Int J School Health. 2017 January; 4(1):e37181. doi: 10.17795/intjsh-37181.

Published online 2016 August 17. **Research Article**

Prevalence of Developmental Defects of Enamel and Dental Caries in 9-Year-Old Children of Areas With Different Levels of Fluoride, Fars Province, Iran

Aira Sabokseir,[1] and Ali Golkari[1,*]

[1]Department of Dental Public Health, School of Dentistry, Shiraz University of Medical Sciences, Shiraz, IR Iran

[*]*Corresponding author*: Ali Golkari, Department of Dental Public Health, School of Dentistry, Shiraz University of Medical Sciences, Shiraz, IR Iran. Tel: +98-9175607254, Fax: +98-71 36270325, E-mail: golkaria@sums.ac.ir

Received 2016 February 17; **Revised** 2016 April 17; **Accepted** 2016 April 25.

Abstract

Background: Developmental defects of enamel (DDEs) and dental caries are two prevalent dental conditions that may have major negative impacts on children's quality of life. Fluoride, especially the level of fluoride in water, can influence the occurrence of both dental caries and DDEs. However, data on the extent of this influence on Iranian children has not been explored.

Objectives: The aim of this study was to compare DDEs and dental caries in three areas with different levels of fluoride in water among 9-year-old children of the Fars Province, Iran, in order to provide data for oral health preventive programs.

Methods: A cross-sectional study was conducted on 400 9-year-old children residing in areas with high, optimal and low levels of fluoride in water of the Fars Province, Iran. Cases with DDE were diagnosed on the standardized one view photographs of the anterior teeth using the modified DDE index. DMFT index was used to evaluate dental caries. The prevalence of children with DDE and dental caries, the mean number of teeth with DDE, and mean DMFT were compared among the three areas by binary logistic and Poisson regressions after adjustment for sex. SPSS software version 22 was used to analyze the data. The significance level was set at $\alpha = 0.05$.

Results: The overall prevalence of DDE was 59.9% with the mean number of teeth with DDE of 1.59 ± 1.97. The most prevalent type of DDE in all three areas was diffuse opacities (35.5%). The overall prevalence of children with dental caries in permanent teeth was 25.6% with the mean DMFT of 0.67 ± 1.187. The percentage of children with untreated caries in permanent dentition was 73.98%. It was found that 24.3% of permanent first molars were affected by caries. The higher level of fluoride was significantly associated with more DDEs and less DMFT.

Conclusions: When planning for oral health care services, it should be noticed that a considerable number of Iranian children in the Fars Province are affected by dental caries and DDEs, which their occurrences have been affected by the level of fluoride in water.

Keywords: Prevalence, Dental Caries, Dental Enamel, Child, Fluoride

1. Background

Oral health is an important element of health. Oral diseases are serious public health problems and, despite direct effect on a small part of body, their consequences involve the entire body and may present serious impacts on a person's life (1). Poor oral health can have detrimental effects on physical and psychological wellbeing (1). Developmental defects of enamel (DDE) and dental caries are two highly prevalent dental diseases that both have significant impacts on people's life, especially children (1-3).

Tooth formation is a sensitive procedure and can be easily deteriorated or disturbed by genetic, systemic or local factors (4). This kind of disturbance may affect the shape, size or structure of a part or the entire tooth. If the enamel is involved and affected, the resulting abnormality can be seen on the surface of the tooth as a DDE. Developmental defects of enamel can be considered as permanent pathologic features affecting both primary and permanent dentition. DDEs could be quantitative (hypoplastic) or qualitative (hypomineralized/hypocalcified) (5). Developmental defects of enamel may be caused by either hereditary or acquired adverse conditions. The acquired causes of DDEs may be either local or systemic conditions that occur during the period of tooth development (4).

Developmental defects of enamel can have a significant effect on esthetic, tooth sensitivity, tooth wear, and dentofacial abnormalities (2) and have a negative impact on the children's daily performance (3). DDEs have, by some authors, been regarded as the main risk factors for dental caries although its nature has not been identified and its cause is not clear (4).

