Dental erosion in Libyan schoolchildren and its association with potential risk factors

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Abstract

Dental erosion appears to be affecting a growing number of children but there are no data on its prevalence and severity in children or adults in Libya. The aim of this study was to determine the prevalence of dental erosion in Libyan schoolchildren, compare with other countries and to test its association with potential risk factors and dental caries. A cross-sectional observational study was carried out in Benghazi, Libya. Ethical approval and permissions were secured from local authorities and written consents obtained from parents/guardians and children. Cluster sampling within schools provided a random sample of 791 12 year-old schoolchildren, mean age 11.7 (SD± 0.31) years (397 boys and 394 girls) attending 36 elementary schools in 15 different districts in Benghazi. Information about potential risk factors for dental erosion was collected through a questionnaire survey based on that previously used in the UK National Diet and Nutrition Survey (2000). A sub-sample of 180 randomly selected subjects completed a three-day food diary with post diary interview. Samples of tap/bottled water were collected from the house of each subject in the sub-sample and from each school to analyse fluoride concentration. Subjects were dentally examined for dental erosion using the index used in the UK National Diet and Nutrition Survey (2000). This index assesses the area and depth of dental erosion affecting the labial and palatal surfaces of upper permanent incisors and occlusal surfaces of the first permanent molars. Dental caries was assessed using the DMFT and DMFS indices and WHO (1997) criteria. The reproducibility of the study was assessed through the re-examination of 10% of the sample. Associations between dental erosion and caries and the variables under study were investigated through processes of bivariate and multivariate analysis. The statistical significance level was set at 5%.

Dental erosion was observed in 40.8% of subjects; erosion into enamel affecting 32.5%, into dentine affecting 8% and into pulp affecting 0.3% of subjects. The prevalence of dental caries was 57.8%. The mean DMFT and DMFS indices were 1.68 (SD± 1.86) and 2.39 (SD± 3.05) for all subjects and 2.90 (SD± 1.56) and 4.14 (SD± 2.97) for subjects with caries experience. Dental erosion was not statistically significantly associated with dental caries. Analysis of the questionnaire survey showed statistically significantly positive associations between the experience of dental erosion and frequency of consumption of fruit-based sugared drinks ($p = 0.006$) and time taken to consume drinks ($p = 0.005$) and a statistically significantly negative association between dental erosion and frequency of consumption of tea with milk ($p = 0.032$). There was a statistically significantly positive association between experience of dental caries and frequency of consumption of fruit-based sugared drinks ($p = 0.002$) and a statistically significantly negative association between dental caries and the level of fathers' education ($p = 0.015$). No statistically significant associations were found between dental erosion or caries and any dietary variable measured through the food diaries with interviews. It is concluded that, the prevalence and severity of dental erosion in 12 year-old children in Benghazi, Libya was in agreement with data reported for the prevalence and severity of dental erosion in European children. The consumption of fruit-based sugared drinks represented the most important risk factor for dental erosion and caries in this sample of Libyan schoolchildren.

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Chapter 1
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1.1 Introduction

Libya is located in North Africa and lies on the Mediterranean Sea with a Mediterranean coastline of nearly 1,800 km. The land area is 1760,000 km^2 making it the fourth largest country in Africa. It lies between Egypt and Sudan from the East, Tunisia and Algeria from the West, Chad and Niger from the South and the Mediterranean Sea from the North. Libya is the 7th largest country in the world. In 2005, the total population was about six million and Benghazi had an estimated 685, 367 inhabitants according to the General Authority of Information (GAI, 2006). The majority (88%) of the Libyan population live in cities (GAI, 2006). Oil was discovered in the 1960s which brought petroleum wealth. There are little published dental epidemiological data for Libya. Generally, for Libyan schoolchildren there are potentially three main influences on dental health; exposure to fluoride, diet and intervention by the dental services. Although much of the water available in Libya is naturally fluoridated, little epidemiological investigation on the prevalence and severity of dental fluorosis has been undertaken. In addition, there have been changes in the Benghazi water supply, which shifted from dependence on a desalination system and other water reservoirs located along the coastal line (North) with a fluoride concentration of 0.8 ppm, to water containing 0.65 ppm (samples of drinking water analysed in Newcastle University laboratory) piped from desert underground water via the Great Man-made River (GMR). Libya is still a developing nation. Few dental epidemiological studies in Libya have been made, data available from the limited epidemiological studies suggest the prevalence of dental caries for twelve year-old children is similar for seven year-olds compared to other Arab countries (Omar and Pitts, 1991; Hawew *et al*., 1996; Al-Sharbati *et al*., 2000; Ingafou *et al*., 2003) and no study has published data related to dental erosion in children or adults in Libya. This means the prevalence and severity of dental erosion in Libya is unknown and this is despite the growing concern regarding the prevalence and severity of dental erosion and its risk factors especially amongst children in developed countries. This situation is alarming, bearing in mind the escalating cost of reparative dentistry. Over recent decades, with the decline in the prevalence and severity of dental caries in children in industrialised countries, there has been an interest in other oral health diseases including dental erosion (Szoke and Petersen, 2000; Walker *et al*., 2000; Nunn *et al*., 2001; Dugmore and Rock, 2003a; Barbour and Rees, 2006; Chadwick *et al*., 2006; Auad *et al*., 2007; McGuire *et al*., 2009). As a result, most epidemiological studies of dental erosion have been undertaken in developed countries and within the last 20 years, many studies on dental erosion have been carried out. In the UK, the evaluation of tooth erosion was included in its National Dental Health Survey in 1993 and in 2003, demonstrating the importance of this problem (O'Brien, 1994; Chadwick and Pendry, 2004). Despite dental erosion being identified as a significant oral health concern within developed countries, it has received no attention in Libya. Tooth surface loss (TSL) is the pathological non-carious loss of tooth substance resulting from erosion, attrition and abrasion. Sometimes however, tooth wear is a result of normal physiological process of aging, but it is usually a combination of attrition, abrasion and erosion. Attrition is the result of wearing of dental hard tissue caused by tooth-to-tooth contact during mastication or grinding of teeth, abrasion is caused by an object-to-tooth contact, such as tooth brushing, while erosion is the irreversible loss of dental hard tissue due to a chemical process not involving bacteria. Combinations of these three processes may result in more TSL (Imfeld, 1996; Chadwick and Pendry, 2004). In children, erosion appears to be the major cause of TSL (Smith and Knight, 1984b; Millward *et al*., 1994b; Milosevic, 1998; Chadwick *et al*., 2006), whereas abrasion is uncommon in children. On the other hand, attrition is common in children, particularly in the primary incisors which show signs of attrition at the time of exfoliation. Attrition and abrasion may compound erosion (Chadwick and Pendry, 2004). Early diagnosis of dental erosion is important in order to provide treatment and prevent further damage to the tooth surfaces and also to prevent the complications of dental erosion such as sensitivity, pain, poor aesthetics and expensive and complex treatment of the eroded teeth (Lussi *et al*., 2000). The aetiology of dental erosion is linked to extrinsic and intrinsic acids. Extrinsic sources of acid include diet, environment and medication, and intrinsic sources include acids due to vomiting, reflux or chronic regurgitation when gastric acids return to the mouth (Imfeld, 1996; Zero, 1996; Wickens, 1999; Hemingway *et al*., 2006; Milosevic, 2006; Jasz *et al*., 2007; Kitchens and Owens, 2007; Waterhouse *et al*., 2008). Several epidemiological studies have found links between the consumption of acidic items and dental erosion (Asher and Read, 1987; Millward *et al*., 1994a; Larsen and Nyvad, 1999; Kunzel *et al*., 2000; Milosevic *et al*., 2004; Dugmore and Rock, 2004b). However, any association between dental erosion and dental caries is not clear and in some studies there is no clear evidence if there are common risk factors between them (Kunzel *et al*., 2000; Truin *et al*., 2005; Auad *et al*., 2009). On the other hand, other researchers report an association between the two conditions (Al-Malik *et al*., 2002; Dugmore and Rock, 2004a; Dugmore and Rock, 2004b; Kazoullis *et al*., 2007). It is difficult, however, to compare the results of different studies due to the use of different indices to measure the prevalence and severity of dental erosion, especially when the sample numbers, age groups, gender, and number of examined teeth included in the studies also differ.

1.2 Dental health care in Benghazi

In Benghazi, the Ministry of Health provides the dental health services to all ages of people through the public dental clinics. In general, dental health services are spread throughout the city. The main treatments are minor oral surgery, tooth scaling and restorations. There has been very little development of preventive services. Government expenditure has been centred on diagnosis and treatment of dental disease rather than preventive programmes. All hospital dental clinics receive support from the Ministry of Health. In addition, there is a private dental sector which provides all types of oral health treatment within different specialities to people who are able to pay the relatively high cost. There is one public Dental School in Benghazi from which dentists graduate after six years of studying and which has contributed to a steady increase in the number of dentists in Benghazi. The Dental School provides care for adults referred from dental clinics and schoolchildren referred through the School Health Programmes. In Benghazi, a privately funded Dental School has recently been established. The oral health services in Benghazi have been developed with little evidence of the dental needs of the population. This may be a result of insufficient priority being given to the collection of oral health data. There are few dental epidemiological data for Libya. Those data available indicate that dental caries is still a major oral health problem for all age groups in Libya, despite significant oral health achievements in developed countries.

1.3 Dental caries

There are indications that dental caries is increasing in children, for example, in a study by Omer (1989) of 7 year-old children in 1989 in the rural area of Kufra in the south of the country, showed the mean dmft was 3.68 and the mean DMFT was 0.90 for 12 year-olds. In the urban area of Tobruk in the north of the country (along the coast line), the mean dmft was 2.81 for 7 year-old children and a mean DMFT of 0.78 was recoded for 12 year-olds. A study undertaken in Tripoli involving 10-13 year-old children reported a mean DMFT of 1.58 (Baccush and Nayak, 1991). In a study by Hawew *et al***.** (1996) the oral health of children in two cities in Libya with different fluoride levels in the drinking water was investigated; Benghazi (0.8 ppm) and Jardinah (1.8 ppm). The mean dmft of 6 year-old children in

Benghazi private schools was 3.12, and in Benghazi state schools was 2.32. In Jardinah state schools (there were no private schools in Jardinah) the mean dmft for 6 year-olds was 1.07. There was no dental caries in 61% of children in Jardinah, while the percentage of children with caries experience in the Benghazi state and private schools were 38% and 33% respectively. Of the children in Benghazi private schools only 4% had one or more restored teeth, while 15% of children had one or more extracted teeth due to caries. In both state schools in Benghazi and Jardinah, there was even less evidence of restorative care with only 1% of subjects having a filling present. Only 2% of children in Jardinah had lost teeth due to dental caries, compared to 10% of children in Benghazi state schools. The DMFT of 12 year-old children from state (1.17) and private schools (1.12) in Benghazi was very similar, while the DMFT of children in the state schools in Jardinah (0.87), was lower than in Benghazi state and private schools. A study by Al-Sharbati *et al*. (2000) investigated the prevalence of dental caries in 6-12 year-old Libyan children, in Benghazi city. The total number of children dentally examined was 762, from 11 public schools and three different socioeconomic levels. The mean DMFT at 12 years was 1.63, and the prevalence of dental caries was 50%, but the filling needs met was only 0.01%. The prevalence of dental caries was higher in lower social areas (66.5%) than in middle social areas (59.8%) and high social areas (59.2%), however the differences were not statistically significant. In a more recent study undertaken in Benghazi in 2002 (Ingafou *et al*., 2003), investigating the oral health of 685 children below the age of six years, it was found that more than half of these children (58%) had carious primary teeth (mean dmft = 2.58), and the prevalence increased in older children. Fewer restored teeth were found in this study; about 23 fillings in 12 children. In addition, there were missing primary teeth due to dental caries in 32 children. Of these pre-schoolers, 72% had plaque deposits and gingivitis, more than half (58%) needed restorative treatment, whereas 8.6% had single or multiple teeth indicated for extraction. Of the total sample, 22 6 year-old children had a mean dmft of 2.27. The results of this study show a similar prevalence of dental caries when compared with study populations of the same age group from published data for other Arab countries which increased with age, but the children had higher levels of gingivitis. The limited published studies regarding dental caries in Libyan children are summarised in Table 1.1 and Table 1.2.

Table 1.1: Results of studies of dental caries affecting the primary teeth of Libyan children.

Author	Date	Area	N	Age	d	m	f	dmft
(Omar, 1989)	1987	Kufra	91	7	3.02	0.55	0.11	3.68
(Omar, 1989)	1987	Tobruk	116	7	2.54	0.27	0.00	2.81
(Hawew *et al.*, 1996)	1994	Benghazi[1]	343	6	2.85	0.22	0.05	3.12
(Hawew *et al.*, 1996)	1994	Benghazi[2]	396	6	2.17	0.13	0.03	2.32
(Hawew *et al.*, 1996)	1994	Jardinah	94	6	1.03	0.03	0.01	1.07
(Ingafou *et al.*, 2003)	2002	Benghazi	22	6				2.27

[1]Private schools [2]State schools

Table 1.2: Results of studies of dental caries affecting permanent teeth of Libyan children.

Author	Date	Area	N	Age	D	M	F	DMFT
(Omar, 1989)	1987	Kufra	97	12	0.49	0.21	0.20	0.90
(Omar, 1989)	1987	Tobruk	130	12	0.56	0.10	0.12	0.78
(Baccush and Nayak, 1991)	1991	Tripoli	720	10-13	1.34	0.21	0.03	1.58
(Hawew *et al.*, 1996)	1994	Benghazi[1]	205	12	0.99	0.03	0.11	1.12
(Hawew *et al.*, 1996)	1994	Benghazi[2]	373	12	1.06	0.05	0.06	1.17
(Hawew *et al.*, 1996)	1994	Jardinah	126	12	0.84	0.02	0.00	0.87
(Al-Sharbati *et al.*, 2000)	1993/94	Benghazi	46	12	1.26	0.35	0.02	1.63

[1]Private schools [2]State schools

1.4 Dental trauma and tooth extraction

Traumatic dental injury has physical and psychological effects. Traumatic injuries amongst children increase as the child starts to walk and continues into childhood due to falls, road traffic accidents and sporting activity. Dental injuries usually involve the anterior teeth which may lead to difficulty in speaking, eating and affect the aesthetic appearance. A study carried out by Khalil *et al*. (1981) investigated the reasons for the extraction of 7000 permanent teeth in adult patients in Benghazi. The most common reason for the extraction was dental caries (66.3%). The other reasons for tooth extraction were periodontal disease (28%), impacted and malpositioned teeth (2.3%), trauma (1.8%), orthodontics (1.2%) and teeth related to cysts and tumours (0.4%). The main reason for the extraction of the first permanent molar in 92.3% of cases was due to dental caries, while for the extraction of the lower central incisors the majority of cases was due to periodontal disease, whilst the loss of the upper central incisors was due to trauma. In a study by Hassan (2000) in Sebha city, a rural area located in the middle of the Libyan desert, the reasons for tooth extraction in 600 adult patients were investigated. The main reason for tooth loss was dental caries; the second most common reason was periodontal disease. The other reasons were trauma, impaction, and orthodontic treatment. The study found the highest incidence of tooth extraction among low education status patients (53%), while the lowest incidence was found among university graduate patients (12%).

In a study carried out in the children's department of Benghazi Dental Hospital, to investigate dental trauma of 1561 preschoolers who attended as patients over a two year period, 5.6% of the children attended the hospital due to trauma to their anterior teeth (Algalyi and Herwis, 2003).

1.5 Exposure to fluorides

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 0.65 ppm. The project was initiated in 1983, and the work commenced in 1984 by the Great Man-made River Authority (GMRA, 1983). 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. The water supply in Benghazi's districts sometimes changes or is mixed with the old water resource (Sidi Mansour and Beninah water wells) if any technical problems occur with the supply from the GMR (GMR Pers. Comm. 2006). An estimation of the concentration of fluoride in drinking water from the GMR is 0.65 ppm (samples of drinking water analysed in Newcastle University laboratory). In Libya, fluoride tablets and fluoride mouth rinses are not generally in use, but fluoride toothpaste has been marketed in Libya for more than forty years. The other source of fluoride is tea, which is the national drink, especially popular in rural areas.

1.6 Diet

Following the discovery and export of oil in Libya in 1960s, the national Libyan income increased. As a result, the whole lifestyle of the nation has changed with many goods and foodstuffs now being imported. Consequently food, culture and customs have changed and have become 'westernised' in terms of consumption of sweets, sugary food and confectionaries. Snacks, high in refined carbohydrate are given to children to by their parents, as a treat between meals. All types of sticky, sweet food are sold in school canteens. Children quench their thirst with sugary drinks rather than water. Consumption of manufactured sugary drinks is considerable because of the high ambient temperature. Sugary foods and drinks are more readily available in urban rather than rural areas (Hawew, 1995). A questionnaire based survey was undertaken in Benghazi and Jardinah for 12 year-old children and collected data about sweet-eating habits, consumption of soft drinks and use of bottled water (Hawew, 1995). Overall, for the sample of 704 children 79.7% reported that they ate sweets once per day, 18.8% ate sweets twice per day, 0.3% ate sweets more than twice a day and 1.3% never ate sweets. In Benghazi private schools, 71.7 % of the children reported that they ate sweets once a day. In Benghazi state schools, 82.8% of the children claimed to eat sweets once a day. In the Jardinah state schools 83.3% of the children reported that they ate sweets once a day. There was no significant difference in sweet consumption between the two cities. In Benghazi private schools 9.8% of the children reported they always drank bottled water, 85.9% sometimes, and 4.4% never drank bottled water. In Benghazi state schools 2.9% always drank bottled water, 65.4% drank it sometimes and 31.6% never drank it. In Jardinah state schools there were marked difference in bottled water consumption, only 0.8% drank bottled water, the majority (99.2%) never consumed it. In the Benghazi private and state schools, similar proportions (92.2%, 92.5%) claimed to have soft drinks once a day whereas, in the Jardinah state schools only 48.4% reported their use once per day. There were marked differences in the frequency of consumption of soft drinks between the three groups.

1.7 Dental opacities

Despite the different concentrations of fluoride in drinking water in different areas of Libya, few studies have been conducted to determine the prevalence of dental opacities in Libyan children. A study carried out by Omar (1989), determined the prevalence of enamel mottling in Kufra, (water F= 0.75 ppm) and Tobruk, (water F= 0.2 ppm). Regarding the proportions of children with enamel mottling by area and gender, it was shown that 2.3% of teeth of the total of 1935 children had enamel mottling, (boys 1.9% and girls 2.7%). The comparable figures for Kufra were 2.0%, 1.6% and 2.6% respectively and for Tobruk the figures were 2.6%, 2.2% and 2.8% respectively. There were no significant differences between areas, but the prevalence of enamel mottling was slightly higher in Tobruk, despite the low fluoride water in this area. The results from this study showed that enamel mottling amongst this sample of Libyan children was not common and not related to fluoride exposure. A total of 532 twelve year-olds from Benghazi and Jardinah were dentally examined to record developmental enamel defects (Ellwood *et al*., 1996). The fluoride concentration of drinking waters was 0.8 and 1.8 ppm respectively during the developmental period of the teeth considered in this study. The prevalence of subjects with dental fluorosis measured using the TF index (Thylstrup and Fejerskov, 1978) on the upper permanent central incisors was 52% in private schools, and 45% in the state schools in Benghazi and 79% in state schools in Jardinah. The prevalence of subjects with demarcated opacities, as recorded by the DDE index (Federation Dentaire Internationale, 1992), was 21% and 14% in private and state schools in Benghazi respectively and 10% in state schools in Jardinah. These differences were not statistically significant.

A recent study conducted to assess developmental enamel defects in 378 7-8.9 year-old children in Benghazi found that of the total sample, 11 children (2.9%) had molar-incisor hypomineralization (MIH). The mean number of demarcated opacities in first molars was 1.5. All the lesions were mild and found only in 1.1% of the children’s first molars. Only 6 children (1.6%) had diffuse opacity and 3 (0.8%) had hypoplasia. The total number of defective teeth was 50 (2.7%); 18 (36%) molars and 32 (64%) incisors. Molar incisor hypomineralization was very rare in this group, only 11 out of 378 children had molar incisor hypomineralization and this is the lowest prevalence of MIH reported so far (Fteita *et al*., 2006).

1.8 Oral health practice and periodontal diseases

Anecdotal evidence from discussions amongst Libyan dentists suggests that many children do not brush their teeth and there is little interest in oral hygiene. This is supported by a number of studies which have looked oral health practices. Omar and Pitts (1991) carried out a study on 2015 schoolchildren to compare the oral hygiene status of rural children (Kufra) with urban children (Tobruk) aged between 7 and 16 years. This study used a simplified oral hygiene index and found that the mean oral hygiene score was 0.13 in the rural group and 0.10 in the urban group and this difference was not statistically significant. The overall mean gingival index for both groups was 0.05. In the rural area 4.9% of the children aged 15 and 16 years had signs of periodontal pocketing, while 3.5% of urban group had signs of periodontal pocketing. The depths of 90.2% of these pockets were between 3.5 and 5.5mm. The author suggested the reasons may be due to the poor dental health education and absence of organised dental preventive measures. In study conducted in Benghazi and Jardinah (Ellwood *et al*., 1996) to record extrinsic stains of 532 12 year-olds, the prevalence of subjects with extrinsic stains as measured by the Lobene Index (Lobene, 1968) was 58% and 70% in private and state schools in Benghazi, and 97% in those subjects living in Jardinah ($p= 0.01$). When oral health practices among 762 children aged 6-12 years from eleven public schools in Benghazi city were investigated in 2000, 42.1% of the total sample did not brush their teeth (Al-Sharbati *et al*., 2000). In higher social groups a lower proportion of children did not brush their teeth (21.2%) compared with middle social groups (38.9%), while the lower social groups had the highest proportion of non-brushers (65.4%). The number of tooth brushers increased with the increased educational levels of both parents. Children with parents who were university graduates brushed their teeth more than whose parents had a lower level of education or were illiterate. A practice-based survey was carried out on 280 Libyan children aged 6-12 years who attended as dental patients in the children's department of Benghazi Dental Hospital (Ali, 2004). Some questions were asked regarding the use of tooth brushing and the survey found that a high number of children (59%) reported undertaking no tooth brushing at all, 19% brushed once per day, 16% brushed twice per day while 7% brushed three times per day.

1.9 Dental erosion

There are no data relating to the prevalence of dental erosion in children or adults in Benghazi or any other area in Libya. Consequently, there are no data on its association with potential risk factors for erosion such as consumption of acidic dietary items or its association with dental caries.

1.10 Summary

There is a lack of dental epidemiological data and there is no information about the prevalence of dental erosion in Libya. Dental caries prevalence and severity in children in Libya are high. Dental services within communities and within the school dental services are not able to provide all the dental treatment needed by children (Al-Sharbati *et al.*, 2000), therefore, there is an urgent need for oral health programmes such as dental health education, caries prevention programmes and improvement of oral health services to meet the treatment need by children. Further oral epidemiological studies are needed in the future to monitor the dental health in Libyan schoolchildren.

Chapter 2
Literature review

2.1 Introduction

Dental erosion appears to be a relatively recent phenomenon. There has been an increasing interest in dental erosion in recent decades, especially following the decline in prevalence of dental caries in children from developed countries (Szoke and Petersen, 2000; Nunn *et al.*, 2001; Dugmore and Rock, 2003a). This decline in dental caries in some countries may be due to reduced consumption of sugar, improved oral hygiene practices, presence of fluoride in tooth paste, topical fluoride application and fluoride rinsing (Bartlett *et al.*, 1996).

In addition, the use of fissure sealants as preventive measures (Simonsen, 2002), and the use of oral health school education programmes in many developed countries (Wang *et al.*, 1998) has enhanced the reduction in caries prevalence.

The aim of this chapter is to provide a summary of the published data related to dental erosion and its association with the potential risk factors.

Some of the literature review will be presented in outline, with the remaining presented in more detail, depending on the level of importance to the current study.

2.2 Aetiology and clinical features of dental erosion

Dental erosion is defined as irreversible loss of dental hard tissues by a chemical process that does not involve bacteria (Eccles and Jenkins, 1974; Imfeld, 1996; Nunn, 1996; Linnett and Seow, 2001). Tooth wear is usually a multifactorial process, comprising; erosion, attrition and abrasion.

Erosion is believed to be the most common mode of tooth wear even though it is often difficult to make a definitive diagnosis (Milosevic, 1998).

Attrition is caused from direct contact of occlusal or proximal surfaces, while abrasion is produced by exogenous material being forced over tooth surfaces. Tensile forces induced by occlusal loads also may lead to tooth wear from cervical enamel micro fractures on facial and occasionally, lingual surfaces; this process is known as abfraction (Osborne-Smith *et al.*, 1999).

Tooth surface loss (TSL) is pathological non-carious loss of tooth tissues resulting from erosion, attrition or abrasion. Erosion is the major cause of TSL in children and adolescents while abrasion is uncommon in this age group (Smith and Knight, 1984b; Milosevic *et al.*, 1994; Millward *et al.*, 1994b; Chadwick *et al.*, 2006). On the contrary, attrition is common in the primary dentition (Chadwick and Pendry, 2004).

Dental erosion is a multifactorial condition; the erosive potential of acidic drinks and foods depends on chemical factors; for example, pH, titratable acidity, mineral content and biological factors; for example, saliva (flow, buffering capacity), acquired pellicle, and position and structure of the tooth related to soft tissues and tongue.

In addition, behavioural factors such as drinking and eating habits, exercise, oral hygiene, acidic drinks and food, regurgitation, vomiting, drugs, occupation 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).

Many cases of dental erosion go undiagnosed in children, and are not identified until adulthood, when the dental erosion becomes severe and difficult to treat (Barron *et al.*, 2003). The aetiology of dental erosion is termed idiopathic, or due to extrinsic or intrinsic acids, according to the case history; idiopathic erosion is the result of contact with acids of unknown origin (Moss, 1998).

Acids with a pH below the critical pH of dental enamel (5.5) can cause superficial demineralization of the enamel and dissolution of the subsurface layers and then loss of tooth structure (Barron *et al.*, 2003).

Extrinsic sources of acid include beverages, such as soft drinks, citric fruit juices, carbonated beverages, fresh fruit excluding bananas, pickled foods and certain sauces which contain acetic or citric acid.

Intrinsic sources of acid can arise from a gastroesophageal reflux, vomiting and bulimia. Frequent swimming in heavily chlorinated water also is considered as major risk factor for dental erosion due to high concentrations of acids in swimming pools (Shaw *et al.*, 1998). Table 2.1 shows the definition of the different types of tooth wear and its clinical features (Gandara and Truelove, 1999).

A smooth silky-glazed appearance with the absence of perikymata and intact enamel along the gingival margin, with cupping and grooving on occlusal surfaces of teeth are some of the documented typical features of dental erosion (Lussi *et al.*, 2006). The location of dental erosion depends on the causative factor (Nunn *et al*., 1996).

The most commonly affected surfaces due to vomiting are the palatal surfaces of the upper anterior teeth and premolars, and the occlusal surfaces of the lower premolar and molar teeth. In contrast, dental erosion is seen on labial surfaces of the upper anterior teeth in addition to the surfaces previously mentioned in the case of high consumption of acidic beverages.

The presentation and location of dental erosion may be influenced by habitual practices; the excessive consumption of oranges by Cuban children explains the erosion seen on upper central incisors along the incisal edges in mesio-distal direction, the typical v-shaped surface loss reflecting the manner in which the children ate the fruit; eating of partly peeled, halved oranges (Kunzel *et al.*, 2000).

Table 2.1: List of the definition of tooth surface loss and clinical appearance (Gandara and Truelove, 1999).

Tooth Wear		
Term	**Definition**	**Clinical Appearance**
Erosion	Progressive loss of hard dental tissue by chemical processes not involving bacterial action	Broad concavities within smooth surface enamel Cupping of occlusal surfaces, (incisal grooving) with dentine exposure. Increased incisal translucency Wear on non-occluding surface "Raised" amalgam restorations Clean, non-tarnished appearance of amalgams Loss of surface characteristic of enamel in young children. Preservation of enamel "cuff" in gingival crevice is common. Hypersensitivity. Pulp exposure in deciduous teeth.
Attrition	Loss by wear of surface of tooth or restoration caused by tooth to tooth contact during mastication or parafunction	Matching wear on occluding surface Shiny facets on amalgam contacts Enamel and dentine wear at the same rate Possible fracture of cusps or restoration
Abrasion	Loss by wear of dental tissue caused by abrasion by foreign substance (e.g., toothbrush, dentifrice)	Usually located at cervical areas of teeth Lesions are more wide than deep. Premolars and cuspids are commonly affected.
Abfraction	Loss of tooth surface at the cervical areas of teeth caused by tensile and compressive forces during tooth flexure	Affects buccal/ labial cervical areas of teeth Deep, narrow v-shaped notch Commonly affects single teeth with excursive interferences or eccentric occlusal loads

2.3 Indices for measuring dental erosion

Several dental indices are available to measure tooth wear in general and dental erosion in particular. Recently, several methods to measure tooth wear in both *in vitro* (Grenby, 1996; Lussi *et al.*, 2000; Johansson *et al.*, 2001; Cairns *et al.*, 2002; Fraunhofer and Rogers, 2004; Hemingway *et al.*, 2006) and human studies have been used.

It is difficult to distinguish between the three main types of tooth wear; dental erosion, abrasion and attrition, since that seen in a mouth may be the result of a combination of all three. Enamel softened by erosion is more susceptible to attrition and abrasion (Linnett and Seow, 2001). Some of the indices provide reasonable estimates of prevalence of dental erosion but they may under-estimate the extent of tooth wear present when compared with histological examination (Al-Malik *et al.*, 2001a). There have been a number of indices used to measure dental erosion in different age groups, and different teeth groups (Table 2.2). These include:

- An index introduced in Wales to measure dental erosion of all permanent teeth of adults. The index was presented as a comprehensive qualitative index, grading both severity and site erosion due to non-industrial causes into three classes of erosion (Eccles and Jenkins, 1974).

- The Smith and Knight index used to measure tooth wear is one of the most comprehensive indices used and has been used in adult population but it does not distinguish between the three main types of tooth wear. Clinical examination of 4 surfaces giving 128 scores in complete adult dentition. Score 0-4 per surface (Smith and Knight, 1984a). Modifications of the index have been introduced (Milosevic *et al.*, 1994; Millward *et al.*, 1994b) and used in several studies.

- An index introduced in Switzerland to assess erosion of permanent teeth in adults using a random sample of 391 subjects. The erosion index assessed the facial, lingual and occlusal surfaces of all teeth except third molars. The index comprised 4 grades for facial surfaces (0-3) and 3 grades for occlusal surfaces (0-2) (Lussi *et al.*, 1991).

- An index used in National Survey of Child Dental Health in the United Kingdom in 1993 to measure dental erosion of primary and permanent maxillary teeth of 17061 5-15 year-olds using a modification of the Smith and Knight index. Assessment of 4 teeth per child for depth and area of erosion. Score of 0-3 for both depth and for area with a score for unable to assess (O'Brien, 1994).

- An index introduced in England to measure dental erosion on patients referred to a dental hospital. The Tooth Wear Index of Smith and Knight (1984) was used. The results were classified into three groups; no or mild erosion, moderate dental erosion (with dentine involvement), and severe dental erosion (Millward *et al.*, 1994a). This index also was used to measure erosion of all primary teeth (Millward *et al.*, 1994b).

- An index used in the UK National Diet and Nutrition Survey (1995) of 1½-4½ year-olds using the same diagnostic criteria for dental erosion as the UK National Survey of Child Dental Health (1993) (Hinds and Gregory, 1995).

- An index introduced in Saudi Arabia to measure dental erosion of maxillary incisors and canines. Clinical, study casts, radiographic and photographic examination were used (Johansson *et al.*, 1996).

- An index introduced in England, used to assess dental erosion in primary and young permanent dentition in children and patients. This index was designed to include the site of erosion on each tooth, grade of severity (worst score for any individual tooth recorded) and area of tooth surface affected by erosion (O'Sullivan, 2000c).

- An index introduced in Cuba to assess dental erosion in maxillary incisors using the following metric grades; grade 0.5, first sign of enamel wear, grade 1, the crown is markedly shortened at the mesial edge (>1mm), grade 2, the incisal destruction has progressed mesio-distally to involve the distal edges of both central incisors, grade 3, further loss of incisal hard tissue involving the mesial edges of the lateral incisors (Kunzel *et al.*, 2000).

- An index introduced in Denmark based on clinical examination, photographs and casts of the teeth, with complicated qualitative and quantitative criteria. Incisors, canines and premolar of adults were assessed. Each tooth surface was scored, with six grades of erosion severity modelled from Smith and Knight (Larsen *et al.*, 2000).

- An index introduced in England, partially recording using 6 or 12 anterior teeth for measuring tooth wear in adults. Tooth wear data were recorded on a surface-by-surface basis on each tooth using Smith and Knight Index. The index used scores 0-4. The combined codes 0 and 1 represent very minor wear (no dentine exposed), grade 2-loss of enamel exposing dentine for less than one-third of surface was considered minimal wear, grade 3-loss of enamel exposing dentine for more than one-third of surfaces but without pulp exposure or exposure of secondary dentine was considered as moderate wear, and grade 4-complete loss of enamel on a surface or exposure of secondary dentine or pulp was considered as severe (Steele and Walls, 2000).

- An index introduced in England, Scotland and Wales used in the 1996/97 National Diet and Nutrition Survey to measure dental erosion of primary and permanent maxillary incisors and primary and permanent first molars of 4-18 year-olds. The index was a modification of the Smith and Knight Index (Walker *et al.*, 2000). This index was also used to measure the prevalence of tooth erosion in 1753 12 year-old Leicestershire children and dental erosion was assessed on the labial and palatal surfaces of upper and lower incisors and on buccal, occlusal and lingual surfaces of first molars (Dugmore and Rock, 2004a). The index also was used to assess dental erosion affecting the labial and palatal surfaces of the upper incisors and the occlusal surfaces of the first permanent molars in 458 13-14 year Brazilian children (Auad *et al.*, 2007).

- An index used to investigate the prevalence of dental erosion in 202 5 year-old children in Cork City and County using a scoring system and criteria based on indices used in the UK. This index assessed the dental erosion affecting palatal and labial surfaces of primary maxillary teeth (Harding *et al.*, 2003).

- An index used in Child Dental Health Survey 2003 in the UK to measure tooth surface loss (TSL) of primary and permanent incisors and permanent molar teeth. The term tooth surface loss was used in preference to erosion which was used in the 1993 survey as it was felt it more accurately reflected the multifactoral aetiology of the condition. The index was a modification of the Smith and Knight Index (Chadwick and Pendry, 2004).

- A new scoring system, the Basic Erosive Wear Examination (BEWE), was introduced recently to provide a basic structure to initiate the development of an internationally standardised accepted index. The BEWE is a partial scoring system recording the most severely affected surface in each sextant with a cumulative score to recommend clinical management. It has been used by research field and dental clinicians. The four scores are; no surface loss (0), initial loss of enamel surface texture (1), hard tissue loss (dentine) less than 50% of the surface area (2) or hard tissue loss equal or more than 50% of surface area (3) (Bartlett *et al.*, 2008).

- A modified wear index according to basic principle of Smith and Knight Index was developed, wear of enamel and dentine recorded separately by area and depth using 5- and 6-point scales, respectively (Fares *et al.*, 2009).

Table 2.2: Indices for measuring dental erosion.

Author	Country	Sample and Age	Index used	Teeth	Surfaces
(Eccles and Jenkins, 1974)	Wales	Adults	3 main classes for erosion (scale of severity)	Permanent teeth	B/L/I/O
(Smith and Knight, 1984a)	UK	Adults	Clinical exam of 4 surfaces giving 128 scores. Score 0-4/surface	Permanent teeth	B/L/I/O/C
(Lussi *et al.*, 1991)	Switzerland	Adults	4 grads for facial surfaces and 3 grads for occlusal surfaces	Permanent teeth	B/L/O
(O'Brien, 1994)	UK	Children 5-15 y-olds CDH Survey 2003	Modified Smith and Knight index	Primary and permanent maxillary incisors	B/L
(Millward *et al.*, 1994a)	England	Children 4-5 y-olds	Modified Smith and Knight index	Primary teeth	B/L/I/O
(Hind and Gregory, 1995)	Scotland, England, Walls	Children 1½-4½ y-olds	Modified Smith and Knight index	Primary teeth	B/P
(Johansson *et al.*, 1996)	Saudi Arabia	19-25 y-olds	Clinical, study casts, radiographic, photographic examination	Maxillary teeth	B/L
(O'Sullivan, 2000c)	England	Children and patients 3-16 y-olds	Three-digit score relating to site of erosion, severity (grade0-5) and area of surface affected	Primary and permanent teeth	B/L/I/O
(Kunzel *et al.*, 2000)	Cuba	Children 12 y-olds	Metric grades of progression	Maxillary incisors	B/I/L
(Larsen *et al.*, 2000)	Denmark	Adults	Combination of clinical exam, Photographs and study casts	Anterior and premolars	B/L/O/C
(Steele and Walls, 2000)	England	Adults	Modified Smith and Knight index	Anterior teeth	B/L/O/I/C
(Walker *et al.*, 2000)	England, Scotland, Wales	Children 4-18 y-olds NDNS	Modified Smith and Knight index	Primary and permanent upper incisors,first molar	B/L/O
(Harding *et al.*, 2003)	Republic of Ireland	Children 5 y-olds Irish Dental Survey	Modified Smith and Knight index	Primary maxillary teeth	B/L
(Chadwick and Pendry, 2004)	UK	Children age groups 8,12 and 15 y-olds CDH Survey 2004	Modified Smith and Knight index	Primary and Permanent incisors and permanent first molars	B/L/O
(Dugmore and Rock, 2004a)	Leicestershire	Children 12 y-olds	Modified Smith and Knight index	Permanent upper, lower incisors and first molars	B/L/P/O
(Auad *et al.*, 2007)	Brazil	Children 13-14 y-olds	Modified Smith and knight index	Permanent upper incisors and first molars	B/L/O
(Bartlett *et al.*, 2008)	UK	Children and adults	Basic Erosive Wear Examination (BEWE), partial scoring system recording the most severely affected surface, scores 0-3		B/L/P/O/C
(Fares *et al.*, 2009)	UK	Adults	Modified wear index, enamel and dentine wear recorded separately	incisors and first molars	B/C/I/P

B = Buccal, L = lingual, I = Incisal, O = Occlusal, C = Cervical

2.4 Prevalence studies of dental erosion in children

The extent of epidemiological data related to dental erosion varies widely between countries. Dental erosion is considered a significant oral health concern in developed countries. There are many information on prevalence of dental erosion and its risk factors in industrialised countries, while few data on dental erosion in developing countries. Dental erosion assessment was first included in the UK Children's Dental Health Survey in 1993 and has been repeated regularly at 10 year intervals.

Using of different methods to assess dental erosion, different teeth groups, age groups and sample sizes made the comparison of the results between countries difficult. Despite these differences, it may be concluded that dental erosion affects many children and adults. Identifying the true prevalence of dental erosion is difficult due to the presence of more than one aetiological factor. In addition, attrition and abrasion may play a role, especially in the elderly (Nunn, 1996). Epidemiological studies have shown an increase in the prevalence of dental erosion over time with different age groups (Nunn *et al.*, 2003). This increase in the prevalence varies widely between 2% and 57% over time and the severity varies from loss of tooth surface characteristics to pulp involvement (Linnett and Seow, 2001). The prevalence of dental erosion has been shown to be high in children and adolescents; approximately 1/3 of 5-6 year-old children in Belgaum, India had dental erosion (Deshpande and Hugar, 2004). In a review paper in Netherlands aimed to investigate data on the prevalence of dental erosion in adults reported that the increase in tooth wear levels have been shown to be significantly related to age (Van't Spijker *et al.*, 2009). The National Survey of Child Dental Health in the UK 1993 to measure dental erosion of primary and permanent maxillary teeth of 17061 5-15 year-olds showed 52% of 5-6 year-olds had one or more eroded primary incisors. Dental erosion had progressed into dentine or pulp in 24% of these children. In the permanent dentition, 27% of 12 year-olds had dental erosion. Dental erosion on the palatal surfaces of maxillary incisors was found in 25% of over 11 year-olds. Dental erosion of the buccal surfaces of maxillary incisors was found in 12% of 12-15 year-olds. Dental erosion into dentine or pulp was found only in 2% of subjects over 13 year of age (O'Brien, 1994).

A study in England to measure dental erosion in patients referred to a dental hospital found that over 80% of the maxillary incisors and 30% of primary molars had tooth wear in dentine (Millward *et al.*, 1994a) and the prevalence of dental erosion was 38% for 178 4-5 year-old children (Millward *et al.*, 1994b).

The 1995 National Diet and Nutrition Survey in 1 1/2 to 4 1/2 year-old children in the UK showed that the prevalence of dental erosion on the palatal surfaces of the maxillary incisors was 19% and on the buccal surfaces of the maxillary incisors was 10% of the 1451 subjects. Dental erosion affecting the palatal surfaces into dentine or pulp in 8%, and buccally into dentine or pulp in 2% (Hinds and Gregory, 1995).

The prevalence of erosion in 1726 4-18 children was 65%, 61%, 52% and 62% in the 4-6, 7-10, 11-14 and 15-18 year-old groups respectively in the 1996/97 UK National Diet and Nutrition Survey (NDNS). The proportion with erosion of the buccal surface of the upper permanent incisors was 9% for 4-6 year-olds, 23% for 11-14 year-olds and 36% for 15-19 year-olds. The proportion of the groups with dental erosion of the palatal surfaces of upper permanent incisors was 10% for 4-6 year-olds, and 56% for 15-18 year-olds, while palatal surfaces of the upper incisors were eroded into dentine or pulp in 3% of 11-14 year-olds and 2% of 15-18 year-olds. The proportions of these groups with dental erosion of the upper permanent first molars were 12% of 7-10 year-olds, 26% of 11-14 year-olds and 34% 0f 15-18 year-olds (Walker *et al.*, 2000).

The prevalence of dental erosion was investigated in palatal and labial surfaces of primary maxillary teeth in 202 5 year-old children in an Irish study; the prevalence of dental erosion was 47% with 21% of children having dental erosion exposing the dentine or pulp (Harding *et al.*, 2003). National surveys of Child Dental Health in the United Kingdom 2003 included measurement of tooth surface loss (TSL) of primary and permanent incisors and permanent molar teeth in 10381 children aged 5, 8, 12 and 15 years of age. The proportions of children with tooth surface loss of the buccal surfaces of permanent upper incisors were 4%, 12% and 14% in 8 year-olds, 12 year-olds, and 15 year-olds respectively. The proportions of children with tooth surface loss of the lingual surfaces of permanent upper incisors were 14%, 30% and 33% in 8 year-olds, 12 year-olds, and 15 year-olds respectively. The proportions of first permanent molars with tooth surface loss on the occlusal surface were 10%, 19% and 22% in 8 year-olds, 12 year-olds, and 15 yea-olds respectively. Only 2% of 12 year-olds and 4% of 15 year-olds had TSL into dentine (Chadwick and Pendry, 2004).

The prevalence of dental erosion in 1753 12 year-old British children from the countries of Leicestershire and Rutland was 59.7%, and 2.7% with erosion into dentine ((Dugmore and Rock, 2004a).

A study conducted in Switzerland to assess dental erosion of permanent teeth in adults using a random sample of 391 subjects showed 30% of 26-30 year-olds and 43% of the 46-50 year-olds had dental erosion into dentine (Lussi *et al.*, 1991). Similarly pronounced dental erosion was found in 28% of the maxillary anterior teeth in 19-25 year-olds in Saudi Arabia (Johansson *et al.*, 1996). A study conducted in Cuba to assess dental erosion in maxillary incisors for 1010 12 year-old children; from of overall, 17.4% of children had dental erosion. The prevalence of erosion was higher in girls (20.7) than in boys (15.0%) (Kunzel *et al.*, 2000). However, a higher prevalence was reported in a Saudi Arabian study; prevalence of erosion in 354 5-6 year-old boys was 95% and 34% had erosion into dentine or pulp 95% of 862 12-14 year-old boys had evidence of erosion, and 26% had erosion into dentine or pulp (Al-Majed *et al.*, 2002). In a prevalence study of dental erosion in 11-12 year-old children in the Hague, the Netherlands, erosion in 12 year-olds in 1998 and 2002 increased from 3% to 23% (Truin *et al.*, 2004).

