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The Journal of Dental Panacea

Journal homepage: <https://www.jdentalpanacea.org/>

## Systematic Review

## Effectiveness of aromatherapy in reduction of dental anxiety in pediatric dental patients: A systematic review

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## ARTICLE INFO

## Article history:

Received 20-05-2024

Accepted 10-06-2024

Available online 11-06-2024

## Keywords:

Pediatric dentistry

Dental treatment

Dental fear

Behavior management

## ABSTRACT

**Introduction:** In recent years, various researchers have attempted to utilize Aromatherapy for allaying dental anxiety in pediatric patients. The present systematic review aims to comprehend the efficacy of aromatherapy in reducing dental anxiety in pediatric patients, exploring different aromatherapy agents, dispersion methods, and their anxiety-relieving capacities.

**Materials and Methods:** A systematic search was performed in the following databases: MEDLINE (Ovid), Pubmed, Pubmed Central, Web of Science Citation Index Expanded (SCIEXPANDED), and Google Scholar using the key terms “Aromatherapy” AND “Pediatric” OR “Children” AND “Dental Anxiety” OR “Fear” to identify articles published in the English language without any restriction for the time of publication.

**Results:** A total of nine randomized controlled trials were identified that assessed various essential oils such as lavender, orange, and lemongrass for aromatherapy in pediatric patients during dental treatment. Most of these studies employed aromatherapy using a diffuser during non-pain-promoting dental treatments in children of 6 to 9 years of age.

**Conclusion:** Aromatherapy is an effective non-pharmacological and non-invasive modality for reducing dental anxiety in pediatric patients which is free of adverse effects. However, there's a need for standardized methods of dispersion and clearer guidelines for oil posology

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## 1. Introduction

Over time, numerous pharmacologic and non-pharmacologic strategies have emerged to alleviate dental anxiety in pediatric patients.<sup>1</sup> While conscious sedation and general anesthesia offer reliable results, their adverse effects cannot be disregarded. General anesthesia and sedation can lead to undesirable conditions like hypoxia, hypothermia, and fluid imbalance.<sup>2,3</sup> The use of vagotonic drugs during treatment can lead to severe adverse effects, including noticeable bradycardia. Therefore, the priority

should be to find effective non-pharmacologic alternatives for pain reduction and anxiety relief in children.

Non-invasive, non-pharmacological techniques like hypnosis, behavior management, and audio-visual distraction are options to combat anxiety in children.<sup>4</sup> The 'Gate-control' theory of pain suggests that pleasant sensations can mask the perception of pain.<sup>5</sup> This principle has led to the development of techniques like audio analgesia targeting the hearing sensation and aromatherapy targeting olfactory sensation.

Aromatherapy involves using essential oils to alleviate emotional or physical discomfort.<sup>6</sup> It's a complementary

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medicine that utilizes volatile plant oils to enhance physical, psychological, and physiological health. These oils can be extracted from various parts of plants and are used in forms like massage, inhalation, baths, and topical application, with the former two being the most commonly used methods in the field of medicine.<sup>7,8</sup> Aromatherapy has been recognized by the World Health Organization as a viable method for pain and anxiety treatment. Recent research has proposed aromatherapy as a complementary approach in medical and dental settings.<sup>9–12</sup> For instance, a blend of lavender, Roman chamomile, and Neroli has shown promise in reducing anxiety and improving sleep and blood pressure stability.<sup>9</sup>

While there are studies on aromatherapy’s anxiolytic effects using questionnaires in dental waiting rooms, there’s limited research on its effect during actual dental treatments for children. Some recent studies have explored the calming effects of lavender aromatherapy during tooth extraction and orange aromatherapy during fissure sealant therapy. The present systematic review aims to comprehend the efficacy of aromatherapy in reducing dental anxiety in pediatric patients, examining different aromatherapy agents, dispersion methods, and their anxiety-relieving capacities.

