DENTAL FLUOROSIS AS A PUBLIC HEALTH PROBLEM

FLUOROZA ZĘBÓW JAKO PROBLEM ZDROWIA PUBLICZNEGO

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ABSTRACT

Fluorosis is caused by excessive exposure to fluoride. The primary source of excess fluoride ingestion is drinking-water with high fluoride concentrations. According to the World Health Organization, fluoride concentrations in drinking-water should not exceed 1.5 mg/l (1.5 ppm). Secondary sources of fluoride exposure include fluoride-rich beverages, foodstuffs and dental products. Excess fluoride intake manifests itself primarily in disrupted tooth enamel formation (dental fluorosis) and bone damage (skeletal fluorosis). The two classification systems widely used for grading the severity of dental fluorosis are the Dean's Index and the Thylstrup-Fejerskov Index. To estimate the scale of dental fluorosis as a global public health problem, a literature search was conducted in the PubMed database with 'fluorosis' as a search term, as well as in publications available in print. The search yielded a number of studies describing the problem of dental fluorosis in countries such as Mexico (100% prevalence), Sri Lanka (72.9%), India (64.3%), the USA (61.3%) and Brazil (from 39.6 to 58.9%). High fluoride drinking-water concentrations influenced the prevalence of dental fluorosis. With the mean concentration of 1.58 ppm, as many as 72.9% of the study population had dental fluorosis (Sri Lanka). Higher fluoride concentrations were correlated with a higher prevalence of more severe manifestations of the disease: the proportion of population affected with stage 6 or 7 (severe) fluorosis was 4.4% at 2.5 ppm and 20.6% at 5.1 ppm (Mexico). In the regions of the world with high fluoride drinking-water concentrations, steps should be taken to prevent dental fluorosis.

Keywords: dental fluorosis, drinking-water, oral health, prevalence.

STRESZCZENIE

Fluoroza jest efektem nadmiernej podaży fluoru w organizmie. Jej głównym źródłem jest woda pitna o wysokiej zawartości związków fluoru. Według Światowej Organizacji Zdrowia zawartość ta nie powinna przekraczać 1,5 mg/l (1,5 ppm). Inne źródła nadmiernej podaży fluoru to bogate we fluor napoje, środki spożywcze i produkty do higieny jamy ustnej. Nadmierna ekspozycja na fluor prowadzi przede wszystkim do zaburzeń rozwoju szkliwa zębów (fluorozy zębów) oraz do uszkodzenia układu kostnego (fluorozy kości). Do pomiaru stopnia zaawansowania fluorozy zębów najczęściej używana jest klasyfikacja Deana lub klasyfikacja Thylstrupa i Fejerskova. W celu oszacowania skali występowania fluorozy zębów jako globalnego problemu zdrowia publicznego dokonano przeglądu literatury na podstawie artykułów znalezionych w bazie PubMed z użyciem słowa kluczowego „fluorosis" oraz materiałów drukowanych. Znaleziono badania, które opisują problem fluorozy zębów w krajach, takich jak: Meksyk (chorobowość 100%), Sri Lanka (72,9%), Indie (64,3%), Stany Zjednoczone (61,3%) oraz Brazylia (od 39,6% do 58,9%). Wyraźnie widać wpływ wysokiej zawartości fluoru w wodzie na współczynniki chorobowości. Przy zawartości 1,58 ppm fluorozę zaobserwowano u aż 72,9% populacji (Sri Lanka). Im wyższa była średnia zawartość fluoru w wodzie, tym częściej występowały bardziej zaawansowane postacie fluorozy: ciężką fluorozę 6 lub 7 stopnia zdiagnozowano u 4,4% populacji przy stężeniach na poziomie 2,5 ppm i u 20,6% populacji przy stężeniach na poziomie 5,1 ppm (Meksyk). W rejonach świata o wysokiej zawartości fluoru w wodzie pitnej należy podjąć działania profilaktyczne w celu ograniczenia liczby zachorowań na fluorozę zębów.

Słowa kluczowe: fluoroza zębów, woda pitna, zdrowie jamy ustnej, chorobowość.

Introduction

Fluorosis is a condition caused by excessive exposure to fluoride [1]. The most common source of excess fluoride ingestion is drinking-water [2]. Thus, fluorosis is often caused by drinking water from local supplies with high fluoride concentrations of either natural or anthropogenic origin [2,3] (**Table 1**).

