



GRADUATION PROJECT

Degree in Dentistry

BEHAVIORAL MANAGEMENT IN PEDIATRIC DENTISTRY

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ABSTRACT

Introduction: Behavioral management is essential for ensuring positive treatment outcomes. Children's dental anxiety and fear affect cooperation, delay treatments and can negatively affect oral health. While Tell-Show-Do and other traditional methods are still often used, innovative technologies like virtual reality have been introduced as alternatives to enhance patient compliance. **Objectives:** The main objective is to assess the effectiveness of multimedia distractions, particularly virtual reality, in reducing anxiety and pain perception. As secondary objective was to compare the different techniques and identify the most effective approach. **Methods:** The PubMed database was used to conduct a systemic review. Of 75 identified articles, only 18 satisfied the inclusion criteria. These selected studies were published between 2014 and 2024, and were focused on pediatric behavioral management techniques, especially on virtual reality, audiovisual and audio-only distractions. **Results:** compared to conventional techniques, virtual reality reduces dental fear and pain during dental treatments. These results are confirmed by physiological indicators like heart rate and salivary cortisol levels. Additionally, virtual reality improves collaboration and treatment efficiency, especially during invasive procedures. Age was a crucial factor, older kids preferred the combination of cognitive behavioral therapy and VR, while younger kids with ages 3-7 years old benefited more from immersive VR. **Conclusion:** In pediatric dentistry virtual reality is an effective, non-invasive behavioral management tool. Due to its immersive qualities, it helps to reduce stress and pain, as well as enhance cooperation, and offers a reusable and sustainable solution in modern clinical practice.

KEYWORDS

Dentistry, pediatric dentistry, behavioral management techniques, virtual reality, dental anxiety

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1. INTRODUCTION

In pediatric dentistry, behavioral management plays a significant role in delivering quality care to children, since without it, dental care becomes very challenging. For this reason, behavioral management in pediatric dentistry has become a foundation aspect of the specialty (1). The American Academy of Pediatric Dentistry and the European Academy of Pediatric Dentistry provide recommendations to educate healthcare providers and parents, as well as behavior guidance techniques applied currently in dentistry (1).

The behavior of the dental team is essential for guiding pediatric patients and parents throughout the visit. The team's attitude and effective communication are crucial for creating a good environment and building trust with the patient and their caregiver (1). However, communication with the children can be challenging sometimes due to their cognitive and emotional development (2). The dental professional has the role of maintaining a three-way conversation. First, build up a connection with both the parent and the child. Then gather the information and answer doubts. Lastly, identify the complexity of the verbal and body language interactions, and address the child's anxiety and concerns (2).

1.1 Challenges and Limitations of Behavioral Management in Pediatric Dentistry.

Factors, such as fear, situational anxiety, pain, previous negative experiences, or deficient preparation for the encounter can contribute to the non-compliant response of some children to dental appointments (1). Moreover, cognitive age, physical or mental disabilities, and acute or chronic illnesses are some other uncooperative factors that can exacerbate the patient's attitude during the dental visit (1). These factors emphasize the relevance of identifying and managing the child's behavior to provide a more comfortable dental experience.

One of the most common behavioral challenges in pediatric dentistry is dental anxiety and dental phobia, which commonly start during childhood, causing avoidance of dental care that will later lead to oral health complications and lower quality of life (3). Behavioral management techniques play a significant role in helping children to manage and reduce dental fear. Dental fear is described as an unpleasant emotion about a particular threatening stimulus in the dental office (4). However, when it intensifies, it can evolve into dental anxiety or dental phobia. Dental anxiety is

characterized as a non-specific feeling of apprehension, concern, or discomfort without a clear underlying cause; whereas dental phobia is a severe type of dental anxiety defined by significant and ongoing fear associated with specific situations (4,5).

Disruptive behaviors originating from anxiety or phobia can interfere with the quality of dental procedures, often increasing treatment time and the risk of injury to the child. The professional's ability to manage young patients' behavior during a dental visit is crucial to having successful treatment (6). Understanding the underlying causes of these behaviors allows dentists to apply correct behavioral strategies to ensure a better dental experience and better the outcome in the patients' oral health. Therefore, many behavioral management techniques have been designed to reduce this conduct and foster the cooperation of young patients during dental visits.

1.2 Basic Techniques

1.2.1 Tell-Show-Do (TSD)

A child's first experience in the dental office often shapes their cooperation for future dental treatment. A positive initial experience will foster a sense of comfort and trust with the dentist, reducing the likelihood of negative attitudes toward future procedures (7). To create a positive foundation the Tell-Show-Do technique has become one of the most frequently used in pediatric dentistry according to multiple studies (8). This technique consists of explaining the procedure using an age-appropriate vocabulary ("tell"), demonstrating the patient the different dental instruments ("show"), and lastly performing the procedure on the child ("do") (7). The main objective of TSD, which was introduced by Addelston, is to desensitize the patients and help them familiarized with the dental setting, equipment, and instruments; therefore, reducing the anticipatory anxiety (1,9).

