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Effects of water consumption frequency on prevalence of dental caries and Erosion

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Abstract
Aims: There is no data neither on consumption frequency of drinking water (exposure to fluoride) nor its effects on the prevalence of dental caries and erosion in Libyan schoolchildren. Therefore, the aims were to estimate the frequency of daily consumption of drinking water and test their relationship with the prevalence of dental caries and erosion in a group of Libyan children in Benghazi.
Methods: A cross-sectional observational study. Data on daily water consumption from a randomly selected sample using a questionnaire survey was obtained. This questionnaire was based on the one previously used in the UK National Diet and Nutrition Survey (2000). Dental caries was assessed using the World Health Organization (WHO) criteria. Dental erosion was assessed using UK National Diet and Nutrition Survey (2000) criteria. Associations between caries, erosion and variables understudy were investigated through processes of bivariate and multivariate analyses.
Results: Seven hundred and eighty eight schoolchildren completed questionnaire survey and underwent dental examination. The mean age was 11.7 years (SD±0.31). Of the sample; 441 (56%) of the subjects consumed both tap and bottled water. Two hundred and thirty four (30%) consumed just tap water with frequency ranged between 0.5 and 8 times a day. One hundred and thirteen children (14%) consumed just bottled water (low fluoride) with frequency ranged between 0.6 and 9 times a day. Four hundred and sixty children (58%) had experience of dental caries and 316 children (40%) exhibited dental erosion. Girls had more experience of dental caries and erosion than boys. There were no statistically significant associations between exposure to fluoride from drinking water (tap/bottled) in terms of frequency and experience of dental erosion and caries.
Conclusion: In this study, the benefit of fluoride in drinking water was overwhelmed by exposure to other variables. Dental erosion and caries have multifactorial aetiology which suggests other factors had influence on their progression. However, drinking water should be encouraged and maintained within Libyan schoolchildren as part of a healthy diet and for its fluoride protection effect against dental caries and erosion and to displace sugared-acidic drinks consumption.

Keywords: Water consumption, caries, erosion, children, Libya

Introduction
Fluoride is a naturally occurring mineral found in water in varying amounts. Over the last 70 years, small amounts of fluoride have been added to drinking water, toothpaste, mouth rinses, and professional dental materials to help strengthen tooth enamel against bacterial acids that cause caries. Drinking water is recognised as a major source of fluoride for the human body. A low volume of water intake usually means a low frequency of water intake which means less frequent exposure to the fluoride in water. Fluoride increases the resistance of teeth to dental caries and erosion. The water fluoridation is important to prevent tooth decay, one of the most prevalent chronic diseases worldwide, and one that greatly affects the quality of life of children.
However, excessive exposure to dietary sugared acids, causes rising in dental erosion and caries prevalence despite the water fluoridation. Thirty years ago dietary counselling focused on reducing sugar intake, and then they have more challenge which is exposure to fluoride. All fluoride sources help strengthen teeth against dental diseases and water fluoridation is essential source of fluoride. In Libya, In the early 1990's the water supply in Benghazi changed from the old water resource (Sidi Mansou and Beninah water wells) with a fluoride concentration of

0.8 ppm, to the Great Man-made River (GMR) with a fluoride concentration 0.66 ppm. The project was initiated in 1983, and the work commenced in 1984 by the Great Man-made River Authority (GMRA, 1983) [10]. The ground water from reservoirs was pumped through pipe lines from the desert in the south to the north where most of cities are located. The first districts to receive water from the GMR were in Benghazi during August 1991 and subsequently through the 1990's the GMR became the main source of drinking water in all Benghazi districts, with Tripoli supplied by September 1996.

