et al.* *China* 2021 [14]	RCT Parallel arms Test group: RV (*n* = 55) Control group: standard care (*n* = 49)	RV: 5.59 ± 0.92 (4–8) Control: 5.66 ± 0.99 (4–8)	104	Local anaesthesia and care less than 30 min (caries, temporary tooth avulsion, abscess incision, root canal treatment).	HTC VIVE VR, China	Diffusion underwater No choice	CFSS-DS, W-BFS, FBRS
Aditya *et al.* *India* 2021 [10]	RCT Parallel arms For all groups: tell-show-do and positive verbal reinforcement when applying topical anaesthesia Group 1: "fidget spinner" game (*n* = 15) Group 2: kaleidoscope (*n* = 15) Group 3: RV (*n* = 15) Group 4: no distractions (*n* = 15)	(6–9)	60	Loco-regional anaesthesia (inferior alveolar nerve). Placement of the VR helmet 5 min before the start of loco-regional anaesthesia. We only considered groups 3 and 4 in this study.	MI VR Headset, Xiaomi, China	Only one episode of "chota bheem" No choice	Oxygen Saturation, HR, VPT
Du *et al.* *China* 2022 [13]	RCT Parallel arms Group 1: RV (*n* = 41) Group 2: without distraction (*n* = 42)	6,3+/−3,5(4,3–8,8)	83	Topical anaesthesia, local anaesthesia, temporary tooth extraction. All operations were completed within 20 min.	HTC VIVE VR, China	Magical virtual world with scenes and sounds of nature No choice	CFSS-DS, W-BFS, Simulator sickness questionnaire (SSQ), The Houpt Rating Scale

RCT: Randomized Controlled Trial, C: Control, VR: Virtual Reality, SD: Standard Deviation.

Table. II. Risk of bias.



care: pulp therapy or root canal treatment [11,14], restoration [11,12,14], temporary tooth extraction [11,13,14], incision of an abscess [14] (Tab. I).

Risk-of-bias assessment

The risk of bias assessment is presented in Table II. In domain one (D1: randomization process), all studies were judged to be low risk because they described the process of random and the secret allocation sequences. Three studies indicated that there was no significant difference in age, gender and other factors between groups. All studies recruited cases and controls from the same population. All judgment criteria have been scientifically validated. Only one study did not describe the judgment criteria (Tab. III).

In domain two (D2: deviations from intended intervention) one study was rated as high risk because the dropout rate is unequal and high between the intervention group (8.33%) and the control group (18.33%).

All studies in domain three (D3: missing data on results) were considered low risk since the results are self-explanatory.

A study in the field four (D4: risk of bias in outcome measurement) was considered high risk since the assessment of anxiety was done by the dentist who was familiar with the intervention received.

For domain five (D5: selection of reported results), all 5 studies were considered "some concerns" because no protocol pre-specifying the methodology was found. Usually, the protocol contains information regarding the outcomes they plan to collect.

In summary, the overall risk of bias in 2 studies was considered high while it was considered "certain concerns" in 3 studies.

Effect of immersive VR on anxiety

The effects of VR on pain and/or anxiety are gathered in Table IV.

- **CFSS-DS**

Buldur *et al.*, Du *et al.* and Ran *et al.* assessed anxiety through the CFSS-DS score [12–14].

The meta-analysis included 134 subjects in the test group and 129 subjects in the control group. This showed a significant reduction in anxiety thanks to VR (SMD = –0.53, 95%CI = -0.77, −0.28, $p<0.0001$). The heterogeneity I^2 was equal to 79% so must be considered when interpreting the results

Among these three studies, the study of Du *et al.* [13] had patients try the VR headset during a first session, then in the waiting room so that they became familiar with it. This study differed from the other two with very wide confidence intervals (postoperative CFSS-DS: VR: 32.32 +/− 15.58, control: 35.16 +/− 14.81).

One study included patients with a mean age of 9.02 +/− 1.39 [12] while the other two included younger patients (6.3 +/− 3.5 and 5.59+/ −0.92) [13,14] (Fig. 2).

