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Dental fluorosis among 15- year- old school children in an endemic district in Sri Lanka

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Aim: To determine the prevalence, severity, and intraoral distribution of dental fluorosis among 15-year-old school children in Kurunegala district of the North-Western Province, Sri Lanka. ***Method***: A cross-sectional study was conducted among 15-year-old school children residing in Kurunegala district since birth. One thousand and forty participants from 42 schools were selected using two stage cluster sampling method. A single calibrated dentist examined all participants for dental fluorosis using Thylstrup and Ferjeskov index. Water samples from the drinking water source of participants were analyzed for their fluoride content. ***Results***: The prevalence of dental fluorosis was 52% and 42% when TF score > 0 and TF score >1 were considered as cut-offs for dental fluorosis respectively. Of those with dental fluorosis, a majority (20.9%) had a TF score of 2. Only 0.5% had a TF score of 6 which was the highest score observed for any participant. With regards to the intra-oral distribution of dental fluorosis, the premolars were the most affected teeth and the least affected were the central incisors. The fluoride levels in the drinking water source ranged between 0.0-1.9 mg/L and the prevalence of dental fluorosis increased with the increase in the fluoride level in drinking water source. ***Conclusions***: The prevalence of dental fluorosis was high and it increased with the increase in the fluoride content in the drinking water source.

Keywords: *prevalence, severity, endemic, Dental fluorosis*

Introduction

Dental fluorosis is an enamel defect that results from excessive intake of fluoride during the developmental stages of teeth. Excessive intake of fluoride could affect the transition and maturation stages of tooth formation, giving rise to hypo-mineralized enamel (Aoba and Fejerskov, 2002). Dental fluorosis could present clinically as minor white striations to more extensive opacities with or without pitting of the enamel (Thylstrup and Fejerskov, 1978). The condition is endemic to parts of the world, where drinking water sources have high levels of naturally occurring fluoride. Moreover, it is an emerging health problem in many countries due to the intake of fluoride from sources other than water, such as the use of supplements and inadvertent swallowing of toothpaste by young children (Celeste *et al*., 2016).

Several studies have assessed the prevalence of dental fluorosis in endemic areas. A recent systematic review and meta-analysis on the fluoride concentration in ground water and prevalence of dental fluorosis in the Ethiopian Rift Valley found that the overall prevalence of dental fluorosis among 7-50-year-olds was 28% (Demelash *et al*., 2019). Shyam et al. (2020) reported that the prevalence of dental fluorosis among 11-14-year-old school children in endemic fluoride areas of Haryana, India was as high as 97%. Dental fluorosis is also endemic to certain areas of Sri Lanka. A study among 14-year-old school children found the prevalence of dental fluorosis in endemic and non-endemic areas to be 51-78% and 5.4% respectively (Warnakulasuriya *et al*., 1990). van der Hoek et al. (2003) found that 43% of 14-year-old school children residing in a rural area of Southern Sri Lanka had dental fluorosis.

The above studies have been either confined to a small geographical area of Sri Lanka or conducted nearly 30 years ago, when marketing and access to fluoridated toothpaste were limited. Assessing changing patterns of disease over time is an important role of epidemiology and therefore, it is timely to conduct a comprehensive study of dental fluorosis to give an insight to the current status of dental fluorosis in Sri Lanka but also whether the patterns related to this condition have changed over the years. The aim of this study was to determine the prevalence, severity and intra-oral distribution of dental fluorosis among 15-year-old school children in Kurunegala district, an endemic district for dental fluorosis in Sri Lanka.

Methods

The data were obtained from a broader study on dental fluorosis among 15-year-old school children in Kurunegala district, Sri Lanka. Ethical clearance for that study was obtained from the Ethics Review Committee, Faculty of Medicine, University of Colombo (Ref no: EC-17-016). Permission to conduct the study was obtained from the Provincial Director of Education of the North-Western Province, the relevant zonal directors of education and school principals. Written informed consent was obtained from parents of the participants while written assent was obtained from participants.

The participants of this cross-sectional study were Grade 10 students attending government schools in Kurunegala district in the North-Western Province. Only permanent residents residing in the area since birth were included. Those with learning difficulties, wearing fixed orthodontic appliances and those who were absent on the day of the oral examination were excluded.

