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The occurrence, severity degree, and associated risk factors of dental fluorosis among the 12-year-old schoolchildren in Jilin, China

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Abstract

This study aims to describe the occurrence, severity degree, and correlated risk factors of dental fluorosis among the 12-year-old schoolchildren of Jilin, China.

We conducted a cross-sectional, observational, and descriptive study among 960 12-year-old schoolchildren in Jilin. The Dean index was utilized to evaluate the severity degree of dental fluorosis. A questionnaire was sent to the guardians of children. Community fluorosis index was measured to estimate the importance of enamel fluorosis for the whole population's public health. The logistic regression analysis was also utilized to identify the correlation between fluorotic teeth and the independent variables.

Nine hundred sixty children were assessed. Among them, 480 (50%) were female. 30.5% of subjects had dental fluorosis, 7.19% had very mild dental fluorosis, 10.73% experienced mild dental fluorosis, 9.58% suffered moderate dental fluorosis, and 3.02% encountered severe dental fluorosis. The overall community fluorosis index was 0.73. The results of logistic regression showed that schoolchildren who brushed teeth more frequently (OR: 2.012, 95% CI 1.767–2.342), deficiency of parental supervision (OR: 4.219, 95% CI 3.887–4.573), and lived in rural areas (OR: 2.776, 95% CI 2.163–3.489) were more correlated with enamel fluorosis. Moreover, schoolchildren whose mothers or fathers were of high education level (OR: 0.336, 95% CI 0.217–0.413 and 0.346, 95% CI 0.113–0.512) and only child (OR: 0.378, 95% CI 0.213–0.415) were protective factors for dental fluorosis.

In the Jilin province of China, the risk indicators for dental fluorosis include rural areas, more frequency of brushing, low educational background of parents, and deficiency of parental supervision.

Abbreviations: CFI = community fluorosis index, DF = dental fluorosis, DI = Dean index.

Keywords: China, dental, fluorosis, prevalence, risk factors

1. Introduction

Fluoride is a nonmetallic chemical element and has been widely utilized to inhibit tooth decay.[1–10] Nevertheless, it has both positive and negative effects on oral health. Long-term high fluoride absorption can cause enamel fluorosis.[1,2,6,10,11]

Dental fluorosis (DF) is classically characterized by the stains which are opaque, white, and lose the gloss of human enamel.[2] Mild dental fluorosis has the features of an opaque area scattered on the teeth with normal tooth morphology. Severe DF has underdeveloped zones in the enamel that can lead to tooth structure being destroyed.[11] Generally, DF is induced by human enamel hypomineralization due to excessive fluoride ingestion during tooth development and mineralization.[2,3,10,12–14] The severity degree of DF is affected by fluoride dose and exposure duration.[11]

Fluoride is broadly offered in many forms, including drinking water, fluoride salt, and fluoride toothpaste, which may cause children to consume too much fluoride.[1–3,15] Pizzo et al[16] reported that DF's prevalence could be significantly increased due to the increase in fluoride exposure. Besides, several non-fluoride factors affect DF, such as socioeconomic status, gender, and education background.[1,2,10,13,17,18]

According to the previous findings, the occurrence of DF is increasing worldwide.[2,6,9,19] Rozier[20] presented that the presence of DF was 30% to 80% in fluoride and 10% to 40% in non-fluoride areas of the United States.[20] Dental fluorosis prevalence among adolescents was 59% in Mexico city,[2] 78% in Eritrea,[10] 63.4% in India,[9] 27.3% in Brazilian,[21] and 11.3% in Enugu Metropolis, Nigeria.[4] However, the prevalence, severity, and related indicators of DF in Jilin remained not clear. Consequently, the objective of the present survey is to report the occurrence, severity, and associated risk indicators of DF among the 12-year-old schoolchildren of Jilin.

2. Materials and methods

The ethics of this study was achieved by the Ethics Committee of Jilin University Stemmatological Hospital. Review No. (62) in 2019. The students, the parents or guardians, and the school

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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authorities were informed of the aim of the study. Besides, the data involved in the present study are available.

