Impact of dental fluorosis on the oral health related quality of life of adolescents in an endemic area

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ABSTRACT

Introduction: Oral diseases and conditions affect the physical, social, and psychological well-being of an individual. The aim of this study was to determine the association between the severity of dental fluorosis and oral health related quality of life (OHRQoL) among 15-year-old school children residing in an endemic area for dental fluorosis in Sri Lanka.

Design: A cross-sectional study was conducted among 989, 15-year-old school children who were lifetime residents of Kurunegala district. A validated Sinhala version of the Child Perception Questionnaire (CPQ 11–14) was used to assess OHRQoL. Dental fluorosis was assessed using the Thylstrup and Ferjeskov index (TF index) while dental caries and malocclusion were assessed using the WHO Basic Methods and Dental Aesthetics Index (DAI) respectively. In addition, information pertaining to parental level of education, type of toothpaste used, frequency of toothbrushing and use of dental services was also gathered.

Results: The prevalence of dental fluorosis was 52%. The overall prevalence of impacts based on the CPQ was 38.2%. The severity of dental fluorosis was not significantly associated with the overall prevalence of impacts. However, the severity of dental fluorosis was significantly associated with three oral impacts namely "having pain in teeth, lips, jaws, or mouth", "felt irritable or frustrated" and "other children teased or called names". According to the multiple logistic regression analysis, use of dental services and moderate to severe malocclusion were significantly associated with poor OHRQoL but not dental fluorosis.

Conclusion: The severity of dental fluorosis was not associated with OHRQoL of the participants.

1. Introduction

Oral health related quality of life (OHRQoL) is an integral part of the general health and well-being of an individual. It is a multidimensional construct that includes subjective evaluation of oral health, functional and emotional well-being, and satisfaction with respect to oral health.[1] It is now considered an important component in the assessment of oral health and outcomes of oral health care. The concept of OHRQoL was developed in response to the growing body of evidence related to the functional, psycho-social, and economic consequences of oral diseases and conditions.[2] Several generic and disease-specific instruments have been developed to assess oral health related quality of life in children

and adolescents. They include the Child Oral Impacts of Daily Performance Index (OIDP), Child Oral Health Impact Profile [COHIP], Early Childhood Oral Health Impact Scale [ECOHIS], Pediatric Oral Health-related Quality of Life, Scale of Oral Health Outcomes and the Child perception questionnaire (CPQ).[3] However, the CPQ developed by Jokovic and co-workers[4] is the most widely tested and validated instrument to measure OHRQoL in children and adolescents.[5] Further, it is considered to be the most appropriate instrument to measure OHRQoL in adolescents due to its validity, reliability, responsiveness, interpretability, less burden, alternative modes of administration and linguistic adaptation.[6]

Dental fluorosis results from an excessive intake of fluoride during

Table 1
Prevalence of oral impacts according to severity of dental fluorosis.

Severity of dental fluorosis	Total impacts		Oral symptoms		Functional limitations		Emotional well-being affected		Social well-being affected	
	N	%	N	%	N	%	N	%	N	%
No (474)	186	39.2	126	26.6	59	12.4	64	13.5	38	8.0
Mild (99)	43	43.4	28	28.3	15	15.2	15	15.2	10	10.1
Moderate (320)	110	34.4	73	22.2	37	14.0	33	10.3	14	4.4
Severe (86)	35	40.7	23	26.7	12	12.6	11	12.8	9	10.5
Total sample (979)	374	38.2	250	25.5	123	12.6	123	12.6	71	7.3
p value	0.432		0.431		0.98		0.31		0.40	

p values are based on chi-square for trend.
TF = 0 no fluorosis, TF = 1 mild, TF = 2,3 moderate, TF $\geq$ 4- severe.
Prevalence of oral impacts was determined by the percentage of participants who had experienced at least one impact item often (score 4) or everyday/almost every day (score 5).

the developmental stages of teeth and is prevalent in areas where the drinking water contains high levels of fluoride.[7] The severity of dental fluorosis depends on the dose, time of exposure and duration of exposure to fluoride.[8] The clinical presentation of fluorosis varies according to the degree of its severity. It could range from the appearance of horizontal white lines running across the surface of the tooth to chalky white spots and in some cases the entire tooth surface may appear chalky white with loss of enamel translucency. Pitting of the tooth surface with yellow to brown staining could be observed in moderate to severe cases.[9] As such a clinical picture could lead to poor dental appearance, dental fluorosis may affect OHRQoL of individuals. However, the evidence related to the effects of dental fluorosis on OHRQoL is not consistent. According to some studies dental fluorosis negatively impacts OHRQoL[10,11] while such an association has not been reported in others.[12]

Dental fluorosis is endemic to certain parts of Sri Lanka and the prevalence of this condition ranges from 20% −70% in different endemic regions.[13,14] However, to the best of knowledge the impact of dental fluorosis on OHRQoL is yet to be assessed in Sri Lanka. Further as dental fluorosis affects aesthetics and there are cultural differences in the perception of dental aesthetics,[15] it is important to assess the impact of dental fluorosis on OHRQoL in different cultures. Considering the above, the objective of this study was to assess the association between the severity of dental fluorosis and OHRQoL among 15-year-old school children who were lifetime residents in Kurunegala district, a district endemic to dental fluorosis in Sri Lanka.

