Community Dental Health (2011) **28,** 248–252
Received 10 November 2009; Accepted 7 June 2010

doi:10.1922/CDH_2614MeyerLückel05

Relationship of caries and fluorosis in adolescents from high- and low-fluoride areas in Iran

H. Meyer-Lueckel[1,*], K. Bitter[2], G. Khorrami[2], A. M. Kielbassa[2] and S. Paris[1]

[1]*Clinic for Conservative Dentistry and Periodontology, School of Dental Medicine, Christian-Albrechts-Universität zu Kiel, Germany;* [2]*Department of Operative Dentistry and Periodontology, School of Dental Medicine, Charité – Universitätsmedizin Berlin, Germany*

Objective: The main aim of the study was to investigate the association between water fluoride concentration and caries as well as fluorosis occurrence in adolescents in Iran. As a secondary aim we studied the relationship between caries and fluorosis occurrence. ***Basic research design:*** We examined 12-16 year-olds (n=373) in Orumiyeh [0.3 mgF$^-$/l, low-fluoride (LF)] and Pol Dasht [3.2 mgF$^-$/l, high-fluoride (HF)] for caries-status [D3-Level, Pitts & Fyffe (DMFS)] and fluorosis prevalence [Thylstrup & Fejerskov index (TF)]. Children completed questionnaires about several sociodemographic and oral health related factors of the previous years. To adjust for confounding, we used log risk regression and estimated relative risks (RR) and 95% confidence intervals (CI). ***Results:*** For 12-13 year-olds mean DMFS were 1.9 (sd 2.5) and 1.1 (2.2) in the LF and the HF-areas, respectively. Prevalence of aesthetically relevant fluorosis (TF>2) was 1% (LF) and 87% (HF). Water fluoride concentration (adjusted for age and SES) was inversely associated with caries-status [RR: 0.7, (CI 0.6-0.8)]. RR for fluorosis was 17 (CI 8-33). In HF-area, caries scores were significantly higher for children with TF≥5 on upper central incisors compared with TF≤4 ($p<0.05$ Mann-Whitney test). ***Conclusions:*** Caries prevalence in the examined areas in Iran is quite low. Above-optimal water fluoride concentration seems to be effective in reducing caries experience, but increases the occurrence of fluorosis. Severe fluorosis seems to be associated with higher caries occurrence in a high-fluoride area.

Key words: *caries, fluorosis, water fluoridation, fluoride, Iran*

Introduction

As a community-based means fluoridated water is beneficial to prevent caries (Petersen and Lennon, 2004). However, excessive ingestion of fluorides during maturation may cause dental fluorosis. In the United States many studies conducted in earlier years found contradictory results about the effects of above-optimal water fluoridation concentrations on caries occurrence (Eklund *et al.*, 1987). Recent cross-sectional studies from outside the US comparing areas with relatively high- (>2.0 mgF$^-$/l) to those with low-fluoride levels (<0.5 mgF$^-$/l) either revealed a negative (Cortes *et al.*, 1996; Narbutaite *et al.*, 2007), a neutral (Ermis *et al.*, 2003) or even a positive (Awadia *et al.*, 2002; Ekanayake and van der Hoek, 2002) relationship between water fluoride concentration and caries experience. Higher levels of water fluoride concentrations were shown to be strongly positively associated with dental fluorosis (Cortes *et al.*, 1996; Ekanayake and van der Hoek, 2002; Ermis *et al.*, 2003; Narbutaite *et al.*, 2007). In areas with high fluoride concentrations severe fluorosis has been positively associated with caries (Ekanayake and van der Hoek, 2002; Wondwossen *et al.*, 2004), but also contradictory results have been reported (Eklund *et al.*, 1987; Yoder *et al.*, 1998). Due to the inconsistent data concerning the association between 'above-optimal' fluoride concentrations and in particular caries as well as the association between severe fluorosis and caries this issue was revisited in the present study in an Iranian population that has not been investigated so far.