1.2.2 Ask-Tell-Ask (ASA)

The Ask-Tell-Ask technique is considered a modification of the Tell-Show-Do method, whose objective is to enhance children's understanding of dental terms and procedures, assess any anxiety that may lead to non-compliant behavior during the dental treatment, and ensure the patient feels comfortable with the treatment plan before proceeding (1,10). This technique consists of first asking the patient's feelings (ask), then explaining the procedure through demonstrations and using a simple, non-intimidating vocabulary to ensure understanding (tell), and finally, asking again to confirm the patient's comprehension (ask) (1).

1.2.3 Positive Reinforcement

This technique consists of recognizing a child's behavior through descriptive feedback on specific actions and outcomes that reinforce positive actions, thus increasing the chances of recurrence of these behaviors in future appointments (1). Evaluative or generalized praises, such as "good job", position the dentist in a more manipulative and judgmental role, whereas descriptive praises like "you sat so still and opened your mouth wide", encourage the child to evaluate their behavior independently, and will help build self-esteem and internal motivation (11).

1.2.4 Voice Control

Young children often respond more to the tone of voice than the actual words spoken (12). This technique involves adjusting the volume, pace, and tone of voice to establish authority and capture the attention of children to prevent negative behaviors. However, it is important to explain to the parents beforehand to prevent any confusion, since the change of tone might be perceived as unpleasant to them (1). This method is contraindicated in children who due to age, disability, or emotional immaturity cannot understand or respond (12).

1.3 Advance Techniques

1.3.1 Protective Stabilization

Protective stabilization is a method of medical restraint indicated primarily for patients unable to cooperate due to physical or developmental conditions, including pediatric patients. However, it is contraindicated in cooperative individuals. This technique consists of limiting the patient's movements using physical restraints or equipment to prevent injuries and ensure the patient remains safe during the dental treatment (13). When physical force is applied over the patient's head, body, or limbs for a limited time, it is considered active restraint (1). Conversely, the use of stabilization devices is considered passive restraints (1). Protective stabilization should be employed cautiously and requires informed consent from the parents (1). Its use has declined due to concerns about potential limitations on respiration or circulation and the increasing preference for alternative methods (13).

1.3.2 Sedation

Conscious sedation is a medically controlled state of reduced consciousness that enables patients to maintain protective reflexes, keep their airways open, and

respond appropriately to stimuli or commands (14). Sedative drugs can be administered through many routes including oral, nasal, intravenous, intramuscular, and subcutaneous. Common medications used for sedation include nitrous oxide, benzodiazepines, propofol, ketamine, hydroxyzine, and chloral hydrate (14). This technique requires a safety margin to reduce the risk of unintended loss of consciousness. The primary objective of this method is to decrease discomfort or pain, control anxiety, and modify movements and behavior that will allow the dentist to safely complete the treatment (1). Prior to use, practitioners are advised to review the “Guideline for Monitoring and Management of Pediatric Patients Before, During, and After Sedation for Diagnostic and Therapeutic Procedures” to ensure proper preparation (1). This method is for patients who are unable to cooperate due to a lack of psychological, emotional, or mental maturity, or because of physical or medical conditions (1).

1.3.3 General Anesthesia

General anesthesia is a medically controlled state of unconsciousness where patients lose all reflexes, the ability to maintain their airways open, or to respond to stimuli. This technique is used as an alternative way when other methods are inadequate, and it is mainly used in uncooperative patients due to disabilities or immaturity, when local anesthesia is not effective due to infections or anatomy, or when the patient is going through an extensive surgery or emergency dental care (1). Practitioners should justify the use of general anesthesia, obtain informed consent, provide preoperative instructions, and complete health evaluations (1).

1.4 Innovative Approaches and Technology for Managing Children in the Dental Office

While the basic behavioral management techniques remain effective, innovative, non-invasive techniques have been introduced. Contemporary distraction techniques, especially multimedia techniques, have been explored as methods to shift the patient’s focus from the unpleasant stimuli, offering immersive, and engaging solutions, that enable dentists to manage children while providing treatment in a calm and stress-free environment (15). Multimedia techniques, such as visual, audiovisual, and virtual reality (VR), combine visual, auditory, and sometimes physical elements that distract and promote relaxation in patients (15).

1.4.1 Audio Distraction

Audio distraction has been widely used over the past decades as a non-invasive method to decrease patient's discomfort. This technique includes, music, storytelling, and guided meditation, all of which help redirect patients attention from dental procedures (16). This technique has been shown to significantly reduce dental anxiety and pain during procedures, especially in pediatric dentistry. Its simplicity and non-invasive use, makes it a useful tool for creating a more comfortable and relaxed environment for children when undergoing any treatment (16,17).

1.4.2 Audiovisual Distraction

Audiovisual distraction is a technique that combines audio and visual stimuli to help divert their attention and focus away from the dental procedure. This technique has caught the attention of dentists due to its high effectiveness for managing anxiety and pain, as well as improving compliance, since it creates a dual-sensory experience (16). The combination of sound and visual images offers an engaging experience for children, especially those who are more anxious and nervous. Audiovisual distraction, such as cartoons and movies, are preferred by children because it offers a more immersive experience than audio-only methods (18).