In a study investigating the prevalence of dental erosion among 391 12 year-old Brazilian schoolchildren for the maxillary incisors found that the prevalence of dental erosion was 13% (Peres *et al.*, 2005a). However, a higher prevalence was found in a more recent study of dental erosion on labial and palatal surfaces of the upper incisors and the occlusal surfaces of the first permanent molars in 458 13-14 year Brazilian schoolchildren; 34.1% of subjects had erosion (Auad *et al.*, 2007). Another study in Brazil investigated the prevalence of dental wear on 24780 dental surfaces in 12 year-old children and found that the overall prevalence of dental wear was 26.9%; 53.2% of incisors, 50.5% of canines, 10.2% of premolars and 10.9% of molars (Peres *et al.*, 2008).

Kazoullis *et al.* (2007) investigated dental erosion in 714 5.5-14.6 year-old Australian children: 489 (68%) of the sample had erosion. Dental erosion was found in 78% of subjects with primary teeth and 25% of subjects with permanent teeth.

El Karim *et al* (2007) assessed the prevalence of dental erosion on the labial and palatal surfaces of maxillary incisors in 157 12-14 year-old Sudanese schoolchildren. The prevalence of dental erosion was 66.9%, of which 45.2% was mild and 21.7% was moderate erosion. A study carried out on 483 12 year-old children in Mashhad, Iran, reported that the prevalence of dental erosion for the labial and palatal surfaces of upper incisors was 38.1%, with no gender difference (Talebi *et al.*, 2009). Similarly, in a prevalence study carried out in 1962 13-19 year-old children in the United States showed that 45.9% had erosive tooth wear in at least one tooth (McGuire *et al.*, 2009).

In a study which investigated influence of diet and salivary characteristics on the prevalence of dental erosion in 389 12 year-old children in Brazil, the overall prevalence of erosion was 26%, erosion into enamel was the most prevalent type (65%), with no significant difference in prevalence in gender (Correr *et al.*, 2009). Another study investigated the association between socioeconomic factors and dental erosion in 983 6-12 year-old children in Brazil showed the overall prevalence of dental erosion to be 19.9%; 61.8% in primary dentition and 38.2% in permanent dentition (Mangueira *et al.*, 2009).

2.5 Dental erosion and the consumption of acidic foods

There is increasing consumption of soft drinks among children generally in the world. From data derived from the Children's Dental Health Survey in 1993 and NDNS study of 4-18 year-olds in 1996/97 the prevalence of dental erosion is increasing in children in the UK (O'Brien, 1994; Walker *et al.*, 2000). Several studies have reported acidic foods and drinks as risk factors for dental erosion (Millward *et al.*, 1994a; Johansson *et al.*, 1997; Milosevic *et al.*, 1997; Larsen and Nyvad, 1999; Johansson *et al.*, 2001; Al-Majed *et al.*, 2002; Harding *et al.*, 2003; Dugmore and Rock, 2004b; Milosvic, 2006; EI Karim *et al.*, 2007; Lussi *et al.*, 2007; Talebi, 2008). The National Child Dental Health Survey reported that erosion is common in children and suggested that it was caused mainly by acid drinks (O'Brien, 1994; Walker *et al.*, 2000). A study of erosive tooth wear in 14 year-old schoolchildren in England revealed that over 80% regularly consumed soft drinks; more than 10% of the children studied had more than three intakes daily (Al-Dlaigan *et al*., 2001b). There is a relationship between nutrition and dental diseases, especially its significant effect on dental erosion and caries with dental erosion being primarily associated with an acidic diet and soft drinks (Moynihan and Petersen, 2004).

A healthy lifestyle, may lead to dental erosion. This is because there has been increased awareness of healthy diet as part of a healthy lifestyle. This may lead to increased consumption of fruits and vegetables. It has been suggested that vegetarian diet may be more acidic (Al-Dlaigan *et al.*, 2001c).

Dental erosion is becoming common in both children and adults, with over half of 15-18 year-olds exhibiting incisal erosion (Al-Dlaigan *et al.*, 2001a). Lussi *et al*. (2004), reported the main aetiological factors for dental erosion are intrinsic and extrinsic acids. Of the extrinsic factors causing dental erosion, environmental, diet, medication and lifestyle are included (Zero, 1996). The extrinsic acids from diet such as citric acid, phosphoric acid, ascorbic acid, malic acid, tartaric acid and carbonic acids are found in fruits and fruit juices, soft drinks, herbal tea, wines and vinegar. Evidence suggests that frequent intake of acidic drinks and foods leads to dental erosion (May and Waterhouse, 2003). Following an acid challenge, the tooth surface softens and then remineralizes on exposure to saliva, but as a result of more frequent acid attack the remineralizing ability of saliva is overcome (Amaechi and Higham, 2001).

Dietary factors are the most important risk factor for children due to the high consumption of acidic foods and drinks. In 1980s, children aged between 2 and 9 years in the UK consumed 42% of fruit drinks (Rugg-Gunn *et al.*, 1986b). Consumption of citrus fruit more than twice per day, a soft drink a day and weekly sports drinks are also considered as risk factors for dental erosion (Jarvinen *et al.,* 1991). In addition, a statistically significant relationship was found between the dental erosion in Saudi Arabian children and frequency of consumption of carbonated soft drinks at night and length of time of these drinks remain in the mouth (Al-Majed *et al.*, 2002). Drinks consumed overnight have been shown to be associated with increased prevalence of dental erosion (Nunn *et al.*, 2003). Studies in children and adults have shown that dental erosion is associated with frequency of consumption of fruit and carbonated drinks (O'Sullivan and Curzon, 2000a; Harding *et al.*, 2003). High risk factors for erosion have been found when citrus fruits were consumed more than twice per day and soft drinks were consumed daily (Jarvinen *et al.*, 1991). Dugmore and Rock (2004b) reported a strong association between dental erosion and the amount and frequency of carbonated drink consumption. A study which investigated the aetiological factors of dental erosion in 15 year-old children found that frequent consumption of beverages was probably related to tooth wear (Milosevic *et al.,* 1997). Consumption of soft drinks was high and common in children with erosion in contrast to consumption of milk, tea, coffee and chocolate (Al-Dlaigan *et al*., 2001b), in those without the condition.

A study of the prevalence of dental erosion and associated factors in 1949 3-5 year-old children in China using the erosion index used by the UK National Survey of Children's Dental Health, found that 112 children had erosion on their maxillary incisors and 17 children had erosion extending into dentine or pulp, with a correlation between the presence of erosion and consumption of fruit drinks at bedtime (Luo *et al*., 2005).

A study conducted to determine the prevalence of dental erosion and investigate the associated risk factors in 157 12-13 year-old schoolchildren in Sudan, the prevalence of dental erosion was 66.9% (45.2% was mild and 21.7% moderate) and was strongly associated with dietary intake (EI Karim *et al*., 2007).

A study investigated prevalence of the dental erosion and its aetiology among 153 11 year-old children in Turkey and found that 28% (43) of the children had dental erosion. Thirty-two per cent of children who consumed carbonated orange juices showed erosion and 40% who consumed carbonated beverages showed erosion. Thirty six per cent of children who consumed fruit yogurt showed erosion (Caglar *et al*., 2005). However, one year later, Caglar *et al*. (2006) tested the pH of each fruit and reported that fruit yogurt has no erosive effect on the teeth. Dental erosion caused by acidic drinks and food consumption commonly affects the labial and palatal surfaces of maxillary anterior teeth where food and drinks take longest to clear and are at greater risk than the mandibular incisors which are subjected to increased salivary washing and buffering (Smith and Shaw, 1993).

Factors such as the way the drink is administered can affect the severity of dental erosion: use of a straw or a child’s feeder cup causes less dental erosion than taking the drink from a glass which prolongs clearance from the mouth (Shaw and Smith, 1994). In addition the frequencies of intake, method of drinking (sipping and swishing being most harmful), whether drinks are chilled or not (warmer acidic drinks are more erosive) and salivary buffering capacity are reported to have an erosive impact (Milosevic, 1998). Unusual eating, drinking swallowing habits and holding acidic drinks in the mouth for a long period before swallowing (which increase the contact time of the acidic drinks with the teeth), increased consumption of acidic drinks or consumption of acidic beverage at bedtime are all risk factors which have been reported to lead to increased prevalence of dental erosion (Gandara and Truelove, 1999; Lussi *et al.*, 2000). The manner in which acidic drinks and foods are introduced into the mouth affects which teeth are contacted by an erosive challenge. An example of this was reported by Kunzel *et al.*(2000) in Cuban children where the typical v-shaped pattern of erosion along the incisal edges in a mesio-distal direction has been attributed to a consequence of the frequency and the manner in which citrus fruits are eaten.

Millward *et al.* (1994b) examined 101 children aged between 4 and 16.5 years to determine the prevalence of dental erosion and found that 21 children had mild erosion, 45 moderate erosion and 35 severe erosion. These differences were statistically significant and related to drinking habits.

Al-Dlaigan *et al.* (2001b) investigated the dietary intake pattern and its relationship with dental erosion in 418 14 years-old British children and found a highly significant correlation between dental erosion and consumption of cola drinks, other carbonated drinks, apple juice, sport drinks and beer. Fruit intake was also correlated to erosion; apples, oranges and grapes all had significant associations. Tomato ketchup and yoghurt also showed a correlation with erosion. Children who consistently took vitamin-C tablets also had significant erosion. Al-Majed *et al.* (2002) investigated dental erosion and its relation with dietary habits on 1216 5-6 and 12-14 year-old Saudi Arabian boys. Parents reported that 65% of 5-6 year-olds took a drink to bed; water was the commonest drink consumed (37%), followed by carbonated soft drinks (21%). In addition 60% of children had sweet food or confectionery to eat in bed or at night. Seventy per cent of 12-14 year-olds consumed drinks at night; water (30%), carbonated soft drinks (27%) and tea or coffee with sugar (18%). In addition, 46% of the boys ate sweet food or confectionery at bedtime.

In contrast, in a study conducted in north west England (Milosevic *et al.*, 2004) to determine the strength of association between dietary factors with tooth wear in 2385 14 year-old schoolchildren, it was found that for consumption of oranges there was no association with dental erosion. Apples and tinned fruit were reported on the borderline of dental erosion but pickles and sauces had the greatest causal association with dental erosion. When the number of cans of carbonated drinks consumed on a daily or weekly basis was investigated it was found that the amount and the frequency of intake of carbonated drinks were statistically significantly positively associated with the experience of dental erosion. Children who consumed more than seven cans of carbonated drinks per week had more tooth wear when compared with children who had a lower consumption of these drinks. Children who consumed carbonated drinks with a frequency of twice a day or more had tooth wear more than children with a lower frequency of consumption.

West *et al.* (2003) evaluated the erosive effect of an experimental formulation carbonated drink with added calcium, compared to a conventional carbonated drink over a 20 days period in 15 volunteers of median age 32 years. The result was the experimental carbonated blackcurrant drink caused significantly less enamel loss than the conventional carbonated orange drink.

An *in vitro* study conducted in USA, where 20 molars and premolars were exposed to different types of beverage for 14 days, found that water tap, root beer, brewed black tea, and black coffee all caused minimal enamel dissolution. Cola beverages (coca-cola, pepsi-cola and Dr Pepper) dissolved enamel 55-65 times more than both water and root beer. Enamel dissolution from non cola drinks (mountain dew, sprite and ginger ale) was 90-180 times greater than dissolution from water. The data suggested that enamel aggressivity is determined by drink composition rather than by drink pH (von Fraunhofer and Rogers, 2004).

An *in vitro* study investigated the relationship between chemical parameters of popular soft drinks and enamel erosion and the effects of tooth brushing after exposure to soft drinks. The most popular six drinks were chosen; apple juice, orange juice, pure apple drink, pure orange drink, cranberry drink and "Tooth Kind" blackcurrant drink. Enamel samples from permanent human molars were exposed to the different six soft drinks. The apple drink had the lowest pH (2.74), whilst the orange juice had the highest (3.95) and other drinks had a pH ranging between these drinks. Toothbrush abrasion caused additional enamel loss which was different for samples exposed to different drinks. The thickness of the softened enamel was dependent on the chemical composition of the erosive drink. The drinks which caused the greatest erosion also cause the greatest enamel surface loss following toothbrushing (Hemingway *et al*., 2006).

An *in vitro* study to determine the pH, titratable acidity of flavoured sparkling bottled waters on the UK market, found these types of water demonstrated erosive potential similar to or greater than that of pure orange juice. The author suggested that flavoured sparkling waters should be considered as acidic drinks rather than water with flavouring (Brown *et al*., 2007). Results of another *in vitro* study showed that both carbonated and non-carbonated beverages (eg. Gatorade sports drink, red bull high-energy drink) displayed a significant erosive effect on dental enamel (Kitchens and Owens, 2007).

An *in vitro* study conducted in the United States investigated the pH and titratable acidities of popular acidic beverages (juices, regular sodas, diet sodas, coke and sports drinks) and erosion of enamel and root surfaces after beverage exposure and suggested that acidic beverages had the potential to erode enamel and root surface (Ehlen *et al*., 2008). However, a study conducted within a group of 210 11-14 year-old children found no relationship between tooth wear and consumption of carbonated or acidic drinks despite the average intake of two cans of carbonated drinks and two glasses of fruit juice a day for a child and a total number of 5000 cans sold in a week for the school (Bartlett *et al*., 1998). Similar results were found by

Al-Dlaigan *et al.* (2001c) in 418 14 year-old schoolchildren of which 10% were vegetarian. There were no significant differences in prevalence of dental erosion between vegetarian and non vegetarian children.

There is scant data about the consumption of alcohol in adolescence and its association with oral health. In a study of 418 14 year-old British adolescents, 23% reported consumption of alcoholic beverages. A small minority (3%) consumed alcohol between eight and more than 21 times a week. Of the sample; 48%, 51% and 1% had low, moderate and severe dental erosion, respectively. Alcohol consumption was statistically significantly associated with dental erosion and statistically significantly greater in boys than girls. The authors suggested that other factors are likely to be of greater importance for the experience of dental erosion in this age group, since only a small minority had a high alcoholic consumption (Al-Dlaigan *et al.*, 2001b).

2.6 Dental erosion and saliva

Dental erosion has a multifactoral aetiology including exposure to acids from diet, environmental and gastric problems (Zero, 1996; Shaw *et al.*, 1998). Erosion also has predisposing factors such as morphology of the teeth, effects of soft tissue and salivary properties, which may have influence on subjects susceptibility to dental erosion (O'Sullivan and Curzon, 2000b). Saliva provides some protection against dental caries, dental erosion, attrition and abrasion as a source of the acquired enamel pellicle and promoting the clearance of sugar and acid from the mouth as well as a supersaturated source of tooth mineral (Dawes, 2008). Saliva’s most important protection function against tooth wear is its role in pellicle formation, buffering, acid clearance and remineralisation (Barbour and Rees, 2006). During an erosive challenge, saliva has several protective mechanisms such as dilution and clearance of the erosive agent from the mouth, neutralisation and buffering of acids and reduction of the dissolution rate through salivary calcium and phosphate (Lussi and Hellwig, 2006; Lussi *et* *al.*, 2007; Lussi and Jaeggi, 2008). The salivary acquired pellicle is a protein-based layer on the tooth surface which is immediately formed after its removal by toothbrushing. It may protect against dental erosion by acting as diffusion barrier preventing the contact between the acids and the tooth surfaces (Lussi *et al.*, 2007; Lussi and Jaeggi, 2008).

A study conducted by Amaechi and Higham, (2001) reported that saliva can remineralise early eroded enamel and it may be responsible in the difference in severity and sites of development of dental erosion within the dental arches and between individuals. Several studies have shown that dental erosion may be associated with low salivary flow and low buffering capacity (Jarvinen *et al.*, 1991; Lussi and Jaeggi, 2008).

O'Sullivan and Curzon (2000b) measured the salivary flow rates, buffering capacity (saliva's ability to neutralise acids that enter the oral cavity) in 103 3-16 year-old children with dental erosion in the UK and compared the results with similar age and sex caries-free and caries-active individuals to find out which may be considered as predisposing factors for dental erosion. The results showed that there was an increase in the salivary flow rate and pH with stimulation, but just under half of the subjects exhibited a low buffering capacity on stimulation which may be an important factor in developing dental erosion; of the total sample 47% with low buffering capacity had dental erosion, while 26% of the sample with high buffering capacity had erosion. A healthy lifestyle with healthy diet and regular exercise may lead to dental erosion. Exercise increases the loss of body fluids and may lead to dehydration and decreased salivary flow and a healthy diet, containing more fruits and vegetables may enhance dental erosion. Risk of erosion increased in swimmers exercising in low pH water and athletes consuming sport drinks frequently (Lussi *et al.*, 2007). In a Brazilian study which aimed to determine the prevalence of dental erosion among 12 year-old children and test the influence of salivary characteristics (salivary flow, buffer capacity and pH) it was suggested that they have no influence on erosion (Correr *et al.*, 2009). Chewing sugar-free gum stimulates salivary flow (Dawes, 2008), and sour foodstuffs have a strong influence on salivary flow (Lussi *et al.*, 2007). However, chewing gums trend to be discouraged due to the risk of abrasion of softened tooth surfaces (Lussi and Hellwig, 2006).

2.7 Dental erosion and its association with caries

Tooth tissue loss is caused by many factors including; trauma, dental caries and tooth wear (Nunn, 1996). It has been suggested that dental erosion may be more common amongst children with a low prevalence of dental caries (Nunn *et al.*, 1996). Dental erosion and caries rarely occur simultaneously at the same site. In the case of dental erosion the tooth surface is demineralised by direct contact with acids, but caries is a result of action of the acids produced by plaque (Moss, 1998; Ehlen *et al.*, 2008). Dental erosion tends to be found on plaque free tooth surfaces, while the presence of plaque is an essential factor for the progression of dental caries (O'Sullivan and Curzon, 2000b). In a study conducted to investigate the prevalence of dental erosion in 1010 12 year-old Cuban children (Kunzel *et al.*, 2000), more than 17% had dental erosion and the mean DMFT was low (1.4). There was no correlation between the caries prevalence in children with or without dental erosion. Truin *et al.* (2005) found a mean DMFT of 0.2 and prevalence of dental erosion was 24% in 12 year-old children in The Netherlands with no difference in the distribution of dental erosion in children with and without caries experience. Moreover, results of a study conducted in 458 14 year-old Brazilian schoolchildren, found the mean DMFT index amongst subjects with and without erosion were very similar, 3.92 and 3.96 respectively and this means there was no statistically significant difference between the association of dental caries and experience of dental erosion (Auad *et al.*, 2009). In contrast, other studies have found a positive association between dental caries and dental erosion. For example, in a study conducted in the United Kingdom to investigate dental erosion and to determine if caries experience influences the prevalence of dental erosion (Dugmore and Rock, 2004a), tooth erosion was found in 1046 (54.7%) of 1753 12 year-old children. Significantly more children with caries experience also had erosion present (66%) compared with those who had no caries experience (54.9%) in their permanent dentition. In addition, children with dental erosion had a higher mean DMFT score of 1.17 compared with the DMFT of 0.83 in those without dental erosion. The author suggested that the 12 year-old children who failed to maintain a non-cariogenic diet, also failed to maintain a non-acidic diet. Of these 1753 children who were examined at age 12 years, 1308 were re-examined at age 14 years. When the data were compared with the prevalence of dental erosion at age 12 years the dental erosion had increased by 50 % (Dugmore and Rock, 2004b). A study conducted in Saudi Arabia (Al-Malik *et al.*, 2002) determined the prevalence of dental erosion and related this to dental caries in 987 preschool children (2-5 years). The results showed that of the 987 children examined, 31% had erosion, 73% had dental caries, and 34% had rampant caries. The mean dmft was 4.80. Of the 384 children who had caries (but not rampant caries) 141 (37%) had erosion, a significantly higher ($p<0.01$) proportion than the 72 (27%) with erosion out of the 267 who were clinically caries free. Of the 336 with rampant caries, 96 (29%) also had dental erosion. In this age group of children, caries was a significant risk factor for dental erosion. A study conducted to investigate dental erosion, dental caries and determine the factors associated with dental erosion in 714 Australian children (Kazoullis *et al.*, 2007), aged 5.5 to 14.6 years, showed 225 children (32%) exhibited no erosion and 489 (68%) had erosion of at least one tooth. Dental erosion had a strong association with caries experience. Many types of food and soft drinks are acidic and also high in non milk extrinsic sugars so dental erosion and caries may be expected to occur together in a proportion of cases (Al-Malik *et al.*, 2002). Dental caries may also occur in patients with erosion where plaque accumulation adjacent to the eroded tooth surfaces (Lussi *et al.*, 2007).

An *in vitro* study, suggested that the presence of plaque can reduce the acid attack of an erosive drink and the relationship of erosive and cariogenic challenges illustrated less enamel change when compared to erosive or cariogenic challenges only (Honório *et al.*, 2008). The relationship between dental erosion and dental caries is not yet clear or well-established and it has to be investigated thoroughly.

2.8 Dental erosion and general health

2.8.1 Dental erosion and gastric acids

Diagnosis and treatment of gastrooesophageal reflux disease (GORD) in its early stages is important not only to preventive dental erosion but also to prevent serious complications such as oesophagitis, oesophageal adenocarcinoma and aspiration pneumonitis. Gastrooesophageal reflux (GOR) is defined as the passage of gastric contents into the oesophagus, whereas GORD is defined as symptoms or complications of GOR. The most common criterion for diagnosis of GORD is the occurrence of heartburn twice or more weekly (Barron *et al.*, 2003). Gastric refluxate has a pH of less than 2.0 which is below the critical pH of dental enamel which is 5.5 and this makes it an intrinsic factor for dental erosion (Barron *et al.*, 2003). Approximately 35-40% of the adults in the Western world suffer from gastrooesophageal reflux disease (Farrokhi and Vaezi, 2007). GORD is a common condition affecting approximately 60% of the population (Jones and Lydeard, 1989). GORD has been shown to occur in children as well as in adults, and often there are no symptoms, but children may complain of heartburn, food regurgitation and epigastric pain (Wilder-Smith and Lussi, 2006). GORD has been connected with tooth erosion and frequently mentioned as a causal factor in erosion in a number of studies (Howden, 1971; Jones and Cleaton-Jones, 1989; Jarvinen *et al.*, 1992). Moreover, dental erosion can be considered the predominant oral manifestation of GORD (Lazarchik and Filler, 1997). The common teeth subject to dental erosion as a result of GORD are both primary and permanent mandibular molars (Ganss *et al.*, 2001a). Gastrooesophageal reflux disease is not easy to diagnose in children without investigation as children usually can not provide an accurate history or understand meaning of heartburn or regurgitation (Gudmundsson *et al.*, 1995).

The poor buffering capacity of saliva in patients with GORD leads to higher the prevalence of tooth wear (Moazzez *et al.*, 2004). Some factors provoke GORD such as excessive food or alcohol especially if taken before sleep as well as some types of dietary components as chocolate, coffee, spicy and fatty food and carbonated drinks (Bartlett *et al.*, 1996). A study which examined patients with gastrooesophageal reflux disease found that, of the total 117 11-54 year-old patients 28 (24%) had dental erosion (Meurman *et al.*, 1994). Schroeder *et al.* (1995) reported 10 of 12 adult dental patients with tooth wear were diagnosed with reflux disease. Schroeder *et al.* (1995) also reported 12 out of 30 adult patients with reflux disease had tooth wear. A similar finding was made by Bartlett *et al.* (1996) who reported 60% of 40 patients with GORD had tooth wear. Jasz *et al.* (2007) suggested that the dentist should always consider in GORD cases of extensive dental erosion. Results from a UK National Survey found that, 4-6 year-old children with health problems related to gastric reflux had a statistically significant higher prevalence of (79%) dental erosion than children without this disease (62%) (Walker *et al.*, 2000). Milosevic *et al*. (2004) investigated tooth wear in 2385 14 year-old children in the UK suffering from indigestion they found that 20% of the total had chances of having tooth wear into dentine (Odds Ratio = 1.24). A study investigating the relationship of the dental erosion and GORD in 225 Nigerian subjects comprising of 100 volunteers and 125 patients with GORD found that the prevalence of dental erosion was statistically significant between GORD patients (16%) and control (5%) ($p < 0.05$) (Oginni *et al.*, 2005). Ersin *et al*. (2006) investigated the effects of GORD on dental erosion on 38 GORD patients with mean age of 6 ½ years and 42 healthy children of the same age and showed that prevalence of erosion in GORD children was statistically significant higher than in healthy children ($p<0.05$). Nunn *et al*. (2003) reported that data from the published national dental surveys of young people in the UK showed an increase in the prevalence of dental erosion and an association between dental erosion and GORD.

Acid regurgitation (when gastric acids reach the oral cavity) is also a common symptom in other diseases and dysfunctions of the upper alimentary tract, such as peptic ulcer and reflux oesophagitis (Jarvinen *et al.*, 1988). In addition, Shaw *et al.* (1998) reported that, there was a relationship between regurgitation and consumption of acidic diet. This means, an acidic diet could affect the prevalence of dental erosion in both ways; intrinsic and extrinsic.

On the other hand, results of a study in the UK examined a random sample of 1753 12 year-old children and 1308 of the same children were re-examined at age 14 years and reported that there was no statistically significant association between problems related to gastric reflux and dental erosion (Dugmore and Rock, 2004b). Further investigation is needed to assess the relationship between tooth wear, diet and gastric reflux.

2.8.2 Dental erosion and eating disorders

Anorexia nervosa and bulimia nervosa are eating disorders. In a study in Spain of 1314 15 year-olds, of the total sample, five had anorexia nervosa, eleven had bulimia nervosa and the study demonstrated an increase in the prevalence of eating disorders in Madrid (Morandé *et al.*, 1999). In a cross-sectional observational study in the UK, 5.5% of 525 14 year-old children reported they vomited their food, but this was not statistically significantly associated with dental erosion (Williams *et al.*, 1999). In another study carried out in UK, only 3% of 2385 14 year-old children suffered from regular stomach upsets or frequent vomiting and there was no statistically significantly association with tooth wear (Milosevic *et al.*, 2004). In a case-control study, a statistically significant difference was observed between the prevalence of erosion among 11 adult female patients with bulimia (69%) and 22 age- and gender-matched controls (7%). Erosive lesions were larger and deeper in patients with bulimia. It was suggested that the presence of dental erosion on the palatal surfaces of upper anterior teeth and buccal surfaces of upper canines, premolars and upper incisors could clinically characterise bulimia nervosa (Jones and Cleaton-Jones, 1989).

2.8.3 Dental erosion and medication

A complication of the medication used in chronic diseases may be regurgitation or dry mouth which are possible reasons for the increase in the prevalence of dental erosion (Johansson *et al.*, 2008). The frequent use of acidic medications such as acetylsalicylic acid (aspirin) and ascorbic acid (vitamin C) has been associated with the experience of dental erosion (Zero, 1996). The consumption of vitamin C tablets has been shown to be statistically significantly associated with the experience of dental erosion (Al-Dlaigan *et al.*, 2001b). Another study this time in Saudi Arabia observed a statistically significant association between the ingestion of vitamin C supplements and the experience of erosion in 54 preschool children. Twenty-eight of the children with regular consumption of vitamin C supplements had erosion and of these, 50% had severe erosion. Children who were taken vitamin C supplements may have up to 4.7 times the risk of erosion (Al-Malik *et al.*, 2001b). A study in the UK of 418 14 year-old children found that 40% of the 42 vegetarian subjects reported a daily consumption of vitamin C tablets and 52% of these children had signs of dental erosion and 48% moderate erosion (Al-Dlaigan *et al.*, 2001c).

2.8.4 Dental erosion and asthma

Although asthma is a relatively common respiratory disease, affecting about 10% of children (Shaw *et al.*, 1998), few data have been published about the association between dental erosion and asthma. In the UK, the National Diet and Nutrition Survey showed that asthma was the commonest medical condition reported in a sample of 1726 4-18 year-old children (Walker *et al.*, 2000). However, there was no association found between asthma and dental erosion and it was suggested this may have been due to no information being collected relating to the period and frequency of asthma attacks (Walker *et al.*, 2000). Another UK study of 1308 children who were examined at ages 12 and 14 found that the reported occurrence of asthma and the use of inhalers were not statistically related to erosion (Dugmore and Rock, 2004b). Similarly, in a case-control study in Iceland for 278 15 year-old children, found no statistically significant association between the use of inhalers and the experience of dental erosion (Árnadóttir *et al.*, 2003). Moreover, a UK study found no statistically significant relationship between experience of tooth wear into dentine and asthma in children (Milosevic *et al.*, 2004).

In contrast, a cross-sectional study which aimed to assess the prevalence of asthma in 418 14 year-old British adolescents and to assess the prevalence of dental erosion among this group, found that 15.8% of children had asthma, among these children 90% were under medication to control the symptoms of the disease and the prevalence of dental erosion was higher in asthmatic children. It was suggested that higher prevalence of erosion among asthmatic adolescents might be related to the acidity of the medication used to control asthma, or reduced the salivary flow, or due to the medication or the asthmatic children had a higher intake of erosive drinks because of a relatively dry mouth (Shaw *et al.*, 2000).

The results from a case-control study in UK, aimed to assess and compare the prevalence of dental erosion and dietary consumption in three groups of children aged 11-18 years; 20 children with asthma, 20 children without asthma and the control group (20 children) with no history of asthma or other medical problems. Significant differences were found in the prevalence of dental erosion between the three groups, a higher prevalence of erosion seen in children with asthma. It was suggested that the medication for preventing asthma and its possible side effects might be the aetiology of dental erosion in asthmatic children (Al-Dlaigan *et al.*, 2002b). Similar results were observed in another case-control study in Australia that reported a statistically significant association between experience of dental erosion and asthma (Sivasithamparam *et al.*, 2002).

2.9 Dental erosion and oral hygiene practices

Tooth wear is usually a multifactorial process, comprising; erosion, attrition and abrasion. The most frequent type of abrasion is that produced at the necks of the teeth by inappropriate toothbrushing. An accelerated abrasion may take place at a surface already demineralised by erosion (Dugmore and Rock, 2004b). There is usually an association between dental erosion and high level of oral hygiene (O'Sullivan and Curzon, 2000b).

However, different findings have been reported in epidemiological studies and still the association between dental erosion and oral hygiene practice is not clear. In a study which examined 1753 children at age 12 and 1308 of same children re-examined at age of 14 years, no statistically significant association was found between the frequency of toothbrushing and dental erosion. When the information from oral examination at age 14 was associated with data collected at age 12, it was found that presence of calculus at age 12 was associated with reduced the chances of dental erosion at age 14 (Dugmore and Rock, 2004b).

In a study of 987 2-5 year-old Saudi Arabian children which investigated the association between dental erosion and oral hygiene habits, no statistically significant association was found between dental erosion and the frequency of toothbrushing or age of introduction of oral hygiene habits (Al-Malik *et al.*, 2001b). Another study based on examination and questionnaire in Trinidad, West Indies determined the prevalence of tooth surface loss in 155 Trinidadian subjects aged 16 years and older. Of the total sample 63% used a medium or hard tooth brush and 91% brushed their teeth twice daily. The results showed no association between frequency of toothbrushing and tooth surface loss (Rafeek *et al.*, 2006).

Al-Majed *et al*. (2002) examined 354 2-5 year and 862 12-14 year Saudi Arabian old boys and found that no statistically significant association between the experience of dental erosion into dentine/or pulp on palatal surfaces of the upper incisors and the reported frequency of toothbrushing. In addition, a study which determined the association of risk factors for tooth wear in 2385 14 year-old children showed that the majority of children brushed their teeth at least twice per day and the frequency of toothbrushing was not statistically significant associated with the experience of tooth wear (Milosevic *et al.*, 2004). Moreover, the results of study conducted in 2351 14 year-old children in the north west England found that brushing twice daily with fluoridated toothpaste and living in fluoridated areas provided added protection from dental erosion (Bardsley *et al.*, 2004).

On the other hand, a study conducted in 418 14 year-old schoolchildren in the UK investigated the association between dental erosion and oral hygiene practices, found 60% of children brushed their teeth twice daily and this was associated with dental erosion (Al-Dlaigan *et al.*, 2002a).

Dental erosion is accelerated in children who consume acid drinks at night before brushing their teeth (Shaw and Smith, 1999). Toothbrushing immediately after consuming acid drinks may increase dental erosion (Zero, 1996). This habit should be discouraged and children should be advised to stop brushing their teeth immediately after an erosive challenge to reduce the risk of abrasion. The most important time for toothbrushing is before bedtime because of reducing of salivary flow and losing of its protective effects during sleep (Dawes, 2008).

Several studies *in vitro* have investigated the association between dental erosion and toothbrushing and found the abrasiveness of toothbrushing adds a physical effect to the demineralization which results in increased tooth wear in people with a high standard of oral hygiene (Attin *et al.*, 2001). In another *in vitro* study by Attin *et al.* (2000) the period of remineralisation needed to re-achieve abrasion resistance to brushing was evaluated. Enamel specimens were submitted to demineralization by immersing them in an erosive soft drink for one minute, and then submitted to remineralisation by storing them in saliva. After that they were submitted to abrasion by brushing. The results showed that abrasion resistance of eroded enamel increased with remineralisation time (Attin *et al.*, 2000). Another similar *in vitro* study done by the same author but on dentine specimens showed the abrasion resistance of dentine to be decreased after erosion, even after two hours of remineralisation (Attin *et al.*, 2001).

An *in situ* study which determined rates of enamel and dentine wear during toothbrushing using different types of toothpaste showed that enamel wear and dentine wear were similar and the overall amount of enamel wear was small (less than 2 microns) for all products (Pickles *et al.*, 2005b). Another *in vitro* study which determined enamel and dentine wear by toothpastes, found that mean enamel wear ranged from 0.05 to 0.40 microns. The mean dentine wear was from -0.024 to 2.38 microns and there was a good correlation between median dentine wear and relative dentine abrasivity (Philpotts *et al.*, 2005). Abdullah *et al*. (2006) compared the effect of brushing versus dipping on dental erosion in an *in vitro* study by using different concentrations of fluoridated toothpastes. They found enamel erosion increased significantly by brushing with toothpastes compared to dipping. Similar results were obtained in another *in vitro* study which investigated enamel loss by cycling of erosion and abrasion and found a significant enamel loss due to toothbrushing (Hemingway *et al.*, 2006). Other *in vitro* studies have assessed the abrasive effect of two whitening toothpastes containing calcium carbonate and perlite on enamel and dentine and found no significant degree of abrasion of the whitening toothpastes after 12 weeks of brushing (Joiner *et al.*, 2005; Pickles *et al.*, 2005a; Joiner, 2006).

2.10 Prevention and treatment of dental erosion

Awareness of dental erosion by people is still not widespread because it is a slowly progressing condition. In addition, it is difficult to distinguish between dental erosion, attrition and abrasion during oral examination (Lussi *et al.*, 2006). Dugmore and Rock (2003a) investigated the knowledge of tooth erosion in 12 year-old children and the dentists' responsibility for advice patients concerning erosion, found that the level of awareness was low for both dentists and patients. When dental erosion begins at a young age, there is a greater chance it may continue over a lifetime if it is not diagnosed and proper preventive measures are taken (Lussi *et al.*, 2007). Early detection of erosion is important to stop and prevent irreversible tooth surface loss; knowledge of the multifactorial nature of tooth wear and its risk factors is also important in its diagnosis and treatment (Tomasik, 2006). Dentists have to know the clinical features, signs, causes of erosion and how to prevent further progression, and if necessary the treatment (Lussi and Jaeggi, 2008). Patients who have dental erosion can be treated successfully if the correct diagnosis and preventive and therapeutic measures are performed (Lussi and Jaeggi, 2004). The seriousness of the complications of dental erosion range from loss of surface characteristics to loss of tooth tissue with pulp involvement. These consequences have accompanying symptoms ranging from sensitivity to severe pain. In addition, the effects of dental erosion may be not limited to wear of the teeth but may affect the surrounding structures leading to temporo-mandibular dysfunction as a result of the loss of occlusal vertical dimension. Moreover, poor aesthetics may lead to psychological problems especially in children. Early erosive damage to the permanent teeth may affect them for their entire lifetime. In addition to all these complication, dental erosion requires complex and costly treatment and maintenance. For this reason early diagnosis and adequate preventive measures should be undertaken (Lussi and Jaeggi, 2006). The first step in treatment of dental erosion is identifying the aetiological factors and start commencing preventive advice. Diagnosis and prevention of the causes of dental erosion are crucial in its management (Lussi *et al.*, 2000). Prevention includes the identification of the people who are at risk of tooth surface loss, for example, individuals who report dental erosion in childhood or have para functional activity, or have eating disorders, consume acidic drinks and erosive foodstuffs or have medical problems resulting in gastric reflex or voluntary vomiting (Wickens, 1999). In order to assess the risk factors of dental erosion, patients should report their food dairies for a period of time, then dietary instruction and advice can be given to them based on the analysis of the their food dairies, in addition to use of fluoride regimes and stimulation of salivary flow rate (Lussi *et al.*, 2006). Excessive consumption of acidic drinks and foodstuffs is the main extrinsic risk factor for dental erosion, also the intake of medicaments (asthma), behavioural factors like unusual eating and drinking habits are possible reasons for dental erosion (Dugmore and Rock, 2004b; Lussi and Jaeggi, 2006).

The best way of dental erosion treatment is to prevent it. In treatment of dental erosion medical history should be identified and treated followed up by diet history for several days (Imfeld, 1996). The dietary history should determine the extent, frequency, and timing of acid consumption in the diet, the medical history to determine if the child suffers from GORD, which can cause dental erosion (Linnett and Seow, 2001).

Dietary advice, dietary modifications and instructions should be given when acidic intake is the likely prime aetiological factor for dental erosion. These instructions may include; limitation of acid intake to mealtimes to allow remineralisation to occur, reduction of the frequency and refraining from consuming acidic food or drink before bedtime because of the absence of salivary flow. Acidic drinks should be swallowed immediately and not swished around the mouth; use of a straw since straw directs drinks past the anterior teeth and towards the pharynx reducing drinking time. Individuals should be advised also to follow the manufacturer's instructions on dilution of soft drinks, consumption of modified soft drinks with added calcium and/or phosphate supplements, citrate and fluoride to reduce dental erosion (Imfeld, 1996; Davis *et al.*, 2007) since soft drinks supplemented with calcium have been shown to have a reduced capacity to cause enamel demineralisation (Hara and Zero, 2008; Bartlett, 2009). Several calcium-added soft drinks are on the market in some countries, and products with naturally high contents of calcium and phosphate are present such as yoghurt, which although have a low pH do not soften the tooth surfaces (Lussi *et al.*, 2007).

Children also should be advised to stop drinking soft drinks and sports drinks immediately following exercise because the salivary flow and the buffering capacity is decreased after exercise (Linnett and Seow, 2001; Lussi and Jaeggi, 2008). Also, finishing a meal with a food high in calcium phosphate such as milk, cheese and yoghurt may be beneficial (Imfeld, 1996; Serra *et al.*, 2009). von Fraunhofer and Rogers (2004b) reported that reducing the residence time of acidic drinks in the mouth by rinsing would be beneficial to reduce dissolution of dental enamel.

Children should be instructed to stop brushing their teeth immediately after an erosive challenge (acidic food intake and vomiting) to reduce risk of abrasion (Zero, 1996; Lussi and Hellwig, 2006). Instead, use of fluoride mouthrinse, milk or cheese or sugar-free yoghurt or rinse with water (Lussi and Hellwig, 2006). Moreover, avoiding toothbrushing immediately before an erosive challenge can be beneficial as the acquired pellicle provides protection against erosion (Lussi and Hellwig, 2006). Using a soft tooth brush and low abrasivity toothpaste with fluoride should be considered because highly abrasive toothpaste may destroy the pellicle (Bartlett, 2005; Bartlett, 2009). In addition, dietary monitoring for acid intake performed at the beginning of the treatment by the dentist and recording at least a three-day detailed diet history is important.

Some medication including vitamin C tablets (especially in chewable tablet form) and iron supplements as well as some mouthwashes, are also acidic and cause dental erosion (Giunta, 1983). Interestingly, fresh fruit and vegetables are good salivary stimulants especially citrus fruit which make them an excellent choice for people with low salivary flow and they can be recommended as part of a healthy, saliva-stimulating diet especially at breakfast (Young, 2005). Regular drinks of 1.5 litres pure water daily to increase salivary flow are necessary for patients with tooth wear or with medications affecting salivation, e.g. drugs given for asthma, depression and hypertension. In addition, sports people should be instructed to drink one litre of water one hour before the sports activity to prevent dehydration (Dawes, 1987; Young, 2001) and reduce the need to consume sport drinks. Fluoride exposure from water fluoridation and from other fluoride supplements in the first twelve years of life increase resistance to dental erosion in adulthood, in the same way that it provides resistance to demineralization by dental caries (Teo *et al.*, 1997).

A topical fluoride varnish should be applied on the erosive defects to stop or reduce the dental erosion; in addition, patients should be instructed to rinse with a neutral fluoride mouthrinse twice per day and gently apply a topical fluoride gel twice a week (Lussi and Jaeggi, 2006). A daily neutral sodium fluoride mouthrinse or gel may be used to minimize hard tissue loss and control sensitivity (Bartlett *et al.*, 1994). In addition to sugar free chewing gum to stimulate salivary flow, fluoride mouth rinse and gel may be beneficial (Imfeld, 1996). Restorative treatment is important to restore the tooth structure lost by dental erosion to improve aesthetics, restore function, alleviate pain in exposed hypersensitive dentine or exposed pulp, to restore occlusal vertical dimension and to prevent further loss of tooth structure (Harley, 1999). It is also important that patients referred or advised to seek medical help when intrinsic causes are involved (Lussi and Hellwig, 2006).

2.11 Summary of the literature review

Several factors have been linked to the development of the erosive process in children, such as aspects related to general health, medication, saliva properties, lifestyle, oral habits, oral hygiene practices and the most important factor, an acidic diet. The literature exploring the association between dental erosion and dental caries has also been investigated. Further longitudinal studies to monitor the prevalence of dental erosion and to investigate the erosive process and its potential risk factors are needed. The prevalence of dental erosion or its relationships with potential risk factors in children or adults is unknown in Libya. Therefore, the aims of this study are to investigate the prevalence of dental erosion in 12 year-old schoolchildren in Libya and its association with acidic dietary items and other risk factors.

Chapter 3
Aims, objectives and hypothesis of the study

3.1 Main aim

To determine the prevalence and severity of dental erosion amongst 12 year-old schoolchildren in Benghazi, Libya.

3.2 Subsidiary aims

3.2.1 To investigate any association between the experience of dental erosion and potential risk factors for dental erosion in children in Benghazi, Libya.

3.2.2 To investigate any relationship between fluoride exposure from water supplies and prevalence and severity of dental erosion in Benghazi, Libya.

3.2.3 To determine the prevalence and severity of dental caries amongst children in Benghazi, Libya.

3.2.4 To investigate the association between the experience of dental erosion and dental caries amongst children in Benghazi, Libya.

3.3 Objectives

3.3.1 To undertake a dental examination of 12 year-old Libyan schoolchildren in Benghazi in order to assess the prevalence and severity of dental erosion and dental caries.

3.3.2 To ask 12 year-old schoolchildren to complete a questionnaire in order to collect information about their consumption of acidic dietary items (foods and drinks) in terms of types of drinks, frequency of consumption and associated habits and other potential risk factors for dental erosion in their general health, oral hygiene practice and lifestyle.

3.3.3 To randomly select a sub-sample of schoolchildren to complete a three-day estimated food dietary record in order to provide detailed dietary information on consumption of public/bottled water and acidic dietary items in terms of amount and frequency.

