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Orapuh Journal

ORIGINAL ARTICLE

Public health significance of dental fluorosis among 12-15 years old school children in Zeway, Oromia Region, Ethiopia

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ARTICLE INFO

Received: 14 September 2021
Accepted: 26 October 2021
Published: 17 November 2021

Keywords:
Public health significance, dental fluorosis, school children

DOI:
https://dx.doi.org/10.4314/orapj.v2i3.4

Peer-Review: *Externally peer-reviewed*

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To cite:
Gebretsadik, H. G. (2021). Public health significance of dental fluorosis among 12-15 school children in Zeway, Oromia Region, Ethiopia. *Orapuh Journal*, *2*(3), e822.
https://dx.doi.org/10.4314/orapj.v2i3.4

ISSN: *2644-3740*

ABSTRACT

Introduction
While fluoride is accepted as being effective in the prevention of dental caries, the excessive consumption of fluoride can put bones and teeth at risk of developing fluorosis. Dental fluorosis is a condition affecting teeth and is caused by an increased intake of fluoride over an extended period during tooth development. Fluoride ingested through drinking water during dental development, until the age of six, may promote the development of fluorosis.

Purpose
The purpose of this study was to assess the public health significance of dental fluorosis among 12-15 years old school children in Zeway, Oromia Region, Ethiopia

Material and Methods
A descriptive cross-sectional study was conducted between June 5, 2018, and July 9, 2018. A total of 1290 school children, aged 12 – 15 years participated in the study. The public health significance of dental fluorosis among the study participants was measured by using the community fluorosis index catalog.

Result
The community fluorosis index of the total population studied was 2.02, which denotes the 'Marked' public health significance of the condition. The public health significance of dental fluorosis increased with increasing distance away from the city center. The community fluorosis index score of the rural population studied was the highest (2.76) compared to the scores of semi-urban (2.26) and urban (1.76) samples, respectively.

Conclusion
Dental fluorosis is a major public health problem in the study population. Beside the general intervention, more attention needs to be given to the semi-urban and rural communities to identify the risk factors of dental fluorosis in the areas and eliminate or modify them to mitigate the prevalence of this oral health problem in the study population.

INTRODUCTION

The prominent Greek physician, surgeon, and philosopher in the Roman Empire, Galen (1973) described what is thought to be dental fluorosis. However dental fluorosis was not recognized and scientifically studied until the early 20th century (Levy, 2011). Eager in 1901 published the first description of ''mottle enamel'' and called it ''Denti di chiaie'', named after the Italian professor Stefano Chiaie (Eager, 1901). Later in 1931, three groups of scientists around the world found out that the disease was caused by a high dose of fluoride in drinking water during childhood (Smith, 1914).

It is hypoplasia or hypomineralization of tooth enamel or dentine produced by chronic ingestion of excessive amount of fluoride during the period when teeth are developing (Dean et al., 1942). Fluorosis can be classified as skeletal and dental based upon its occurrence in bone and teeth respectively (Ng'ang'a & Valderhaug, 1993). It can be manifested as both skeletal and dental in areas endemic to the disease (Horowitz, 1996).

Dental fluorosis (also known as mottling of teeth) is an extremely common disease, described by hypomineralization of tooth enamel caused by ingestion of excessive fluoride during enamel development (Neville et al., 2015). Visually it appears as a change in enamel color (discoloration) and in some cases physical damage to the teeth (Lijima et al., 1987). The extent of severity of the condition depends on the dose, duration, and age of the individual at the time of exposure (Akosu et al., 2009). The degree of dental fluorosis can range from very mild to severe depending on the number of teeth surfaces (proportions of teeth) involved and the extent of physical damage (pitting and disfiguring) to the teeth (Dean et al., 1942).

In the past decades, a substantial decline in dental caries has occurred among children of several developed countries mainly the United States of America (USA) and several European countries (Aguilar et al., 2010; Bardesen et al., 1999). Fluoride has been recognized as one of the most influential factors responsible for the observed decline of caries among children as well as adults of these countries (Verma et al., 2017).