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The formula for estimating a population proportion with absolute precision was used to calculate the sample size (Lwanga and Lemeshow, 1991). Using the prevalence of dental fluorosis (78%) estimated through a pilot study at a 95% confidence interval and accepting a sampling error of 5%, a minimum sample of 264 was required. As it was decided to use the cluster sampling method to select the sample, it was necessary to consider the design effect. Making allowance for a 2.9% design effect and a non-response rate of 10%, the sample required was 842.

A two-stage cluster sampling method with probability proportionate to size technique was used. According to the information obtained from educational authorities, students who had completed their 15th but not their 16th year were in the Grade 10 class. Therefore, the Grade 10 class was considered as the cluster. Considering the average number of students in a class as the cluster size (20), the number of clusters required was 42 (842/20=42). To obtain a representative sample, 42 clusters were selected from a total of 577 government schools with a grade 10 class in Kurunegala district according to probability proportionate to size technique in the first stage. In the second stage, students were selected from a chosen cluster. In the case of schools with several grade 10 classes, one class was selected randomly. If there were more than 20 students in a class, then all students who satisfied the inclusion criteria were selected. If the number of students in a school with a single grade 10 class was <20, then the school closest to that school in the same area was considered. All students from a selected grade 10 class were recruited as it was not ethical to exclude some from the class. Accordingly, the size of the final sample was 1040, even though the calculated sample size was 842.

Dental fluorosis was recorded using the Thylstrup and Fejerskov Index (TF Index) (Thylstrup and Fejerskov, 1978) on buccal, lingual and occlusal surfaces of all teeth present in the mouth. Of the three scores given to a tooth, the highest score was considered as the score for that tooth. TF Index assesses dental fluorosis objectively on an ordinal scale from 0 to 9. TF scores 1 and 2 indicate smooth surfaces with white opaque lines, 3 indicates a smooth surface with cloudy areas. TF score 4 is given when the entire surface is affected with opacities. TF scores of 5 to 9 indicate varying degrees of pitted enamel surfaces. To differentiate fluorotic from non-fluorotic defects the commonly accepted criterion was considered; whether the distribution of the defect was asymmetrical or non-discrete symmetrical and if it was the latter it was considered to be due to fluorosis (Cuttress and Suckling, 1990).

The first author (calibrated against a specialist in Restorative Dentistry) conducted the oral examination in the school premises under natural light while the participant was seated on a mobile dental chair. The teeth were wiped with sterile gauze before recording dental fluorosis. A trained assistant recorded the data. To determine intra-examiner variability, 5% of the participants examined on a given day were reexamined. The Kappa statistic was 0.91.

The day before the intended visit to a school, the first author contacted the principal to request him/her to instruct the students to bring a sample of water from their usual drinking water source. On the day of the visit, 25ml from each sample was dispensed to a clean polyethylene bottle and sent to the National Water Supply and Drainage Board Regional Laboratory, Kurunegala, for fluoride analysis. Fluoride content in the water was measured using spectrophotometry.

After the oral examination, a short questionnaire was administered to the participants to obtain socio-demographic information.

SPSS software version 20.0 (SPSS Inc., Chicago, USA) was used for data analysis. The highest TF score recorded for a tooth was considered as the TF score for the participant. The association between fluoride levels in drinking water and the prevalence of dental fluorosis was determined using chi square test for trends.

Results

A total of 1040 students participated, of whom 51 had to be excluded for not providing drinking water samples or inability to give reliable information about their place of residence since birth. Accordingly, the final sample size was 989 with a response rate of 95.1%. Of the total sample, 45.2% were males.

The overall prevalence of dental fluorosis (TF score > 0) was 52 % and when a TF score of > 1 was considered as the cut-off, it was 42% (Table 1). Table 2 summarises the severity of dental fluorosis. Most (21%) had a TF score of 2 indicating pronounced opacities and only 0.5% of the sample had a TF score of 6 (regular pits < 2mm) which was the highest score recorded.

The upper first and second premolars were the most affected teeth and the upper central incisors the least affected (Figure 1).

The prevalence of dental fluorosis (TF>0) increased with the increase in the fluoride level in drinking water and the trend was statistically significant (Table 3).

Discussion

The prevalence of dental fluorosis in the sample was 52% and 42% when cut-off scores of TF score >0 and >1 were used as the diagnostic threshold. The prevalence of dental fluorosis in this study is lower than reported in Sri

Table 1. Prevalence of dental fluorosis (n=989).

TF score	*%*
TF score > 0	51.7
TF score > 1	41.5
TF score > 2	20.5

Table 2. Severity of dental fluorosis according to highest TF score recorded (n=989).

