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Caries and fluorosis in 6- and 9-year-old children residing in three communities in Iran

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Abstract – *Objectives:* The aim of this study was to investigate the caries and fluorosis prevalence among 6- and 9-year-old students in three communities in Iran with varying urbanization and fluoride in piped water. *Methods:* Data were obtained from 523 dental examinations of 6- and 9-year olds in an upper middle class district in Teheran (T) (0.3 mg F/l), the city of Semnan (S) (1.3 mg F/l), and the village Dibaj (D) (0.2 mg F/l). *Results:* Children in the naturally fluoridated town showed slightly higher dmfs/dfs (SD) values for both 6-year olds [S: 9.1 (9.2), T: 7.2 (7.4), D: 7.1 (6.1)] and 9-year olds [S: 6.0 (6.2), T: 4.4 (4.2), D: 5.0 (4.7)], whereas the mean dmft/dft values as well as the numbers of caries-free children were comparable. A lower prevalence of dental restorations was reported for both Semnan and Dibaj compared with Teheran. A higher prevalence of fluorosis [Tooth Surface Index of Dental Fluorosis (TSIF) 3–7] was observed in the naturally fluoridated town compared with the low-fluoridated communities. *Conclusions:* The ingestion of naturally fluoridated water (1.3 mg F/l) seemed to have a negligible effect on caries prevalence, but resulted in higher prevalence of dental fluorosis. It is emphasized that the study population was not adjusted for socioeconomic status, availability of dental care nor for exposures to other sources of fluoride. Nevertheless, it can be concluded that caries prevalence in Iran is quite low compared with that in other countries in the Middle East and that the elevated fluoride levels in the drinking water in Semnan may contribute to the development of mild to severe fluorosis.

Key words: caries prevalence; epidemiology; fluorosis; Iran; Middle East; public health; water fluoridation

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Water fluoridation at the 1.0 mg F/l level is supposed to be beneficial for caries prevention, excessive ingestion of flouride during maturation may cause dental fluorosis (1). On the contrary, it is known that the relative effectiveness of systemic fluoridation has diminished over time since the 1990s when caries decline has leveled off in economically developed countries. Here, population-based preventive programs like water fluoridation might no longer be effective because a relatively low caries prevalence has already been achieved (2–5) – this hypothesis has not been supported by two recent studies (6, 7). It is emphasized that, particularly with the widespread use of fluoridated dentifrice, it may nowadays be difficult to discern the effects of water fluoridation in the general population.

Data concerning caries prevalence from developing countries reveal a wide range of experiences (8). In various countries with emerging market economies (e.g. India, Nepal and Sri Lanka), caries prevalence is on the rise. With increasing urbanization, people switch from traditional starchy, staple foods to refined carbohydrates (9). Moreover, insufficient dental care as well as lack of preventive regimens have been blamed for this development (8).

From Iran, only negligible data about caries prevalence or fluorosis can be found in the accessible literature. Public dental health programs using

systemic fluoridation are not established, although some studies reported higher concentrations of natural fluoride in the drinking water in some provinces (10–12). In Iran, tap water is used commonly. In order to give recommendations about the needs in dental health regimens in different locations in Iran, the aim of this first cross-sectional study was to compare caries and fluorosis prevalence of 6- and 9-year-old schoolchildren residing in three communities.

Subjects and methods

This cross-sectional study was carried out in three communities in northern Iran on schoolchildren aged 6 and 9 years. The clinical examination took place from February to April 2003. Approval to the study was given by the Division of Education in Iran. Consent for inclusion in the study was obtained from the principals of the selected schools who were also requested to inform the parents about the study to give them the possibility for negative consent prior to the examination.

Community 1 was situated in the northern part of Teheran (district 6, Youssefabad), which is known as a place of a higher socioeconomic level (upper middle class) in the capital of Iran. From the 10 basic schools (six girls', four boys' school) of the district, one of each public boys' and girls' schools was chosen randomly and the children of each three randomly chosen classes of the relevant grades were examined. Community 2, a town named Semnan (lower middle class), is located in the province Semnan (lower middle class). From 54 primary schools (30 girls', 24 boys' school) in this city, one of each public boys' and girls' schools was chosen and the students of each two classes of the relevant grades were asked to participate in the study. None of the children present refused to be examined. The third community, a village named Dibaj (3), is located in the mountains of the province Semnan. From the only primary school (coeducation), all attending 6- and 9-year-old children were examined.