2. Methods

The data for this paper were obtained from a broader cross-sectional study that assessed the prevalence of dental fluorosis in Kurunegala district, an endemic area for dental fluorosis in the North-Western province of Sri Lanka. Ethical clearance for the study was obtained from the Ethics Review Committee, Faculty of Medicine, University of Colombo (Ref-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 assent was obtained from the participants and written consent was obtained from their parents. The participants were Grade 10 students attending government schools in Kurunegala district who were lifetime residents of the district. Those with learning difficulties as identified by the class teacher were excluded as it was perceived that they may not be able to answer a self-administered questionnaire. Further students wearing fixed orthodontic appliances were excluded as it was difficult to identify fluorotic spots in the presence of fixed appliances. Students absent from school on the day of the oral examination were also not included.

A cross-sectional analytical study design was used to assess the association between dental fluorosis and OHRQoL. The formula for hypothesis testing for two sample means was used to calculate the sample size.[16] Using the mean and standard deviation of total CPQ scores of those with (28.28 ± 8.23) and without dental fluorosis (26.06 ± 5.65) obtained from a pilot study, at a significance level of 95% and power of 90%, a minimum of 213 participants were required per group. This was increased by 10% to compensate for non-responses, giving a total of 235. As there were two groups (with dental fluorosis and without dental fluorosis), the total sample required was 470. However, as this study was part of a broader study the sample of the parent study was adopted for this part of the study as well.

The sampling technique used in the parent study was applicable to this study and therefore, the same sampling technique used in the parent study was considered to select the sample for this part of the study as well. A two-stage cluster sampling method with probability proportionate to size technique was used to select the participants. The Grade 10 class was considered as the cluster and the average number of students in a grade 10 class (n = 20) was considered as the cluster size. Therefore, based on the calculated sample of 842 for the parent study, a total of 42 clusters (842/20 = 42) were required. In the first stage, the clusters were selected from 577 government schools with a grade 10 class according to probability proportionate to size technique while students were selected from a chosen cluster during the second stage. All students from a selected grade 10 class cluster, were recruited as it was considered unethical to exclude some students from the class. As a result, the final sample was 989 students. A detailed description of sample selection is given elsewhere.[17]

Data related to OHRQoL were collected by means of a validated, pretested self-administered Sinhala version of the Child Perception Questionnaire.[18] The CPQ: ISF -16 includes a total of 16 items in 4 domains: 4 items each on oral symptoms, functional limitations, emotional well-being, and social wellbeing. The response to each item is recorded on a 5-point Likert scale; 1 = never, 2 = once or twice, 3 = sometimes, 4 = often and 5 = every day or almost every day over the past 3 months. The total score ranges from 16 to 80. The higher the CPQ total score poorer the oral health related quality of life.

The oral examination included the assessment of dental fluorosis, dental caries, and malocclusion. Dental fluorosis was assessed using Thylstrup and Fejerskov Index (TF Index).[9] Fluorotic lesions were differentiated from non-fluorotic defects using the commonly accepted criterion; whether the distribution of the defect was asymmetrical or non-discrete symmetrical and if it was the latter, such defects were considered to be fluorotic defects.[19] Prior to recording dental fluorosis status, the teeth were wiped with a piece of sterile gauze. Dental caries were assessed using the WHO Basic Methods[20] and recorded at the level of the dentine. Dental Aesthetics Index (DAI) was used to assess malocclusion status.[21]

Prior to the main study, the first author was calibrated against a specialist in Restorative Dentistry to record dental fluorosis, dental caries and an orthodontist to record the DAI. Inter-rater reliability when assessed using Kappa statistics were 0.71,1.00 and 0.77 for dental

Table 2
Severity of impacts (item, domain, and total scores of CPQ 11–14) according to severity of dental fluorosis.

