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Link between High Fluoride in Drinking Water and Dental Caries Prevalence

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Abstract

Introduction: Numerous community trials have revealed a negative correlation between higher fluoride levels in drinking water and reduced dental caries incidence. However, the debate over its effectiveness and safety persists, necessitating more research. While some evidence supports the safety and efficacy of water fluoridation in decreasing dental caries, other studies caution against the health risks of excessive fluoride exposure. This review evaluates the evidence regarding fluoride addition to drinking water as a measure to curb dental caries.

Methods: We searched medical databases, including PubMed and Embase, for community trials examining the effect of water fluoridation on dental caries rates. Two reviewers independently screened the studies for relevance based on predetermined eligibility criteria. Initially, 35 studies were deemed relevant and included in the analysis. Eligible studies encompassed randomized controlled trials, cohort, case-control, cross-sectional studies, and systematic reviews that investigated fluoride's impact in drinking water on dental caries, covering various populations and settings worldwide.

Results: Water fluoridation, initiated as a public health policy in the US in 1951, has seen varying global adoption, with about 69.2% of Americans accessing fluoridated water by 2006. Adoption rates differ internationally, with countries like New Zealand, Brazil, and Ireland implementing fluoridation programs. Nonetheless, some areas have ceased fluoridation due to alternative dental health strategies and health risk concerns. Evidence indicates that while higher fluoride levels in drinking water can decrease dental caries, they may increase dental fluorosis rates. The occurrence of dental caries and fluorosis varies by region, with limited research on fluoride levels in water and their effects on dental health in certain regions, including Arab countries.

Conclusions: Research confirms that elevated fluoride levels in drinking water can reduce dental caries but may heighten dental fluorosis risk. The incidence of both conditions differs across regions, with a noted research gap in the study of water fluoride concentration and its dual impact on dental caries and fluorosis in various areas.

Keywords: Cariea, Filling, Decay, Side-Effects, Fluoridation

Introduction

Fluoride is a crucial element for human health and is found in various sources like drinking water, milk, plants, tea, fish, soil, and air, among others. Upon ingestion, fluoride is absorbed by the intestines and deposited in bones and teeth, serving as an effective agent against dental caries at optimal levels. Yet, excessive intake can lead to dental fluorosis. Research indicates that fluoride levels of 0.7-1 ppm in drinking water can significantly lower the incidence of dental caries, particularly in children during the calcification phase of their teeth. At this stage, fluoride integrates into the enamel, enhancing its hardness and resistance to caries, and promotes tooth remineralization, thereby halting the early stages of dental caries. The negative impacts of fluoride vary from mild dental fluorosis to severe skeletal fluorosis, with the severity and duration of exposure influencing these effects. The earliest accounts of dental fluorosis date back to 1888 in Durango, Mexico, with subsequent reports in the early 1900s in the USA and other countries.

The interaction between fluoride and teeth has been under investigation since the nineteenth century, with significant milestones in understanding its benefits and drawbacks over time. Fredrick McKay, an American researcher, dedicated nearly three decades to identifying the cause of brown tooth pigmentation, ultimately linking it to fluoride exposure, now known as dental fluorosis. Early research highlighted the absence of dental caries in brown-pigmented teeth and investigated the correlation between fluoride levels in drinking water and dental health. These studies paved the way for adding fluoride to drinking water as a public health measure to combat dental caries, with notable reductions in caries rates reinforcing the practice's adoption despite some skepticism regarding the evidence. He found that fluoride is the main factor for dental pigmentation [10]. In the fourth decade and the early fifth decade of the twentieth century, H T Dean and his co-workers had published several epidemiological studies indicating that the concentration of fluoride at 1 ppm has a relation with the low rate of dental caries in hot areas and may cause dental fluorosis but at a low level which does not affect the aesthetics of the teeth. In other studies, it has been found that the only effect of fluoride is dental fluorosis even at 8 ppm concentration [11]. To test a hypothesis that the addition of fluoride may reduce the rate of dental caries, HT Dean and his co-workers did an experiment. They add Fluoride to water in Michigan and Grand Rapid states from 25th January 1945 and the results were published in 1950 indicating that there was a significant decrease in the rate of dental caries [12, 13]. Other researchers have been done in other countries similarly such as Canada and in tael, Collymberg in the Netherlands, and Britain and have concluded similar results [10]. According to the current standards, the above studies and other studies are unconvincing, however, a significant reduction in dental caries rates have persuaded public health professionals for the benefits of adding fluoride to water [14]. This review aims to evaluate the evidence supporting the addition of fluoride to drinking water as a strategy for reducing dental caries, reflecting on historical and contemporary research findings.

