

Optimal fluoride levels in pediatric toothpastes: A review of the literature

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Abstract

Aim: Through this literature review, we seek to determine the optimal level of fluoride present in pediatric toothpastes, identifying the recommended amount according to scientific literature, in addition to evaluate the effects of fluoride on children's dental health and its effectiveness in prevention of caries and also identify the risks of excessive fluoride exposure.

Materials and methods: Searches were carried out for articles published in the last 5 years in electronic databases such as PubMed, Scopus, Scielo, ScienceDirect, UpToDate, Google Academic. The search used a combination of the following keywords: "toothpaste" AND "pediatrics" AND "dosage" AND "fluoride".

Results: 14,118 abstracts were registered: 1,407 from PubMed, 1,043 from Scopus, 355 from ScienceDirect, 10,200 from Google Academic, 913 from Scielo, 200 from UpToDate. After reviewing the abstracts, 14,095 records were removed according to the inclusion and exclusion criteria, leaving 31 full-text articles for examination. Finally, 19 full-text articles were included and evaluated in this review.

Conclusion: The presence of adequate concentrations of fluoride in toothpastes has a positive influence in oral health, especially on the prevention of dental caries. Several reviewed studies reveal that the optimal amount of fluoride in pediatric toothpastes should be greater than 1000 ppm but not exceed 1500 ppm to obtain the maximum anti-caries effect and prevent adverse effects such as dental fluorosis.

Keywords: Toothpaste; Pediatrics; Dosage; Fluoride

1. Introduction

Fluoride, present worldwide due to its release from minerals, magmatic gas emissions and industrial processes, moves through the atmosphere and water. Exposure to low concentrations of fluoride has a positive impact on oral health, especially the prevention of dental caries. This disease, which affects millions of people around the world, is characterized by a continuous process of demineralization and remineralization of dental mineral. (1)

Tooth decay is triggered by an imbalance in this process over time, where demineralization of the tooth structure is caused by organic acids generated by interactions between cariogenic bacteria present in dental plaque and fermentable carbohydrates, mainly sugars. (1) (2) (3)

Likewise, the dental caries process is influenced by the susceptibility of the tooth surface, the bacterial profile, the quantity and quality of saliva and the presence of fluoride, which favors remineralization and inhibits the demineralization of the dental structure. (1) (2)

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Regarding the use of fluorides, currently, there are multiple toothpastes designed to be used by children, which can cause confusion among parents when selecting the appropriate option. Sometimes the choice is based on the taste of the product rather than considering the concentration of fluoride it contains. (2)

Fluoride has long been used to prevent cavities through a variety of different methods including toothpaste, water, milk, mouthwashes, dental gels and varnishes, through different mechanisms of action that generally occur parallel to each other, such as: (1) (3)

1.1. Fluoride coatings on the enamel surface

The supplied fluoride reacts with calcium ions in the tooth. Calcium fluoride is created, the acidic pH values of the leaching favor the reaction, the reaction product is deposited on the tooth surface (top layer). The special importance of the top layer is that it dissolves again at low pH values and in the process fluoride is released, the released fluoride can then develop its remineralizing effect. The clinical importance of the calcium fluoride covering layer lies in the fact that it represents a fluoride reservoir. From this reservoir, fluoride is released in low concentration exactly at the place and time when the carbohydrates in plaque bacteria are metabolized into acids. (3)

1.2. Remineralization

Mineral exchange takes place between the hydroxyapatite of the tooth enamel and the surrounding liquid phase in the interprismatic substance of the enamel, but also in saliva and plaque. By its mere presence, fluoride influences this dynamic balance in favor of remineralization. Demineralization is inhibited and remineralization is promoted. (3)