For Iran relatively high levels of water fluoride concentrations (>1 mgF$^-$/l) have been reported for some areas (Meyer-Lueckel *et al.*, 2006; Ramezani *et al.*, 2004). In Iran, tap water is not only used for cooking, but also for tea preparation as well as drinking water. Elevated fluorosis prevalence could be observed with high water fluoride concentrations (>2.4 mgF$^-$/l) in children and adolescents (Meyer-Lueckel *et al.*, 2007; Meyer-Lueckel *et al.*, 2006; Ramezani *et al.*, 2004). For the north-western parts of Iran (West-Azerbaijan) even higher water fluoride concentrations were suspected from reports of the local authorities (personal communication).

The first aim of the present study was to investigate the association between water fluoride concentration and caries as well as fluorosis occurrence in adolescents situated in a high- (3.2 mgF$^-$/l) and a low-fluoride area (0.3 mgF$^-$/l) in Iran. Secondly, association between fluorosis severity and caries occurrence in lifelong residents was analysed in the high-fluoride area.

Methods

This cross-sectional study was carried out in West-Azerbaijan in northwest Iran in Orumiyeh (capital of the region) and Pol Dasht (small city) on schoolchildren aged 12-13 and 15-16 years. The study was approved by the Division of Education in West-Azerbaijan. Consent for inclusion in the study was obtained from the principals of the selected schools, who were also requested

Correspondence to: Dr Hendrik Meyer-Lückel, Clinic for Conservative Dentistry and Periodontology, School of Dental Medicine, Christian-Albrechts-Universität zu Kiel, Arnold-Heller-Str. 3, Haus 26, 24105 Kiel, Germany. E mail: meyer-lueckel@konspar.uni-kiel.de

to inform the parents about the study to give them the possibility for negative consent prior to the examination in April 2004. Both areas rely on tap water from mountain springs that is mainly consumed without prior boiling. In Orumiyeh and Pol Dasht water fluoride concentrations of 0.5 mgF-/l (LF area) and 3.2 mgF-/l (HF area), respectively, were reported by the local authorities (personal communication).

In each area for each age range (middle schools for 12-13 year-olds and high schools for 15-16 year-olds) one boys' and one girls' public schools were chosen by the Division of Education (convenience sampling). The principal of each school selected a class to participate. Examinations were performed on every child present on that day. In Orumiyeh (LF), population 435,200, the 2 schools selected from the 77 middle schools and 2 from the 25 high schools served a local population estimated at 7000. Some 96 (1.3%) of the LF middle school's 6,343 role were examined. For the LF high school these data were 91 (1.3%) of 2,786. In Pol Dasht (HF), population 36,000, the 2 schools selected from the 20 middle schools and from the 11 high schools served a local population estimated at 900. Here 95 (11%) of the HF middle school's 856 role were examined. For the HF high school these data were 91 (10%) of 348.

A questionnaire written in the local language and tested in a previous study (Meyer-Lueckel *et al.*, 2007) was completed by all the children before the dental examination and gathered socio-demographic and oral health data (Table 1). The questionnaires were checked immediately by an assistant of the examiner.

Before the survey, a dentist (GK) was trained by an examiner involved in several previous epidemiological studies using the current indices (HML). After tooth brushing, children were examined under natural light in well-lit schoolrooms with a dental mirror and a wooden spatula to WHO criteria but without the use of a blunt probe. No drying procedure using pressured air was performed. Lesions at the dentinal (D3) level (Pitts, 2008) (i.e. according to ICDAS second digit code 4, 5 and 6) were judged as decayed. Decayed, missing, and filled tooth surfaces (DMFS) and teeth (DMFT) were recorded on a computer. The individual components of DMFT (DT, MT, and FT) and the proportion of 'caries-free' children (CF) were calculated.

Mottling due to fluorosis was assessed on the buccal surfaces of all permanent teeth using the Thylstrup & Fejerskov index (1978). The higher of two scores was taken as the common score for a pair of homologous teeth being at least 75% erupted (mainly premolars in 12-13 year-olds). In absence of a homologous pair the score of the single present tooth was considered. For descriptive analyses of the central incisors, first bicuspids, and first molars the TF-index was stratified as follows: no fluorosis (TF=0), mild (TF=1+2), moderate (TF=3+4), severe (TF=5+6), and very severe (TF=7-9).