2. Materials and Methods

A systematic search was performed in the following databases: MEDLINE (Ovid), Pubmed, Pubmed Central, Web of Science Citation Index Expanded (SCIEXPANDED), Google Scholar using the key terms “Aromatherapy” AND “Pediatric” OR “Children” AND “Dental Anxiety” OR “Fear”. The search was filtered for the articles published in the English language without any restriction for the time of publication. Furthermore, cross-references of the articles included in the final analysis were also scanned for additional eligible studies that may have been missed out during the search. Only randomized clinical trials were included in the review while cross-sectional studies, in-vitro studies, case reports, and review articles were excluded. The PICO’s criteria used for the selection of articles in the present systematic review is listed in Table 1. Data including authors, study year, design, sample size, age range, eligibility criteria, randomization method, aromatherapy details, procedures conducted, qualitative findings, and study limitations were recorded. To minimize bias in selection and review process, the data was extracted independently by two groups of authors, and discrepancies were resolved through mutual agreement.

3. Results

Nine studies met the eligibility criteria and were included in the systematic review (Figure 1). The findings from these studies are summarized in Tables 2, 3 and 4.<sup>12–20</sup>

Table 1: PICO’s Criteria used for the selection of studies in the present systematic review

Category	Inclusion Criteria	Exclusion Criteria
Population/Participants Intervention	<ul style="list-style-type: none"><li>• Patients’ ages ranging from 3 to 12 years</li><li>• Aromatherapy provided before/during various dental procedures</li></ul>	<ul style="list-style-type: none"><li>• Studies involving adult subjects</li><li>• Ambiguity regarding the type protocol of the aromatherapy used</li></ul>
Comparison	<ul style="list-style-type: none"><li>• The anxiety levels before and after the administration of aromatherapy</li></ul>	<ul style="list-style-type: none"><li>• Studies not comparing pre-operative and post-operative anxiety after administration of aromatherapy</li></ul>
Outcome	<ul style="list-style-type: none"><li>• The difference in reduction of anxiety in patients treated with aromatherapy and those treated without aromatherapy.</li><li>• Alteration in anxiety levels measured subjectively by various scales or objectively by pulse rate, respiration rate, or blood pressure.</li></ul>	<ul style="list-style-type: none"><li>• Studies not assessing anxiety-related factors</li></ul>
Study design	<ul style="list-style-type: none"><li>• Randomized clinical trials</li></ul>	<ul style="list-style-type: none"><li>• Cross-sectional studies</li><li>• In-vitro studies</li><li>• Case reports and case series</li><li>• Review articles</li></ul>

Table 2: Designs of the various studies included in the present systematic review

S.No.	Author	Year	Type of Study	Study design	Sample size	Age group	Inclusion criteria	Exclusion criteria
1	Jaafarzadeh et al.	2013	RCT	Crossover in two sessions	30	6 to 9; 7.66	<ul style="list-style-type: none"><li>• Age 6–9 years,</li><li>• Had two permanent molars that needed fissure sealant</li><li>• Frankle + in cooperation</li></ul>	(i) Any systemic problems, physical and mental disabilities, (ii) History of a previous dental visit (iii) Children with common cold and allergy
2	Soni et al.	2018	RCT	Parallel design	30	6 to 9;7.60	<ul style="list-style-type: none"><li>• Age 6–9 years</li><li>• Class 1 cavity</li><li>• Frankl rating 3 in cooperation</li><li>• First dental visit</li></ul>	(i) Systemic problems (ii) Physical and mental disabilities (iii) History of previous dental visit
3	Radhalakshmi et al.	2018	RCT	Parallel design	40	8 to 11	<ul style="list-style-type: none"><li>• Age 8–11 years</li><li>• First dental visit</li><li>• Sound physical, psychological, and mental health.</li></ul>	(i) History of previous dental visit.(ii) History of allergies or other medical ailments.
4	Arsilan et al.	2020	RCT	Parallel design	126	6 to 12;8.8	<ul style="list-style-type: none"><li>• Age 6 to 12 years</li><li>• Need at least one deciduous mandibular molar tooth to be extracted</li><li>• Category 2, 3, 4 according to Frankl Behavior Rating Scale</li></ul>	(i) Patients aged under 6 years, (i) Cognitive cooperation (category 1) (iii) Systemic problems (iv) Common allergies (v) Dental pain
5	Ghaderi et al.	2020	RCT	Crossover in two sessions	24	7 to 9	<ul style="list-style-type: none"><li>• Age 7–9 years</li><li>• Frank's behavior rating grade III or IV</li><li>• Decayed lower second primary molars bilaterally requiring a class I restorative treatment.</li></ul>	(i) History of previous dental visits (ii) Common cold or history of allergy (iii) Current use of medication, (iv) History of dental pain
6	James et al.	2021	Clinical trial with questionable randomization	Parallel design	150	6 to 8	<ul style="list-style-type: none"><li>• Age 6–8 years • Requiring routine dental restoration</li><li>• Frankel + ve or Frankel–ve in cooperation.</li></ul>	(i) Medically compromised and special children. (ii) Common cold, allergy, (iii) acute dental pain. (iv) previous dental experience. (v) Respiratory tract illnesses or cardiac problems
7	Nirmala and Kamatham	2021	RCT	Parallel design	150	8 to 12; 9.56	<ul style="list-style-type: none"><li>• Age 8-12 years</li><li>• Complete physical and mental health,</li><li>• A score of &gt;6 on MCDASFS</li><li>• Requirement of LA administration (in maxilla/mandible for pulp therapies/extraction of primary teeth</li></ul>	(i) Previous LA administration, (ii) Dental or medical emergency (iii) Systemic disorders
8	Pasupuleti and Hassan	2022	RCT	Parallel design	40	6 to 10; 8.4	<ul style="list-style-type: none"><li>• Children aged between 6-10 years• Children requiring restoration in mandibular molars</li><li>• Children who have sound physical, psychological, and mental health.</li><li>• Children with no history of a previous dental visit.</li><li>• Children with no history of allergies or other medical ailments.</li></ul>	(i) Children showing uncooperative behavior (ii) Previous dental visit (iii) Common cold and allergy
9	Abd-elgawad et al.	2022	RCT	Parallel design	32	4 to 7	<ul style="list-style-type: none"><li>• Age 4-7.</li><li>• Informed consent was taken from parents</li><li>• Children who require administration of local anesthesia.</li></ul>	(i) Patient with special needs. (ii) Respiratory tract infection. (iii) History of bad dental experience.