1.4.3 Virtual Reality (VR)

Virtual reality is a cutting-edge technology that is both immersive and captivating. VR has emerged as a potent tool for behavior management in pediatric dentistry because it distracts kids from the dental setting, which lessens their discomfort, anxiety, and fear during procedures (5,19). Children are forced to divert their attention from potentially upsetting stimuli, such as dental instruments and sounds, by the interactive experience. Its potential to improve the clinical and psychological aspects of pediatric dentistry care is highlighted by this finding (5). Virtual reality can be categorized into three primary types based on the level of immersion.

The first type is non-immersive virtual reality, where children interact with the game through a screen and controllers. This type uses common displays such as computers, smartphones, Nintendo, and PlayStations (20,21). Non-immersive VR allows the user to interact with virtual environment without being completely submerged. User can control certain elements or characters in the virtual world in non-immersive VR (21).

Secondly, there is semi-immersive virtual reality. This type of VR offers a partial immersive experience, through the use of a computer screen or VR headsets, allowing the user to be immersed in a three-dimensional environment (20). However, users' physical perceptions are limited. They will only be visually immersed even if they move around and observe a virtual environment (21).

Lastly, the fully immersive offers a completely comprehensive sensory experience where users are immersed in a simulated environment (21). With the use of advanced hardware, such as haptic devices and head mounted displays, users can engage with the virtual world in a way that closely mimics the real-world interactions (20,21)

1.5 Anxiety Assessment Methods

1.5.1 Modified Child Dental Anxiety Scale (MCDAS)

This method is a self-report questionnaire that was created to assess dental anxiety in children, especially between the ages of 6 and 16 (22). It shows typical dentistry scenarios, such as receiving an injection or having a tooth drilled, and asks children to rate their level of anxiety through the Likert-type scale, which ranges from 1 to 5, 1 being very scared and 5 not scared at all (4). A redesigned version of this technique, the MCDAS-f, includes facial expressions to help younger patients better understand and respond to the questions (23).

1.5.2 Venham Picture Test (VPT)

The Venham Picture Test is a very popular project measure that was designed to assess dental anxiety in children through a simple and non-verbal approach. It is made of a sequence of paired cartoon-like pictures with two opposing emotional states, one is shown as calm or happy, and the other as nervous (4). The method consists of asking the children which emotion better captures their feelings before and during the dental procedures. VPT is especially useful for patients who lack verbal communication abilities, since it avoids the complex verbal explanation and helps assess if any behavioral management technique is necessary during dental treatment (3,4).

1.5.3 Facial Image Scale (FIS)

The FIS method consists of a friendly visual assessment tool with five faces that are positioned in a row, arranged from very happy to very unhappy (24). In this method, patients are asked to select the face that best represents how they feel about going to the dentist or having a dental procedure (24). FIS is considered to be a child-friendly tool since it allows children to explain their emotions in a non-verbal way, being more beneficial to those children who do not have verbal skills (4). Moreover, this method has been used across many studies of pediatric dentistry and has shown a strong correlation with other physiological markers like heart rate and VPT (3).

1.5.4 Heart Rate and Respiratory Rate Monitoring

Monitoring heart and respiratory rate offers a valuable and objective insight into physiological response to dental anxiety. When the autonomic nervous system of a child is triggered by a stressful situations, the heart rate increases (tachycardia) as well as the breathing (tachypnea) (25). When younger patients are unable to express their feelings, these physiological changes are very helpful as they are reliable indicators of the child's stress level. Clinicians can evaluate this by measuring these parameters before, during, and after the dental treatment (25). Moreover, pulse oximetry has been widely used in pediatric dentistry as a non-invasive and effective method to measure dental anxiety. By using this method, dentists can customize behavioral control techniques that are responsive to the child's physiological stress (25).

1.5.5 Salivary Cortisol Levels

Salivary cortisol is a widely used, trustworthy, and non-invasive biomarker for assessing physiological stress in adults and children. This method reflects the activity of the hypothalamic-pituitary-adrenal axis, which is triggered during stressful situations, like it can be dental procedures (25). Elevated cortisol levels are often linked to increased stress or worry, providing a measurable indicator of emotional stimulation. This method is a kid-friendly monitoring technique since it avoids the discomfort and fear associated with obtaining blood (25). Salivary cortisol levels help dentists and researchers to measure stress levels of children before, during, and after dental treatments, helping to evaluate the effectiveness of anxiety-reduction techniques (25).

1.6 Pain Assessment Methods

1.6.1 Visual Analog Scale (VAS)

It is a subjective instrument for evaluating acute and chronic pain in many clinical contexts. It consists of a horizontal or vertical straight line, 10 cm long, with 2 endpoints representing extremes like “no pain” on one end and “worst imaginable pain” on the other end (26). Children are indicated to make a mark on the line that most accurately describes the level of discomfort they are feeling in the moment. As other methods, this approach is particularly useful for young groups who might find it difficult to communicate vocally the discomfort (26). However, the reliability of this method increases with cognitive development and has been validated for use with children as young as 5 years old (26).

1.6.2 Wong-Baker FACES Pain Rating Scale

This method consists of a self-report tool designed to help children express their pain using a series of six facial expressions ranging from 0, meaning “no hurt”, and 10, indicating “hurts worst” (27). Clinicians ask children to select a face that best represents the level of pain they are feeling. This facilitates communication of the pain intensity, especially for those kids who cannot express it verbally. This method has been validated for use in children between the ages of 3 to 18 years and it is widely used due to its effectiveness (28).

