Migration Letters

Volume: 20, No: S1 (2023), pp. 2950-2958

ISSN: 1741-8984 (Print) ISSN: 1741-8992 (Online)

www.migrationletters.com

The Role Of Fluoride In Preventing Dental Caries: A Contemporary Review

Majed Marshud Altarjami[1], Tariq Zuhair A Sadayo[2], Sultan Rubayan Alsulami[3], Anwar Saeed Alhabib[4], Raneem TariqQurban[5], Hamdi Abdullah Altukhays[6], Saud Attallah Aljoaid[6], Mohammad Abdullah alharbi[6], Abdullah Mansour Alrajeh[6], Fawaz Mohammed Adl Alotaibi[6], Hussain Adi Hussain Aldayhani[9], Zyad Mohammed Albarrak[10]

Abstract

This study provides a comprehensive review of the role of fluoride in inhibiting dental caries. Fluoride has been widely recognized as an effective agent in caries prevention for decades. The study utilized secondary data sources, including previous research studies, reviews, and meta-analyses, to examine the current evidence supporting the use of fluoride in maintaining oral health. The review discusses the various mechanisms through which fluoride prevents dental caries, including remineralization of enamel, inhibition of demineralization, and disruption of bacterial biofilm formation. It also highlights the significance of community water fluoridation programs in decreasing the occurrence of dental caries at the population level. The study further explores the different forms of fluoride available for use, such as fluoridated toothpaste, mouth rinses, professional fluoride varnishes, and gels, and provides recommendations for optimal fluoride exposure in various age groups. In conclusion, this review underscores the continued importance of fluoride in preventing dental caries and emphasizes the need for public health [1]strategies to promote its use. It also calls for further research to address emerging challenges, such as the increase in non-fluoridated bottled water consumption and the growing popularity of natural oral care products without fluoride.

Keywords: *Fluoride, Dental caries, Demineralization, Fluoridated toothpaste, Enamel.*

1. Introduction

Tooth decay, often known as dental caries, is still a key global public health issue that can cause pain, tooth loss, and reduced oral health. Due to its capacity to impede demineralization and promote remineralization of tooth enamel, fluoride has long been acknowledged as a critical mediator in the prevention of dental caries (Munteanu, 2022). The decrease in dental caries rates over the years has been largely attributed to the use of fluoride in a variety of applications, including professional treatments, toothpaste, mouthwash, and community water fluoridation.

[1]Dental laboratory technician, Al Yatma Health Center. Medina, Saudi Arabia.
[2]Dental resident doctor, Al-Adel Primary HealthcareCenter,Mecca, Saudi Arabia
[3]General Dentist, Ministry of health, Riyadh, Saudi Arabia, Saudi Arabia.
[4]Bachelor degree of dental surgery,Dilam PHCC, Saudi Arabia.
[5]Dentistry, Qunfuda - Second Doqa PHC, Saudi Arabia.
[6]General Dentist, ministry of health, Saudi Arabia.
[7]General Dentist, Ministry of health, Saudi Arabia.
[8]Endodontist, Dental Clinics Complex West of Riyadh, Saudi Arabia.

This contemporary review aims to explore the role of fluoride in inhibiting dental caries and provide an updated analysis of current research and guidelines. The review will examine the mechanisms of fluoride action, including its impact on biofilm formation, acid production, and mineral metabolism. Furthermore, the review will assess the effectiveness of different fluoride delivery methods and their optimal concentrations for caries prevention (Spencer, 2018).

Despite the proven merits of fluoride in reducing the incidence of dental caries, alarms have been raised regarding possible risks associated with excessive fluoride exposure, such as dental fluorosis and skeletal fluorosis (Ullah, 2015). Therefore, this review will also discuss the importance of monitoring fluoride exposure levels to ensure its safety and effectiveness in caries prevention.

Through the compilation of the most recent data regarding fluoride's ability to prevent dental caries, this review aims to offer useful information to the public, legislators, and oral health professionals. In the end, a deeper comprehension of the advantages and restrictions of fluoride in caries prevention can support the best possible oral health results and direct the development of evidence-based recommendations for fluoride usage in dental practice (Wiegand, 2007).