3.3.4 To interview these children in order to clarify the information provided in the food diaries.

3.4 Null hypotheses

3.4.1 There is no difference in the prevalence and severity of dental erosion in 12 year-old children in Benghazi, Libya compared with European children.

3.4.2 There is no relationship between dental erosion and dental caries in 12 year-old children.

3.4.3 There is no relationship between the prevalence and severity of dental erosion and the amount and frequency of consumption of acidic dietary items.

3.4.4 There is no relationship between the prevalence and severity of dental erosion and exposure to other risk factors for dental erosion.

Chapter 4
Materials and Methods

4.1 The study site

Benghazi is the second largest city in Libya after the capital, Tripoli (Appendix 4.1). The city is divided into 15 districts with rapidly progressing developments in all aspects of life. Benghazi is a very good example of a Libyan urban area comprising a population with different socioeconomic, cultural and original backgrounds. Therefore, it is an appropriate site for the study and suitably representative of the Libyan population.

4.2 The study sample

4.2.1 Schools in Benghazi

Table 4.1 shows the different Districts of Benghazi. In 2005, the total number of schoolchildren aged 12 years in Benghazi was approximately 7682 (corresponding to the sixth grade of elementary school). These children were studying at 81 public elementary schools (Appendix 4.2). The public schools comprised 90% of the total number of schools in Benghazi (GAI, 2006).

4.2.2 Inclusion and exclusion criteria

For subjects to be included in the study, the following criteria were required to be met:

- Schoolchildren resident in Benghazi, Libya.
- Schoolchildren aged 12 years, but not yet 13 years of age.

- Schoolchildren with written consent to participate in the study from their parents/guardians.
- Schoolchildren present on the day of dental examination.

The following subjects were excluded:

- Schoolchildren who were not resident in Benghazi, Libya.
- Schoolchildren not aged 12 years.
- Schoolchildren without the written consent from their parents/guardians.
- Schoolchildren who were absent on the day of dental examination.

Table 4.1: Number of 12 year-old children and public schools in the 15 Districts of Benghazi, Libya.

Name of Districts	Number of public elementary schools	Number of 12 year-old schoolchildren attending schools
Al Bayan Al awal	6	670
Sidi Hussain	4	381
Al Sabri (west)	5	400
AlSabri (East)	7	351
Al Mukhtar	5	545
Al Salmani (East)	7	370
Al Salmani (West)	5	400
Dawood (North)	4	450
Dawood (West)	8	650
Khalid Ben Walid	6	600
Dawood (South)	8	700
Al Jazeera	3	252
Garyounis	3	337
Al Fuwayhat (west)	4	631
Benghazi al Jadidah	6	945
Total	**81**	**7682**

Source: Great Socialist People's Libyan Arab Jamahiriya:
General Authority of Information (GAI, 2006) A preliminary result of general population census 2006.

4.2.3 Gender

Both genders were included in this study. Numbers of schoolchildren and schools are not equal in each district in Benghazi, as they depend on the density of population in these districts. Both boys and girls in Benghazi attend elementary schools. A cluster sampling within the schools was used for school sampling, then a random selection of boys and girls from each elementary school was made. Twelve year-old children were selected for this study because at this age the index teeth have been present in the mouth for about six years and exposed to possible intrinsic and extrinsic aetiological factors which may cause dental erosion. In addition, use of this age group allowed comparison with results from previous studies in the same age group in different countries.

4.3 Statistical power of the study

The statistical power of the study was calculated with the assistance of a medical statistician, Dr Nick Steen, Principal Research Associate, Institute of Health and Society, Newcastle University. There are no published data concerning the prevalence of dental erosion in Libya. Consequently, the prevalence of dental erosion in 11 to 14 year-old British children, which had been estimated as 52% in a study by Walker *et al.* (2000) was considered. In addition, the prevalence of dental erosion in 13-14 year-old Brazilian children (Auad *et al.*, 2007) (34%) was also considered. Based on these figures, it was expected in the proposed study that the prevalence of dental erosion in 12 year-old school children in Benghazi could be 35% +/- 5%. Therefore, the sample size was calculated based on this estimate; with a sample of 665 subjects the 95% confidence interval was +/-4% able to detect prevalence of erosion 35% +/- 5% (standard error 2.04%).

Undertaking dietary assessment on a sub-sample of 175 children also gave a 95% power to detect a Pearson correlation coefficient of 0.3 assuming a Type 1 error rate of 5%.

4.4 The sampling procedure

Cluster sampling, using the schools as the clusters was used for the sampling procedure. Based on a typical estimate of an intra-class correlation coefficient of around 0.05 and the 95% confidence interval to be the point estimate +/-5%, a cluster sampling procedure required recruitment of 19 children from each school in a random selection of 35 schools, providing a sample size of 665. In addition, to allow for withdrawals, overall a total of 22 children were recruited from each randomly selected school, providing a total sample size of 770. The sample was felt to be sufficiently large enough, including thirty five schools drawn from the 15 different districts with different socioeconomic groups and cultures to make the study sample in Benghazi reasonably representative of other regions of Libya. First, a random sample of schools was selected; at least one school from each district, and at least two schools from districts with 6 or more schools. Two people unrelated to the study at Newcastle University helped to randomly select the schools by drawing out of a hat, one or two schools from each district. Then, a random selection of a sample of girls and a random selection of boys for whom consent to take part in the study had been obtained from their parents from each elementary school (elementary schools have both boys and girls attending) was made. For the selection of these random samples a list of girls (or boys) was made alphabetically and assigned consecutive numbers. Boys and girls were sampled separately to ensure representative samples. Using a list of randomly generated numbers between 1 and 99, a selection of the first 22 children was made using columns, for example starting with column 2 to sample 11 girls or 11 boys from within a school. If a child with that number did not exist, the examiner moved to the next number that corresponded to a child.

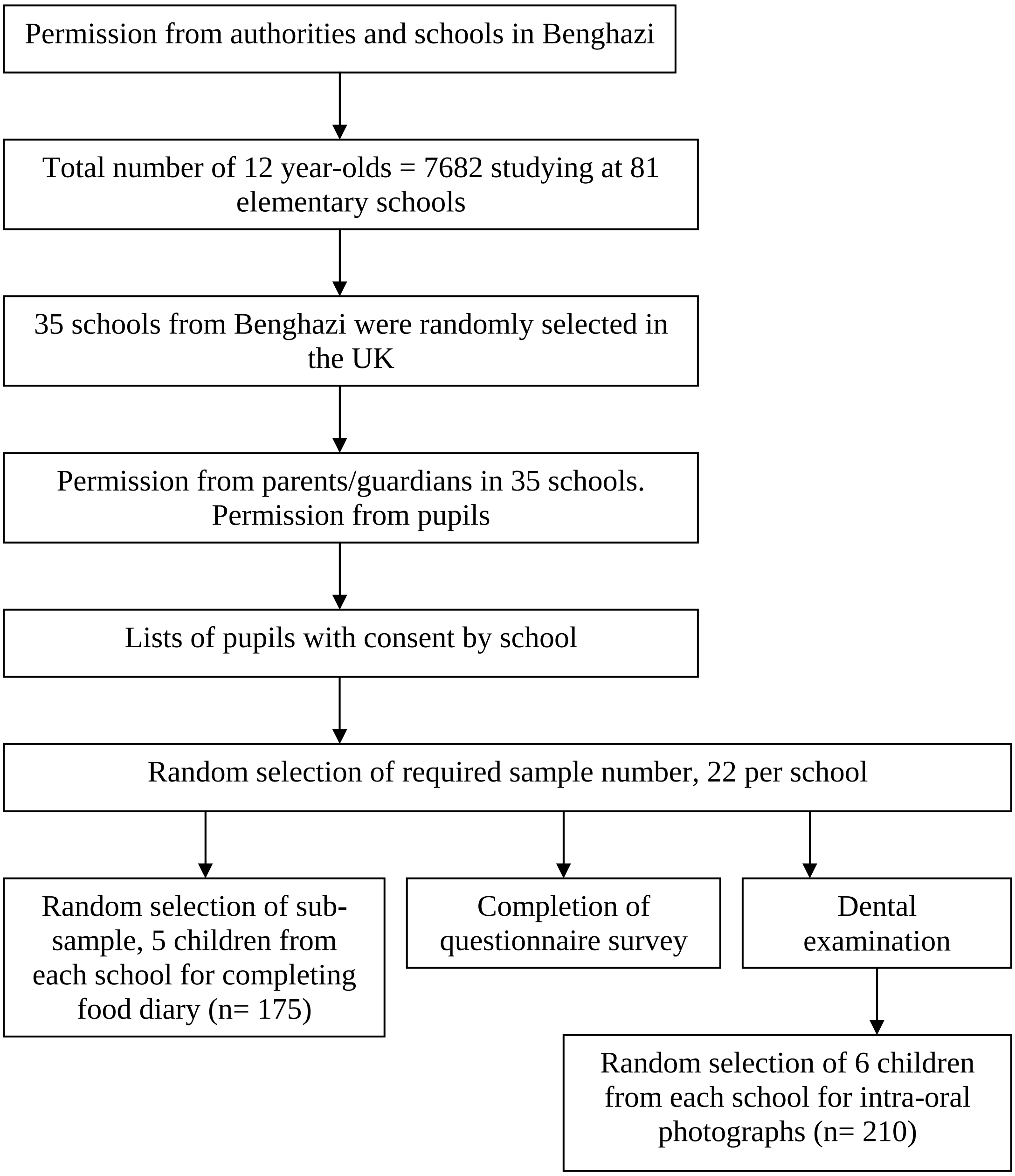
The sub-sample of 175 children for the 3-day estimated food diaries was selected from 35 schools. Five children were randomly selected from the previous randomly selected list in each 35 schools to achieve a sub-sample of 175. Then, 6 subjects from each school were randomly selected for intra-oral photography.

Figure 4.1 demonstrates the sampling procedure and steps of the field work.

4.5 Planning and preparation at Newcastle University

The data collection forms used in the study were prepared in the School of Dental Sciences, Newcastle University. The Oral Health Assessment Form (Appendix 4.3) contained a dental charting for the maxillary and mandibular teeth with designated cells for coding the entry of dental erosion and dental caries. In addition, diagnostic criteria codes for dental erosion and caries were also contained within the form as an aide-memoire for the examiner's quick reference. Both the oral health assessment form and the questionnaire contained demographic information such as, ID number, gender, school number, date of birth, and date of examination.

Figure 4.1: Flow chart of the field work in Benghazi, Libya.



4.6 Data collection

4.6.1 Clinical dental data

4.6.1.1 Measuring the prevalence and severity of dental erosion

The prevalence of dental erosion was determined using the index used in the oral health component of the UK National Diet and Nutrition Survey (NDNS) (Walker *et al.*, 2000) (Appendix 4.3). This index assesses the labial and palatal surfaces of the upper incisors and occlusal surfaces of the first permanent molars. The conduct of the examination and criteria for the assessments are presented in detail in Appendix 4.4. This index was also used in the Children's Dental Health Survey in the UK (Chadwick and Pendry, 2004). Table 4.2 shows the criteria used to assess dental erosion (Walker *et al.*, 2000).

Table 4.2: Criteria used to assess dental erosion (Walker *et al.*, 2000).

Code	Depth	Area of surface affected
0	Normal	Normal
1	Enamel only	Less than one third of surface involved
2	Enamel and dentine	One third up to two thirds of surface involved
3	Enamel, dentine and pulp	Two thirds or more of surface involved
9	Assessment cannot be made	Assessment cannot be made

4.6.1.2 Measurement of dental caries:

The data collection form for recording dental caries was based on the indices recommended by the World Health Organization (WHO, 1997). The prevalence of dental caries was assessed in accordance with the World Health Organization criteria on crown surfaces using the DMFT (decayed, missing and filled teeth) and DMFS (decayed, missing and filled surfaces) indices for the permanent dentition (Table 4.3). The dental examination forms contained the diagnostic criteria codes for the examiner's quick reference, demographic information (ID number, date of birth, gender, and school number) and a dental charting with designated cells for coding the entry of dental erosion and dental caries data (Appendix 4.3).

All maxillary and mandibular teeth were examined for dental caries. Teeth were examined in the following order: Upper Left - Upper Right - Lower Right - Lower Left. Each surface was examined, coded and called in the following order: Distal - Occlusal - Mesial - Buccal - Lingual (WHO, 1997) (Appendix 4.4).

Table 4.3: WHO criteria for assessing dental caries (WHO, 1997).

Condition/State	Code
Sound	0
Decayed	1
Filled, with decay	2
Filled, with no decay	3
Missing, as a result of caries	4
Missing, any other reason	5
Fissure sealant	6
Bridge abutment, special crown or veneer/implant	7
Unerupted tooth (crown)	8
Trauma (fracture)	T
Not recorded (e.g. because of orthodontic bands or severe hypoplasia, etc.)	9

4.6.1.3 Calibration of the researcher for the dental examination

Calibration of the researcher in the use of the dental erosion and dental caries indices took place in the Division of Child Dental Health, School of Dental Sciences under the supervision of an experienced calibrator and examiner, Professor June Nunn, from Trinity College, Dublin. Professor Nunn was involved in the development and introduction of the modified Smith and Knight Tooth Wear Index for use in epidemiological studies (O'Brien, 1994; Hind and Gregory, 1995; Walker *et al.*, 2000; Chadwick and Pendry, 2004). She participated in the UK National Surveys and the calibration of dental examiners in these surveys. The training process included a one-to-one training session when Professor Nunn illustrated projected 35 mm clinical slides from different patients with varying severity of dental erosion using the Child Dental Health 2003 examiner calibration compact disc. Professor Nunn explained the clinical features of dental erosion and answered all the queries of the researcher. In addition, Professor Nunn trained the researcher the criteria and indices of dental caries and tooth condition of the World Health Organization. After that Professor Nunn re-viewed all the slides and examined the ability of the researcher to identify the different codes of dental erosion. Following this, the researcher (RH) observed Professor Nunn during the dental examination of two volunteers, who were students at the Child Dental Health Clinic, School of Dental Sciences, Newcastle University. The researcher revised the CD of the clinical slides of dental erosion and caries back at Benghazi and when ever needed as recommended by Professor Nunn.

4.6.2 Questionnaire data

4.6.2.1 Questionnaire design

An English version of the questionnaire was prepared at Newcastle University before the field trip to Libya. The questionnaire included questions on amount, frequency and timing of consumption of acidic foods and drinks, consumption of tap or bottled water, oral hygiene practices, and risk factors for dental erosion (Appendix 4.5). This questionnaire was based on the questionnaire used in the oral health component of the NDNS in the UK (Walker *et al.*, 2000).

The frequencies of consumption of the acidic, non acidic, sugared, and non sugared drinks were categorised as follows:

More than twice/day, more than once/day, once/day, less than once/day, never.

The frequencies of consumption of fruits were categorised as follows:

More than four/day, 2-4/day, more than one/day, one/day, less than one/day

The questionnaire was designed to be applicable to 12 year-old schoolchildren, who were old enough to understand the questions and able to make written answers. The questionnaire was simple, and easily understood. In addition, a pilot questionnaire was given to five 11-12 year-old UK based Arabic speaking children not involved in the study, in order to test its content validity and to comment on clarity and content and obtain information regarding any difficulties. They understood, answered and completed the questionnaire without difficulty. Following this, the questionnaire was translated into a simple Arabic language by the researcher at Newcastle University and then printed and copied according to the expected sample size in Benghazi.

4.6.3 Three-day estimated dietary diary

4.6.3.1 Design and preparation

The three-day estimated food diary with dietary interview is a validated method to collect dietary information, and has been used to assess the diets of children by researchers at Newcastle University for more than 20 years (Hackett *et al.*, 1984) due to its accuracy and lack of reliance upon the subject's memory (Anderson, 1995; Biro *et al.*, 2002).

As Appendix 4.6 shows, the three-day estimated food diary for collecting data about dietary intake over three days for this study contained written instructions to help the schoolchildren complete the diary over three consecutive days, two week days and one weekend day, and recorded everything they ate and drank including amounts consumed. In addition, details of any medicine taken and information about the time of consumption of foods, drinks and medicines was recorded.

4.6.3.2 Training in dietary assessment

Training in dietary assessment was undertaken under the supervision of Professor Paula Moynihan at Newcastle University. Approaches on how to clarify portion sizes were also discussed. In the UK, 3 volunteers aged 11-12 years were asked to complete the 3-day estimated food dairy as a pilot study, and discussion undertaken in how to clarify the written dietary information during the interviews using the verbal responses of the volunteers.

4.6.4 Water fluoride concentration

4.6.4.1 Permissions obtained for transportation and analysis of the water samples

The researcher secured a permission letter from the Libyan Embassy in London, and from the Health Ministry and Dental Faculty in Benghazi to allow the transfer of the samples from Benghazi to the UK. In addition, permission was obtained from Food Standards Agency in the UK to allow the import of samples to the UK and permission from the Newcastle University to allow the storage and analysis of the water samples in a University Laboratory.

4.6.4.2 Collection of water samples

Collection of samples of tap and bottled water was undertaken from each subject's house in the sub-sample (n= 175) and from each of the 35 randomly selected schools, in Benghazi. These collected samples were kept in fluoride-free plastic containers and frozen at -20º Celsius freezer at the Dental Faculty in Benghazi during the time of data collection and until time of shipping. Then, the frozen samples were defrosted prior to shipping and the examiner dried the outside of every tube carefully with tissues prior to them being transported at ambient temp back to the UK. Then the samples were refrozen in the UK prior to fluoride analysis.

4.6.4.3 Coding of water samples collected during 3-day food diary

Each water sampling tube was labelled as follows before being handed to the subjects:

a- Type of water; Tap (T) from home, bottled (B) or other resource of tap water out the subject's house (O).

b- The ID code of the subject (similar to that on food diary).

c- Time of collection; morning (M), afternoon (A).

d- Day of collection; the first day (1), or the third day of the 3-day food diary (3).

Each water sample was collected in a 30 ml Universal tube by the child's parent, who was asked to collect the water sample after one minute of running water from the tap to maintain consistency in collection of the samples. A total of four water samples were collected by the child's parent from tap water at home; at 8.30am, before school time, and at approximately 3pm, after home time, on the first and third day of food diary. The water sample in each container (30ml) was divided into two small bijous (7ml) (Scientific Laboratory Supplies Ltd) by the researcher prior to freezing, one for transport to the UK for analysis of the fluoride concentration and the other container stored in Libya as backup. In addition, every child was given a further four containers (30ml) to collect water samples from bottled and from any other sources of drinking water she/he may have consumed outside the home. Each water sample (30ml container) collected was divided into two bijous by the researcher and stored/transported as described previously. In addition, a total of four water samples, each in a 30ml container, were collected by the researcher from each school. These comprised a sample collected twice a day; morning and afternoon on each of the first and third day of the food diary. The total of 4 water samples was divided by the researcher into 8 bijous.

Each bijou of water sample collected by the researcher was labelled as follows:

a- Tap water sample from school (S).

b- School number (001 to 035)

c- Time of collection; morning (M), afternoon (A).

d- Day of collection (either the first day (1), or the third day of the 3-day food diary (3))

4.6.4.4 Storage of all water samples prior to transport to the UK

Each water sample collected in a universal tube was divided into two bijous (7ml), each of which was placed in a separate plastic bag before freezing; one was transported to the UK and used for analysis of the fluoride concentration, while the other was stored as a backup in Benghazi.

4.6.4.5 Analysis and storage of water samples in the UK

At the University of Newcastle the samples were stored in a -20° Celsius freezer until fluoride concentration was analysed by either the researcher (RH) or the lab technician using a Standard Operating Procedure (SOP) following appropriate training (Appendix 4.7). This protocol has been used previously to describe the direct analysis procedure for determination of fluoride concentration in water (Zohouri and Rugg-Gunn, 1999; Martinez-Mier *et al.*, 2004; Soto-Rojas *et al.*, 2004; Soto-Rojas *et al.*, 2005).

Data were entered into a Microsoft Excel (2003, Microsoft office) software program for calculating the results.

4.6.5 Time scale for the study in Benghazi

The field work schedule was prepared at Newcastle University to allow the examiner to rotate between the 35 selected schools in Benghazi (Appendix 4.8). On a weekly basis it was planned that three schools would be visited for dental examination, questionnaire completion, and distribution of food diaries.

The fieldwork took place in the schools in Benghazi, according to the schools' calendar during the first semester starting in September 2007. Appendix 4.8 demonstrates the order and timing of the various elements of the field work in Benghazi.

4.6.6 Planning, preparing and training for the study

The planning, preparation and training of the examiner was undertaken at Newcastle University. Table 4.4 shows the planning and preparation of the study at Newcastle University and in Benghazi, Libya.

Table 4.4: Planning and preparation of the study in the UK and in Benghazi.

Planning, preparation and training at Newcastle University	Planning, preparation and implementation in Benghazi
Before data collection: Attending courses. Study procedure for dental examination. Study procedure for three-day estimated food diaries with dietary interview. Preparing questionnaire. Calibration of the researcher. Arrangement with Data Entry Services. Learning fluoride analysis method for water Seeking permission from Academic Advisor of Libya at the Libyan Cultural Bureau, London. Arrangements for importing water samples to UK. Arrangement for transferring dental equipments, water samples' tubes to Benghazi.	**Before data collection:** Seeking ethical permissions Training of an assistant. Preparing the Arabic version of the written documents: food diaries, questionnaire, and oral health assessment sheets. **During data collection:** Three-day estimated food diaries with dietary interviews. Questionnaire survey. Clinical dental examination. Collection and storage of water samples (tap and bottled). **After data collection:** Arrangement for transferring the water samples from Benghazi to Newcastle University. Arrangement for transferring the written documents (oral health assessment forms, questionnaires and food diaries), and dental equipments from Benghazi to Newcastle University. Shipping of samples to the UK.

4.7 Planning and preparation in Benghazi, Libya

4.7.1 Ethical approval and permissions

4.7.1.1 Permission from local authorities and Dental School

The first step was seeking the permission to carry out the field study in Benghazi from the academic advisor of Libya at the Libyan Cultural Bureau in London (Appendices 4.9 and 4.10). After the official permission from the researcher's sponsor was obtained, the second step was seeking the permission from the Ministry of Education (Appendix 4.11), and the

Ministry of Health in Benghazi (Appendix 4.12). Subsequent to these permissions, the Ministry of Education sent official letters to the selected schools. The Dean of the Dental Faculty was also contacted directly and following discussion relating to the aims and method of the study, supporting letters to the schools (Appendix 4.13) and to customer services to permit transportation of the drinking water samples for analysis from Benghazi to the UK were provided (Appendix 4.14). In addition, the Dean supported the study by allowing sterilisation of the dental instruments in the facilities of the Dental School, Benghazi, repeatedly throughout the study.

4.7.1.2 Permission from schools

There is no governmental classification of geographical areas based on socioeconomic information for Benghazi, so the selection of the 36 schools from the total of 81 public schools was done randomly by cluster sampling within the schools. The permission letters from the Ministry of Education and Ministry of Health and the supporting letter from the Dental School were handed to the head teachers of the selected schools. Permission from each selected school was sought to carry out the dental examinations (Appendix 4.15).

4.7.1.3 Preparatory visits to schools

Once the permission was obtained, the examiner visited each of the randomly selected 36 schools for a preparatory visit to facilitate the study implementation in the schools by assessing the availability of a room suitable for dental examination, and encourage the co-operation of the school officials to facilitate the flow of students during the dental examination. At the preparatory visit, schoolchildren’s records for the selected age group were reviewed to obtain the essential information about each participant, such as the name of the subject, gender, and date of birth.

4.7.1.4 Recruitment of children from schools

Finally, due to poor postal services in Benghazi, it was necessary to obtain parents' consent with the support of Head Teacher or the secretary in each school in the presence of the researcher. The researcher explained the importance of the study to the parents/guardians of children, providing information about the study. The researcher then provided the parents a permission letter, explaining the aims and methods of the study, seeking an expression of interest in the study. The researcher mentioned that the possibility of leaving the study at any point was assured, and also explained that random selection of children would be used and not all children providing consent would be included in the research (Appendix 4.16). A form for written, informed consent for all elements of the study including dental photography accompanied the letter (Appendix 4.17). After the parents signed the permission letters at the Head teacher or secretary's office, the pupils were also encouraged to sign a letter containing similar information and the written consent (Appendix 4.18). This approach also helped to maximise the response rate. A list of names of schoolchildren who had been consented was made based on the inclusion criteria, and then 22 participants were selected randomly as described in the sampling procedure (Section 4.4). Table 4.5 lists the different ethical permissions secured prior to the fieldwork. The national and school holidays were considered during the preparations for the field study. Appendix 4.2 lists the schools and numbers of 12 year-old schoolchildren in the different schools in each District in Benghazi.

Table 4.5: Ethical permission from Libyan authorities obtained prior to Fieldwork.

Ethical Permission
Permission from Libyan Cultural Bureau in London
Permission from Ministry of Education
Permission from Ministry of Health
Permission from Dental Faculty, Benghazi University
Permission from Head Teacher of schools
Permission from Parents
Permission from pupils

4.7.2 Training an assistant

An assistant with Dental Nursing qualification was trained by the researcher (RH) in Benghazi. The assistant helped with the preparation of all the materials which were used in the dental examination sessions and in ushering each subject from their class room. During the training process, the assistant was given a list with the names of all randomly selected subjects to be examined during the fieldwork. In addition the assistant was trained in scribing data by initially including an explanation of the coding system of dental examination form followed by training in the proper method of transcribing the dictated diagnostic information onto the dental examination forms. The same assistant accompanied the examiner on every school visit involving dental examination and dietary interviewing, to help in entering the diagnosed criteria codes on the examination form and collection of water samples.

4.7.3 Three-day food diary

The researcher started the data collection in October 2007, distributing and then collecting the 3-day food diary from the sub-sample before the dental examination was undertaken. The sub-sample was selected randomly, using the method described in Section 4.4, from each school to complete the food diary. The sub-sample of children was asked to complete the food diary during three consecutive days, two week days (Thursday and Saturday) and one weekend day (Friday). The subjects were asked to carry the food diary with them all the times during the three-day period and to record the foods and beverages consumed at the time of consumption. The subjects were also asked to record if the drinking water was from a tap or bottle. In addition, subjects were asked to record the amount of foods and drinks consumed by estimating using household measures (e.g. cups, tablespoons) and these records were confirmed by the researcher at the time of interview by using food models (Anderson, 1995; Biro *et al.*, 2002). Subjects were asked also to record any medication taken and also to collect the four water samples of tap water (Section 4.5.1.4). A dietary interview was undertaken between the researcher (RH) and each child in order to clarify the recorded 3 day dietary information. The interviews took place in any available space within school on Day 4 (Sunday) after completion of food diaries for three days (Thursday, Friday, and Saturday). The dietary interviews were scheduled for Day 4 immediately after the completion of the three-day food diary in order not to compromise the subjects' ability in remembering their dietary intake. A list with all drinks, food and confectionery mentioned in the food diaries was made. The researcher measured the weight of every subject that completed a food diary in the sub-sample using weighing scales (Seca, Germany), and the water samples were collected from subjects during the interviews. Children who completed the food diaries received stationery boxes as means of thanks for their help with the study. The three-day dietary diary and the interview were completed before the dental examination sessions to minimise the risk of subjects changing their dietary habits due to increased dental awareness.

4.7.4 Study procedure for questionnaire

The researcher distributed the questionnaire to the 22 randomly selected subjects from each school. Copies of questionnaires were prepared prior to each school visit then, distributed for completion in any free places; classrooms, sports rooms, laboratories, libraries. All the randomly selected subjects (22 subjects) answered their questionnaires separately but in the same location at the same time. The researcher asked the children to complete the questionnaire after explaining the importance of their honest answers, emphasising that there were no right or wrong answers, and providing reassurance that their answers and names would be kept confidential. Completed questionnaires were collected immediately following completion. This approach was taken to try to maximise the response. After collection of the questionnaires, the researcher scanned the answers quickly and asked the children to complete any missing answers if there were any uncompleted answers. This method helped to minimise any missing data. The questionnaire surveys were completed by the children before dental examination to prevent the risk of bias following the dental examination. After the fieldwork was completed, the collected data were photocopied and parcelled in boxes according to the school order and subject numbers. After completion of the field study, the written documents (oral health assessment forms, questionnaires and food diaries) were transported from Benghazi to Newcastle upon Tyne, UK by DHL International Ltd.

Water samples were transported from Benghazi to Newcastle upon Tyne, UK by World Courier Ltd UK.

4.7.5 Study procedure for dental examinations

Dental examinations were conducted at schools after the completion of the three-day estimated food diary with interview, and after completion of the questionnaire. Ten per cent of the total sample size was randomly selected and dentally examined for a second time during each dental examination session to assess the reproducibility of this study. The dental examination was undertaken in any available space, such as class rooms, computer 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 used for the dental examination; pre-packed sterilised oral examination kits which contained, a plain mouth mirror and a CPITN probe to help detect dental caries by removing food debris. Packages of sterilised gauze were used to dry the tooth surfaces. Gloves, masks and a digital camera with intra-oral photography mirrors and cheek retractors were available for use where necessary. The photography mirrors and the cheek retractors were sterilised with cold sterilisation solution. After drying the tooth surfaces by gauze, dental mirrors were used to visually inspect the teeth. The dental examination was undertaken to record dental caries, filled, and missing teeth using the criteria for dental caries as mentioned before (Appendix 4.3).

Dental erosion was recorded by depth and area for the labial and palatal surfaces of all permanent maxillary incisors and the occlusal surfaces of the first permanent molars (Appendix 4.3). For protection of identifiers on the data, a subject number was used throughout the study and the name with subject number kept separately and stored in a locked filing cabinet in key locked office. The teeth surfaces were examined for loss of surface enamel characteristics, and exposure of dentine or pulp. The date of examination was recorded. The date of birth was recorded from school files. Revision of the CD of clinical slides from patients with varying severity of dental erosion and caries from the 2003 Dental Health Survey of children and young people which was recommended by Professor June Nunn was undertaken every week, before the dental examination for the purposes of maintaining acceptable intra-examiner agreement.

At the end of each dental examination, all the clinical waste was disposed in a waste bin box. Disinfection solution was carried for disposal at the Dental School. All used instruments were taken to be sterilised in the sterilization centre at the Dental Faculty. 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 (Appendix 4.19). All participants received a stationery box and a certificate as a means of thanks for their participation in the study (Appendix 4.20).

4.7.5.1 Intra-oral photography

Clinical intra-oral digital photographs were obtained using a FinePix S602 Zoom digital camera using the auto-focus mode dial and macro-mode with a shooting distance of between 10cm-80cm). Overall, 210 subjects were photographed intra-orally representing 25% of the total sample. These children were randomly selected using the same procedures mentioned previously. More than 642 intra-oral digital photographs were taken. Three intra-oral photographs for each subject (labial, palatal and vertical views) along the long axis of the anterior teeth using same method for each child from six randomly selected pupils in each school were taken. Intra-oral photographs were obtained to assess the level of inter-examiner agreement and for illustrative purposes. Intra-oral photography mouth mirrors, cheek retractors with cold sterilisation solution were used. All the photographic images of the six subjects in each school were transferred from the digital camera and saved on a password-protected computer, and each intra-oral photograph, labelled as following: school number, subject number, view (labial, or palatal, or long axis), and saved in a new folder named by school number in the same day. The images were also saved on a CD and stored in a locked filing cabinet in key locked office.

The reproducibility of the study was also assessed using clinical intra-oral photographs taken with the level of inter-examiner agreement calculated by the Cohen's Kappa statistic (WHO, 1997). A selection of these photographs with sufficient diagnostic quality were separately coded for dental erosion by the researcher and by Dr Paula Waterhouse and used to assess the level of inter-examiner agreement, using SPSS 17.0 for Windows.

4.7.5.2 Reproducibility of the study

Efforts were made to maintain the intra-examiner variability at an acceptable level by regular revision of the training CD which contained a series of clinical slides, and simulated the criteria of dental erosion. This was undertaken each week and also by the presence of criteria for recording dental erosion and caries on the oral assessment forms.

In each school, after completion of the dental examination of 22 individuals, 10% of the total sample, i.e. 2 subjects per school were re-examined on the same day for both dental erosion and caries to ensure the reproducibility of the application of diagnostic criteria. Overall, 70 subjects were re-examined. To ensure the examiner was blind to those subjects on the day of dental examination the assistant was instructed to randomly re-call two pupils during the dental examination session without informing the examiner and another clinical examination was undertaken, allowing an interval of at least two hours between the two examinations. The results of the dental examination were analysed for reproducibility by Cohen's Kappa (WHO, 1997) and used to show if there was a shift in diagnosis between first and second examination.

4.7.6 Contact with supervisors

Contact with the researcher's supervisors was made at two week intervals via e-mail during the period of the fieldwork in Benghazi, and also when there was an enquiry by the researcher. The researcher provided the supervisors with update reports about every step done in the fieldwork according to the time table in the fieldwork (Appendix 4.21).

4.7.7 Preparation of data for transportation to UK

Once the data collection period was complete, all the collected data, the oral health assessment forms, questionnaires, and food diaries were checked for clear coding, scribing and data entry and parcelled in number order in Benghazi. Then, the written documents were transported to the UK by the DHL International Ltd.

4.8 Managing the data in the UK

The collected data were entered into computer data file and then verified by the Data Preparation Service at Newcastle University. After MS Excel files of entered data were received from Data Preparation Service, they were converted into Statistical Package for Social Sciences-SPSS 15.0 for Windows statistical programme. Whenever there was an enquiry or space, in the questionnaire, the written documents were re-visited by the researcher and any queries clarified. There were three repeated ID numbers in the oral health assessment forms, which were clarified by the examiner by further examination of the school number and examination date.

4.9 Statistical analysis

Data were analysed using the Statistical Package for Social Sciences-SPSS 15.0 for Windows. Descriptive analysis was used to characterise the different aspects of questionnaire data, and oral health assessment forms regarding; dental caries and dental erosion. The statistical procedures used for data analysed were detailed in each corresponding chapter. Associations between dental erosion variables and erosion-related variables were tested through a process of bivariate analysis, using the exact versions of the non-parametric test Chi-Square, Fisher's and Linear Association. Odds ratio (OR) and 95% Confidence Intervals (CI) were calculated for 2 x 2 tables. Only two-sided statistical tests were used. The statistical significance level was established at 5%. After completion of the bivariate analysis a multivariate analysis using a forward stepwise logistic regression model was used to determine the variables independently associated with experience of dental erosion.

Chapter 5
The prevalence of dental erosion

5.1 Introduction

Dental erosion has been defined as progressive irreversible loss of dental hard tissues by a chemical process, not involving bacteria (Imfeld, 1996; Nunn *et al.*, 1996; Linnett and Seow, 2001) Erosion is a multifactorial condition influenced by the interaction of chemical, biological and behavioural factors which explains why some individuals exhibit more erosion than others (Dugmore and Rock, 2004b; Lussi and Jaeggi, 2008).

Erosion is often associated with other forms of tooth wear such as abrasion and attrition (Bartlett, 2009). Attrition is the wear of tooth against tooth, and abrasion is the wear of teeth by physical means other than opposing teeth such as tooth brushing (Gandara and Truelove, 1999; Osborne-Smith *et al.*, 1999). The term 'tooth wear' was used as a reflection of all three conditions (erosion, abrasion and attrition), in relation to the aetiological factors (Smith and Knight, 1984a). The majority of tooth wear in childhood is due to dental erosion (Smith and Knight, 1984b; Milosevic *et al.*, 1994; Millward *et al.*, 1994b; Milosevic, 1998; Chadwick *et al.*, 2006). Adequate preventive measures can only be put in place when the risk factors are known (Lussi *et al.*, 2007).

The main causes of dental erosion are intrinsic or extrinsic acids; intrinsic acids from gastro-oesophageal reflux or frequent vomiting, while the source of extrinsic acids may be frequent consumption of acidic foods and beverages, particularly fruits and fruit juices, soft drinks, herbal tea, wines and vinegar and frequent swimming in heavily chlorinated water (Millward *et al.*, 1994b; Johansson *et al.*, 1996; Shaw and Smith, 1999; Nunn *et al.*, 2001; Al-Dlaigan *et al.*, 2001b; Al-Dlaigan *et al.*, 2001c; Chadwick and Pendry, 2004; Milosevic *et al.*, 2004; Bartlett, 2009).

Poor salivary flow or inadequate buffering capacity are factors that exacerbate dental erosion (Moynihan and Petersen, 2004). However, the most important cause of erosion in children is the frequent intakes of acidic foods and drinks (May and Waterhouse, 2003). Dental erosion in children is a common condition with early damage to the teeth potentially affecting oral health for an entire lifetime and requiring extensive, difficult and complicated treatment. There is a growing concern that the prevalence of erosion has been increasing amongst children (Walker *et al.*, 2000; Al-Dlaigan *et al.*, 2001a; Nunn *et al.*, 2003; Chadwick and Pendry, 2004). Therefore, early diagnosis and prevention of erosion in children and adults is important. The decline in caries has made dental erosion become increasingly recognized as a public health concern amongst children and adolescents (McGuire *et al.*, 2009).

Dental erosion assessment was first included in the UK Children's Dental Health Survey in 1993 and has been repeated periodically at 10 year intervals. The 1993 Child Dental Survey used the term dental erosion (O'Brien, 1994) but the term tooth surface loss (TSL) was used in the 2003 survey as it more accurately reflects the multifactoral aetiology of the condition (Chadwick and Pendry, 2004).

Several studies have assessed the prevalence of dental erosion using different indices and criteria and showed a wide range of prevalence figures. This wide range of results may be due to the absence of a unified approach to assess dental erosion (Eccles and Jenkins, 1974; Lussi *et al.*, 1991; O'Brien, 1994; Hind and Gregory, 1995; Kunzel *et al.*, 2000; Larsen *et al.*, 2000; Walker *et al.*, 2000; O'Sullivan, 2000c; Al-Dlaigan *et al.*, 2001a; Chadwick and Pendry, 2004; Wiegand *et al.*, 2006).

Most dental erosion data are derived from European studies; only a few epidemiological studies of dental erosion prevalence have been undertaken in developing countries (Johansson *et al.*, 1996; Al-Malik *et al.*, 2001b; Al-Majed *et al.*, 2002; Peres *et al.*, 2005a; Auad *et al.*, 2007; El Karim *et al.*, 2007).

There are no published epidemiological studies relating to the prevalence of dental erosion in Libya or its association with consumption of acidic foods and drinks, nor has any association of dental erosion with caries been investigated in Libya. Consequently, both the prevalence and severity of dental erosion in Libya are currently unknown.

5.2 Aims

The aims of the study were:

5.2.1 To determine the prevalence and severity of dental erosion amongst 12 year-old schoolchildren in Benghazi, Libya.

5.2.2 To examine gender differences in relation to the prevalence and severity of dental erosion amongst 12 year-old schoolchildren in Benghazi, Libya.

5.3 Objectives

- To undertake a dental examination of 12 year-old Libyan schoolchildren in Benghazi in order to assess the prevalence and severity of dental erosion.

5.4 Null hypothesis

- There was no difference in the prevalence and severity of dental erosion in 12 year-old children in Benghazi, Libya compared with European children.

5.5 Methods:

The main methods are discussed in detail in Chapter 4.

5.5.1 The study sample

The study sample comprised 12 year-old schoolchildren resident in Benghazi, in the sixth grade of elementary schools. Both genders were included in this study. These children were studying at public elementary schools in 15 different Districts in Benghazi.

The sample size was designed to be representative of the children in Benghazi. The sample size needed to provide suitable statistical power was calculated with the assistance of a medical statistician, Dr Nick Steen, Principal Research Associate, Institute of Health and Society, Newcastle University. See Chapter 4 (Section 4.3).

5.5.2 The sampling

Cluster sampling, with the schools as clusters was used for the sampling procedure. The total number of 12 year-old schoolchildren studying in the 81 public elementary schools in Benghazi was 7682 children. Public schools comprised 90% of the total number of schools in Benghazi (GAI, 2006). Further details on the sampling procedures used were given in Chapter 4 (Section 4.4).

5.5.3 Calibration of the researcher

Calibration of the researcher for the dental examination in the use of the dental erosion and dental caries indices took place in the Division of Child Dental Health, School of Dental Sciences under the supervision of an experienced calibrator, Professor June Nunn from the School of Dental Sciences, Trinity College, Dublin University. The calibration included a one-to-one training session using the Child Dental Health 2003 examiner calibration compact disc. See Chapter 4 (Section 4.4.1.1).

5.5.4 Timetable for the study in Benghazi

The time table for the field work in Benghazi schools was prepared at Newcastle University. It was planned that it would take five months to finish the field work with three schools being visited for dental examination each week. Figure 5.1 shows the number of schools, schoolchildren, participating schools and children in each school, while Appendix 4.8 demonstrates the order and scheduling of its various elements.

5.5.5 Ethical approval and permissions from local authorities

Ethical clearance and permissions to conduct the study in Benghazi was obtained from the local authorities and schools as Section 4.6.1 described.

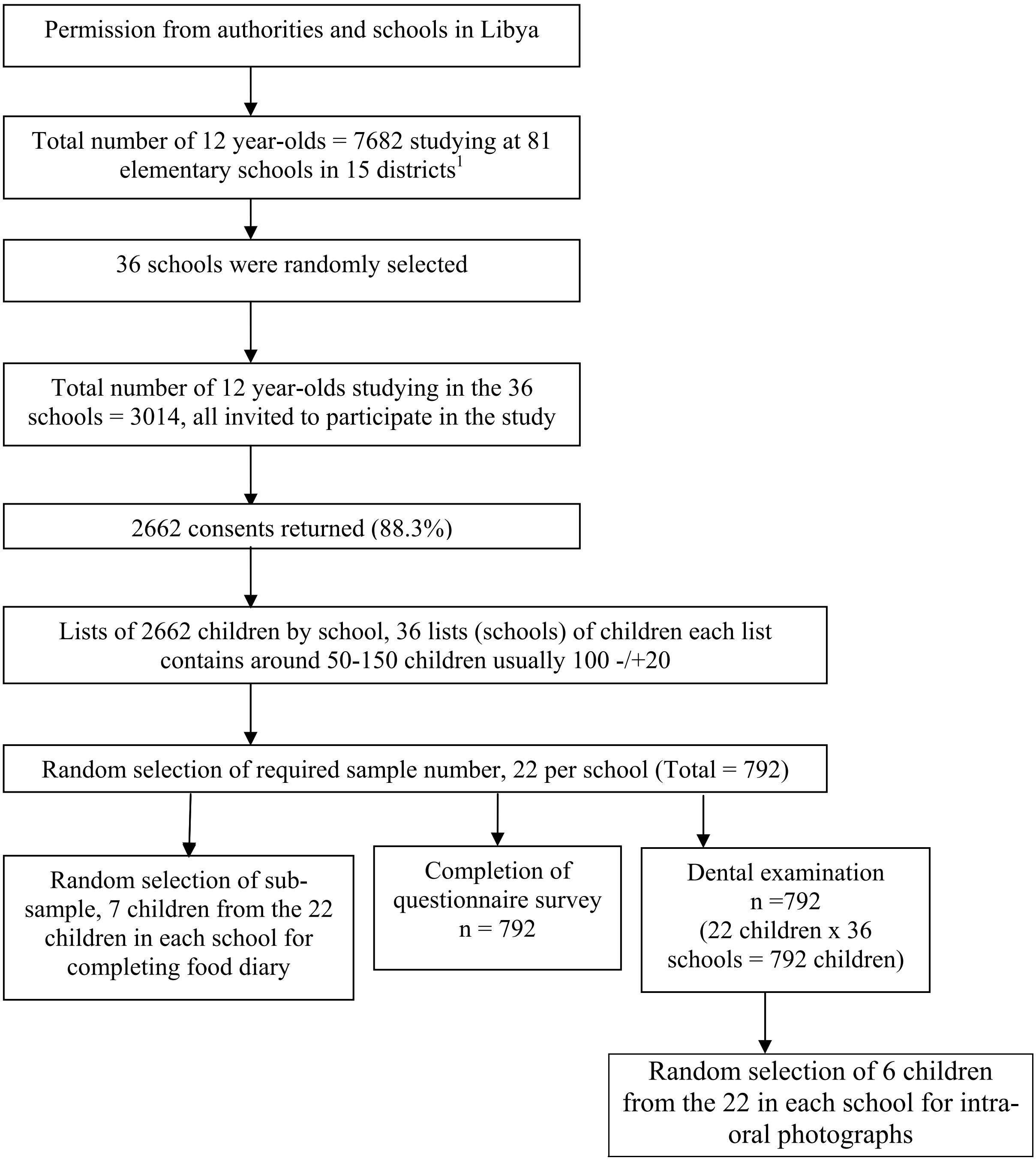
5.5.6 Training of an assistant

An assistant with dental nursing background working in Benghazi Dental School was trained in scribing the clinical data and entering the diagnosed codes on the examination form by the researcher in Benghazi. The assistant helped with the preparation of all the materials needed for the dental examination.

