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The relationship between aging and oral health inequalities assessed by the DMFT index

ABSTRACT

Aim A cross-sectional study to determine the caries experience characteristics and their relationship with aging.
Materials and methods Using stratified sampling method, 748 subjects divided into 3 age groups of 11-14, 14-17 and 17-20 year-olds (355 females and 393 males, aged 15.11 ± 2.23 years) were examined in urban area of Isfahan (Iran). The DMFT scores (DT, MT, FT) were recorded. The Student t-test was used to assess any differences in the mean DMFT score between genders. Simple (DMFT >0), severe caries experience (DMFT >8), severe form of filling (FT>3), and decay (DT>6) were calculated. Chi-square tests were performed to assess any relationship between gender and DMFT variables. Binary logistic regression was used to estimate the predictive value of gender and age groups for the DMFT categories dichotomized into presence or absence of DMFT-related variable. Scatter plots and Spearman rank correlation coefficients were used to explore the relationships between the DMFT (DT, MT, FT) and participant's age.
Results The mean DMFT values for the sample, 11-14, 14-17 and 17-20 year-olds were 4.94, 3.03, 5 and 6.66, respectively. Caries prevalence (DMFT >0) and active caries prevalence (DT >0) were 88.8 and 81.8 percent, respectively. Prevalence of active caries (DT) did not vary significantly between genders; however, prevalence of fillings (FT) was higher in females (OR=1.96, 95% CI, 1.45-2.67). The odds of experiencing caries (DMFT, DT, FT) increased with increase in participant's age. Prevalence of subjects with DT>6 was higher in males than in females (OR=1.50, 95% CI, 1.04-2.01). Prevalence of subjects with FT>3 was higher in females than in males (OR=1.74, 95% CI, 1.10-2.73). Significant positive correlations existed between the participant's age and DMFT (rho = 0.40), DT (rho = 0.34) and FT scores (rho = 0.194), respectively.
Conclusion Caries experience was highly prevalent in our sample. With increase in age, there was an upward trend in caries prevalence and mean DMFT.

Introduction

Caries experience is believed to be on the raise in many third world countries and this is mainly due to increase in consumption of processed carbohydrates and sugar [Sheiham, 1984]. Cleaton-Jones et al. [2006] reviewed the published materials on caries experience between 1970 and 2004 and found out that both mean prevalence and mean DMFT were lowest in Sub-Saharan Africa and highest in Latin America and the Caribbean. However, the common perception that dental caries rates are increasing in developing countries was not supported in this systematic review [Cleaton-Jones et al., 2006]. Etiology of dental caries is a complex one and is associated with factors such as tooth brushing frequency [Chestnutt et al., 1998], fluoride exposure [Featherstone, 1999; Zero, 2006], and receipt of sealants [Hiiri et al., 2006].

With aging the caries experience follow some established patterns. Sheiham and Sabbah [2010] reviewed the previous studies and suggested that there are some established characteristics and trends in dental caries patterns of permanent teeth that can be used for interpreting data and planning dental services for populations. Previous studied showed that there were clear trends in caries prevalence from the age of 5 to 32 years [McDonald and Sheiham, 1992; Broadbent et al., 2008]. According to Massler et al. [1954], McDonald and Sheiham [1992], and Broadbent et al. [2008] the level of caries at 6 years of age can predict the caries level in adulthood.

One of the indices that provide information on oral health status is the DMFT index. Based on previous studies caries experience (DMFT) is quite common in Iranian children (Table 1). Few studies investigated the oral health status in Iran and reported DMFT values that ranged from 0.38 to 4.3 (Table 1). However, these studies were carried out mainly in the capital (Tehran) and few surrounding cities. To our knowledge the trends and characteristics of caries experience in different age groups has not been investigated in the Iranian population. Therefore, the primary aim of this investigation was to determine the mean caries experience (DMFT and its components) for three age groups of 11-14, 14-17, and 17-20 year-olds in an urban Iranian population. The secondary aim of the present study was to investigate the relationship between caries experience and participants' age.

Materials and methods

Statistical analysis

Permission to undertake the survey was obtained from the Ministries of Health and Education. The ethical approval was given by the Research Ethics Committee and Faculty of Community Dentistry, School of Dentistry, Isfahan University of Medical Sciences.