Table 3: Settings related to aromatherapy used by the authors of various studies included in the present systematic review

S.No.	Author	Year	Essential oil used	Dispersion method	Quantity	Parameters assessed for Anxiety		
						Subjective	Objective	
1	Jaafarzadeh et al.	2013	Orange	Electrical aroma diffuser	2 ml solution activated for 2 min every 10 min.	None	Pulse rateCortisol level in Unstimulated saliva	
2	Soni et al.	2018	Orange	Ceramic diffuser	10 minutes prior, before starting the treatment, the room was exposed to orangearoma.	Venham's Picture Test	Pulse oximeter - Pulse rate and SO2 levelBlood Pressure - Sphygmomanometer	
3	Radhalakshmi et al.	2018	Lemongrass	Candle warmer	Aroma oil diluted with water in the ratio of 1:1 was placed and activated half an hour before the arrival of the first patient.Duration of 15 minutes in waiting room prior to treatment	Venham's Picture Test	Pulse rate and SO2 level	
4	Arslan et al.	2020	Lavender	Inhalation from a med patch	Two drops (0.1 cc per drop) of lavender oilIn a separate room prior to the interventions.	face image scale (FIS) FLACC Wong-Baker pain rating scale (WBS)	Blood pressure and heart rate Oxygen Saturation	
5	Ghaderi et al.	2020	Lavender	Humidifier	2 drops poured in 100 ml water in the humidifier and diffused in the air 30 min before the patient's arrival	Face Rating Scale for pain	Pulse rateCortisol level in Unstimulated saliva	
6	James et al.	2021	Orange	Electric aroma diffuser	half an hour before the patient's arrival	Venham's picture testfacial image scale (FIS).	Pulse rateOxygen saturationRespiratory rate	
7	Nirmala and Kamatham	2021	Lavender	20 minutes before starting the treatment (as for children in aromatherapy groups,2 minutes of inhalation and 15 minutes of induction period were employed)For inhaler:Two drops of lavender oil were dispensed into a cotton wick of the inhaler, whereas for those in the sweet orange group, 3 drops were dropped into the wick.The children were asked to inhale the aroma of theinhalers for 2 minutes followed by an induction period of15 minutes.For nebulizer:80 mL of distilled water, as a medium, was dispensed into the water tank of the nebulizer, followed by six drops of essential oil. For those in orange oil group, for 80 mL of distilled water, eight drops of essential oil was added. All the children were subjected to aromatherapy for about 2 minutes followed by 15 minutes of induction period			FLACC scaleFaces Pain Scale-Revised	Pulse rate
8	Pasupuleti and Hassan	2022	Lemongrass	Method not mentioned	Method not mentioned	Venham's picture test		
9	Abd-elgawad et al.	2022	Lavender	Inhalation from piece of cotton or handkerchief	Sprinkling 4 drops on the cotton or handkerchief	Facial image scale	Pulse rate	