Dental caries is a mulifactorial disease through interaction between the tooth surface, microbial dental plaque and sugar (6). Tooth decay, a significant global public health concern, is the most worldwide chronic disease and the most common disease during childhood and it affects all ages (1). Untreated permanent teeth can result in frequent tooth pain, and difficulty in eating and sleeping, can affect child growth, and is also a main reason of absence from school and work, even in the developed countries (1). Physical, biological, environmental, behavioral, and lifestyle-related factors, inadequate salivary flow, insufficient fluoride exposure, poor oral hygiene, inappropriate methods of feeding infants, and poverty are all considered as risk factors for dental caries (7).

The literature review on the prevalence of enamel defects shows a wide range. They range from 4% (8) to 99.6% (9). A study in 2013 on schoolchildren residing in Granada (Spain) using the modified DDE index showed a prevalence of 52% in permanent dentition (10). Another study in 2008, using the modified DDE index revealed the prevalence of 28% diffuse opacities among 9-year-old children of Auckland (11). In 2008, the prevalence of enamel opacities in permanent teeth of 11 - 12-year-old children of Kuala Lumpur, Malaysia, was reported as 90.7% (12). In a study conducted in 2010 in Saudi Arabia, a neighboring country to Iran, the prevalence of DDE among preschool children in Jeddah was 45.4% (13). According to a study conducted in 2011 on 8 - 10-year old children of Shiraz, Iran, 76.7% of children were affected by DDEs (14).

Also, the DMFT index (D for decay, M for missing teeth due to caries only, F for filling, and T for teeth) for permanent teeth (dmft index is used for primary teeth) is the most commonly used epidemiological index to assess dental caries (15). A study in 2006 showed that the prevalence of dental caries in 9-year-old schoolchildren in Italy was 60.8% with the mean DMFT value of 0.55% $\pm$ 1.09 (16). Another study in 2007 on 9-year-old children of Chandigarh, India, found that the prevalence of dental caries in the mixed dentition was 92.11% with a mean sum of deft (decayed, extracted, and filled primary teeth) plus DMFT of 4.61 $\pm$ 3.14 (17). In a study conducted in 2015 on 6 - 9 year old children of Eastern Saudi Arabia, the overall prevalence of dental caries was 77.8% with the mean dmft value of 3.66 $\pm$ 3.13 (18). In a study conducted in 2010, the mean DMFT value of 9-year-old children of Mashhad, Iran, was 1.87 $\pm$ 1.4 (19).

Fluoride has a significant effect on the reduction of dental caries. Fluoride affects dental caries process through: inhibiting demineralization and accelerating remineralization, making enamel more resistance to acidic attack, and having antimicrobial action (20). A recent systematic review of efficacy and safety of fluoridation has concluded that fluoridation of drinking water is the most effective means of equal exposure to the caries prevention effects of fluoride in the community (21). The optimal range of fluoride in water is 0.6 - 1.1 ppm, depending on the climate, in order to reduce both dental caries and the occurrence of fluorosis (21). Regarding DDE, An adverse relationship has been shown between DDE and the concentration of fluoride in the water (22, 23).

To the best of knowledge of authors, data on the extent of the influence of the level of fluoride in water on DDEs and dental caries among Iranian children has not been explored. This is while the information regarding the differences in the prevalence of DDEs and dental caries is essential for the planning for oral health care services, especially in the current time, in which the Iranian government is investing on preventive oral measures.

2. Objectives

The aim of this study was to assess the prevalence of DDEs and dental caries among 9-year-old children of three areas with different levels of fluoride in water in the Fars Province, Iran, and to provide data for oral health preventive programs.

3. Methods

This cross-sectional study was conducted on 400 9-year-old children of three towns of the Fars province, Iran, with high fluoride in water (Gerash with 2.12 - 2.85 ppm), optimal level of fluoride (Shiraz with 0.62 - 1.22 ppm), and low fluoride in water (Sepidan with 0.24 - 0.29 ppm). Ethical permission was obtained from the ethical committee of Shiraz University of Medical Sciences (SUMS) and the educational head office of the Fars province. Written consent forms were sent to the parents of the selected children in order to explain the objectives of the study and obtain their consents. Cases with DDE were diagnosed by the modified DDE index (24) and dental caries were assessed by the DMFT index (25).