1.6.3 FLACC Behavioral Pain Scale

The FLACC Behavioral Pain Scale is an observational pain tool, especially for children unable to communicate their pain verbally. FLACC stands for: Face, Legs, Arms, Cry, and Consolability (29). In this method, the overall score ranges from 0 to 10, where each category receives a number between 0 and 2. FLACC has shown to be a reliable method when measuring post-operative pain in pediatric patients (29).

2. JUSTIFICATION

Based on the information previously discussed, the topic is important as it addresses the ongoing discussion regarding the most effective technique for managing children’s behavior in the dental clinic. The effectiveness of each technique varies depending on each child, and the dentist must be able to identify the approach that

best suits each patient. This helps to build trust, reduce anxiety and fear, improve children's oral health, and encourage cooperation in future visits.

3. OBJETIVE

The primary objective is to evaluate innovative and multimedia techniques, especially virtual reality, examining their impact on managing children's behavior during dental visit, with the aim of reducing anxiety and pain, and enhancing their comfort and cooperation during the dental procedures.

The secondary objective of the investigation is to explore the various behavioral management techniques to decrease dental anxiety and pain perception in young patients and create a positive experience during dental visits.

Contribute to the field of pediatric dentistry by establishing, through the findings, the most effective multimedia methodologies for managing children's behavior during dental consultations.

4. MATERIAL AND METHODS

A thorough electronic review search was performed on the behavioral management of pediatric dentistry. The investigation was conducted using the electronic database PubMed, accessed through the UEM library resources. The keywords used in the search were behavioral management techniques, dentistry, audiovisual distraction, virtual reality, and multimedia.

The following search terms and combinations were used in search through PubMed, (Behavioral management OR behavioral techniques) AND dentistry AND (audiovisual distraction OR virtual reality OR multimedia) AND children* NOT adults. The initial search using these mesh terms resulted in the identification of 75 articles. However, exclusion criteria were applied to ensure the most relevant studies. As a result, the number of articles was narrowed to 18, which were considered the most relevant and appropriate for further analysis.

Inclusion criteria:

- Articles written in English and Spanish.
- Articles written between 2014 and 2024.
- Articles which discuss effective behavioral management strategies for children.

- Articles which include technological techniques for reducing pain and anxiety in children during dental visits.

Exclusion criteria

- Articles in other languages that are not English or Spanish.
- Articles written before 2014.
- Articles that include adults in their investigations.
- Articles involving patients with special needs.
- Articles without any discussion about dentistry.

After carefully applying all the exclusion criteria and thoroughly reviewing the studies available, the final articles chosen for this investigation amount to a total of 18. These 18 articles meet the necessary requirements and standards for a comprehensive analysis to ensure relevance to the findings in this study.