2. Literature Review

Tooth decay, often known as dental caries, is a solemn global public health hazard that primarily affects children and adolescents. Due to its ability to promote enamel remineralization and impede the demineralization process, fluoride has long been known to be a beneficial dental caries preventive agent (Šket, 2017). The purpose of this review of the literature is to examine how fluoride helps prevent dental caries and to provide an overview of the results of earlier research.

The efficiency of fluoride in preventing dental cavities has been the subject of several investigations. Spencer (2018) found good evidence that fluoride toothpaste is beneficial in preventing dental caries in kids and teenagers based on a systematic evaluation of randomized controlled trials. Pitts (2017) conducted a meta-analysis in another study and came to the conclusion that fluoridating water is an efficient and economical method of preventing dental caries in populations.

Apart from fluoridating water and toothpaste, fluoride varnish has also demonstrated efficacy in averting dental cavities. A randomized controlled trial by Kanduti (2016) discovered that applying fluoride varnish decreased the incidence of dental caries in kids. Additionally, a systematic review by Fejerskov (2015) found that fluoride varnish is a secure and reliable way to shield kids, especially those who are at high risk, from dental caries.

The impact of fluoride varnishes on preventing caries in primary teeth was assessed in a Buzalaf (2019) study. The occurrence of caries in kids was found to be effectively reduced by fluoride varnishes, especially in those who were at a high risk of developing tooth decay. According to the study, applying topical fluoride treatments can help prevent cavities in the primary dentition.

Adair (2006) conducted a longitudinal cohort research in which a group of infants was followed from birth to age six, and the caries experience of the children was evaluated in connection to fluoride exposure. The children who were exposed to higher fluoride levels—either by toothpaste usage or water fluoridation—had significantly lower caries rates than the children who were exposed to lower fluoride levels. Strong data supporting fluoride's ability to prevent dental cavities is presented in this study.

Fluoride has been shown to be beneficial in avoiding dental caries. However, other studies have raised concerns about possible side effects, like dental fluorosis, from fluoride intake. Dental fluorosis, which appears as white or brown patches on teeth, might result from an excessive fluoride intake during tooth growth, according to a review of research by Bansal (2015). On the other hand, severe dental fluorosis is uncommon and avoidable with careful monitoring of fluoride consumption.

3. Methodology

This study's methodology section tries to describe the methods and strategies used to examine the available data on fluoride's potential to prevent dental caries. The review was carried out using the subsequent procedures:

3.1 Literature Search:
A thorough search of the literature was carried out with the aid of computerized databases like Web of Science, PubMed, and Scopus. Search terms pertaining to dental caries, fluoride, prevention, and efficacy were employed to locate pertinent research articles published in publications with peer review.

3.2 Inclusion and Exclusion Criteria:
The review comprised studies that evaluated the effectiveness of fluoride in decreasing dental caries across various demographic groups. Studies that did not match the eligibility requirements were eliminated, and only those published in English were included.

3.3 Data Extraction:
A uniform data synthesis form was utilized to extract data from the studies that were included. Data were gathered on the study's design, sample size, fluoride intervention, outcome measures, and important discoveries.

3.4 Data Synthesis:
An overview of the available data on fluoride's role in preventing dental caries was created by synthesizing the results of the included studies. A qualitative synopsis of the main conclusions and, if necessary, a meta-analysis were included in the synthesis.

3.5 Bias Assessment:
Possible sources of bias in the involved studies were identified and discussed, and their impact on the overall conclusions of the review was considered.

3.6 Limitations:
The limits of the review, such as the possibility for publication bias or the inclusion of studies with varying methodological quality, were acknowledged and discussed.

3.7 Interpretation of Findings:
To determine if fluoride is useful in reducing dental caries, the review's findings were evaluated in light of recent research and clinical practices.

In summary, this study employed a systematic approach to review the role of fluoride in preventing dental caries, using a rigorous methodology to evaluate and synthesize the available evidence.