The sample size was calculated based on the estimated prevalence of DMFT and fluorosis in Iran (prevalence of DDE was not available). Sample size using the prevalence of fluorosis (61%) was adopted as a greater number was achieved. considering d = 6.1% (10% expected prevalence) and α = 0.05, the calculated sample size was 246. With an estimated response rate of 80%, a total of around 300, 100 from each area, was needed, if simple randomization was used. The selection of children in Gerash and Sepidan (with high and low fluoride levels) was performed by simple randomized sampling. However, in Shiraz (an area with optimum fluoride level), the simple randomization was not possible as it was a large city. Therefore, a stratified randomization method was conducted. This method was performed using the four different educational zones, list of primary schools, and list of children inside each selected school. The number of sample size in Shiraz was multiplied by 2 (k = 2) to increase the accuracy as a stratified sampling method was used. Therefore, 100 9-year-old schoolchildren of Gerash, 100 from Sepidan and 200 from Shiraz were selected from lists of students.

Children aged between 9 years and zero months to 9 years and 11 months were included. Children who had lived more than six months (from birth to 5 years of age) in other towns with different concentration of fluoride in water, children with less than 7 permanent incisor teeth present in their mouth or less than 50% of their incisor crowns erupted, children with orthodontic brackets, overlapped teeth, large filling or severe extrinsic stains on their teeth, and children whose parents did not provide consent were excluded from the study.

The examination was carried out using headlight, disposable mirror and tongue blade with children seated on a chair. A chart to record DMFT and dmft of the permanent and primary dentition based on recommendation of WHO for screening studies (26) was filled.

A one-view photograph was taken from anterior part of dentition of selected children using a digital camera (Nikon D7100, AF-S VR Micro-Nikkor 105 mm f/ 2.8 G IF-ED). Methods described by Wong et al. were used for photography (26). The camera was focused on the center of four central incisors while they were closed edge to edge. These photographs were used to assess DDEs. To prevent from bias due to the awareness of the rate of fluoride in the area, the photographs were randomly ordered and shown to a calibrated dentist who was blind to the clinical condition and place of residence of the subjects. The modified DDE index is a descriptive index, created specifically for epidemiological studies based on their macroscopic appearance (24). The modified DDE index divides the defects to three main types: demarcated opacities, diffuse opacities and hypoplasia and there are codes 0 to 9 for the type of defects (0 for normal, 1 and 2 for white/cream and yellow/brown demarcated opacities, 3 to 6 for diffuse opacities as lines, patchy, confluent, and confluent/patchy + staining + loss of enamel, 7 and 8 for hypoplasia as pits and areas of missing enamel, and 9 for any other defect). There are also codes 0 to 3 for the extension of the defect on the teeth (0 = Normal, 1 = less than 1/3 of tooth surface, 2 = between 1/3 and 2/3, and 3 = more than 2/3 of tooth).

The SPSS software version 22 was used for data analysis. Findings on the DMFT and the modified DDE indices were presented descriptively and were compared among the three areas using binary logistic regression and Poisson regression after adjustment for child's sex. The significance level was set at $\alpha = 0.05$.

4. Results

A total of 367 9-year-old children were included in the final analysis: 171 (46%) girls and 196 (53%) boys. The final numbers of samples were 88, 189, and 90 in Gerash (high fluoride), Shiraz (optimal fluoride) and Sepidan (low fluoride), respectively.

The overall prevalence of DDE was 59.9%. The most prevalent type of DDE in all three areas was diffuse opacities, with an overall 35.5% of children affected. The most affected teeth were upper central incisors. The percentages of DDEs in areas with high, optimal, and low levels of fluoride in water were 79.5%, 57.1% and 39%, respectively ($P < 0.001$) showing a significant positive relationship between the level of fluoride in water and the percentage of children with DDEs (Table 1). The overall mean number of teeth with DDE was 1.59 ± 1.97. There was also a significant decrease in average number of teeth with DDEs from areas with high to low range of fluoride in water (Table 1). There was neither a significant relationship between children's sex and number of children with DDE ($P = 0.849$) nor between sex and mean number of teeth with DDE per child ($P = 0.455$).