5.5.7 Dental examination

The dental examination was undertaken in each school as discussed in Chapter 4. Dental erosion was determined using the index used in the oral health component of the UK National Diet and Nutrition Survey (NDNS) (Walker *et al.*, 2000) (Table 4.2). 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 were recorded on the oral health assessment sheets (Appendix 4.3), the teeth surfaces being examined for a range of appearances from loss of surface enamel characteristics to exposure of dentine or pulp.

Figure 5.1: Flow chart of the field work to show the response rate; number of 12 year-old children, schools, districts, consent forms, completed consent and participating schools and schoolchildren.



[1]Source: Great Socialist People's Libyan Arab Jamahiriya: General Authority of Information (GAI, 2006) A preliminary result of general population census 2006.

Depth of dental erosion on a surface was scored as code 1 if erosion was seen in enamel only, code 2 if erosion was seen in enamel and dentine, code 3 if involving enamel, dentine and pulp. The area of dental erosion on a surface was scored as code 1 if dental erosion affected less than one third surface, code 2 if a affected up to two thirds of the surface and code 3 if it was more than two thirds. The criteria for dental examination are described in Appendix 4.4. In cases where there was doubt over the assessment of a surface, the lower score was assigned (Walker *et al.*, 2000).

5.5.8 Reproducibility of the study

For the purpose of reproducibility, in each school, 10% of the dentally examined children, two subjects per school, were re-examined on the same day as the dental examination to determine the reproducibility of the application of diagnostic criteria. Overall, 75 subjects provided data for intra-examiner reproducibility. The following thresholds were considered; score 0 (total disagreement), score 0.4-0.6 (moderate agreement), score 0.6-0.8 (substantial agreement), score >0.8 (good agreement) and score =1 (perfect agreement) (WHO, 1997).

5.5.9 Intra-oral photography

Overall, 200 subjects (25% of the total sample) were randomly selected and underwent intra-oral photography. Using the method described in Section 4.6.5.1, 3 intra-oral photographs (labial, palatal and a vertical view along the long axis of the anterior teeth) were taken for each subject and used to assess the level of inter-examiner agreement in the diagnosis of dental erosion and for illustrative purposes.

5.5.10 Data handling and statistical analysis

The collected data from the dental examination sheets were entered into computer data file and then verified by the Data Preparation Service at Newcastle University. Data related to dental erosion were then copied into a database designed within the Statistical Package for Social Sciences-SPSS 15.0 for Windows. A second database, with data from subjects who had been examined in duplicate, was developed to measure the level of intra-examiner agreement in assessing dental erosion. The prevalence of erosion was calculated as the number and proportion of subjects affected and number and proportion of dental surfaces affected, groups of teeth affected, and the severity based on depth and area affected. Dental erosion for area and for depth was cross tabulated with gender.

The following outcome variables were derived:

For area: Total score for all surfaces (12) examined per mouth and mean surface score per mouth.

For depth: Total score for all surfaces (12) examined per mouth and mean surface score per mouth.

5.6 Results

5.6.1 The response rate

All 12 year-old schoolchildren of both genders attending 36 randomly selected schools in Benghazi were invited to participate in the study. Written consents were obtained from 2662 out of the 3014 subjects (total number of 12 year-olds in the 36 schools). The overall response rate was 88.3% (Figure 5.1). The main reasons for non-responses in the 338 children who did not take part were lack of signed parental consent (n= 311; 10.8%) or absence from schools (n= 27; 0.9%).

5.6.2 The study sample

The study sample was 792 12 year-old schoolchildren resident in Benghazi. Since one oral health assessment form was missing when data were collected, the total number of the sample became 791 subjects; 397 boys and 394 girls. These children were studying at the sixth grade in 36 elementary co-educational public schools; a random selection of 11 boys and 11 girls with parental permission was examined clinically in each school. The age range was 10.8-

12.5 years (mean age, 11.7 years, standard deviation, 0.307). Data collection in schools took five months from 8th of September 2007 to 31st of January 2008 (Appendix 4.8).

5.6.3 Reproducibility of the study

The levels of intra-examiner agreement in the assessment of dental erosion, as measured by Cohen's Kappa statistic (WHO, 1997) for code 1 by depth (erosion into enamel only) were 89%, 91% and 77% for the labial, palatal surface of incisors and occlusal surface of molars respectively. This indicated a good level of agreement for labial and palatal surface of incisors and substantial agreement for occlusal surface of molars (Appendix 5.1).

5.6.4 Intra-oral photography

Due to poor lighting in the schools only 31 x 3 (5% of the total taken) intra-oral photographs (labial, palatal and vertical view along the long axis of the anterior teeth) were clear. The inter-examiner reliability for photographic assessment of dental erosion at code 1 for depth on labial and palatal surfaces of anterior teeth measured by the Cohen's Kappa statistic was 65% and 77% respectively, indicating a substantial level of agreement (WHO, 1997). Intra examiner reliability could not be assessed because there was an incomplete data set between photo images and actual clinical examination.

5.6.5 Description of prevalence and severity of dental erosion

The prevalence and severity of dental erosion seen is presented as:

a) Mouth prevalence (Yes/No): by subject and mean score per mouth (for area and for depth).

b) Mouth severity for index teeth (for area and for depth): by gender and by tooth type.

c) Tooth prevalence for index teeth: for all surfaces and by tooth type.

5.6.6 Mouth prevalence of dental erosion

Of the 791 examined subjects, 323 subjects (40.8%) exhibited dental erosion (code >0) for depth in one or more upper permanent incisors, or upper and lower first permanent molars; 59.2% of subjects had no clinical evidence of dental erosion. Dental erosion into enamel only was the most common finding, into dentine was relatively uncommon, while into pulp was rare (Table 5.1). Based on area affected, 323 subjects (40.8%) exhibited dental erosion (code >0), with 32.6% of these subjects having erosion affecting more than two thirds of one or more surfaces examined (Table 5.2).

The mean total scores for dental erosion for all surfaces per mouth by area and by depth were both 2.69. The median was equal to zero (Table 5.3).

Table 5.1: Mouth severity of erosion categorised by distribution of the highest codes scored for dental erosion for depth (all index teeth).

Score	Score 0 Normal	Score 1 Enamel only	Score 2 Enamel and dentine	Score 3 Enamel, dentine and pulp	Total	Score >0
No. of subjects (%)	468 (59.2)	258 (32.5)	63 (8.0)	2 (0.3)	791 (100)	323 (40.8)

Table 5.2: Mouth prevalence of erosion categorised by distribution of the highest codes scored for dental erosion for area (all index teeth).

Score	Score 0 Normal	Score 1 <1/3 surface	Score 2 1/3 < 2/3 surface	Score 3 >2/3 surface	Total	Score >0
No. of subjects (%)	468 (59.2)	3 (0.4)	62 (7.8)	258 (32.6)	791 (100)	323 (40.8)

Table 5.3: Mean, standard deviation (SD), median and range of the total score of erosion for all surfaces per mouth by area and by depth.

12 surfaces (4 labial+4 palatal+4 occlusal) per mouth	Mean	SD	Median	Range
Total score for all surfaces by area (n = 791)	2.69	3.81	0.0	0-12
Total score for all surfaces by depth (n = 791)	2.69	3.81	0.0	0-12

5.6.7 Mouth prevalence and severity of dental erosion by gender

A higher prevalence of erosion was observed amongst girls (46.7%) than boys (35.0%). This difference was statistically significant (Fisher's exact test; p= 0.001, Odds Ratio 1.63, 95% CI 1.22, 2.16) (Table 5.4). Of the 184 girls (46.7% of total girls sample) with experience of dental erosion; 144 (36.6% of total girls sample) had evidence of erosion into enamel only, 38 (9.6%) into dentine and 2 (0.5%) into pulp. Of the 139 boys (35% of total boys sample) with evidence of dental erosion, 114 (28.7% of total boys sample) had evidence of erosion into enamel only, 25 (6.3%) into dentine and no one (0%) had erosion into pulp. The difference in number of girls and boys with experience of dental erosion by depth was statistically significant (Pearson Chi-Square; p= 0.004) (Table 5.5). With regard to the extent of erosion by area, as Table 5.6 shows, 153 girls (38.8%) and 105 boys (26.4%) had evidence of erosion involving more than two thirds of the surfaces. This difference was statistically significant (Pearson Chi-Square; p= 0.001).

Table 5.4: Significance of association (P) between the mouth prevalence of dental erosion and gender (for depth and/or area > 0).

	Experience of dental erosion								
Gender	**Girls**			**Boys**			**Both**		
	Yes	**No**	**Total**	**Yes**	**No**	**Total**	**Yes**	**No**	**Total**
No. of subjects (%)	184 (46.7)	210 (53.3)	394 (100)	139 (35)	258 (65)	397 (100)	323 (40.8)	468 (59.2)	791 (100)

Fisher's exact test; p= 0.001 OR= 1.63 (95% CI 1.22, 2.16)

Table 5.5: Mouth severity of erosion categorised by distribution of the highest codes scored for depth for all index teeth by gender.

Score	**Score 0 Normal**	**Score 1 Enamel only**	**Score 2 Enamel and dentine**	**Score 3 Enamel, dentine and pulp**	**Total**	**Score >0**
No. of boys (%)	258 (65.0)	114 (28.7)	25 (6.3)	0 (0.0)	397 (100)	139 (35.0)
No. of girls (%)	210 (53.3)	144 (36.6)	38 (9.6)	2 (0.5)	394 (100)	184 (46.7)
Total (%)	468 (59.2)	258 (32.5)	63 (8.0)	2 (0.3)	791 (100)	323 (40.8)

Pearson Chi-Square; p= 0.004

Table 5.6: Mouth prevalence of dental erosion categorised by distribution of the highest codes scored for area for all index teeth by gender.

Score	Score 0 Normal	Score 1 <1/3 surface	Score 2 1/3 < 2/3 surface	Score 3 >2/3 surface	Total	Score >0
No. of boys (%)	258 (65.0)	3 (0.8)	31 (7.8)	105 (26.4)	397 (100)	139 (35.0)
No. of girls (%)	210 (53.3)	0 (0.0)	31 (7.9)	153 (38.8)	394 (100)	184 (46.7)
Total (%)	468 (59.2)	3 (0.4)	62 (7.8)	258 (32.6)	791 (100)	323 (40.8)

Pearson Chi-Square; p= 0.001

5.6.8 Mouth prevalence and severity of dental erosion by tooth type

The subjects had at least one tooth of the 2 tooth types assessed i.e upper incisors and first permanent molars.

5.6.8.1 Labial surface of upper incisors by depth

Of the 791 subjects, 198 subjects (25%) had evidence of dental erosion with one or more labial surfaces of the incisors examined scoring >0 for depth. Of the 791 subjects, 24.6% had erosion which was seen to be affecting enamel only, 0.3% had erosion into dentine and 0.1% had highest code of erosion affecting enamel, dentine and pulp (Table 5.7). The mean score for erosion (depth) labial surfaces of incisors was 0.96±1.67 (Table 5.8).

Table 5.7: Mouth prevalence of dental erosion categorised by distribution of the highest codes scored by depth for labial and palatal surfaces of incisors.

Depth score	Score 0 Normal	Score 1 Enamel only	Score 2 Enamel and dentine	Score 3 Enamel, dentine and pulp	Total	Score >0
Labial surface No. of subjects (%)	593 (75.0)	195 (24.6)	2 (0.3)	1 (0.1)	791 (100)	198 (25.0)
Palatal surface No. of subjects (%)	589 (74.5)	199 (25.1)	2 (0.3)	1 (0.1)	791 (100)	202 (25.5)

Table 5.8: Mean, standard deviation (SD), median and range of the total scores per mouth for dental erosion of labial and palatal incisor surfaces by area and by depth.

4 labial and 4 palatal surfaces of incisors per mouth	Mean	SD	Median	Range
Total score for labial surfaces by area (n = 791)	1.01	1.71	0.0	0-6
Total score for labial surfaces by depth (n = 791)	0.96	1.67	0.0	0-4
Total score for palatal surfaces by area (n = 791)	1.02	1.72	0.0	0-6
Total score for palatal surfaces by depth (n = 791)	0.98	1.69	0.0	0-4

5.6.8.2 Palatal surface of upper incisors by depth

Of the 791 subjects, 202 subjects (25.5%) had evidence of dental erosion with one or more palatal surfaces examined scoring >0 for depth. Of the 202 subjects with erosion, 199 (25.1%) of total sample had dental erosion affecting enamel only. Only one subject had erosion into pulp (Table 5.7). The mean score = 0.98± 1.69 and median was zero (Table 5.8).

5.6.8.3 Labial surface of upper incisors by area:

Of the 791 subjects, 198 subjects (25%) had evidence of erosion (score >0 for area) affecting one or more labial surfaces of the incisors examined. Of these 198 subjects with erosion, 196 (24.7%) of total subjects erosion affected more than two thirds of the labial surface of incisors (Table 5.9). The mean score= 1.01±1.71, median = zero (Table 5.8).

5.6.8.4 Palatal surface of upper incisors by area:

Of the sample, 202 subjects (25.5%) had evidence of erosion of one or more palatal surfaces of incisors (scoring >0 for area) affecting more than two thirds of one or more palatal surfaces (Table 5.9). The mean score = 1.02±1.72 (Table 5.8).

Table 5.9: Mouth prevalence of dental erosion categorised by distribution of the highest codes scored by area for labial and palatal surfaces of incisors.

Area score	Score 0 Normal	Score 1 <1/3 surface	Score 2 1/3 < 2/3 surface	Score 3 >2/3 surface	Total	Score >0
Labial surface						
No. of subjects	593	0	2	196	791	198
(%)	(75.0)	(0.0)	(0.3)	(24.7)	(100)	(25.0)
Palatal surface						
No. of subjects	589	0	0	202	791	202
(%)	(74.5)	(0.0)	(0.0)	(25.5)	(100)	(25.5)

5.6.8.5 Occlusal surface of first permanent molars by depth

The distribution of erosion severity affecting first permanent molars can be seen in Table **5.10** and Table 5.11. Of the total sample, 180 (22.8%) had evidence of dental erosion (score >0 for depth) affecting the occlusal surface of at least one of first permanent molars examined; 14.9% of subjects had dental erosion affecting enamel only. The remaining (7.9%) had erosion affecting dentine (Table 5.10).

5.6.8.6 Occlusal surface of first permanent molars by area:

Of the sample, 180 subjects (22.7%) had evidence of dental erosion (scoring >0 for area) affecting the occlusal surface of molars while 19.1% of subjects had dental erosion affecting up to two thirds of the occlusal surface of one or more of their permanent first molars (Table 5.11).

Table 5.10: Mouth prevalence categorised by distribution of the highest codes scored by depth on occlusal surfaces of all 4 first permanent molars.

Score	Score 0 Normal	Score 1 Enamel only	Score 2 Enamel and dentine	Score 3 Enamel, dentine and pulp	Total	Score >0
No. of subjects	611	118	62	0	791	180
(%)	(77.2)	(14.9)	(7.9)	(0.0)	(100)	(22.8)

Table 5.11: Mouth prevalence categorised by distribution of the highest codes scored by area on occlusal surfaces of all 4 first permanent molars.

Score	Score 0 Normal	Score 1 <1/3 surface	Score 2 1/3 < 2/3 surface	Score 3 >2/3 surface	Total	Score >0
No. of subjects (%)	611 (77.3)	16 (2.0)	151 (19.1)	13 (1.6)	791 (100)	180 (22.7)

5.6.9 Tooth prevalence of dental erosion

5.6.9.1 For all index teeth

In total, 6328 upper permanent incisors and upper and lower permanent first molars were evaluated. Among these teeth, 1372 (21.7%) had evidence of erosion. On 172 of the examined teeth (2.7%), an erosion assessment could not be made, and 4784 (75.6%) had no evidence of dental erosion (Appendix 5.2).

5.6.9.2 For all index teeth surfaces

In total, 9492 dental surfaces were evaluated. Of these surfaces, 2128 (22.4%) surfaces had evidence of erosion, while for 209 (2.2%), an erosion assessment could not be made. The remaining 7155 surfaces (75.4%) did not present with dental erosion (Appendix 5.3).

5.6.9.3 For labial and palatal surfaces of permanent maxillary incisors

Of the 6328 surfaces evaluated, 1531 (24.2%) had evidence of erosion (code >0 for area or depth), while on 70 surfaces (1.1%), an erosion assessment could not be made and 4727 (74.7%) did not present with any dental erosion (Appendix 5.4).

5.6.9.4 Labial surfaces of maxillary incisors

In total, 3164 incisors were evaluated. Among these teeth, 756 (23.9%) incisors had evidence of erosion on their labial surfaces, while 2371 incisors (74.9%) did not present with dental erosion on the labial surface (Table 5.12).

Table 5.12: Tooth prevalence of erosion (code > 0 for area or depth) for labial surfaces of permanent maxillary incisors.

Tooth	No. examined	No. with dental erosion		No. without dental erosion		No. not assessed	
		N	%	N	%	N	%
Left lateral incisor	791	187	23.6	596	75.3	8	1.0
Left central incisor	791	191	24.2	591	74.7	9	1.1
Right central incisor	791	191	24.1	590	74.6	10	1.3
Right lateral incisor	791	187	23.6	594	75.1	10	1.3
Total	3164	756	23.9	2371	74.9	37	1.2

5.6.9.5 Palatal surfaces of maxillary incisors

Of the total sample, 3164 palatal surface were evaluated. There was evidence of erosion on 775 (24.5%) incisors, while 2356 incisors (74.5%) had no erosion on the palatal surface (Table 5.13).

Table 5.13: Tooth prevalence of erosion (code > 0 for area or depth) for palatal surfaces of permanent maxillary incisors.

Tooth	No. examined	No. with dental erosion		No. without dental erosion		No. not assessed	
		N	%	N	%	N	%
Left lateral incisor	791	195	24.6	589	74.5	7	0.9
Left central incisor	791	193	24.4	590	74.6	8	1.0
Right central incisor	791	193	24.4	589	74.5	9	1.1
Right lateral incisor	791	194	24.6	588	74.3	9	1.1
Total	3164	775	24.5	2356	74.5	33	1.0

5.6.9.6 Occlusal surfaces of first permanent molars

Of the 3164 maxillary and mandibular permanent first molars examined, 2428 molars (76.7%) had no evidence of dental erosion and 597 molars (18.9%) had evidence of erosion (Table 5.14). The mean total scores per mouth for erosion of occlusal surfaces of molars by area and by depth were 0.93 and 0.75, respectively (Table 5.15).

Table 5.14: Tooth prevalence of dental erosion on occlusal surfaces of maxillary and mandibular first permanent molars.

Tooth	No. examined	No. with dental erosion		No. without dental erosion		No. not assessed	
		N	%	N	%	N	%
Maxillary Left First Molar	791	158	19.9	612	77.4	21	2.7
Maxillary Right First Molar	791	154	19.5	615	77.7	22	2.8
Mandibular Right First Molar	791	140	17.7	602	76.1	49	6.2
Mandibular Left First Molar	791	145	18.4	599	75.7	47	5.9
Total	3164	597	18.9	2428	76.7	139	4.4

Table 5.15: Mean, standard deviation (SD), median and range of the total score per mouth of dental erosion for occlusal surfaces of molars by area and by depth.

4 occlusal surfaces per mouth	Mean	SD	Median	Range
Total score for occlusal surfaces by area (n = 791)	0.93	1.5	0.0	0-4
Total score for occlusal surfaces by depth (n = 791)	0.75	1.46	0.0	0-4

5.6.10 Area x Depth score for dental erosion

5.6.10.1 Introduction

Dental erosion was also measured using an additional derived score for a surface; Area x Depth. This used to seek to quantify the total loss produced by erosion on each tooth surface and to provide a greater range of scores. The distribution of this derived score was considered in terms of its usefulness in determining severity as it gave a broader range of scoring. When the results for separate area and depth scores were considered there was never a code 0 for depth with >0 for area, or a code 0 for area and >0 for depth. The new surface score was derived by multiplying Area x Depth, to provide a range of scores of 1, 2, 3, 4, 6 and 9 for each surface evaluated.

This derived score for a surface measured the volume loss of the tooth surface. For example, if a surface had an erosion by Depth score 1 initially (erosion into enamel only), and if erosion by Area was <1/3 dental surface (score 1 by Area) the new derived score was 1 (1 x 1 = 1).

If erosion was scored code 3 by Depth (erosion into enamel, dentine and pulp), the derived Depth x Area score would be either 3, 6 or 9. Score 3; for erosion up to pulp and affecting <1/3 surface. Score 6; for erosion up to pulp and affecting 1/3<2/3 surface. Score 9; for erosion up to pulp and affecting >2/3 surfaces.

The following outcome variables were derived for Area x Depth:

- Total score for all surfaces examined per mouth by Area x Depth (sum of Area x Depth scores for each scored surface of index teeth) and mean surface score per mouth by Area x Depth (total surface score/number of surfaces scored).

- Total score per mouth for: incisors (2 labial surfaces), incisors (2 palatal surfaces) and incisors (4 labial and palatal surfaces) and mean score per mouth (total score/number of surfaces scored).

- Total score of occlusal surfaces of molars per mouth by Area x Depth (sum of Area x Depth scores for each surface scored) and mean occlusal surface score for molars per mouth (total surface score/number of surfaces scored).

- Total score and mean score per mouth for: upper molars (2 surfaces), lower molars (2 surfaces), right molars (2 surfaces) and left molars (2 surfaces).

5.6.10.2 Mouth prevalence and severity of erosion for total Area x Depth scores by gender

Of the total sample, 323 subjects (40.8%) exhibited dental erosion (code >0) for Area x Depth in one or more upper permanent incisors, or upper and lower first permanent molars; 468

subjects (59.2%) had no dental erosion (Table 5.16). Prevalence of erosion was higher amongst girls than boys. This difference was statistically significant (Fisher's exact test; p= 0.001, Odds Ratio 1.63, 95% CI 1.22, 2.16). Figure 5.2 shows the distribution of erosion scores by Area x Depth for all index teeth and by gender.

Table 5.16: Significance of association (P) between the number and proportion (%) of subjects with or without experience of erosion (scored by Area x Depth > 0) according to gender.

	Experience of dental erosion								
Gender	**Girls**			**Boys**			**Both**		
	Yes	**No**	**Total**	**Yes**	**No**	**Total**	**Yes**	**No**	**Total**
No. of subjects (%)	184 (46.7)	210 (53.3)	394 (100)	139 (35)	258 (65)	397 (100)	323 (40.8)	468 (59.2)	791 (100)

Fisher's exact test; p= 0.001 OR= 1.63, 95% CI 1.22, 2.16

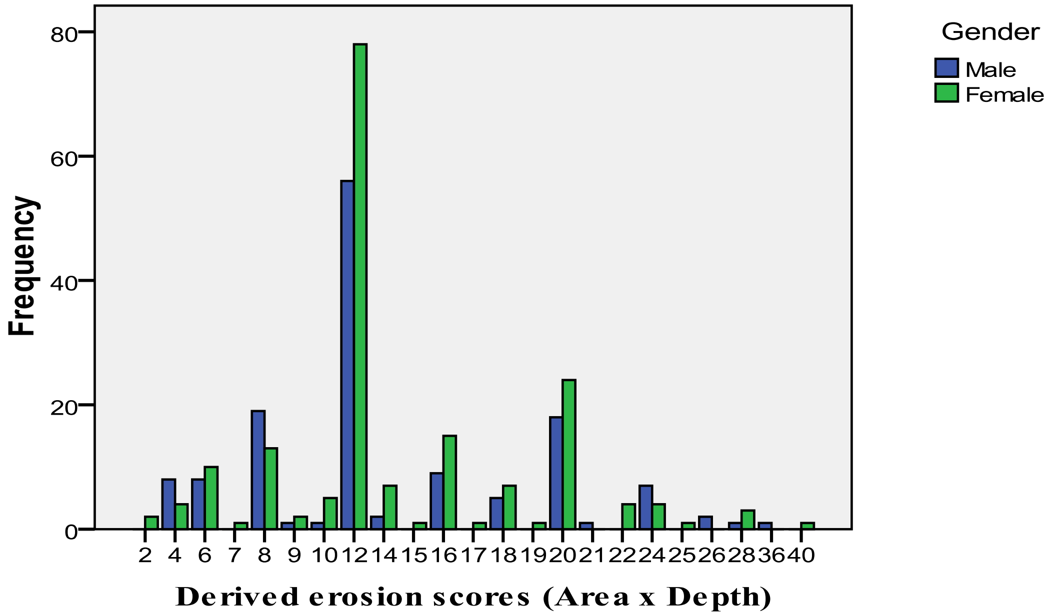
The mean (SD) total score for dental erosion per mouth based on Area x Depth scores for all index teeth surfaces was 7.60 (10.98). The mean (SD) index tooth surface score per mouth was 0.95 (1.37) (Table 5.17).

Table 5.17: Mean, standard deviation (SD), median and range of the total score of dental erosion for all index teeth per mouth by Depth x Area (n =783).

12 surfaces (4 labial + 4 palatal + 4 occlusal)	Mean	SD	Median	Range
Sum of Depth x Area scores for all index teeth surfaces	7.60	10.98	0.0	0-52
Mean index tooth surface score by Depth x Area (Total score/number of index teeth)	0.95	1.37	0.0	0-7

Missing 8 subjects (assessment could not be made)

Figure 5.2: Severity of erosion by subjects categorised by distribution of Area x Depth scores for all index teeth surfaces by gender.



5.6.11 Mouth prevalence of erosion (scored by Area x Depth) according to tooth type

5.6.11.1 Upper incisors

Labial erosion of central incisors was slightly more common than lateral incisors (Table 5.18). A symmetrical pattern of dental erosion scored by Area x Depth for central and lateral upper incisors was found. Almost the same number of subjects had erosion for right and left central and lateral incisors on the labial and palatal surfaces (Table 5.18).

The mean (SD) total upper incisor score for all 8 surfaces (labial and palatal) per mouth by Area x Depth was 5.84 (9.25). The mean (SD) incisor score per mouth was 1.46 (2.31) (Table 5.19). Table 5.20 shows the different scores by Area x Depth for each individual incisor examined.

Table 5.18: Number (N) and proportion (%) of subjects with dental erosion by Area x Depth scores categorised by the upper central and lateral incisors affected.

Groups of teeth	Number of subjects			
	Labial erosion		Palatal erosion	
	N	%	N	%
Central incisors				
UR1	191	24.2	193	24.4
UL1	191	24.2	193	24.4
Lateral incisors				
UR2	187	23.6	194	24.6
UL2	187	23.6	195	24.6

Table 5.19: Mean, standard deviation (SD), median and range of the total scores of dental erosion for all incisor surfaces per mouth by Area x Depth

8 surfaces (4 labial + 4 palatal)	Mean	SD	Median	Range
Total score for all incisor surfaces by Area x Depth	5.84	9.25	0.0	0-36
Mean score for incisor by Area x Depth (Total score /number of incisors)	1.46	2.31	0.0	0-9

Missing 1subject (assessment could not be made) (n= 790)

Table 5.20: Severity of dental erosion on labial, palatal and both surfaces of upper central and lateral incisors based on Area x Depth (n = 791).

Incisor	No erosion N (%)	Area x Depth score 1 N (%)	Area x Depth score 2 N (%)	Area x Depth score 3 N (%)	Area x Depth score 4 N (%)	Area x Depth score 6 N (%)	Area x Depth score 9 N (%)	No. of surfaces not assessed N (%)
Labial-surface								
UR1	590 (74.6)	0 (0.0)	2 (0.3)	187 (23.6)	0 (0.0)	2 (0.3)	0 (0.0)	10 (1.3)
UL1	591 (74.7)	0 (0.0)	2 (0.3)	187 (23.6)	0 (0.0)	2 (0.3)	0 (0.0)	9 (1.1)
UR2	594 (75.1)	0 (0.0)	1 (0.1)	186 (23.5)	0 (0.0)	0 (0.0)	0 (0.0)	10 (1.3)
UL2	596 (75.3)	0 (0.0)	1 (0.1)	186 (23.5)	0 (0.0)	0 (0.0)	0 (0.0)	8 (1.0)
Palatal-surface								
UR1	589 (74.5)	0 (0.0)	0 (0.0)	192 (24.3)	0 (0.0)	1 (0.1)	0 (0.0)	9 (1.1)
UL1	590 (74.6)	0 (0.0)	0 (0.0)	192 (24.3)	0 (0.0)	1 (0.1)	0 (0.0)	8 (1.0)
UR2	588 (74.3)	0 (0.0)	0 (0.0)	192 (24.3)	0 (0.0)	2 (0.3)	0 (0.0)	9 (1.1)
UL2	589 (74.5)	0 (0.0)	0 (0.0)	194 (24.5)	0 (0.0)	1 (0.1)	0 (0.0)	7 (0.9)
Both surfaces[1]								
UR1	536 (67.8)	0 (0.0)	2 (0.3)	241 (30.5)	0 (0.0)	3 (0.4)	0 (0.0)	9 (1.1)
UL1	537 (67.9)	0 (0.0)	2 (0.3)	241 (30.5)	0 (0.0)	3 (0.4)	0 (0.0)	8 (1.0)
UR2	539 (68.1)	0 (0.0)	1 (0.1)	240 (30.3)	0 (0.0)	2 (0.3)	0 (0.0)	9 (1.1)
UL2	541 (68.4)	0 (0.0)	1 (0.1)	241 (30.5)	0 (0.0)	1 (0.1)	0 (0.0)	7 (0.9)

[1]Bassed on worst surface score (labial or palatal)

5.6.11.2 First permanent molars

Of the sample, maxillary first permanent molars had the highest frequency of dental erosion affecting the occlusal surface scoring >0 for Area x Depth (Table 5.21). The mean total score for erosion of occlusal surfaces of four molars per mouth by Area x Depth was 1.81. The mean tooth score per mouth was 0.45. The median score was equal to zero (Table 5.22). Table 5.23 shows the mean total score and means tooth score per mouth by Area x Depth of upper, lower, right and left molars. The median was equal to zero. Table 5.24 shows the different scores of the index, Area x Depth for each individual molar examined.

Table 5.21: Number and proportion (%) of subjects with dental erosion by Area x Depth categorised by the occlusal surfaces of first permanent molars affected.

Tooth	Number of subjects with occlusal erosion	
	N	%
Upper right first permanent molar	154	19.5
Lower right first permanent molar	140	17.7
Upper left first permanent molar	158	19.9
Lower left first permanent molar	145	18.4

Table 5.22: Mean, standard deviation (SD), median and range of the Area x Depth scores of dental erosion for occlusal surfaces per mouth for all four molars (n = 784).

4 occlusal surfaces of molars per mouth	Mean	SD	Median	Range
Total Area x Depth score for all 4 molars	1.81	3.73	0.0	0-24
Mean molar Area x Depth score (total score/number of molars assessed)	0.45	0.93	0.0	0-6

Missing 7 subjects (assessment could not be made)

Table 5.23: Mean, (SD), median and range of the total score and means tooth score per mouth by Depth x Area for upper, lower, right and left molars where both teeth could be assessed.

	Mean	SD	Median	Range
Total score for upper molars (n =781[1])	0.91	1.94	0.0	0-12
Mean score for upper molars (total score/2)	0.46	0.97	0.0	0-6
Total score for lower molars (n =767[1])	0.92	2.06	0.0	0-12
Mean score for lower molars (total score/2)	0.46	1.03	0.0	0-6
Total score for right molars (n =781[1])	0.90	1.87	0.0	0-12
Mean score for right molars (total score/2)	0.45	0.93	0.0	0-6
Total score for left molars (n =782[1])	0.92	1.89	0.0	0-12
Mean score for left molars (total score/2)	0.46	0.94	0.0	0-6

[1]Missing subjects (assessment could not be made)

Table 5.24: Severity of dental erosion on occlusal surfaces of upper and lower first permanent molars using the index, Depth x Area.

Molar	No erosion N (%)	Area x Depth score 1 N (%)	Area x Depth score 2 N (%)	Area x Depth score 3 N (%)	Area x Depth Score 4 N (%)	Area x Depth Score 6 N (%)	Area x Depth score 9 No (%)	Surface not assessed N (%)
UR6	615 (77.7)	9 (1.1)	114 (14.4)	7 (0.9)	23 (2.9)	1 (0.1)	0 (0.0)	22 (2.8)
UL6	612 (77.4)	11 (1.4)	120 (15.2)	5 (0.6)	21 (2.7)	1 (0.1)	0 (0.0)	21 (2.7)
LR6	602 (76.1)	8 (1.0)	93 (11.8)	9 (1.1)	29 (3.7)	1 (0.1)	0 (0.0)	49 (6.2)
LL6	599 (75.7)	8 (1.0)	95 (12.0)	7 (0.9)	33 (4.2)	2 (0.3)	0 (0.0)	47 (5.9)

5.7 Discussion

5.7.1 The study sample

The study sample was 791 12 year-old schoolchildren. The number of participating schools in the study was 36 public elementary schools present in 15 Districts of Benghazi, the second largest city in Libya after the capital, Tripoli. More than 88% of the whole Libyan population live in cities (GAI, 2006). The sample was sufficiently large enough (791), to be reasonably representative of Benghazi and other urban regions of Libya. However, it is important to take into account that the present sample did not aim to be representative of the national population as a whole.

5.7.2 The aims of the study

Despite the growing concern about dental erosion in children in developed countries, there are no published data related to the prevalence and severity of dental erosion in children or adults in any region in Libya. For these reasons, this study aimed to determine the prevalence and severity of dental erosion in children and investigate the gender differences in relation to dental erosion. Based on the findings in relate to dental erosion this study also aimed to provide the Libyan government with information for future planning and monitoring of dental services in Benghazi and Libya as a whole.

5.7.3 Limitations of the study

Although the field work in Benghazi was received with encouragement and support from the authorities, schools and parents, there were some difficulties and limitations. At the time of the fieldtrip, the number of Districts in Benghazi was 15. Organisation of the Districts has often changed in terms of extension or shrinkage, names and numbers, resulting in non-fixed data. In addition, there was a lack of updated demographic information relating to the population of each district and exact student numbers in each school. The dental examinations took place in schools which lead to particular challenges such as interruption of dental examinations due to school activities or only small space available within the school for dental examination or rooms with poor lighting conditions which made the use of the headlamp essential. However, co-operation of the School teachers, the staff and subjects helped to finish the dental examination smoothly. The presence of a trained assistant helped in scribing the data and preparing for each dental examination.

5.7.4 Dental examination

The erosion index and criteria used in the present study had been validated in National Surveys in the UK (Walker *et al.*, 2000; Chadwick and Pendry, 2004). This index was selected because it is simple, easy to use and can evaluate severity and affected tooth surface area. It had been specially designed to assess erosive tooth surface loss in the children and has been used in large epidemiological studies. Since the 1993 UK Survey of Children Dental Health (O'Brien, 1994), the criteria for use of the index remained the same, apart from the inclusion of first permanent molars in 2003. Tooth surface loss (TSL) has multifactoral aetiology, but dental erosion is the major contributor in children (Chadwick *et al.*, 2006). In the present study, the criteria used in the dental examination were also used previously in the oral health component of the UK National Diet and Nutrition Survey (NDNS) (Walker *et al.*, 2000), and several studies (Al-Majed *et al.*, 2002; Dugmore and Rock, 2004a; Auad *et al.*,

2007) so that comparisons could be made between the data from Libya and the United Kingdom and other countries (see section 5.5.1.1). All subjects were examined clinically by the one examiner (RH) who had previously undergone one-to-one training session with Professor J Nunn, who has previous experience in calibration examiners in the use of the erosion index in the UK.

Overall, 75 subjects (10%) were re-examined for dental erosion to provide data for intra-examiner reproducibility. A good level of intra-examiner agreement was achieved using the Cohen's Kappa statistic (WHO, 1997), for dental erosion into enamel only (score 1 for depth). This has been shown to be the most difficult erosion score to diagnose (O'Brien, 1994; Chadwick and Pendry, 2004), and it was re-assuring to find that the reproducibility was similar to that found in previous studies assessing dental erosion (Al-Majed *et al.*, 2002; Al-Malik *et al.*, 2002; Dugmore and Rock, 2004a; Peres *et al.*, 2005a; Auad *et al.*, 2007; Peres *et al.*, 2008). Although there was a single examiner in this study, it is necessary to consider that assessment of the early stages of erosion may be challenging and subject to variability (Nunn *et al.*, 2003; Larsen *et al.*, 2005). It is difficult to detect dental erosion at an early stage but, the most important feature for dental professionals to diagnose dental erosion is change in the clinical appearance of the tooth surfaces especially in early stage of erosive tooth wear (Lussi *et al*., 2007). In the UK Children's Dental Health Survey report, dentists found it difficult to agree on the diagnosis of the presence of erosion in enamel only (Chadwick and Pendry, 2004), and these results were presented with caution because of low agreement between dentists in the diagnosis of erosion into enamel (Chadwick and Pendry, 2004). It was decided that the UK's 1993 survey approach of highlighting the clinical importance of erosion into dentine and into dentine and pulp should be followed (O'Brien, 1994). Tooth wear into dentine and pulp are much easier to identify and it is possible to obtain good agreement between examiners for this level of tooth involvement (Chadwick and Pendry, 2004). But this is not particularly useful as early detection of erosive process is important to stop and prevent irreversible tooth surface loss before clinical restorative intervention is required.

Although the researcher had received full training in intra-oral photography for the purposes of the study, because of poor lighting in the schools and insufficient practice in taking photographs by the researcher, only 31 x 3 (5%) of intra-oral photographs (labial, palatal and vertical view along the long axis of the anterior teeth) were clear and assessed for inter-examiner reliability by the researcher and Dr Paula Waterhouse. The inter-examiner reliability for intra-oral photography for assessing dental erosion by code 1 for depth on labial and palatal surfaces of anterior teeth measured by the Cohen's Kappa statistic was 65% and 77% respectively, indicating a substantial level of agreement (WHO, 1997). The levels of intra- and inter-examiner agreement achieved suggest that it might be easier to diagnose erosion into enamel (Yes/No) on palatal surfaces than labial surfaces.

Since there was an incomplete data set between photo images and actual clinical examination, with no standardized data set, similar number of images, similar views, or similar lighting conditions, intra examiner reliability between clinical examination and photographs could not be assessed. In future, it may be better to use a photographer with more expertise, or a variable focus camera or the researcher should undertake more practice in taking photo images.

In the present study, 12 year-olds were examined. At this age the first permanent molars would have been present in the mouth for approximately six years. The upper four permanent incisors would have been present in the mouth for approximately four or five years. Consequently, these teeth would have been exposed in the mouth to potential risk factors associated with dental erosion for a considerable length of time. This was useful for comparison purposes since several published studies have focused on similar age groups ranging from 12-14 years (Bartlett *et al.*, 1998; Kunzel *et al.*, 2000; Al-Dlaigan *et al.*, 2001a;

Al-Majed *et al.*, 2002; Auad *et al.*, 2007). The results of these comparisons are discussed in Section 5.6.5.

However, with other studies, use of different indices, criteria, age groups, number of the sample, gender and groups of teeth and tooth surfaces examined made comparisons more difficult. Some studies have assessed the prevalence of dental erosion (Millward *et al.*, 1994b; Al-Dlaigan *et al.*, 2001a), and others have assessed the prevalence of tooth wear (Milosevic *et al.*, 1994). A unified approach to assess the prevalence and severity of erosion is needed. Recently there are moves to do this, a new scoring system, the Basic Erosive Wear Examination (BEWE), was introduced to provide a basic structure to initiate the development of an internationally standardised accepted index (Bartlett *et al.*, 2008) and a modified wear index according to basic principle of Smith and Knight Index was developed (Fares *et al.*, 2009).

5.7.5 Mouth prevalence of dental erosion

The results of the present study showed that the mouth prevalence of dental erosion was 40.8%. This figure was lower than the value found in the UK NDNS for 11-14 year-olds, in which 52% of the children examined were affected (Walker *et al.*, 2000). On the other hand, the prevalence in this study was higher than the 27% for 12 year-olds and 32% for 14 year-olds, respectively (O'Brien, 1994) found in the 1993 UK Child Dental Health Survey and prevalence of 33% for 12 year-olds (Chadwick and Pendry, 2004) found in the 2003 UK CDH Survey. When comparing the present findings with other studies which have used the same index and criteria, the prevalence of erosion in this study was found to be higher than the prevalence of erosion found in 458 13-14 year-old Brazilian children (34%) (Auad *et al.*, 2007). Conversely, the prevalence found in this study was lower than the 60% found amongst 1753 12 year-olds in Leicestershire and Rutland (Dugmore and Rock, 2004a). It was also much less than the prevalence of 95% recorded in 862 12-14 year-old Saudi Arabian boys

(Al-Majed *et al.*, 2002). Both these figures were higher than the findings of the present study; the reason might be due to the high consumption of acidic drinks by Saudi Arabian subjects which was reported by Saudi Arabian studies (Johansson *et al.*, 1996; Al-Majed *et al.*, 2002), and 27% of 862 12-14 year-old Saudi Arabia boys consumed acidic drinks at night reported by Al-Majed *et al.* (2002). The UK National Diet and Nutrition Survey amongst 11-14 year-olds reported a mean daily intake of 240 grams of carbonated drinks (Walker *et al.*, 2000). In contrast with other studies which used different methodology and indices, the prevalence of dental erosion in the present study was lower than the prevalence of 57% found for 210 11-14 year-olds in London using the Smith and Knight tooth wear index (Bartlett *et al.*, 1998) and lower than the 66.9% found among 157 12-14 year-old Sudanese children also using Smith and Knight tooth wear index (EI Karim *et al.*, 2007), but it was higher than the one reported in a study in San Antonio, US in 307 12-17 year-olds, in which 5.5% of the children affected by dental erosion (Mungia *et al.*, 2009), an Australian study in 714 5-14 year-olds using a modified erosion index, in which 25% of the subjects with permanent teeth were found to have erosion (Kazoullis *et al.*, 2007), the 26% of 389 12 year-old Brazilian children using O'Sullivan index (Correr *et al.*, 2009), the 37% of 125 11-13 year-old children in the UK and 41% of 129 11-13 year-old children in US (Deery *et al.*, 2000), the 37% amongst 13 year-old children in United States using the modified Smith and Knight Tooth Index (McGuire *et al.*, 2009) and higher than the 38.1% amongst 483 12 year-old children in Iran using O'Sullivan index (Talebi *et al.*, 2009).

In the present study, dental erosion into enamel only was the most common finding and the majority of children had only erosion in enamel. This is in agreement with other studies (Bartlett *et al.*, 1998; Deery *et al.*, 2000; Walker *et al.*, 2000; Al-Majed *et al.*, 2002; Dugmore and Rock, 2003b; Chadwick and Pendry, 2004; Dugmore and Rock, 2004a; Caglar *et al.*, 2005; Larsen *et al.*, 2005; Peres *et al.*, 2005a; Auad *et al.*, 2007; Correr *et al.*, 2009; Mungia *et al.*, 2009). Dental erosion in enamel is difficult to measure (Nunn *et al.*, 2003; Chadwick and Pendry, 2004). Comparing the proportion of erosion into enamel only (32.5%) found in this study to others, it was less than the 48% in 418 14 year-old children in Birmingham using Smith and Knight tooth wear index (Al-Dlaigan *et al.*, 2001a), and less than the 57% found for 12 year-old Leicestershire children (Dugmore and Rock, 2004a).