**Table 4:** Treatments performed by authors, limitations of their studies, and conclusive findings reported across the various studies included in the present systematic review

S. No.	Author	Treatment performed	Limitations	Conclusions
1.	Jaafarzadeh et al.	• Routine fissure sealant therapy	<ul style="list-style-type: none"> <li>• No scales used for subjective assessments</li> <li>• small sample size</li> <li>• Precautions for not contaminating saliva such as not eating before the procedure</li> </ul>	<ul style="list-style-type: none"> <li>• Aromatherapy with the natural essential oil of orange significantly reduces salivary cortisol and pulse rate due to the child anxiety state</li> </ul>
2.	Soni et al.	• Class 1 restoration with type IX GIC	<ul style="list-style-type: none"> <li>• Gender distribution not provided</li> <li>• who performed the treatment not provided</li> <li>• Patients with allergies or sinusitis not excluded</li> <li>• Small sample size</li> </ul>	<ul style="list-style-type: none"> <li>• Use of orange essential oil in dental settings reduces blood pressure, pulse rate, and anxiety due to child's anxious state though it was statistically non-significant.</li> </ul>
3.	Radhalakshmi et al.	• Only pre-treatment conditioning was assessed	<ul style="list-style-type: none"> <li>• Treatment was not performed</li> <li>• The sample size is small</li> </ul>	<ul style="list-style-type: none"> <li>• Significant reduction in anxiety and pulse rate in patients exposed to lemongrass aroma</li> <li>• Non-significant difference in SO2</li> </ul>
4.	Arslan et al.	Extraction under local anesthesia 4% articaine solution with 0.0006 mg/ml epinephrine	<ul style="list-style-type: none"> <li>• The choice of treatment was extraction under LA, which should have been a conservative procedure</li> <li>• Effect of LA could be confounding</li> <li>• Frankel behavior rating 2 and 4 were included</li> <li>• Prior dental visit not mentioned</li> </ul>	<ul style="list-style-type: none"> <li>• According to the current results, decreased heart rate, and lowered systolic and diastolic blood pressures were found in the lavender group, whereas saturation showed no significant difference.</li> <li>• Statistically significant pain reduction was found in the lavender group after tooth extractions and anxiety levels subsided.</li> <li>• These results were indicative of the positive relaxing effect of lavender oil inhalation among children both psychologically and physiologically.</li> </ul>
5.	Ghaderi et al.	Local anesthetic injection after topical application of anesthetic gel, cavity preparation, and caries removal using high and low-speed dental handpieces followed by composite filling	<ul style="list-style-type: none"> <li>• Effect of LA could be confounding</li> </ul>	<ul style="list-style-type: none"> <li>• The reduction in the salivary cortisol level and pulse rate showed that the use of lavender aroma in dental settings can be effective in reducing the child's anxiety.</li> <li>• Lavender aroma can also decrease pain perception during local anesthetic injection in children.</li> </ul>