Unfortunately, in Libya, both the incidence and prevalence of dental erosion and caries appear to be on the rise regardless of the water fluoridation (Baccush and Nayak, 1991; Hawew *et al.*, 1996; Al-Sharbati *et al.*, 2000; Huew *et al.*, 2011; Huew *et al.*, 2012; Abuaisha and Zainuddin, 2018; Kabar *et al.*, 2019) [5, 13, 3, 14, 15, 1, 20]. There have been no studies based in Benghazi to investigate the relationship between consumption frequency of drinking water and dental erosion and dental caries. The objectives were to undertake dental examination in 12 year-old schoolchildren and to ask them to complete a questionnaire in order to collect information about their consumption of tap and bottled water in terms of frequency and amount to investigate any association between dental caries and erosion and fluoride exposure from drinking water.

Methods and materials

Ethical approval and the sample

Permissions were obtained from local authorities and schools in Benghazi. Statistical power of the study was calculated for investigating the oral health in 12 year-old schoolchildren.

The study sample was resident in Benghazi. These children were studying at the sixth grade in elementary co-educational public schools. Numbers of schoolchildren and schools are not equal in each district in Benghazi, as they depend on the density of population in these districts. A cluster sampling within the schools was used for school sampling and then a random selection of schoolchildren from each elementary school was made. Schoolchildren were randomly selected from the previous randomly schools to achieve 850 subjects (to allow for withdrawals).

Questionnaire survey

The researcher distributed the questionnaire to the randomly selected subjects from each school for completion in any free places; classrooms, sports rooms, laboratories, libraries. The questionnaire based on the one previously used in the oral health component of the UK National Diet and Nutrition Survey (NDNS) (Walker *et al.*, 2000) [27]. It included questions on amount and frequency consumption of tap or bottled water and other dietary questions will be published somewhere else.

Dental Examination

The dental examination was undertaken in any available space, such as class rooms, libraries, and laboratories. The dental examination was conducted under artificial light, with additional lighting via a headlamp which was used throughout the dental examination as the diagnostic source of light. The subjects were seated in an ordinary chair, in front of the examiner. The examiner (RH) used for the dental examination; pre-packed sterilised oral examination kits which contained, a plain mouth mirror and a probe to help detect dental caries by removing food debris. Packages of sterilised gauze were used to dry the tooth surfaces. Gloves and masks were used. After drying the tooth surfaces by gauze, dental mirrors were used to visually inspect the teeth. Dental caries was assessed using WHO (1997) [29] criteria. The dental examination was undertaken to record dental caries, filled, and missing teeth using the criteria for dental caries. Dental erosion was determined using the index used in the oral health component of the UK National Diet and Nutrition Survey (Walker *et al.*, 2000) [27]. The depth and area of tooth surface loss for the labial and palatal surfaces of all permanent maxillary incisors and the occlusal surfaces of the first permanent molars. At the end of dental examination every subject received a letter, to be given to the parents/guardians; the letter contained the result of dental examination and a note and advice if the child need to seek dental treatment. All participants received a stationery box and a certificate as a means of thanks for their participation in the study.

Data analysis

Following descriptive analysis, all questionnaire data were analysed using SPSS with Chi-Square analysis, to determine if there was a statistically significant difference in the responses for different groups. The data were also analysed by gender (Chi-Square analysis).

The normality of distribution of the data related to consumption frequency of water was assessed using One-Sample Kolmogorov-Smirnov Z test. The data were presented as mean, with standard deviation (SD), and 95% Confidence Intervals (CI). For the individuals with data from both the dental examination and the questionnaire survey a process of bivariate analysis for non-parametric data using the exact versions of Chi-Square, Fisher's and Linear Association was used. The bivariate process was used to investigate the associations between the experience of dental erosion, dental caries and exploratory variables. In addition, Odds ratio (OR) and 95% Confidence Intervals (CI) were calculated for 2 x 2 tables. The statistical significance level was set at 5% ($p< 0.05$). The experience of dental caries and dental erosion (Yes/No) was the dependent variable.

Results

The sample

Eight hundred and fifty questionnaires were distributed to the randomly selected schoolchildren in randomly selected public schools. From these, seven hundred and eighty eight completed the questionnaire and attended the clinical dental examination.