4. Results and Discussion

4.1 Fluoride and dental caries

4.1.1 Mechanisms of action:

Fluoride is widely recognized for its multiple methods of action in preventing tooth cavities. The remineralization of enamel is one of the main mechanisms of action. Fluoride can be integrated into the hydroxyapatite crystals of enamel in the oral cavity to generate fluorapatite, which is more resistant to acid assaults (Horst, 2018). This procedure aids in the regeneration of demineralized enamel and stops carious lesions from spreading.

Additionally, fluoride can inhibit the demineralization of enamel by reducing the solubility of hydroxyapatite in acidic environments. Fluoride can also interfere with the metabolic action of cariogenic microbes, such as Streptococcus mutans, by inhibiting enzymes involved in acid production (Munteanu, 2022). This reduction in acid production can help maintain a neutral pH in the oral cavity, preventing the demineralization of enamel.

4.1.2 Types of fluoride:

There are several different types of fluoride compounds that are commonly used for caries prevention. The most common form is sodium fluoride, which is available in many toothpaste formulations and dental treatments (Peroš, 2013). Sodium fluoride can be easily incorporated into oral care products and has been shown to effectively prevent dental caries.

Another commonly used form of fluoride is stannous fluoride, which is often used in professional fluoride treatments and varnishes. Stannous fluoride has been shown to have both anti-caries and anti-inflammatory effects, making it a valuable tool in preventing dental caries and periodontal disease (Sharma, 2015). In addition to sodium and stannous fluoride, fluoride can also be found in other forms, such as fluoride varnishes, gels, foams, and mouth rinses. These different formulations allow for a variety of delivery methods to meet the specific needs of patients and can be tailored to provide targeted fluoride exposure for at-risk populations (Ullah, 2015).

4.1.3 Fluoride sources:

Fluoride can be obtained from various sources, both naturally occurring and added. The main natural sources of fluoride include water, certain foods, and beverages. Water fluoridation is a public health intervention that encompasses regulating the fluoride quality in community water supplies to the optimal level for caries prevention. Studies have shown that water fluoridation can expressively decrease the occurrence of dental caries in populations (Wiegand, 2007).

In addition to water fluoridation, fluoride is also present in certain foods and beverages, such as tea and seafood. However, the fluoride content in these sources may vary widely, making it challenging to ensure consistent fluoride intake (Ullah,2015). As such, fluoride supplementation may be recommended for persons who are in higher danger of getting caries.

Furthermore, fluoride can be delivered through topical applications such as fluoride varnishes, gels, and mouth rinses. These treatments offer a high level of fluoride directly to the tooth surface, promoting remineralization and reducing the risk of caries (Singh, 2018). Professional fluoride treatments are often recommended for individuals with a higher caries risk or those who may have difficulty maintaining good oral hygiene practices.

Overall, a variety of fluoride compounds, sources of fluoride intake, and modes of action have all contributed to the well-established use of fluoride in the inhibition of dental caries. To preserve the best possible oral health, dental professionals must inform patients about the advantages of fluoride and suggest the right products or treatments that contain fluoride (Spencer, 2018). To ensure the safe and efficient use of fluoride for the reduction of dental caries, further study and monitoring of fluoride exposure and effectiveness in caries prevention are required.

4.2 Efficacy of fluoride in inhibiting dental caries

4.2.1 Research Evidence:
Numerous investigations have shown the success of fluoride in inhibiting dental caries. A review by Peroš (2013) concluded that fluoride in various forms, such as toothpaste, mouthwash, and professional treatments, significantly reduces the prevalence of dental caries. Another meta-analysis by Petersen (2016) found that community water fluoridation reduces decayed, missing, or filled teeth (DMFT) by 20-40% in permanent teeth and 40-50% in primary teeth. These findings emphasize the importance of fluoride in caries prevention.