A cross-sectional study was carried out. The target

Study / Age Range	Mean DMFT (SD)	Sample Size / Place of Study
Ramezani et al. (2004) 10-16 year-olds	1.8 (1.73)	506/ Dayer
Daneshkazemi and Davari (2005) 12 year-olds	1.8 (1.75)	1223/ Yazd and Hadi Shahr
Momeni et al. (2006) 12 year-olds	1.1 (1.5),Tehran 0.38 (0.82), Rural area	1102 / Tehran and rural area in Isfahan
Meyer-Lueckel et al. (2006) 6 and 9 year-olds	6 year-olds: Semnan: 3.3 (2.9), Tehran: 3.3 (2.7), Dibaji: 2.6 (2.6)	523 / Semnan, Tehran, Dibaji
Saied-Moallemi et al. (2006) 9 year-olds	4.2 (2.9) in boys 3.4 (2.6) in girls	459 / Tehran
Meyer-Lueckel et al. (2007) 12 and 15 year-olds	Semnan: 1.5 (1.8), Tehran: 1.2 (0.7), Dibaji: 0.7 (1.0)	593/ Semnan, Tehran, Dibaji
Hessari et al. (2008) 18 year-olds	4.3	4448 / 29 provinces
Hamissi et al. (2008) 15 and 16 year-olds	2.71 (0.86)	780 / Qazvin
Yazdani et al. (2008) 15 year-olds	2.1	506 / Tehran

TABLE 1 - *Summary of previous cross-sectional studies in Iran and the reported mean DMFT score and SD*

DMFT	N	Mean (SD)	95% CI
Whole sample	748	4.94 (3.59)	4.69-5.20
Male	393	4.89 (3.67)	4.52-5.25
Female	355	5.01 (3.51)	4.64-5.37
Age groups			
11-14	224	3.02 (2.51)	2.69-3.35
14-17	282	5.00 (3.37)	4.61-5.40
17-20	242	6.66 (3.82)	6.17-7.14

TABLE 2 - *Distribution of DMFT scores in the study sample.*

population for the present study consisted of urban Iranian school children aged 11-20 years in the city of Isfahan, Iran. This age group represents the period of eruption of the permanent canines and premolars when the majority of potential dental and orthodontic problems become evident. The subjects were further divided into 3 groups: (1):11-14, (2):14-17 and (3):17- 20 year-olds.

Isfahan is the capital city of Isfahan province and Iran third largest city. The city of Isfahan is located in the central part of Iran and houses 3% of the whole population. In the 2006 census the city had a population of 1,986,542 and the Isfahan metropolitan area had a population of 3,430,353, making it the second most populous metropolitan area in Iran after the capital.

Exclusion criteria for this study were: subjects with craniofacial anomalies (clefts and syndromes) and non-Iranian nationals. To ensure random selection from the schools, a stratified sampling method within different clusters were used in a population comprising 11-20 year-olds subjects. Forty public and private schools were selected from different geographic locations in the city of Isfahan, and between 15 to 20 subjects from different age groups were examined in each of them. Overall 748 subjects (355 females and 393 males, with mean age of 15.11 years-old) participated in this study.

The DMFT scores were recorded by two calibrated examiners. During the calibration process repeated examination of 38 subjects were carried out. The inter- and intra-examiner repeatability for the DMFT scores exceeded 80 percent agreement. The examination chairs were placed in the rooms in such a way as to ensure an adequate source of natural light while at the same time avoiding direct sunlight. A mouth mirror and a disposable dental probe were used during the examination and data collection.

ORAL HEALTH ASSESSMENT

DMFT

The DMFT, the sum of decayed (DT), missing (MT) and filled teeth (FT) indices were recorded and used to assess the oral health outcomes. The index includes a record of the presence/absence of all teeth including presumptive cause of tooth loss, and is a cumulative measure of caries experience.

Apart from using a dental explorer for detecting the cavities on the proximal surfaces, the following were sufficient to record proximal decay: if the marginal ridge showed darkening / shadowing as evidence of caries of dentine, or if caries in dentine was visualized as a loss of translucency producing a shadow in a calculus free and stain-free proximal surface.