*Continued on next page*

Table 4 continued

6.	James et al.	Restorative procedure	<ul style="list-style-type: none"> <li>• Restoration details not provided</li> <li>• Did not specify who performed the treatment procedures</li> <li>• Randomization details not provided</li> <li>• Ethical details not provided</li> </ul>	<ul style="list-style-type: none"> <li>• Aromatherapy was found to be very effective in reducing anxiety levels of the children compared to the controls when compared between aromatherapy and music distraction, the posttreatment levels did not yield statistical significance.</li> <li>• Music distraction showed a better result with a comparatively more reduction in levels of pulse rate and respiratory rate and a meager increase in levels of oxygen saturation</li> </ul>
7.	Nirmala and Kamatham	<ul style="list-style-type: none"> <li>• Routine la administration</li> </ul>	<ul style="list-style-type: none"> <li>• Details of la administration not mentioned pain could vary with the region or technique of LA</li> <li>• Frankle's behavior rating scale was not used for inclusion</li> </ul>	<ul style="list-style-type: none"> <li>• Aromatherapy with lavender or sweet orange using either nebulizer or inhaler decreases the dental anxiety of children</li> <li>• Aromatherapy with lavender or sweet orange reduced the pulse rate in children.</li> <li>• The effect of essential oils on this parameter was more with an inhaler compared to a nebulizer</li> <li>• Aromatherapy with sweet orange using either nebulizer or inhaler decreased the pain reported by children</li> <li>• Lavender using nebulizer decreased the pain whereas an inhaler could not.</li> <li>• Aromatherapy decreased the LA pain in children. Thus, aromatherapy had a positive impact on the dental anxiety and pain of children undergoing LA administration.</li> </ul> <p>Aromatherapy reduces anxiety while not affecting pain in anxious pediatric dental patients</p>
8.	Pasupuleti and Hassan	<ul style="list-style-type: none"> <li>• Caries removal by spoon excavator and airtor.</li> <li>• Restoration with glass ionomer cement</li> </ul>	<ul style="list-style-type: none"> <li>• Method of aroma dispersion not mentioned</li> <li>• Surface requiring restoration not mentioned</li> <li>• Only one subjective test used for assessment and no objective tests used</li> <li>• Details of oil used not provided</li> </ul>	
9.	Abd-elgawad et al.	Dental anesthesia injection	<ul style="list-style-type: none"> <li>• Details of oil not provided</li> <li>• Method of randomization not provided</li> <li>• Method of dispersion is questionable</li> <li>• Details of aromatherapy not provided</li> <li>• Small sample size</li> </ul>	Anxiety level and pulse rate were significantly lower in patients exposed to lavender aroma

Various parameters were assessed, including age groups, behavior, and procedures performed during the assessment of aromatherapy's effect on anxiety.

#### 4. Discussion

All the included studies (n=9) were randomized clinical trials which would only be rational considering the nature of our research question and the intervention (aromatherapy, which requires a functioning olfactory system). Of these, n=7 had a parallel arm design wherein the experimental group was exposed to aromatherapy before or during the procedure and the effect on anxiety was compared to a control group that was not subjected to aromatherapy.

Considering the study designs, two studies had a crossover design wherein aromatherapy was given to the patients in one session along with treatment while the treatment was performed without aroma in the other.<sup>12,16</sup> An advantage of the crossover designs is that the sample size gets doubled given the fact that the same patient serves as a sample in both, the experimental as well as the control arms of the study. However, one important confounding factor, in this case, is the difference in the child's attitude during the first and second dental visits.

Owing to insufficient cognitive development in young children aged under 6 years, subjective scales are not generally reliable. Therefore, n=8 studies have taken age groups between 6-12-year-old children. Children of age 6 to 9-years are nearly in the concrete operation of Piaget's stage and are as the child is mature enough to use logical thoughts or operations.<sup>13,21</sup> In contrast, in another study by Abd-elgawad et al., age group of 4 to 7 years amongst the paediatric patients was included in the study.<sup>20</sup> Children of the 4 to 7-year age group are usually associated with much riotous negative behaviour and their behaviour is most difficult to control, so the authors deemed it essential to concentrate on the particular age group.