Table 1. The Prevalence of Children With DDE and Mean Number of Teeth With DDE per Child Among Three Areas With Low, Optimal, and High Levels of Fluoride in Water

Area	Number of Included Children	Number of Children With DDE, %	Mean Number of Teeth With DDE per Child
High fluoride	88	69 (78.4)	2.39 ± 2.32
Optimal fluoride	189	109 (57.7)	1.43 ± 1.91
Low fluoride	90	40 (44.4)	1.02 ± 1.39
Total	367	218 (59.4)	1.59 ± 1.97
P value optimal/high		0.001[a]	< 0.001[b]
P value low/high		< 0.001[a]	< 0.001[b]

Abbreviation: DDE, developmental defects of enamel.
[a]Binary logistic regression. Sex P value = 0.849.
[b]Poisson count regression. Sex P value = 0.455.

The overall prevalence of children with DMFT > 0 was 30.2%, with the mean DMFT of 0.67 ± 1.19. It was found that 24.3% of permanent first molars were affected by caries while only 4.9% of them were filled. The overall percentage of children with untreated dental caries in their permanent teeth was 25.6% and about three-fourth of the DMFT value was related to untreated dental caries (D). The prevalence rates of children with DMFT > 0 residing in areas with high, optimal and low ranges of fluoride in water were 13.6%, 37.0%, and 32.2% ($P < 0.001$) with the mean DMFT values of 0.20 ± 0.590, 0.88 ± 1.349, and 0.68 ± 1.140 (P <

0.001), respectively (Table 2). There was no significant relationship between sex and the prevalence of children with DMFT > 0 or with untreated dental caries; however, the mean DMFT value was significantly greater in girls than in boys (P = 0.034).

The overall percentage of children with dmft > 0 (in primary teeth) was 90.2%. The overall mean dmft was 4.45 ± 2.88. The prevalence rates of dmft > 0 in areas with high, optimal and low levels of fluoride in water were 87.5%, 89.9%, and 93.3% with the mean dmft values of 3.48 ± 2.57, 4.49 ± 2.92, and 5.31 ± 2.81, respectively. The overall prevalence of untreated dental caries in primary dentition was 88.3%, which showed that almost all (98%) of children with dmft > 0 had at least one untreated tooth decay. There was no significant relationship between dmft-related variables and fluoride in drinking water.

5. Discussion

The findings of the current study show that the occurrence of DDE significantly increased with the increase in the level of fluoride in water. On the other hand, dental caries in permanent dentition was only significantly lower in area with a high fluoride concentration in water, compared with the two other areas. In other words, the increase in the fluoride level from low to optimal did not decrease the occurrence of dental caries in permanent teeth. Also, as explained in the results section, no relationship was found between the level of fluoride in water and existence of dental decay in primary dentition of the 9-year-old children.

The found relationship between DDE and fluoride was easily predictable, especially as the main type of DDE was diffuse opacities. That is because dental fluorosis usually presents itself as diffuse opacities.

An overall negative significant correlation was found between DMFT and the level of fluoride in water. It was also expected to find that DMFT would decrease with every increase in fluoride. This was not the case in this study. When comparing the areas two by two, both the percentage of children with DMFT > 0 and mean DMFT of children were increased, although not significantly, from the low fluoride to the optimal fluoride areas. This could mean that either fluoride can only affect the occurrence of dental caries of children in higher concentrations; or other risk factors had dominated the effects of fluoride. The latter could be justified as the area with optimal fluoride was a big city compared to the other two areas that were much smaller towns.

Findings of the current study show that high amount of fluoride in water reduces the risk of dental caries but increases the risk of DDEs. The same results were concluded in a study performed on 9-year-old children in Auckland, New Zealand (27). They also reported that the main DDE type, the type that markedly increased in the area with higher fluoride concentration, was diffuse opacities.