The decayed component also included the arrested caries of dentine, with a hard, smooth, 'non-sticky' surface. Tooth filled due to decay was recorded when a tooth had one or more permanent restorations placed to treat caries. Fissure sealants were not included in the F component of the DMFT index unless there were signs of cavity preparation. If the same tooth had both a filling and a fissure sealant the filling was counted. The missing component was recorded when a tooth had been extracted due to pathology (verified by interview).

Other measures used

For this study we also assessed the presence of malocclusion using the DAI index [Cons et al., 1986], and the Aesthetic component of the IOTN index [Evans and Shaw, 1987]. The socioeconomic status of the population was also assessed during the interview (parental education, employment and household size). Presenting the other measures used for this study will be beyond the scope of this report and they will be reported separately [Borzabadi-Farahani et al., 2010].

Statistical analysis

Data were collected and entered into the SPSS 17 program for statistical analysis (Statistical Package for Social Sciences, SPSS Inc., Chicago, Illinois, USA). Histograms, bar charts and error bars were used to show
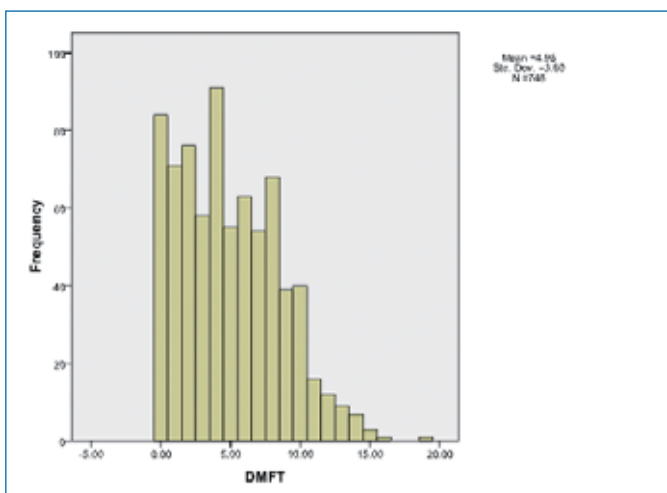
FIG. 1 - *Distribution of DMFT scores in the study sample (n = 748).*

FIG. 2 - *Boxplot of DMFT score within the different age groups.*

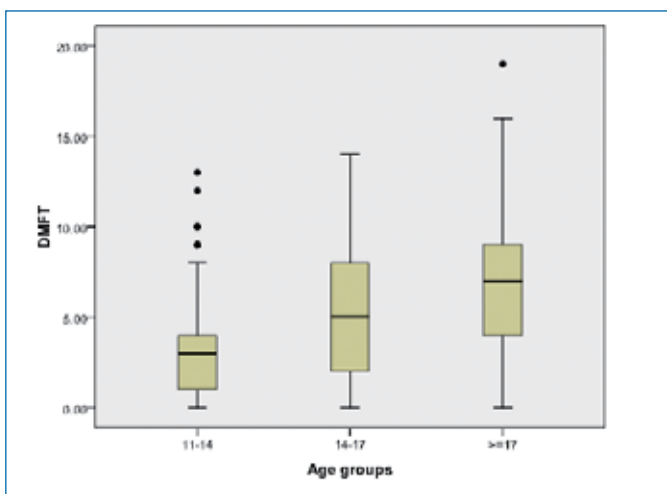**FIG. 3 -** *95% confidence interval of the mean DMFT for the different age groups.*

the distribution of DMFT scores in the study sample. Descriptive statistics such as means and standard deviations were calculated in the data analysis. Confidence intervals were calculated for the average DMFT scores for both genders and different categories investigated.

The Student t-test was used to assess any differences in mean DMFT between genders. All groups were tested with Levene's test for equality of variances before performing the t-test. Because the DMFT was not distributed normally, for the analysis we created the following two level categorical variables: simple (DMFT >0) and severe caries (DMFT >8) prevalence. We selected 9 as our cut-off value because children with a DMFT >8 were above the 75th percentile for our sample.