Water fluoride concentrations were determined by measurement of a duplet of water samples taken from taps (centralised water supplies) of each school location (Orion Auto chemistry System 960, Fisher Scientific, Ulm, Germany) using an ion-specific electrode (type 96-09 BNC; Fisher Scientific). TISAB III (1:10; Fisher Scientific) was used to control the ionic strength of the water samples. The instrument was standardised with 0.1 M fluoride solution (Fisher Scientific).

Table 1. Descriptive (percentage distribution within each area) and bivariate analyses of the interview data of the 12-16 year-olds in Iran

	LF-area (n=187)	*HF-area (n=186)*	*p*
Gender			
Male	48	46	
Female	52	54	n.s.
Age			
12/13	51	51	
15/16	49	49	n.s.
Father's occupation (n=176; n=184)			
Low	40	60	
High	60	40	<0.001
Mother's employment			
Yes	12	5	
No	88	95	<0.05
Daily brushing			
Yes	90	72	
No	10	28	<0.001
Favourite drinks (n=180; n=181)			
Soft drinks/Juices	94	97	
Water/Tea	6	3	n.s.
Daily sweets consumption			
never/once	35	25	
>once	65	75	<0.05
Annual dental visits			
Yes	66	37	
No	34	63	<0.001
Using brush and toothpaste			
Yes	83	62	
No	17	38	<0.001
Average mark in school (range 10-20)			
<17	30	54	
≥17	70	46	<0.001

Significant differences (p) of frequencies (%) between both areas are indicated with level of significance (χ^2 test).

To study the intra-individual reliability of the caries assessment, we did not do a test-retest assessment of the children. Instead, we measured intra-examiner consistency by comparing the caries scores of one side with those of the other side. Pearson's correlation coefficients of DMFS between both sides were calculated and corrected to determine the reliability coefficient (Rugg-Gunn and Holloway, 1974).

Caries experience (DMFS/DMFT) and fluorosis prevalence (TF) between long- and short-time residents was analysed (Mann-Whitney and χ^2 test, respectively). Frequency distributions of the interview data of both areas were compared using χ^2 tests. DMFT, DMFS, DT, MT, and FT (Mann-Whitney tests) as well as CF and TF scores (χ^2 tests) were analysed with respect to area and gender within both age groups. DMFT and DMFS in relation to dental fluorosis on upper central incisors were compared for children from the HF-area (Mann-Whitney test). All tests were performed at a 5% level of significance (SPSS 11.5; SPSS, Munich, Germany).

To estimate adjusted relative risks (RR) and corresponding 95% confidence intervals, we set up log risk regression models by use of PROC GENMOD (SAS 9.1; SAS Institute, Cary, North Carolina). Outcomes were dichotomised as follows: caries (DMFS=0 / DMFS≥1) and fluorosis score on upper central incisors (TF=0 / TF≥1). To identify the minimal sufficient set of adjustment variables, we used a causal diagram (DAG) (Greenland *et al.*, 1999) to specify our assumed causal structures. According to our DAG, age and SES as measured by father's occupational status (low / high) belonged to the adjustment set. Regression model #1 is the unadjusted model which presents the crude effect estimates. Model #2 adjusts for the identified confounders. We studied the sensitivity of our results due to caries misclassification by changing the threshold of caries (DMFS) and fluorosis (TF) classification from score 1 to score 2 (model #3).

Results

Water fluoride concentrations were measured at similar concentrations as reported by the authorities [HF: mean 3.2 (sd 0.3) mgF-/l and LF: 0.3 (0.1) mgF-/l]. A total of 373 school children were examined, of whom 22% had moved to the respective district. Since comparable caries experience could be observed for lifelong and non-lifelong residents (p>0.05; Mann-Whitney test), data of both groups were pooled. However, both groups differed significantly with respect to fluorosis scores in the HF-area (p<0.05; χ^2 test), whereas in the LF-area length of residency did not affect fluorosis scores significantly (p>0.05). Teachers reported a high attendance rate of their pupils on the days of examination (>95%) and all children present agreed to participate. Intra-examiner reproducibility of caries assessment according to the internal consistency method yielded a correlation coefficient of 0.87 (good agreement).