Methods

An online search was performed in medical databases, including PubMed and Embase, to find community trials investigating the effects of water fluoridation on dental caries rates. The search also aimed to identify any local or systemic side effects reported from fluoridating water. Two reviewers independently screened the studies for relevance based on the abstracts and alignment with the study criteria. Initially, 35 studies met these criteria and were incorporated into the review. The search utilized keywords such as "fluoride," "drinking water," "dental caries," "tooth decay," "systematic review," and "meta-analysis," focusing on publications in English. The review included randomized controlled trials, cohort studies, case-control studies, cross-sectional studies, and systematic reviews assessing the impact of fluoride in drinking water on dental caries. It considered studies reporting on dental caries prevalence or incidence, involving participants of any age, and conducted across various countries and

settings. Data from the selected studies were extracted by two reviewers using a standardized form, including information on study design, participant demographics, fluoride exposure levels, outcome metrics, and findings.

Results and discussion

In America, Water fluoridation was adopted as a health policy in 1951 and by 1960 it became more widespread in the United States of America [15], as the number of those who drink fluoridated water was about 50 million people (11). In 2006 it was estimated that 69.2% of Americans drink fluoridated water [16]. In New Zealand, water fluoridation began in 1953 and it reached to 65% of the community in 1968 [17]. Water fluoridation began in Brazil in 1953, organized by a governmental law in 1974 and by 2004 a 71% of the community became drinking fluoridated water [18]. In the Republic of Ireland, an enactment law of water fluoridation was done in 1960, and because of constitutional constraints, it was applied in 1964 and in 1996, 66% of the community became drinking fluoridated water [10].

A program of water fluoridation was used in other countries then prevented to be continued, as in Finland in the city of Kuopio, where water fluoridation was used for decades but it was discontinued because of health services provided in schools, which provide useful programs in using fluoride. A lower rate of dental caries was noted with these programs, likewise, water fluoridation programs had been stopped and replaced by salt food in the Swiss city of Basel [11]. Fredrick McKay thought that dental fluorosis occurred before the emergence of teeth. While Dean and his co-workers thought that the protective action of the Fluoride against dental caries started before the emergence of the teeth and this misconception still continued for several years. But by 2000, the local effect of fluoride in water or tooth pastes has been recognized and acknowledged that the constant level of fluoride in mouth, by any method, is the best way to reduce dental caries [14]. The process of applying water fluoridation programs has started in United States and Canada in 1945 and 1946 respectively [19]. This process has been adopted to varying degrees in several countries around the world including Argentina, Australia, Brazil, Chile, Colombia, Hong Kong, Ireland, Israel, Korea, Malaysia, New Zealand, Philippines, Singapore, Spain, Britain and Vietnam. Statistics indicate that about 12 million people in Western Europe and 171 million in the United States (61.5% of the total population) and 355 million worldwide drink water artificially fluoridated. In addition to, at least 50 million of people worldwide drink naturally fluoridated water [15,16]. In some African areas, China and India, it has been found that the concentration of fluoride in the water is more than the optimal level, and it is believed that approximately 200 million people in China drink water at the optimum concentration of fluoride or higher than this concentration. Artificially fluoridated water is used in several countries, including Argentina, France, Gabon, Libya, Mexico, Senegal, Sri Lanka, Tanzania, USA and Zimbabwe [20]. Water fluoridation has been dispensed in Finland, Germany and Japan, Netherlands, Sweden and Switzerland and other countries due to the presence of alternative strategies. In France and Germany and other European countries, the use of fluoride in various ways (such as using fluoridated salt, fluoridated tooth pastes and the use of fluoridated mouth washes) is essential for resistance to dental caries [21].