Fluorine is the most electronegative of all chemical elements and is largely found in the chemically combined state of fluoride (Anandhan, 2013). It is the largest naturally abundant element in the earth's crust. Fluoride is found in varying concentrations at different geographical locations on the earth (Farfan et al., 2011). One of the landmark discoveries in the history of preventive dentistry is the charismatic role of fluoride, which is used in man's battle against dental caries (Baskaradoss et al., 2008). It is considered a double-edged sword because when its level is below optimum, it does not have the caries protective action and when its concentration is above optimum, it causes dental and skeletal fluorosis in various forms (Yeung, 2008; Forrest, 1956). Fluoride at an optimum level does not only decrease the incidence of dental caries but also maintains the integrity of oral tissues (Manji et al. 1986). While fluoride is accepted as being effective in the prevention of caries, the excessive consumption of fluoride can put bones including maxillofacial and teeth at risk of developing fluorosis (Neville, 2015; Eklund et al., 1987).

Dental fluorosis is a condition affecting teeth and is caused by an increased intake of fluoride over an extended period during tooth development (Bronckers et al., 2009). Clinically it is characterized by hypo-mineralization with opaqueness and brownish discoloration (staining) of tooth surfaces (Whelton et al., 2004; Hiremath, 2011). Fluoride ingested through drinking water during dental development, until the age of six, may promote the development of fluorosis (Hong et al., 2006; Bucher et al., 1987).

According to the world health organization (1997), more than 200 million people worldwide rely on drinking water with fluoride levels exceeding the present WHO norm of 1.5mg/l. India and Brazil are among the most highly affected countries whose drinking water has levels higher than the accepted norm of WHO recommendation (John, 2012).

Rift valley countries in East Africa, such as Kenya, Ethiopia, and Uganda are affected by the high incidence of dental fluorosis (Mulu et al., 2009; Mann et al., 1987). The Ethiopian Central Rift Valley (ECRV) with an estimated 8 million people is at risk of fluorosis (Olsson, 1978). Due to the area's geology and climate, it has some of the world's highest concentrations of fluoride in drinking water, mainly in deep wells in the semi-arid parts (WHO, 1997).

In industrialized countries, the caries decline has been related to the use of fluoride in different forms (Driscoll et al., 1983). The therapeutic range of fluoride is narrow, and an association between fluoride and drinking water and the degree of dental fluorosis has been documented worldwide (Tazawa et al., 1979). While fluoride is accepted as effective in the prevention of caries, the excessive consumption of fluoride can put bones and teeth at risk of developing fluorosis (Hazza et al., 2015). Dental fluorosis is a condition affecting teeth and is caused by an increased intake of fluoride over an extended period during tooth development (Joshi & Sujan, 2013). Clinically it is characterized by hypomineralization with opaqueness and brownish discoloration (staining) of tooth surfaces (Fuente-

Hernandez, 2011). Fluoride ingested through drinking water during dental development, until the age of six years, may promote the development of fluorosis (Farfan et al., 2011). Though fluorosis (Skeletal and Dental) in general has a discernible negative health impact on nearly tens of million world population globally and about 8 million people are at risk of the condition in the rift valley regions of Ethiopia, comparable public health actions and scientific studies have never been conducted (Fantaye et al., 2004). As a result, the global prevalence of dental and skeletal fluorosis is not entirely clear (Heifetz, 1988). This study, therefore, will be used as a base for other large-scale studies to bridge the knowledge gap in the field. The ECRV is known for its world's highest concentration of fluoride, mainly in deep wells in which little yearly rainfall appears (Mulu et al., 2009).

In Zeway Town, wells had high fluoride levels (mean: 9.4-10.5 mg/l; range: 1.1 to 68 mg/l), which go beyond the WHO drinking water guideline limit of 1.5mg (WHO, 1997). This study was initiated to investigate the severity of dental fluorosis among school children aged 12-15 years in Zeway Town, Oromia region, Ethiopia.

MATERIALS AND METHODS

A descriptive cross-sectional study was conducted to assess the public health significance of dental fluorosis among 12-15 years old school children in Zeway. The study analysed the data collected from the study participants at a specific point and depicted the public health significance of dental fluorosis, which the researcher aimed to ascertain. The public health significance of dental fluorosis among the studied population was assessed by using the community fluorosis index catalog.

Sampling

The sample size was calculated by the sample size formula for prevalence studies. With a 95% confidence interval, 10% non-response rate, and 5% margin of error, 1290 study participants were involved in this descriptive cross-sectional study.