Dental Caries

Four hundred and sixty children (58%) had experience of dental caries, 328 (42%) were caries free. Experience of caries was greater amongst girls (64%) than boys (51%). This association was statistically significant (Linear Association exact test p=0.002).

Dental erosion

Of the examined subjects, 316 subjects (40%) exhibited dental erosion, 472 (60%) of subjects had no clinical evidence of dental erosion. A higher prevalence of erosion was observed amongst girls (47%) than boys (34%). This difference was statistically significant (Fisher's exact test; p= 0.001).

Consumption of tap and bottled

When children were asked about the type of drinking water

they consumed, 56% of the children consumed both tap and bottled water, 30% consumed just tap water, and 14% consumed just bottled water, with no gender difference (Pearson Chi-Square; p= 0.927) (Table 1). Out of 788 subjects, 234 subjects (30%) consumed tap water and the mean frequency of tap water consumption was 3 times a day and ranged between 0.5 and 8 times a day. Out of 788 subjects, 113 subjects (14%) consumed bottled water and the mean frequency of bottled water consumption was 2 times daily and ranged between 0.6 and 9 times daily (Table 2).

Table 1: Consumption of tap, bottled and all waters by gender in Libyan schoolchildren.

Gender	Bottled water N (%)	Tap water N (%)	Tap and bottled water N (%)
Girls	57 (14)	113 (29)	223 (57)
Boys	56 (14)	121 (31)	218 (55)
Total	113 (4)	234 0)	441 (56)

Table 2: Mean, median and range of daily consumption frequency of tap and bottled water for the subjects.

Subjects	Mean (SD)	Median	Range
Daily frequency of tap water consumption (no. of intakes)	3.0 (1.69)	2.63	0.5-8.0
Daily frequency of bottled water consumption (no. of intakes)	2.0 (1.56)	1.87	0.6-9.0

Prevalence of dental caries and erosion and its association with the consumption frequency of water

There were no statistically significant associations between frequency consumption of tap (with fluoride), bottled (low fluoride) and both tap and bottled water and experience of dental caries and erosion. The association of dental caries and erosion with consumption of tap, bottled or both waters (Table 3 and 4).

Table 3: Significance of association (P) between the number (N) and proportion (%) of subjects with and without experience of dental caries and consumption of tap, bottled and all water consumption.

Water consumption	Experience of caries		Total N	P (Pearson Chi-Square)
	Yes N (%)	No N (%)		
Tap water	131 (29)	103(30)	234	0.146
Bottled water	58 (13)	56 (18)	114	
Both	266 (58)	174 (52)	440	
Total	455 (100)	333 (100)	788	

Table 4: Significance of association (P) between the number (N) and proportion (%) of subjects with and without experience of erosion and consumption of tap, bottled and both water consumption.

Water consumption	Experience of erosion		Total N	P (Pearson Chi-Square)
	Yes N (%)	No N (%)		
Tap water	96 (31)	138 (30)	234	0.091
Bottled water	56 (17)	57 (12)	113	
Both	169 (52)	272 (58)	441	
Total	321 (100)	467 (100)	788	

Discussion

Fluoride has a beneficial effect on dental health. Drinking water is recognized as a healthy drink because of fluoride and it is a sugar-free drink. In a fluoridated area (0.66 mg/litre) like Benghazi, the consumption of water from public water supplies is a significant determinant of the possible effectiveness of water fluoridation as a public oral health measure. Drinking water is recognized as a major source of fluoride for the human body.

Up to now, in Libya the drinking water fluoridation protection against dental erosion has scarcely been examined. This is the first study carried out in Libya to assess frequency of drinking water consumption (tap/bottled) and to investigate its association with dental caries and erosion.