Table 1. The countries with high fluoride concentrations in drinking-water

Europe	Asia	Africa	North America	South America
Germany Norway Spain	China India Indonesia Israel Japan Pakistan Saudi Arabia Sri Lanka Thailand Turkey	Eritrea Ethiopia Kenya Niger Nigeria Senegal South Africa Sudan Tanzania Uganda	Canada Mexico USA	Argentina Brazil

Data source: Fawell et al. [2].

Fluoride intake occurs also through unintentional swallowing of fluoridated dental products, breathing in fluoride-polluted ambient air, and consumption of fluoride supplements, and fluoride-rich foods and beverages. The last category includes brick tea, locally used food additives (such as the so-called *trona* in Tanzania), fluoride-contaminated barley, rice and maize, and special foodstuffs (e.g. salt) fluoridated to prevent dental caries. While human breast milk does not have high fluoride levels, infant formulas prepared with fluoride-rich water often do. Therefore, the consumption of such products, coupled with fluoride-rich drinking-water, may also contribute to fluorosis [2, 4]. The course and severity of fluorosis are determined by the age at which excessive fluoride exposure occurs as well as the duration of the exposure [5]. Excess fluoride intake can lead to various manifestations of fluorosis, from disturbances of enamel and tooth formation called dental fluorosis, to bone damage causing the potentially crippling skeletal fluorosis, which is sometimes linked to neurological impairments [2, 3, 5, 6]. The manifestation with the highest global prevalence is dental fluorosis, presenting itself as staining, pitting, or cracking of the teeth. While mild fluorosis is mainly a cosmetic concern, moderate and severe fluorosis entails permanent weakening and damage of teeth [2]. Since it is caused by an elevated fluoride level in the developing enamel, dental fluorosis starts at a young age, with children up to the age of 3 years being the most susceptible [1]. According to the World Health Organization, the level of fluoride in drinking-water should not exceed 1.5 mg/l (1.5 ppm) [2], as regular consumption of water with higher fluoride levels causes clinical fluorosis [7]. However, given the fact that fluoride is also absorbed from sources other than drinking-water, the optimum concentration recommended by the WHO ranges from 0.5 to 1.0 mg/l [8]. The problem of drinking-water with fluoride concentrations exceeding the maximum guideline level is relatively rare in Poland. Within the last few years, excessive concentrations have been mainly observed in Pomorskie province, with peak values of 3 mg/l [9]. The Polish quality standards for drinking-water are laid down in the Regulation of the Minister of Health of 7 December 2017 on the quality of water intended for human consumption [10]. Fluoride levels are monitored on a regular basis by water supply companies and local offices of the Polish state sanitary inspection. However, the obligatory regular monitoring does not apply to small water supplies (e.g. privately owned wells) used by over 2 million Poles [9].

The classification systems measuring the severity of dental fluorosis include Dean's Index, Community Fluorosis Index, Thylstrup-Fejerskov Index, Tooth Surface Index of Fluorosis, Fluorosis Risk Index and Developmental Defects of Enamel Index. The first two systems listed above are used the most widely. The Dean's Index (DI) uses a six-point scale from 0 (normal teeth), through 1 (questionable fluorosis), 2 and 3 (very mild to mild fluorosis, with opaque white areas on tooth surfaces), 4 (moderate fluorosis), to 5 (severe fluorosis, with brown stains, marked wear and pitting). The Thylstrup-Fejerskov Index (TFI) is a ten-point scale, where 0 means no fluorosis symptoms, 1–5 – different levels of mild fluorosis, and 6 or more points – severe dental changes [6].

Material and methods

To estimate the scale of dental fluorosis as a global public health problem, a literature search was carried out in the PubMed database with 'fluorosis' as a search term, as well as in publications available in print.