Prevalence of dental caries and fluorosis in many countries

To find out the relationship between water fluoridation, dental caries and dental fluorosis, hundreds of studies have been carried out all around the world [22-25]. The objective of these studies was to investigate the relationship between the concentration of fluoride in drinking water and the prevalence of dental caries. These studies showed that the prevalence of dental caries in areas with a high concentration of fluoride in drinking water was much lower compared to areas with less concentration of fluoride. Studies were also conducted to determine on the relationship between water fluoridation and dental fluorosis. The results showed that dental fluorosis is directly proportional to the increase of fluoride in drinking water [26, 27]. Studies on the relationship

between the concentration of fluoride in drinking water and both dental caries and dental fluorosis were done also in several countries [28-32]. They all agreed that the high percentage of fluoride in drinking water reduces dental caries, but raises the incidence of dental fluorosis. In the city of Kuopio, in Finland, A study was conducted to determine the prevalence of caries in primary teeth after stopping water fluoridation. The results indicated that the prevalence of dental caries did not increase in children after 3 years of stopping water fluoridation, due to the high heath education and the presence of alternative sources of fluoride [33]. In contrast to the expected results, A study done in the East of Germany on the prevalence of dental caries in children, after stopping water fluoridation indicated that dental caries has decreased. This decrease had been explained by the increase in parents and children health awareness and by rising health services and the use of pastes containing fluorine [34].

In most Arab countries, there is no report of statistical or health institutions about the adoption of industrial fluoridation of water or about the natural concentrations of fluoride in the drinking water. In addition to that, the studies on the concentration of fluoride in the drinking water and its relation to both dental caries and dental fluorosis in the Arab countries are rare and confined to a small geographic scope and a small population [35- 38]. A study done by Kader and Al-Maqtari and his partner in 2010 to assess the relationship between the concentration of fluoride in drinking water and the prevalence of dental fluorosis in some central areas of Yemen. They concluded that the prevalence of dental fluorosis is confined to areas with a high concentration of fluoride in drinking water [39]. Dental caries will be detected using DMFT index (decayed, missed, and filled teeth). Each permanent tooth is considered individually and if it is decay (D), missing due to caries (M), or filled (F) it scores one. The total of affected teeth is an expression of an individual's dental caries experience [40].

Several techniques have been proposed to improve the appearance of tooth stains. Teeth discolored by fluorosis or hypoplasia may be treated by performing enamel bleaching, microabrasion, placement of veneers, or artificial crowns. The choice among these treatments depends on the severity of the disease [40]. Usually, enamel microabrasion is the chosen technique. This therapy removes superficial parts of the lesion by abrasion with a slurry of hydrochloric acid and pumice or commercially available products with various acids at different concentrations, combined with abrasive agents and certain gel solutions [41]. Unfortunately, with this technique, substantial amounts of enamel often have to be eroded to improve appearance. The inherent danger of using a strong acid intraorally, and the inconvenience and time required for application have led to the search for a safer, quicker, easier therapy.

Conclusions

Based on the literature, it is clear that adding of dental fluoride within allowed limit to the drinking water associated with reduction in dental caries prevalence among children. No reported side effects either on dental health or general health was confirmed. In many Arabic countries, there is no report of statistical or health institutions about the adoption of industrial fluoridation of water or about the natural concentrations of fluoride in the drinking water. In addition to that, the studies on the concentration of fluoride in the drinking water and its relation to both dental caries and dental fluorosis in the Arabic countries are rare and confined to a small geographic scope and a small population.

Conflict of interests

The authors declared no conflict of interests.

References

1-Binbin W, baoshan Z, ching Z, guangqian Y, xiaojing L: Relationship between fluorine in drinking water and dental health of residents in some large cities in China. Envint 2004;30:1067-1073.