The water fluoride concentration was controlled by measurement of a triplet of water samples taken from three different water taps in each location (Orion Auto chemistry System 960; Fisher Scientific, Ulm, Germany) using an ion-specific electrode (type 96-09 BNC; Fisher Scientific). TISAB III (Fisher Scientific) was used to control the ionic strength of the water samples. The instrument was standardized with 0.1 M fluoride solution (Fisher Scientific).

The children were examined under natural light in well-lit school rooms with a dental mirror and a wooden spatula to hold off lips and tongue. Lesions at the dentinal (D3) level were judged as decayed, whereas sealed surfaces were assumed as sound. Findings were specified by sex and registered on standardized record sheets. For the 6-year-old pupils, dmfs/dmft was used and for children at the age of 9 years, dfs/dft was chosen as the appropriate index. The Unmet Restorative Index (UNT/unt) as the ratio of decayed teeth over decayed plus filled teeth, the individual components of the dmft/dft and the proportion of 'caries-free' children (dmft/dft = 0) were calculated. Moreover, the dmfs/dfs data were related to the dmft/dft values (SPSS 11.5; SPSS, Munich, Germany).

The distribution of the dmfs/dfs was related to various tooth types and the proportions of various sites in relation to all dmfs/dfs teeth were calculated. Mottling because of fluorosis was assessed clinically on the buccal surfaces of all existing permanent molars and central incisors as well as on all surfaces of the deciduous central incisors and first molars using the Tooth Surface Index of Dental Fluorosis (TSIF).

A single examiner was trained by an experienced examiner prior to the survey by re-examination of 10 dental students on different days. In order to estimate the reliability of the caries recording, internal examiner consistency was measured by comparing the caries scores of deciduous teeth in 6-year olds of one side with that for the other side. Pearson's correlation coefficient values were calculated for each side and corrected to determine the reliability coefficient of both sides of the mouth (13). Differences in dmfs/dmft and dfs/dft between both sexes were tested at a 5% level of significance (*t*-test) and ordinal data compared using the chi-square test.

Results

The mean concentrations of fluoride (SD) in the water samples collected were found to be 0.3 (0.02) mg F/l in Teheran, 1.3 (0.03) mg F/l in Semnan, and 0.2 (0.01) mg F/l in Dibaj. A total of 523 6- and 9-year-old schoolchildren, who had lived continuously since birth in their respective communities were examined. The nonattendance and nonconsent

rate of the randomly chosen classes were below 5%. Thus, approximately 14% (Youssefabad; Teheran), 4% (Semnan), and 90% (Dibaj) of the children living in the various communities were examined (Table 1). The percentage of examined children [male (49%) and female (51%)] was similar in the three communities ($P > 0.05$; chi-square test).

In Table 2, the caries prevalence related to the surfaces and teeth for the both ages and sexes is shown. At the age of 6 years (Table 2a), in Teheran, a comparable caries prevalence was registered for boys and girls, although male pupils showed a lower 'unt' than females. In Semnan, significantly higher dmfs and dmft values could be observed in boys than in girls ($P < 0.01$; t-test), a trend that could also be observed in Dibaj, although not being significantly different ($P > 0.05$).

The 9-year-old boys (Table 2b) showed a slightly but not significantly higher dft than girls in all communities ($P > 0.05$). For the pooled data of both sexes, the dft in Teheran was higher than that in Semnan or Dibaj, whereas the dfs value in Teheran

Table 1. Profile of the schoolchildren within the three communities in both age groups

	Teheran/Youssefabad		Semnan		Dibaj	
Inhabitants (year)	40 000[a] (2000)		142 000 (1996)		3385 (1996)	
Number of primary schools	10		54		1	
Schools chosen	2		2		1	
Age (years)	6	9	6	9	6	9
Classes in these schools	7	8	4	4	1	2
Classes examined	6	6	4	4	1	2
Children attending	135	165	117	111	55	90
Children examined	103	106	93	90	51	80
Estimated inhibitants	675	825	3100	3000	55	90
Percentage examined	15	13	4	4	93	89

[a] Number of inhabitants in Teheran/Youssefabad as estimated from the population data of Teheran.