Comparison of the frequency distributions of the interview data revealed significant differences between both areas for various variables as sweet consumption, parents' occupational status, school performance, dental visits, and oral hygiene (p<0.05; χ^2 test). Percentage of examined boys and girls, percentage distribution within age groups and consumption of soft drinks/juices as a favourite drink were similar within both areas (p>0.05) (Table 1). No fluoridated salt or tablets were used.

DMFS, DMFT, DT, and FT values were significantly higher (p<0.05; Mann-Whitney test), CF-, and TF-scores were significantly lower in the LF- (p<0.05; χ^2 test) compared with the HF-area. Outcomes were similar between both genders (Table 2).

In the LF-area only few opacities due to fluorosis (TF>0) could be observed on upper and lower central incisors (6% and 1%, respectively), first bicuspids (both 1%) and first molars (both 1%) for all residents. As mentioned above in the HF-area lifelong residents differed significantly from non-lifelong residents in TF-scores (p<0.05; χ^2 test). Therefore, only data of the lifelong residents of children are depicted (Figure 1). In the HF-area high percentage of children showed severe fluorosis (TF≥5), being most prevalent on upper (56%) and least on lower (13%) central incisors. Lateral incisors, second bicuspids, and second molars in each quadrant showed very similar frequency distributions as their respective counterparts central incisors, first bicuspids, and first molars, respectively.

Table 3 presents crude relative risk ratios of water fluoride concentration on caries (all residents) and fluorosis prevalence (only lifelong residents) as well as regression models adjusted for age as well as for age and status of father's occupation (SES). A negative and a positive association between fluoride level in drinking water and the risk of caries and fluorosis prevalence, respectively, could be revealed. In the age- and SES-adjusted model a relative risk ratio [RR (95% confidence interval (CI)] of 0.68 (0.6-0.8) was calculated. For fluorosis prevalence the risk estimate (CI) was 17 (8-33). Sensitivity analyses for caries [0.56 (0.4-0.7)] and fluorosis [17 (8-33)] yielded to similar estimates as the respective main model.

DMFS and DMFT in the HF-area were significantly higher with TF-scores %+ compared to TF-scores <5 (p<0.05; Mann-Whitney test) (Table 4).

Discussion

In this study, we provide evidence that 'above-optimal' water fluoride concentration (3.2 mgF-/l) decreases the risk of caries in adolescents. However, this effect is accompanied by a considerably higher risk of fluorosis. Moreover, the study could show a positive relationship between fluorosis and caries in the area with relatively high water fluoride concentration.

Several previous studies on the effects of relatively high water fluoride levels (>2 mgF-/l) on caries and fluorosis experience agree with the present data (Cortes *et al.*, 1996; Ekanayake and van der Hoek, 2002; Narbutaite *et al.*, 2007). However, also neutral (Ermis *et al.*, 2003) or even positive (Awadia *et al.*, 2002; Ekanayake and van der Hoek, 2002) association between water fluoride concentration and caries prevalence have been reported. In particular, comparison of fluorosis levels between studies is complicated by different teeth being evaluated, different indices used and inter-examiner variability (Cochran *et al.*, 2004). Moreover, potential confounders should be considered. This study used an up to date strategy (DAG) to specify assumed causal structures to identify the minimal sufficient set of adjustment variables for regression analysis. An advantage over identification of potential confounders by purely statistical methods (i.e. forward/backward analyses) is that *a priori* knowledge is used so potential confounders are only considered if they are supported by a causal structure (Greenland *et al.*, 1999). Sensitivity analyses of both outcomes revealed similar results. Therefore, the observed associations between water fluoride concentration and caries (inverse) as well as fluorosis (positive) are considered valid and corroborate previous results (Cortes *et al.*, 1996; Narbutaite *et al.*, 2007).