2-Harrison P: Fluoride in water: A UK perspective. Journal of Fluorine Chemistry 126 (2005) 1448–1456.

3- Picton D C A : Basis for the use of topical and systemic fluorides in caries prevention. Journal of the Royal Society of Medicine Supplement No. 14 Volume 79 1986.

4- World Health Organization: Guide for line for drinking water .vol 1; 3rd ed. WHO, Geneva 2004.

5- Black, G.V. and McKay, F.S. Mottled teeth: an endemic developmental imperfection of the enamel of the teeth heretofore unknown in the literature of dentistry. Dent. Cosmos. 1916; 58: 129— 156 Quoted from K. Bailey, J. Chilton, E. Dahi, M. Lennon, P. Jackson and J. Fawell. Fluoride in Drinking water. World 1-Iealth Organization (WHO); 2006.

6- Szpunar SM and Burt B A. Dental caries, fluorosis, and,fluoride exposure in Michigan schools children. J Dent Res 1988; 69:802-806.

7-Toverud G, Finn SB, Cox GJ, Bodecker CF, Shaw JH : A Survey of the Literature of Dental Caries. Washington, DC: National Academy of Sciences—National Research Council; 1952. Publication 225. p. 325–414.

8-Ripa LW: A half-century of community water fluoridation in the United States: review and commentary . J Public Health Dent. 1993;53(1):17–44.

9-Peterson J: Solving the mystery of the Colorado Brown Stain. J Hist Dent. 1997;45(2):57–61.

10-Mullen J: History of water fluoridation. Br Dent J. 2005;199(7s):1–4. 11-Lennon M: One in a million: the first community trial of water fluoridation. Bull World Health Organ. 2006;84(9):759–60.

12-Dean HT, Arnold FA, Jay P, Knutson JW: Studies on mass control of dental caries through fluoridation of the public water supply. Public Health Rep. 1950;65(43):1403–8.

13-The story of fluoridation; National Institute of Dental and Craniofacial Research. 2008-12-20 [cited 2010-02-06].

14-Burt BA, Tomar SL: Changing the face of America: water fluoridation and oral health. The History and Practice of Public Health in Twentieth-century America. Oxford University Press; 2007 p. 307–22. 15-Griffin SO, Gooch BF, Lockwood SA, Tomar SL: Quantifying the diffused benefit from water fluoridation in the United States. Community Dent Oral Epidemiol 2001; 29: 120–9.

16-Division of Oral Health, National Center for Chronic Disease Prevention and Health Promotion. 2008-09-17 [cited 2008-12-22].

17-Akers HF: Collaboration, vision and reality: water fluoridation in New Zealand (1952–1968) . N Z Dent J. 2008;104(4):127–33.

18-Buzalaf MA, de Almeida BS, Olympio KPK, da S Cardoso VE, de CS Peres SH: Enamel fluorosis prevalence after a 7-year interruption in water fluoridation in Jaú, São Paulo, Brazil. J Public Health Dent. 2004;64(4):205–8.

19-Sellers C: The artificial nature of fluoridated water: between nations, knowledge, and material flows. Osiris. 2004;19:182–200.

20-One in a Million: The facts about water fluoridation. British Fluoridation Society; 2004]. p. 55–80.

21-Cheng KK, Chalmers I, Sheldon TA: Adding fluoride to water supplies .BMJ. 2007;335(7622):699–702.

22-Robinson B, Pethybridge R, Rugg-Gunn AJ: Dental caries experience of 16-17-year-old naval recruits related to the water fluoride level in their home town. Community Dent Oral Epidemiol 1983; 11 : 183-7.

23-Stockwell AJ, Medcalf GW, Rutledge GJ, Holman CDJ, Roberts M; Dental caries experienee in schoolchildren in lluoridated and non-lluoridated communities in Western Australia. Community Dent Oral Epidemiol 1990; 18: 184-9.

24-Seppa L, Karkkainen S, Hausen H: Caries frequency in permanent teeth before and after discontinuation of water fluoridation. Community Dent Oral Epidemiol 1998; 26: 256–62.