1.3. Fluoride absorption into tooth enamel.

The degree of fluoride absorption depends on the pH value, the degree of enamel mineralization and the fluoride concentration. Only relatively small amounts of fluoride are stored in healthy tooth enamel, which are limited to the upper micrometers of tooth enamel. If tooth enamel is demineralized, fluoride can occupy defects in the hydroxyapatite crystal lattice. This creates mixed hydroxyl and fluorapatite crystals. This means that fluoride not only has a primary preventive effect, but is also important in secondary prevention. Fluoride-secured remineralized tooth surfaces exhibit increased resistance to cariogenic attacks. As a result, temporarily demineralized and fluoridated tooth enamel is better protected against acid attacks than original, healthy tooth enamel. (3)

1.4. Effects on bacterial biofilm

Fluoride may also have an effect on the bacterial biofilm that settles on teeth. Various enzymes of bacterial glycolysis can be inhibited, thereby impairing the growth and metabolism of oral microorganisms. Additionally, fluoride can interfere with the adhesion of microorganisms to the tooth surface. This can reduce the formation of plaque that promotes cavities. (3)

In the past, it was common to find children's toothpastes with low levels of fluoride or even no fluoride on the market, due to concerns about children's tendency to ingest toothpaste and the risk of fluorosis. Interestingly, these toothpastes occupied a large share of the market thanks to effective advertising strategies. (4)

Additionally, the labels on these toothpastes were often confusing, featuring varying fluoride concentrations and age recommendations that were not always based on solid evidence. In recent times, there has been an increase in availability of fluoride-free toothpastes, promoted as safe for ingestion by children. (4) (13)

Chronic ingestion of fluoride from toothpaste in young children is common, and despite great variation in the amount ingested, the younger children are, the more likely they are to swallow larger amounts, often representing a substantial amount. Although the precise amount of ingested fluoride beyond which fluorosis can occur is unknown, a threshold of 0.05 to 0.07 mg F/kg body weight has been suggested. (8)

A child-sized toothbrush coated with a full strip of toothpaste contains approximately 0.75 g to 1.0 g of toothpaste, and each gram of fluoride toothpaste contains approximately 1.0 mg of fluoride; Children under 6 years of age can swallow approximately 0.3 g of toothpaste per brushing (0.3 mg fluoride) and may inadvertently swallow up to 0.8 g. As a result, it is generally recommended that 6 years children and younger be supervised when brushing their teeth with fluoride toothpaste and that only a pea-sized amount of toothpaste be used. (1) (8)

For these reasons, throughout this literature review the level of fluoride considered adequate in pediatric toothpastes and its impact on children's oral health will be explored.

2. Materials and methods

2.1. Search strategies

For the present literature review, searches were carried out for articles published in the last 5 years in electronic databases such as PubMed, Scopus, Scielo, ScienceDirect, UpToDate, Google Academic. The search used a combination of the following keywords: "toothpaste" AND "pediatrics" AND "dosage" AND "fluoride."

2.2. Eligibility criteria

The articles were selected according to the following inclusion and exclusion criteria.

2.2.1. Inclusion criteria

- Articles published in the last 5 years.
- Articles in Spanish, English, and Portuguese.
- Studies that include children between 1 and 12 years old.
- Studies that compare the different concentrations of fluoride in pediatric toothpastes.
- Studies that evaluate the effectiveness of pediatric toothpastes.
- Studies that evaluate the risks of excessive fluoride use.

2.2.2. Exclusion criteria:

- Studies that include children over 12 years of age.
- Studies that focus on the use of toothpastes for adults.
- Studies that do not present information on the amount of Fluoride.
- Studies that do not meet acceptable quality standards, such as studies with a very small sample size or that do not have adequate control groups.
- Studies that do not provide information on the effectiveness or possible side effects of using fluoride in pediatric toothpastes.

3. Results

3.1. Selection of articles

As shown in Figure 1, the database search retrieved 14,118 abstracts: 1,407 from PubMed, 1,043 from Scopus, 355 from ScienceDirect, 10,200 from Google Academic, 913 from Scielo, 200 from UpToDate. After reviewing the abstracts, 14,095 records were removed according to the inclusion and exclusion criteria, leaving 31 full-text articles for examination. Details on the number of articles and reasons for exclusion at each step are shown in Figure 1. Finally, 19 full-text articles were included and evaluated in this review.