2.1. Sample size calculation

We calculated the sample size using the following formula:

$$n_1 = \frac{z^2 p(1p)}{e^2}$$

In the formula, n_1 was the simple size, z was the level of confidence and when the confidence was 95%, z was 1.96, p was the dental caries prevalence (28.9% as reported by the 3rd National Oral Health Survey in China),[22] and the non-response rate was 5%. The admissible error of prevalence was set at 15%. Finally, the sample size in our study was 960.

2.2. Design, subjects, and study sample

We evaluated the risk factors for DF as the primary outcome and assessed the incidence and severity of DF as the secondary outcome. From April to August 2017, we used multistage, stratified, random sampling to choose respondents of 960 12-year-old schoolchildren in 4 areas of Jilin Province, including the Changchun area, Changling area, Baicheng area, and Nong' an area. At first, 3 schools were selected from each area at random. Then, 80 12-year-old students were randomly chosen from every school, with an equal proportion of boys and girls. If the sample size of a school were insufficient, the residual pupils would be selected from the nearby schools.

2.3. Nine hundred sixty 12-year-old schoolchildren

Students under the survey should meet the following criteria:

(1) less than 3 months away from their area of residence between birth and the age of 6,
(2) they had lived in the local area for more than 6 months before the survey.

Exclusion criteria:

(1) children received orthodontics fixation and had difficulty in oral examination,
(2) children who did not appear at school during the investigation period.

Numerous variables, such as the current residence, the education degree of parents, the frequency of tooth brushing, the use of toothpaste, parental supervision, drinking water from tap or groundwater, the gender of students, oral hygiene, only child or not, and exposure to other fluoride products, were collected from self-reported questionnaires. The questionnaires were completed by the parents of the schoolchildren and were carefully reviewed before submitted to the recorder. If there were omissions, the guardians of students were asked to fill in the blanks.

2.4. Clinical examination and data collection

The clinical assessment and the data collection were performed by a trained and experienced team that consisted of 3 examiners and 3 recorders. The former completed a clinical examination, and the latter underwent data collection. To determine the reliability of the diagnosis, 10% of the subjects received duplicated examinations. The mean kappa value (SPSS 23.0 software, IBM Corp., Armonk NY) was 0.82. The evaluation criteria of kappa value are as follows: kappa ≥ 0.75 indicates that the diagnostic results of the 2 methods are in good consistency; 0.4 ≤ kappa < 0.75 suggests that the diagnostic results of the 2 methods are in general consistency; kappa < 0.4 indicates that the diagnostic results of the 2 methods are in poor consistency.

DF was determined by the Dean index (DI) that was advocated by the WHO.[23] The DI classification was used to assess tooth damage severity based on enamel color, gloss, and defect size. The severity degree of DF was divided into the following grades: DI = 0 representing normal, DI = 0.5 representing questionable, DI = 1 representing very mild, DI = 2 representing mild, DI = 3 representing moderate, and DI = 4 representing severe.

International standards for infection control were applied during the process of clinical examination. To assess both buccal and labial surfaces of all erupted permanent teeth, we used a flat dental mirror in the natural light of the day. The 2 worst scores were of DF are defined as individual scores. When the 2 teeth' evaluation results are inconsistent, the score of the less damaged teeth was considered the DI of the respondents. When the 2 teeth' evaluation results are consistent, the score was regarded as the DI of the children.[24] The occurrence of DF = (very mild + mild + moderate + severe)/the number of participants × 100%. Community fluorosis index (CFI) was utilized to evaluate DF's public health significance for the entire residents.[25] CFI = (0.5 × questionable + 1 × very mild + 2 × mild + 3 × moderate + 4 × severe)/the number of participants.

2.5. Statistical analysis

Statistical analysis was done by SPSS 21.0 (IBM SPSS, IBM Corp., Armonk NY). We used descriptive statistics to estimate the occurrence of DF. We also compared the DF prevalence in different areas and different genders by using the Pearson χ^2 test. Besides, we utilized logistic regression analysis to determine the connection between DF and the independent variables. $P < .05$ was defined as statistically significant.

3. Results

A total of 960 12-year-old participants, including 480 male and 480 female, were investigated to estimate DF in the present study, and all the students finished the oral examination. The overall DF was found in 30.5% (n = 293). It presented a different prevalence among different areas in Jilin, ranging from 8.33% to 64.17%. DF prevalence in Changchun, Baicheng, Changling, and Nong'an was 8.33% (n = 20), 20% (n = 48), 64.17% (n = 154), and 29.58% (n = 71), respectively. The overall CFI value was 0.73.