Table 2. Mean and standard deviation values (SD) of caries prevalence in 6- (a) and 9-year olds (b) for deciduous teeth related to registered surfaces or teeth and the contribution of each dmf/df component for both sexes

Loc.	n	Sex	Mean (SD) (dmfs)	Mean (SD) (dmft)	Caries-free (%)	d/dmft	m/dmft	f/dmft	UNT (%)
(a) Age 6 years									
T	103	Total	7.2 (7.4)	3.3 (2.7)	17	1.3	0.1	1.7	42
	56	f	7.7 (8.6)	3.5 (3.1)	19	1.6	0.2	1.7	48
	47	m	6.5 (5.8)	3.0 (2.1)	15	1.0	0.1	1.8	36
S	93	Total	9.1 (9.2)	3.3 (2.9)	19	3.0	0.2	0.1	97
	48	f	5.7 (6.6)	2.4 (2.5)	23	2.1	0.2	0.1	94
	45	m	**12.7 (10.3)**	**4.2 (3.1)**	17	3.9	0.2	0.1	99
D	51	Total	7.1 (6.1)	3.6 (2.6)	12	3.3	0.1	0.2	94
	26	f	5.7 (6.7)	3.2 (3.1)	19	2.9	0.1	0.2	93
	25	m	8.6 (5.2)	4.1 (1.9)	4	3.7	0.1	0.2	94

Loc.	n	Sex	Mean (SD) (dfs)	Mean (SD) (dft)	Caries-free (%)	d/dft	f/dft	unt (%)	m (not scored)
(b) Age 9 years									
T	106	Total	4.4 (4.2)	2.6 (2.2)	23	1.0	1.4	42	11.3
	60	f	4.1 (4.0)	2.4 (2.1)	28	0.9	1.3	41	
	46	m	4.7 (4.6)	3.0 (2.5)	20	1.3	1.5	43	
S	90	Total	6.0 (6.2)	2.1 (2.0)	30	2.1	0.2	91	11.5
	44	f	5.3 (6.2)	2.1 (2.0)	30	1.9	0.2	90	
	46	m	6.7 (6.2)	2.5 (2.0)	22	2.3	0.2	92	
D	80	Total	5.0 (4.7)	2.0 (1.7)	28	1.7	0.2	88	12.1
	38	f	3.8 (4.0)	1.7 (1.6)	32	1.3	0.3	81	
	42	m	**6.0 (5.0)**	2.3 (1.8)	24	2.1	0.1	95	

Significant differences of the dmf/df values between both genders are emboldened (t-test; $P < 0.05$).
n, size of sample; UNT, Unmet Restorative Index; T, Teheran; S, Semnan; D, Dibaj; m, male; f, female.

was lower than that in Dibaj or in Semnan. In Semnan, at both ages, the relation of the mean values of dfs to dft (2.6–2.8) was higher compared with that of the other two communities (1.7–2.5). Moreover, a lower prevalence of dental restorations was reported for both Semnan and Dibaj, whereas a relatively low 'unt' could be observed in Teheran.

The percentages of caries-free permanent teeth in 9-year olds were comparable in the three communities (84–90%). Nevertheless, in Teheran, 77% of the permanent teeth (predominately occlusal surfaces of the first molars) in need of a filling were actually filled, whereas this was the case for only 23% in Semnan and 46% in Dibaj. Only few (<5% of the molars) fissure sealants could be observed in Teheran, but none in the two other communities.

The deciduous molars accounted for most of the dmfs/dfs score. In particular, the occlusal (33–55%) and buccal/lingual (35–40%) surfaces were affected. In 9-year olds, the highest proportion of occlusal dfs in deciduous molars was found in Teheran (55%), whereas this proportion was quite low in 6-year olds from Semnan (33%) (Fig. 1). A further perspective to the distribution of the dmfs/dfs is given in Fig. 2. In Teheran, the 'f' component accounted for twice as much of the dmfs/dfs as the 'd' component in deciduous molars, whereas in Semnan and Dibaj negligible numbers of filled deciduous molars were registered.