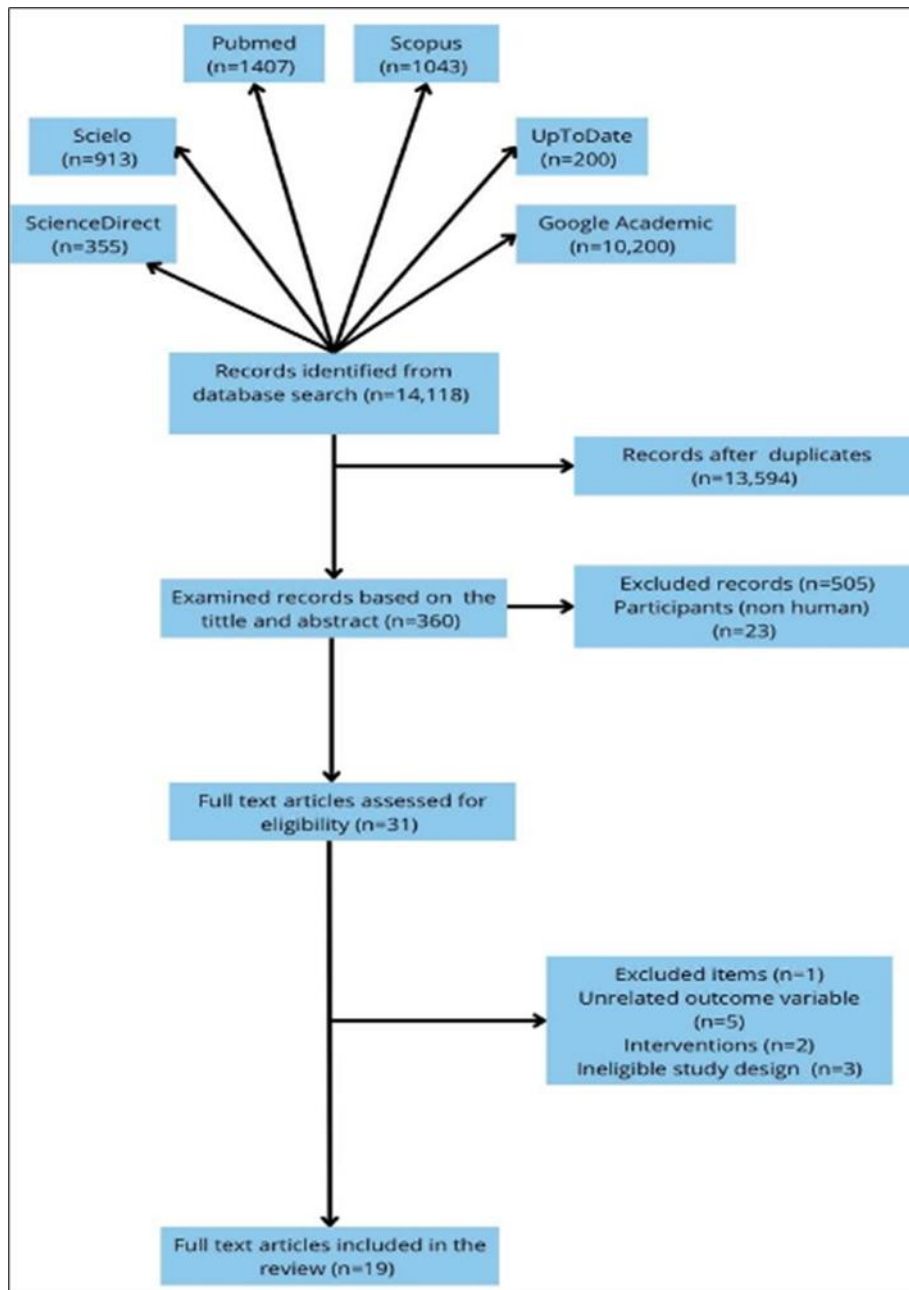


Figure 1 Details of the number of articles and the reasons for exclusion

3.2. Characteristics of the articles

In this literature review, literature reviews, systematic reviews, descriptive, cross-sectional studies, and meta-analysis were included, which showed the effectiveness of fluoride in preventing dental caries, through different concentrations (ppm).