The mean DMFT (0.67) found in the current study was not in consistent with the mean DMFT (1.87) in children of the same age in Mashhad, Iran (19). Also, compared to a study conducted among 7- to 9-year-old children of Tangshan, China, in 2015, where the prevalence of caries in the permanent first molar was 47.49% with the mean DMFT of 1.30 ± 1.59 (28) or in neighboring country of Iran, Saudi Arabia, which the prevalence of permanent first molar caries was 64% (29), the prevalence of caries in permanent teeth in the current study was much lower. However, in comparison with some European countries such as Germany and Hungary, where the mean DMFT/dmft of 8 - 9 year olds were reported to be 0.7/3.5 and 0.4/2.3 respectively, the dmft obtained in the current study was higher (30).

The current study showed that almost a quarter of permanent first molars were affected by tooth decay and only 4.9% of the permanent first molars had been filled. Considering the time interval between the appearance of first permanent molars in the mouth and examination time, these figures represent the necessity for urgent actions to tackle this serious oral disease. However, the main issue observed in the examined children was the status of untreated carious teeth. About three-fourth of DMFT value was related to untreated dental caries, and almost 90% of children had at least one untreated, left behind, carious primary tooth.

No association was found in the current study between the level of fluoride and dmft of primary dentition. One reason could be the fact that fluoride affects dental health partly during the formation and calcification of teeth. The crowns of primary teeth are fully formed and mostly calcified during the gestational age period and placenta limits the amount of fluoride reaching the embryo. On the other hand, dental caries is multifactorial and several other factors such as nutrition and socioeconomic status have effects on caries condition. A more comprehensive study that considers dmft of primary teeth along with as many risk factors as known for dental caries is recommended to better understand the process that fluoride level could, or could not, affect caries formation in primary dentition.

The inverse association between dental caries in permanent teeth and the level of fluoride in water indicates that children could benefit from community caries prevention programs. However, according to a study conducted in 54 cities of five provinces in Iran, the general level of fluoride is much lower than the recommended level, which the people, especially the children, could benefit from (31).

The data obtained in the current study are alarming and should be addressed by oral health policy makers. In-

Table 2. The Prevalence of Children With Dental Caries in Permanent Teeth and Mean DMFT per Child Among Three Areas With Low, Optimal, and High Levels of Fluoride in Water

Area	Number of Included Children	Number of Children With Active Dental Caries in Permanent Teeth, %	Number of Children With DMFT > 0, %	Mean DMFT
High fluoride	88	9 (10.2)	12 (13.6)	0.20 ± 0.59
Optimal fluoride	189	61 (32.3)	70 (37.9)	0.88 ± 1.35
Low fluoride	90	24 (26.7)	29 (32.2)	0.68 ± 1.14
Total	367	94 (25.6)	111 (30.2)	0.67 ± 1.19
P Value optimal/high		< 0.001[a]	< 0.001[b]	< 0.001[c]
P Value low/high		0.006[a]	0.004[b]	< 0.001[c]

[a]Binary logistic regression. Sex P value = 0.132.
[b]Binary logistic regression. Sex P value = 0.094.
[c]Poisson count regression. Sex P value = 0.034 showing greater mean DMFT in girls.

formation about dental caries is a basis for preventive programs and an indicator for treatment needs. The epidemiological data related to oral diseases would be useful for early preventative approaches such as application of fluoride varnish and fissure sealant among primary schoolchildren in order to reduce dental caries (32). The findings of this study could help the establishment of prevention programs.

Footnotes

Authors' Contribution: Study concept and design: Aira Sabokseir and Ali Golkari; acquisition of data: Aira Sabokseir; analysis and interpretation of data: Aira Sabokseir and Ali Golkari; drafting of the manuscript: Aira Sabokseir; critical revision of the manuscript for important intellectual content: Ali Golkari; statistical analysis: Aira Sabokseir and Ali Golkari; administrative, technical, and material support: Ali Golkari; study supervision: Ali Golkari.

Funding/Support: This manuscript is based on data extracted from ASa PhD thesis, which was registered in Shiraz University of Medical Sciences (# PhD 122) and was financially supported by the vice-chancellery for research.