Chi-square tests were performed to assess any possible relationship between gender and DMFT variables (simple and severe caries prevalence). The binary logistic regression was used to estimate the predictive value of age groups for DMFT categories dichotomized into presence or absence of severe caries (DMFT>8 or DMFT=<8). The binary logistic regression was used to estimate the predictive value of gender and age groups for the presence of tooth decay (DT>0) or tooth filling (FT>0) dichotomized into yes or no.
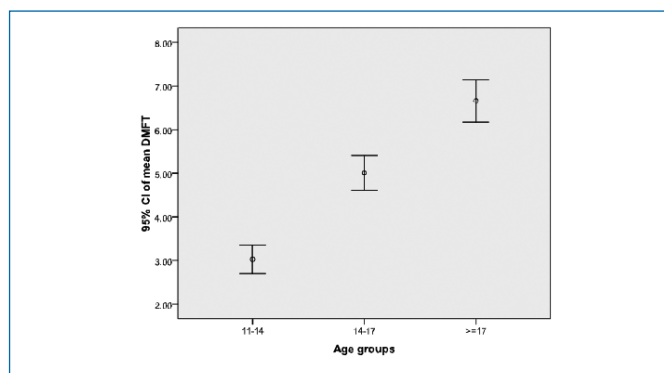
We divided the sample into 2 groups on the basis of the number of decayed teeth (DT): (DT > 6) and (DT =<6). The sample was also divided into 2 groups on the basis of the number of filled teeth (FT): (FT > 3) and (FT =<3). Again we selected 7 and 4 as our cut-off points for the number of decayed and filled teeth because children with a DT > 6 and FT>3 were above the 75th percentile for our sample, and presented the severe form of the variable, respectively. Similarly, logistic regression test were performed to estimate the predictive value of gender and age groups for the presence of severe form of tooth decay (DT > 6, DT =<6) and filled teeth (FT > 3, FT =<3) dichotomized into yes or no.

Scatter plots and Spearman rank correlation coefficients (rho) were used to explore the relationships between the DMFT scores (and its components, DT, FT, MT) and age of the participants. Any P values less than 0.05 were interpreted as statistically significant.

Results

Caries prevalence (DMFT >0) and active caries prevalence (DT >0) in the present study sample were 88.8 and 81.8 percent, respectively. The prevalence of active caries (DT) did not vary significantly between genders; however, the prevalence of fillings (FT>0) was higher in females (OR=1.96, P<0.01, 95% CI, 1.45-2.67). Table 2 shows the statistical characteristics of the study sample. The mean DMFT score for the study sample was 4.94 ± 3.59 (SD) (95% CI, 4.69-5.20). There was no significant difference for mean DMFT scores with regard to gender (P>0.05, 95% CI of mean difference, -0.63-0.39). The mean DMFT scores for male and female subjects were 4.89 ± 3.67 (SD) and 5.01 ± 3.51 (SD), respectively. Figure 1 shows the histogram of DMFT scores. Figures 2 and 3 show the box plot and 95% confidence interval of the mean DMFT for 3 different age groups, respectively. With aging, the mean DMFT showed an upward trend and increased from 3.02 point in 11-14 year-olds to 6.66 point in 17-20 year-olds. The differences in mean DMFT between the age categories were statistically significant (P<0.05) (Table 2, Figure 3).

Table 3 shows the distribution of DT and FT components of the DMFT index. The mean DT score for the sample was

DMFT		Male	Female	Total
DMFT	=0	51 (13.0)	33 (9.3)	84 (11.2)
(simple prevalence)	>0	342 (87.0)	322 (90.7)	664 (88.8)
DMFT	=<8	325 (82.7)	295 (83.1)	620 (82.9)
(severe caries prevalence)	>8	68 (17.3)	60 (16.9)	128 (17.1)
Prevalence of DT>6	>6	88 (22.4)	57 (16.1)	145 (19.4)
(severe) $	=<6	305 (77.6)	298 (83.9)	603 (80.6)
Prevalence of FT >3	>3	36 (9.2)	53 (14.9)	89 (11.9)
(severe) *	=<	357(90.8)	302 (85.1)	659 (88.1)
Total		393	355	748

$ Pearson Chi-Square=4.79, P<0.05

* Pearson Chi-Square=5.92, P<0.05

TABLE 3 - *Descriptive (%) information about the sample.*

Age group	n	% (DMFT>8)	P value	OR	95% C.I.
11-14	224	4.0	0.00	1	
14-17	282	16.3	0.00	4.65	2.22-9.73
17-20	242	30.1	0.00	10.31	5.01-21.22