4.2.2 Effectiveness in Different Age Groups:
It has been demonstrated that fluoride works to prevent tooth cavities in all age groups. It has been demonstrated that fluoride toothpaste and varnish can lower the incidence of dental cavities in youngsters by up to 30% (Kanduti, 2016). Using fluoride mouthwash and toothpaste has been linked to a decreased incidence and advancement of caries in adults (Horst, 2018). Furthermore, all age groups benefit from professional fluoride treatments, such as dental fluoride gel applications, including elderly persons who may be more susceptible to caries because of things like decreased salivary flow and exposed teeth.

4.2.3 Long-Term Benefits:
The long-term benefits of fluoride in inhibiting dental caries are well-documented. A study by Cummins (2013) found that individuals who used fluoride toothpaste regularly from childhood to adulthood had suggestively lower rates of caries compared to those who did not use fluoride toothpaste. This highlights the importance of consistent fluoride use over a lifetime for maintaining oral health. Additionally, community water fluoridation has been shown to have long-term benefits, with studies demonstrating a continued reduction in caries prevalence over several decades (Buzalaf, 2018). These findings support the notion that fluoride provides lasting protection against dental caries.

In general, the research evidence clearly demonstrates the value of fluoride in inhibiting dental caries. Fluoride is effective in different age groups, from children to older adults, and offers long-term benefits when used consistently over time. These findings underscore the importance of incorporating fluoride into daily oral hygiene routines and promoting community water fluoridation to improve oral health outcomes and decrease the burden of dental caries.

4.3 Recommendations for fluoride use
4.3.1 Community-based fluoridation programs:
The review's conclusions offer insightful information about how well community-based fluoridation initiatives work to promote dental health. According to the literature study, dental caries rates are substantially lower in fluoridated areas than in non-fluoridated ones (Adair, 2006). This bolsters the body of research showing fluoridating community water systems as an economical and successful strategy for preventing tooth decay in all demographic groups. Moreover, it has been demonstrated that community-based fluoridation initiatives lessen inequities in dental health, especially in underprivileged and low-income populations

(Anusavice, 2005). Thus, in order to enhance the general state of dental health, we advise spreading fluoridation programs to further regions.

4.3.2 Guidelines for fluoride application:
The review also highlights the importance of following guidelines for fluoride application to achieve optimal benefits and reduce potential risks. It is vital to use the right concentration of fluoride in water and dental products to prevent dental caries effectively. The American Dental Association recommends a fluoride level amount of 0.7 ppm in community water fluoridation programs and specific guidelines for fluoride toothpaste use based on age groups (Bansal, 2015). Overuse of fluoride can lead to dental fluorosis, a disorder described by dental staining, which emphasizes the need for adherence to recommended guidelines (Fejerskov, 2015). Healthcare providers should educate patients on proper fluoride consumption and application to ensure the benefits of fluoride without adverse effects.

4.3.3 Safety Considerations:
Safety considerations are paramount when it comes to fluoride use, especially in susceptible people like children and pregnant women. The review findings emphasize the importance of monitoring fluoride intake from various sources to prevent excessive exposure. Health authorities should regularly assess fluoride levels in water supplies and adjust concentrations as needed to maintain the ideal balance for dental health welfare (Iheozor-Ejiofor, 2015). Furthermore, healthcare providers should consider individual risk factors, such as age, health status, and dietary habits, when recommending fluoride supplements or treatments. It is vital to inform patients about the possible dangers of fluoride overdose and the significance of following dosage recommendations to ensure safety.

4.3.4 Recommendations for fluoride use:
With respect to the findings of this review, we provide the following recommendations for fluoride use:

- Community-based fluoridation programs should be expanded to reach more underserved populations and reduce oral health disparities.
- Healthcare providers should educate patients on proper fluoride consumption and guidelines for fluoride application to maximize benefits and minimize risks.
- Regular monitoring of fluoride levels in water supplies and individual assessment of fluoride intake are essential to ensure the safe and effective use of fluoride.
- More investigation is needed to well understand the long-term impact of fluoride exposure and inform evidence-based procedures for fluoride use in dental care.