The distribution of DF severity was as follows: 61.67% (n = 592) had normal teeth, 7.81% (n = 75) had questionable results, 7.19% (n = 69) had very mild fluorosis, 10.73% (n = 103) had mild fluorosis, 9.58% (n = 92) had moderate fluorosis, and 3.02% (n = 29) had severe fluorosis (Fig. 1).

Rural areas had more severe fluorosis prevalence than urban areas ($P < .05$), 13.83% (n = 347) from urban areas, and 39.97% (n = 613) from rural areas had fluorosis. We found no difference in DF between males and females ($P > .05$); 29.58% (n = 480) of males and 31.46% (n = 480) of females had fluorosis. Children of less-educated parents showed a higher rate of DF. Besides, the only child had less dental fluorosis than not only child (Table 1).

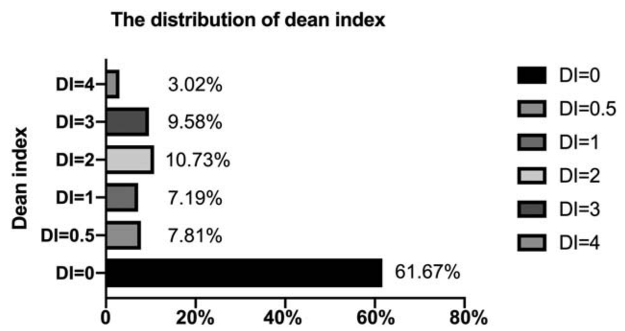

Figure 1. Distribution of Dean fluorosis scores of the 12-year-old schoolchildren in Jilin.

As for brushing frequency, 59.48% (n=571) of students brushed once or twice per day, and 40.52% (n=389) brushed 3 times per day. A majority of parents or guardians (83.02%, n=797) did not supervise their children's brushing, but a minority of parents (16.98%, n=163) supervised brushing. Only 14.79% (n=142) of students were exposed to other fluoride forms, including fluoride usage in dental clinics or mouthwash.

Among schoolchildren, who brushed their teeth 1 or 2 times per day, 20.49% experienced DF, while who brushed 3 or more times per day, 45.14% suffered DF ($P<.001$). Of the schoolchildren whose brushing was supervised by their guardians, the occurrence of DF was no more than 7.3% ($P<.001$). Few participants were exposed to other fluoride products, and among them, 28.17% had DF. Nevertheless, no statistical differences were observed between children with and without fluoride product exposure (Table 1).

The outcomes of the logistic regression model were presented in Table 2. Students, who reside in rural areas (OR: 2.776, 95% CI 2.163–3.489), had a higher frequency of brushing (OR: 2.012, 95% CI 1.767–2.342), and deficiency of the supervision from parental (OR: 4.219, 95% CI 3.887–4.573), were more

Table 2

Bivariate analysis of related factors with dental fluorosis in 12-year-old schoolchildren in Jilin.

Variables	OR	95% CI	P
Area			
Urban	1		
Rural	2.776	2.163–3.489	<.001
Father's education			
≤9 yrs	1		
>9 yrs	0.346	0.113–0.512	.006
Mother's education			
≤9 yrs	1		
>9 yrs	0.336	0.217–0.413	<.001
Only child			
No	1		
Yes	0.378	0.213–0.415	<.001
Brushing			
1–2 times	1		
3 times	2.012	1.767–2.342	<.001
Parental supervision			
Yes	1		
No	4.219	3.887–4.573	<.001

CI=confidence interval, OR=odds ratio.

Table 1

Multivariate analysis of associated factors with dental fluorosis in 12-year-old students in Jilin.