The results are detailed in table 1.

Table 1 Details of the articles

Title of article	Authors	Fluoride recommended ppm	Author's conclusion
Fluoride toothpastes of different concentrations for preventing dental caries. ³	Walsh Worthington HV, Glenny AM, Marinho VCC, Jeronic TO.	1000 to 1250 ppm or 1450 to 1500 ppm of toothpaste with fluoride reduce increments of cavities in comparison with the toothpaste without fluoride	This Cochrane Review supports the benefits of using fluoride toothpaste to prevent cavities compared to non-fluoride toothpaste.
Guidelines on the use of fluoride for the prevention of caries in children: an updated EAPD policy document. ⁴	Toumba KJ, Twetman S, Splieth C, Parnell C, van Loveren C, Lygidakis NA.	They recommended concentrations of at least 1000 ppm. The toothpastes with lower concentrations can have some beneficial effects, and they could be considered for children with bass risk of cavities	The authors support the use of fluoride in toothpastes, especially in programs aimed at socioeconomic groups high-risk children and ethnic minorities.
Fluoride content in children's dentifrices marketed in Lima, Peru. ⁷	Chávez BA, Vergel GB, Cáceres CP, Perazzo MF, Vieira-Andrade RG, Cury JA.	The authors state that the minimum concentration necessary for promoting an anti-caries effect is 1000 ppm	The authors recommend that fluoride concentrations in toothpastes be rectified in public health policies for effective caries control.
What concentration of fluoride toothpaste should dental teams be recommending? ⁸	Levine RS	It is proposed that the concentration of fluoride necessary for an anti-caries effect is 1000 ppm	Toothpastes containing at least 1000 ppm fluoride are effective in reducing cavities compared to toothpaste without fluoride. Any decision of recommending the use of toothpaste containing more than 1500 ppm must balance the risk potential for increased fluoride intake with any benefit of reduction of cavities that may arise.
Total and soluble fluoride concentration in children's toothpastes in Spain. ⁹	Pérez-Silva A, Cury JA, Martínez-Beneyto Y, Serna-Muñoz C, Cabello Malagón I, Ortiz-Ruiz AJ.	A was established concentration minimum of 1000 ppm in patients pediatric	The authors conclude that concentrations lower than 1000 ppm do not generate an effective action on caries from the point of view of public health.
The additional benefit of professional fluoride application for children as an adjunct to regular fluoride toothpaste: a systematic review and meta-analysis. ¹⁰	Yu L, Yu X, Li Y, Yang F, Hong J, Qin D, et al.	The authors recommend the use of toothpaste with a concentration of at least 1000 ppm	The authors conclude that the main method of preventing cavities in children is the use of toothpaste with a minimum concentration of 1000 ppm
Fluoride concentration in toothpaste marketed to children in Brazil and Mexico, and discussion on	Leite Filho AM, Valdivia-Tapia AC, Costa R de CNP, Espinoza EV, Ricomini Filho AP, Cury JA.	The authors recommend that the toothpastes for children contain 1000 to 1500 ppm total fluoride	The authors conclude that the minimum concentration is 1,000 ppm of soluble fluoride to provide an anticaries effect.