Only little opacities caused by fluorosis (TSIF > 0) could be observed in deciduous teeth in Teheran (6%) and in Semnan (2%). A higher prevalence of moderate to severe fluorosis (TSIF > 2) was found in the upper permanent first molars (10%) and central incisors (23%) in 9-year olds in Semnan. In this community, there was only a slightly enhanced chance to be caries-free when having fluorosis (TSIF > 2) on the upper central incisors (OR: 1.3; 95% CI: 0.4–4.0). As no significant differences were found for gender ($P > 0.05$: *t*-test), the pooled data for fluorosis are depicted in Fig. 3. The reliability estimates, based on internal consistency, gave a coefficient of reliability of 0.8 for the dmft scores in 6-year olds (13).

Discussion

Reliability was measured by the internal consistency method (bilateral comparison) which is supposed to give results somewhat lower than those obtained by test–retest estimation (13). This effect is due to the heterogeneous nature of caries distribution that both sides of the mouth are in fact not true mirror images of each other. Nevertheless, in a recent study in older schoolchildren (age: 12–19 years) it could be shown that bilateral occurrence of dental caries in first molars is very high (86–92%) (14), so that the total error variance is only slightly increased by the genuine variance. In the present study, only data of the 6-year olds were taken for reliability testing, as the genuine variance was very likely to be increased in 9-year olds because of missing teeth (either because of change in dentition or extraction). The internal consistency method seems to be appropriate, when test–retest reliability measurement is not feasible because of governmental restrictions (e.g. not allowed to go to the schools more than once) or infrastructural difficulties. In these cases, reliability determination by test–retest estimation conducted within short periods (hours) does not meet the requirements either.

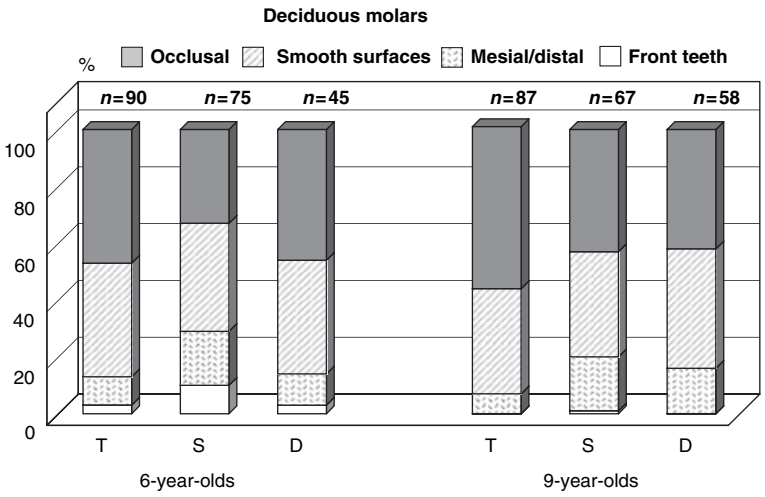

Fig. 1. Proportion of dmf/df teeth in relation to various subgroups of teeth for 6- and 9-year olds. It is obvious that <10% of the dmft/dft was observed in other teeth than deciduous molars (T, Teheran; S, Semnan; D, Dibaj).

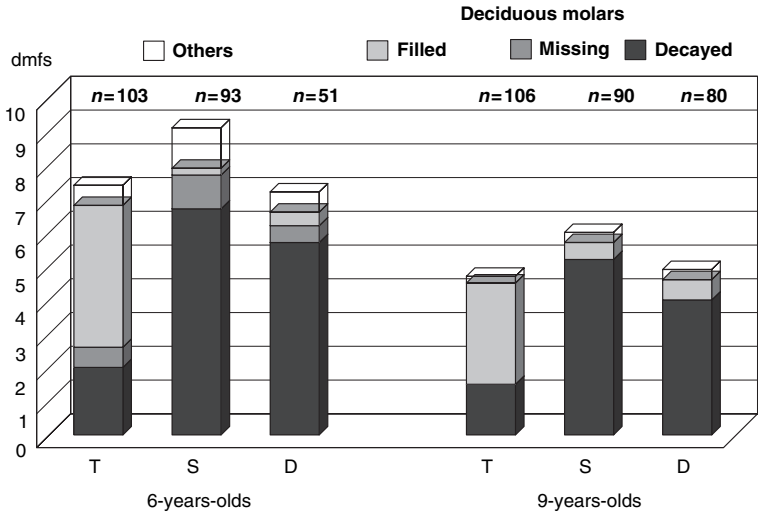

Fig. 2. Distribution of dmfs/dfs and proportion of the single components in deciduous molars for 6- and 9-year olds. Carious (Semnan and Dibaj) and filled (Teheran) deciduous molars accounted for most of the dmfs/dfs.