Highest TF score recorded	*%*
TF0 Normal	48.3
TF1 Narrow white lines	10.2
TF2 Pronounced opacity	20.9
TF3 Cloudy areas of opacity	11.8
TF4 Entire surface of opacity	5.9
TF5 Pits <2mm	2.3
TF6 Regular pits <2mm	0.5

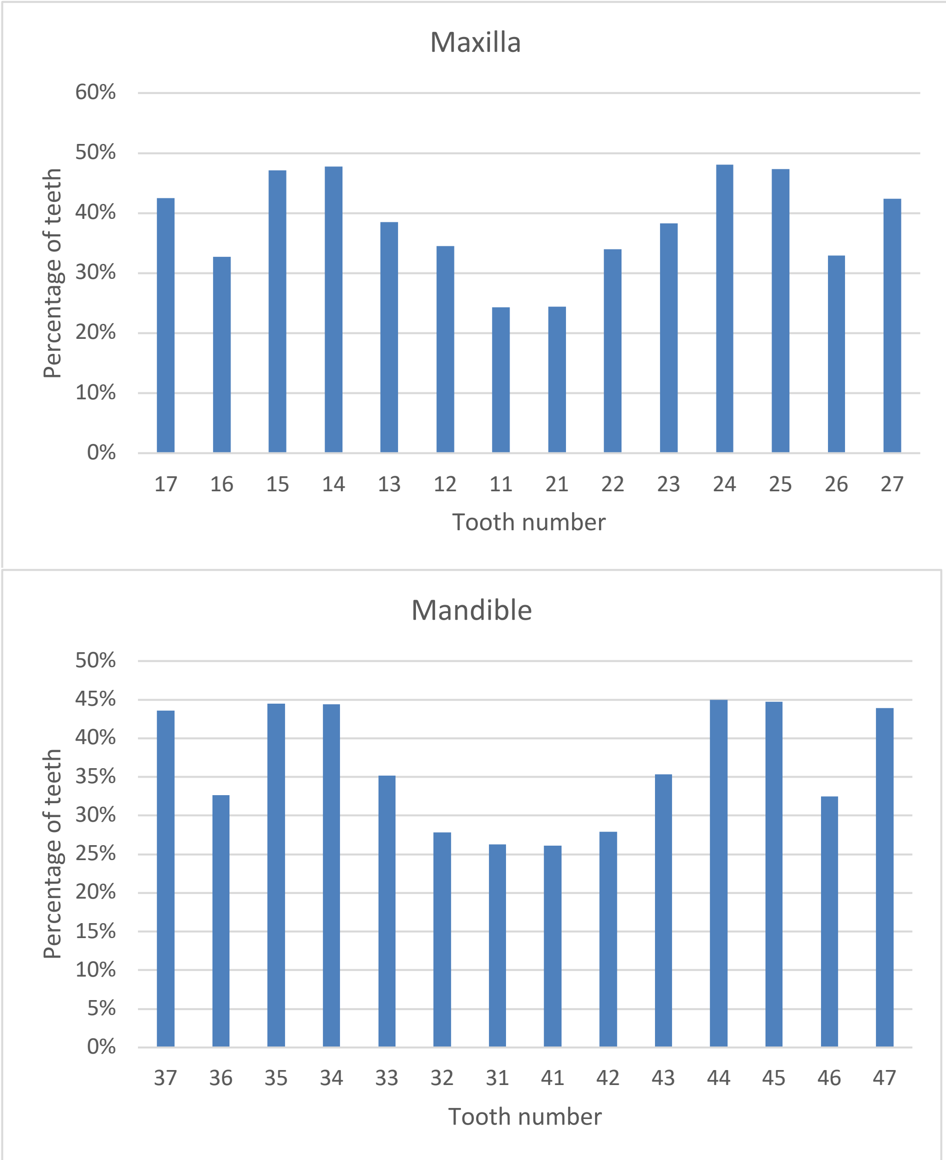

Figure 1. Prevalence of dental fluorosis by tooth type. TF>0.

Table 3. Association between fluoride level in drinking water and prevalence of dental fluorosis (TF score>0).