Domains of CPQ with items	Dental fluorosis				
	No (n = 474)	Mild (n = 99)	Moderate (n = 320)	Severe (n = 86)	p value
	Median (IQR)				
Oral symptoms	9(7–11)	9(7–11)	8(7–10)	8(7–11)	0.156
pain in teeth, lips, jaws or mouth	2(1–3)	2(1–3)	2(1–3)	2(1–3)	0.002*
sores in mouth	2(1–3)	2(1–3)	2(1–3)	3(2–3)	0.437
bad breath	2(1–3)	2(1–3)	2(1–3)	3(1–3)	0.974
food stuck in or between teeth	3(2–3)	3(3–3)	3(2–3)	3(2–3)	0.672
Functional limitations	6(4–8)	6(4–8)	6(4–8)	6(4–8)	0.493
taken longer than others to eat meals	1(1–2)	1(1–3)	1(1–2)	1(1–2)	0.210
difficulty to bite or chew	1(1–1)	1(1–1)	1(1–2)	1(1–2)	0.157
found difficulty to say words	1(1–1)	1(1–2)	1(1–2)	1(1–2)	0.236
found difficulty to eat or drink hot or cold foods	2(1–3)	2(1–3)	1(1–3)	2(1–3)	0.692
Emotional wellbeing	5(4–7)	6(4–8)	6(4–8)	6(4–8)	0.06
felt irritable or frustrated	1(1–1)	1(1–2)	1(1–1)	1(1–3)	>0.001*
felt shy	1(1–1)	1(1–2)	1(1–1)	1(1–1)	0.059
been upset	1(1–2)	1(1–2)	1(1–2)	1(1–2.25)	0.243
been concerned what other people think about your teeth, lips, mouth, or jaws	1(1–3)	2(1–3)	1(1–3)	1(1–3)	0.967
Social wellbeing	4(4–6)	5(4–7)	4(4–6)	4(4–6)	0.384
avoided smiling or laughing when around other children	1(1–1)	1(1–2)	1(1–1)	1(1–1)	0.204
argued with other children or family	1(1–1)	1(1–1)	1(1–1)	1(1–1)	0.423
other children teased or called names	1(1–1)	1(1–1)	1(1–1)	1(1–1)	0.020*
other children asked questions about your teeth, lips, jaws, or mouth	1(1–2)	1(1–2)	1(1–2)	1(1–2)	0.866
Total CPQ score	25 (21–31)	27 (22–34)	25(21–30)	26.5 (21.7–32.2)	0.363

p value based on Jonkheere- Terpstra trend test.

fluorosis, dental caries, and malocclusions respectively. Oral examinations were carried out by the first author under day light while the participant was seated on a mobile dental chair. An assistant recorded the data. Data collection took place either in the Science or Home Science laboratory of the school. Following the oral examination, the first author administered the CPQ questionnaire to the students and gave them instructions on how to respond to it. She was available for students to clarify their doubts.

To assess intra-rater reliability, one student from each school was reexamined by the first author and Kappa statistics recorded for dental fluorosis, DAI, and dental caries were 0.91, 0.82 and 0.95 respectively.

SPSS software for windows version 20.0 (SPSS Inc., Chicago, USA) was used for data analysis. The prevalence of oral impacts was determined by the percentage of participants who had experienced at least one impact item often (score 4) or everyday/almost every day (score 5). Chi square test for trends was used to assess the association between the ordered categories of dental fluorosis and prevalence of oral impacts. The overall CPQ score was calculated by summing scores for responses for all items of the CPQ while the score for each domain (oral symptoms, functional limitations, emotional wellbeing, and social wellbeing) was calculated by summing scores for responses of all items of that domain. As the CPQ scores were not normally distributed, Jonckheere-Terpstra test, a non-parametric test, was used to assess the differences in CPQ scores across the ordered categories of dental fluorosis. Binary logistic regression analysis was used to determine the associations between independent variables and the dependent variable OHRQoL. The independent variables considered were sex, education level of parent based on the highest education attainment of either parent, use of fluoride/non fluoride toothpaste, toothbrushing frequency categorized as $\leq$ once/day, $\geq$ twice/day, whether used/not used dental services and malocclusion status categorized as no (DAI $\leq$25), mild (DAI 25–30) and moderate to severe (DAI >30) malocclusion. Dental caries experience measured in terms of the DMFS index was included as a continuous variable in the model. Dental fluorosis was categorized as no fluorosis (TF = 0), mild (TF = 1), moderate (TF = 2,3) and severe (TF $\geq$ 4). The dependent variable was dichotomized as poor OHRQoL (1) if a score of 4 or 5 was recorded for at least one item of the CPQ 11–14 and good OHRQoL (0) if the score of 4 or 5 was not recorded for any item of the CPQ11-14. All independent variables considered were included in the adjusted model even if they were not associated with the dependent variable at p < 0.05 in the unadjusted analysis to control for confounding.