5. RESULTS AND DISCUSSION

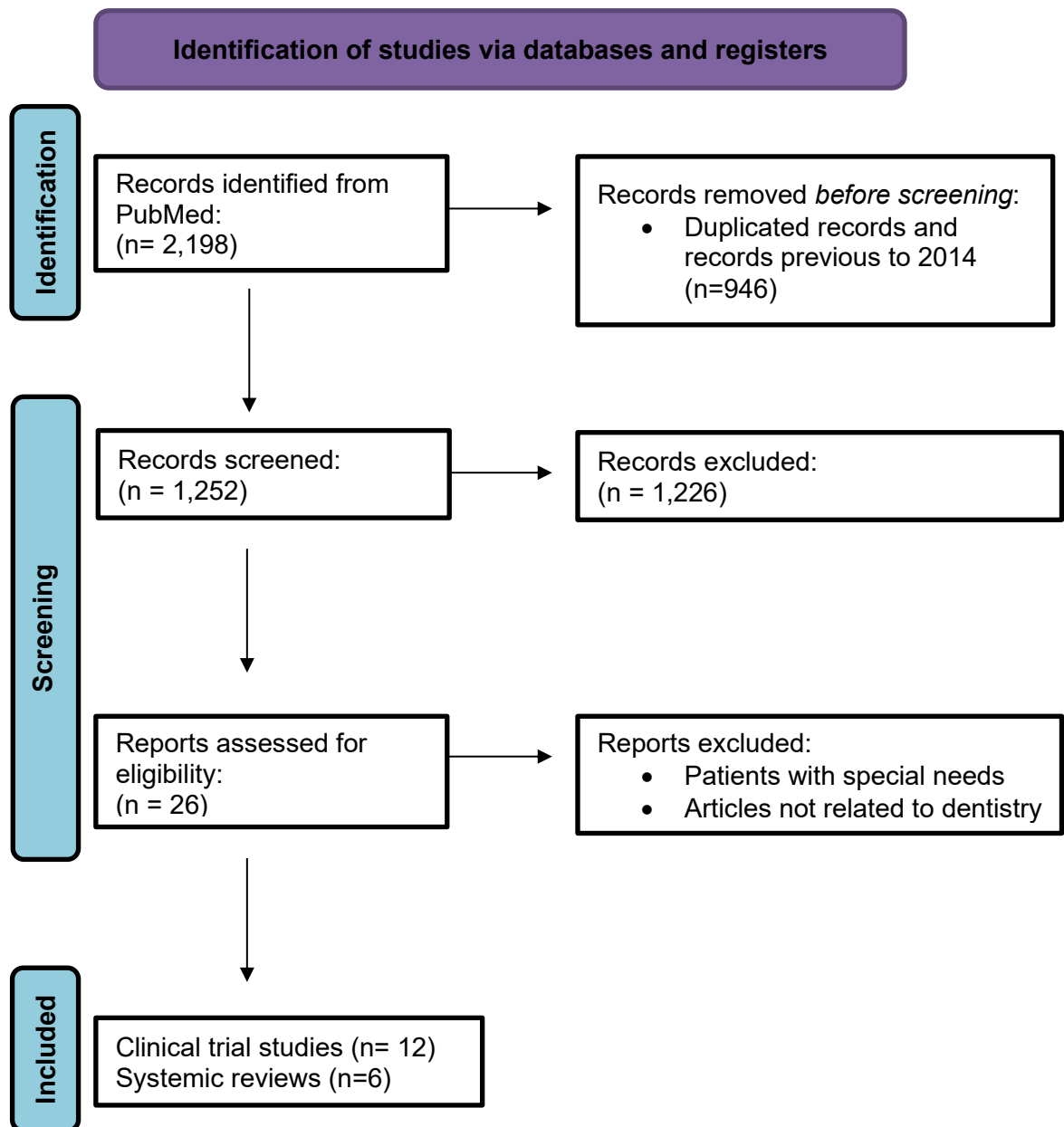


Figure 1: Prisma flow chart

A summary of the chosen articles, including the authors, the year of publication, sample size, study type, variable and a brief conclusion for each, is shown in the table below.

Authors	Sample size	Age	Type of study	Conclusion
Vabitha Shetty et al. (2019) (30)	120 children	5 to 8 years old	Randomized clinical trial	VR distraction significantly reduced pain perception, anxiety and salivary cortisol levels.
Osama M Felemban et al. (2021) (31)	50 children	6 to 12 years old	Randomized clinical trial	Compared to standard behavior, VR detracting effectively reduced pain and anxiety
Custódio NB et al. (2021) (32)	44 children	6 to 9 years old	Randomized clinical trial	Audiovisual distraction using eyeglasses is effective during dental care.
Padmini K et al. (2021) (33)	70 children	7 to 12 years old	Randomized clinical trial	Biofeedback relaxation and audiovisual distraction are effective in reducing dental anxiety during local anesthesia.
Pamungkas SA et al. (2024) (34)	42 children	5 to 6 years old	Randomized clinical trial	Animated video cartoons reduce anxiety in children undergoing GIC restoration procedures.
Pande P et al. (2021) (35)	60 children	5 to 8 years old	Randomized controlled trial	Among many different behavior techniques, audiovisual distraction is the most effective way to reduce dental anxiety and fear.
Ghadimi S et al. (2021) (36)	28 children	4 to 5 years old	Crossover randomized clinical trial	Visual distraction significantly reduces anxiety during dental treatments.
Longkuan Ran et al. (2021) (37)	120 children	4 to 8 years old	Clinical study	VR application is effective in non-drug behavioral management during short term dental treatments.
Khandelwal D et al. (2021) (38)	400 children	5 to 8 years old	Clinical study	“Tell-Show-Do” method combined with audiovisual distraction diminishes anxiety in children.
Rajwinder Kaur et al. (2015) (16)	60 children	4 to 8 years old	Comparative clinical study	Audiovisual distraction was more effective than just audio distraction in reducing anxiety in children.
Alshatrat SM et al. (2022) (26)	54 children	5 to 12 years old	Pilot study	VR effectively reduces pain during different dental procedures in children.
Pathak PD et al. (2021) (39)	30 children	6 to 12 years old	Clinical evaluation	VR devices are practical and effective during local anesthesia and extractions.

Table 1: Summary of clinical studies articles

Author	Sample size	Type of Study	Variable	Conclusion
Diana Xavier de Barros Padilha et al. (2023)(19)	22 randomized control trial	Systemic review	VR vs traditional behavioral management, tablet, audiovisual, cognitive behavioral therapy (CBT), positive reinforcement. VR while rubber dam placement, local anesthesia, extractions and cavity preparations	Audiovisual distraction effectively reduces anxiety in pediatric patients and improves cooperation.
Yunkun Liu et al. (2021)(40)	9 cohort studies	Systemic review	Audiovisual distraction vs traditional behavioral techniques, audiovisual, audio only, CBT, aromatherapy. VR while rubber dam placement, local anesthesia, extractions and cavity preparations	Virtual reality significantly reduces dental anxiety and helps improve patients' behavior in dental appointments.
Prado I M et al. (2019)(41)	20 randomized controlled trial	Systemic review	Audiovisual distraction vs traditional behavioral techniques, audiovisual, CBT, music therapy. VR while rubber dam placement, local anesthesia, extractions and cavity preparations	Audiovisual distraction techniques reduce dental anxiety during dental procedures. It promotes better behavioral responses.
Cunningham A et al. (2021)(42)	4 randomized controlled trial	Systemic review	Audiovisual distraction vs traditional behavioral techniques, audiovisual, smartphone app. VR while rubber dam placement, local anesthesia, extractions and cavity preparations	Virtual reality decrease anxiety significantly in children. The study confirmed virtual reality as a beneficial tool for improving dental experience.
Joana Monteiro et al. (2020) (43)	26 randomized control studies	Systemic review and meta-analysis	Audiovisual distraction vs traditional behavioral techniques, audiovisual, CBT. VR while rubber dam placement, local anesthesia, extractions and cavity preparations	In pediatric dentistry, virtual reality is a useful, non-invasive behavioral management technique. Its immersive qualities improve collaboration, lessen pain and tension, and provide a reusable and sustainable solution for contemporary healthcare practice.
J S Quek et al. (2021)(44)	13 systematic reviews	Umbrella review	Audiovisual distraction vs traditional behavioral techniques, audiovisual, CBT, aromatherapy. VR while rubber dam placement, local anesthesia, extractions and cavity preparations	Children that used immersive distraction techniques, such as virtual reality, reported less discomfort and improved cooperation. The findings highlight how VR may improve patient comfort during dental operations.