TABLE 4 - *Percentages of subjects with severe caries (DMFT>8) in the study sample. Odds ratio (OR) and 95% confidence interval (CI) are relative to the group with age range of 11 to 14 year-olds.*

| Age group	n	% (DMFT>8)	P value	OR	95% C.I.
11-14	224	3.5	0.00	1	
14-17	282	14.5	0.00	4.57	2.09-9.69
17-20	242	19.8	0.00	5.32	2.43-11.64

TABLE 5 - *Percentages of subjects with (DT>6) in the study sample. Odds ratio (OR) 95% confidence interval (CI) are relative to the group with age range of 11 to 14 year-olds.*

Age group	n	% (DMFT>8)	P value	OR	95% C.I.
11-14	224	5.3	0.00	1	
14-17	282	19.2	0.00	4.20	2.18-8.07
17-20	242	32.6	0.00	8.56	4.51-16.24

TABLE 6 - *Percentages of subjects with FT>3 in the study sample. Odds ratio (OR) and 95% confidence interval (CI) are relative to the group with age range of 11 to 14 year-olds.*

3.63 ± 3.10 (SD) (95%CI, 3.40-3.85). The mean DT scores for male and female subjects were 3.77 ± 3.21 (SD) and 3.46 ± 2.96 (SD), respectively.

The mean FT score was 1.14 ± 2.12 (SD) (95%CI, 0.99-1.29). The mean FT scores for male and female subjects were 0.88 ± 1.97 (SD) and 1.43 ± 2.25 (SD), respectively.
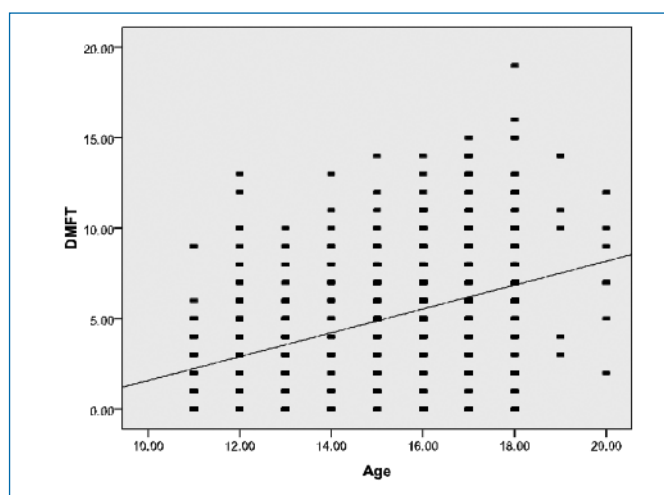
FIG. 4 - *Scatter plot of DMFT scores (caries experience) and age of the participants in the study (n=748). Solid line shows the regression line.*

Severe (DMFT>8) caries prevalence was seen in 17.1% of the study sample.

There was no significant differences between genders with regard to simple (DMFT>0, P>0.05, Chi-square=2.53) and severe (DMFT>8, P>0.05, Chi-square=0.02) caries prevalence.

Compared with the 11-14 year-olds group, the odds of observing severe caries (DMFT>8) was nearly 4.6 (95% CI, 2.2-9.7) and 10.3 (95% CI, 5.0-21.2) times higher in 14-17 and 17-20 year-olds, respectively (Table 8). Compared with the 11-14 year-olds group, the odds of observing severe form of tooth fillings (FT>3) was nearly 4.6 (95% CI, 2.2-9.7) and 10.3 (95% CI, 5.0-21.2) times higher in 14-17 and 17-20 year-olds, respectively (Tables 4-6). The prevalence of subjects with DT>6 was higher in males than in females (OR=1.50, P<0.05, 95% CI, 1.04-2.01). However, the prevalence of subjects with FT>3 was higher in females than in males (OR=1.74, P<0.05, 95% CI, 1.10-2.73). Statistically significant positive correlations existed between the age of participants and DMFT (rho = 0.40, P < 0.01), DT (rho = 0.34, P < 0.01) and FT scores (rho = 0.194, P < 0.01), respectively. Figures 4-6 show the relationship between the age of the participants and DMFT, DT and FT scores, respectively.