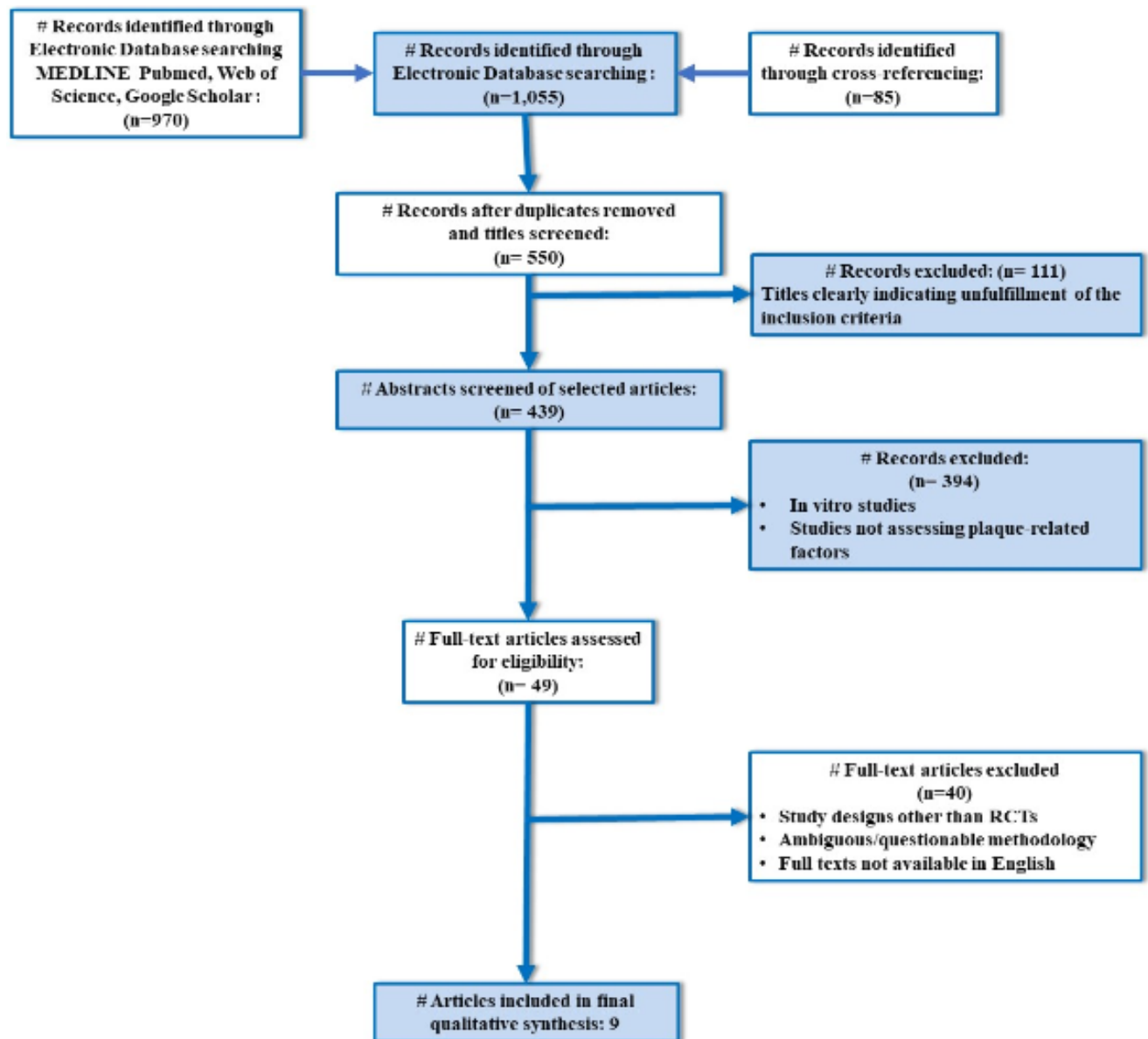
It is essential to select children with a suitably appropriate behavior in clinical trials that are required to test reduction in anxiety levels during dental treatment procedures. In the present systematic review, n=5 studies included patients exhibiting the Frankl rating 3 in cooperation i.e children who accepted treatment with cautious behavior at times; willing to comply with the dentist, at times with reservation, but followed the dentist's direction cooperatively.<sup>22</sup> James et al.<sup>17</sup> included negative as well as positive patients while Ghaderi and Solhjoui included positive and definitely positive patients. Arslan et al.<sup>15</sup> on the other hand, included patients through the categories negative to definitely positive (Categories 2 to 4). Selection of appropriate category of behavior for the inclusion of patients can greatly influence the patient's cooperation during the intervention and subsequently, the obtained results.

Besides the inherent behavior of the child, the procedure being performed also plays a major role in determining the level of anxiety for the child. While choosing a stressor, dental treatment including oral prophylaxis and fissure sealant therapy were selected by Jaafarzadeh et al.<sup>12</sup> because of their convenience, non-invasiveness, and ethical nature. Because these two procedures are painless, it was supposed that any changes in the measured parameters might be as a result of stress and not because of pain. Routine restorative procedures are usually painless or involve very mild pain, which make them quite suitable for testing the effectiveness of a technique in reducing the anxiety levels. In line with this statement, n=4 studies performed routine restorative procedure comprising Class I caries removal followed by restoration with type IX glass ionomer cement.<sup>13,16,17,19</sup> However, different depths of restorations can cause different levels of pain; for instance, caries closer to the pulp would lead to greater levels of pain subsequently generating higher levels of anxiety. Even so, none of the authors mentioned the depth of caries in their inclusion criteria. We recommend that future studies incorporate intraoral radiographs and select only teeth that have caries not exceeding half the depth of coronal dentin.