Data Collection Instrument

In this research, a structured data collection approach was applied. Information was gathered from participants in a comparable pre-specified way. The questionnaire that incorporates the Dean`s fluorosis index and the WHO oral health assessment form was used. The questionnaire was completed by the researcher (clinician) after conducting a careful oral examination. Headlight, wooden spatula, and disposable gloves were used during the clinical oral examination. The community fluorosis index catalog formula was used to quantify the public health significance of dental fluorosis among the studied population.

Data Analysis

The Statistical Package for the Social Sciences (SPSS) Version 20.0 was used to analyze the quantitative data. Data were checked for completeness before analysis.

Ethical Clearance

The Oromia regional health authority approved the in-country clearance after investigating the research proposal. Furthermore, the Zeway Town health and educational authorities wrote permission letters to all primary schools directors to assist, facilitate and cooperate with the researcher to conduct the research.

RESULT

The main objective of this study was to describe the public health significance of dental fluorosis among 12-15 years old school children in Zeway. The findings have been organized around this objective.

Socio-Demographic Characteristics

The socio-demographic characteristics of the respondents are described according to gender, age group, and residential areas.

i. *Gender of the studied population*

Out of the total 1290 studied population, 636 (49.2%) were males while the remaining 654 (50.8%) were females. Relatively more females than males participated in the study.

ii. *Age of the studied population*

37.05% (n=478) of the total studied population were 12 years old, followed by 13- and 14-years old children with 31.9% (n=411) and 26.7% (n=345), respectively. The rest 4.3%(n=56) were 15 years old.

iii. *Residential conditions (areas) of the studied population*

Out of the total respondents, 90% (n=1161) were urban residents followed by 6% (78) and 4% (51) semi-urban and rural residents, respectively.

Findings on the research's main objective

The prime objective of this study was to describe the public health significance of dental fluorosis among school children, in Zeway. Hence, the results of the study have been organized around the objective.

i. Public health significance of dental fluorosis in the total population

The community fluorosis index of the total studied population was 2.02, which denotes 'Marked' public health significance of the condition based on the public health significance measurement criteria (Christine 2017: 638). Out of the total, the 15 years old age group scored the highest community fluorosis index of 2.37 followed by 14-, 12- and 13-years old age groups with 2.05, 1.85, and 1.83, respectively. All the above scores were ranged between 2.0 and 3.0, which indicates 'Marked' public health significance based on the public health significance measurement criteria (Christine 2017:638).

Table 1:
Public health significance of dental fluorosis in the total population

Age in years	Sex	Sample	Index	Community Fluorosis Index (CFI)	
				Community Fluorosis Index (CFI)	*Age-Specific Community Fluorosis Index (CFI)*
12	M	250	Dean/CFI	1.77	1.85
	F	214	Dean/CFI	1.92	
13	M	212	Dean/CFI	1.93	1.83
	F	211	Dean/CFI	1.72	
14	M	148	Dean/CFI	2.06	2.05
	F	198	Dean/CFI	2.04	
15	M	26	Dean/CFI	2.36	2.37
	F	31	Dean/CFI	2.37	
Total	M	636	Dean/CFI	2.01	2.02
	F	654	Dean/CFI	2.03	
Total	M+ F	1290	Dean/CFI	2.02	2.02

ii. Public health significance of dental fluorosis by residential settings

The community fluorosis index score of the rural sample was the highest with 2.76 compared to 2.26 and 1.76 of the semi-urban and urban studied populations, respectively. All the rural, semi-urban and urban studied populations fell within the community fluorosis index range of 2.0 -3.0, which meant 'Marked' public health significance. The public health significance of dental fluorosis was found to be increased with more de-urbanization settings.

a) Public health significance of dental fluorosis in the urban population

The community fluorosis index of the total urban population studied was 1.76, which denoted the 'Medium' public health significance of the condition. Out of the total urban population, 15 years old study participants have scored the highest community fluorosis index of 2.07 followed by 14-, 12- and 13-years old with 1.88, 1.76, and 1.63, respectively. All scores (except the 15 years old age group score, which was in the 'Marked' category) were in the community fluorosis index value range of 1.0 - 2.0 which indicates 'Medium' public health significance.