current regulations. ¹¹			
Recommending 1000 ppm fluoride toothpaste for caries prevention in children. ¹²	Hu S, Lai WPB, Lim W, Yee R.	It is recommended concentrations of 1000 ppm fluoride for prevention of cavities	There was moderate to high evidence that toothpaste with fluoride of 1000 ppm or more was more effective in preventing cavities compared to non-fluoride toothpaste.
Tooth brushing and fluoride levels in toothpaste used by peruvian children under 12 years old. ¹³	Hernández-Vásquez A, Azañedo D.	The authors declare that the concentrations of fluoride should be 1000 ppm	The authors conclude that it is necessary to strengthen the promotion of recommendation of tooth brushing and use of toothpaste fluoride content greater than 1000 ppm
PPM of labeled fluorine and analyzed fluorine in pediatric toothpaste commercialized in Lima-Peru. ¹⁴	Córdova-López O, Hermoza-Moquillaza RV, Darwin Yanac Calero DYC, Arellano-Sacramento C.	The use of toothpaste with a concentration of 1000 ppm since the eruption of the first deciduous tooth.	The authors conclude that use in children should be at least 1000 ppm
Level of knowledge in parents about the use of toothpaste in association with estimated fluoride intake in children. ¹⁵	Fernández Quintana, Luz, Lloberola Reyes, Claudia S., Caballero García, Stefany, Leon Rios, Ximena A.	The European academy of odontology recommends toothpaste with a concentration of fluoride of 1000 ppm and if they have a high risk of cavities should use 1450 ppm toothpastes	The authors conclude that parents have a medium level of knowledge on the use of toothpastes with fluoride, recommend implementing health preventive strategies measures on oral health.
Chemically soluble fluoride in toothpastes marketed in Colombia. ¹⁶	Lina María Marín, Gina Alejandra Castiblanco, Margarita Usuga-Vacca, Jaime Aparecido-Cury, Stefania Martignon.	Is proposed that the concentration minimum required to exercise a protective effect against caries is > 1000 ppm F.	The authors conclude that the level of fluoride in toothpastes should not be less than the minimum required.
An assessment of the current status of children's toothpaste in Australia. ¹⁷	B D Smith, C MacPhail, J Russell	Children should start using "low fluoride" toothpaste starting at 18 months, with the recommended dose being 500 to 550 ppm for ages 18 months to 5 years, and 1000 to 1500 ppm for children ages 6 years and up.	The authors indicate that fluoride levels greater than 500 ppm are ideal.
Fluoride content and labeling of toothpaste marketed in Indonesia. ¹⁸	Atik Ramadhani, Steffi Wijaya, Ana Mardlianah, Melissa Adiatman, Febriana Setiawati, Harun A. Gunawan, Diah A. Maharani	Children from the first dental eruption up to six years old and children older than six years old should use 1000 ppm and 1450 ppm fluoride toothpaste ppm, respectively.	The authors indicate that a minimum concentration needed is 1000 ppm for a toothpaste to have adequate anti-caries properties.

Fluoride content, cost, and labeling of Toothpastes Marketed in Indonesia. ¹⁹	Juwairiah Wafa Anisa, Mohammad Haniff Abdul Hamida, Norasmiha Mohd Norb, Ni Azlida Mohd NiC	Children's toothpastes had fluoride concentrations ranging from 500 and 1000 ppm.	The evidence suggests that the use of fluoridated toothpaste with a minimum concentration of 1000 ppm is effective in preventing cavities
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4. Discussion

The use of fluorides is one of the most common strategies to prevent oral diseases in children, and its inclusion in toothpastes has had a significant impact on the population by reducing the incidence of dental caries (1). Toothpastes with fluoride provide 30% to 70% protection compared with toothpastes that do not contain fluoride. For this reason, its use is recommended from the eruption of the first primary tooth. (2) (4)

The typical concentration of a common or household toothpaste is typically around 1,000 to 1,500 parts per million (ppm) fluoride, but there are many other concentrations available worldwide. There is no minimum concentration of fluoride, but the maximum concentration allowed for a toothpaste varies by age and country (1) (3). A stronger fluoride toothpaste may offer greater protection against cavities, but it also increases the risk of fluorosis (enamel defects caused by chronic ingestion of excessive amounts of fluoride during the period of tooth formation). (3)

The frequency of toothpaste use along with the rinsing method after brushing are other factors that influence the effectiveness and safety of fluoride toothpaste. Brushing twice a day or more, rinsing less thoroughly, or not rinsing at all would confer greater cavity reductions than brushing once a day or less, or rinse with larger volumes of water after brushing your teeth. (2) (3) (8)

Although acute toxicity is rare, young children are especially at risk for ingesting toxic doses of fluoride from a standard 125 g tube of toothpaste, which contains 1100 ppm F (1.1 mg F/g of toothpaste). As the likely toxic dose is around 5 mg F/kg body weight, accidental ingestion of one or two thirds (45 g-90 g) of a tube of toothpaste is potentially fatal. For this reason, it is recommended to keep fluoride toothpaste out of the reach of young children. (3)

Due to this, it is important to take into consideration the ideal concentration of fluoride for pediatric patients to achieve an adequate anti-caries effect.

