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Association between High Fluoride Concentration of the Drinking Water and Prevalence of Dental Caries: A Systematic Review

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Abstract

Introduction: The inverse relationship between higher fluoride concentration of the drinking water and lower level of dental caries experience was demonstrated by several community trials but the augment about effectiveness and safety is still a matter of debate and requires further research and investigation. While some studies have shown that adding fluoride to drinking water can be a safe and effective way to reduce dental caries, others have raised concerns about potential health risks associated with exposure to high levels of fluoride. This review aim to assess the evidence of adding fluoride in drinking water to reduce dental caries.

Methods: A web search was conducted in medical databases such as PubMed and Embase to identify community trials that aimed to assess the impact of fluoridation of drinking water on occurrence of dental caries. Two reviewers screened the eligible papers and read abstract to determine the alignment with eligibility criteria. After primary screening, 35 studies were found relevant and included in the review. Inclusion criteria were randomized controlled trials, cohort studies, case-control studies, cross-sectional studies, and systematic reviews that evaluate the effect of fluoride in drinking water on dental caries. Studies that report on the prevalence or incidence of dental caries as an outcome measure, studies that include participants of any age, and studies conducted in any country or setting.

Results: Water fluoridation was first adopted as a health policy in the United States in 1951 and gradually became more widespread, with an estimated 69.2% of Americans drinking fluoridated water by 2006. Several other countries also adopted water fluoridation programs to varying degrees, including New Zealand, Brazil, and Ireland. However, the process has been discontinued in some areas due to alternative strategies, such as the provision of health services in schools, and concerns about potential health risks. Studies have shown that the high concentration of fluoride in drinking water reduces dental caries but raises the incidence of dental fluorosis. The prevalence of dental caries and dental fluorosis varies between countries and regions,

and studies on the concentration of fluoride in drinking water and its relation to both dental caries and dental fluorosis are limited in some areas, such as in Arab countries.

Conclusions: Studies have shown that high fluoride concentration in drinking water reduces dental caries but raises the incidence of dental fluorosis. The prevalence of dental caries and dental fluorosis varies between countries, and studies on the concentration of fluoride in drinking water and its relation to both dental caries and dental fluorosis are limited in some areas.

Keywords: Fluoride, Drinking Water, Dental Caries, Tooth Decay, Side-Effects.

Introduction

Fluoride is one of the most important element necessary for human health [1] and it is present in different concentrations of many sources such as drinking water, milk, plants, tea, fish, soil, air and others. When fluoride enters the human body, it is absorbed by the intestines and then deposited in bone and teeth. Fluoride is considered as an effective material in resisting dental caries when taken in optimal amounts, however, it may have repercussions on the teeth if taken in high concentrations causing what is called dental fluorosis [2]. Studies have shown that 0.7-1 ppm fluoride in drinking water reduces dental caries occurrence especially in children where teeth are in the phase of calcification. In this stage, fluoride merges in the outer layer of the teeth (Enamel) increasing its hardness and resistance to caries. It also helps in tooth remineralization and thus stops dental caries in early stages [3].

The adverse effects of fluoride range from mild dental fluorosis to crippling skeletal fluorosis as the level and period of exposure increase. Crippling skeletal fluorosis is a significant cause of morbidity in a number of regions of the world [4]. The first reports of the occurrence of dental fluorosis date back to (1,888), when a family from Durango, Mexico was described as having black teeth. Subsequently, dental fluorosis was described in the early (1900) at several locations in the USA and in many other countries around the world [5,6]. The relationship between teeth and fluoride has been studied since the beginning of the nineteenth century. In 1850 researchers proved the presence of fluoride with different concentrations in the teeth, bones and in drinking water and in 1900 researchers thought that fluoride protect teeth from caries and suggested adding fluoride in food. They are also noted the existence of what they called Brown teeth without knowing its causes [7]. The history of research on fluoride can be divided into three periods: The first period (1901-1933) focused on the causes of brown pigmentation of the teeth. The second period (1933-1945) focused on studying the relationship between the concentration of fluoride in drinking water and its relationship to both the brown teeth and dental caries where it has been proved that the optimal level of fluoride in drinking water reduces the incidence of dental caries. The third period (after-1945) focused on adding fluoride to drinking water at community level [8].

An American researcher named Fredrick McKay spent nearly 30 years to find out the cause of brown pigmentation of the teeth and with the help of GV Black and other researchers, they have demonstrated that the reason is fluoride and they called it Colorado brown stain and later became known as dental fluorosis [9]. Norman Ainsworth, a British dentist, in 1925 did the first research where he referred the lack of dental caries prevalence in teeth which are brown pigmented. In 1931, a chemical researcher HV Churchill concerned about the probability of a relationship between aluminum and dental fluorosis. He analyzed water from several areas of high prevalence rate of dental fluorosis. 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 aim to review the evidence of adding fluoride in drinking water to reduce dental caries.

Methods

A web search was conducted in medical databases such as PubMed and Embase to identify community trials that aimed to assess the impact of fluoridation of drinking water on occurrence of dental caries. The secondary outcomes were identification of any reported local or systematic side effects due to water fluoridation. Two reviewers screened the eligible papers and read abstract to determine the alignment with eligibility criteria. After primary screening, 35 studies were found relevant and included in the review. The search strategy was developed with the following keywords will be used: "fluoride," "drinking water," "dental caries," "tooth decay," "systematic review," and "meta-analysis." The search was limited to studies published in English. Inclusion criteria were randomized controlled trials, cohort studies, case-control studies, cross-sectional studies, and systematic reviews that evaluate the effect of fluoride in drinking water on dental caries. Studies that report on the prevalence or incidence of dental caries as an outcome measure, studies that include participants of any age, and studies conducted in any country or setting. Two reviewers independently extracted data from the selected studies using a standardized data extraction form. The following data were extracted: study design, population characteristics, fluoride exposure, outcome measures, and results.

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

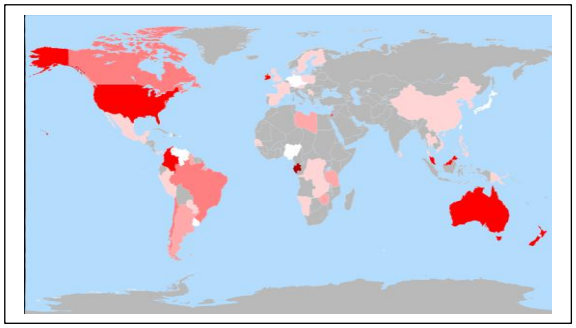

Figure 1: Fluoridation of drinking water by country

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.

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