Water fluoride mg/L	*% with Fluorosis*	*p (Chi sq for trend)*
< 0.3 (n= 639)	42.3	<0.001
0.31-0.6 (n=199)	62.8	
0.61- 0.9 (n=97)	70.1	
> 0.9 (n=54)	88.9	

Lanka previously. A study in a small village in Kurunegala district described the prevalence among 15-year-olds at 80% (Perera *et al*., 2013). Although that village is in the same district where the present study was conducted, the fluoride concentration in drinking water sources of participants of that study was much higher (0.62- 2.16 ppm) than for participants in this study (0.0 -1.9 ppm**)**. Further, as the participants in this study were selected from the entire district of Kurunegala, which included non-endemic areas for dental fluorosis, the overall prevalence in this study should be expected to be lower than in areas considered to be endemic to dental fluorosis. In a more recent study, 73% of school children residing in three villages in Northern Sri Lanka had clinical evidence of dental fluorosis (Rajapakse *et al.,* 2017).

Most children affected by fluorosis had very mild to mild signs (32% TF score 2 and 3), with severe signs present in less than 5% of the participants. These findings are compatible with previous studies in Sri Lanka (Perera *et al*., 2013; Rajapakse *et al*., 2017). However, in Haryana, India, most children had moderate signs (26% TF score 4), with severe signs present in 4% (Shyam *et al*., 2020).

The intra-oral distribution of dental fluorosis appears to differ between studies. Here, maxillary first premolars were the most affected, followed by the maxillary second premolars and the least affected were the maxillary central incisors followed by the first molars. A slightly different pattern was observed in Sri Lanka where the maxillary first premolars were the most affected tooth by diffused opacities, followed by the maxillary canines and the least affected teeth were the mandibular first molars (Ekanayake and van der Hoek, 2003). Diffused opacities are caused by dental fluorosis. It is not possible to give a definite reason for the difference between that study and the present, but one reason could be the difference in the number of teeth examined in the two studies. As only 10 teeth were examined in that study, the distribution of dental fluorosis may have been masked. On the other hand, an Indian study has reported two different patterns in the distribution of dental fluorosis in the permanent teeth. In areas with low to moderate levels of fluoride in drinking water second molars were the most affected followed by premolars, canines and the least affected were the incisors and first molars while in high fluoride areas the prevalence increased from anterior to posterior teeth with second molars being mostly affected (Sudhir *et al*., 2012). The intra-oral distribution of dental fluorosis in permanent teeth depends on several factors such as the age at commencement of fluoride intake, duration, and completion of enamel formation as well as tooth eruption age (Bhagavatula *et al*., 2016).

According to Kumar *et al*. (2000) the higher occurrence of dental fluorosis in posterior teeth is not related to the long pre-eruptive period of these teeth. They argued that if dental fluorosis is related to the duration of the pre-eruptive stage of a tooth, then the prevalence of dental fluorosis in central incisors and first molar teeth should be the same. As such a finding could not be observed in their study their view was that teeth with longer maturation periods and thicker enamel are more susceptible to adverse effects of fluoride than those with shorter periods of maturation and thinner enamel.

A positive linear trend was observed between the level of fluoride in drinking water and the prevalence of fluorosis. Even in concentrations as low as <0.3mg/L the prevalence was high. This concurs with previous data from Sri Lanka (van der Hook *et al*., 2003) and several other countries (Wang *et al*., 2012; Sebastian *et al*., 2016). Fejerskov et al. (1990) described a linear relationship (r^2 =0.87) between fluoride dose and dental fluorosis and due to this relationship even at very low levels of fluoride intake from water, a certain level of dental fluorosis can be observed.

The present study was strengthened by the fact that it was the first study to have used the TF index to assess dental fluorosis in Sri Lanka. As the TF index correlates with the macroscopic appearance and histological aspects of dental fluorosis, use of this index gave a real picture of the severity of the condition (Thylstrup and Fejerskov, 1978). Further unlike previous studies, which were confined to one or two endemic villages, we sampled across a wide geographical area of Sri Lanka. A non-discrete symmetrical defect was considered as a criterion to differentiate a fluorotic defect from a non-fluorotic defect of enamel. However, non-discrete symmetrical defects could arise from other sources such as metabolic, physiological, other trace elements, and malnutrition (Sabokseir *et al*., 2016). Therefore, there is a possibility that the prevalence rates may have been slightly overestimated. This is a limitation of this study.

Conclusions

In conclusion, the prevalence of dental fluorosis was high in this endemic district of Sri Lanka. Therefore, it is important that policy makers implement public health programmes such as installation of water treatment plants to remove excess fluoride from drinking water sources in this area.

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