3. Results

The sample consisted of 989, Fifteen-year-old students and ten participants had to be excluded as they had not responded to at least one item of the 16 item CPQ questionnaire. Fifty five percent of the sample consisted of females. The prevalence of dental fluorosis was 52% and 10%, 33% and 9% were affected by mild, moderate, and severe dental fluorosis respectively.

Table 1 shows the prevalence of oral impacts according to the severity of dental fluorosis where the prevalence was determined by the percentage of participants who had experienced at least one impact item often (score 4) or everyday/almost every day (score 5). The overall prevalence of oral impacts in the sample was 38% while 37% of participants who were affected with dental fluorosis had experienced an oral impact. Further oral impacts were experienced by 43%, 34% and 41% with mild, moderate, and severe dental fluorosis respectively. In all fluorosis groups, the highest prevalence of impacts was associated with the domain of oral symptoms. Neither the overall prevalence of impacts nor the prevalence of impacts in the different domains of the CPQ was associated with the severity of dental fluorosis.

Item, domain, and total scores of CPQ 11–14 (median and interquartile range) according to the severity of dental fluorosis is shown in Table 2. Although the total CPQ score was highest in those with severe dental fluorosis, there was no significant difference between the severity of dental fluorosis and total CPQ scores. There were significant associations between the severity of dental fluorosis and three impact items namely 'pain in teeth, lips, jaws, or mouth', 'felt irritable or frustrated' and 'other children teased or called names'.

Table 3 shows the variables associated with poor OHRQoL. Unadjusted logistic regression analyses show that the use of dental services

Table 3

Factors associated with poor OHRQoL based on binary logistic regression analysis.

Variable	Unadjusted model			p value	Adjusted model			p value
	OR	95% CI			OR	95% CI		
Sex								
Female	1				1			
Male	1.09	0.841	1.412	0.516	1.045	0.789	1.384	0.757
Education level of parent								
Up to 5 years	1				1			
6–10 years	1.804	0.853	3.817	0.123	1.842	0.827	4.106	0.135
11–13 years	1.3	0.606	2.788	0.5	1.274	0.562	2.887	0.562
>13 years	1.625	0.554	4.762	0.376	1.656	0.533	5.149	0.383
Type of toothpaste used								
Without fluoride	1				1			
With fluoride	0.896	0.654	1.229	0.497	1.036	0.739	1.453	0.837
Frequency of toothbrushing								
≤Once	1				1			
≥Twice	0.839	0.624	1.129	0.246	0.892	0.65	1.224	0.479
Use of dental services								
No	1				1			
Yes	2.016	1.445	2.812	<0.001*	2.049	1.425	2.947	<0.001*
DMFS score	1.038	0.981	1.098	0.199	1.068	0.993	1.149	0.076
Malocclusion status								
No malocclusion	1				1			
Mild malocclusion	1.041	0.745	1.455	0.813	1.029	0.718	1.474	0.878
Moderate to severe malocclusion	1.581	1.111	2.25	0.011*	1.506	1.035	2.191	0.032*
Severity of dental fluorosis								
No	1				1			
Mild	1.189	0.767	1.843	0.439	1.095	0.684	1.754	0.704
Moderate	0.811	0.604	1.09	0.165	0.855	0.622	1.176	0.336
Severe	1.063	0.665	1.697	0.799	1.044	0.615	1.774	0.873

OHRQoL dichotomized as good = 0 if score 4 or 5 was not recorded for any item of the CPQ whilst.

poor = 1 if score 4 or 5 was recorded for at least one item of the CPQ.

95% CI, 95% confidence interval: OR Odds Ratio.

and moderate to severe malocclusion were significantly associated with poor OHRQoL. Both these variables were independently associated with poor OHRQoL when adjusted for other variables in the logistic regression analysis. However, the severity of dental fluorosis and dental caries were not associated with poor OHRQoL in the adjusted model.

4. Discussion

Although the effects of oral conditions such as dental caries and periodontal status on OHRQoL of Sri Lankan adolescents have been assessed previously,[22] the present study was the first to have assessed the impact of dental fluorosis on OHRQoL in adolescents. The prevalence of dental fluorosis was 52% and of those, 37% had experienced an oral impact. On the other hand, Peres et al.[23] found that only 15% of 12-year-old Brazilian adolescents were affected by dental fluorosis but the prevalence of oral impacts when assessed using the Oral Impacts on Daily Performance scale was 52%.