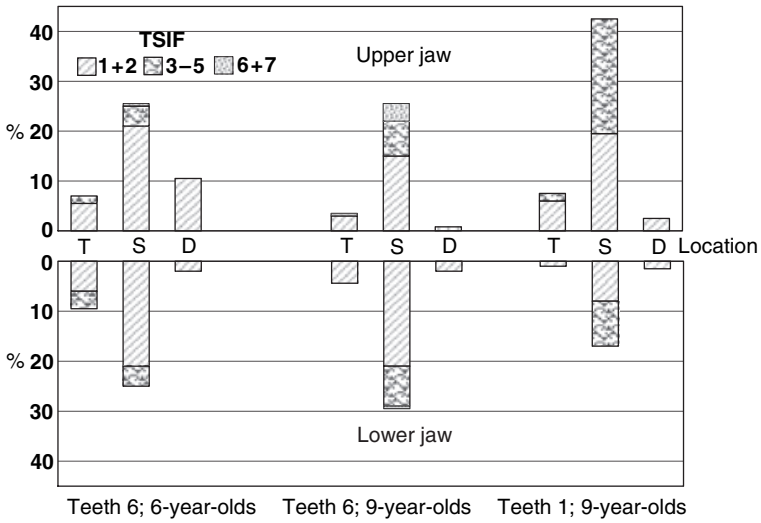

Fig. 3. Percentage distribution of the fluorosis scores (TSIF) for the buccal surfaces of the paired lower and upper first molars at both ages as well as for the upper central incisors in 9-year olds (T, Teheran; S, Semnan; D, Dibaj).

For the village Dibaj and at least partially for Youssefabad/Teheran representative data could be evaluated, which was not the case for Semnan. It should be taken into account that, because of the political and ethical issues, conducting a survey in an Islamic country is subjected to a number of governmental restrictions. As the male examiner was considered as a foreigner, numerous certifications were required to get access to the schools and it was particularly difficult for the male surveyor to be allowed to go to girls' schools. Therefore, it was unfeasible to undergo the administrational procedure in every community several times.

For reasons of hygiene (no adequate sterilization) no dental probe was used either to clean fissures and pits or caries diagnosis. Not using a probe for dental examinations does not meet the requirement of the WHO for epidemiological studies (15). However, it is widely accepted that the additional use of an explorer does not improve the diagnosis of pit and fissure caries (16). Moreover, no dental chairs and professional light sources were available. Nevertheless, the use of either artificial or natural light sources commonly available in the schools allowed discerning caries at the dentinal level appropriately.

In only a few studies, DMF/dmf scores related to the surface (and not teeth) has been used for caries evaluation (2, 5, 7, 17). As an index related to the surfaces reflects the caries prevalence more accurately, the use of an index related to teeth might give a shifted perspective of the 'real' caries prevalence in epidemiological studies. For example, a study in Italy that focused on the influence of water fluoridation on caries prevalence in two communities with either high (>2.5 mg F/l) or low (0.3 mg F/l) levels revealed a comparable DMFT, although the DMFS values were lower in the fluoridated area (5). Thus, if only DMFT had been scored, no benefits of the fluoridated water would

have been observed, which was actually seen when DMFS was calculated. Therefore, an index related to surfaces might give a more accurate view in epidemiological studies.

At higher water fluoride concentrations (2.2–6.0 mg F/l), moderate to severe dental fluorosis is highly prevalent in the primary dentition (18, 19). Studies have also documented that primary tooth fluorosis can be found in areas with fluoride levels of 0.8–1.5 mg F/l or even below 0.5 mg F/l (20, 21). In these regions, fluorosis is most likely caused by postnatal exposures, and are observed particularly in the primary second molars which maturate after birth. Therefore, it is not surprising that in the present study, where only the primary first molars and central incisors were judged, negligible primary-tooth fluorosis could be detected. Moreover, in epidemiological studies not using a professional light source the primary-tooth fluorosis might easily be overlooked particularly in the molars, because it is often hard to recognize under these circumstances (22). Therefore, the values reported for fluorosis in the primary dentition might be underestimated in the present study. Similar fluorosis in permanent teeth could be found in two recent studies for communities with slightly lower water fluoride levels (6, 7), although it seems to be rather difficult to compare fluorosis levels either because of the evaluation of various teeth or the use of different indices in these studies.