Table 2: Summary of systemic review articles

5.1 Clinical Studies Results

5.1.1 Virtual Reality and Anxiety Reduction

Several studies demonstrated the efficacy of virtual reality distraction in reducing dental anxiety in children. Anxiety was measured with self-report tools and with physiological indicators. The Modified Child Dental Anxiety Scale (MCDAS) was the method used in the study of Shetty et al. where they concluded that children between the ages of 5-8 years old experienced a significant reduction in the anxiety score when virtual reality in comparison with the control group (30). Additionally, they measured salivary cortisol levels, a biomarker of physiological stress, and found that using virtual reality significantly reduced the cortisol levels, suggesting that immersive technology has a stress-relief effect (30).

Another study made by Ran et al. compared VR and the TSD technique and discovered that children using virtual reality experienced a greater anxiety reduction. Heart Rate (HR) is a widely used physiological indicator of anxiety. This method was used during the study and demonstrated that anxiety levels remained more stable in children using VR, whereas anxiety increased significantly in those who received the TSD technique (37). Similarly, another study by Pathak et al., supported this opinion but with the use of Venham Picture Test (VPT) and HR monitoring during local anesthesia and extractions. With significant difference, they discovered that the VR group showed significantly lower anxiety levels and a more stable HR (39).

Furthermore, the clinical study made by Khandelwal et al. evaluated anxiety in four groups: control group, Tell-Show-Do, audiovisual and a combined TSD + AVD group. They assessed anxiety using the Facial Image Scale (FIS) and Venham Picture Test (VPT) and found that the combination group showed the greatest reduction in anxiety levels, with VPT scores decreasing from 4.32 to 1.50 before and after the procedure (38). Even though they support the advantages of multimodal behavioral techniques, this research does not study virtual reality specifically. However, the combination of immersive distraction (VR or AVD) and the guided communication (TSD) seems to work better together than either techniques individually, especially for kids with high levels of anxiety (38).

Some authors, like Custódio et al., noted that age influenced on the effectiveness of the virtual reality and other distraction technique over anxiety. This study reported that children between 6-7 years old showed higher behavioral changes and

compliance when using audiovisual distractions (32). Moreover, this suggests that when selecting distraction techniques, the developmental stage of the children must be taken into consideration. However, future studies are suggested to stratified results by age group for more individualized insights (32).

Finally, Padminee et al. evaluated audiovisual distraction and biofeedback relaxation methods during local anesthesia. With no significant difference between them, they both reduced anxiety, respiration rate and heart rate (33). This implies that both techniques are equally successful, providing flexibility for the dentists to choose the most suitable technique depending on the available resources, clinical setting and the preference of every child (33).

5.1.2 Virtual Reality and Pain Perception and Pain Reduction

As well as reducing anxiety, virtual reality also proved to be effective in reducing pain perception during dental treatments, especially in invasive treatments like tooth extractions, local anesthesia, and pulp treatments. Authors, like Alshatrat et al., examined virtual reality during non-painful (like fluoride application) and painful treatments (like pulp therapy, extractions) (26). These authors used Visual Analog Scale (VAS), Wong-Baker FACES Pain Rating Scale, and the FLACC Behavioral Pain Scale to assess pain, and found that virtual reality significantly reduces the pain scores during painful procedures (26). However, no significant difference was observed during non-painful treatments like fluoride therapy. This highlights that the analgesic effect of virtual reality is procedure-dependent and most effective with higher levels of discomfort (26).

Similarly, Ran et al. showed that children using virtual reality had significantly lower pain scores during extractions and caries treatments compared to those treated with the TSD technique alone (37). Additionally, dental procedures involving the use of virtual reality were completed faster and more efficiently due to the reduce of discomfort and pain (37). Pathak et al. reported similar findings, confirming that the VR group had lower FLACC scores during local anesthesia (1.45 vs 2.11) and during treatments (2.23 vs 3.11) compared to the control group (39).

Furthermore, Shetty et al. demonstrated the connection between anxiety reduction and pain perception by observing that the lower salivary cortisol levels coincided with the decrease reports of pain, thereby, confirming a close physiological relationship between stress and pain (30). However, Custódio et al. found that children using

audiovisual eyeglasses reported less pain after the treatment than those in the control group. This reinforces that immersive distraction simpler than virtual reality can still effectively reduce both emotional and physical discomfort during dental procedures (32).