Further, according to the findings of the unadjusted model the severity of dental fluorosis was not associated with the prevalence of oral impacts and when the independent association between the severity of dental fluorosis and OHRQoL was determined controlling for confounders in the adjusted model, a similar result was observed. These findings are consistent with previous studies. Onoriobe and colleagues[12] in their study on 11-12-years old American school children found that there was no association between the severity of dental fluorosis in anterior teeth and OHRQoL when 5 different instruments were used to measure OHRQoL whilst Do et al.[24] found that the severity of dental fluorosis had no impact on poor perceptions of oral health. Further presence of dental fluorosis did not have an impact on OHRQoL in Indian school going adolescents.[25] On the other hand, some studies have shown that only severe dental fluorosis (TF > 4) had a negative impact of OHRQoL.[10,11] Chankanka et al.[26] in their review on aesthetic perceptions of dental fluorosis and relationships with oral health-related quality of life have concluded that mild dental fluorosis has no effect

on OHRQoL. Further a study based on photographs have found that children from fluoridated communities did not find mild fluorosis (TF score 1) to be aesthetically objectionable.[27] In contrast to the conclusions of the above two studies mild dental fluorosis (TF scores 1 and 2) had a positive impact on the OHRQoL of 11–14-year-old Australian children and their parents.[24] Peres et al.[23] too found that mild dental fluorosis was associated lower oral impact scores indicating better OHRQoL. There are several plausible explanations for the differences between studies. First, some domains of generic measures of OHRQoL may not be appropriate to measure impacts associated with dental fluorosis particularly if the condition is mild. Second, the prevalence and severity of dental fluorosis vary in different populations, and it may therefore affect the clinical presentation of the condition. Also, there are ethnic, social, cultural differences regarding perceptions of aesthetics. In fact, a study conducted to determine aesthetic perceptions of dental fluorosis among 15- year-old Mexican adolescents has shown that adolescents from medium socio-economic groups were more concerned about the colour and appearance of their fluorosed teeth than those from low socio-economic groups.[28]

There were no significant differences between the severity of dental fluorosis and total CPQ and domain CPQ scores and these findings are consistent with those of Shyam et al.[25] In contrast, according to some studies the total CPQ and domain CPQ scores differed according to the severity of dental fluorosis.[24] The highest CPQ score was reported in relation to the oral symptoms domain and is in agreement with a previous study.[24] However, according to other studies, the highest CPQ score has been reported in relation to the social well-being domain.[11,12] In the present study, there was a significant difference between the severity of dental fluorosis and CPQ scores related to the item 'pain in teeth, lips, jaws, or mouth'. Dental caries is an important cause for oral pain.[29] It was apparent that both the prevalence and severity of dental caries were significantly associated with the prevalence of oral impacts in the sample. However, the table related to these data are included as a supplementary table as they are not directly related to the objectives of

the study. Therefore, it is plausible that this finding is due to the significant differences in dental caries in the different dental fluorosis groups rather than due to dental fluorosis per se. Further the severity of dental fluorosis was associated with two other impacts namely "felt irritable/frustrated" and "other children teased". Adolescents with a TF score of 2 or more have concerns about their tooth color, smile and appearance.[28] It is possible that having such concerns made them feel irritable. Further due to the abnormal appearance of fluorosis teeth, there is a possibility that those with dental fluorosis may have been teased by their peers. In fact Al-Bitar and colleagues in their study on Jordanian adolescents found that many children were bullied because of their dental or facial appearance.[30]

As the association between dental fluorosis and OHRQoL could be confounded by other oral conditions particularly severity of dental caries and malocclusion, these two conditions were considered as explanatory variables in the multiple logistic regression analysis and moderate/severe malocclusion emerged as a predictor of poor OHRQoL. A study conducted among 8–13-year-old Australian children also found that severity of dental fluorosis was not associated with poor perception of oral health, but severe malocclusion had an effect.[24] This study was strengthened by the fact that it was the first to have made a comprehensive assessment of the impact of dental fluorosis on OHRQoL in Sri Lankan adolescents. However, there are few limitations to the study. As the CPQ instrument is based on the past experiences of impacts recall bias could influence the findings. Further, the diagnostic criterion for dental fluorosis was considered as a non-discrete symmetrical defect. However, it is possible that non-discrete symmetrical defects of enamel could arise due to other causes thus slightly over-estimating the prevalence of dental fluorosis.

5. Conclusions and recommendations

In conclusion, although the prevalence of dental fluorosis was 52%, the severity of dental fluorosis was not associated with OHRQoL in adolescents residing in Kurunegala district which is an endemic district for dental fluorosis in Sri Lanka.

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Declaration of competing interest

There is no conflict of interest for this study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jobcr.2023.03.015.

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