In this study, dental erosion into dentine was relatively uncommon, affecting 63 subjects (8%); higher than the 1% found in 12 year-olds (O'Brien, 1994), 2.7% of 1753 12 year-olds in Leicestershire and Rutland (Dugmore and Rock, 2004a), 3% in 11-14 year-olds (Walker *et al.*, 2000) and 4.9% in 12 year-old children in Leicestershire (Dugmore and Rock, 2003b). Moreover, no exposed dentine was found in the 57% of 210 11-14 year-olds found with tooth erosion in London (Bartlett *et al.*, 1998). In contrast, other studies have shown a significant percentage (26%) of 862 12-14 year-old Saudi Arabian boys exhibiting erosion into dentine or into pulp (Al-Majed *et al.*, 2002), while 30% of 1035 14 year-olds in Liverpool (Milosevic *et al.*, 1994), 51% of 418 14 year-old children in Birmingham, UK (Al-Dlaigan *et al.*, 2001a), and 53% of 2351 14 year-olds in North West England (Bardsley *et al.*, 2004) showed erosion into dentine. It is possible that different exposures to risk factors might have influenced the differences in the severity of dental erosion observed in those studies. Although it is difficult to make comparisons between the findings of various studies due to different methodologies, it may be safer to compare the proportion of subjects with more easily diagnosed dentine exposure (Chadwick and Pendry, 2004).

In the present study, the palatal surfaces were affected slightly more often than labial surfaces. This confirms the findings of National Surveys in the UK which reported that the palatal surfaces of incisors were more commonly affected by erosion than the labial surfaces (O'Brien, 1994; Walker *et al.*, 2000; Chadwick and Pendry, 2004) and it was also in agreement with previous epidemiological studies from different countries (Al-Majed *et al.*, 2002; Dugmore and Rock, 2004a; Larsen *et al.*, 2005; Auad *et al.*, 2007; Patchett, 2009). However, it has been suggested that the abrasive effect of the tongue on softened, demineralised enamel contributes to a greater loss of tooth surface palatally (Gregg *et al.*, 2004). Alternatively it could be ascribed to a cofounding abrasion factor as a result of the oral hygiene practices of the children of this age.

Mouth prevalence of erosion for the upper permanent incisors in the present study was 25% (25% of subjects had evidence of erosion on labial surfaces, 25.5% on palatal surfaces). This figure was much less than that found in Saudi Arabian study (72%) using the same diagnostic criteria (Al-Majed *et al.*, 2002). It was also lower than 30% and 33% found in 12 and 15 year-olds, respectively, in the 2003 CDH Survey who had tooth surface loss affecting the palatal surfaces of the upper incisors (Chadwick and Pendry, 2004). On the other hand, it is in agreement with a previous study which found that dental erosion occurred in 25% of 11-15 year-old children on the palatal surfaces of upper incisors (O'Brien, 1994), but it was higher than the figure 12% reported in the labial surfaces. Moreover, the present results were higher than 12% and 16.9% reported for the prevalence of erosion on palatal and labial surfaces of incisors in 525 14 year-old schoolchildren in London (Williams *et al.*, 1999).

When comparing the present study with other studies which used different indices, it was found that the prevalence of erosion in the present study was much less than in a study which used the Smith and Knight Tooth Wear Index, in which 66.9% of 157 12-14 year-old Sudanese children had erosion on the labial and palatal incisors (EI Karim *et al.*, 2007), but it was higher than the prevalence of erosion (13%) present in the four maxillary incisors of 499 12 year-old Brazilian school children examined (Peres *et al.*, 2005a).

Only two subjects (0.3%) had erosion into dentine for upper permanent incisors in this study. This proportion was far lower than the findings of a Saudi Arabian study of 12% for 862 12-14 year-olds and 21.7% for 157 12-14 year-old Sudanese schoolchildren (Al-Majed *et al.*, 2002; EI Karim *et al.*, 2007) respectively, also lower than 3% of 12 year-olds (Chadwick and Pendry, 2004) and lower than the finding of the UK 1993 survey of 2% for children over 13 years-old, using the same diagnostic criteria (O'Brien, 1994). The differences between these studies and the present study might be due to the cultural differences with respect to dietary habits, such as frequency of acidic drinks intakes and the duration of drinks lasting in the mouth, or may be also due to differing oral hygiene practices and the differences in subjects' age.

Erosion into pulp was uncommon. Two maxillary incisors only were pulpally involved by erosion in the present study. Similar findings were reported in 12-14 year-old Saudi Arabian boys (Al-Majed *et al.*, 2002).

A symmetrical distribution of dental erosion across the midline was observed in the present study, confirming the findings of other studies (Al-Majed *et al.*, 2002; Dugmore and Rock, 2004a; Auad *et al.*, 2007; Patchett, 2009). The two central incisors were affected by erosion to a similar extent, for both labial and palatal surfaces, as were the two lateral incisors. The two central incisors were more affected than the lateral incisors on the labial surfaces but there was a similar effect for the palatal surfaces. The reason might be due to the flow of liquids over the area of the central incisors, or might be as the central incisors erupt in the mouth before the lateral incisors, they have probably been exposed to potential risk factors for a longer period of time, when compared with the lateral incisors.

The prevalence of dental erosion for the occlusal surfaces of first permanent molars in the children studied was 22.8%. Prevalence of dental erosion or tooth wear for molars has been reported with figures ranging between 5% and 90% (Millward *et al.*, 1994b; Bartlett *et al.*, 1998; Walker *et al.*, 2000; Al-Majed *et al.*, 2002; Chadwick and Pendry, 2004; Auad *et al.*, 2007). However, the prevalence of erosion in the present study was slightly higher than those reported in 12 year-olds in the UK with tooth wear on the occlusal surface of molars (19%) (Chadwick and Pendry, 2004) and higher than the findings in 13-14 year-old Brazilian children (5%) (Auad *et al.*, 2007). On the other hand, the prevalence found in this study was much less than the 91% found in 862 12-14 Saudi Arabian boys (Al-Majed *et al.*, 2002).

There was no erosion into pulp on occlusal surfaces of molars in the present study. It is in agreement with Saudi Arabian study (Al-Majed *et al.*, 2002), and the findings of the National Surveys in the UK (Walker *et al.*, 2000; Chadwick and Pendry, 2004), which fond only 2% of 12 year-olds with erosion into dentine (Chadwick and Pendry, 2004).

5.7.6 Tooth prevalence of dental erosion

In the present study, a total of 9492 dental surfaces were evaluated. Among these surfaces, 75.4% were free of dental erosion and 22.4% had erosion, the remaining 2.2% of surfaces could not be assessed. This is similar to the findings in 295 12 year-old Brazilian schoolchildren, in whom 73.1% of the total surfaces examined were free of erosion and 26.9% with erosion (Peres *et al.*, 2008). However, comparing the present study with the results of the Brazilian study requires caution due to the use of different methodologies; the Brazilian study examined the whole dentition and used a modified version of the tooth wear index (TWI).

Interestingly, in the present study, upper and lower molars appeared to be similarly affected by erosion, while in a study by Chadwick and Pendry (2004) found that lower molars were more affected. In addition, a study which assessed dental erosion using pre-orthodontic study models, found that lower molars were more affected by erosion (Ganss *et al.*, 2001a; Patchett, 2009).

The difference observed between the prevalence of dental erosion in this study and in other studies might be due to the different criteria and indices used in the various studies to measure dental erosion. In addition, different teeth were included in the studies and subjects were examined at different ages, ranging from 12 to 14 years which may have influenced the prevalence of erosion found. Differences in time of exposure to risk factors, such as consumption of acidic drinks as snacks or at meal times or at bedtime, frequency of consumption of acidic drinks and foods and duration of drinks retained in the mouth may have exposed children to different degrees of risk. Comparing prevalence of dental erosion of subjects at different ages is unsafe because of the interference of a generalized progression of tooth wear with age (Dugmore and Rock, 2003b).

5.7.7 Dental erosion and gender

A higher experience of erosion was observed amongst girls (46.7%) than boys (35%) in the present study. This difference was statistically significant (p= 0.001). Similar results, with girls more affected by erosion than boys, were reported in a Cuban study on 12 year-olds (Kunzel *et al.*, 2000). In contrast, several studies have reported that boys had more experience of dental erosion than girls (Milosevic *et al.*, 1994; Walker *et al.*, 2000; Al-Dlaigan *et al.*, 2001a; Dugmore and Rock, 2003b; Larsen *et al.*, 2005; Auad *et al.*, 2007), and other studies have reported no significant gender differences (Bartlett *et al.*, 1998; Deery *et al.*, 2000; Walker *et al.*, 2000; Caglar *et al.*, 2005; Peres *et al.*, 2005a; Peres *et al.*, 2008).

In the present study, 6.3% of boys had exposed dentine compared with 9.6% of girls. These proportions were less than that reported in a Liverpool study with 35% boys and 24% of girls having exposed dentine (Milosevic *et al.*, 1994). In addition, 56% of boys and 49% of girls showed exposed dentine in a study of 14 year year-old children in Birmingham (Al-Dlaigan *et al.*, 2001a). The significant differences in the prevalence of dental erosion between boys and girls in the present study may perhaps be explained by a difference of exposure to risk factors in this population and will be discussed further in Chapters 7 and 8.

5.7.8 Derived score for erosion (Area x Depth)

A derived score was used in the present study to measure the severity of dental erosion by Area x Depth. This score provided a greater range of values and was used as a proxy for the volume loss due to erosion on each tooth surface. Since the result showed that no individuals had a score 0 for depth and >0 for area or vice versa the new derived score was calculated by multiplying Area and Depth scores. This scoring gave rise to derived scores of 1, 2, 3, 4, 6 and 9, for each tooth surface. Area x Depth provided a wider range of scores which may help to predict need for dental treatment. Score 1 is mild and scores 2 and 3 are more worrying. Dentine exposure score diagnosed by the derived score Area x Depth by ≥2 for Depth and ≥1 for Area which is ≥2 overall, and this score needs dental treatment. Similar results were found when dental erosion by Area x Depth score was compared with separate Depth and Area scores. This derived score needs to be validated.

5.8 Conclusions

5.8.1 The main aim of this study was; to determine the prevalence and severity of dental erosion amongst 12 year-old children in Benghazi, Libya was achieved.

- Of the total sample (791 subjects); 323 subjects (40.8%) had experience of dental erosion for depth and for area, while 468 subjects (59.2%) were free of dental erosion.
- Erosion into enamel only was the most common finding, affecting 258 subjects (32.5%), erosion into dentine was relatively uncommon, affecting 63 subjects (8%) and erosion into pulp was rare, affecting 2 subjects (0.3%).

5.8.2 With respect to dental erosion and gender:

- The prevalence of erosion was greater in girls (49.7) than boys (35%); this difference was statistically significant (p= 0.001).
- Of the 139 boys with evidence of dental erosion, from these boys, 25 boys (6.3%) of total sample had exposed dentine and no one with erosion into pulp.
- Of the 184 girls with evidence of dental erosion, 38 girls (9.6%) of the total sample had exposed dentine and two girls had erosion into pulp.

5.8.3 The null hypothesis of this study was accepted:

- The prevalence and severity of dental erosion in 12 year-old children in Benghazi, Libya was in agreement with data reported for the prevalence and severity of dental erosion in European children.

In the present study, the significant proportion of children in Benghazi, Libya affected by dental erosion emphasizes the importance of preventive measures needed to control the erosive process, before the need for invasive treatment to restore eroded teeth.

Chapter 6
The prevalence of dental caries

6.1 Introduction

Dental caries is the most common oral disease in children and adults in developed and developing countries and is the main cause of loss of teeth in younger people. Despite the fact that dental caries is preventable, it continues to be a major public health concern. Although the prevalence of dental caries has declined in developed countries during the last 30 years, it remains a significant dental disease and a major public health challenge in children and adults (Petersson and Bratthall, 1996; Petersen, 2005). Significant proportions of children and adults are still affected by caries in developing countries and it is also still increasing in many of these countries where fluoride is not available and the population has increasing opportunities to consume free sugars (Moynihan and Petersen, 2004). Changing life-styles and dietary patterns have led to a marked increase in caries incidence in developing countries (Al-Khateeb *et al.*, 1991; Taani, 1997; Al-Dosari *et al.*, 2004; Al-Ismaily *et al.*, 2004; Behbehani and Scheutz, 2004; Beiruti and Van Palenstein Helderman, 2004; Taani, 2004; Sudha *et al.*, 2005). Countries with mean scores above a DMFT of 3, have failed to meet the World Health Organisation (WHO) global goal for the year 2000 for children aged 12 years (WHO/FDI, 1982). The WHO global goal for the year 2020 is for a mean DMFT of not more than 1.5 for the same age group (Peterson, 2003).

Despite the fact that caries is the commonest dental disease in children, little attention has been given to studies measuring the prevalence of caries amongst Libyan schoolchildren. The importance of monitoring the prevalence of dental caries is in planning services and determining whether progress has been made towards controlling the distribution of this dental disease. In Libya, data from a cross-sectional observational study of dental caries in

762 6-12 year-old schoolchildren in Benghazi in 1993/94 showed that the DMFT was 1.63, and the prevalence of dental caries was 50% (Al-Sharbati *et al.*, 2000). Similarly, a 2002 study investigating the prevalence of caries in 685 preschoolers in Benghazi showed that 58% of children had carious primary teeth (mean dmft 2.58) (Ingafou *et al.*, 2003).

Dental caries is a multi-factorial disease. Frequency of consumption of a sugary diet is the most important aetiological factor in the development of dental caries. Conclusive evidence supports the association between sugars intake and dental caries (Rugg-Gunn and Hackett, 1993; Sheiham, 2001; Moynihan, 2002; WHO, 2003; Moynihan and Petersen, 2004; Yabao *et al.*, 2005). In addition, dental caries is often related to individuals with low standards of oral hygiene (Sheiham, 2001) and several factors such as salivary flow rate and buffering capacity might also affect the development of dental caries. Control of sugar intake is the most effective factor to control caries while a second important factor is fluoride. Sources of fluoride include water, tea, a range of foods, and toothpaste. Exposure to fluorides in school-based programmes, lozenges, toothpaste, and education have been shown to be related to the caries decline (Birkeland *et al.*, 2000).

6.2 Aims

The aims of the study were:

6.2.1 To determine the prevalence and severity of dental caries amongst 12 year-old schoolchildren in Benghazi, Libya.

6.2.2 To investigate the association between the experience of dental erosion and dental caries amongst children in Benghazi, Libya.

6.3 Objectives

- To undertake a dental examination of 12 year-old Libyan schoolchildren in Benghazi in order to assess the prevalence and severity of dental caries.

6.4 Null hypothesis

- There is no relationship between dental erosion and dental caries in 12 year-old children in Benghazi, Libya.

6.5 Methods

6.5.1 Ethical approval and permissions from local authorities

Ethical clearance and permissions from authorities to conduct the study in Benghazi were secured. Written informed consents were received from the parents/guardians and participant children (Section 4.6.1).

6.5.2 The study sample

This cross-sectional observational study was conducted in Benghazi. There were 7682 eligible schoolchildren in the target age group registered at 81 elementary schools in 15 districts in Benghazi. The public schools comprised 90% of the total number of schools in Benghazi. A cluster sampling method with schools as cluster was used for sampling, with a random selection of boys and girls from each selected elementary school made. The sampling procedure was described in detail in Chapter 4 (Section 4.4). The final sample was 791 12 year-old schoolchildren of both genders resident in Benghazi, studying at the sixth grade in 36 elementary public schools which had pupils of both genders. The sample size estimate was calculated for the main study (Chapter 5), based on the prevalence of dental erosion in 11-14 year-old British children, estimated as 52% in a study by Walker *et al.* (2000). In addition, the prevalence of dental erosion in 13-14 year-old Brazilian children (Auad *et al.*, 2007) (34%) was also considered to estimate the power of the study and thus, the sample size required. With a sample of 665 subjects the 95% Confidence Interval +/-4 (standard error 2.04%) able to detect prevalence of erosion 35%+/-5. The sample size was valid and appropriate for this study.

6.5.3 Dental examination

Clinical dental examinations of participant subjects were conducted in the schools with the child seated in an ordinary classroom-type chair and using artificial lighting and a headlamp. The criteria were visual, limited to dentine caries and no diagnostic aids were employed. The examiner was calibrated previously by an experienced examiner, Professor June Nunn, from Trinity College, Dublin using the DMFT and DMFS indices and WHO diagnostic criteria (WHO, 1997) (Table 4.3). The procedures used during the dental examination are described in Chapter 4 (Section 4.6.5). Data collection forms for recording dental caries were based on the indices recommended by the World Health Organization (WHO, 1997) (Appendix 4.3). All maxillary and mandibular teeth were examined for dental caries. The criteria for the assessment of dental caries was based upon those recommended by the World Health Organization (WHO, 1997) (Appendix 4.4). The prevalence of dental caries was assessed in accordance with the World Health Organization criteria using the DMFT (decayed, missing and filled teeth) and DMFS (decayed, missing and filled surfaces) indices for the permanent dentition (WHO, 1997) (Table 4.3).

6.5.4 Data recording

The dental examination data collection forms contained a dental charting for all the maxillary and mandibular teeth with designated cells for coding the entry of dental caries data, diagnostic criteria codes for dental caries and demographic information such as, name, gender, school number, date of birth, and date of examination (Appendix 4.3).

6.5.5 Reproducibility of the study

To ensure the reproducibility of the application of diagnostic criteria in each school, two subjects were re-examined on the same day after completion of the dental examination of the 22 children. Overall, 75 subjects, 10% of the total sample, were re-examined. The examiner was blind to the identity of the subjects re-examined. The assistant was instructed to randomly re-call two pupils during the dental examination session allowing an interval of at least two hours between the two examinations. The results of the dental examination were analysed for intra-examiner reproducibility using Cohen's Kappa (WHO, 1997).

6.5.6 Data entry

Dental caries data were entered into MS Excel files. In sequence, the dental caries indices were calculated using a programme developed in the School of Dental Sciences, Newcastle University (Nunn *et al.*, 1992). The results were entered into a second database, developed in the Statistical Program for Social Sciences-SPSS 14.0 for Windows statistical programme (SPSS 14.0 for Windows). The data entry was cross-checked by comparing the data entry of 20 randomly selected subjects with the data collection. To measure the levels of intra-examiner agreement in assessing dental caries, a third database was developed using data from subjects who had been re-examined to determine the reproducibility of the application of diagnostic criteria. The Cohen's Kappa statistic (WHO, 1997) was used for measuring the level of intra-examiner agreement (Section 4.6.5.2). Prevalence of dental caries was calculated as the number and proportion of subjects with caries experience in the permanent dentition. Severity of dental caries was assessed using DMFT and DMFS indices. A Kolmogorov-Smirnov Z test was used to assess the normality of distribution of the data related to the DMFT and DMFS indices. Measures of central tendency (mean, median) and dispersion (standard deviation and interquartile range) of the DMFT and DMFS indices were calculated for all subjects and for subjects with caries experience. The subjects were categorised into three groups using the 50th percentile of the distribution of the DMFT amongst subjects with caries experience as the cut-off point between subjects with lower and higher caries experience. These categories were: without caries experience (DMFT= 0), with lower caries experience (DMFT= 1-3) and with higher caries experience (DMFT≥ 4). The subjects were also categorised into three groups depending on the DMFS index: without caries experience (DMFS= 0), with lower caries experience (DMFS= 1-4) and with higher caries experience (DMFS≥ 5). In addition, the subjects were also categorised into six groups using the DMFT distribution used by the WHO at 12 years (WHO, 2000): without caries experience (DMFT= 0), with very low caries experience (DMFT= 0-1.1), low caries experience (DMFT= 1.2-2.6), moderate caries experience (DMFT= 2.7-4.4), high caries experience (DMFT= 4.5-6.5) and very high caries experience (≥ 6.6). Associations between the experience and severity of dental caries and the experience of erosion were tested through a process of bivariate analysis, using the exact version of the non-parametric tests; Chi-square, Fisher's and Linear Association. Odds ratio (OR) and 95% Confidence Intervals (CI) were calculated for 2 x 2 tables. Only two-sided statistical tests were used. The statistical significance level was established at 5%. Differences in the mean DMFT and DMFS scores in relation to the experience of dental erosion were also assessed.

6.6 Results

6.6.1 Reproducibility of the study

The levels of intra-examiner agreement in the assessment of dental caries, as measured by the Cohen's Kappa statistic (WHO, 1997) for the DMFT and DMFS indices were 0.95 and 0.93, respectively (Appendix 6.1) indicating an excellent level of agreement (WHO, 1997).

6.6.2 DMFT and DMFS indices

For all subjects (n= 791), the means (standard deviations) for the DMFT and DMFS indices were 1.68 (SD± 1.86) and 2.39 (SD± 3.05) respectively (Table 6.1). For subjects with caries experience (n= 457), the mean DMFT and DMFS indices were 2.90 (SD± 1.56) and 4.14 (SD± 2.97) respectively (Table 6.2). The results, tested for normality by a Kolmogorov-Smirnov Z test, showed that the data were not normally distributed for both DMFT ($p < 0.001$) and DMFS ($p < 0.001$) indices therefore non-Parametric tests were used. Suitable measures of central tendency and dispersion were calculated using median and interquartile range for all subjects (791) and for subjects with caries experience (457) (Table 6.3).

Table 6.1: Mean, (SD) of the DMFT and DMFS indices for all subjects.

Index	No. of subjects	Mean	SD	Decayed		Missing		Filled	
				Mean	SD	Mean	SD	Mean	SD
DMFT	791	1.68	1.86	1.60	1.79	0.05	0.24	0.03	0.28
DMFS	791	2.39	3.05	2.12	2.59	0.21	1.18	0.06	0.54

Table 6.2: Mean, (SD) of the DMFT and DMFS indices for subjects with caries experience.

Index	No. of subjects	Mean	SD	Decayed		Missing		Filled	
				Mean	SD	Mean	SD	Mean	SD
DMFT	457	2.90	1.56	2.78	1.52	0.07	0.31	0.05	0.37
DMFS	457	4.14	2.97	3.69	2.43	0.35	1.53	0.10	0.71

Table 6.3: Median and interquartile range (IQR) for the DMFT and DMFS indices for all subjects and for subjects with caries experience.

	All subjects (n = 791)		Subjects with dental caries experience (n = 457)	
	DMFT	DMFS	DMFT	DMFS
Median	1.00	1.00	3.00	4.00
IQR	3.00	4.00	2.00	3.00

6.6.3 Prevalence of dental caries

Four hundred and fifty seven subjects (57.8 %) had experience of dental caries, 334 (42.2 %) were caries free. The means and standard deviations for the decayed component of DMFT and DMFS indices for all subjects were 1.60 (SD± 1.79), 2.12 (SD± 2.59) respectively (Table 6.1). The Decay Index for all subjects (DT/DMFT x 100%) was 95.2% (Table 6.4).

The means and standard deviation for the decayed component of DMFT and DMFS indices for the 457 subjects with caries experience were 2.78 (SD± 1.52) and 3.69 (SD± 2.43) respectively (Table 6.2). The D (decayed) component comprised the greatest proportion of the caries experience seen. The Decay Index for subjects with caries experience was 95.9% (Table 6.4).

Table 6.4: Mean DMFT for all subjects and with subjects with caries experiences and their Decay, Missing and Care Indices.

Index	Mean	SD	Decay index %	Missing index %	Care index %
DMFT for all subjects	1.68	1.86	95.2	3.0	1.8
DMFT for subjects with caries experience	2.90	1.56	95.9	2.4	1.7

6.6.4 Prevalence of missing teeth

The means and standard deviation for the missing component (missing teeth due to dental caries) of DMFT and DMFS indices for all subjects were 0.05 (SD± 0.24) and 0.21 (1.18) respectively (Table 6.1). The Missing Index for all subjects (MT/DMFT x 100%) was 3.0% (Table 6.4).

The means and standard deviation for the missing component of DMFT and DMFS indices for subjects with caries experience were 0.07 (0.31) and 0.35 (1.53), respectively (Table 6.2). The Missing Index for subjects with caries experience was 2.4% (Table 6.4).

6.6.5 Prevalence of filled teeth

The means and standard deviation for the filled teeth in the DMFT and DMFS indices for all subjects were 0.03 (SD± 0.28), and 0.06 (SD± 0.54) respectively (Table 6.1). The Care Index for all subjects (FT/DMFT x 100%) was 1.8% (Table 6.4).

The F (filled) component comprised the lowest of all components of the indices. The means and standard deviation for filled teeth in the DMFT and DMFS indices for the subjects with caries experience were 0.05 (SD± 0.37), and 0.10 (SD± 0.71) respectively (Table 6.2). The Care Index for subjects with caries experience was 1.7% (Table 6.4).

6.6.6 Gender and caries prevalence and severity

Dental caries was more prevalent amongst girls than boys; the difference was statistically significant (Fisher's exact test; p= 0.002) (Table 6.5). The means and standard deviation for the DMFT and DMFS indices were higher in girls than boys (Table 6.6). For the girls, the mean DMFT and DMFS indices were 1.88 (SD± 1.94) and 2.71 (SD± 3.28) respectively. For the boys, the mean DMFT and DMFS indices were 1.48 (SD± 1.76) and 2.08 (SD± 2.77) respectively. Difference between both DMFT and DMFS indices were statistically significant in relation to gender (Table 6.6). When the association between the severity of dental caries and gender was tested according to the grouping system for the DMFT index (Section 6.4.6) similar results were observed. The proportions of subjects with lower caries experience (DMFT between 1 and 3 and DMFS between 1 and 4) and higher caries experiences (DMFT≥ 4 and DMFS≥ 5) were greater amongst girls than boys; the difference was statistically significant (Table 6.7 and Table 6.8). This is similar to the results found when the DMFT by gender was compared within that the categories used by WHO (WHO, 2000).

The proportion of subjects with very low, moderate (DMFT= 2.7-4.4), high caries (DMFT= 4.5-6.5) experience was greater amongst girls than boys (Table 6.9), while the proportion of subjects without, with low and very high caries experience was higher in boys. This association was statistically significant (p= 0.002).

Table 6.5: Significance of association (P, Odds Ratio and 95% CI) between the number (N) and proportion (%) of subjects with or without dental caries experience and gender.

Experience of dental caries									
Gender	**Girls**			**Boys**			**Both**		
	Yes	**No**	**Total**	**Yes**	**No**	**Total**	**Yes**	**No**	**Total**
No. of subjects	250	144	394	207	190	397	457	334	791
%	63.5	36.5	100.0	52.1	47.9	100.0	57.8	42.2	100.0

Fisher's exact test; p= 0.002 OR= 1.594 (95% CI 1.199, 2.118)

Table 6.6: Significance of differences (P) between the DMFT and DMFS indices when categorised by gender.

Index	Gender	No. of subjects	Mean	SD	Median	IQR	P *
DMFT	Girls	394	1.88	1.94	1.00	3.00	0.002*
DMFT	Boys	397	1.48	1.76	1.00	3.00	
DMFS	Girls	394	2.71	3.28	2.00	4.00	0.002*
DMFS	Boys	397	2.08	2.77	1.00	4.00	

*Mann-Whitney U test, statistically significant at p< 0.01

Table 6.7: Significance of association (P) between the number (N) and proportion (%) of subjects without, with lower and with higher caries experience (DMFT) and gender based on 50th percentile of distribution of DMFT amongst subjects with caries experience.

Gender	**Severity of caries DMFT**						**All**		**P (Linear Association exact test)**
	Without caries DMFT= 0		**Lower caries DMFT= 1-3**		**Higher caries DMFT≥4**				
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	
Girls	144	36.5	153	38.8	97	24.6	394	100.0	0.002*
Boys	190	47.9	133	33.5	74	18.6	397	100.0	

*Statistically significant at p< 0.01

Table 6.8: Significance of association (P) between the number (N) and proportion (%) of subjects without, with lower and with higher caries experience (DMFS) and gender based on the DMFS index.

Gender	Severity of caries DMFS						All		P (Linear Association exact test)
	Without caries DMFS= 0		Lower caries DMFS= 1-4		Higher caries DMFS ≥5				
	N	%	N	%	N	%	N	%	
Girls	144	36.5	161	40.9	89	22.6	394	100.0	0.001*
Boys	190	47.9	142	35.8	65	16.4	397	100.0	

*Statistically significant at p< 0.01

Table 6.9: Significance of association (P) between the number (N) and proportion(%) of subjects without, with very low, low, moderate, high and very high caries experience and gender based on DMFT categories used by World Health Organisation (WHO, 2000).

Gender	Severity of caries														P (Linear Association exact test)
	Without caries DMFT =0		Very low caries DMFT =0-1.1		Low caries DMFT =1.2-2.6		Mode rate Caries DMFT =2.7-4.4		High caries DMFT =4.5-6.5		Very high caries DMFT ≥6.6		All		
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	
Girls	144	37	55	14	56	14	108	27	24	6	7	2	394	100	0.002*
Boys	190	48	42	11	59	15	85	21	19	5	2	5	397	100	

*Statistically significant at p< 0.01

6.6.7 Dental caries and its association with dental erosion

One hundred and ninety-two subjects (42%) of the 457 with caries experience also had experience of dental erosion, whilst 131 subjects (39.2%) of the 334 who did not have dental caries, had clinical signs of dental erosion. This difference was not statistically significant (Fisher's exact test; p= 0.464, OR= 1.123, 95% CI 0.842-1.497) (Table 6.10). No statistically significant difference was observed when the association between severity of dental caries and experience of erosion was tested.

The mean DMFT and DMFS indices amongst subjects with and without erosion were very similar. The mean for the DMFT index for subjects with and without erosion were 1.71 (SD± 1.94) and 1.65 (SD± 1.80), respectively. The median and interquartile range were 1.00 and 3, respectively, both for subjects with and without dental erosion (Linear association exact test;

p= 0.671). The DMFS for subjects with and without erosion was 2.48 (SD± 3.23) and 2.34 (SD± 2.91), respectively.

The median and interquartile range for the DMFS index were 1.00 and 4, respectively, for the two groups (Linear association exact test; p= 0.513) (Table 6.11). The proportions of subjects with erosion were higher for all caries experience groupings although these differences were not statistically significant (Table 6.12 and Table 6.13).

Table 6.10: Number (N) and proportion (%) of subjects with and without experience of caries categorised by the experience of dental erosion.

Experience of dental erosion	Experience of dental caries				Total		P (Fisher's exact test)	OR (Odds Ratio)	95% CI (Confidence Interval)
	Yes		No						
	N	%	N	%	N	%			Lower-Upper
Yes	192	42.0	131	39.2	323	40.8	0.464	1.123	0.842-1.497
No	265	58.0	203	60.8	468	59.2			
Total	457	100	334	100	791	100			

Table 6.11: Mean, (SD), median, interquartile range (IQR) for DMFT and DMFS indices according to experience of dental erosion.

Index	Experience of dental erosion	Mean	SD	Median	IQR	P (Linear Association exact test)
DMFT	Yes	1.71	1.94	1	3	0.671
DMFT	No	1.65	1.80	1	3	
DMFS	Yes	2.48	3.23	1	4	0.513
DMFS	No	2.34	2.91	1	4	

Table 6.12: Proportion (%) of subjects without, with lower and with higher caries experience (DMFT) and the experience of erosion based on 50th percentile of distribution of DMFT amongst subjects with caries experience.

Experience of dental erosion	Severity of dental caries (DMFT)						Total		P (Linear Association exact test)
	Without caries DMFT= 0		Lower caries DMFT= 1-3		Higher caries DMFT≥ 4				
	N	%	N	%	N	%	N	%	
Yes	131	39.2	126	44.1	66	38.6	323	40.8	0.884
No	203	60.8	160	55.9	105	61.4	468	59.2	
Total	334	100	286	100	171	100	791	100	

Table 6.13: Significance of the association (P) and proportion (%) of subjects without, with lower and with higher caries experience (DMFS) and the experience of erosion based on the DMFS index.

Experience of dental erosion	Severity of dental caries (DMFS)						Total		P (Linear Association exact test)
	Without caries DMFS= 0		Lower caries DMFS= 1-4		Higher caries DMFS ≥5				
	N	%	N	%	N	%	N	%	
Yes	131	39.2	127	41.9	65	42.2	323	40.8	0.471
No	203	60.8	176	58.1	89	57.8	468	59.2	
Total	334	100	303	100	154	100	791	100	

6.7 Discussion

6.7.1 The study sample

The study sample was from Benghazi which is the second largest city in Libya after the capital, Tripoli. In total, 791 12 year-olds of both genders (394 girls and 397 boys) were included in the study. There was no existing classification of social class in Benghazi which could be used to provide a sampling frame, therefore cluster sampling within schools was used. The study sample was sufficiently large enough (791), including thirty six schools drawn from the 15 different districts with different socioeconomic groups and cultures to make the study sample reasonably representative of 12 year-olds in Benghazi and other urban regions of Libya.

6.7.2 The response rate

Written consents were obtained from 2662 out of the 3014 subjects; a response rate of 88.3%. From those written consents, lists by school were made and the required sample number (791 pupils; 29.7% of the consenting children) was selected randomly and included in the study.

6.7.3 Aims of the study

As well as no published data relating to the prevalence and severity of dental erosion in children or adults being available in any region in Libya, additionally, no data had tested the relationship between dental erosion and caries. Moreover, dental caries is still a major dental health disease in Libya and only a few published studies related to dental caries have been published. This study was also undertaken to help focus the attention of the Libyan government for future planning and monitoring of dental services in Benghazi.

6.7.4 Reproducibility of the study

To establish the diagnostic variability of the examiner, 10% of the total sample was re-examined for dental caries. A good level of intra-examiner agreement was achieved for both the DMFT and DMFS indices using the Cohen's Kappa statistic which is described by the World Health Organization as acceptably consistent (WHO, 1997). Similar levels of reproducibility have been observed in other studies assessing dental caries (Al-Malik *et al*., 2002; Auad *et al*., 2009).

6.7.5 Dental caries experience of the sample

The present study has provided useful information about the prevalence and severity of dental caries in 12 year-old Libyan schoolchildren in Benghazi. The study findings contribute to the overall picture of Libyan schoolchildren's dental health, although with hindsight this may be an underestimate as no radiographic examinations were undertaken.

In the present study the prevalence of dental caries was high; 457 subjects (57.8%) had experience of dental caries. The reasons for this could be exposure to caries associated risk factors such as poor oral hygiene, less exposure to fluoride (Ali, 2004), absence of dental hygienists in Benghazi, poor dietary practices and increased consumption of sugars due to cheap and easy access to sugar-containing foods. However, a number of other factors must also be taken into consideration such as absence of both dental health education and caries prevention programmes.

Comparing the prevalence of dental caries in this study that found in previous studies conducted in other countries with a similar age group, shows that the prevalence found in the present study was higher than that found in India (10%) (Bradley and Wendell, 2009), Iran (36.2%) (Momeni *et al.*, 2006), Tunisia (48.3%) (Abid, 2004), Uganda (40.2%) (Kiwanuka *et al.*, 2006), Italy (43.1%) (Campus *et al.*, 2007) and in the UK (32.7%) (Pitts *et al.*, 2006). On the other hand, the prevalence of dental caries found in the present study was lower than that found in 12 year-old schoolchildren in Philippines (74.9%) (Yabao *et al.*, 2005), and in 12-13 year-old schoolchildren in Riyadh and Qaseem, Saudi Arabia (92.3%, 87.9%), respectively (AlDosari *et al.*, 2004). Similarly it was lower than the prevalence of 78% in 13-14 year-old schoolchildren in Brazil (Auad *et al.*, 2009).

The mean DMFT and DMFS in the present study was 1.68 (SD± 1.86) and 2.39 (SD± 3.05), respectively. The 'WHO goal' for the year 2000 was for a mean DMFT lower than 3.0 for children aged 12 years, therefore the results of the present study met this goal (WHO/FDI, 1982), but this figure (1.68) was higher than the new oral health goals for the "year 2020 WHO health 21 policy": no more than a DMFT of 1.5 should be observed for children of age 12 years (Peterson, 2003). Comparing the results of the present study, the overall mean DMFT was much lower than the mean DMFT reported by previous studies conducted in other developing countries, in Hungary (3.8), Oman (3.23), Saudi Arabia (5.06), Kuwait (2.6)**,** the Philippines (3.68) and Brazil (3.95), respectively (Szoke and Petersen, 2000; Al-Ismaily *et al.*, 2004; AlDosari *et al.*, 2004; Behbehani and Scheutz, 2004; Yabao *et al.*, 2005; Auad *et al.*, 2009) (Table 6.14).

The decayed component (D) was the highest component of the DMFT index for 12 year-old children in the present study, the Decay Index being 95.2% for all subjects and 95.9% for subjects with caries experience. The Decay Index in the present study when compared with other developing countries, was shown to be higher than in studies of 12 year-old children in Tunisia (44.7%) (Abid, 2004), Mexico (82.3%) (Irigoyen and Sanchez-Hinojosa, 2000), Iraq (54.8%) (Ahmed *et al.*, 2007), Iran (58.7%) (Momeni *et al.*, 2006), India (73%) (Bradley and Wendell, 2009) and in Romania (89%) (Nuca *et al.*, 2009) (Table 6.14).

High levels of caries are usually related to high treatment needs and the high level of untreated caries is a cause for concern. Untreated caries lesions dominated the DMFT among the schoolchildren representing a high rate of unmet treatment needs. This might be attributed to lack of dental health awareness and emphasises the importance of prevention programmes and treatment of carious teeth in children. In addition, in Libya dental services within communities and within the school dental services are not able to provide all the dental treatment needed by children (Al-Sharbati *et al.*, 2000). The high numbers of untreated carious lesions were an indicator of the inability of current dental services to cope with the dental caries problem. If dental services are unavailable in the public sector, children may be forced to seek dental treatment from private dental services, which are expensive. In addition, lack of dental awareness and unhealthy dietary habits may have worsened the situation (Yabao *et al.*, 2005). Also, limited tooth brushing amongst children has led to limited access to use of fluoride toothpastes and their caries prevention properties (Ali, 2004). Furthermore, the absence of public caries prevention programmes and lack of dental hygienists in Libya may have contributed to the high prevalence of dental caries.

The decayed component (D) in the present study was 1.60. This figure was higher than that found in England, London and Scotland (0.52, 0.47, 0.82), respectively (Pitts *et al.*, 2000), France (0.8) (Bourgeois *et al.*, 2004), Brazil (1.12) (Auad *et al.*, 2009), Tunisia (1.18) (Abid, 2004), and in Hungary (1.5) (Szoke and Petersen, 2000) as Table 6.14 shows. Conversely, the decayed (D) component in the present study was lower than that found in Mexico (1.8) (Irigoyen and Sanchez-Hinojosa, 2000), Oman (2.8) (Al-Ismaily *et al.*, 2004), Jordan (2.9)

(Taani, 2004), Riyadh and Qaseem, Saudi Arabia (4.65, 4.11), respectively (AlDosari *et al.*, 2004) and in Brazil (5.3) (Bonecker and Cleaton-Jones, 2003) (Table 6.14).

In contrast, the lowest component of the index was the filled (F) component. The Care index which reflects the restorative care of those who have suffered dental caries was 1.8% in present study; less than that found in Oman (3%) (Al-Ismaily *et al.*, 2004), 12 year-olds in Tunisia (5%) (Abid, 2004), 12 year-olds in India (13%) (Bradley and Wendell, 2009), 12 year-olds in Iran (37.9%) (Momeni *et al.*, 2006), and much less than that found in 11 year-old children in the UK (42%) (Pitts *et al.*, 2006), 12 year olds in the UK (48%) (Pitts *et al.*, 1998) and 12 year-old children in three surveys in Brazil (50.5%, 66.4%, 56.3%) (Tagliaferro *et al.*, 2008). This may have arisen because of poor access to oral health services, with the low F component being an indicator of the inability of current dental services to adequately treat children's decay. Most oral health services in Libya provide symptomatic treatment rather than restoration and prevention (Al-Sharbati *et al.*, 2000). The mean filled (F) component in this study was (0.03), this figure was lower than that found in Tunisia (0.05) (Abid, 2004), Oman (0.1) (Al-Ismaily *et al.*, 2004), Riyadh and Qaseem, Saudi Arabia (0.26, 0.16), respectively (AlDosari *et al.*, 2004), Jordan (0.3) (Taani, 2004), Brazil (0.5) (Bonecker and Cleaton-Jones, 2003), Mexico (0.6, 0.7) (Irigoyen and Sanchez-Hinojosa, 2000), England, London and Scotland (0.86, 0.77, 1.13) respectively, (Pitts *et al.*, 2000), France (0.9) (Bourgeois *et al.*, 2004), and in Hungary (2.1) (Szoke and Petersen, 2000). It was also much lower than 3.82 in Brazil (Auad *et al.*, 2009).

The Missing index was 3.0% for all subjects and 2.4% for subjects with caries experience. This figure was lower than that found in Iran (3.4%) (Momeni *et al.*, 2006), Iraq (3.6%) (Ahmed *et al.*, 2007), India (7%) (Bradley and Wendell, 2009), and in France (Bourgeois *et al.*, 2004) (11%). The mean missing component (M) was 0.05. Similarly, M component of 0.04, 0.07 and 0.09, respectively, were found in Mexico (Irigoyen and Sanchez-Hinojosa, 2000), Tunisia (Abid, 2004) and in Brazil (Auad *et al.*, 2009). This figure might be due to limited access to oral health services and also might be due to lack of parental dental awareness of the importance of treating caries in childhood due to their erroneous belief that children's teeth are replaceable and not important.

The M component in this study was low when compared with previous studies from different countries. The missing (M) component in Hungary (0.1) (Szoke and Petersen, 2000), Jordan (0.1) (Taani, 2004), Oman (0.3) (Al-Ismaily *et al.*, 2004), France (0.2) (Bourgeois *et al.*, 2004), England, London and Scotland (0.12, 0.07, 0.21), respectively (Pitts *et al.*, 2000) and in Riyadh and Qaseem, Saudi Arabia (0.16, 0.25), respectively (AlDosari *et al.*, 2004) (Table 6.14).

Table 6.14: The prevalence of dental caries and the mean DMFT and its components in present study, previous studies in Libya, some developing and developed countries.