References

1. FDI World Dental Federation . The challenge of oral disease - A call for global action: The oral health atlas. ; 2015.
2. Yadav PK, Saha S, Jagannath GV, Singh S. Prevalence and Association of Developmental Defects of Enamel with, Dental- Caries and Nutritional Status in Pre-School Children, Lucknow. *J Clin Diagn Res.* 2015;**9**(10):ZC71–4. doi: 10.7860/JCDR/2015/13401.6681. [PubMed: 26557622].
3. Vargas-Ferreira F, Ardenghi TM. Developmental enamel defects and their impact on child oral health-related quality of life. *Braz Oral Res.* 2011;**25**(6):531–7. [PubMed: 22147234].
4. Salanitri S, Seow WK. Developmental enamel defects in the primary dentition: aetiology and clinical management. *Aust Dent J.* 2013;**58**(2):133–40. doi: 10.1111/adj.12039. [PubMed: 23713631] quiz 266.
5. FDI World Dental Federation . An epidemiological index of developmental defects of enamel. ; 1982.
6. Silk H. Diseases of the mouth. *Prim Care.* 2014;**41**(1):75–90. doi: 10.1016/j.pop.2013.10.011. [PubMed: 24439882].
7. Selwitz RH, Ismail AI, Pitts NB. Dental caries. *Lancet.* 2007;**369**(9555):51–9. doi: 10.1016/S0140-6736(07)60031-2. [PubMed: 17208642].
8. Cahen PM, Obry-Musset AM, Grange D, Frank RM. Caries prevalence in 6- to 15-year-old French children based on the 1987 and 1991 national surveys. *J Dent Res.* 1993;**72**(12):1581–7. [PubMed: 8254126].
9. King NM, Wei SH. Developmental defects of enamel: a study of 12-year-olds in Hong Kong. *J Am Dent Assoc.* 1986;**112**(6):835–9. [PubMed: 3458798].
10. Robles MJ, Ruiz M, Bravo-Perez M, Gonzalez E, Penalver MA. Prevalence of enamel defects in primary and permanent teeth in a group of schoolchildren from Granada (Spain). *Med Oral Patol Oral Cir Bucal.* 2013;**18**(2):e187–93. [PubMed: 23229271].
11. Schluter PJ, Kanagaratnam S, Durward CS, Mahood R. Prevalence of enamel defects and dental caries among 9-year-old Auckland children. *N Z Dent J.* 2008;**104**(4):145–52. [PubMed: 19180867].
12. Yusoff N, Jaafar N, Razak IA, Chew YY, Ismail N, Bulgiba AM. The prevalence of enamel opacities in permanent teeth of 11-12 year-old school children in Kuala Lumpur, Malaysia. *Community Dent Health.* 2008;**25**(1):55–8. [PubMed: 18435236].
13. Farsi N. Developmental enamel defects and their association with dental caries in preschoolers in Jeddah, Saudi Arabia. *Oral Health Prev Dent.* 2010;**8**(1):85–92. [PubMed: 20480059].
14. Golkari A, Sabokseir A, Pakshir HR, Dean MC, Sheiham A, Watt RG. A comparison of photographic, replication and direct clinical examination methods for detecting developmental defects of enamel. *BMC Oral Health.* 2011;**11**:16. doi: 10.1186/1472-6831-11-16. [PubMed: 21510890].
15. Steinbach MM, Klein SJ. The Effects of Gonadotropic Hormones in the Treatment of Experimental Tuberculosis. *J Exp Med.* 1937;**65**(2):205–17. [PubMed: 19870595].
16. Perinetti G, Varvara G, Esposito P. Prevalence of dental caries in schoolchildren living in rural and urban areas: results from the first region-wide Italian survey. *Oral Health Prev Dent.* 2006;**4**(3):199–207. [PubMed: 16961029].
17. Goyal A, Gauba K, Chawla HS, Kaur M, Kapur A. Epidemiology of dental caries in Chandigarh school children and trends over the last 25 years. *J Indian Soc Pedod Prev Dent.* 2007;**25**(3):115–8. [PubMed: 17951925].
18. Farooqi FA, Khabeer A, Moheet IA, Khan SQ, Farooq I, ArRejaie AS. Prevalence of dental caries in primary and permanent teeth