In this study the data from the questionnaire survey highlighted the fact that large proportions of subjects consumed tap water, bottled water or both types of water (30%, 14% and 56%, respectively), but with low consumption frequency. A low frequency of water consumption which means less frequent exposure of the teeth to the fluoride in water. The low consumption frequency of drinking water in the present study seems to be in line with dietary patterns observed for adolescents in other countries, with highlighting some children did not drink water but drank just soft drinks. In the UK, the NDNS survey reported that a high proportion of children did not consume any plain tap water (Gregory *et al.*, 2000) [11]. In the present study, these frequencies may be not enough to help in protection the teeth against dental caries and erosion by the local effect of fluoride on tooth surfaces and may be it was one of the causes of the high prevalence of dental caries and erosion, 58% of the children had experience of dental caries and 40% exhibited dental erosion. Despite the water fluoridation in Libya, the prevalence of dental erosion and caries appear to be on the rise. In previous Libyan studies, data from a cross-sectional observational studies showed that caries prevalence in schoolchildren were 56.9%, 50%, 50%, 57.8%, 55.8%, 74.7%, respectively (Baccush and Nayak, 1991; Hawew *et al.*, 1996; Al-Sharbati *et al.*, 2000; Huew *et al.*, 2011; Abuaisha and Zainuddin, 2018; Kabar *et al.*, 2019) [5, 13, 3, 14, 15, 1, 20]. Unfortunately, these results showed that an upward trend of the caries prevalence in Libya. The findings of this study, there were no statistically significant associations between frequency consumption of tap (with fluoride 0.66 part per million), bottled (low fluoride) and both tap and bottled water and experience of dental caries and erosion. This finding was supported by several studies reported that there was no difference in caries prevalence between the lowest and the highest fluoride area. A study conducted in Sudan found no association between the fluoride concentration of water and prevalence of dental caries (Ibrahim *et al.*, 1997) [18]. Another study conducted in Brazil reported there was no statistically significant difference between DMFT in children, regardless of the presence or absence of fluoride in the water supply (Sales-Peres and Bastos, 2002) [24]. A study in 256 9-14 years-old Tanzanian children reported that subjects in the high fluoride concentration were at a significantly higher risk of dental caries than children in the low fluoride areas (Awadia *et al.*, 2002) [4]. In a study conducted to assess the effect of fluoride on caries prevalence among 299 Sudanese schoolchildren age 11-13 years exposed to different concentrations of fluoride reported that there was no difference in caries prevalence between the lowest and the highest fluoride area (Birkeland *et al.*, 2005) [8]. Another study investigated the prevalence of caries among 600 12 year-old children from high and low fluoride concentration reported that high prevalence of caries regardless of concentration of fluoride in the drinking water (Narbutaite *et al.*, 2007) [22]. This is because although fluoride increases a tooth's resistance to dental caries, it does not remove the cause of dental caries which is dietary sugars

(WHO, 2003) [30].

In the present study, there were no statistically significant associations between experience of dental erosion and consumption frequency of drinking water. This is in agreement with a study conducted to assess the prevalence of erosion and its association with dietary factors in 202 5 year-old Irish school children which found that levels of dental erosion in fluoridated and non-fluoridated areas were similar, the prevalence of dental erosion in fluoridated areas was 47% and in non-fluoridated areas was 43% (Harding *et al.*, 2003) [12]. Another study conducted to measure the prevalence of dental erosion in adults in Ireland and its association with water fluoridation reported there was no significant association between fluoridation and tooth wear (Burke *et al.*, 2010) [7]. In a study by Teo *et al.*, (1997) [26] reported that erosion of the mandibular occlusal surfaces occurred with equal frequency in fluoridated and non-fluoridated subjects which suggested other factors had influence on the experience of dental erosion and reported fluoride exposure in early life may protect teeth from dental erosion to some extent. These findings should be interpreted with caution due to small sample size of 49 subjects. Bardsley *et al.*, (2004) [6] reported that subjects in non-fluoridated areas are 1.5 times more likely to have dental erosion compared with subjects in fluoridated areas but there were significantly more cases of dental erosion in children in the fluoridated areas when all examined surfaces were measured. Lifelong exposure to fluoride in the water supply did not result in a statistically significant reduction in the number of surfaces with dental erosion (Bardsley *et al.*, 2004) [6].