Results

There are a number of regions in the world with a high prevalence of dental fluorosis. One of them is Brazil, where Moimaz et al. found dental fluorosis in a majority (58.9%) of their study group of 496 12-year-old children. 44.4% of the group had very mild, 11.9% – mild, 2.4% – moderate, and 0.2% – severe fluorosis (DI). A vast majority (94.9%) of the children who noticed the symptoms of fluorosis in themselves expressed a wish to have the fluorosis spots removed. Excessive fluoride concentrations in public water supplies were found to be strongly correlated with the presence of dental fluorosis ($p = 0.0004$) [11]. In another Brazilian study carried out by Oliveira et al. in a group of 2,755 schoolchildren, fluorosis of various severity was observed in 39.6% of the subjects [12]. As regards India, in a 2017 study by Verma et. al. conducted in a group of 1,026 adolescents aged 12–17 years, 64.3% of the participants were diagnosed with dental fluorosis, and over 50% with moderate or mild fluorosis (DI) [13]. In the USA, Wiener et al. compared data from two national surveys conducted in the years 2001–2002 and 2011–2012 to check whether the prevalence of dental fluorosis changed between the first and the second survey. The study sample in each data set consisted of 875 adolescents aged 16–17 years. In the years 2001–2002, questionable fluorosis was found in 20.5%, and very mild or above levels of fluorosis in 29.7% of the participants. In the years 2011–2012, questionable fluorosis was diagnosed in 7.5% of the subjects, while mild or above – in 61.3% (DI). Over the decade, the prevalence of mild or above fluorosis increased by 31.6% [14]. A Mexican study of 2017 conducted among 308 adolescents aged 15 years

found fluorosis in all the participants. Their socioeconomic status and the resulting fluoride exposure greatly affected the severity of the disease. Among the participants with lower socioeconomic status, exposed to the mean fluoride concentration of 5.1 ppm in drinking-water, 12.3% had stage 2 or 3 fluorosis, 67.1% stage 4 or 5 fluorosis, and 20.6% stage 6 or 7 (severe) fluorosis (TFI). Among the participants with medium socio-economic status who drank water with the mean fluoride concentration of 2.5 ppm, 50% had TFI of 2–3, 45.6% TFI of 4–5, and 4.4% TFI of 6–7. A majority of the participants with TFI of 4–5 and 6–7 expressed concerns about their tooth colour, smile, and general appearance [15]. According to a 2017 Sri Lankan study, dental fluorosis of varying degrees of severity affected 72.9% of the examined 307 schoolchildren in a region with the mean fluoride drinking-water concentration of 1.58 mg/l. 18.8% of the population had moderate of severe fluorosis (DI). All the affected children's mothers were seriously concerned about the appearance of their children's teeth, especially about its possible impact on the children's future education, employment and marriage opportunities. The children aged 11 years or more, and teenage girls in particular, expressed similar worries [16].

Discussion

The studies found during the literature search demonstrated that dental fluorosis is a serious public health problem and a source of serious concern for the affected populations in countries such as Brazil (prevalence from 39.6% to 58.9%), India (64.3%), the USA (61.3%), Mexico (100%), and Sri Lanka (72.9%). The available research points to a strong association between fluoride concentrations in drinking-water exceeding the optimum level of 0.5–1 ppm and the prevalence and severity of the disease. With the mean concentration of 1.58 ppm, as many as 72.9% of the study population were diagnosed with dental fluorosis (Sri Lanka). Wherever fluoride concentrations substantially exceeded the maximum guideline of 1.5 ppm, the differences between concentrations strongly influenced the severity of dental fluorosis. At 2.5 ppm, 4.4% of the study group presented with stage 6–7 fluorosis (TFI), while at 5.1 ppm the proportion reached 20.6% (Mexico).

Conclusions

In some regions of the world, high fluoride concentrations in drinking-water, whether of natural or anthropogenic origin, require taking steps towards ensuring the supply of water with concentrations below the maximum limit of 1.5 mg/l recommended by the WHO. There are a number of available public health measures aiming to prevent dental fluorosis. They include: defluoridation of drinking-water with excess fluoride, use of alternative drinking-water sources (such as well-tested bottled waters and deep-seated waters) with low fluoride concentrations, discouraging at-risk populations from the consumption of naturally fluoride-rich or artificially fluoridated beverages and foodstuffs, promotion of the use of fluoride-free dental products in children at the age of enamel formation, educating the populations at risk of developing dental caries on the importance of monitoring the use of fluoride dental products in children, promotion of breastfeeding instead of using infant formulas, promotion of oral hygiene and, last but not least, providing populations with equitable access to dental care and dentistry.

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