- HR:

Aditya *et al.* and Buldur *et al.* assessed anxiety through HR [10,12]. One study evaluated the effect of VR on patients aged 7–12 yr receiving local anaesthesia followed by conservative care [12] while the other study evaluated the effect of VR on patients aged 6–9 yr during loco-regional anaesthesia only [10].

Table III. Summary of study characteristics and assessment of risk of study bias.

Study characteristics	Studies n	Risk of bias assessment	Studies n
Year of publication		**Selection**	
2021	*3*	*Definition of cases*	*5*
2022	*2*	*Selection of cases*	*4*
		Definition of controls	*5*
		Selection of controls	*4*
Study design		**Comparability**	
Crossover	*1*	*Matching for age and genders*	*3*
Parallel arms	*4*	*Matching of other factors*	*3*
Evaluation		**Measures**	
Pain	*4*	*Measurement description*	*4*
Anxiety	*5*	*Validation of measurement technique*	*5*

Table IV. Effect of immersive VR on pain or anxiety.

	Pain			*Anxiety*				
	Visual Analog Scale (VAS)	Wong-Baker Faces rating scale (W-BFS)	Face Legs Activity Cry Consolability Scale (FLACC)	Heart Rate (HR)	Children's Fear Survey Schedule-Dentale Subscale (CFSS-DS)	Facial Image Scale (FIS)	Franckl Behaviour Rating Scale (FBRS)	Venham Picture Test (VPT)
Aditya et al. [10]				↘				↘
Alshatrat et al. [11]	↘	↘	↘					
Buldur et al. [12]		↘		↘	↘	↘		
Du et al. [13]		↘			↘			
Ran et al. [14]		↘			↘		↘	

↘: decrease in the judgment criterion, =: no effect on the judgment criterion.

The meta-analysis included 53 subjects in the VR group and 53 subjects in the control group. This showed a significant decrease in heart rate (SMD = -0.91, 95% CI = -1.31, −0.51, $p<0.00001$). Nevertheless, the few available studies did not allow to give a firm conclusion (Fig. 2).

Effect of immersive VR on pain

- W-BFS:

Alshatrat *et al.*, Buldur *et al.*, Du *et al.* and Ran *et al.* assessed pain through the W-BFS [11–14]. One study evaluated the effect of VR in a population aged 7–12 yr receiving local anaesthesia and then conservative restoration [12]. One study evaluated the effect of VR on a population aged 4 to 9 yr receiving local anaesthesia before avulsion of a temporary tooth [13] while two other studies evaluated the effect of VR during anaesthesia local before a dental treatment lasting less than 30 min on patients aged 5 to 12 yr [11] and 4 to 8 yr [14]. After inclusion of 151 subjects in the VR group and 143 subjects in the control group, a significant reduction in pain emerged (SMD = -0.99, 95%CI = -1.24, −0.74, $p<0.00001$). Nevertheless, the heterogeneity was very important ($I^2 = 91\%$) (Fig. 2).

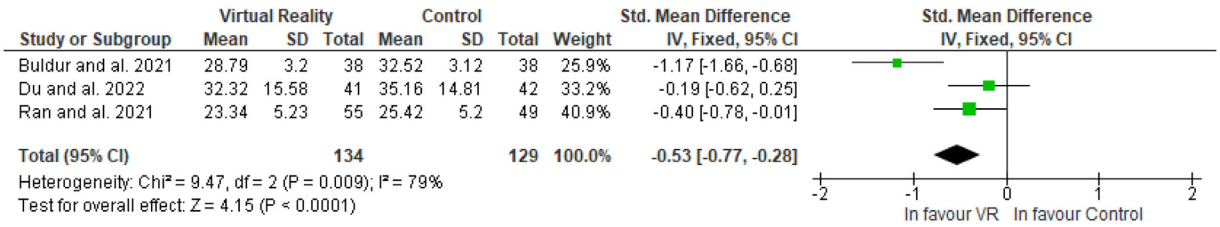
Discussion

We performed a systematic review and meta-analysis to assess the effect of immersive VR in reducing pain and anxiety in pediatric dentistry. To the best of our knowledge, this meta-analysis is the first study that has been conducted about immersive VR stricto sensu. The meta-analysis showed a significant decrease in anxiety and pain with immersive VR.