25-Kirkeskov L, Kristiansen E, Bøggild H, von Platen-Hallermund F, Sckerl H,Carlsen A, Larsen MJ, Poulsen S: The association between fluoride in drinking water and dental caries in Danish children. Linking data from health registers, environmental registers and administrative registers. Community Dent Oral Epidemiol 2010; 38: 206–212.

26-Clarkson JJ, O,Mullane DM: Prevalence of enamel defects/fluorosis in fluoridated and non-fluoridated areas in Irland. Community Dent Oral Epidemiol 1992; 20 : 196-9.

27-Bårdsen A, Klock KS, Bjorvatn K: Dental fluorosis among persons exposed to high- and low-fluoride drinking water in western Norway. Community Dent Oral Epidemiol 1999; 27: 259–67.

28-Kumar J, Swango P, Lininger L, Leske G, Green E, Haley V : Changes in Dental Fluorosis and Dental Caries in Newburgh and Kingston, New York. Am J Public Health. 1998;88:1866-1870.

29-Villa AE, Guerrero S, Villalobos J: Estimation of optimal concentration of fluoride in drinking water under conditions prevailing in Chile. Community Dent Oral Epidemiol 1998; 26: 249–55.

30-Stephen KW, Macpherson LMD, Gilmour WH, Stuart RAM, Merrett MCW: A blind caries and fluorosis prevalence study of schoolchildren in naturally fluoridated and nonfluoridated townships of Morayshire, Scotland. Community Dent Oral Epidemiol 2002; 30: 70–9.

31-Meyer-Lueckel H, Paris S, Shirkhani B, Hopfenmuller W, Kielbassa AM: Caries and fluorosis in 6- and 9-year-old children residing in three communities in Iran. Community Dent Oral Epidemiol 2006; 34: 63–70.

32-Kanagaratnam S, Schluter P, Durward C, Mahood R, Mackay T: Enamel defects and dental caries in 9-year-old children living in fluoridated and nonfluoridated areas of Auckland, New Zealand. Community Dent Oral Epidemiol 2009; 37:250–259.

33-Seppa L, Karkkainen S, Hausen H: Caries in the primary dentition, after discontinuation of water fluoridation, among children receiving comprehensive dental care. Community Dent Oral Epidemiol 2000; 28: 281–8.

34-Künzel W, Fischer T, Lorenz R, Brühmann S: Decline of caries prevalence after the cessation of water fluoridation in the former East Germany. Community Dent Oral Epidemiol 2000; 28: 382–9.

35-Ellwood RP, Hawew RM, Worthington HV, Blinkhorn AS:Developmental enamel defects and extrinsic tooth stain in Libya schoolchildren.Community Dent Oral Epidemiol 1996:24: 419-20.

36-Ibrahim YE, Affan AA, Bjorvantn K: Prevalence of dental fluorosis in Sudanese children from two villages with 0.25 and 2-56 ppm fluoride in the drinking water. International Journal of Paediatric Dentistry 1995; 5: 223-229.

37-Hamdan M.A.M: The prevalence and severity of dental fluorosis among 12-year-old schoolchildren in Jordan. International Journal of Paediatric Dentistry 2003; 13: 85–92.

38-Aldosari AM, Akpata ES, Khan N, Wyne AH, Al-Meheithif A: Fluoride levels in drinking water in the Central Province of Saudi Arabia. Ann Saudi Med. 2003 Jan-Mar;23(1-2):20-3.

39-Kadir RA, Al-Maqtari RA: Endemic fluorosis among 14-year-old Yemeni adolescents: an exploratory survey. Int Dent J. 2010 Dec;60(6):407-10.

40-Akpata ES. Occurrence and management of dental fluorosis. Int Dent J 2001;51:325–33.

41-Croll TP, Cavanaugh RR. Enamel color modification by controlled hydrochloric acid-pumice abrasion. I. Technique and examples. Quintessence Int 1986;17:81–7.


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