Discussion

For the present study, the diagnosis of dental caries was predominantly made by the visual method; however, probing with a dental explorer was used as a diagnostic adjunct, to confirm the softness of the carious lesion or the break in enamel at the proximal surfaces. A possible limitation of the current study is the lack of use of radiographs, which could result in the under-diagnosis of proximal lesions. This limitation can alter the results of the present study. For ethical reasons, radiographs were not used for caries diagnosis. The radiographic dental examination has been shown to contribute little additional information to epidemiologic data [Mitropoulos et al.,
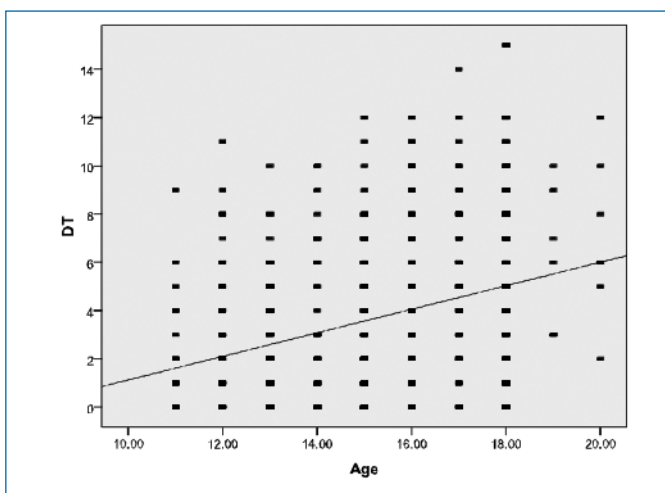
FIG. 5 - *Scatter plot of DT scores (number of active caries) and age of the participants in the study (n=748). Solid line shows the regression line.*
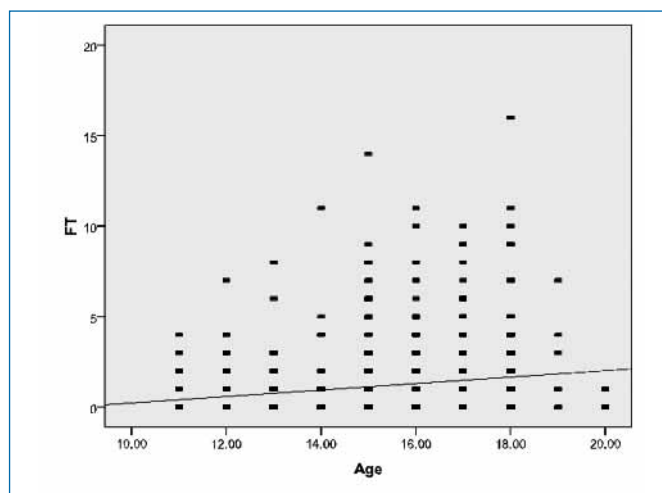
FIG. 6 - *Scatter plot of FT scores (number of tooth fillings) and age of the participants in the study (n=748). Solid line shows the regression line.*

1984]. Therefore, we think this issue has very minimal effect on our findings.

The mean DMFT (4.94) and caries prevalence (DMFT>0) (88.8%) for the present study sample was relatively high. The high caries prevalence as seen in the current study, may largely be attributed to factors such as family income, parental education, parents' dental knowledge, attitude and behavior, the child's dietary and oral hygiene habits, and place of residence. The reasons for this high prevalence could also include, increasing urbanization and switch from traditional starchy, staple foods to more refined carbohydrates [Ettinger,1999], insufficient dental care as well as lack of preventive regimens [Barmes, 1999], and finally lack of public dental health programs using systemic fluoridation [Meyer-Lueckel et al., 2006]. Nearly 82 percent of all children had one or more active or past carious (arrested caries) lesions. In general, there was no significant difference between boys and girls in terms of caries experience. This is contrary to previous reports that show that females usually have more caries than males of the same age [Burt and Eklund, 1999].

Comparison of our findings with previous studies is difficult due to different age ranges these studied employed. In our study, the mean DMFT value for 11-14 year-olds was 3.02. This was relatively higher than the reported values for 12 year-old schoolchildren in Iran (1.1-1.8) [Daneshkazemi and Davari, 2005; Momeni et al, 2006; Meyer-Lueckel et al., 2007], United Arab Emirates (1.6) [El-Nadeef et al., 2009], Syria (1.8-2.3) [Beiruti et al., 2001], Iraq (1.7) [Ahmed et al., 2007], Turkey (1.9) [Gökalp et al., 2010], 12-13-year-olds in Jordan (2.51) [Albashaireh and al-Hadi Hamasha, 2002] , and 12-year olds children in European countries (1.75-2.58) [Bollin et al., 1996]. The mean level of caries in 11-14 year-olds in our study was comparable to the reported values in 12-13-year-olds children in urban Saudi Arabia (2.69) [al-Shammery et al., 1999] and 12-14 year-olds in Yemen (3.22) [Al-Haddad et al., 2010].