Natural water fluoride concentration is relatively stable since the years of maturation of the teeth of the examined children. Other current sources of fluoride delivery as toothpaste, fluoridated tablets or salt were taken into

Table 2. Means (sd) and frequency distributions (%) of the dental status of the 12-13 and 15-16 year-olds children from the two areas in Iran

			Caries data, mean (sd)					*%**		*Fluorosis# %*	
Area	*Age*	*n*	*DMFS*	*DMFT*	*DT*	*MT*	*FT*	*CF*	*n*	*TF>0*	*TF>2*
LF	12-13	96	3.4 (5.9)	1.9 (2.5)	1.4 (2.0)	0.1 (0.4)	0.5 (1.3)	33	77	7	1
HF		95	2.4 (5.5)	1.1 (2.2)	0.9 (2.2)	0.1 (0.2)	0.1 (0.3)	55	68	93	87
LF	15-16	91	6.6 (6.2)	4.1 (3.5)	2.4 (2.5)	0.1 (0.5)	1.5 (2.5)	16	76	4	3
HF		91	4.9 (7.6)	1.8 (2.5)	1.4 (2.1)	0.2 (0.6)	0.2 (1.0)	43	70	91	86

*caries-free (CF) #only lifelong residents
DMFS, DMFT, DT, and FT ($p<0.05$; Mann-Whitney test) as well as CF- and TF-scores ($p<0.05$; χ^2 test) differ significantly between the two areas within both age groups.

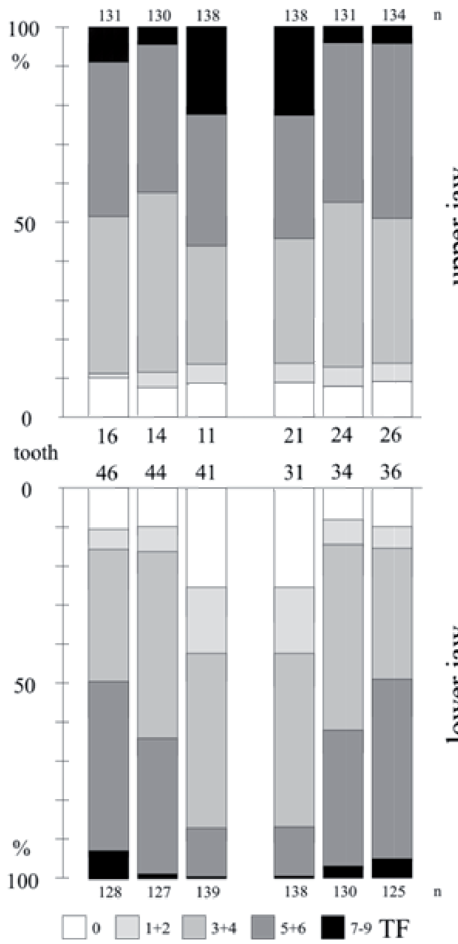

Figure 1. *Percentage distributions of the fluorosis scores [TF 0-9; (Thylstrup and Fejerskov, 1978)] for the buccal surfaces of the lower and upper central incisors, first bicuspids and first molars for the lifelong residents in the high-fluoride area (Pol Dasht)*

Table 3. Estimated relative risks and 95% confidence intervals for the association between water fluoride concentration and risk of caries (DMFS=0 / DMFS>0) as well as fluorosis (TF=0 / TF>0) among Iranian adolescents

model	*caries*		*fluorosis#*	
	LF-area	*HF-area*	*LF-area*	*HF-area*
1*		0.7 (0.6-0.8)		18 (9-35)
2+	Reference	0.7 (0.6-0.8)	Reference	17 (8-33)
3°		0.6 (0.4-0.7)		17 (8-33)

*crude relative risk estimates (model #1) for caries (DFMS=0 / DFMS>0) (n=373) and fluorosis occurrence (#only lifelong residents; TF=0 / TF>0) (n=291),
+models #2 adjusted for age and SES (n=360),
°sensitivity models (#3) accounting for misclassification of both outcomes (dichotomised as ≤1 / >1) adjusted for age and SES (n=360).

Table 4. Means (sd) of caries experience (DMFT, DMFS) of lifelong residents from the high-fluoride area (n=138) related to dental fluorosis on upper central incisors

TF	*n*	*DMFS*	*DMFT*
0-2	19	2.2 (6.0) A	0.9 (2.0) A
3+4	42	1.7 (2.8) A	0.7 (0.9) A
5+6	46	4.8 (7.0) B	1.9 (2.6) B
7-9	31	5.9 (9.2) B	2.1 (3.5) B

DMFS and DMFT differ significantly between the various fluorosis scores as indicated with different superscript letters ($p<0.05$; Mann-Whitney test) (n=size of sample).

account as well. Fluoride from toothpaste might not have contributed to a great extent to the fluoride uptake, since toothpastes from Iran were shown to contain less fluoride than claimed (unpublished). Moreover, reliability of interview data of adolescents should be treated with caution (Kwan and Williams, 1998). Nevertheless, it seems to be very likely that in particular in the high-fluoride area tap water has been the predominant source of fluorides.