5.1.3 Impact of Virtual Reality on Compliance and Procedural Efficiency Compared to other Techniques.

Beyond anxiety and pain relief, virtual reality significantly impacts treatment compliance and clinical efficiency. According to Ran et al. children in the VR group during dental treatments were more cooperative than those in the TSD group (37). Due to this cooperation observed with VR, dentists were able to complete treatments faster with an average duration of approximately 19 minutes compared to around 28 min in the TSD group (37). This implies that virtual reality reduces behavioral disruption, enabling smoother and more efficient dental procedures.

According to Pathak et al. children that use virtual reality (VR) during anesthesia and extractions showed better behavior and needed less staff involvement. According to the authors, VR might be a non-invasive and effective behavioral intervention in dentistry settings for substituting the need for pharmaceuticals like nitrous gas (39). Furthermore, Custódio et al. objectively measured behavior using accelerometry and found that audiovisual eyeglass users, especially those around the ages of 6–7, show less wrist movements indicating improved collaboration (32).

5.2 Systemic Review Results

For this research, six systematic reviews were chosen, including one umbrella review, one systematic review of cohort studies, and four reviews based on randomized controlled trials. Most of these studies evaluate the effectiveness of different behavioral management methods like the Tell-Show-Do method, cognitive distraction, audiovisual distraction, and virtual reality, in reducing dental anxiety and pain. While some others also assessed their impact during specific procedures such as rubber dam placement, local anesthesia, alveolar nerve block, and other general procedures. The age of the patients that were studied through these articles ranges between the ages of 3- 16 years old.

5.2.1 Comparison Among Behavioral Techniques

5.2.1.1 *Virtual Reality vs Traditional Behavioral Technique*

All the systemic reviews selected compared the use of virtual reality with other traditional techniques like Tell-Show-Do (TSD), modeling, and positive reinforcement. While TSD and positive reinforcement depend on the children's cooperation, virtual VR offers an immersive distraction that blocks the visual and auditory senses, preventing the patients from perceiving dental instruments and procedures (19). This immersive distraction makes patients lower their pre-procedural and procedural anxiety, especially during the application of local anesthesia and procedures like obturations (40,41). However, two of the articles found that while traditional behavioral distractions were helpful for children to build a familiarity with the dental procedures and to have more effective cooperation, they failed to alleviate highly anxious patients (43,44).

The effectiveness of virtual reality varies depending on the age. Children between 3-6 years old responded better to audiovisual and virtual reality distraction because they engage easier with immersive experiences (19,40). However, one of the articles states that children from 8 years old and older prefer a combination of VR and cognitive coping strategies, such as Tell-Show-Do and desensitization (42).

Several studies measure anxiety through heart rate, salivary cortisol levels, and other anxiety scores. According to three of these articles, VR significantly lowered salivary cortisol levels and heart rate compared to traditional techniques (40,42,44). On the other hand, one of the articles noted that the traditional techniques failed to have a notable reduction in anxiety markers, while VR always reduced this marker consistently (42). Overall, the findings showed that VR was more effective than any traditional behavior technique when reducing dental anxiety (19,40–42,44).

5.2.1.2 *Virtual Reality vs Audiovisual*

The effectiveness of both techniques for reducing anxiety in pediatric patients has been widely studied. While audiovisual distraction offers visual and auditory engagement, VR offers more immersive experience. Across multiple systemic articles, a lot of agreements and disagreements on their effectiveness are revealed. Some articles agreed that both techniques are effective in reducing dental anxiety, but there is a greater efficacy with VR due to the immersive experience (19,40–42). Audiovisual distraction is not considered as effective as virtual reality because it does not remove

completely the awareness of the dental environment (40,41). However, some children preferred audiovisual distraction due to the comfort levels during the procedure (42).

5.2.1.3 Virtual Reality vs Cognitive Behavioral Therapy (CBT)

According to multiple studies, virtual reality offers the patient a short-term anxiety reduction, while cognitive behavioral therapy is more effective for long term (19,40–42,44). CBT is a technique that requires multiple sessions but is a method that helps with the fear desensitization in future dental visits making it the best long term management method (40,44). Despite this, children's active participation is required for its success. On the other hand, VR is an immersive experience that distract children from the clinical setting making it useful for instant relief during the dental visit and long interventions (19,42).

Depending on the age, one is more effective than the other when trying to reduce anxiety during dental visits. Younger patients from 3 to 6 years old cope better and suffer less anxiety while using VR and audiovisual distraction (19,40). However, one article finds children older than 8 years old to prefer a combination of CBT and VR (42). Another article, suggest that adolescents (10 years old and more) are more receptive to CBT than younger patients, which makes this a better long-term strategy (44).

5.2.1.4 Virtual Reality vs Audio Only

Only one of the six systemic reviews examined the effectiveness of virtual reality and audio only distraction in anxiety reduction. In this article the authors included music, guided relaxations and white noise as audio only distraction. Furthermore, while both methods are useful for reducing anxiety and improve cooperation, the effectiveness of each method depends on the engagement of the children, the level of immersion, and the dental procedure performed (40). This article mentions that children between the ages of 4-6 years old prefer VR over audio only distraction when reducing dental anxiety since visual engagement plays a critical role in reducing clinical anxiety. Furthermore, audio only distraction was an effective method to reduce mild anxiety while VR was more effective on highly anxious patients since it provides an instant relief (40).