4.4 Future directions and research opportunities in Fluoride and dental caries
4.4.1 Innovations in Fluoride Delivery:
Several innovations in fluoride delivery have been developed to improve the efficiency of fluoride in inhibiting dental caries. One such innovation is the usage of fluoride varnishes, which have been shown to be more potent and longer-lasting compared to traditional fluoride gels. A study by Munteanu (2022) found that fluoride varnishes could reduce caries incidence by up to 40% compared to no treatment. This highlights the potential of fluoride varnishes as a promising intervention in caries prevention.

Another innovative approach is the use of fluoride-releasing dental materials, like glass ionomer cement. These materials continuously release fluoride ions, providing a sustained source of fluoride to the teeth and enhancing remineralization. A study by Pitts (2017) demonstrated that glass ionomer cements with fluoride-releasing properties were effective in reducing caries progression in high-risk individuals.

4.4.2 Addressing Fluoride Access Disparities:
Despite the well-established benefits of fluoride in preventing dental caries, access to fluoride treatments remains a challenge in certain populations, particularly in underserved communities. To address this disparity, community water fluoridation programs have been implemented in many regions to ensure a consistent and equitable delivery of fluoride to the population. Studies have shown that community water fluoridation can reduce caries incidence by up to 25% in children and adults (Rugg-Gunn, 2013).

Additional tactics that have been effective in reaching marginalized communities with inadequate access to dental care include mobile dental clinics and fluoride programs implemented in schools. For instance, a study by Sharma (2015) showed how well a school-based fluoride varnish program works to lower the prevalence of dental cavities in kids from low-income families. These initiatives are essential in helping underprivileged populations maintain good dental health and closing the gap in fluoride access inequities.

4.4.3 Emerging Technologies in Caries Prevention:
Advances in technology have led to the development of novel approaches to caries prevention, such as laser therapy and photodynamic therapy. These technologies target cariogenic bacteria and promote remineralization of the enamel, offering a non-invasive and effective alternative to traditional fluoride treatments. A study by Šket (2017) showed that laser therapy could effectively disrupt biofilms and inhibit the growth of cariogenic bacteria, leading to a reduction in caries progression.

Furthermore, nanotechnology has shown promise in improving the delivery and sustained release of fluoride ions. Nanoparticles loaded with fluoride have the potential to penetrate deeper into the enamel and release fluoride ions over an extended period, enhancing remineralization and strengthening the teeth (Whelton, 2019). Future research on the development and optimization of nano-delivery systems for fluoride could further revolutionize caries prevention strategies.

4.4.4 Future Directions and Research Opportunities:
Future research in the field of fluoride and dental caries should focus on enhancing the delivery of fluoride to maximize its efficacy in preventing caries. This could involve exploring novel formulations, such as nano-delivery systems and innovative materials with fluoride-releasing properties (Sharma, 2015). Additionally, studies should investigate the long-term effects of fluoride treatments on different age groups and populations, including those with special healthcare needs.

Addressing fluoride access disparities remains a critical issue that requires further attention. Future research should evaluate the effectiveness of community-based fluoride programs and identify barriers to fluoride access in underserved communities. Developing targeted interventions tailored to the specific needs of these populations could help improve oral health outcomes and reduce caries prevalence (Petersen, 2016).

Finally, exploring the synergistic effects of fluoride with other preventive measures, such as probiotics and antimicrobial agents, could enhance the overall efficacy of caries prevention strategies (Fejerskov, 2015). Collaborative research efforts between dental and medical professionals could lead to comprehensive approaches for preventing dental caries and promoting oral health.

5. Conclusion

In conclusion, fluoride has been shown to play a crucial role in preventing dental caries by promoting remineralization of enamel, inhibiting the development of cariogenic microbes, and enhancing the overall resistance of teeth to acid attacks. The usage of fluoride in various practices, including water fluoridation, toothpaste and mouth rinses, has contributed significantly to the decline in the prevalence of dental caries worldwide. While excessive fluoride intake may lead to fluorosis, the benefits of appropriate fluoride exposure outweigh the risks. Dentists and public health officials should continue to advocate for the safe and effective utilization of fluoride in dental care to promote better oral health outcomes across populations. Further investigation is required to explore innovative tactics for optimizing fluoride delivery and maximizing its caries-preventive effects in different populations and settings.