The mean caries experience in 14-17 year-olds was 5. Similarly, this was considerably higher than the reported

value for 15 and 15-16 year-old schoolchildren in Iran (2.1-2.7) [Yazdani et al. 2008; Hamissi et al., 2008], 15 year-old schoolchildren United Arab Emirates (2.5) [El-Nadeef et al., 2009], Turkey (2.3) [Gökalp et al., 2010], and 14-15 year-olds in Jordan (3.13) [El-Qaderi et al., 2006]. We observed the highest caries experiences in 17-20 year-olds (6.6), which was higher than the previously reported value for 18 year-olds in Iran (4.3) [Hessari et al., 2008]. Similar to previous studies in India [Khera et al., 1984], Southwestern China [Lo et al., 1999] and Uganda [Nalweyiso et al., 2004] our data showed that decayed teeth account for the highest percentage of total DMFT. This suggests that there are sufficient contributing factors for decay to occur and progress but the children are not undergoing treatment either due to lack of facilities or lack of awareness.

According to Sheiham and Sabbah (2010) caries levels for groups follow predictable trend lines, if environmental conditions are reasonably stable and where there is no effective intervention. Similarly, in the present study the mean DMFT was significantly higher in 14-17 and 17-20 year-olds compared to 11-14 year-olds and scatter plots also showed an upward trend in caries experience with increase in age. In agreement with our results, studies conducted on caries experience in northern India [Gauba et al., 1986] and southern India [Rao et al., 1999; Saravanan et al., 2008] also reported an increase in mean DMFT scores with increase in age. The present study also showed a positive correlation of the DMFT scores (and its components, DT, FT and MT) with the age of the participants. The mean DMFT score was the highest in the 17-20 year-olds. There may be a number of explanations for our findings. The older adolescents are at risk for a longer period of time, which would suggest that older adolescents would be more likely to have caries.

The DMFT index has traditionally been used to measure the occurrence of caries, but it provides an incomplete view of this condition in situations of polarized distribution. Sheiham et al. [1987] pointed out the limits of the DMFT index. Using the DMFT, all missing teeth are

considered as having experienced caries. However, with the aging process, tooth loss can be due to the periodontal disease. The same argument applies to filled teeth, which are considered as having once been carious, even though it could be a preventive measure rather than restorative. Using the DMFT index, a decayed tooth or decayed surface and a filled tooth are given the same importance. Therefore, the benefit of restorative treatment is diminished as the transformation of a decayed tooth into a filled tooth has no influence on the indices. Finally, the DMFT index gives the same weight to untreated caries, extraction and restorations, which evolve differently in population sub-groups [Benigeri et al., 1998].

Another problem associated with the DMFT index is the inability to provide information about the active lesions, whether lesion is in a plaque stagnation area, and the tactile sensation (texture) of the lesion. This information is needed for planning preventive or operative management [Nyvad and Fejerskov, 1997; Ekstrand et al., 1998; Nyvad et al., 1999; Ekstrand et al., 2007]. With these issues in mind, one could be to a certain extent cautious in interpretation or comparison of studies based on the DMFT index. To address these issues and more accurately describe lesion characteristics, the International Caries Detection and Assessment System (ICDAS) has been developed for clinical research, clinical practice and epidemiological surveys (Ismail et al., 2007). In future studies the ICDAS can be used to address the shortcoming associated with the DMFT index. Despite all these issues, the DMFT index is one of the most commonly used tools to assess the caries experience and the current information will help developing and planning preventive measures for the future.

Conclusion

The current findings suggest that dental caries experience in the Iranian children investigated was highly prevalent and increasing in severity with the processes of aging. Prevalence of active caries (DT) did not vary significantly between genders; however the prevalence of filled teeth (FT) was higher in females. Community-based oral disease prevention programmes are needed for the promotion of oral health in this region.

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