From Iran, only one study on dental health is available in the accessible dental literature, reporting a very high prevalence of nursing caries (20%) (23). In addition to two studies (24, 25), several studies are available from the Middle East in the relevant age groups. From Saudi Arabia a slightly higher dmft compared with the data of the present study could be observed in 6- (5.1), and 8–9-year-olds (4.6) (26, 27). Recently, a similar level of caries-free children (17%) could be observed in Saudi Arabia (28), albeit the 5-year-old children showed double dmft (7.1) compared with the 6-year-old Iranians in the present study. In Oman (4.6) and Iraq (5.2) slightly higher dmft values were reported for 6-year olds (26, 29). Five-year olds in Abu Dhabi showed a much higher dmft (5.7 and 8.6) (30), whereas the caries prevalence in Jordan (4.6) seemed to be comparable with that this study (31). These levels of caries from Arabian countries are much higher than those stated for Europe, which range from 0.8 to 3.1 for 5-year olds (32). Thus, caries levels in 6-year olds from Iran are rather low compared with that of other Arabian countries but comparable with those experienced in some industrialized countries.

In the present study, fluoridated water did not seem to have a positive effect on dental health, as it might have been expected in a community with the respective caries prevalence. Although, controversy exists about the beneficial effects of fluoridated water in low-caries populations (2, 3, 6), its benefits in high-caries-prevalent cohorts are generally accepted (33). The observations in the present study might be explained by differences in socioeconomic backgrounds, diet, sources of fluoride as well as varying urbanization of the areas.

Studies from either developed (34, 35) or developing countries (25, 31) revealed a lower caries prevalence for the well-off. In Saudi Arabia, students from private schools had lower dmft values than those from public schools (24). In the present study, the district Youssefabad consisted of schoolchildren with a relatively high socioeconomic status (SES). Since the children from the naturally fluoridated town Semnan had a lower SES, one might think that the comparison between Teheran and Semnan might be compromised. On the contrary, it has been shown in a study from Abu Dhabi that high parental education attainment is related to lower caries experience, and conversely, high parental income is related to higher caries experience (30). Moreover, the rural community showed a similar caries prevalence as reported for Teheran. As two studies from neighboring countries revealed no influence of urbanization (30, 36) on dental caries experience, the data from Youssefabad, Teheran seem to be appropriate for an estimation of the caries prevalence.

In the present study, differences in the caries pattern were found between Semnan and Teheran. On the one hand this might be explained by more smooth surface decay in Semnan in particular in molars, whereas on the other, the higher number of occlusal fillings in molars in Teheran compared with Semnan gives an additional explanation. It is speculated that this greater amount of restorations might result from a higher dentist to population ratio in Teheran. As a similar number of dental visits could be observed in both communities with older students (H. Meyer-Lueckel, K. Bitter, B. Shirkhani, W. Hopfenmuller, A. M. Kielbassa, unpublished data) the greater number of dentists in Teheran having subsequently fewer patients might be more aware of their patients and set lower thresholds for cavity preparation.

The significant differences in caries prevalence for gender in Semnan might be due to the varying SES of the schools chosen, if one presumes that in this city a more privileged girls' than boys' school was selected. Nevertheless, in Dibaj, where almost every domestic 9-year-old could be examined, a significant difference in dfs for gender could also be observed. Moreover, a tendency of male students having more decay could be confirmed in most of the age groups and locations, as well. In previous studies in Saudi Arabia, a lack of consistent differences between the two genders (28, 30, 37) as well as a higher caries prevalence for males could be observed (36). Therefore, it is likely that the observed differences between genders really exist, and might be explained by cultural differences in growing-up boys and girls in an Arabian population.

It can be concluded, that the caries prevalence in the three districts examined in Iran were quite low compared with that in other countries in the Middle East. An improved professional dental care, as it can be partly stated for a district with a higher SES in Teheran, would be desirable for the whole of Iran. No obvious benefits of water fluoridation could be confirmed, although it has to be taken into account that the sample chosen was neither adjusted to SES, individual dental care nor the exposure to other fluoride sources.

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