Anyway, these previous studies encouraged to use fluoridation measures to reduce erosion progression or to protect their teeth from dental erosion and dental caries (Teo *et al.*, 1997; Ganss *et al.*, 2001; Al-Dosari *et al.*, 2004; Bardsley *et al.*, 2004; Hughes *et al.*, 2004) [26, 9, 2, 6, 17]. Subjects with dental diseases have been found to drink acidic drinks more frequently and milk and water less frequently than subjects without dental erosion (O'Sullivan and Curzon, 2000) [23]. Fluoride increases teeth resistance to dental caries and reduces the prevalence and severity of caries. Several studies have been conducted and have confirmed the beneficial effects of fluoride in drinking water in the prevention of dental caries (Teo *et al.*, 1997; Al-Dosari *et al.*, 2004; Lee *et al.*, 2004) [26, 2, 21]. The inverse relationship between fluoride concentration in drinking water and caries is well established with the decline seen in dental caries experience being higher in areas with fluoridated water supplies (Sheiham, 2001) [25].

Dental erosion is a multifactorial condition; the erosive process depends on chemical, biological and behavioural factors and interaction of all these factors explain why some individuals exhibit more erosion than others and only certain teeth are affected with erosion in the mouth, after exposure to the same acid challenge (Lussi and Jaeggi, 2008) [19]. Dental caries has multifactorial aetiology. Fluoride defends against caries and reduces dental caries by up to 50% in children (WHO, 1994) [28]. In the present study, the prevalence of dental caries was 58% and erosion 40% which may show that Libyan children did not have much benefit from fluoride in drinking water or the frequencies of water consumption may be not enough to help in protection the teeth against dental caries and erosion by the local effect of fluoride on tooth surfaces or the fluoride was overwhelmed by exposure to acidic and sugared diets. In addition, the risk of dental caries and erosion was increased with subjects who consumed low fluoride concentration bottled water. Also it might be due to high consumption of sugared-acidic drinks and foods, lack of dental awareness and unhealthy dietary habits may have worsened the situation (Yabao *et al.*, 2005; Huew and Ali, 2020) [16]. Fluoride increases resistance to dental caries, erosion and reduces their prevalence and severity, but these benefits will not be achieved without a reduction in acidic sugared intakes. It is also important to highlight that the present study is cross-sectional. The dietary data about frequency daily intake of drinking water may not be representative of a longer-term diet, which could potentially contribute to the progress of dental erosion and caries. Given that dental caries and erosion are preventable, reduction of the amount and frequency of sugar and acid intake, good oral hygiene and exposure to fluoride are still the main methods to attain optimum benefit in dental caries and erosion prevention. The regular consumption of drinking water should be encouraged and maintained within Libyan schoolchildren as part of a healthy diet and for its fluoride protection effect against dental diseases and to displace sugared-acidic drinks consumption.

Conclusions

In the present study, dietary data were collected through a questionnaire survey highlighted the fact that large proportions of subjects consumed water. This was a welcome finding and reinforced the need for regular consumption of water to be encouraged and maintained within Libyan schoolchildren for its fluoride protection effect against dental caries and dental erosion and as part of a healthy diet to displace sugared and acidic drinks consumption. Dental erosion and dental caries have multifactorial aetiology, looking at one variable in isolation is challenging. In this study exposure to fluoride in the drinking water, with low frequencies, did not result in a significant reduction in the prevalence of dental erosion and caries which suggested other factors had influence on the progress of these conditions. Any taxes on bottled water should be reduced to encourage children to drink bottled water as an alternative to soft drinks when tap water is not available. However, in a developing country such as Libya where the dental caries prevalence is significantly high and dental erosion prevalence is relatively moderate and with low community dental awareness, water fluoridation remains an important public health objective.

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