Positive (Ekanayake and van der Hoek, 2002; Wondwossen *et al.*, 2004) as well as negative (Eklund *et al.*, 1987; Yoder *et al.*, 1998) relationship between fluorosis severity and caries experience in areas with high water fluoride concentrations have been observed. Differentiation between severe forms of fluorosis from caries at D3 level is rather difficult. Therefore, we did not perform a surface level analysis. In general, data presented on this issue seem rather weakened by confounding or inadequate sample size. Therefore, this association should be re-examined carefully in high-fluoride areas (>2.0 mgF-/l) using larger sample sizes; although this study clearly corroborates a positive association between fluorosis severity and caries experience in HF-areas.

Several Iranian studies of adolescents' caries and fluorosis experience have been published since 1995. DMFT between 0.4 and 2.0 has been reported for 12-13 year-olds (Meyer-Lueckel *et al.*, 2007; Pakshir, 2004; Ramezani *et al.*, 2004). Similar results were observed for both areas in the present study. Moreover, for the LF-area negligible fluorosis occurrence was reported as in other Iranian areas with similar low water fluoride concentrations (Meyer-Lueckel *et al.*, 2007).

Fluorosis develops during maturation, which is completed at differing ages for various teeth. Therefore, fluorosis severity and prevalence differ within the dentition (Fejerskov *et al.*, 1990). However, in the present study fluorosis was similar among incisors, bicuspids, and molars, less severe in lower incisors. A reason might be that these teeth mature during the first months of life, where nutrition might be less reliant on tap water.

There are factors limiting our results. First, sampling was at the convenience of the local authorities. However, those authorities were unaware of the relationship between fluoridation, caries and fluorosis which might have influenced their choice. Second, misclassification of potential confounders might have occurred in particular for 'father's occupational status' used as a surrogate for SES being considered more reliable than parents' income or education for the population of studied. Third, dental chairs and professional light sources were not available though the use of artificial light sources allowed detection of caries at the dentinal level. A visual caries detection method was used instead of the more conservative approach scoring only lesions with cavities at least 0.5 mm in size, which should have resulted in more sensitive caries diagnosis (Pitts, 2008). Fourth, fluorosis was scored without using pressured air, before taking photographs of the buccal surfaces. Prolonged drying results would have resulted in higher differences in refractive indices between tooth structure and pores, since saliva in the pores is replaced by air and most probably in higher fluorosis scores (Cochran *et al.*, 2004). For both reasons (light and drying condition) fluorosis scores might be underestimated. Nonetheless, this holds mainly true for lower TF scores. Fifth, reliability was not assessed by a test-retest procedure. This intra-examiner consistency approach has been discussed recently (Meyer-Lueckel *et al.*, 2006). Reliability of fluorosis scoring was not determined, but validity of clinical fluorosis scoring was assessed by comparison with fluorosis scores assessed from digital photographs of teeth in the upper jaw (bicuspids to bicuspids) (unpublished).

In summary, caries experience of schoolchildren in the examined areas in Iran is quite low. 'Above-optimal' water fluoride concentration seems to be effective in reducing caries prevalence, but increases the occurrence of fluorosis. Severe fluorosis seems to be associated with higher caries occurrence in a high-fluoride area.

Acknowledgements

We thank the West-Azerbaijan authorities for their support.

References

Awadia, A.K., Birkeland, J., Haugejorden, O. and Bjorvatn, K. (2002): Caries experience and caries predictors--a study of Tanzanian children consuming drinking water with different fluoride concentrations. *Clinical Oral Investigations* **6**, 98-103.

Cochran, J.A., Ketley, C.E., Sanches, L., Mamai-Homota, E., Oila, A.M., Arnadottir, I.B., van Loveren, C., Whelton, H.P. and O'Mullane, D. (2004): A standardized photorapic method for evaluating enamel opacities including fluorosis. *Community Dentistry and Oral Epidemiology* **32** (Suppl. 1), 19-27.