Pain-inducing procedures invoke the greatest levels of anxiety amongst children which include administration of local anesthetic agent by injection and pulpectomy. The sight of injection itself provokes anxiety in the children and therefore, the local anesthesia procedure was adopted by some authors.<sup>15,16,18,20</sup> The injection was followed by restorative procedure and by extraction of the deciduous mandibular molar in the studies conducted by Ghaderi and Solhjoui and Arslan et al. respectively.<sup>15,16</sup> Radhalakshmi et al. did not perform any treatment procedure and instead analyzed only the pre-treatment conditioning effect of aromatherapy.<sup>14</sup>

The selection of appropriate scale for the measurement of anxiety levels is also of utmost importance. Venham's picture test and FIS are two reliable measures of self-portrayed anxiety in children. They are a suitable measure for assessing state child dental anxiety in even very young children.<sup>23</sup> FLACC has reliability and validity to determine observational pain of children aged between 3 and 18 years during the medical procedures.<sup>24</sup> This scale is preferred due to its simplicity of application among children. The WBS is a self-reported, reliable, and valid scale, which combines pictures and numbers to rate pain.<sup>25</sup> The administration of WBS is also easy, not time-consuming, and requires minimal instructions.

Pulse rate was chosen by n=8 studies for analysis because it is the simplest biological parameter to measure and also because an increase in heart rate is the most common physiological indicator for anxiety and fear. It has been shown that this index is more in line with the anxiety experienced in dental visits than the other physiological



**Figure 1:** PRISMA flow diagram indicating the process of selection and exclusion of articles in the present systematic review

parameters.<sup>26</sup>

It is believed that rise in the respiratory rate corresponds to rise in anxiety which is a result of the increased involuntary muscle contraction which results in the increased activation of respiratory muscles and the respiratory centers in the brain.<sup>27</sup> Stress and anxiety can alter the respiratory rate, which in time, may alter oxygen saturation and/carbon dioxide levels in the blood.<sup>28</sup> Additionally, the pulse rate was assessed by means of a pulse oximeter by all the authors who assessed the parameter. These devices are easily available and usually also measure the oxygen saturation making it much more convenient for the researchers to simultaneously assess the latter parameter at the same time. Hence, measurement of

oxygen saturation rate was also used to assess the anxiety levels by some authors.

While an array of agents have been used for aromatherapy in literature, in the present review we found that n=3 studies used lavender essential oil,<sup>15,16,20</sup> n=3 studies used orange essential oil,<sup>12,13,17</sup> and n=2 studies used lemongrass oil.<sup>14,19</sup> In a study performed by Fitzgerald et al., the effect of gender and ethnicity on preferences and attitudes in children was investigated.<sup>29</sup> Their findings indicated that children possess distinct olfactory and taste preferences compared to adults, and they tend to have a favorable inclination towards essential oils that they find enjoyable. The study concluded that aromatherapy holds attraction and suitability for school-age children, suggesting



that certain essential oils like sweet orange or lemon are particularly well-received by children.

The process is thought to commence with the absorption of volatile odor molecules during inhalation. These molecules subsequently trigger a chemical response in the olfactory bulb, amygdala, and limbic system, leading to the release of specific hormones like enkephalin, endorphins, and serotonin. This hormonal activity contributes to generating positive sensations.<sup>30,31</sup> Furthermore, inhalation-induced recollections of pleasurable odors from the past could emerge, influencing pain perception alteration and alleviating dental anxiety. Consequently, the use of inhalation aromatherapy with lavender oil might contribute to regulating elevated vital signs.<sup>30</sup>

Techniques used for diffusion used by authors ranged from inhalation on a cotton or handkerchief, or med patch to the use of a candle warmer, humidifier, electric diffuser, inhaler, and nebulizer. Nirmala and Kamatham used both lavender essential oil and orange essential oil as well as two different methods of diffusion, that is, by inhalation from an inhaler and a nebulizer. In most of the techniques for diffusion, aroma was given 10 to 15 minutes prior to the dental procedure.<sup>18</sup> In techniques like electronic diffuse, humidifier, and candle warmer aroma of the essential oil is present continuously in the operatory or in the waiting area and has been demonstrated to achieve better results than inhaler, however aromatherapy using the latter has also proven to be effective.<sup>18</sup>

Nebulizer is an electronic machine that turns liquid into mist through ultrasonic action and also has humidifier action.<sup>32</sup> When comparison was made among nebulizers and inhalers, nebulizers had better impact on decreasing the anxiety scores.<sup>18</sup> The potential advantage of the nebulizer may stem from its consistent release of essential oil molecules, contrasting with the intermittent delivery through inhalers. When comparing inhaler variations, lavender exhibited a lesser influence than sweet orange. This discrepancy was attributed to the differing odors, with lavender being more pungent and sweet orange having a milder, more agreeable scent.