and its relation with tooth brushing habits among schoolchildren in Eastern Saudi Arabia. *Saudi Med J.* 2015;**36**(6):737–42. doi: 10.15537/smj.2015.6.10888. [PubMed: 25987118].
19. Ebrahimi M, Ajami BA, Sarraf Shirazi AR, Afzal Aghaee M, Rashidi S. Dental treatment needs of permanent first molars in mashhad schoolchildren. *J Dent Res Dent Clin Dent Prospects.* 2010;**4**(2):52–5. doi: 10.5681/joddd.2010.014. [PubMed: 22991597].
20. Buzalaf MA, Pessan JP, Honorio HM, ten Cate JM. Mechanisms of action of fluoride for caries control. *Monogr Oral Sci.* 2011;**22**:97–114. doi: 10.1159/000325151. [PubMed: 21701194].
21. Yeung CA. A systematic review of the efficacy and safety of fluoridation. *Evid Based Dent.* 2008;**9**(2):39–43. doi: 10.1038/sj.ebd.6400578. [PubMed: 18584000].
22. Wong HM, McGrath C, Lo EC, King NM. Association between developmental defects of enamel and different concentrations of fluoride in the public water supply. *Caries Res.* 2006;**40**(6):481–6. doi: 10.1159/000095646. [PubMed: 17063018].
23. Ekanayake L, van der Hoek W. Dental caries and developmental defects of enamel in relation to fluoride levels in drinking water in an arid area of Sri Lanka. *Caries Res.* 2002;**36**(6):398–404. [PubMed: 12459611].
24. Clarkson J, O'Mullane D. A modified DDE Index for use in epidemiological studies of enamel defects. *J Dent Res.* 1989;**68**(3):445–50. [PubMed: 2921385].
25. World Health Organization . Oral Health Surveys-Basic Methods. ; 2013.
26. Wong HM, McGrath C, Lo EC, King NM. Photographs as a means of assessing developmental defects of enamel. *Community Dent Oral Epidemiol.* 2005;**33**(6):438–46. doi: 10.1111/j.1600-0528.2005.00245.x. [PubMed: 16262611].
27. Kanagaratnam S, Schluter P, Durward C, Mahood R, Mackay T. Enamel defects and dental caries in 9-year-old children living in fluoridated and nonfluoridated areas of Auckland, New Zealand. *Community Dent Oral Epidemiol.* 2009;**37**(3):250–9. doi: 10.1111/j.1600-0528.2009.00465.x. [PubMed: 19302574].
28. Xue Y, Lin W, Jie L, Qing D. [Caries status of the first permanent molar among 7- to 9-year-old children in Tangshan city and their correlation]. *Hua Xi Kou Qiang Yi Xue Za Zhi.* 2015;**33**(1):54–7. [PubMed: 25993752].
29. Al-Samadani KH, Ahmad MS. Prevalence of first permanent molar caries in and its relationship to the dental knowledge of 9-12-year olds from jeddah, kingdom of saudi arabia. *ISRN Dent.* 2012;**2012**:391068. doi: 10.5402/2012/391068. [PubMed: 22461990].
30. Borutta A, Brauner K, Hufnagl S, Marton S, Mavrodisz K, Tarjan I. Oral health in 8-9 year-old children in Saxony-Anhalt (Germany) and in two Hungarian cities (Budapest and Debrecen). *Community Dent Health.* 2006;**23**(1):26–30. [PubMed: 16555716].
31. Ramezani G, Valaie N, Rakhshan V. The effect of water fluoride concentration on dental caries and fluorosis in five Iran provinces: A multicenter two-phase study. *Dent Res J (Isfahan).* 2015;**12**(1):31–7. [PubMed: 25709672].
32. Ahovuo-Saloranta A, Forss H, Walsh T, Hiiri A, Nordblad A, Makela M, et al. Sealants for preventing dental decay in the permanent teeth. *Cochrane Database Syst Rev.* 2013(3):CD001830. doi: 10.1002/14651858.CD001830.pub4. [PubMed: 23543512].