Variables	Fluorosis (%)	N	Fluorosis severity (%)						CFI	χ^2	P*
			DI=0	DI=0.5	DI=1	DI=2	DI=3	DI=4			
Area											
Urban	13.83	347	80.98	5.19	3.46	5.76	3.75	0.86	0.32	71.367	<0.001
Rural	39.97	613	50.73	9.30	9.30	13.54	12.89	4.24	0.97		
Gender											
Female	31.46	480	59.23	9.31	15.43	9.14	4.13	2.76	0.62	0.398	0.528
Male	29.58	480	55.45	14.97	13.46	8.34	5.14	2.64	0.64		
Father's education											
>9 yrs	10.51	389	76.73	12.76	4.56	3.21	1.97	0.77	0.26	123.131	<0.001
≤9 yrs	44.13	571	44.16	11.71	30.22	8.45	3.40	2.06	0.71		
Mother's education											
>9 yrs	13.71	311	80.39	5.90	9.21	3.12	0.97	0.41	0.23	60.462	<0.001
≤9 yrs	38.52	649	51.00	10.48	25.35	6.39	4.56	2.22	0.66		
Only child											
Yes	17.36	538	74.34	8.30	8.77	5.38	2.17	1.04	0.34	101.091	<0.001
No	47.39	422	35.00	17.61	33.67	9.89	2.12	1.71	0.75		
Brushing											
1–2 times	20.49	571	53.45	26.06	10.54	5.43	3.32	1.20	0.49	66.857	<0.001
3 times	45.14	389	26.74	28.12	30.79	5.64	3.37	5.34	0.88		
Parental supervision											
Yes	7.36	163	88.15	4.49	5.32	1.14	0.57	0.33	0.13	49.657	<0.001
No	35.26	797	50.74	14.00	28.60	3.75	1.88	1.03	0.53		
Other products with fluoride											
Yes	28.17	142	50.45	21.38	15.23	7.34	4.10	1.50	0.59	0.435	0.510
No	30.93	818	50.00	19.07	16.73	8.78	2.96	2.46	0.63		

CFI=community fluorosis index, DI=Dean index.
* $P<.05$ was defined as statistically significant.

correlated with DF. Besides, schoolchildren whose mothers or fathers with high education level (OR: 0.336, 95% CI 0.217–0.413 and 0.346, 95% CI 0.113–0.512), and only child (OR: 0.378, 95% CI 0.213–0.415) were protective factors for DF.

4. Discussion

In the present study, the overall DF was 30.5% (n=293), and it presented a different prevalence among different areas in Jilin, ranging from 8.33% to 64.17%. Students whose mothers or fathers with high education level and only child were protective factors for DF. On the contrary, schoolchildren who reside in rural areas, had a higher frequency of brushing, and deficiency of the supervision from parental, were more correlated with DF. Moreover, as highlighted by the WHO, children's oral health is monitored worldwide at aged 12 years.[26] Consequently, we selected 12-year-old schoolchildren as the subjects.

When comparing with other countries[2,9,10,19,20] in which the most common age group selected for study was 12 to 17-year-old children, Jilin has a low occurrence and severity of DF. Armas-Vega et al demonstrated that the prevalence of dental fluorosis was of 89.96% in 2019.[27] Verma and his colleagues found that the incidence of DF was 68.8% in 2011.[9] Molina-Frechero et al[2,19] reported that Mexico also increased average dental fluorosis from 26% in 2002 to 59% in 2015. Verma et al[9] found a high occurrence of dental fluorosis in India, which was more than 50% of the population suffered from severe or moderate dental fluorosis. Andegiorgish et al[10] described 78% dental fluorosis in Eritrea. In our study, the occurrence of DF in Jilin was 30.5%, which was slightly lower than in other countries. In our opinion, this may be related to the fact that our investigation time is later than previous reports. In recent years, Jilin province has carried out extensive knowledge promotion of DF prevention, strengthening parents' concept of DF prevention in children.

Jilin has a higher occurrence of DF than most other Chinese provinces.[6] It is lower than Guizhou and Tianjin, which might be due to coal pollution in Guizhou and the high fluoride concentration of drinking water in Tianjin.[6] However, Jilin has a higher occurrence of DF (30.5%) than the other provinces in China, including 0.1% in Guangxi, 1.9% in Fujian, 2.1% in Beijing, 10.2% in Zhejiang, and 16.8% in Ningxia.[6] In our opinion, these different prevalence characteristics can be attributed to various factors, including study background, sample size, dietary behaviors, attitude concerning dental hygiene, knowledge, and social and cultural background differences, and this view was also agreed by the authors.[3,10] In the current study, we also concluded that the occurrence of DF varied between 8.33% and 64.17% in different areas of Jilin. We believe that regional characteristics are related to this result. Changling, as the area with the highest prevalence of DF in this survey (64.17%), is located in the northwest of Jilin and belongs to high-fluoride area, which may lead to increased ingestion of fluoride in children. Besides, we suggest that differences in educational background, oral hygiene, and socioeconomic status can reasonably explain the results. This view was also agreed by many other scholars.[1–3,13,28]