5.2.1.5 Virtual Reality vs Dental Smartphone Applications

Dental smartphone applications, according to one of the systemic review articles, is very useful as a preparation tool before treatments but not during treatments. This article showed that children that used smartphone apps before any dental procedure showed better coping skills. However, smartphones application does not offer anxiety relief during the treatment while virtual reality and audiovisual are more engaging and shift the pediatric patient focus away from the dental setting (42). More studies are needed to examine the effectiveness of smartphone apps in reducing anxiety (42).

5.2.2 Effectiveness of Behavioral Interventions in Specific Dental Procedure

5.2.2.1 Virtual Reality and Local Anesthesia

According to some systemic articles the most effective technique when applying local anesthesia for immediate anxiety relief is virtual reality (19,43). However, other article states that cognitive behavioral therapy is useful for long term desensitization but is not practical for single-visit anesthesia procedures (44). On the other hand, other articles showed that techniques like Tell-Show-Do and positive reinforcement were useful methods for preparing the children but were not effective in managing severe needle phobia (43).

5.2.2.2 Virtual Reality and Dental Extractions

The biggest challenges in dental extractions are pain perception and fear during the extraction. Despite this, distraction techniques help to reduce this anxiety and fear of pain. According to some articles, virtual reality is the most effective technique since it significantly decreases stress level measured by heart rate or salivary cortisol levels (19,41). When children are under VR immersion, they are more cooperative and required less verbal reassurance from the dentist. This technique prevent children to not focus on the pulling sensation and sounds of the extraction (19,43). However, cognitive behavioral therapy and Tell-Show-Do, benefit children with past traumatic experiences and helps shape a correct behavior, but they are less practical for reducing anxiety during a one-time extraction (44).

5.2.2.3 Virtual Reality and Cavity Preparation and Restoration

As previously mentioned, virtual reality has been demonstrated to be the most effective technique for reducing anxiety, and cavity preparation and restoration are no exception. During this procedure VR successfully blocks the sight, sound and

sensation of the drilling by creating an immersive distraction (19). One of the studies stated that the use of VR reduces the possibility for pediatric patients to make sudden movements, improving the overall outcome of the treatment (41). Furthermore, audiovisuals like cartoons and music provide moderate relief since they are less immersive and allow children to listen and perceive everything in their surroundings. This technique is not as effective as virtual reality for patients with high anxiety levels (40,44). Meanwhile, cognitive therapy behavior and Tell-Show-Do, helps the children become more familiar with the environment and the instruments but it does not reduce the anxiety or fear during the treatment, making them less effective than VR in reducing anxiety levels (43,44).

6. CONCLUSIONS

Based on clinical and systematic reviews findings, it is evident that multimedia techniques, especially virtual reality, are highly effective when managing children's behavior during dental appointments. Throughout this study it has been demonstrated that virtual reality is significantly more effective than other conventional methods, like Tell-Show-Do technique, in reducing anxiety and pain perception especially during dental procedures like local anesthesia application, cavity preparation and extractions. Along with behavioral indicators, physiological markers like heart rate and salivary cortisol levels give evidence to the conclusion that immersive distraction techniques are more effective than other traditional methods. However, virtual reality not only relaxes the child but also improves compliance and treatment efficiency, allowing better dental experience and requiring fewer dental staff intervention.

Age plays a key role in the selection of the best technique. It has been demonstrated that children between 3 to 7 years old benefit most from the immersive distraction like virtual reality. However, older kids may respond better to a mix of VR and cognitive behavioral therapy. Moreover, virtual reality is particularly helpful for one-time procedures since it stands out for immediate relief, while cognitive behavioral therapy offers long-term desensitization.

To conclude, the results offer valuable information for pediatric dentistry suggesting that the use of virtual reality and other immersive techniques can completely transform the approach to behavioral management. By considering variables such as child's age, type of procedure and anxiety level, dentists can adapt their approach to select the most appropriate technique. This approach not only enhances the conduct, cooperation, and clinical outcome of the child, but also helps

to diminish the dental fear many children associate with dental visits and procedures. These developments provide better experience for the patient and a more solid relationship between dentist and patient.

7. SUSTAINABILITY

The use of sustainable methods in pediatric dentistry is increasingly relevant, in addition to its therapeutic effectiveness. Virtual reality, along with other multimedia distraction techniques, not only offers psychological advantages but also contributes to more efficient resource use within the dental clinics. Virtual reality technology provides a more sustainable alternative than a single-use distraction since it can be reused and updated digitally. Additionally, it contributes to shorter treatment duration, which also decreases the energy consumption per procedure and increases the overall clinical efficiency. This approach is cost-effective and viable for continuous use in many clinical settings due to the increasing accessibility and affordability of digital devices. Furthermore, it is very adaptable and applicable due to its versatility across different age groups, cultural backgrounds, and levels of anxiety. With the ongoing technological advancements, these tools continue to be useful and up to date, supporting their value as a long-term and patient-centered solution.

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