Table 2:
Public health significance of dental fluorosis in the urban population

Age in years	Sex	Sample	Index	Community Fluorosis Index (CFI)	
				Community Fluorosis Index (CFI)	*Age-Specific Community Fluorosis Index (CFI)*
12	M	221	Dean/CFI	1.89	1.76
	F	192	Dean/CFI	1.63	
13	M	184	Dean/CFI	1.84	1.63
	F	190	Dean/CFI	1.42	
14	M	136	Dean/CFI	1.91	1.88
	F	185	Dean/CFI	1.85	
15	M	25	Dean/CFI	2.06	2.07
	F	28	Dean/CFI	2.08	
Total	M	566	Dean/CFI	1.83	1.76
	F	595	Dean/CFI	1.69	
Total	M + F 12 -15 years	1161	Dean/CFI	1.76	1.76

b) Public health significance of dental fluorosis in the semi-urban group

The community fluorosis index of the total sample was 2.26, which denotes 'Marked' public health significance. The 13 years old age

group scored the highest community fluorosis index of 2.6 followed by 14-, 12- and 15-years old age groups with 2.4, 2.15, and 0 (zero) community fluorosis index scores, respectively. All scores (except the 15 years old age group score which was in the 'Negative' category) were in the community fluorosis index value range of 2.0 – 3.0, which means 'Marked' public health significance.

Table 3:
Public health significance of dental fluorosis in the semi-urban group

Age in years	Sex	Sample	Index	Community Fluorosis Index (CFI)	
				Community Fluorosis Index (CFI)	*Age-Specific Community Fluorosis Index (CFI)*
12	M	18	Dean/CFI	2.2	2.15
	F	13	Dean/CFI	2.1	
13	M	18	Dean/CFI	2.5	2.6
	F	12	Dean/CFI	2.7	
14	M	7	Dean/CFI	2.24	2.4
	F	6	Dean/CFI	2.5	
15	M	1	Dean/CFI	0	0
	F	3	Dean/CFI	0.17	
Total	M	44	Dean/CFI	2.44	2.26
	F	34	Dean/CFI	2.08	
Total	M + F 12 -15 years	78		2.26	2.26

c) *Public health significance of dental fluorosis in the rural population*

The community fluorosis index of the total rural studied population was 2.76, which denotes 'Marked' public health significance of the condition and the highest compared to the semi-urban and rural studied population scores. The 12 years old age group scored the highest (Very Marked) community fluorosis index of 3.12 followed by 14-, 15- and 13 with 2.05, 1.85, and 1.83, respectively. Moreover, the 12 years old age group in the rural studied population has scored the highest of all scores recorded in this study. All scores (except the 12 years old age group) were in the community fluorosis index value range of 2.0 - 3.0, which means 'Marked' public health significance.

Table 4:
Public health significance of dental fluorosis in the rural population

Age in years	Sex	Sample	Index	Community Fluorosis Index (CFI)	
				Community Fluorosis Index (CFI)	*Age-Specific Community Fluorosis Index (CFI)*
12	M	11	Dean/CFI	3.2	3.12
	F	9	Dean/CFI	3.03	
13	M	10	Dean/CFI	2.63	2.4
	F	9	Dean/CFI	2.17	
14	M	5	Dean/CFI	1.9	2.5
	F	7	Dean/CFI	3.1	
15 (No Participants)	M	15	-	-	
	F	15	-	-	
Total	M	26	Dean/CFI	2.7	2.76
	F	25	Dean/CFI	2.82	
Total	M + F 12 - 15 years	51	Dean/CFI	2.76	2.76

DISCUSSION

Fluorosis is a condition caused by excessive exposure to fluoride (Do et al., 2016). The most common source of excess fluoride ingestion is drinking water (Chandrashekar & Anuradha, 2004). Thus, fluorosis is often caused by drinking water from local supplies with high fluoride concentrations of either natural or anthropogenic origin (Fuente-Hernandez, 2011). A study has revealed that higher fluoride concentrations were correlated with a higher prevalence of more severe manifestations of the disease (Neville, 2015). The overall finding of this study might support the above argument. Nevertheless, it is essential to conduct correlational studies in the region (Hong et al., 2006). The community fluorosis index scores and interpretation in terms of public health significance of dental fluorosis for the urban, semi-urban, rural, and total studied population are discussed. The community fluorosis index of the total studied population was 2.02 which denotes the 'Marked' public health significance of the condition. Out of the total studied population, the 15 years old age group scored the highest community fluorosis index of 2.37 followed by 14-, 12- and 13 with 2.05, 1.85, and 1.83, respectively. All scores in all age groups of the total studied population were in the community fluorosis index

value range of 2.0 – 3.0 which indicates 'Marked' public health significance.