Source	Year of study	Country	Age	N	DT	MT	FT	DMFT	Prevalence of caries %	Decay Index %	Missing Index %	Care Index %
Present study	2007	Libya	12	791	1.60	0.05	0.03	1.68	57.8	95.2	3.0	1.8
(Omar, 1989)	1987	Libya	12	130	0.56	0.10	0.12	0.78		71.8	12.8	15.0
(Baccush and Nayak, 1991)	1989	Libya	10-13	720	1.34	0.21	0.03	1.58	56.9	84.8	13.0	1.9
(Hawew *et al.*, 1996)	1994	Libya	12	373	1.06	0.05	0.06	1.17	50.0	90.6	4.0	5.0
(Al-Sharbati *et al.*, 2000)	93/94	Libya	12	46	1.26	0.35	0.02	1.63	50.0	77.0	21.5	1.0
(Abid, 2004)	1994	Tunisia	12	602	1.18	0.07	0.05	1.30	48.3	90.8	5.0	4.0
(Behbehani and Scheutz, 2004)	2000	Kuwait	12					2.6				
(Taani, 2004)	2004	Jordan	12-13	718	2.9	0.10	0.3	3.2		90.0	3.0	9.0
(Al-Ismaily *et al.*, 2004)	2004	Oman	15	2,860	2.8	0.3	0.10	3.23	73.2	86.7	9.0	3.0
(Al-Dosari *et al.*, 2004)	2004	Saudi Arabia	12-13	392	4.65	0.16	0.26	5.06	92.3	91.9	3.0	5.0
(Al-Dosari *et al.*, 2004)	2004	Saudi Arabia	12-13	281	4.11	0.25	0.16	4.53	87.9	90.7	5.5	3.5
(Szoke and Petersen, 2000)	1996	Hungary	12	900	1.5	0.10	2.1	3.8	84.5	39.5	2.6	55.0
(Irigoyen and Sanchez-Hinojosa, 2000)	1997	Mexico	12	1,138	1.8	0.04	0.6	2.47	72.3	72.8	2.0	25.0
(Irigoyen and Sanchez-Hinojosa, 2000)	1988	Mexico	12	2,275	6.6	0.10	0.7	4.39	89.7	82.0	1.0	16.0
(Yabao *et al.*, 2005)	2003	Philippines	12	175				3.68	74.9			
(Bonecker and Cleaton-Jones, 2003)	1997	Brazil	11-13		5.3	0.4	0.5	6.3		84.0	6.0	8.0
(Auad *et al.*, 2009)	2009	Brazil	13-14	458	1.12	0.09	3.82	3.95	78.0	28.0	2.0	96.7
(Sudha *et al.*, 2005)	2005	India	11-13	171				1.83	82.5			
(Momeni *et al.*, 2006)	2005	Iran	12	1,102				0.77	36.2	58.7	3.4	37.9
(Kiwanuka *et al.*, 2006)	2004	Uganda	12	614				0.98	40.2	61.7		1.1
(Ahmed *et al.*, 2007)	2003	Iraq	12	384	1.3	0.1	0.3	1.7	62.0	54.8	3.6	15.0
(Adekoya-Sofowora *et al.*, 2006)	2003	Nigeria	12	402				0.14	13.9	77.2	7.0	15.8

Table 7.14: Continued, the prevalence of dental caries and the mean DMFT and its components in present study, previous studies in Libya, some developing and developed countries

Source	Year of study	country	Age	N	DT	MT	FT	DMFT	Prevalence of caries %	Decay Index %	Missing Index %	Care Index %
(Pitts *et al.*, 1998)	96/97	UK	12	129,941	0.48	0.10	0.54	1.13	44.0	42.5	8.8	48.0
(Pitts *et al.*, 2000)	98/99	UK	14	121,550	0.59	0.15	1.02	1.76		33.5	8.5	58.0
(Pitts *et al.*, 2006)	04/05	UK	11	135,075	0.34	0.08	0.30	0.72	32.7	47.0	11.0	42.0
(Campus *et al.*, 2007)	2004	Italy	12	5,342				1.09	43.1			
(Bourgeois *et al.*, 2004)	1993	France	12	1,331	0.6	0.2	1.3	2.1	65.3	29.0	10.0	62.0
(Bourgeois *et al.*, 2004)	1998	France	12	6,000	0.8	0.2	0.9	1.9	60.8	42.0	11.0	47.0
(Bradley and Wendell, 2009)		India	12	442	0.11	0.01	0.02	0.15	10.0	73.0	7.0	13.0
(Nuca *et al.*, 2009)	2007	Romania	12	259	2.94	0.11	0.25	3.31	77.2	89.0	3.3	7.6

6.7.6 Gender differences

The mean DMFT in girls (1.88) was higher than in boys (1.48), and this difference was statistically significant ($p<0.002$). A similar pattern has been reported by other studies, girls having been found to have a higher caries experience than boys (Misra and Shee, 1979; Saimbi *et al.*, 1983; Singh *et al.*, 1985; Kiwanuka *et al.*, 2006; Auad *et al.*, 2009). However, in the UK, a National Survey found the same proportion of boys and girls with experience of caries for 11-14 year-olds (Walker *et al.*, 2000) and no gender difference was found in a study of 12 year-olds in India (Bradley and Wendell, 2009) and in Romania (Nuca *et al.*, 2009). In contrast, boys were found to have a higher DMFT index than girls in a previous study of 12 year-olds in Libya (Al-Sharbati *et al.*, 2000), of 12-13 year-olds in Saudi Arabia (AlDosari *et al.*, 2004) of 11-13 year-olds in India (Sudha *et al.*, 2005) and of 12 year-olds in Tunisia (Abid, 2004), but these gender differences were not statistically significant. In the present study, the prevalence of dental caries experience was slightly lower in boys as compared with girls; an unexpected result as girls generally pay greater attention to hygiene and aesthetics than boys. However, this might be explained by the fact that generally there is a trend towards earlier permanent tooth eruption in girls than boys and they are exposed to risk factors for dental caries for a longer period of time than in boys. But the differences in eruption times are only a few months which clinically may result in little difference.

6.7.7 Comparison the present study with previous studies in Libya

In this study, the mean DMFT and the prevalence of dental caries found was similar to that found in previous Libyan studies which reported a mean DMFT of 1.58 and prevalence of caries of 56.9% for 10-13 year-olds (Baccush and Nayak, 1991) and a mean DMFT of 1.17 but with relatively lower prevalence of caries (50%) in 12 year-olds (Hawew *et al.*, 1996). Moreover, when the present study was compared with a more recent study undertaken in Libyan schoolchildren (Al-Sharbati *et al.*, 2000), the mean DMFT score was 1.63 and the prevalence of dental caries was 50% for 12 year-old children. These three Libyan studies have shown that the mean DMFT for 12 year-old children increased from 0.78 in 1987 in Tobruk (Omar, 1989) to 1.17 in 1994 in Benghazi (Hawew *et al.*, 1996) to 1.63 in 1994 in Benghazi (Al-Sharbati *et al.*, 2000), while the present study showed a mean DMFT of 1.68. The severity of dental caries seen in the present study was greater than that reported by these studies involving a similar age group eighteen, eleven and seven years earlier. This may be an indication of an upward trend in dental caries prevalence in Libya, possibly due to an increased availability of refined sugary products with, poor oral hygiene and less exposure to fluoride due to lack of tooth brushing and toothpaste use (Al-Sharbati *et al.*, 2000; Ali, 2004).

The Decay Index was 95.2% in the present study. Most other dental caries studies in the same age groups in Libya have also reported high figures; 71.8%, 84.8%, 90.6%, 77% (Omar, 1989; Baccush and Nayak, 1991; Hawew *et al.*, 1996; Al-Sharbati *et al.*, 2000), respectively. The D component contributed most to the DMFT index in both boys and girls and increased with time in the same age group (Table 6.14). The Care Index was low in this study (1.8%). It was also low in previous studies within similar age groups in Libya 15%,1.9%, 5%, 1%, respectively (Omar, 1989; Baccush and Nayak, 1991; Hawew *et al.*, 1996; Al-Sharbati *et al.*, 2000). This downward trend in the Care Index might be due to limited access to dental services, despite the growing number of children. The Missing Index in the present study was 3%. In previously published Libyan studies it was

12.8%, 13%, 4%, 21.5%, respectively (Omar, 1989; Baccush and Nayak, 1991; Hawew *et al.*, 1996; Al-Sharbati *et al.*, 2000).

6.7.8 Comparison of the present Libyan study with other developing countries

In several developing countries, children do not benefit from preventive oral health programmes. The prevalence of dental caries in these countries is expected to increase in the future as a result of growing consumption of sugars and limited fluoride exposure (Petersen, 2005). When comparing the mean DMFT found in the present study (1.68), a similar figure (mean DMFT 1.7) was observed for 384 12 year-old schoolchildren from Baghdad, Iraq (Ahmed *et al.*, 2007), while lower DMFTs have been observed for 12 year-olds in Portugal (1.5) (Almeida *et al.*, 2003), Tunisia (1.3) (Abid, 2004), and in Egypt (1.2) (Abid, 2004). An almost similar figure was reported for the mean DMFT in 11-13 year-olds in Mangalore, India (1.83) (Sudha *et al.*, 2005), but, the prevalence of dental caries (82.5) was much higher than that observed in the present study. Also in a similar pattern to the present study, the D component contributed most of the DMFT. On the other hand, contrary to the relatively low mean DMFT in the present study, most developing country studies have shown relatively high mean DMFTs; 2.6, 2.3, 3.2, 3.7, 3.31 in 12 year-old schoolchildren in Kuwait, Syria, Jordan, the Philippines and Romania respectively (Behbehani and Scheutz, 2004; Beiruti and Van Palenstein Helderman, 2004; Taani, 2004; Yabao *et al.*, 2005; Nuca *et al.*, 2009). In the same way, the mean DMFT in the present study was lower than the 2.6 found in 10-12 year-old schoolchildren in Sudan (Ibrahim *et al.*, 1997), the 3.23 in 12 year-old Omani schoolchildren (Al-Ismaily *et al.*, 2004). Moreover, it was also lower than the mean DMFT of 3.95 found in 14 year-old Brazilian schoolchildren (Auad *et al.*, 2009). In fact, the mean DMFT score in the present study was much lower than the DMFT of 5.06 and 4.53 reported by AlDosari *et al.* (2004) in 12-13 year-old schoolchildren in two regions in Saudi Arabia, the 5.2 reported by Khan *et al.* (2007) in 10 year-olds in Saudi Arabia and the 4.74 found in 15-16 year-olds in Jordan (Taani, 1997). The suggested reasons from the authors for these high figures were the caries related risk factors such as oral hygiene and dietary practices. In contrast, the DMFT found in 12 year-old children in the Islamic Republic of Iran (DMFT 0.77) (Momeni *et al.*, 2006), and in Uganda (DMFT 0.98) (Kiwanuka *et al.*, 2006) were lower than that found in the present study. There are downward trends reported in 16 developing countries from 1970 to 2000 in Latin America and the Caribbean (Bonecker and Cleaton-Jones, 2003). In Brazil, the mean DMFT was 9.2 in 1971, and declined to 3.8 in 1988 and to 2.1 in 1996 (Bonecker and Cleaton-Jones, 2003). A similar pattern has been observed in Mexico, where the mean DMFT index dropped in 12 year-olds from 4.4 in 1988 to 2.5 in 1997 (Irigoyen and Sanchez-Hinojosa, 2000) (Table 6.14). In the same way, the mean DMFT declined from 5.0 in 1985 and 4.3 in 1991 to 3.8 in 1996 in the East European country of Hungary (Szoke and Petersen, 2000). Although these figures represent downward trends in mean DMFT, the mean DMFT in the present study was still substantially lower than the mean DMFT reported in these countries.

6.7.9 Comparison of the present study with developed countries

Although the prevalence of dental caries has decreased in developed counties, the disease still affects a significant proportion of people worldwide (Petersen, 2005). The prevalence of dental caries has declined in developed countries and it has been suggested that this may be due to a sensible approach to sugar consumption, improvement in oral hygiene practices and introduction of fluoride-containing dentifrices, along with increased dental awareness and comprehensive preventive programmes (Jamieson *et al.*, 2004). Furthermore, dental health information provided through schools may have improved the oral health behaviour of the children. The mean DMFT in 12 year-olds in France in 1998 was 1.9 (Bourgeois *et al.*, 2004), a figure higher than that in the present study. However, the mean DMFT in France has declined over time; from 4.2 in 1987 to 2.1 in 1993 to 1.9 in 1998 (Bourgeois *et al.*, 2004). In contrast, the DMFT found in Libyan studies has shown an increase from 0.78 in 1989 (Omar, 1989) to 1.17 in 1996 (Hawew *et al.*, 1996) to 1.63 in 2000 (Al-Sharbati *et al.*, 2000) and has continued to increase up to the present study in which a DMFT of 1.68 was found.

Campus *et al.* (2007) reported that the mean DMFT in 12 year-old Italian children was 1.09 which was lower than the value in the present study. Lower figures of mean DMFT have been reported also for 14 year-olds in England (1.51), in East Scotland (1.22) and in London (1.32). But higher figures have been reported in North West Scotland (2.16) and Northern and Yorkshire regions (1.89). Overall, the mean DMFT across the UK was 1.76 (Pitts *et al.*, 2000) slightly higher than that found in the present study. In this study, the prevalence of dental caries was 57.8%, while lower figures for the prevalence of dental caries (51%) have been reported for 13-14 year-olds (O'Brien, 1994) and for 11-14 year-olds (Walker *et al.*, 2000) in National Surveys in the UK, and 12 year-olds in Italy (43.1%) (Campus *et al.*, 2007).

6.7.10 Association between dental caries and erosion

In the present study, the experience and severity of dental caries was not statistically associated with experience of dental erosion, confirming the findings of a previous study (Auad *et al.*, 2009). From the subjects with experience of dental caries, almost 42% also had experience of dental erosion, while the proportion of subjects with dental erosion among those without dental caries was 39.2%. The differences in the DMFT and DMFS indices were also not statistically significant between subjects with and without dental erosion. This is also in agreement with previous studies (Kunzel *et al*., 2000; Truin *et al*., 2005; Auad *et al*., 2009). Other studies however have reported that many types of food and soft drinks are acidic and also high in non-milk extrinsic sugars, so dental erosion and caries might be expected to occur together and have reported a statistically significant association between these variables (Al-Malik *et al*., 2002; Dugmore and Rock, 2004a; Dugmore and Rock, 2004b; Kazoullis *et al*., 2007).

6.8 Conclusions

6.8.1 The first aim of this part of the study was to determine the prevalence and severity of dental caries amongst 12 year-old children in Benghazi, Libya was achieved.

- The prevalence of dental caries was 57.8%, 457 subjects had experience of dental caries, with 334 subjects (42.2 %) caries free.
- The severity of dental caries as expressed by the mean DMFT was 1.68 in 12 year-olds, while the mean DMFS was 2.39.
- Girls had statistically significantly higher prevalence of dental caries (63.5%) than boys (52%) ($p= 0.002$).
- Girls had statistically significantly higher mean DMFT and DMFS (1.88 and 2.71) than boys (1.48 and 2.08), respectively ($p= 0.002$).
- The prevalence of dental caries and DMFT indices were low when compared with the results from other developing countries.

- The mean DMFT for this study met the WHO goal for year 2000; a mean DMFT < 3.0 for 12 year-olds (WHO/FDI, 1982), but it was higher than the WHO goal for year 2020; a mean DMFT ≤ 1.5 for the same age group (Petersen, 2003).
- The Decay Index was 95.2%, Missing Index was 3% and Care Index was 1.8%. The high level of untreated caries is a cause for concern, representing a high rate of unmet treatment need.

6.8.2 The second aim of this part of study was to investigate the association between dental caries and erosion was achieved.

- There is no relationship between dental erosion and dental caries in 12 year-old children in Benghazi, Libya; the experience and severity of dental caries was not statistically associated with the experience of dental erosion. The null hypothesis of this study was accepted.

Chapter 7
Dietary risk factors for dental erosion: a questionnaire survey

7.1 Introduction

Different epidemiological studies have indicated that dietary factors are the most important in the development of dental erosion for children due to the consumption of acidic drinks and foods (Jarvinen, 1991; O'Brien, 1994; Millward *et al.*, 1994a; Larsen and Nyvad, 1999; Shaw and Smith, 1999; Lussi *et al.*, 2000; Walker *et al.*, 2000; O'Sullivan and Curzon, 2000a; May and Waterhouse, 2003; WHO, 2003; Luo *et al.*, 2005; El Karim *et al.*, 2007). Evidence from studies suggests that carbonated drinks play an important role in development of dental erosion in children and adults (Dugmore and Rock, 2004b; Waterhouse *et al.*, 2008). The consumption of acidic drinks by children has increased markedly over the last few decades (Gregory *et al.*, 2000). In addition, there has been increasing concern to adopt a healthy diet (fruits, vegetables and fruit juices) which has lead to increased consumption of acidic foods and drinks (Lussi *et al.*, 1991; Ganss *et al.*, 1999b; Al-Dlaigan *et al.*, 2001c). Moreover, many people are vegetarian which may also result in increasing acid consumption in the diet since vegetarians consume acidic drinks, yogurts, grapes, vinegar and salad dressings more frequently than non-vegetarians (Al-Dlaigan *et al.*, 2001c). However, there are few published data about the association between vegetarianism and dental erosion. A high intake of dietary acids may be an important aetiological factor for dental erosion whether part of a vegetarian or non-vegetarian diet (Al-Dlaigan *et al.*, 2001c). In relation to the intake of acidic drinks, several factors may affect the severity of dental erosion such as the frequency and amount of acidic drinks intake, length of time the drink is retained in the mouth, use of a straw, method of drinking and salivary buffering capacity (Milosevic, 1998; Kunzel *et al.*, 2000; Lussi *et al.*, 2000; Chadwick and Pendry, 2004; Milosevic *et al.*, 2004; Moynihan and Petersen, 2004). In addition, consumption of acidic drinks overnight has been shown to significantly increase the prevalence and severity of dental erosion (Al-Majed *et al.*, 2002; Nunn *et al.*, 2003; Talebi *et al.*, 2009). Prevalence of tooth surface loss is also high in people with a high standard of oral hygiene reported who brush after an erosive challenge (O'Sullivan and Curzon, 2000b). In contrast, amount and frequency of free sugars consumption are the most important aetiological factors in the development of dental caries (Al-Khateeb *et al.*, 1991; Rugg-Gunn and Hackett, 1993; Sheiham, 2001; Moynihan, 2002; WHO, 2003; AlDosari *et al.*, 2004; Moynihan and Petersen, 2004; Sudha *et al.*, 2005; Yabao *et al.*, 2005).

7.2 Aims

The aims of the present study were:

7.2.1 To collect data and explore relationships about dietary patterns, oral hygiene practices, general health, chronic diseases, lifestyle and socio-economic status relating to risk factors for dental erosion in 12 year-old schoolchildren in Benghazi, Libya.

7.2.2 To investigate any association between the experience of dental erosion and its potential risk factors in 12 year-old schoolchildren in Benghazi, Libya.

7.2.3 To investigate any association between the experience of dental caries and its potential risk factors in 12 year-old schoolchildren in Benghazi, Libya.

7.3 Objectives

To ask 12 year-old schoolchildren to complete a questionnaire in order to collect information about:

- Their consumption of acidic dietary items (foods and drinks) in terms of types of drinks, frequency of consumption and associated habits.
- Their consumption of non-acidic dietary items (foods and drinks) in terms of types of drinks and frequency of consumption.
- Their consumption of tap and bottled water.
- Other potential risk factors for dental erosion in their general health (chronic health problem), oral hygiene practices, oral habits, lifestyle and socio-economic status of children's parents.

7.4 Null hypotheses

- There is no relationship between the prevalence and severity of dental erosion and the frequency of consumption of acidic dietary items.
- There is no relationship between the prevalence and severity of dental erosion and exposure to other potential risk factors for dental erosion such as oral hygiene practice, oral habits, lifestyle and socio-economic status of children's parents.

7.5 Materials and methods

7.5.1 Preparation for questionnaire survey in Newcastle

Data were collected about the dietary intake of 792 subjects aged 12 years in Benghazi through a 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) and that used by Auad *et al.* (2009) for a study on dental erosion in Brazil. The questionnaire survey included questions on amount, frequency and timing of consumption of acidic food and drink items, consumption of tap or bottled water, consumption of non-acidic drinks, sugared drinks, bedtime drinks, oral hygiene practices, general health, socio-economic status, and other potential risk factors for dental erosion (Appendix 4.5). The acidic-sugared drinks included sugared carbonated drinks, sports drinks, squashes, fruit-based sugared drinks and natural unsweetened fruit juices (natural unsweetened fruit juices are not sugars free, can contain up to 12% Non-Milk Extrinsic Sugars (NMES)). The acidic sugars-free drinks included sugars-free carbonated drinks, and carbonated water. The non-acidic drinks included milk, flavoured milk, sugared tea with milk and tap or bottled water. Information about the use of carbonated drinks, squashes, and fruit juices consumed at bedtime was also collected. The questionnaire was prepared and designed in the School of Dental Sciences at Newcastle University and then translated into simple Arabic language by the researcher. As the Arabic language was used in the questionnaire, the questions were labelled using English letters and Arabic numbers, which are the same as English numbers, to facilitate data entry. The questionnaire was piloted in the UK in order to test content and face validity and obtain information regarding any difficulties with completion of the questionnaire. Five 11-12 year-old children based in the UK who were Arabic speaking and were not involved in the study were asked to complete the questionnaire and provide comments regarding ease of use which were then used to refine the design of the questionnaire.

7.5.2 Field work in Benghazi, Libya

Once consent for the study had been obtained (Section 4.6.1), the questionnaire was printed and copied according to the sample size. Following written consent from the parents of the study children, the questionnaires were distributed to the randomly selected sample of 792 12 year-old schoolchildren; 22 school children (11 boys and 11 girls) from each one of the 36 randomly selected schools. With regard to the timetable for questionnaire completion, it was planned that three schools would be visited for dental examination and questionnaire completion each week. The questionnaires were distributed to the children in schools before the dental examination to prevent bias following the dental examination. On the day of the survey within each school, the children were grouped into any free place to complete the questionnaires including laboratories, libraries, classrooms and sports rooms. The questionnaires were distributed to the children and the researcher explained the importance of their honest answers and that there were no wrong or right answers. The importance of understanding the meaning of each question before starting to answer them was also highlighted. The researcher asked the children to complete the questionnaire after giving instructions to help them to understand the questions where necessary. The researcher remained available during the completion of the questionnaire and also explained that answers and names would remain confidential. The researcher collected the questionnaires immediately after completion. This method maximized the response rate. After the children returned the questionnaire, the examiner reviewed the questionnaire quickly for any incomplete entries, and asked the children to complete unanswered questions.

7.5.3 Post-field work in Benghazi

Once questionnaires were completed, they were photocopied to provide a backup and then stored in boxes according to the school order and subject numbers. These original documents were then transported from Benghazi to Newcastle upon Tyne, UK by DHL International Ltd after completion of the field work.

7.5.4 Post-field work in the UK

Upon their arrival to the UK, the completed questionnaires were hand delivered to the Data Preparation Services at Newcastle University where they were entered into Excel files. The Excel data set was converted by the researcher into a data file within the Statistical Package for Social Sciences (SPSS) version 14.0 for Windows (SPSS Incorporation). Whenever there was query or space in the questionnaire, the original written document was re-visited by the researcher and any query clarified. This approach was used to try to minimise missing data.

7.5.5 Data-analysis

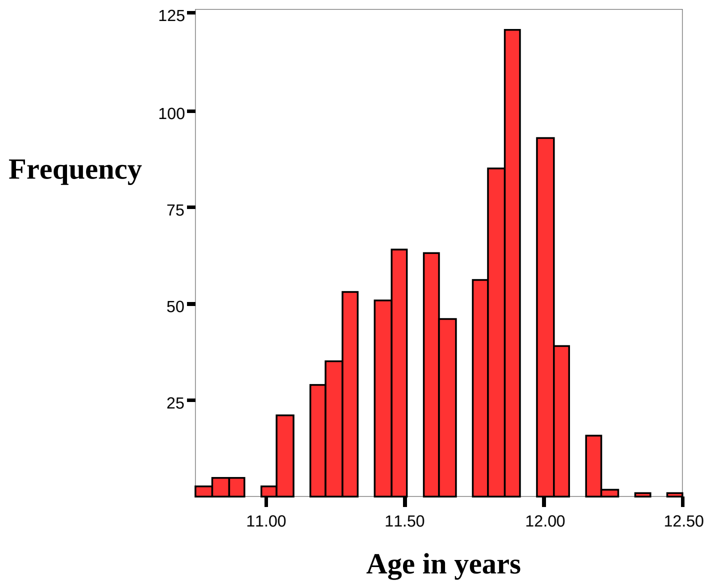
Following descriptive analysis, all questionnaire data were analysed using SPSS with Chi-Square analysis, to determine if there was a statistically significant difference in the responses for different groups. The data were also analysed by gender (Chi-Square analysis). For the 791 individuals with data 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. Non-parametric test was used because data was not normally distributed. The bivariate process was used to investigate the associations between the experience of dental erosion, dental caries and exploratory variables which included, reported intake of acidic foods and drinks, oral habits, oral hygiene practices and parents' education level. In addition, Odds ratio (OR) and 95% Confidence Intervals (CI) were calculated for 2 x 2 tables. Only two-sided statistical tests were used because two-sided statistical test applies in the situation where the direction of the results is unknown. The statistical significance level was set at 5% ($p < 0.05$). Contingency coefficient used to give the strength of association between the two variables, it ranges from 0 to 1. The experience of dental erosion (Yes/No) was the dependent variable, as erosion into enamel only was the most common finding amongst the Libyan children (Chapter 5).

7.6 Results

7.6.1 The response rate and age distribution of the sample

For the 791 children included in the study, the age range was 10.8-12.5 years (mean age, 11.7 years, standard deviation, 0.307). Approximately 30-50 minutes were needed to complete the questionnaire. There were no reported difficulties in understanding or completing the questionnaires. The response rate was 88.3%. Figure 7.1 shows the age distribution of the schoolchildren who participated in the study. The field work took five months from 8th of September 2007 to 31st of January 2008.

Figure 7.1: Age distribution of schoolchildren (Y) who participated in the questionnaire survey.



7.6.2 Types of drinks consumed and frequency of consumption

All drinks consumed by the 12 year-old schoolchildren reported in the questionnaire are described in Table 7.1 and Table 7.2. Sugared carbonated drinks, fruit-based sugared drinks, squashes, sugared tea with milk and milk, were the drinks most commonly consumed once or more a day. Boys reported a higher frequency of consumption of all types of drinks compared with girls (Table 7.1 and Table 7.2).

7.6.2.1 Frequency of consumption of acidic-sugared drinks

Sugared carbonated drinks were most commonly consumed less than once a day with 64.8% reporting this frequency of use, followed by once per day (16.2%), more than once per day (8.7%) and more than twice a day (6.8%).

There were no statistically significant differences in consumption of sugared carbonated drinks between boys and girls (Pearson Chi-Square; p= 0.101). With regard to fruit-based sugared drinks, the most commonly reported frequency of consumption was less than once per day (47.2%), followed by once a day (28.2%) and more than once per day

(11.7%). The difference between gender in consumption of these drinks was not statistically significant (Pearson Chi-Square; p= 0.194). For squashes, the most common frequency of the consumption was less than once per day (53%), followed by once per day (19.4%). There was no statistically significant difference between gender for frequency of consumption of squash (Pearson Chi-Square; p= 0.082).

The majority (89%) of the subjects claimed to never consume sports drinks, but of the children who did consume sport drinks there were statistically significant more boys than girls (Pearson Chi-Square; p= 0.001). The majority (88.1%) of the subjects never consumed natural unsweetened fruit juices. The difference between gender in consumption of these drinks was not statistically significant (Pearson Chi-Square; p= 0.501) (Table 7.1).

7.6.2.2 Frequency of consumption of acidic sugars-free drinks

Non-sugared carbonated drinks and carbonated water were less frequently consumed by the subjects, although boys were more likely to consume these drinks than girls. The majority of the subjects (90.2%) did not consume non-sugared carbonated drinks.

A statistically significant greater number of boys consumed these drinks than girls (Pearson Chi-Square; p= 0.017). Of the subjects 84.1% never consumed carbonated water. The difference between gender was not statistically significant (Pearson Chi-Square; p= 0.086) (Table 7.1).

Table 7.1: Types and frequency of acidic drinks taken by 12 year-old children by gender.

Type of drinks	Gender	>2/day N (%)	2/day N (%)	1/day N (%)	<1/day N (%)	Never N (%)	P (Pearson Chi-Square) M v F[1]
Sugared carbonated drinks	Male	35 (8.8)	38 (9.6)	67 (16.9)	241 (60.9)	15 (3.8)	0.101
	Female	19 (4.8)	31 (7.8)	61 (15.4)	272 (68.7)	13 (3.3)	
	Total	54 (6.8)	69 (8.7)	128 (16.2)	513 (64.8)	28 (3.5)	
Fruit-based sugared drinks	Male	28 (7.1)	42 (10.6)	115 (29.0)	178 (44.9)	33 (8.3)	0.194
	Female	17 (4.3)	51 (12.9)	108 (27.3)	196 (49.5)	24 (6.1)	
	Total	45 (5.7)	93 (11.7)	223 (28.2)	374 (47.2)	57 (7.2)	
Squashes	Male	23 (5.8)	29 (7.3)	76 (19.2)	198 (50.0)	70 (17.7)	0.082
	Female	18 (4.5)	13 (3.3)	78 (19.7)	222 (56.1)	65 (16.4)	
	Total	41 (5.2)	42 (5.3)	154 (19.4)	420 (53.0)	135 (17.0)	
Sports drinks	Male	2 (0.5)	4 (1.0)	8 (2.0)	51 (12.9)	331 (83.6)	0.001**
	Female	1 (0.3)	3 (0.8)	4 (1.0)	14 (3.5)	374 (94.4)	
	Total	3 (0.4)	7 (0.9)	12 (1.5)	65 (8.2)	705 (89.0)	
Natural unsweetened fruit juices	Male	2 (0.5)	5 (1.3)	15 (3.8)	29 (7.3)	345 (87.1)	0.501
	Female	5 (1.3)	5 (1.3)	9 (2.3)	24 (6.1)	353 (89.1)	
	Total	7 (0.9)	10 (1.3)	24 (3.0)	53 (6.7)	698 (88.1)	
Non-sugared carbonated drinks	Male	6 (1.5)	1 (0.3)	8 (2.0)	37 (9.3)	344 (86.9)	0.017*
	Female	5 (1.3)	2 (0.5)	4 (1.0)	15 (3.8)	370 (93.4)	
	Total	11 (1.4)	3 (0.4)	12 (1.5)	52 (6.6)	714 (90.2)	
Carbonated water	Male	3 (0.8)	2 (0.5)	17 (4.3)	53 (13.4)	321 (81.1)	0.086
	Female	0 (0.0)	2 (0.5)	9 (2.3)	40 (10.1)	345 (87.1)	
	Total	3 (0.4)	4 (0.5)	26 (3.3)	93 (11.7)	666 (84.1)	

[1]Male versus female *Statistically significant at p< 0.05 **Statistically significant at p< 0.01

7.6.2.3 Consumption of non-acidic drinks

The most popular non-acidic drinks were sugared tea with milk, milk, and flavoured milk. More than half of the children (52.3%) consumed sugared tea with milk once per day, while 12.4%, 9%, 6.6% consumed this drink less than once per day, more than once per day, more than twice per day, respectively and 19.8% subjects did not consume tea with milk. Boys consumed sugared tea with milk statistically significantly more often than girls (Pearson Chi-Square; p= 0.001). Of the subjects 9.1%, 11.5%, 37.1%, 17.8% consumed milk more than twice per day, more than once per day, once a day, less than once per day, respectively, with boys consuming milk statistically significantly more frequently than girls (Pearson Chi-Square; p= 0.016) (Table 7.2).

Table 7.2: Types and frequency of non-acidic drinks taken by 12 year-old schoolchildren in Benghazi, Libya by gender.

Type of drinks	Gender	>2/day N (%)	2/day N (%)	1/day N (%)	<1/day N (%)	Never N (%)	P (Pearson Chi-Square) M v F[1]
Sugared Tea with milk	Male	34 (8.6)	37 (9.3)	225 (56.8)	47 (11.9)	53 (13.4)	0.001**
	Female	18 (4.5)	34 (8.6)	189 (47.7)	51 (12.9)	104 (26.3)	
	Total	52 (6.6)	71 (9.0)	414 (52.3)	98 (12.4)	157 (19.8)	
Flavoured milk	Male	14 (3.5)	14 (3.5)	42 (10.6)	152 (38.4)	174 (43.9)	0.859
	Female	11 (2.8)	18 (4.5)	42 (10.6)	143 (36.1)	182 (46.0)	
	Total	25 (3.2)	32 (4.0)	84 (10.6)	295 (37.2)	356 (44.9	
Milk	Male	45 (11.4)	48 (12.1)	156 (39.4)	67 (16.9)	80 (20.2)	0.016*
	Female	27 (6.8)	43 (10.9)	138 (34.8)	74 (18.7)	144 (28.8)	
	Total	72 (9.1)	91 (11.5)	294 (37.1)	141 (17.8)	194 (24.5)	

[1]Male versus female *Statistically significant at $p< 0.05$ **Statistically significant at $p< 0.01$

7.6.2.4 Consumption of tap and bottled water

When 12 year-old schoolchildren were asked about the type of drinking water they consumed, as Table 7.3 shows, 55.8% of the subjects consumed both tap and bottled water, 29.7% consumed just tap water, and 14.5% consumed just bottled water, with no gender difference (Pearson Chi-Square; p= 0.927).

Table 7.3: Consumption of tap, bottled and all waters by gender in 12 year-old children.

Gender	Tap water N (%)	Bottled water N (%)	Tap and bottled water N (%)
Male	120 (30.3)	57 (14.4)	219 (55.3)
Female	115 (29.0)	58 (14.6)	223 (56.3)
Total	235 (29.7)	115 (14.5)	442 (55.8)

7.6.2.5 Length of time taken to consume acidic drinks

When asked about the length of time they usually took to drink soft drinks; 30.4% of the subjects reported the habit of having the drink straight away, 61.6% made it last up to 15 minutes, 4.4% made it last between 15 and 30 minutes, and 3.5% made it last longer than 30 minutes. Girls took statistically significantly longer to consume acidic drinks than boys (Pearson Chi-Square; p= 0.001) (Table 7.4).

Table 7.4: Length of time taken to consume acidic drinks by 12 year-old schoolchildren.

	Length of time acidic drinks last in the mouth			
Gender	**Drink it straight away N (%)**	**Up to 15 minutes N (%)**	**Between 15 and 30 minutes N (%)**	**Longer than 30 minutes N (%)**
Male	182 (46.0)	190 (48.0)	14 (3.5)	10 (2.5)
Female	59 (14.9)	298 (75.3)	21 (5.3)	18 (4.5)
Total	241 (30.4)	488 (61.6)	35 (4.4)	28 (3.5)

7.6.2.6 Habits associated with drink consumption

Two hundred (25.3%) out of 792 subjects consumed acidic drinks such as carbonated drinks, squashes, and fruit juices at bedtime, with 27.3% of boys consuming acidic drinks at bedtime compared with 23.2% of girls while 74.7% of the subjects reported they did not consume these drinks at bedtime (Table 7.5). However, the difference between the boys and girls was not statistically significant (p= 0.220).

Table 7.5: Consumption of acidic drinks (carbonated drinks, squash, fruit juices) at bedtime in 12 year-old Libyan children by gender.

	Drinking of carbonated drinks, squashes, fruit juices at bedtime	
Gender	**Yes N (%)**	**No N (%)**
Male	108 (27.3)	288 (72.7)
Female	92 (23.2)	304 (76.8)
Total	200 (25.3)	592 (74.7)

7.6.3 Dietary patterns and habits associated with dental erosion

7.6.3.1 Frequency of consumption of acidic foods

When subjects were asked how often they ate fresh fruits other than bananas each day, 25%, 20%, 55% of the subjects claimed consumption of fruits, more than one per day, once per day, less than one per day, respectively, with statistically significantly more boys than girls consuming fruit (Pearson Chi-Square; p= 0.016) (Table 7.6).

7.6.3.2 Consumption of sugared and sugar-free gum

The habit of chewing gum once or more than once a day was reported by 93.7% of the subjects; the majority (89.9%) chewed sugared gum, only 3.8% chewed sugar free gum. While there was no significant gender difference in having the habit of chewing gum (Pearson Chi-Square; p= 0.086), girls chewed gum significantly more frequently than boys (Pearson Chi-Square; p= 0.022) (Table 7.6).

Table 7.6: Frequency of consumption of fruits other than bananas, chewing gum and oral hygiene practice by gender in 12 year-old schoolchildren.

	Male N (%)	Female N (%)	Total N (%)	P (Pearson Chi-Square) M v F[1]
Frequency of fruit consumption				0.016*
>4/day	19 (4.8)	12 (3.0)	31 (3.9)	
>2-4/day	32 (8.1)	13 (3.3)	45 (5.7)	
2/day	63 (15.9)	55 (13.9)	118 (14.9)	
1/day	78 (19.7)	83 (21.0)	161 (20.3)	
<1/day	204 (51.5)	233 (58.8)	437 (55.2)	
Frequency of chewing gum				0.022*
>1/day	93 (23.5)	120 (30.3)	213 (26.9)	
1/day	271 (68.4)	258 (65.2)	529 (66.8)	
Never	32 (8.1)	18 (4.5)	50 (6.3)	
Frequency of tooth brushing				0.280
>2/day	46 (11.6)	62 (15.7)	108 (13.6)	
2/day	156 (39.4)	160 (40.4)	316 (39.9)	
1/day	79 (19.9)	76 (19.2)	155 (19.6)	
<1/day	115 (29.0)	98 (24.7)	213 (26.9)	

[1]Male versus female *Statistically significant at p<0.05

7.6.4 Medication and health-related questions

When subjects were asked if they took vitamin C supplements, 722 (91.2%) of the subjects reported non-use. Only 8.8% (70) of subjects took vitamin C; 6.6% (52) as liquid, 2.0% (16) as a tablet swallowed whole and 0.3% (2) as a chewable tablet. Significantly more boys (13.4%) than girls (4.3%) took vitamin C (Fisher's Exact Test; p= 0.001). The prevalence of reported chronic health problems such asthma, diabetes, acid taste in the mouth, heart burn, regular stomach upsets was 4.7% (37), 0.6% (5), 8.2% (65), 21.3% (169), 13% (103), respectively. The most common chronic health problems reported by children were heart burn (21.3%) and regular stomach upsets (13.0%). The difference in gender was not statistically significant except for regular stomach upsets; girls (16.2%) suffered more of these than boys (9.8%) (Fisher's Exact Test; p= 0.011).

7.6.5 Oral habits and attitude-related questions

The most commonly reported frequency of tooth brushing was twice a day (39.9%), followed by less than once a day (26.9%), once a day (19.6%) and more than two times a day (13.6%). There was no significant gender difference (Pearson Chi-Square; p= 0.280) (Table 7.6). When subjects asked if they had the habit of brushing their teeth after consuming any of the following: carbonated drinks, squashes, fruit juices, the majority (83.7%) did not brush their teeth after consumption of these drinks. The gender difference was not statistically significant (Fisher's Exact Test; p= 0.248). The majority of subjects (57.4%) claimed they knew the brand of the toothpaste they were using at the time of questionnaire survey, while 95.6% of the children reported that they never used a fluoride mouthwash, or fluoride tablets, and 490 (61.9%) had previously attended a dentist.

7.6.6 Habit of clenching or grinding the teeth

Only 13.5% (107) of the subjects reported the habit of clenching or grinding their teeth, while 69.2% (548) did not and 17.3% (137) did not know if they had the habit. However, there was no statistically significant difference between genders (Pearson Chi-Square; p= 0.353).

7.6.7 Socio-economic status of children's parents

As Table 7.7 shows, for 51.4 % of children, their fathers had received higher education, in 40.0 % their education was up to secondary school level, and in 8.5% it was up to elementary school level. In 36.2%, 47.1% and 16.6 % of the subjects, the mother's education was at higher, secondary and elementary level respectively.

Table 7.7: Fathers' and mothers' education level.

Parents' educational level		Subjects	Fathers N	Fathers %	Mothers N	Mothers %
Higher	Postgraduate degrees/college	Male	200	50.5	150	37.9
		Female	207	52.3	137	34.6
		Total	407	51.4	287	36.2
Up to Secondary	Intermediate school/Secondary school	Male	159	40.1	186	47.0
		Female	158	39.9	187	47.2
		Total	317	40.0	373	47.1
Up to Elementary	Illiterate/Elementary school	Male	37	9.4	60	15.2
		Female	31	7.8	72	18.2
		Total	68	8.5	132	16.6

7.6.8 Associations between consumption of acidic drinks

There was a statistically significantly association ($p = 0.001$) with weak strength of association between consumption of fruit-based sugared drinks and sugared carbonated drinks, squash, sugared tea with milk, milk and fruits (Table 7.8).

7.6.9 Clinically measured dental erosion and questionnaire

Table 7.9 lists the acidic drinks categories as acidic sugared (including sugared carbonated, fruit-based sugared drinks, squash, sports drinks and natural unsweetened fruit juices) and acidic non-sugared (including non-sugared carbonated drinks and carbonated water). Table 7.10 categorises the non-acidic drinks (sugared tea with milk, flavoured milk and milk). Intakes of acidic and non-acidic drinks were divided into "higher" (once per day and two or more times per day), "lower" (less than once per day) and "never" frequencies of consumption. Table 7.11 shows acidic food (including fresh fruits) intake dichotomized into "higher" (daily intake of ≥ one portion per day) and "lower" (< one portion per day) frequency of consumption.

Table 7.8: Relationship between frequency of consumption of fruit-based drinks and carbonated drinks, squash, tea with milk, milk and fruits (*Pearson Chi-Square; p<0.01).

	Fruit-based sugared drinks						
Frequency	**>2/day N (%)**	**2/day N (%)**	**1/day N (%)**	**<1/day N (%)**	**Never N (%)**	**Total N**	**P***
Sugared carbonated drinks							0.001*
>2/day	13 (28.9)	13 (14.0)	19 (8.50)	6 (1.60)	3 (5.30)	54	
>1/day	6 (13.3)	13 (14.0)	23 (10.3)	23 (6.10)	4 (7.00)	69	
1/day	11 (24.4)	13 (14.0)	49 (22.0)	47 (12.6)	8 (14.0)	128	
<1/day	13 (28.9)	51 (54.8)	121 (54.3)	291 (77.8)	37 (64.9)	513	
Never	2 (4.40)	3 (3.20)	11 (4.90)	7 (1.90)	5 (8.80)	28	
Total	45 (100)	93 (100)	223 (100)	374 (100)	57 (100)	792	
Squash							0.001*
>2/day	13 (28.9)	8 (8.60)	12 (5.40)	7 (1.90)	1 (1.80)	41	
>1/day	4 (8.90)	15 (16.1)	8 (3.60)	14 (3.70)	1 (1.80)	42	
1/day	8 (17.8)	21 (22.6)	62 (27.8)	47 (12.6)	16 (28.1)	154	
<1/day	16 (35.6)	34 (36.6)	97 (43.5)	247 (66.0)	26 (45.6)	420	
Never	4 (8.90)	15 (16.1)	44 (19.7)	59 (15.8)	13 (22.8)	135	
Total	45 (100)	93 (100)	223 (100)	374 (100)	57 (100)	792	
Sugared tea with milk							0.001*
>2/day	9 (20.0)	14 (15.1)	15 (6.70)	13 (3.50)	1 (1.80)	52	
>1/day	4 (8.90)	8 (8.60)	20 (9.00)	33 (8.80)	6 (10.5)	71	
1/day	14 (31.1)	47 (50.5)	112 (50.2)	208 (55.6)	33 (57.9)	414	
<1/day	4 (8.90)	8 (8.60)	31 (13.9)	48 (12.8)	7 (12.3)	98	
Never	14 (31.1)	16 (17.2)	45 (20.2)	72 (19.3)	10 (17.5)	157	
Total	45 (100)	93 (100)	223 (100)	374 (100)	57 (100)	792	
Milk							0.001*
>2/day	13 (28.9)	13 (14.0)	23 (10.3)	18 (4.80)	5 (8.80)	72	
>1/day	7 (15.6)	18 (19.4)	32 (14.3)	30 (8.00)	4 (7.00)	91	
1/day	11 (24.4)	31 (33.3)	85 (38.1)	135 (36.1)	32 (56.1)	294	
<1/day	5 (11.1)	10 (10.8)	41 (18.4)	81 (21.7)	4 (7.00)	141	
Never	9 (20.0)	21 (22.6)	42 (18.8)	110 (29.4)	12 (21.1)	194	
Total	45 (100)	93 (100)	223 (100)	374 (100)	57 (100)	792	
Fruits							0.001*
>4/day	10 (22.2)	8 (8.60)	7 (3.10)	6 (1.60)	0 (00.0)	31	
2-4/day	8 (17.8)	8 (8.60)	15 (6.70)	9 (2.40)	5 (8.80)	45	
>1/day	7 (15.6)	22 (23.7)	40 (17.9)	36 (9.60)	13 (22.8)	118	
1/day	5 (11.1)	22 (23.7)	70 (31.4)	55 (14.7)	9 (15.8)	161	
<1/day	15 (33.3)	33 (35.5)	91 (40.8)	268 (71.7)	30 (52.6)	437	
Total	45 (100)	93 (100)	223 (100)	374 (100)	57 (100)	792	

7.6.9.1 Dental erosion and its association with acidic drinks

Fruit-based sugared drinks, sugared carbonated drinks and squashes were the most common drinks consumed by the children. Statistically significant negative associations were observed between the experience of erosion and the frequency of consumption of sport drinks and carbonated water while a statistically significant positive association was observed between the experience of erosion and the frequency of consumption of fruit-based sugared drinks.