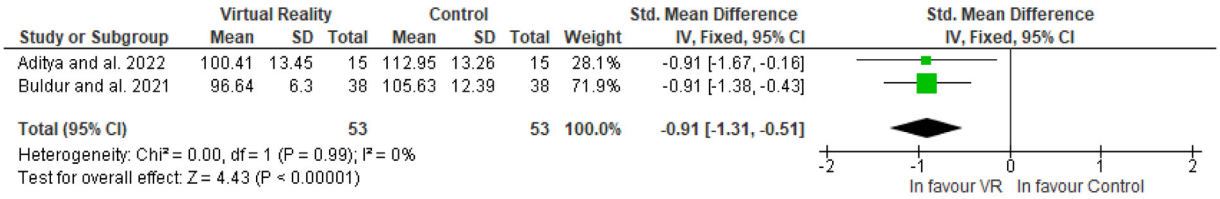
Nevertheless, our results should be interpreted in light of the limitations of the included studies. Indeed, there is clinical heterogeneity between the studies as well as significant statistical heterogeneity in all the meta-analyses (≥65%). Moreover, studies were rated as "some concerns" and "high risk". All studies are single-census, with a low number of subjects included (varying from 54 to 104) and a limited age range (from 4 to 12). The population within the studies can be considered heterogeneous since it includes young children and

1. Anxiety

A. CFSS-DS



B. HR



2. Pain

C. W-BFS:

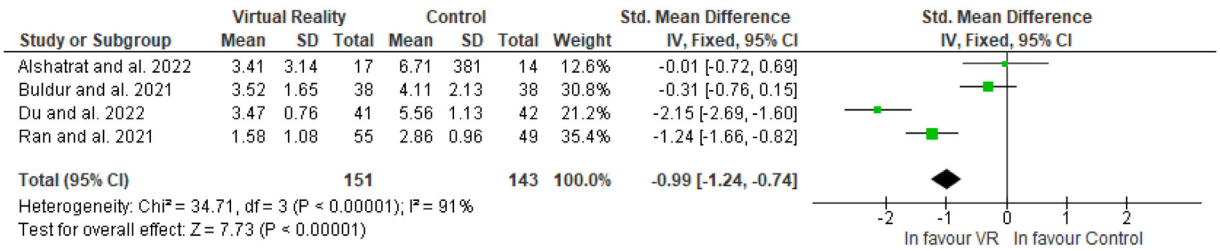


Fig. 2. (A) Forest plot of CFSS-DS. (B) Forest plot of HR (C) Forest plot of W-BFS. The squares represent the effect sizes of each of the studies (the size is proportional to the weight of the study) and the lines on the abscissa indicate the 95% confidence interval. The solid diamonds represent the size of the overall effect (on the abscissa the width indicates the 95% confidence interval). Total: number of subjects.

pre-adolescents. Last but not least, it exists a publication bias that decreases the credibility of the results of this review which might influence the validity of the evidence.