In general, the community fluorosis index score of the rural studied population was the highest with 2.76 compared to the 2.26 and 1.76 scores of semi-urban and urban samples, respectively. Except for the urban studied population with a 1.76 community fluorosis index score, which grouped in the 'Medium' public health significance category, the semi-urban and urban studied population were in the community fluorosis index range of 2.0 -3.0 that indicates 'Marked' public health significance. In other words, dental fluorosis was not equally distributed in urban, semi-urban, and rural areas. The problem increased with more de-urbanization. A cross-sectional study in Southern India to assess the prevalence of dental fluorosis among 1026 adolescents found a 2.3 community fluorosis index score in the total population which is a closely comparable finding to this study which was 2.02 community fluorosis index score (Anand-Verma et al., 2016).

In general, the oral health of the less well-off fluoridization is reported to be worse than that of the rest of the population (Mikkonen et al., 2018). The findings of a study which was conducted in the villages of Birbhum district, West Bengal, India to assess the prevalence and severity of dental fluorosis concerning fluoride in groundwater support this argument (Mondal et al., 2012). Another study which was conducted in Davangere, India has also shown an increase in dental fluorosis prevalence concerning the extent of fluoridization of drinking water (Chandrashekar & Anuradha, 2004). Furthermore, a prospective cohort study has shown the natural history and long-term impact of dental fluorosis. Accordingly, individuals exposed to drinking water with a higher concentration of fluoride have presented severe dental fluorosis in the long term (Do et al., 2016). The public health significance of dental fluorosis was reported higher amongst children and adolescents with fluoridated water supplies (Whelton et al., 2004). Similarly, a study that was conducted to assess dental fluorosis of 490 respondents using Dean's index (DI) and the tooth surface index of fluorosis (TSIF) has revealed the public significance of the condition in part of India. According to the DI, the percentage of severely affected respondents was lowest in Chalk Atla (0%) and highest in Deshnabagram (50%). The percentage of severely affected respondents was lowest in Kamdebpur and Chalk Atla (0%) and highest in Nowapara (20%) according to the TSIF score. The age group 10–20 years showed the highest percentage of severe DI (40.8%) and the age group 21–30 years showed the highest percentage of severe TSIF (22.51%) compared to the other age groups in the study. The positive relationship between the fluoride level in the water and the severity of dental fluorosis has been proved statistically. The high mean score of dental fluorosis has indicated dental fluorosis was a public problem and endemic throughout the study area (Mondal et al., 2012). Another study which aimed to assess the prevalence and severity of dental fluorosis and its relationship with fluoride levels in drinking water in India has concluded that dental fluorosis was a major dental public health problem among children in Davangere district and is related to drinking water with 0.74ppm fluoride or above (Chandrashekar & Anuradha, 2004). The findings of this cross-sectional study have also shown that dental fluorosis is a major dental public health problem in Zeway.

CONCLUSIONS

Several studies in developing countries have revealed that dental fluorosis is a public health problem. The "Marked" category of community fluorosis index in this research suggests that fluorosis is a major public health problem in the study area. The public health significance of dental fluorosis varies among urban, semi-urban, and rural residential settings. Moreover, the public health significance of dental fluorosis increased with increasing distance away from the city center. Therefore, besides the general intervention, more attention needs to be given to the semi-urban and rural settlements. In general, these public health measures should be considered: defluorination 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.

Acknowledgment: I would like to express my deepest appreciation to Professor Gloria Thupayagale-Tshweneagae for her valuable recommendations and encouragement during the making of this project. I would like also to acknowledge the very kind cooperation of health and educational bureau officers, the primary schools' directors, teachers, parents of the study participants, and students of Zeway Town.

Ethical Approval: The Oromia regional health authority approved the in-country clearance after investigating the research proposal. Furthermore, the Zeway Town health and educational authorities wrote permission letters to all primary schools directors to assist, facilitate and cooperate with the researcher to conduct the research.

Conflicts of Interest: The authors declare no conflict of interest.

ORCID iDs: Nil identified

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