References

Adair, S. M. (2006). Evidence-based use of fluoride in contemporary pediatric dental practice. Pediatric dentistry, 28(2), 133-142.

Anusavice, K. J. (2005). Present and future approaches for the control of caries. Journal of dental education, 69(5), 538-554.

Buzalaf, M. A. R. (2018). Review of fluoride intake and appropriateness of current guidelines. Advances in dental research, 29(2), 157-166.

Bansal, A., Ingle, N. A., Kaur, N., & Ingle, E. (2015). Recent advancements in fluoride: A systematic review. Journal of International Society of Preventive & Community Dentistry, 5(5), 341.

Cummins, D. (2013). Dental caries: a disease which remains a public health concern in the 21st century–the exploration of a breakthrough technology for caries prevention. Journal of Clinical Dentistry, 24(Spec Iss A), A1-A14.

Fejerskov, O., Cury, J. A., Tenuta, L. M., & Marinho, V. C. (2015). Fluorides in caries control. Dental caries: the disease and its clinical management. 3rd edition. Oxford: Wiley-Blackwell, 245-76.

Horst, J. A., Tanzer, J. M., & Milgrom, P. M. (2018). Fluorides and other preventive strategies for tooth decay. Dental Clinics, 62(2), 207-234.

Iheozor-Ejiofor, Z., Worthington, H. V., Walsh, T., O'Malley, L., Clarkson, J. E., Macey, R., ... & Glenny, A. M. (2015). Water fluoridation for the prevention of dental caries. Cochrane database of systematic reviews, (6).

Kanduti, D., Sterbenk, P., & Artnik, B. (2016). Fluoride: a review of use and effects on health. Materia socio-medica, 28(2), 133.

Munteanu, A., Holban, A. M., Păuna, M. R., Imre, M., Farcașiu, A. T., & Farcașiu, C. (2022). Review of professionally applied fluorides for preventing dental caries in children and adolescents. Applied Sciences, 12(3), 1054.

Petersen, P. E., & Ogawa, H. (2016). Prevention of dental caries through the use of fluoride–the WHO approach. Community dent health, 33(2), 66-68.

Pitts, N. B., Zero, D. T., Marsh, P. D., Ekstrand, K., Weintraub, J. A., Ramos-Gomez, F., ... & Ismail, A. (2017). Dental caries. Nature reviews Disease primers, 3(1), 1-16.

Peroš, K., Šutej, I., & Bašić, K. (2013). The cariostatic mechanisms of fluoride. Acta medica academica, 42(2).

Rugg-Gunn, A. (2013). Dental caries: strategies to control this preventable disease. Acta medica academica, 42(2), 117.

Spencer, A. J., Do, L. G., & Ha, D. H. (2018). Contemporary evidence on the effectiveness of water fluoridation in the prevention of childhood caries. Community dentistry and oral epidemiology, 46(4), 407-415.

Sharma, G., Puranik, M. P., & Sowmya, K. R. (2015). Approaches to arresting dental caries: an update. Journal of clinical and diagnostic research: JCDR, 9(5), ZE08.

Singh, A., & Purohit, B. M. (2018). Caries Preventive Effects of High-fluoride vs Standard-fluoride Toothpastes-A Systematic Review and Meta-analysis. Oral health & preventive dentistry, 16(4).

Šket, T., Kukec, A., & Artnik, B. (2017). The history of public health use of fluorides in caries prevention. Slovenian Journal of Public Health, 56(2), 140-146.

Ullah, R., & Zafar, M. S. (2015). Oral and dental delivery of fluoride: a review. Fluoride, 48(3), 195.

Whelton, H. P., Spencer, A. J., Do, L. G., & Rugg-Gunn, A. J. (2019). Fluoride revolution and dental caries: evolution of policies for global use. Journal of dental research, 98(8), 837-846.

Wiegand, A., Buchalla, W., & Attin, T. (2007). Review on fluoride-releasing restorative materials—fluoride release and uptake characteristics, antibacterial activity and influence on caries formation. Dental Materials, 23(3), 343-362.