In Jilin Province, rural areas had more severe dental fluorosis than urban areas (39.97% vs 13.83%). Baskaradoss et al[18] suggested that rural areas have more severe fluoride pollution than urban areas. Fluoride levels in rural areas can be affected by several factors, including food, underground water, and air pollution.[6] Ranasinghe et al[29] indicated that 12% of children aged <12 years (0.52 million) were exposed to water fluoride levels of >1.0 mg/L and could be considered a higher risk for fluorosis. Garcia-Perez et al[15] also believe that DF can be significantly affected by fluoride drinking water levels. In China, people in urban areas usually drink tap water with low fluoride concentration. In contrast, residents in rural areas use groundwater, which often contains more than 1 part per million fluorides.[6] Therefore, it is essential to implement drinking water de-fluoridation schemes and upgrade drinking water quality in the rural areas of Jilin.[30]

In the present study, the incidence of DF showed no significant differences between males and females. This result was consistent with the previous findings of Molina-Frechero et al[2] and Zhou et al.[6] However, Armas-Vega et al[27] reported that females were more likely to have DF. Regretfully, they did not analyze the reasons for this interesting result. We believe that DF is mainly related to the fluoride content consumed by children. There is no significant difference in DF prevalence among male and female children living in similar environments.

Concerning the frequency and parental supervision of brushing, we found that children who brushed more often had more dental fluorosis, and these results were consistent with those of other literature.[14,31] Besides, schoolchildren who brushed their teeth lack parental supervision showed a higher DF; this result might be due to more toothpaste being used than the required.[2] It is quite challenging for children to spit the residues of toothpaste out from their oral after brushing, which results in children ingested between 64.3% and 83.9% of toothpaste. Even at the age of 5, children can take up to 30% of their toothpaste.[32,33] Furthermore, our study demonstrated that children who were the single child showed a lower risk of dental fluorosis, primarily because they received more supervision from their parents.[26]

Regarding the socioeconomic status of the students, the authors found the parents with low socioeconomic conditions were more likely to settle in rural areas and have less health knowledge about the potential damage of fluoride.[17] Molina-Frechero et al[2] reported that low-income residents had higher fluorosis prevalence because they had very little purchasing power, and all family members used the same brand of toothpaste, which resulted in children's exposure to high fluoride levels from the moment they started brushing their teeth. On the contrary, Angulo et al[12] found that schoolchildren with lower socioeconomic status were not susceptible to DF due to they had less opportunity to the fluoridated merchandise sold on the market. Unfortunately, this study did not investigate the impact of socioeconomic status on dental fluorosis in Jilin. However, the authors still consider socioeconomic status as a risk indicator for DF.

Hu et al[1] described that although population exposure to fluorides in the same situation, the severity of different individuals might differ and might not be affected. This phenomenon resulted from multiple compound factors, including genetic susceptibility, individual health status, diet, and duration of fluoride exposure. It is notable to determine all the related risk indicators and all fluoride sources to reduce the prevalence of DF. Besides, the government should strictly monitor substances, beverages, toothpaste, and foods that contain fluorine.

In the present study, even though we acquired specified, quantitative, and updated DF information, there are still many limitations. To begin with, we did not assess the impact of parents' economic status on the prevalence of dental fluorosis among children in Jilin province. However, many scholars believe that guardians' economic status is also related to dental fluorosis incidence in children.[2,12,17] In the next place, there is a deviation in the proportion of rural and urban pupils, which might cause the conclusion not to be available for the whole population of 12-year-old children in Jilin Province. Consequently, we should rigorously restrict the exclusion standards and inclusion standards of the research objects and collect the information uniformly and accurately.

5. Conclusion

In the Jilin province of China, risk factors for DF include rural areas, more frequency of brushing, low educational background of parents, and deficiency of parental supervision.

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Author contributions

Data curation: Chong Chen.
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Writing – review & editing: Rui Wang.

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