Of 323 subjects who had experience of dental erosion; 39.6% consumed fruit-based sugared drinks with frequency less than once per day, 52.3% consumed the drink with a frequency of one or more than once per day and 8.1% reported they never consume fruit-based drinks. This was a statistically significant positive association ($p = 0.006$, Odds Ratio1.498, 95% CI 1.124, 1.996) although the strength of the association was weak (contingency coefficient = 0.098). Of 323 subjects who had experience of dental erosion; 6.2% reported consumption of sports drinks less than once a day, four subjects (1.2%) reported consumption with frequency one or more a day and 92.6% reported never consume sport drinks, this association was statistically significant negative ($p < 0.01$) and weak (contingency coefficient = 0.101). Of 323 subjects who had experience of dental erosion; 12.7% reported consumption of carbonated water with frequency less than once per day, five subjects (1.5%) reported the frequency once or more than once a day, this association was statistically significant negative ($p < 0.05$) and weak (contingency coefficient = 0.110). When the association between the experience of erosion (Yes/No) and frequency of consumption of acidic drinks was assessed, no statistically significant associations were observed for sugared carbonated drinks, sugars-free carbonated drinks, squashes and natural unsweetened fruit juices (Table 7.9).

Table 7.9: Relationships between the number (N) and (%) of subjects with (n = 323, 40.8%) and without experience of erosion (n = 468, 59.2%), and the frequency of consumption of acidic drinks, categorised by the type of acidic drinks consumed.

Acidic drinks	Experience of erosion n =791			P[1]	Contingency Coefficient	+/-[2]
	Yes N (%)	No N (%)	Total N			
Sugared carbonated				0.993		
drinks	11 (3.40)	17 (3.60)	28			
Never	210 (65.0)	302 (64.5)	512			
<1/day	102 (31.6)	149 (31.8)	251			
≥1/day	323 (100)	468 (100)	791			
Total				0.006**	0.098	+ve
Fruit-based sugared	26 (8.10)	31 (6.60)	57			
drinks	128 (39.6)	232 (49.6)	360			
Never	169 (52.3)	205 (43.8)	374			
<1/day	323 (100)	468 (100)	791			
≥1/day				0.979		
Total	47 (14.6)	88 (18.8)	135			
Squashes	188 (58.2)	232 (49.6)	420			
Never	88 (27.2)	148 (31.6)	236			
<1/day	323 (100)	468 (100)	791			
≥1/day				0.004**	0.101	-ve
Total	299 (92.6)	405 (86.5)	704			
Sports drinks	20 (6.20)	45 (9.60)	65			
Never	4 (1.20)	18 (3.80)	22			
<1/day	323 (100)	468 (100)	791			
≥1/day				0.203		
Total						
Non-sugared carbonated	296 (91.6)	417 (89.1)	713			
drinks	19 (5.90)	33 (7.10)	52			
Never	8 (2.50)	18 (3.80)	26			
<1/day	323 (100)	468 (100)	791			
≥1/day				0.572		
Total						
Natural unsweetened fruit	282 (87.3)	415 (88.7)	697			
juices	23 (7.10)	30 (6.40)	53			
Never	18 (5.60)	23 (4.90)	41			
<1/day	323 (100)	468 (100)	791			
≥1/day				0.048*	0.110	-ve
Total	277 (85.8)	389 (83.1)	666			
Carbonated water	41 (12.7)	51 (10.9)	92			
Never	5 (1.50)	28 (6.00)	33			
<1/day	323 (100)	468 (100)	791			
≥1/day						
Total						

*Statistically significant at p< 0.05 **Statistically significant at p< 0.01
[1]p= Linear Association exact test [2]Direction of association

7.6.9.2 Dental erosion and its association with non-acidic drinks

The consumption of non-acidic drinks was statistically significantly negatively associated with experience of dental erosion. A statistically significant association was observed between the consumption of sugared tea with milk and flavoured milk and experience of erosion ($p < 0.05$). The proportion of subjects who had no evidence of erosion increased from 11.1% to 70.7% when the frequency of sugared tea with milk consumption increased from less than once per day to one or more per day. This was a statistically significant negative association ($p < 0.05$). The proportion of subjects with experience of erosion was 13.9% when the consumption frequency of flavoured milk was once or more than once a day and increased to 38.4% when the consumption frequency was less than once a day and to 47.7% with no consumption of flavoured milk. This was a statistically significant negative association ($p < 0.05$) (Table 7.10).

Table 7.10: Relationships between the number (N) and proportion (%) of subjects with (323, 40.8%) and without experience (468, 59.2%) of erosion, and the frequency of consumption of non-acidic drinks, categorised by non-acidic drinks consumed.

Non-acidic drinks	Experience of erosion (n =791)		Total	P[1]	Contingency Coefficient	+/-[2]
	Yes N (%)	No N (%)	N			
Sugared tea with milk				0.032*	0.076	-ve
Never	72 (22.3)	85 (18.2)	157			
<1/day	46 (14.2)	52 (11.1)	98			
≥1/day	205 (63.5)	331 (70.7)	536			
Total	323 (100)	468 (100)	791			
Flavoured milk				0.043*	0.082	-ve
Never	154 (47.7)	202 (43.2)	356			
<1/day	124 (38.4)	171 (36.5)	295			
≥1/day	45 (13.9)	95 (20.3)	140			
Total	232 (100)	468 (100)	791			
Milk				0.266		
Never	81 (25.1)	113 (24.2)	194			
<1/day	67 (20.7)	74 (15.8)	141			
≥1/day	175 (54.2)	281 (60.0)	456			
Total	323 (100)	468 (100)	791			

*Statistically significant at $p < 0.05$ [1]p= Linear Association exact test [2]Direction of association

7.6.9.3 Dental erosion and its association with tap and bottled water consumption

Of the total sample of 791 subjects, 235 reported tap water consumption, of those 138 subjects (29.5%) had no evidence of dental erosion and 97 subjects (30%) had dental erosion. Of 115 subjects with a reported consumption of bottled water; 58 (12.4%) had no evidence of clinical dental erosion and 57 (17.6%) had erosion. Of the 441 subjects who reported the consumption of both waters; 272 (58.1%) had no evidence of erosion, 169 (52.3%) had dental erosion. However, the association was not statistically significant (p= 0.091) (Appendix 7.1).

7.6.9.4 Dental erosion and its association with fruit consumption

Of 323 subjects who had experience of dental erosion; 98.5% consumed fruit (excluding bananas and fruit juices) less than once per day and 1.5% consumed fruit once or more per day. This association was statistically significant (p= 0.002), but weak (contingency coefficient = 0.108) (Table 7.11).

7.6.9.5 Dental erosion and its association with chewing sugared-gum

Of 323 subjects who had experience of dental erosion; 26.9% chewed gum with a frequency of more than once a day and 69.7% chewed gum once per day (p= 0.169) (Table 7.11).

Table 7.11: Relationships between the number (N) and proportion (%) of subjects with and without experience of dental erosion and the frequency of consuming fruits (other than bananas), chewing gum and tooth brushing.

Frequency	Experience of erosion Yes N (%)	Experience of erosion No N (%)	Total N	P[1]	Contingency Coefficient	+/-[2]
consumption of fruit				0.002*	0.108	-ve
≥1/day	5 (1.50)	28 (6.00)	33			
<1/day	318 (98.5)	440 (94.0)	758			
Total	323 (100)	468 (100)	791			
chewing gum				0.169		
>1/day	87 (26.9)	125 (26.7)	212			
1/day	225 (69.7)	313 (66.9)	538			
Never	11 (3.40)	30 (6.40)	41			
Total	323 (100)	468 (100)	791			
tooth brushing				0.720		
≥2/day	177 (54.8)	246 (52.6)	423			
1/day	59 (18.3)	96 (20.5)	155			
<1/day	87 (26.9)	126 (26.9)	213			
Total	323 (100)	468 (100)	791			

*Statistically significant at p< 0.01 [1]p= Linear Association exact test [2]Direction of association

7.6.9.6 Dental erosion and its association with length of time taken to consume acidic drinks

Dental erosion was statistically significantly positively associated with the length of time taken to consume acidic drinks. Of subjects who had evidence of erosion; 24.8% had the habit of drinking drinks straightaway compared with 75.2% who made drinks last up to 15 minutes or more than 15 minutes. The experience of erosion was higher amongst subjects who made the drink last up to 15 minutes or more. This association was statistically significant (p= 0.005, OR 1.593, 95% CI 1.161, 2.186) (Table 7.12).

Table 7.12: Relationship between the number (N) and proportion (%) of subjects with and without experience of dental erosion and length of time taken to consume drinks.

Length of time taken to consume drinks	Experience of erosion Yes N (%)	Experience of erosion No N (%)	Total N	P (Fisher's exact test)	OR (Odds Ratio)	95% CI (Confidence Interval) Lower Upper
Drink it straight away	80 (24.8)	161 (34.4)	241	0.005*	1.593	1.161, 2.186
≥ 15 minutes	243 (75.2)	307 (65.6)	550			
Total	323 (100)	468 (100)	791			

*Statistically significant at p< 0.01

7.6.9.7 Dental erosion and its association with bedtime acidic-drinks consumption

When the habit of consumption of acidic drinks at bedtime was associated with the experience of dental erosion, unexpected results were observed. Of subjects who had experience of dental erosion, 26.3% reported the habit of consuming acidic drinks at bedtime compared with 73.7% who did not. But the observed association was not statistically significant (Fisher's exact test; p= 0.618, OR= 0.912, 95% CI 0.659, 1.262) (Table 7.13).

7.6.9.8 Dental erosion and its association with tooth brushing after consuming acidic drinks

The majority of subjects (83.7%) did not brush their teeth after consuming acidic drinks. There was no association between this habit and dental erosion (Fisher's exact test; p= 0.283, OR= 1.247, 95% CI 0.844, 1.843) (Table 7.13).

Table 7.13: Significance of associations (P, OR and 95% CI) between the number (N) and proportion (%) of subjects with and without experience of dental erosion and consumption of bedtime acidic drinks and tooth brushing after consumption of acidic drinks.

	Experience of erosion			P (Fisher's exact test)	OR (Odds Ratio)	95% CI (Confidence Interval)
	Yes	No	Total			Lower Upper
	N (%)	N (%)	N			
Consumption of bedtime acidic drinks				0.618	0.912	0.659, 1.262
Yes	85 (26.3)	115 (24.6)	200			
No	238 (73.7)	353 (75.4)	591			
Total	323 (100)	468 (100)	791			
Tooth brushing after consumption of acidic drinks				0.283	1.247	0.844, 1.843
Yes	47 (14.6)	82 (17.5)	129			
No	276 (85.4)	386 (82.5)	662			
Total	323 (100)	468 (100)	791			

7.6.9.9 Dental erosion and its association with oral hygiene practices

The associations between the experience of dental erosion and number of times subjects brushed their teeth were not statistically significant (p= 0.720) (Table 7.11).

7.6.9.10 Dental erosion and its association with parents' education

Dental erosion was more prevalent among subjects whose mothers were educated up to secondary school or had a university degree or beyond than in subjects whose mothers who were illiterate. A similar trend was observed for the educational level of fathers, with the highest proportion of subjects with erosion observed amongst those fathers with a university degree or beyond. None of these differences however, were statistically significant (Table 7.14).

Table 7.14: Relationship between the number (N) and proportion (%) of subjects with and without erosion experience and parents' education level.

Parents' education	Total number of subjects	experience of erosion		P (Linear Association exact test)
		Yes N (%)	No N (%)	
Level of mother's education				0.130
Illiterate	51	17 (5.30)	34 (7.30)	
Up to secondary school[1]	454	181 (56.0)	273 (58.3)	
Higher[2]	286	125 (38.7)	161 (34.4)	
Total	791	323 (100)	468 (100)	
Level of father's education				0.443
Illiterate	17	7 (2.20)	10 (2.10)	
Up to secondary school[1]	367	144 (44.6)	223 (47.6)	
Higher[2]	407	172 (53.3)	235 (50.2)	
Total	791	323 (100)	468 (100)	

[1]Elementary school and intermediate school [2]College/postgraduate

7.6.10 Dental caries

7.6.10.1 Dental caries and its association with frequency of sugared-acidic drinks consumption

When the association between experience of dental caries and frequency consumption of fruit-based sugared drinks was tested, the proportion of subjects who had evidence of dental caries increased with increasing the frequency of fruit-based sugared drinks consumption. This was statistically significant positive but weak association ($p < 0.01$) (contingency coefficient = 0.107).

There were no statistically significant associations between experience of dental caries and frequency of consumption of acidic drinks such as sugared carbonated drinks, squash, sports drinks, sugar-free carbonated drinks, and natural unsweetened fruit juices (Table 7.15).

7.6.10.2 Dental caries and its association with frequency of non-acidic drinks consumption

There was no statistically significant association between the proportion of subjects who had evidence of dental caries and frequency of consumption of sugared tea with milk, flavoured milk and milk (Table 7.15).

7.6.10.3 Dental caries and its association with the consumption of water

There was no statistically significant difference in the proportion of subjects who drank tap, bottled or both waters with or without dental caries ($p= 0.146$) (Appendix 7.2).

7.6.10.4 Dental caries and its association with the habit of having bedtime sugared-acidic drinks

Of the 457 subjects who had experience of dental caries; 24.9% reported the habit of consumption of acidic drinks at bedtime compared with 75.1% did not. However, the observed difference was not statistically significant (Fisher's exact test; p= 0.804, OR= 1.043, 95% CI 0.755, 1.443) (Appendix 7.3).

7.6.10.5 Dental caries and its association with oral hygiene practices

There was no statistically significant association between the experience of dental caries and frequency of tooth brushing (p= 0.251) (Appendix 7.4).

7.6.10.6 Dental caries and its association with parents' education

The highest proportion of subjects without caries experience observed amongst those mothers who were educated up to secondary school or beyond than in subjects whose mothers were illiterate, although this difference was not statistically significant (p= 0.924).

Regarding fathers' educational level, the highest proportion of subjects without caries experience observed amongst those fathers who were educated up to secondary school (41.6%) or beyond (56.6%) than in subjects whose fathers were illiterate (1.8%) and this was statistically significant negative association (p= 0.015). Overall, the experience of caries decreased with increasing affluence and higher parents' education levels (Table 7.16).

Table 7.15: Relationships between the number (N) and proportion (%) of subjects with (n= 457, 57.8%) and without experience of dental caries (n= 334, 42.2%), and the frequency of consumption of drinks, categorised by the type of drinks consumed.

Type of drinks	Experience of caries (n = 791)		Total N	P (Linear Association exact test)
	Yes N (%)	No N (%)		
Sugared carbonated drinks				0.347
Never	17 (3.70)	11 (3.30)	28	
<1/day	301 (65.9)	211 (63.2)	512	
≥1/day	139 (30.4)	112 (33.5)	251	
Total	457 (100)	334 (100)	791	
Fruit-based sugared drinks				0.002*
Never	30 (6.60)	27 (8.10)	57	
<1/day	198 (43.3)	176 (52.7)	374	
≥1/day	229 (50.1)	131 (39.2)	360	
Total	457 (100)	334 (100)	791	
Squashes				0.801
Never	74 (16.2)	61 (18.3)	135	
<1/day	253 (55.4)	167 (50.0)	420	
≥1/day	130 (28.4)	106 (31.7)	236	
Total	457 (100)	334 (100)	791	
Sports drinks				0.050
Never	418 (91.5)	286 (85.6)	704	
<1/day	30 (6.60)	35 (10.5)	65	
≥1/day	9 (2.00)	13 (3.90)	22	
Total	457 (100)	334 (100)	791	
Non-sugared carbonated drinks				0.050
Never	422 (92.3)	291 (87.1)	713	
<1/day	22 (4.8)	30 (9.00)	52	
≥1/day	13 (2.80)	13 (3.90)	26	
Total	457 (100)	334 (100)	791	
Natural unsweetened fruit juices				0.384
Never	408 (89.3)	289 (86.5)	697	
<1/day	26 (5.70)	27 (8.10)	53	
≥1/day	23 (5.00)	18 (5.40)	41	
Total	457 (1000	334 (100)	791	
Sugared tea with milk				0.422
Never	98 (21.4)	59 (17.17)	157	
<1/day	51 (11.2)	47 (14.1)	98	
≥1/day	308 (67.4)	228 (68.3)	536	
Total	457 (100)	334 (100)	791	
Flavoured milk				0.862
Never	206 (45.1)	150 (44.9)	356	
<1/day	168 (36.8)	127 (38.0)	295	
≥1/day	83 (18.2)	57 (17.1)	140	
Total	457 (100)	334 (100)	791	
Milk				0.709
Never	114 (24.9)	80 (24.0)	194	
<1/day	82 (17.9)	59 (17.7)	141	
≥1/day	261 (57.2)	195 (58.4)	456	
Total	457 (100)	334 (100)	791	

*Statistically significant at p< 0.01

Table 7.16: Relationship between the number (N) and proportion (%) of subjects with and without caries experience and parents' education level (p= Linear Association exact test).

Parents' education	Total number of subjects	experience of caries		P	Contingency coefficient	Direction of association +/-
		Yes N (%)	No N (%)			
Level of mother's education				0.924		
Illiterate	51	31 (6.80)	20 (6.00)			
Up to secondary school[1]	454	260 (56.9)	194 (58.1)			
Higher[2]	286	166 (36.3)	120 (35.9)			
Total	791	457 (100)	334 (100)			
Level of father's education				0.015*	0.088	-ve
Illiterate	17	11 (2.40)	6 (1.80)			
Up to secondary school[1]	367	228 (49.9)	139 (41.6)			
Higher[2]	407	218 (47.7)	189 (56.6)			
Total	791	457 (100)	334 (100)			

*Statistically significant at $p< 0.05$ [1]Elementary school and intermediate school [2]College/postgraduate

7.7 Discussion

7.7.1 Design and completion of the questionnaire

The questionnaire was based on the questionnaire used in the oral health component of the UK National Diet and Nutrition Survey (NDNS) (Walker *et al.*, 2000), designed to be applicable to 12-year-old schoolchildren. The questionnaire and the answering process were simple, easy, and understandable to 12 year-old schoolchildren and there were no reported difficulties in completing it. The questionnaire was not long; it consisted of 27 questions asking the subject to write a number in a box to the right of the sheet (Appendix 5.5). It was piloted in the UK to test content and face validity and to obtain any comments regarding the questionnaire. Arabic speaking children not involved in the study were asked to complete the questionnaire. During schools visits, copies of questionnaires were prepared and distributed for completion and collection on the same day. Instructions were given to the subjects by the researcher to help them to understand the questions where required. The researcher explained also the importance of honest answers and that answers and names would remain confidential. It took approximately 30-50 minutes for a child to complete the questionnaire.

7.7.2 Acidic drinks consumption

The most popular drinks consumed were fruit-based sugared drinks, then sugared carbonated drinks and thirdly squash. Of the subjects, 96.5% consumed sugared carbonated drinks. This figure is similar to the 97% reported in a Brazilian schoolchildren study (Waterhouse *et al.*, 2008) but higher than in UK studies (Walker *et al.*, 2000; Al-Dlaigan *et al.*, 2001b; Dugmore and Rock, 2004b). The proportions of subjects reporting consumption of carbonated drinks and fruit-based sugared drinks with a frequency of once per day in the present study were 16.2% and 28.2% respectively. These figures are higher than figures for 11-14 year-old children in the UK at 13% and 15%, respectively (Walker *et al.*, 2000). However, in the present study, sugared carbonated drinks were consumed more than once a day by only 8.7% of the total sample while a higher proportion (17%) was reported by Waterhouse *et al.* (2008). In general, in the present study, 28.3% of the subjects consumed soft drinks more than once a day, this figure is higher than the 21% reported for 12 year-olds in Iraq (Ahmed *et al.*, 2007). The reason for high drinks consumption could be the high day-time temperature especially in summer and also the availability of these drinks at a relatively low cost. Conversely, in the present study the majority never consumed non-sugared carbonated drinks, sports drinks, natural unsweetened fruit drinks, and carbonated water (90.2%, 89%, 88% and 84%) respectively. In the present study, sport drinks were consumed by only 11% of the subjects, while a higher figure (44%) has been reported by Al-Dlaigan *et al.* (2001b) for 14 year-old British children. In addition, in the present study, boys consumed more acidic drinks than girls and the same pattern of gender difference was reported in UK studies (Al-Dlaigan *et al.*, 2001b; Milosevic *et al.*, 2004). In the present study, 200 (25.3%) out of 792 subjects consumed acidic drinks such as carbonated drinks, squashes, and fruit juices at bedtime; a figure similar to the proportion of 12-14 year-old Saudi Arabian schoolchildren consuming carbonated drinks at night (27%) (Al-Majed *et al.*, 2002), but much higher than the 4.8% of 12-14 year-old Brazilian schoolchildren consuming acidic drinks at bedtime (Waterhouse *et al.*, 2008). When asked about the length of time they took to drink a soft drink, the majority (61.6%) claimed they made the drinks last up to 15 minutes; higher than the 26.3% reported for 12-14 Brazilian children (Auad, 2006). In the present study 30.4% reported they consumed the drinks straight away; lower than the 64% and 67% reported for 11-14 year-olds in the UK and for 12-14 year-old Brazilian children, respectively (Walker *et al.*, 2000; Auad, 2006). Boys consumed their drinks straight away more frequently than girls (P= 0.001) and this followed a similar pattern reported for 12 year-old Iraqi schoolchildren (Ahmed *et al.*, 2007), while in the present study girls made their drinks last up to 15 minutes more frequently than boys (p= 0.001).

7.7.3 Consumption of non-acidic drinks

The most popular non acidic drinks consumed were sugared tea with milk, milk, and flavoured milk consumed by 80.3%, 75.5% and 55% of subjects respectively. In contrast, in a UK study, milk was consumed by 71 % of 418 14 year-old children (Al-Dlaigan *et al.*, 2001b). These dietary related factors are in accordance with findings of other studies (Johansson *et al.*, 1996; Al-Majed *et al.*, 2002; Ahmed *et al.*, 2007). Consumption of sugared tea with milk once or more than once per day was more frequent in boys than in girls, similar to findings reported by Ahmed *et al.* (2007).

7.7.4 Acidic food consumption

In this study, fruits other than bananas were consumed by only 6% of the Libyan subjects with a frequency of two to four portions per day, the majority of subjects consuming one or less than one portion per day. This is below the current dietary guidelines which recommend at least five portions of fruits and vegetables per day (WHO, 2003), although the present study did not measure the frequency of vegetable consumption. These fruits were consumed by 14.9% of the subjects with a frequency of once per day, higher than 5% and 3% of 11-14 year-olds consuming apples and citrus fruits with same frequency in the UK (Walker *et al.*, 2000), and higher than the 10% reported for 14 year-olds in the UK by Al-Dlaigan *et al.* (2001b). On the other hand, in the present study, fruits consumed by 9.6% of the subjects with a frequency of two or more per day is lower than the 18% of subjects who consumed with the same frequency in Brazil (Auad, 2006). Regarding acidic food consumption, boys also had a higher intake of fruits than girls at frequencies more than one per day, but girls had a higher intake of fruits at frequencies once or less per day. This contrasts with previous findings from a UK based study where girls had a greater overall intake of fruits than boys (Al-Dlaigan *et al.*, 2001b).

7.7.5 Chronic medical conditions related to dental erosion

In the present study, the proportion of children reporting chronic medical conditions was very low. The most common chronic health problems reported by children were heart burn (21.3%) and regular stomach upsets (13%). The 21.3% of subjects who reported suffering from heart burn, is half the proportion of subjects (46%) who suffered from the same condition in a UK study (Bartlett *et al.*, 1998), and double the proportion found in a Brazilian study, 12% (Auad, 2006). The 13% who regularly suffered with stomach upsets, represents a much higher proportion than that found in the UK study (3%)

(Milosevic *et al.*, 2004). Of the subjects, 8.2% suffered from acid taste in the mouth; lower than the 15% reported for 14 year-old children in the UK by Milosevic *et al.* (2004). Only 4.7% of children in the present study suffered from asthma, slightly higher than the prevalence found in Brazilian subjects (3.3%) (Auad, 2006) and lower than the 16% found in the UK studies by Walker *et al.* (2000) and Milosevic *et al.* (2004). Of the subjects, only 0.6% suffered with diabetes; a proportion slightly higher than that reported in a UK study (0.3%) (Milosevic *et al.*, 2004).

7.7.6 Overall oral health habits and attitudes

Only 40% of the subjects claimed they brushed their teeth twice a day. Although this figure is higher than the 19.7% reported in a Saudi Arabian study (Al-Majed *et al.*, 2002) it is lower than the 55.6% reported in Portugal (Almeida *et al.*, 2003), 60% reported in UK study (Al-Dlaigan *et al.*, 2002a), and the 69% reported by Al-Omiri *et al.* (2006). An even higher proportion of subjects have reported twice daily tooth brushing in other studies; 70% by Yabao *et al.* (2005), 72% by White *et al.* (2006) and 78% by Milosevic *et al.* (2004). Twenty percent of subjects brushed their teeth once a day, similar to the 19% reported by Milosevic *et al.* (2004) in the UK, but lower than the 25% reported by Al-Dlaigan *et al.* (2002a) in the UK, and 63% reported by Ahmed *et al.* (2007) in Iraq.

In the present study, 12% brushed their teeth more than twice per day, similar to the 12% reported in the UK study (Al-Dlaigan *et al.*, 2002a). Regular tooth brushing was reported more frequently for girls than boys, showing a similar pattern to that reported in a Jordanian study (Taani, 2004), UK study (Al-Dlaigan *et al.*, 2002a) and a Iraqi study (Ahmed *et al.*, 2007). Only 4.4% of the subjects used fluoride mouthwash, or fluoride tablets, this may be because tap drinking water in Benghazi is fluoridated. Of subjects, 61.9% had visited a dentist before. This figure was slightly higher than that (57.8%)

reported by Jamieson *et al.* (2004) for Fijian children, and lower than the 74% reported for UK 14 year-olds by Al-Dlaigan *et al.* (2002a).

7.7.7 Socio-economic factors

In Libya, there is no governmental classification of areas based upon socioeconomic information. For this reason, the parents' education level was used to assess the socioeconomic status of the subjects. Of the total sample, 51.4% and 36.2% reported a higher (collage/postgraduate) education level of their fathers and mothers, respectively. And 40% and 47% were up to secondary school level for fathers and mothers, respectively. Only 9% and 17% of the fathers' and mothers' education respectively, were up to elementary level. This sample is representative of Benghazi; further research is needed to test the parent's education level as a proxy measure of socioeconomic status and experience of dental erosion in different regions in Libya.

7.7.8 Dental erosion and its association with acidic drinks

In the present study, intakes of acidic and non-acidic drinks were divided into "higher" (once per day, two or more times per day), "lower" (less than once per day) and "never" frequencies of consumption. Intake of acidic foods was dichotomized into "higher" (daily intake of ≥ one portion per day) and "lower" (< one portion per day) frequency of consumption; a similar method was used by Waterhouse *et al.* (2008). In the present study there was a statistically significant positive association between experience of erosion and consumption of fruit-based sugared drinks, and statistically significant negative weak association between experience of erosion and consumption of sport drinks and carbonated water. However, since the majority of the subjects (89% and 84%) never consumed sports drinks and carbonated water, respectively, it is possible that the findings have been influenced by the impact of this low frequency of consumption of these types of drinks. In contrast, fruit-based sugared drinks were the most common type of drink, and were consumed by majority of subjects either once or more than once per day. There were no statistically significant relationships between experience of dental erosion and frequency of consumption of sugared carbonated drinks, non-sugared carbonated drinks, squash and natural unsweetened fruit juices. This is in agreement with the findings of the review of British Child Dental Health Survey of 1993 and two National Diet and Nutrition Surveys in 1992/3 and 1996/7, where no statistically significant association was found between dental erosion and dietary intake (Nunn *et al.*, 2003). The present results were also in agreement with findings of Bartlett *et al*. (1998), who assessed the prevalence of tooth wear in 210 11-14 schoolchildren and its relationship with acidic drinks and found there was no correlation between intake of carbonated drinks and tooth wear. Further support comes from another study which investigated the prevalence of dental erosion and its association with acidic drinks in 153 11 year-old children and found no significant statistically relationship between erosion and carbonated drinks (Caglar *et al.*, 2005). The present results also appear to agree with the findings of Wiegand *et al*. (2006), who investigated the relationship of dental erosion and dietary intake in 463 2-7 year-old German children as well as in other studies (Milosevic *et al*., 1997; Árnadóttir *et al.*, 2003; Milosevic *et al*., 2004) where no statistically significant association was found.

In contrast, several other studies have found a statistically significant relationship between the consumption of acidic drinks and the experience of dental erosion or tooth wear (Eccles and Jenkins, 1974; Lussi *et al.*, 1991; Millward *et al.*, 1994a; O'Sullivan and Curzon, 2000a; Al-Dlaigan *et al.*, 2001b; Al-Malik *et al.*, 2001b; Harding *et al.*, 2003; Milosevic *et al.*, 2004; Dugmore and Rock, 2004b; EI Karim *et al.*, 2007). Harding *et al*. (2003) reported that the frequency of acidic drinks intakes was associated with dental erosion in 5 year-old Irish children. Waterhouse *et al.* (2008) found a statistically significant association between sugared carbonated drinks and erosion in a Brazilian study. Luo *et al.* (2005) found an association between prevalence of erosion in 3-5 year-old children in China and an acidic diet. In the present study, the reason for no significant association between experience of dental erosion and acidic drinks intake (except fruit based sugared drinks) might be due to the influence of other factors such as differences in salivary flow rate, buffering capacity, the amount of drinks consumed, different drinking patterns and time of drink consumption (i.e. as snacks or with meals). In addition, some of the acidic drinks were consumed by only a small number of children. It may be that drinks available in Libya are less erosive than elsewhere but there was no study to prove this and further research is needed. In addition, it is important to highlight that the present study is a cross-sectional study. All these factors might have contributed to the findings of present study and these results do not provide enough evidence to exclude a possible relationship between experience of dental erosion and consumption of these acidic drinks.

7.7.9 Dental erosion and its association with non-acidic drinks

Interestingly, the overall consumption of non-acidic drinks showed a statistically significant negative association with experience of dental erosion. In Libya, tea with milk is usually consumed with added sugar. In the present study, a statistically significant negative association was observed between the frequency of consumption of sugared tea with milk and flavoured milk (might be fruit-flavoured) and experience of dental erosion. This is in agreement with the results of a study in the UK, in which the consumption of tea and milk was significantly lower amongst children with dental erosion (O'Sullivan and Curzon, 2000a). A Brazilian study also found a statistically significant negative association between consumption of tea and erosion (Waterhouse *et al.*, 2008). However, it may be suggested that subjects who consumed sugared tea with milk, milk and flavoured milk more frequently had a lower consumption of acidic drinks as the non-acidic drinks displaced the acidic drinks from the diet and the protective effect of fluoride in tea can be considered. This might have contributed to a lower experience of dental erosion. It could be argued that the results of the present study suggest a protective effect against erosion related to tea with milk, milk and flavoured milk, although the inclusion of sugar in tea increases its cariogenic potential.

7.7.10 Dental erosion and its association with drinking water

There was no statistically significant association between frequency of consumption of tap water, bottled water or both types of water and experience of dental erosion. The present study highlighted the fact that large proportions of subjects consumed tap water, bottled water or both types of water (29.7%, 14.5% and 55.8%, respectively). The regular consumption of water should be encouraged and maintained within Libyan schoolchildren for its fluoride protection effect against dental erosion and to displace acidic drinks consumption.

7.7.11 Erosion and its association with acidic food consumption

Surprisingly, in the present study, experience of dental erosion decreased when the frequency of fruit consumption increased. This negative association was statistically significant, but weak. As almost 96% of the subjects consumed acidic foods less than once a day, it is possible that the results were influenced by the impact of this low frequency of consumption. Several studies have found association between fruit consumption and experience of dental erosion (Eccles and Jenkins, 1974; Kunzel *et al.*, 2000; Al-Dlaigan *et al.*, 2001b), while other studies have found no association (Williams *et al.*, 1999; Walker *et al.*, 2000; Harding *et al.*, 2003; Caglar *et al.*, 2005; Waterhouse *et al.*, 2008). Milosevic *et al.* (2004) reported that the consumption of oranges or apples was not statistically associated with experience of tooth wear. In contrast, Dugmore and Rock (2004b) reported that eating fruit other than apples or citrus fruits was statistically associated with the experience of erosion amongst 12 year-olds in the UK. In the present study the Libyan subjects who also reported an intake of one or more than one fruit per day did not have a higher risk of erosion compared with children with low intake. This level of fruit intake is below the current dietary recommendations of at least five portions of fruits and vegetables per day (WHO, 2003), although the vegetables intake was unknown. It is reassuring that this current recommendation does not cause a significant risk for dental erosion as most vegetables and fruits such as bananas are not erosive. The present results suggested it would be wise to encourage the consumption of fruits as they are important part of a healthy diet. It is also important to note that this study is cross-sectional and the collected dietary information might be not representative of a long-term dietary pattern which potentially contributes to the experience of dental erosion.

7.7.12 Dental erosion and chewing sugared gum

In the present study, there was no statistically significant association between experience of erosion and chewing sugared-gum. Sugared gum was chewed once or more than once per day by 95% of the subjects. It is well-known that chewing gum increases the salivary flow rate and consequently, the oral clearance of acids (Dawes and Macpherson, 1992; Árnadóttir *et al.*, 2003). Tooth surface loss may be further compounded by dental attrition that occurs during mastication. Therefore, it is difficult to confirm the role of chewing gum in experience of dental erosion. In studies conducted *in vitro* it has been found that the acidic filling of chewing gum reduced the microhardness of the enamel

(Lussi *et al.*, 2000; Cairns *et al.*, 2002; Bolan *et al.*, 2008), also in a study of Brazilian 12-14 year-olds, a statistically significant association was observed between chewing gum and erosion (Waterhouse *et al.*, 2008).

7.7.13 Dental erosion and length of time taken to consume the drinks

There was statistically significant positive relationship between experience of dental erosion and the duration of time taken to consume drinks. A higher experience of erosion was found amongst subjects who made the drink last up to or more than 15 minutes. This is in agreement with the findings of Al-Majed *et al.* (2002), who found a statistically significant association between the number of permanent upper incisors with pronounced dental erosion and the length of time taken to consume a drink. Conversely, other studies (Walker *et al.*, 2000; Auad *et al.*, 2007) have showed no significant association between experience of erosion and the length of time taken to consume the drinks.

7.7.14 Dental erosion and consumption of bedtime drinks

There was no statistically significant association between the experience of dental erosion and the habit of consuming an acidic drink at bedtime. This is in agreement with the results of two studies (Milosevic *et al.*, 2004; Waterhouse *et al.*, 2008), although other studies have found a statistically significant association between experience of dental erosion and bedtime acidic drinks consumption. A Saudi Arabian study found a statistically significant association ($p = 0.020$) between consumption of bedtime drinks and experience of dental erosion (Al-Majed *et al.*, 2002), while another study conducted in Saudi Arabia found that consumption of fruit juices in a bottle at bedtime was statistically significantly associated with experience with dental erosion amongst 2-5 year-olds (Al-Malik *et al.*, 2001b). In addition, in a study amongst 1949 3-5 year-olds in China a statistically significant association ($p < 0.05$) was shown between the experience of dental erosion and consumption of fruit drinks at bedtime (Luo *et al.*, 2005). In addition, Millward *et al.* (1994a) reported a statistically significant association between experience of dental erosion and fruit drinks consumption at bedtime amongst 101 children who were patients of a Dental Hospital in Birmingham, UK. In the present study the lack of association found might have been due to a low proportion reporting consumption of acidic drinks at bedtime; only 16% (129) out of the 791 subjects reported this habit, which made it difficult for any possible association to become clear. This is in agreement with a Brazilian study; only 4.8% of the 458 subjects consumed acidic drinks at bedtime and no statistically significant association between the experience of erosion and consumption of acidic drinks at bedtime was found (Waterhouse *et al.*, 2008).

7.7.15 Dental erosion and oral hygiene practice

The experience of dental erosion was not statistically significant associated with frequency of tooth brushing, confirming the findings of other studies (Ganss *et al.*, 1999a; Al-Malik *et al.*, 2001b; Al-Dlaigan *et al.*, 2002a; Harding *et al.*, 2003; Truin *et al.*, 2005; Wiegand *et al.*, 2006). However, there has been one study showing a statistically significant association between dental erosion and children brushing their teeth at night (Al-Dlaigan *et al.*, 2002a). In the present study, there was also no statistically significant association between experience of dental erosion and tooth brushing after consuming acidic drinks. This finding agrees with that reported by Ganss *et al.* (1999a), who suggested that after an acidic drink intake, a few minutes may be enough for tooth remineralisation (Ganss *et al.*, 1999a). Further support comes from an *in situ* study which found that topical application of fluoride is effective in reducing enamel mineral loss under erosive conditions (Ganss *et al.*, 2004). Ganss *et al.* (1999a) reported that fluoride is capable of reducing the amount of tooth brush abrasion. On the other hand, Milosevic (2006) reported that tooth brushing after an enamel challenge by erosion leads to additional loss by subsequent abrasion. Another study reported that abrasion from tooth brushing is increased after an erosive challenge even after 2 hours of remineralisation (Attin *et al.*, 2001).

7.7.16 Dental erosion and parental educational level

Because there is no governmental classification of areas based upon socioeconomic information in Libya, parents' education levels could be considered as a proxy measure of socioeconomic status. Schoolchildren whose mothers had been educated up to secondary school level or to a higher level (college/postgraduate) had a higher experience of dental erosion than children whose mothers were illiterate, but the difference was not statistically significant. Similar results were seen with fathers' education; children whose fathers' level of education was to college/postgraduate level had a higher experience of dental erosion. But again this was not statistically significant. A similar result was found in a Brazilian study; no significant association between parental educational levels and experience of dental erosion (Auad *et al.*, 2007). Similar findings were found in the UK National Diet and Nutrition Survey (NDNS); 12-14 year-old schoolchildren whose mothers had higher education levels had a higher experience of dental erosion than children whose mothers had lower educational levels (Walker *et al.*, 2000). In a Brazilian study the author suggested that the reason might be parents who had a higher education levels spending more time away from home which might be influencing the increased frequency of consumption of fast food and carbonated drinks (Mangueira *et al.*, 2009). A significantly higher prevalence of dental erosion was found in 1949 3-5 year-old preschool children in China whose parents had a higher education level than those whose parents had lower level of education (Luo *et al.*, 2005) and the author suggested that the reason may be parents who had high educational level have adopted a more Western style diet for their children such as carbonated soft drinks and fruit juices, while parents with low educational level may choose traditional drinks such as tea for their children.

7.7.17 Dental caries and sugared-acidic and non-acidic drinks

In the present study, the experience of caries was not statistically significant associated with consumption of sugared-acidic drinks, except for consumption of fruit-based sugared drinks ($p<0.01$). Surprisingly, similar proportions of subjects with or without experience of dental caries had the habit of having bedtime sugared-acidic drinks. It might be expected that subjects with a habit of having bedtime sugared-acidic drinks have more caries experience than subjects without the habit.

7.7.18 Dental caries and oral hygiene practice

Surprisingly, there was no association between experience of dental caries and frequency of tooth brushing. This is might be because the frequency of tooth brushing did not compensate the destructive effect of sugars intake (Hind and Gregory, 1995). It has been reported that tooth brushing only has a low effect in preventing dental caries (Ashley *et al.*, 2000). Moreover, another study reported that the decline in dental caries is related to accessibility of fluoride toothpaste and changes in the pattern and amount of sugars intake (Sheiham, 1984) rather than frequency of toothbrushing. The association may have been confounded by the age at which brushing was stared (Kwan and Williams, 1998). The results of the present study are in agreement with other studies that reported no statistically significant association between dental caries and frequency of tooth brushing (Ainamo and Parviainen, 1979; Shetty and Tandon, 1988; Sudha *et al.*, 2005; Yabao *et* *al.*, 2005). Conversely, Jamieson *et al.* (2004) reported that children who brushed infrequently had higher caries experience than those who brushed more frequently. Baccush and Nayak (1991) reported that children with poor oral hygiene had a significantly higher caries experience than those with good oral hygiene.

7.7.19 Dental caries and parents' education

In the present study, the proportion of subjects with dental caries increased with the increasing of mothers' educational level up to secondary school level, then decreased at higher level. The experience of caries decreased with fathers' increasing educational level, the highest proportion without caries experience however, was observed among children whose fathers' were educated to college/postgraduate level and this negative association was statistically significant. The reason for this may be that parents with a high educational level observe and control the dietary habits of their children despite the fact that wealthy families who parents had high education level could afford costly sugar products. These results suggest a strong influence of a parents' educational level in the patterns of dental health of their children and confirm the findings of a previous Libyan study in 10-13 year-old that children whose mothers had a high education level had a lower caries experience than those children with mothers of low educational level (Baccush and Nayak, 1991). It has been suggested that higher educational levels are related to improved oral health (Walker *et al.*, 2000) and similar trends were present in the present study. The present study also confirms the findings of another study conducted to assess the prevalence of dental caries and its association with sociodemographic characteristics in 5-6 year-olds in Ajman, UAE, which found that children of mothers with lower levels of education had higher caries experience (Hashim *et al.*, 2006).

In contrast, a study conducted in Iraq to investigate dental caries and its risk factors in 12 year-old schoolchildren reported that caries experience rose significantly with higher education of the mother (Ahmed *et al.*, 2007), The author suggested that the reason might be the availability of sugar was low in Iraq due to sanctions and consumption of sugars was restricted to rich families with parents of high education of level and who could afford expensive sugar products. The study was conducted shortly after the end of the sanctions. In addition, a study conducted to assess the relationship between dental caries and the socioeconomic condition in 18 year-old Brazilian males found that the mother's education was the only independent variable associated with the levels of dental caries (Peres *et al.*, 2005b).

7.8 Conclusions

The aims of this part of the study were achieved.

7.8.1 With regard to dietary patterns and habits:

- Carbonated drinks, fruit-based sugared drinks and squash were the most commonly consumed acidic drinks by 12 year-old Libyan schoolchildren.
- Sugared tea with milk, milk and flavoured milk were the most commonly consumed non-acidic drinks by 12 year-old Libyan schoolchildren.
- Tap water, bottled water or both types of water were consumed by 29.7%, 14.5% and 55.8% of subjects, respectively.
- Only 6% of the subjects claimed consumption of two to four portions of fruit per day.
- The majority (89.9%) of children reported they had the habit of chewing sugared gum on a daily basis.

- The majority (61.6%) of children reported they had the habit of making the drink last up to 15 minutes.
- One-third of children reported they had the habit of consuming acidic drinks at bedtime.
- The majority (83.7%) of children reported they did not brush their teeth after consuming acidic drinks.

With regard to oral hygiene practices:

- The majority (39.9%) of children reported brushing their teeth two times per day.
- Almost all (95.6%) children reported they did not use fluoride mouth wash or fluoride tablets.

With regard to general health and chronic diseases:

- Only 21.3%, 13%, 8.2%, 4.7% and 0.6% of subjects suffered from heart burn, regular stomach upsets, acid taste in the mouth, asthma and diabetes, respectively.
- Majority (91.2%) of children reported they did not take vitamin C.

With regard to socio-economic status of children's parents:

- For 51% of schoolchildren, the fathers were educated to the level of college/postgraduate education, 40% up to secondary school level and 9% up to elementary school level or illiterate.
- For 36% of children, the mothers were educated to the level of college/postgraduate education, 47% up to secondary school level and 17% up to elementary school level or illiterate.

7.8.2 In relation to experience of dental erosion and exposure to potential risk factors for dental erosion:

- The consumption of fruit-based sugared drinks ($p = 0.006$) was statistically significantly positively associated with the experience of dental erosion.