An induction period of 10 to 15 minutes has been recommended irrespective of method used for diffusion of aroma. Delivering the aroma through a cotton soaked in the essential aromatic oil can be considered as an easy, efficient, feasible and economic method for aromatherapy with the advantages of availability and simplicity.<sup>20</sup> Despite the multitude of methods to deliver the aromatic agents, there is no standardized method or posology of aroma and the duration of exposure described in literature.<sup>18</sup> It is recommended that future studies compare the effectiveness and efficiency of various concentrations of the agents and the methods used to deliver them.

Lastly, it is important to discuss certain limitations present in the studies included in the systematic review

concerning the study methodology or aromatherapy in general. With the exception of  $n=3$  studies that had a sample size of between 120 to 150 children,<sup>15,17,18</sup> all the others had a total sample of about 30 to 40 children. Given the fact that the majority of the studies were of a parallel-arm design, a larger sample size would definitely be crucial for increasing the validity and reliability of the results.

Blinding is an essential component of randomized clinical trials that ensures minimization of bias on the part of clinicians as well as the patients.<sup>33</sup> Given the nature of the studies concerning aromatherapy, blinding is not possible as the aroma inhaled by the dental professionals, those making the assessments as well as the patients would reveal the intervention used. Therefore, only single-blind randomization could be achieved in such studies. Furthermore, memories associated with the aroma could influence the results produced for a particular patient. For example, a child who has had a negative experience associated with a particular aroma in the past would become more stressed rather than being relaxed.<sup>4</sup> The presence of the distinctive odor of zinc oxide eugenol commonly found in dental clinics could add complexity to the child's experience.

Toet et al. revealed that in large dental clinics, various sources of distraction in waiting rooms, including high background activity and continuous patient movement, could impact the results.<sup>34</sup> Additionally, it's uncertain whether the anxiety reduction achieved through aromatherapy in the waiting room persists during the actual dental procedure. Jafarzadeh's study noted that the results might have been influenced by extra sources of distraction, such as loud noises and crowding.<sup>12,34</sup> Furthermore, the improper administration of aromatherapy or decreased aroma potency due to the hospital's air circulation system might also affect the distribution of the aroma to the patient.<sup>35</sup>

Furthermore, the temperature and other factors varying during different daytimes would also alter the diffusion rate and effect produced by the aromatherapy. Therefore, it is recommended that the procedures are to be performed at a fixed time of the day for all the patients in a study. Only  $n=2$  studies included in the present review had a standardized time of treatment of 8 AM to 9 AM.<sup>12,16</sup> The time period selected by the authors ensured that the interference was minimal while similar environmental conditions were present for all the patients during the intervention.

The different methods of collection of unstimulated saliva across different studies could possibly introduce some errors or variations in the measurement of salivary cortisol.<sup>12,16</sup> The foods consumed by the children before the procedure could further alter the salivary cortisol levels.<sup>16</sup> Therefore, standardizing these methods of collection and refraining the patients from eating foods at least half hour before the procedure is recommended for future studies.

## 5. Conclusion

Aromatherapy to be an effective non-pharmacological and non-invasive modality for reducing dental anxiety in pediatric patients which is free of adverse effects. However, there's a need for standardized methods of dispersion and clearer guidelines for oil posology. Despite the identified gaps, aromatherapy has demonstrated effectiveness in anxiety reduction, with potential benefits for vital signs such as pulse rate and respiratory rate. Further exploratory studies are recommended to address the existing limitations in the literature.

## 6. Source of Funding

None.

## 7. Conflict of Interest

None.

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**Cite this article:** Padawe D, Wankhade A, Takate V, Dighe K, Agrawal A, Sachdev SS. Effectiveness of aromatherapy in reduction of dental anxiety in pediatric dental patients: A systematic review. *J Dent Panacea* 2024;6(2):81-91.