Thus, Walsh et al. (3), suggest a fluoride concentration ranging from 1000 to 1500 ppm, thus supporting the benefits associated with this mineral. In a similar way, Toumba et al. (4), recommend an optimal concentration of 1000 ppm. However, they point out that lower concentrations could be considered, especially in children with a low cariogenic risk. This coincidence in the recommendation of fluoride concentration between both studies highlights the need for a personalized approach in choosing the appropriate concentration.

In the same way, Chávez et al. (7), point out that the minimum concentration to achieve an anti-caries effect is 1000 ppm, coinciding with the recommendation of Levine et al. (8), who also mentions that before any decision to recommend the use of toothpaste with a concentration beyond 1500 ppm is crucial to carefully evaluate the balance between the associated risks and benefits. This convergence of opinions underscores the importance of fluoride concentration and highlights the need for a cautious approach when making decisions involving higher fluoride levels.

Equivalently, Pérez-Silva et al. (9), recommend a minimum concentration of 1000 ppm for effective action against caries, similarly, this concentration is recommended by Yu et al. (10). On the other hand, Leite et al. (11), recommend concentrations of 1000 to 1500 ppm, with 1000 ppm being the minimum concentration to provide an anti-caries effect.

In line with these findings, Hu et al. (12), and Cordova et al. (14), agree that the minimum recommended concentration of fluoride in toothpastes is 1000 ppm, a perspective supported by Hernández et al. (13). This authors not only confirm the importance of reaching this threshold, but also highlight the need to apply appropriate amounts according to the individual's age and promote the practice of tooth brushing as an essential component to strengthen oral health. This convergence of opinions highlights the relevance of fluoride concentration and brushing habits in promoting oral health.

Likewise, in accordance with the recommendations of Fernandez et al. (15), the choice of toothpastes with a fluoride concentration ranging between 1000 ppm and 1450 ppm is suggested, based on consideration of the child's age and the

specific associated caries risk. These parameters are supported by Marín et al. (16), who establish that the minimum concentration of fluoride in toothpastes to achieve an effective anti-caries effect is at least 1000 ppm. Additionally, they point out the importance of ensuring that the total fluoride concentration does not exceed 1500 ppm. This correlation between the recommendations of both research teams emphasizes the relevance of carefully choosing toothpastes, considering both the anti-caries efficacy and the established concentration limits, to guarantee optimal oral health

Following the guidelines of Smith et al. (17), the need to adjust the fluoride concentration in toothpastes based on the age of the children is emphasized. They recommend specific concentrations: 500 ppm to 550 ppm for children under 6 years of age, and 1000 ppm to 1500 ppm for those over 6 years of age. However, these findings present discrepancies with those of Ramadhani et al. (18), and Anisa et al. (19), who maintain that a toothpaste must have a minimum concentration of 1000 ppm of total soluble fluoride to exhibit adequate anti-caries properties.

5. Conclusion

In summary, this literature review supports the positive influence of the presence of adequate concentrations of fluoride added to toothpastes on oral health, especially the prevention of dental caries. The diversity of toothpaste options for children has created confusion among parents when selecting the most appropriate one. Therefore, the importance of considering the child's age and the risk of cavities when choosing a toothpaste with a specific concentration of fluoride is highlighted. The findings, according to several studies reviewed, reveal that the optimal amount of fluoride in pediatric toothpastes is greater than 1000 ppm but does not exceed 1500 ppm to obtain the maximum anti-caries effect and prevent adverse effects such as dental fluorosis.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this document

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