Cortes, D.F., Ellwood, R.P., O'Mullane, D. and de Magalhaes Bastos, J.R. (1996): Drinking water fluoride levels, dental fluorosis, and caries experience in Brazil. *Journal of Public Health Dentistry* **56**, 226-228.

Ekanayake, L. and van der Hoek, W. (2002): Dental caries and developmental defects of enamel in relation to fluoride levels in drinking water in an arid area of Sri Lanka. *Caries Research* **36**, 398-404.

Eklund, S.A., Burt, B.A., Ismail, A.I. and Calderone, J.J. (1987): High-fluoride drinking water, fluorosis, and dental caries in adults. *Journal of the American Dental Association* **114**, 324-328.

Ermis, R.B., Koray, F. and Akdeniz, B.G. (2003): Dental caries and fluorosis in low- and high-fluoride areas in Turkey. *Quintessence International* **34**, 354-360.

Fejerskov, O., Manji, F. and Baelum, V. (1990): The nature and mechanisms of dental fluorosis in man. *Journal of Dental Research* **69** Spec No, 692-700.

Greenland, S., Pearl, J. and Robins, J.M. (1999): Causal diagrams for epidemiological research. *Epidemiology* **10**, 37-48.

Kwan, S.Y. and Williams, S.A. (1998): The reliability of interview data for age at which infants' toothcleaning begins. *Community Dentistry and Oral Epidemiology* **26**, 214-218.

Meyer-Lueckel, H., Bitter, K., Shirkhani, B., Hopfenmuller, W. and Kielbassa, A.M. (2007): Prevalence of caries and fluorosis in adolescents in Iran. *Quintessence International* **38**, 459-465.

Meyer-Lueckel, H., Paris, S., Shirkhani, B., Hopfenmuller, W. and Kielbassa, A.M. (2006): Caries and fluorosis in 6- and 9-year-old children residing in three communities in Iran. *Community Dentistry and Oral Epidemiology* **34**, 63-70.

Narbutaite, J., Vekhalahti, M.M. and Milciuviene, S. (2007): Dental fluorosis and dental caries among 12-yr-old children from high- and low-fluoride areas. *European Journal of Oral Science* **115**, 137-142.

Pakshir, H.R. (2004): Oral health in Iran. *International Dental Journal* **54**, 367-372.

Petersen, P.E. and Lennon, M.A. (2004): Effective use of fluorides for the prevention of dental caries in the 21st century: the WHO approach. *Community Dentistry and Oral Epidemiology* **32**, 319-321.

Pitts, N.B. (2008): The impact of diagnostic criteria on estimates of prevalence, extent, and severity of dental caries; In: *Dental Caries: The disease and its clinical management*, 2nd edn; eds. Fejerskov, O. and Kidd, E.A.M. pp147-159. Oxford: Blackwell Munksgaard.

Ramezani, G.H., Valaei, N. and Eikani, H. (2004): Prevalence of DMFT and fluorosis in the students of Dayer city (Iran). *Journal of the Indian Society of Pedodontics and Preventive Dentistry* **22**, 49-53.

Rugg-Gunn, A.J. and Holloway, P.J. (1974): Methods of measuring the reliability of caries prevalence and incremental data. *Community Dentistry and Oral Epidemiology* **2**, 287-294.

Thylstrup, A. and Fejerskov, O. (1978): Clinical appearance of dental fluorosis in permanent teeth in relation to histologic changes. *Community Dentistry and Oral Epidemiology* **6**, 315-328.

Wondwossen, F., Astrom, A.N., Bjorvatn, K. and Bardsen, A. (2004): The relationship between dental caries and dental fluorosis in areas with moderate- and high-fluoride drinking water in Ethiopia. *Community Dentistry and Oral Epidemiology* **32**, 337-344.

Yoder, K.M., Mabelya, L., Robison, V.A., Dunipace, A.J., Brizendine, E.J. and Stookey, G.K. (1998): Severe dental fluorosis in a Tanzanian population consuming water with negligible fluoride concentration. *Community Dentistry and Oral Epidemiology* **26**, 382-393.