In this study, only immersive VR headsets stricto sensu were included. Indeed, there are very few VR headsets on the market and the only existing VR glasses are still at the prototype stage to date. This meta-analysis is therefore innovative since it is not only the first to carry out a quantitative analysis but also the first to include only VR headsets and to exclude all studies on audio-visual distraction. Indeed, among the existing systematic reviews in the literature, the systematic reviews by Cunningham *et al.* [15], Addab *et al.* [7], Barac'h *et al.* [16], Custodio *et al.* [17], Gurav *et al.* [6], Barros Padilha *et al.* [18], Lopez-Valverde *et al.* [19], and Yan *et al.* [20] confuse with the term virtual reality: smartphone headset [15,16,19], audiovisual distraction glasses [6,7,15–20] and immersive VR [7,16,18,20]. Most of the systematic review demonstrate the successful use of audiovisual distraction to decreased pain and anxiety compared with no intervention [7,15,16,18]. The studies included in those systematic reviews use very different methodologies: split mouth [7,16,18], without group control [7], parallel arm [7,15,16,18] or cross-over [16]. Moreover, among the meta-analyses, only two demonstrate significant difference in pain [20] and anxiety (VPT [6], HR [6], [20]) in relation to audiovisual distraction glasses use. The other meta-analyses, evaluating the effect of audiovisual distraction glasses, observe no differences in anxiety (HR [17], FLACC [17,19], MCDAS [19]) and pain (W-BFS [17,19]). Gurav *et al.* [6] found significant reduction of HR and VPT using immersive VR comparing to audiovisual distraction such as tablet, VR, music, laptop with earphones, television or smartphone.

Perspectives

Regarding the type of treatments in this meta-analysis, all the studies mixed teeth extraction, pulp therapy, restoration, coronary preparation, abscess incision, root canal treatment and local anaesthesia. It could be interesting to compare the efficacy of virtual reality between the different type of dental treatment.

The decrease in anxiety by VR can be explained by the fact that the VR headset protects the patient from all potentially unpleasant sound and visual stimuli during dental care. Indeed, the sight of blood, the anaesthesia needle, metal and sharp instruments as well as the hearing of turbine noises are all stimuli that can generate anxiety. The choice of VR headset is therefore of paramount importance since it should be as immersive as possible so that the patient ignores the gestures of the practitioner. However, other practical elements should be taken into account: the weight of the helmet — an VR helmet can be heavy (approximately 700 grams) — its size — a helmet that is too bulky can hinder the practitioner in his gesture — its compatibility with the respect for asepsis during treatment — even if there are single-use protections on certain brands of VR helmet, disinfection between each patient must be made possible by the manufacturer. A study comparing the effectiveness of different VR headsets available on the market could be interesting.

In four studies included in this systematic review, subjects are discovering VR for the first time. One study has patients try the VR headset during a first session, then in the waiting room so that they became familiar with it. This study differs from the other with a very wide confidence interval. One might wonder whether there is not a novelty effect. Thus, a new study could be conducted to evaluate the effect of VR over time and observe a possible increase or decrease in the effects of VR.

No adverse events were reported in all included studies. Nevertheless, according to the National Agency for Food, Environmental and Occupational Health Safety (ANSES), exposure to virtual reality can disrupt the sensory system and lead to symptoms such as nausea, dizziness, sweating, pallor, loss of consciousness. Balance… grouped under the name "cyberkinetosis". In people who are sensitive to it, these symptoms may appear from the first minutes of use. Furthermore, VR devices use LED screens potentially rich in blue light which, when viewed in the evening or at night, can disrupt our biological rhythm (delay in falling asleep, sleep disruption). Finally, exposure to the temporal modulation of the light emitted by these LED screens — flashing of light sometimes imperceptible to the eye — can trigger epileptic seizures in people with favourable conditions.

Conclusion

This meta-analysis confirms the very recent interest of immersive VR in reducing pain and anxiety in pediatric dentistry. Nevertheless, despite the recent interest in virtual reality, the number of studies on immersive virtual reality is still low, with heterogeneous methodology and a limited number of patients. Indeed, further studies are needed to reach a firm and definitive conclusion.

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Conflicts of interest

The authors declare that they have no conflict of interest.

Data availability statement

The authors make the data collected in this systematic review and meta analysis available to readers of this article.

Author contribution statement

L.D conceived the idea. L.D and A.E conducted the systematic review and meta-analysis. L.D and A.E led the writing. C.G.R contributed to the writing and critically revised the manuscript.

Ethics approval

Ethical approval was not required. Nevertheless, the proposed systematic review was registered in PROSPERO under registration number CRD42024512193.

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