- The consumption of sport drinks ($p = 0.004$) and carbonated water ($p = 0.048$) were statistically significantly negatively associated with the experience of dental erosion. However, since the majority of the subjects (89% and 84%) never consumed sports drinks and carbonated water, respectively, it is possible that the findings have been influenced by the impact of this low frequency of consumption of these types of drinks.

- The consumption of sugared tea with milk ($p = 0.032$) and flavoured milk ($p = 0.043$) were statistically significantly negatively associated with experience of erosion. The experience of erosion decreased with the increasing frequency of consumption of sugared tea with milk and flavoured milk.

- The experience of dental erosion increased with reduction of frequency of consumption of fruits ($p = 0.002$), but it is possible that the results have been influenced by impact of the low frequency of consumption of fruits by majority of the subjects. Therefore, the present results suggest excluding the association between the consumption of fruits and experience of erosion.

- The experience of dental erosion increased with increasing the length of time taken to consume drinks, especially when the drinks lasted up to 15 minutes. This was a statistically significantly positive association ($p = 0.005$).

Neither consumption of acidic drinks at bedtime, brushing teeth after consuming acidic drinks, chewing gum, frequency of tooth brushing or parents' education were found to be associated with dental erosion.

7.8.3 Null hypotheses:

- There is no relationship between the prevalence or severity of dental erosion and the frequency of consumption of acidic drinks. The null hypothesis was rejected.

- There is no relationship between the prevalence or severity of dental erosion and exposure to other potential risk factors for dental erosion such as oral hygiene practice, oral habits, lifestyle and socio-economic status of children's parents. The null hypothesis was rejected.

7.8.4 In relation to experience of dental caries and potential risk factors for dental caries:

- There was a statistically significantly positive association between dental caries and consumption fruit-based sugared drinks (p= 0.002).

- There was a statistically significantly negative association between dental caries and the level of father's education (p= 0.015).

Chapter 8
Dietary risk factors for dental erosion: data from the three-day food diaries with interview

8.1 Introduction

In order to assess the role of an acidic diet in the aetiology of dental erosion it is important to collect detailed information about dietary consumption. When embarking on dietary analysis, it is necessary to have a wide picture about the subjects' diet, so that any specific evaluation might be considered in a broader context. Good knowledge of the dietary intake of children is essential to provide data for the evidence base for preventing dental diseases and improving dental health programmes. Dietary assessment is important in epidemiological research because diet has an important affect on oral health and has an impact on public health policy.

8.1.1 Three-day food diary

There are a number of methods by which dietary intake data can be collected. The two main categories of dietary assessment use retrospective and prospective methodologies. Retrospective methods include 24-hour recall, diet history, food frequency questionnaires and diet inventory (Anderson, 1995). The two main prospective methods which are commonly used are the weighed food inventory and estimated food inventory (Anderson, 1995). Each dietary assessment method has its advantages and disadvantages. Three-day food diaries are a validated and prospective method and justified for use for children (Hackett *et al.*, 1984; Adamson *et al.*, 1992; Fletcher *et al.*, 2004a; Auad, 2006). Subjects are asked to complete a 3-day food diary on three consecutive days, two week days with one weekend day between and are interviewed on the fourth day to clarify the information in the diary. The food diary provides more accurate information about the quantity, time and pattern of consumption of foods and drinks than questionnaire surveys. This results in a more in depth analysis which may be used as the basis for future dietary advice. When using an estimated dietary record, all foods and drinks consumed are recorded by the child or parent (depending on age) over a set number of days. The three-day dietary diary is the one of the best and most effective methods in dietary assessment in children due to its accuracy; day to day variation can be measured and the method does not rely upon memory (Anderson, 1995). It also uses a simple method of recording. Quantification is determined using household food measures and photographs. The use of food models and photographs improves estimation of portion size (Nelson *et al.*, 1997). It is sensitive enough to estimate the total daily non-milk extrinsic sugars (NMES) (Hackett *et al.*, 1983). The three-day dietary diary has been used to assess NMES and acidic food intake (Auad, 2006). Furthermore, it gives information on whether each sugary or acidic food and drink item was consumed with a meal or as a snack or close to bedtime. On the other hand, dietary diary completion requires the co-operation of subjects, eating habits might be changed during the recording, requires subjects to be literate, and the recording is time consuming for the subjects (Anderson, 1995; Biro *et al.*, 2002).

Three-day food diaries require estimation of food portion size and therefore they are not as accurate as weighed dietary intakes. However, their use is less likely to interfere with the subject's daily eating pattern and give a more representative assessment of actual habitual dietary intake. Estimated food diaries with interview using food models provide a good estimate of actual food intake (Hackett *et al.*, 1983; Cade, 1988; Adamson *et al.*, 1992; Fletcher *et al.*, 2004a).

To aid compliance with this method of dietary intake assessment, compliance instructions are given to each subject regarding the amount of detail of food intake required and they are asked to write down the amount and time of consumption of all foods and drinks consumed during a pre-determined period of time, a minimum of three days. Details recorded by the subject include the time food is eaten, type of food, brand name and weight of food consumed. As the food is eaten, the subject records the quantity of food consumed using household measures such as plates, cups, glasses and spoons. Since eating patterns vary between weekend days compared with weekdays (Hackett *et al.*, 1985), it is important to collect dietary data over both weekdays and weekend days. After completion of food diaries, subjects are interviewed in order to clarify the dietary information recorded in the food diaries and to determine the best estimate of the quantity of food and drink consumed.

8.1.2 Diet and dental diseases

The importance of diet-related diseases has increased over the last 30 years (Watt and Sheiham, 1999; Moynihan, 2005). Healthy eating guidelines in the UK encourage the message to decrease NMES intake and increase fruit and vegetables intake to improve dental and general health (WHO, 2003). Diet is influenced by many different factors such as age and the media, as well as family, social and economic pressures. Children are one of the vulnerable subgroups within the population to oral health diseases, and the importance of a balanced diet for the maintenance of health is unquestionable.

8.1.2.1 Diet and dental caries

Diet has an important effect in the development of oral disease, its most significant local effect on teeth is in the development of dental caries and dental erosion (Moynihan and Petersen, 2004). There is evidence that NMES (those sugars present in a free form or added to food) play an important role in the development of dental caries. The NMES include sugars outside the cellular structure of a food, excluding the sugars naturally present in milk and milk products (Department of Health, 1989). Surveys have shown that the intake of dietary sugars has an important role in the aetiology of dental caries. Moreover, the risk of dental caries increases with more frequent sugar consumption. Sugars consumption between meals is associated with a greater potential risk of dental caries than consumption at meals

(Al-Malik *et al.*, 2002; Dugmore and Rock, 2004a; Ahmed *et al.*, 2007), as salivary flow and its buffering capacity are high at meals and low between meals.

8.1.2.2 Diet and dental erosion

In recent years, growing concern has been drawn to the impact of diet in dental erosion (Johansson *et al.*, 1996; Al-Dlaigan *et al.*, 2001b; Dugmore and Rock, 2004b). The UK Children's Dental Health Survey showed that the prevalence of dental erosion is increasing (Chadwick and Pendry, 2004); the 1993 Survey recorded that 27% of 12 year-olds and 32% of 14 year-olds respectively had erosion while 33% of 15 year-olds in 2003 were affected by dental erosion (O'Brien, 1994; Chadwick and Pendry, 2004). In addition, the 2000 National Diet and Nutrition Survey (NDNS) of young people aged 4 to 18 years showed that 52% of 11-14 year-olds were affected by erosion (Walker *et al.*, 2000). Evidence from several epidemiological studies proved an association between increased prevalence of dental erosion and the frequency of consumption of acidic foods and drinks (O'Sullivan and Curzon, 2000a; Al-Dlaigan *et al.*, 2001c). Dietary acids have been identified as a major risk factor for the progression of dental erosion (Millward *et al.*, 1994a; Lussi *et al.*, 2007). However, with regard to dietary acids, most attention has been paid to soft drinks because of their high consumption particularly among children (O'Brien, 1994; Zero, 1996; Larsen and Nyvad, 1999; Shaw and Smith, 1999; Walker *et al.*, 2000; O'Sullivan and Curzon, 2000a; Al-Majed *et al.*, 2002; Harding *et al.*, 2003; Moynihan and Petersen, 2004). The UK National Diet and Nutrition Survey (NDNS) of young people aged 4 to 18 showed that the mean daily consumption of acidic drink was more than a litre, for all age groups, and mean daily intake of 240 grams and 352 grams for carbonated drinks and concentrated ready to drink soft drinks respectively amongst 11-14 year-olds (Walker *et al.*, 2000).

The best method of dental disease prevention, including dental erosion, is to modify the risk factors for these conditions. To improve dental health, the dietary habits of children should be changed by reducing their intake of sugary and acidic foods and drinks. A greater understanding of nutritional knowledge and attitudes relating to dental health is needed to build intervention programmes targeted to these children.

8.1.3 The reasons for the present study

In Benghazi, Libya, no dietary assessments have been carried out to obtain accurate estimations of foods and drinks consumed by children. The method chosen to assess the diet has to be suitable for the population it is assessing. Consequently, the present study aimed to collect data on detailed dietary patterns of a sub-sample of the subjects recruited for a dental epidemiological survey in Benghazi, Libya using a three-day food diary with interview.

8.2 Aims

The main aims of this part of the study were:

8.2.1 To determine the daily intake of acidic drinks and foods in a sub-sample of 12 year-old schoolchildren in Benghazi, Libya.

8.2.2 To determine the relationship of reported daily intake of acidic drinks and foods with measured dental erosion in a sub-sample of 12 year-old schoolchildren in Benghazi, Libya.

8.2.3 To determine the relationship of reported daily intake of acidic drinks and foods with measured dental caries in a sub-sample of 12 year-old schoolchildren in Benghazi, Libya.

The subsidiary aims were:

8.2.4 To obtain dietary data (daily intakes of acidic foods and drinks, macronutrients and tap/bottled water) to investigate their relationship with dental erosion and dental caries.

8.2.5 To investigate the relationship between the above stated variables and gender

8.2.6 To investigate any relationship between fluoride exposure from water supplies and the prevalence and severity of dental erosion in children in Benghazi, Libya.

8.2.7 In order to assess if the sub-sample was representative of the main study sample, an additional aim was:

- To report the subjects' experience of dental erosion.
- To report the subjects' experience of dental caries.

8.3 Objectives

- To randomly select a sub-sample of schoolchildren to complete a three-day estimated food diary in order to provide detailed dietary information on consumption of tap/bottled water and acidic dietary items in terms of amount and frequency.
- To interview these children in order to clarify the information provided in the food diaries.
- To estimate the daily intake (grams/day) of acidic drinks and foods including acidic confectionery.
- To estimate the daily energy intake (kJ/day).
- To estimate the total weight (grams/day) of acidic items consumed as meals and snacks.
- To estimate the daily intake of sugars, total sugars, non-milk extrinsic sugars (NMES), intrinsic milk sugars (IMS), protein, fat, carbohydrate (grams/day and percentage contribution to daily energy intake).
- To estimate the daily intake of tap and bottled water (litres).
- To estimate the daily intake (mg) of fluoride from tap and bottled water and proportion of daily intake (%).

8.4 Materials and Methods

8.4.1 Pilot study

A pilot study was carried out to familiarise the researcher with the dietary assessment method and interviewing technique. In the UK, three volunteers aged 12 years were given written instructions and asked to complete a 3-day estimated food dairy. Using these data discussion was undertaken with Professor Paula Moynihan on how to clarify the written dietary information during the interviews and how to clarify portion sizes. These data were not included in the main study.

8.4.2 Obtaining the sub-sample

Ethical approval and permissions were secured from local authorities and schools as described in Chapter 4 (Section 4.6.1). From the children with parental written consent, a sub-sample was randomly selected from the total sample to complete three-day food diaries. Using a list of randomly generated numbers between 1 and 99 a selection of the first 22 children was made using columns, for example starting with column 2 to sample 11 girls or 11 boys from within a school. Seven children were randomly selected from the previous randomly selected list in each of 36 schools to achieve a sub-sample of 252 subjects. The statistical power of the study was calculated with the assistance of a medical statistician, Dr Nick Steen, Principal Research Associate, Institute of Health and Society, Newcastle University. Undertaking dietary assessment on a sub-sample of 175 children gave a 95% power to detect a correlation coefficient of 0.3 assuming a Type 1 error rate of 5%.

8.4.3 Food diaries with interview

The subjects were asked to complete a 3-day estimated food diary (Appendix 4.6) on three consecutive days, two week days (Thursday and Saturday) with one weekend day (Friday) between and were interviewed on the fourth day to clarify the information in the diary. Prior to commencement, for the 252 randomly selected subjects, school number and study number were recorded on the front of the diary (Appendix 5.6). Food diaries were completed before the questionnaire survey and dental examination being undertaken in the schools by the researcher (RH) to minimize the risk of changing the dietary habits due to dental awareness. The researcher met the subjects in the classroom or in any available place in the school and explained to the subjects how to complete the food diary and asked them to carry the food diary with them all the time during the three days. The researcher asked the subjects to record everything they ate or drank, and to write down the amount of food or drink consumed using household measures (i.e. plates, glasses, spoons). The subjects were also asked to record the time of consumption, the type of food or drink consumed using household measures (i.e. plates, glasses, and spoons), information about any medicines consumed and the time when they went to bed. The importance of not changing their dietary pattern during the collection period was stressed. The interviews were undertaken on the first week day following completion of the food diaries in order not to compromise the subjects' ability to remember their dietary consumption. The interview was used to clarify the types and amounts of foods and drinks consumed over three days. All participating schools agreed for subjects to be interviewed during school hours. The interview took place in any available space within the schools. If the food diary was forgotten or the child was absent, the interview was carried out on the following day. The weight of each child was recorded using weighing scales (Seca, Germany). Shoes were removed and any items taken out of pockets. No dietary advice was given to the children before or after completion of the diaries and no comment was made on their food intake or spelling of any words. Diaries were not included in the study if they were lost or returned incomplete (food diaries with only one or two days dietary recording). All information that was provided by the subjects was kept confidential. All records containing a subjects’ name were stored in a locked cabinet in a locked office. Children were thanked for their co-operation and for participating in the study. All participants received a stationery box as a means of thanks.

8.4.4 Water samples

8.4.4.1 Permissions

All permissions were secured from the Libyan authorities, Health Ministry, Education Ministry and Dental Faculty, for transport of the water samples from Benghazi to the UK (Appendices; 4.11, 4.12, 4.14). In addition, permission was obtained from the Food Standards Agency in the UK to allow the import of water samples and a permission from the Newcastle University to allow the storage and analysis of the water samples in a University Laboratory (Section 4.5.1.4).

8.4.4.2 Collection of water samples

The subjects were asked to collect four drinking water samples; home tap water on the morning (before school) and afternoon (after school) of the first and third day of the food diary. The subjects were also asked to collect samples of other bottled waters or tap water consumed outside the house. In addition, water samples were collected by the researcher from each school on the morning and afternoon of the first and third day of the food diary completions in that school.

8.4.4.3 Storage and analysis of water samples

The collected water samples were kept in fluoride-free plastic containers and frozen at -20º Celsius freezer at the Dental Faculty in Benghazi during the time of data collection and until time of shipping. After that, the frozen samples were defrosted prior to shipping and the examiner dried the outside of every tube carefully with tissues prior to being transported at ambient temperature back to the UK. In the UK, the samples were stored in the fluoride research laboratory at Newcastle University in a -20° Celsius freezer until fluoride concentration was analysed by the researcher or lab technician using a Standard Operating Procedure (SOP) (Appendix 4.7). This method has been used previously to describe the direct analysis procedure for determination of fluoride concentration in water (Zohouri and Rugg-Gunn, 1999; Martinez-Mier *et al.*, 2004; Soto-Rojas *et al.*, 2004; Soto-Rojas *et al.*, 2005). Data were entered into a Microsoft Excel (2003, Microsoft Office) software program for calculating the fluoride concentration in the drinking tap and bottled water. Then the data were collated and transferred to the Statistical Package for Social Science; SPSS 15.0 for Windows and analysed with the other variables.

8.4.4.4 Estimations of water consumption

The following estimations were made and the mean, median and range were calculated for tap, bottled and tap and bottled water consumption.

In respect of tap water:

- Volume of tap water (litre) consumed by child on Day 1, Day 2 and Day 3.
- Volume of tap water (litre) consumed by child over the 3 days.
- Fluoride intake (mg) from tap water consumed by child on Day 1, Day 2 and Day 3 = volume of tap water (litre) consumed on that day x mean fluoride concentration (mg/litre) of tap water for that child based on tap water samples.
- Fluoride intake from tap water consumed by child for the 3 days = fluoride intake for Day 1 + Day 2 + Day 3.
- Mean daily fluoride intake of tap water = fluoride intake for the 3 days/3.
- Mean fluoride concentration of tap water (mg/litre) = fluoride intake (mg) from tap water/volume of tap water (litre).
- Daily frequency of intake of tap water by child.

In respect of bottled water:

- Similar procedures were done for bottled water.

In respect of both water (tap and bottled water) consumption:

- Sum of volumes of tap and bottled water consumed by child over 3 days.
- Mean daily intake of tap and bottled water (litre) = sum of volume of tap and bottled water intake (litre) by child over 3 days/3.
- Mean daily fluoride intake (mg) from tap and bottled water = (fluoride intake from tap over 3 days + fluoride intake from bottled water over 3 days)/3.
- Mean fluoride concentration of tap and bottled water (mg/litre) = daily fluoride intake (mg) from tap and bottled water/mean daily volume of tap and bottled water (litre) consumed.

8.4.5 Estimation of food portion sizes

In order to help the subjects estimating the food portion sizes, during the interviews the researcher used different sizes of domestic measures of quantities (cups, mugs, plates, and spoons) to quantify food eaten. A list of all types of foods and drinks mentioned in the food diaries was made. Dietary information from local supermarkets was collected in order to help in estimating the food portion sizes. Branded food, drinks and confectionery recorded in the food diaries were assessed using information in supermarkets and shops in Benghazi. For the Libyan foods and drinks where a direct match was not found in UK food tables, a best match was used. Moreover, many of the Libyan foods and drinks were the same as in the UK and many drinks and confectionery consumed by the subjects were made in the UK. However, for foods reported which were not found in the UK food tables, Libyan recipes were consulted in order to estimate the amount of each food present whilst considering the number of portions suggested by the recipe. For instance, using a Libyan recipe for a traditional meal made with vine leaves stuffed with rice and meat, the amount of each food item was initially determined.

Following this, these amounts were divided by the number of portions as stated in the recipe; vine leaves stuffed with rice (which comprised 80% of the recipe) were already present in the UK food tables and minced beef comprised 20% of the total portion. The same method was used for the recipe aubergine and peppers stuffed with rice and meat. Any weight recorded which appeared suspect for that food was checked with the raw data in the child's food diary.

The estimation of the amounts of food and drink intakes for the food diaries was made by associating the additional information collected during the dietary interview. Each food item was then entered, considering the portion size reported by the subjects, from the food portion size sold in supermarkets and shops in Libya, and from estimation of typical food portion sizes for children aged 11-14 years in the UK (Wrieden *et al.*, 2008) and from the food portion sizes guide book (Crawley *et al.*, 1993).

8.4.6 Coding of data from food diaries

Following the estimation of food portion sizes, food diaries were coded according to the 'best matches' found in the UK food tables. The data were entered by the researcher into the pre-existing database designed in the Microsoft Access Program-Windows 2000, developed in the Human Nutrition Research Centre, at Newcastle University.

An intake: was defined as foods eaten all at one time and that consisted of a few code items e.g. "Tea with milk, bread and cheese" is one intake, and next few items which eaten together at one time would be a second intake. Information regarding the time of intake of foods and drinks was defined as meal or snack (Hackett *et al.*, 1984). Twenty minutes was the time interval used to distinguish intakes. Criteria used to define meals or snacks was important as it could have a detrimental effect on the accuracy of the study.

A meal: defined as any intake including at least three of these criteria; a number of items eaten together and consisting at least three items, making a major contribution to the energy intake for that day, eaten at recognised mealtimes, eaten with a knife, fork or spoon and usually be consumed over a period of more than 15 minutes.

A snack: defined as any intake not meeting the mentioned criteria of a meal. When foods were taken at a usual mealtime but consisted of foods that are normally consumed as snacks they were regarded as snacks.

8.4.7 Data entry and collation

The raw data were entered into the database by the researcher. All efforts were made to reduce errors associated with data entry such as by data re-entry of 20 randomly selected food diaries to check accuracy of dietary entry. Any extreme weights were checked with the raw food diary data. Checks were carried out to ensure each child had three food diary days entered. Food diaries with only one or two days of dietary recording were excluded from further analysis.

8.4.8 Derived outcome variables from dietary assessment

The outcome variables for dietary food diaries were daily intake of:

- Acidic drinks (grams/day).
- Acidic foods (grams/day).
- Acidic confectionery (grams/day).
- Total weight of acidic food and drink consumed as meals and snacks.
- Daily energy intake (kcal).

Daily intake (grams/day and percentage contribution to daily energy intake) of:

- Sugars (total sugars, NMES, IMS), protein, fat and carbohydrate.

Daily volume intake (litre) of:

- Tap water, bottled water and both tap and bottled water.

Daily fluoride intake (mg) from:

- Tap water, bottled water and both tap and bottled water.

The mean daily frequency of consumption of:

- Tap water and bottled water (Section 8.4.4.4).

The mean intake (grams/day) of different acidic dietary items reported by the subjects was calculated for the following categories:

- Acidic drinks: included sugared carbonated drinks, non-sugared carbonated drinks, fruit juices and fruit-flavoured drinks.
- Acidic foods: included all fruits (except bananas), jelly, yogurt and sauces (ketchup and vinegar based sauces).
- Acidic confectionery: included fruit-flavoured sweets and fruit-flavoured sugared chewing gum.
- Total acidic intake: included acidic drinks, foods and confectionery.

8.4.9 Data analysis

Dietary data were transferred to the Statistical Package for Social Sciences; SPSS 15.0 for Windows licensed to Network License User, Newcastle University and analysed. The normality of distribution of the data related to intake of foods and drinks was assessed using One-Sample Kolmogorov-Smirnov Z test. For continuous variables that were normally distributed, data were presented as mean, with standard deviation (SD), and 95% Confidence Intervals (CI). For continuous variables that had a skewed distribution, data were presented as the median with the interquartile range (IQR). Comparison between genders was carried out using an unpaired t-test for normally distributed data and Mann-Whitney test for skewed data. Data from the dental examinations and dietary data from food diaries for the sub-sample of 180 subjects was also analysed using a process of bivariate analysis. Associations between dental erosion variables (Yes/No) and erosion-related variables were tested through a process of bivariate analysis, using the exact versions of the non-parametric test Man-Whitney U

(Section 8.5.10-11). Interquartile range (IQR) and 95% Confidence Intervals (CI) were calculated for 2 x 2 tables. Only two-sided statistical tests were used. The statistical significance level was established at 5%. Associations between dental caries variables (Yes/No) and caries-related variables were also tested through a process of bivariate analysis (Section 8.5.12). After completion of the bivariate analysis, a multivariate analysis using a forward stepwise logistic regression model was developed, to determine the variables independently associated with experience of dental erosion (Chapter 9).

8.4.10 Validation of dietary assessment

The mean physical activity level (PAL) was calculated for all subjects using the total daily energy expenditure in Mega Joules (MJ) divided by Basal Metabolic Rate (BMR). The PAL or ratio of energy intake (EI) to BMR (EI:BMR) was used to identify the proportion of subjects who may have under-reporting and over-reporting their energy intakes. BMR is defined as the energy expenditure of an individual lying at physiological and mental rest in a thermoneutral environment, or it is the energy expended by the body at rest to main bodily function like respiration, heart beat, body temperature and other body functions or can be defined as the amount of energy consumed while inactive (Garrow *et al.*, 2000). The BMR is influenced by age, gender, weight, height, environmental temperature and dieting and exercise habits and can be measured from regression equations based on age, gender, and body weight (Garrow *et al.*, 2000). The equations for children aged 10-17 years are:

For boys: BMR = (0.074 x Child's weight (kg)) + 2.754

For girls: BMR = (0.056 x Child's weight (kg)) + 2.898.

The following provisional cut-off points purposed for children aged 6 to 18 years were used to identify 'under-reporters' and 'over-reporters' for dietary intake among the children (Torun *et al.*, 1996): For boys: Under-reporters: PAL<1.39, Over-reporters: PAL>2.24

For girls: Under-reporters: PAL<1.30, Over-reporters: PAL>2.10.

8.5 Results

8.5.1 The sub-sample

Two hundred and fifty two food diaries were distributed to the randomly selected schoolchildren in thirty six randomly selected public schools. Seven food diaries were distributed per school. From these, 49 food diaries were returned with only one or two day food diary entries. Sixteen subjects forget or lost the food dairies and seven were absent on several occasions when the diaries were being collected. Therefore, complete food diaries were obtained from one hundred and eighty subjects (71%) who were interviewed and also attended the clinical dental examination. There were 92 boys (51.1 %) and 88 girls (48.9 %). The mean age of the 180 children was 12.3 years (SD± 0.29). The mean weight of all the children was 42.82 kg (SD± 9.06). The food dairy completion with dietary interview started in the first week of October 2007 and ended in the first week of January 2008.

8.5.2 Validation of dietary data

The mean BMR for the 92 boys was 5.96 (SD± 0.68) and 5.25 (SD± 0.49) for the 88 girls. The mean PAL for the sub-sample (n = 180) was 1.3 (SD± 0.32). The mean PAL for the boys was 1.2 (SD±0.32) and 1.3 (SD±0.29) for girls, suggesting that the boys were under-reporters and the girls indentified as normal-reporters. Eighty three subjects (46%) of the sub-sample were classified as under-reporters; 51 boys, (55% of the boys) and 32 girls, (36% of the girls).

8.5.3 The daily energy intake and the macronutrients consumption by the sub-sample study population

A one-Sample Kolmogorov test showed that data for intake of protein, fat, carbohydrate and starch were normally distributed. Data for these food components are presented as mean, SD, and 95% Confidence Interval (CI) in Table 8.1. The mean daily intakes of carbohydrate, fat and protein were 237 (SD±51), 58 (SD±17) and 65 grams/day (SD±16), respectively. The mean daily energy intake was 1675 kcal (SD±368), (7060 kJ (SD±1548)). Carbohydrate made the major contribution to this daily food intake (54%), followed by fat (30.3%) and protein (15.7%). Starch comprised most of the carbohydrate intake and contributed 32.8% to the daily energy intake (Table 8.1).

Data for intake of total sugars, IMS, and NMES were also normally distributed. Data are presented as mean, SD, and 95% Confidence Interval (CI) in Table 8.2. Total sugars contributed 20.4% of the daily energy intake, mainly in the form of NMES 12.6%, while IMS were 7.8%.

The mean daily intake of total sugars was 90 grams/day (SD±32), mainly in the form of NMES (56grams/day (SD±26)) with 34 grams/day (SD±18) in the form of milk and intrinsic sugars. Non-milk extrinsic sugars in snacks contributed 22.7% to the daily energy intake from snacks, while from meals they contributed 7.5 % of the daily energy intake (Table 8.2).

Table 8.1: Mean, standard deviation (SD), median, minimum, maximum and 95% (CI) Confidence Intervals for daily energy intake, daily intake and percentage contribution of fat, carbohydrate and protein for the sub-sample of 180 subjects based on a 3-day food diary.

	Mean	SD	Median	Minimum	Maximum	95% CI
Energy intake(kcal/day)	1675	368	1620	974.2	2786.6	1620, 1729
Energy intake (kJ/day)	7060	1548	6837	4111.5	11718.7	6832, 7288
Carbohydrate (g/day)	237.2	51.0	230.4	145.7	402.5	229.7, 244.7
% energy from carbohydrate	54.0	4.7	54.5	41.4	64.3	53.3, 54.7
Protein (g/day)	64.8	15.8	63.2	36.7	130.9	62.8, 67.8
% energy from protein	15.7	2.2	15.8	10.9	21.0	15.4, 16.1
Fat (g/day)	58.2	17.3	56.3	27.1	129.9	55.6, 60.7
% energy from fat	30.2	4.6	29.7	20.9	44.2	29.6, 30.9

Table 8.2: Mean, standard deviation (SD) and 95% CI for daily intakes of total sugars, IMS, NMES, percentage contribution of total sugars to energy intake, percentage contribution of IMS and NMES to total sugars, percentage contribution of snacks and meals to NMES for the sub-sample of 180 subjects based on a 3-day food diary.

	Mean (SD)	95% CI for mean Lower Upper
Total sugars (g/day)	90.3 (31.9)	85.4, 94.8
IMS (g/day)	34.3 (18.0)	31.6, 36.9
NMES (g/day)	56.0 (25.6)	52.1, 59.6
% of total energy from:		
Total sugars	20.4 (5.5)	19.5, 21.2
IMS	7.8 (3.8)	7.2, 8.4
NMES	12.6 (4.7)	11.8, 13.2
% of total energy from NMES (snacks)	22.7 (9.9)	28.6, 24.1
% of total energy from NMES (meals)	7.5 (4.2)	6.8, 8.0

8.5.4 The consumption of acidic dietary items

A one-Sample Kolmogorov-Smirnov test showed that data relating to the consumption of acidic foods, drinks and confectionery items were not normally distributed.

Data are presented as median and interquartile range (IQR). The median daily intake of total acidic items was 203 grams/day (IQR 114.5-355.7). Acidic drinks were the main source of dietary acids, with a median daily intake of 145 gram/day (IQR 66.7-266.7).

The median daily intake of acidic food was 58 gram/day, with a median daily consumption of fresh fruits (excluding fruit juices) of 10 grams/day (IQR 4.5-15.4). The median daily intake of acidic confectionery was 11 grams/day (IQR 6.1-18.9) (Table 8.3).

Total acidic intake represented a median of 2.8% (IQR 1.7-5) of the daily energy intake from snacks and a median of 3.3% (IQR 1.6-4.7) of the daily energy intake from meals. The median intake of total acidic intake with meals was 104 grams/day (IQR 33.8-176.7), and with snacks it was 83 gram/day (IQR 3.0-200) (Table 8.3).

Table 8.3: Mean, standard deviation (SD), median, minimum, maximum and interquartile range (IQR) for the daily energy intake, total acidic foods, total acidic foods with meals and as snacks, acidic drinks, fruits and confectionery for the sub-sample of 180 subjects based on data from the 3-day food diary.

	Mean	SD	Median	Minimum	Maximum	IQR
Acidic drinks (g/day)	188.0	164.5	145.5	0.0	793.3	66.7-266.7
Energy (kJ) from acidic drinks	248.6	150.7	252.8	3.9	574.2	160-330
Fruits (g/day)	12.0	8.6	10.2	2.2	50.5	4.5-15.4
Confectionery (g/day)	13.6	10.0	11.4	0.4	51.5	6.1-18.9
Energy (kJ) from acidic food	220.9	62.7	210.9	27.1	568.8	189.6-252
Total intake of acidic items (g/day)	246.5	187.8	203.3	0.0	966.7	114.5-355
Energy (kJ) from total acidic foods	421.8	355.8	330.0	3.9	2194.5	189.6-565
Total intake of acidic items with meals (g/day)	120.8	112.6	104.3	0.0	560.0	33.8-176.7
% Energy (kJ) intake from total acidic foods consumed with meals	3.6	2.5	3.3	0.1	14.9	1.6-4.7
Total intake of acidic items as snacks (g/day)	125.8	131.5	83.3	0.0	674.0	3.0-200.0
% Energy (kJ) intake from total acidic foods consumed as snacks	3.6	2.8	2.8	0.1	16.2	1.6-5.0

8.5.5 Gender and consumption of macronutrients

The data showed the mean daily intakes of protein, fat, carbohydrate and intrinsic-milk sugars were higher in boys than girls while the mean daily intakes of total sugars and non-milk extrinsic sugars were higher in girls. The mean (SD) daily intake of carbohydrate was 237.7 g/day (51.5) and 236.7g/day (50.7) for boys and girls respectively. This difference was not significant (p= 0.899). The mean (SD) daily intake of NMES was 54.3 g/day (24.3) and 57.5 g/day (26.9) for boys and girls, respectively. This difference was not statistically significant (p= 0.465). The mean (SD) daily total sugars intake for boys was 89.7g/day (30.5) and 90.7g/day (33.4) for girls. This difference was not significant (p= 0.824) (Table 8.4).

The mean (SD) daily energy intake for boys was 1686kcal/day (392.8) and 1663kcal/day (342.5) for girls. This difference was not statistically significant (p= 0.465).

Table 8.4: Mean, standard deviation (SD) and 95% Confidence Intervals for daily energy intake and daily intake of macronutrients for the sub-sample of 180 subjects by gender.

	Boys (n = 92)			Girls (n = 88)		
	Mean (SD)	**Median**	**95% CI**	**Mean (SD)**	**Median**	**95% CI**
Energy intake (kcal/day)	1686 (392.8)	1641	1605, 1767	1663 (342.5)	1615	1590, 1735
Energy intake (kJ/day)	7107 (1650)	6931	6765, 7448	7011 (1442)	6809	6705, 7317
Protein (g/day)	65.8 (17.7)	63.3	62, 69.4	64.9 (16.2)	63.1	61.4, 68.3
Fat (g/day)	59.1 (19.1)	56.2	55.1, 63	57.3 (15.4)	56.3	54.0, 60.5
Carbohydrate (g/day)	237.7 (51.5)	231	227, 248.3	236.7 (50.7)	227	225.9, 247
Total sugars (g/day)	89.7 (30.5)	87.8	83.3, 95.9	90.7 (33.4)	87.5	83.6, 97.7
NMES (g/day)	54.3 (24.3)	49.5	45.3, 59.3	57.5 (26.9)	52.5	51.7, 63.1
IMS (g/day)	35.3 (19.3)	30.5	31.3, 29.7	33.3 (16.7)	31.5	29.7, 36.7
Total intake of acidic items(g/day)	244 (197.8)	203.7	203, 285	249 (177.9)	202	211, 286
Acidic drinks (g/day)	188.6 (175)	133.3	152, 224	187 (153.7)	176.7	154, 219
All confectionery (g/day)	13.2 (10.2)	8.1	7.6, 17.7	17.5 (10.0)	17.1	12.2, 22.6
Total intake of acidic items with meals (g/day)	119.3 (118)	77.8	94.9, 143.8	122.3 (107)	110	99.6, 145
Total intake of acidic items as snacks (g/day)	125.1 (134)	78.2	97.3, 152.9	126.5 (129)	84.7	99, 153.9

8.5.6 Gender and consumption of acidic dietary items

The data showed the mean daily intake of total intake of acidic items, acidic drinks and acidic confectionery intake were higher in girls than boys (Table 8.4). The mean (SD) daily intake of total intake of acidic items for boys was 244 g/day (197.8) and 249 g/day (177.9) for girls. Mann-Whitney test showed that there was a statistically significant difference in the mean total daily intake of acidic items between boys and girls (p= 0.015). The mean (SD) daily intake of acidic drinks for boys was 188 g/day (175) and 187g/day (153.7) for girls, respectively. The mean daily intake of acidic confectionery for boys was 13.2g/day (10.2) and 14g/day (10.0) for girls, respectively. There were no statistically significant gender differences for daily acidic drinks and confectionery intakes (Mann-Whitney test). When the mean daily total intake of acidic items was compared by eating event and gender; the mean daily intake of total intake of acidic items with meals for the boys (119 g/day) was less than girls (122 g/day). The mean daily total acidic foods intake as snacks for boys (125 g/day) was also less than girls (126 g/day), respectively. These differences were not statistically significant (Table 8.4).

8.5.7 Water and fluoride

8.5.7.1 Tap water

Out of 180 subjects, 153 subjects (85%) consumed tap water. Mean daily tap water intake was 0.34 litres (SD±0.27). The mean frequency of tap water intake was 2.5 times a day and ranged between 0.3 and 7 times a day. The overall mean daily fluoride intake from tap water was 0.26 mg (SD±0.165), while the mean fluoride intake from tap water was 0.29 mg (SD±0.188), 0.25 mg (SD±0.204), and 0.25 mg (SD±0.189) for the first, second and third day of the food diaries respectively. The mean total fluoride intake from tap water consumed by child over 3 days was 0.80 mg (SD±0.495) (Table 8.5).

8.5.7.2 Bottled water

Out of 180 subjects, 56 subjects (31%) consumed bottled water and the mean daily intake for subjects who consumed bottled water was 0.09 litres (SD±0.19). The mean frequency of bottled water intake was 1.8 times a day and ranged between 0.3 and 8.7 times daily. The mean daily fluoride intake from bottled water consumed was 0.08 mg (SD±0.087). The mean fluoride intakes from bottled waters were 0.10 mg (SD±0.117), 0.07 mg (SD±0.103) and 0.06 mg (SD±0.091) for first, second and third day respectively. The mean total fluoride intake from bottled water consumed by children who drank bottled water over 3 days was 0.25 mg (SD±0.260) (Table 8.6).

8.5.7.3 Tap and bottled water

Mean daily intake of water (tap and bottled) by the total number of the sub-sample (180 subjects) was 0.43 litres. The mean daily fluoride intake from water was 0.24 mg (SD±0.164). The mean fluoride intake from water over three days was 0.74 mg (SD±0.493). The mean fluoride concentration of water consumed was 0.57 mg/litre (SD±0.205) (Table 8.7).

The number of children who just consumed tap only, bottled only and both water (tap and bottled) were 119 (66%), 22 (12%) and 34 (19%), respectively.

Table 8.5: Mean, standard deviation (SD), median and range of fluoride intake over 3 days, daily fluoride intake, fluoride concentration, daily intake of tap water, intake of tap water over 3 days and daily frequency intake of tap water for the 153 subjects in the sub-sample consuming tap water.

N = 153 subjects	Mean (SD)	Median	Range
Total fluoride intake from tap water over 3 days (mg)	0.80 (0.49)	0.73	0.07-2.69
Daily fluoride intake from tap water (mg)	0.26 (0.16)	0.24	0.02-0.90
Fluoride concentration of tap water (mg/litre)	0.66 (0.11)	0.67	0.29-1.10
Volume of tap water intake over 3 days (litre)	1.00 (0.80)	0.88	0.0-3.23
Daily tap water intake (litre)	0.34 (0.27)	0.29	0.0-1.08
Daily frequency of tap water intake (no. of intakes)	2.5 (1.49)	2.33	0.33-7.0

Table 8.6: Mean, standard deviation (SD), median and range of the fluoride intake over 3 days, daily fluoride intake, fluoride concentration of bottled water, intake of bottled water over 3 days, daily bottled water intake and daily frequency of bottled water intake for 56 subjects in the sub-sample consuming bottled water.

N = 56 subjects	Mean (SD)	Median	Range
Total fluoride intake from bottled water over 3 days (mg)	0.25 (0.26)	0.14	0.01-1.07
Daily fluoride intake from bottled water (mg)	0.08 (0.08)	0.05	0.0-0.36
Fluoride concentration of bottled water (mg/litre)	0.27 (0.16)	0.25	0.05-0.77
Volume of bottled water intake over 3 days (litre)	0.28 (0.56)	0.00	0.0-3.56
Daily bottled water intake (litre)	0.09 (0.19)	0.00	0.0-1.19
Daily frequency of bottled water intake (no. of intakes**)**	1.80 (1.46)	1.67	0.3-8.67

Table 8.7: Mean, (SD), median and range of the fluoride intake over 3 days, daily fluoride intake, fluoride concentration of tap and bottled water, intake of tap and bottled water over 3 days and daily intake for the sub-sample of 180 subjects based on 3-day food diary.

N = 180 subjects	Mean (SD)	Median	Range
Total fluoride intake from tap and/or bottled water over 3 days (mg)	0.74 (0.49)	0.68	0.0-2.69
Daily fluoride intake from tap and/or bottled water (mg)	0.24 (0.16)	0.22	0.0-90.0
Fluoride concentration of tap and bottled water (mg/litre)	0.57 (0.20)	0.61	0.0-1.10
Volume of tap and bottled intake water over 3days (litres)	1.29 (0.75)	1.23	0.0-3.76
Daily tap and bottled water intake (litre)	0.43 (0.25)	0.41	0.0-1.25

8.5.8 Prevalence of dental erosion in the sub-sample

Of the 180 subjects, 70 (38.9%) had experience of dental erosion. There were 110 subjects (61.1%) had no evidence of dental erosion.

A higher experience of erosion was observed amongst girls than boys, but this difference was not statistically significant (Fisher's exact test; p= 0.647) (Table 8.8).

Table 8.8: Significance of association (P) between the number (N) and proportion (%) of subjects with or without experience of dental erosion in the sub-sample and gender.

Experience of dental erosion									
Gender	**Girls**			**Boys**			**Both**		
	Yes	**No**	**Total**	**Yes**	**No**	**Total**	**Yes**	**No**	**Total**
No. of subjects	36	52	88	34	58	92	70	110	180
%	40.9	59.1	100.0	37.0	63.0	100.0	38.9	61.1	100.0

Fisher's exact test; p= 0.647 OR= 1.18 (95% CI 0.65, 2.15)

8.5.9 Prevalence of dental caries of the sub-sample

Of the 180 subjects, 111 (61.7%) had experience of dental caries. There were 69 subjects (38.3%) had no evidence of dental caries.

A higher experience of caries was observed amongst boys than girls. This difference was statistically significant (Fisher's exact test; p= 0.047) (Table 8.9).

Table 8.9: Significance of association (P) between the number (N) and proportion (%) of subjects with or without experience of dental caries in the sub-sample and gender.

Experience of dental caries									
Gender	**Girls**			**Boys**			**Both**		
	Yes	**No**	**Total**	**Yes**	**No**	**Total**	**Yes**	**No**	**Total**
No. of subjects	61	27	88	50	42	92	111	69	180
%	69.3	30.7	100.0	54.3	45.7	100.0	61.7	38.3	100.0

Fisher's exact test; p= 0.047 OR= 1.90 (95% CI 1.03, 3.50)

8.5.10 Erosion and its association with acidic drinks and foods

The mean total acidic items and acidic drinks intakes for subjects with and without dental erosion were similar. In addition, subjects with erosion had a similar acidic fruit and acidic confectionery intakes when compared with subjects without erosion ($p> 0.5$) (Table 8.10).

8.5.11 Erosion and its association of drinking water consumption

Subjects with and without dental erosion had similar mean daily fluoride intakes from tap, bottled and both tap and bottled water and similar mean daily volume intakes of tap, bottled and both tap and bottled water ($p>0.5$). In addition, there were no statistically significant associations between fluoride concentration of tap, bottled and both tap and bottled water and experience of dental erosion (Table 8.11).

8.5.12 Dental caries and sugared-acidic drinks and foods

The majority of subjects (61.7%, 111) had experience of dental caries whilst 38.3% (69) had no evidence of caries. Subjects with and without dental caries had similar total acidic items, acidic drinks, fruit, acidic confectionery, total sugars and Non-Milk Extrinsic Sugars (NMES) intakes. The associations were not statistically significant (Table 8.12).

8.5.13 Caries and its association of drinking water consumption

Subjects with and without dental caries had similar mean daily fluoride intakes from tap and both tap and bottled water and similar mean daily volume intakes of tap and both tap and bottled water ($p>0.5$), but there were statistically significant positive associations between dental caries and mean daily fluoride intake and mean daily volume intakes of bottled water ($p<0.05$). There were no statistically significant associations between fluoride concentration of tap, bottled and both tap and bottled water and experience of dental caries (Table 8.13).

Table 8.10: Daily total acidic intake, acidic drinks, fruit, confectionery: comparison of Libyan children (n = 180 subjects, based on a 3-day food diary) with (n = 70, 38.9%) and without dental erosion experience (n = 110, 61.1%) and mean, standard deviation (SD), mean difference, 95% Confidence Intervals (CI) of the mean difference, median, interquartile range (IQR) and significance of difference (P) between the median daily intakes of these items.

	Experience of erosion (n = 180)	Mean	SD	Mean difference	95% CI of the mean difference[1] Lower Upper	Median	IQR	P[2]
Total acidic intake (g/day)	Yes	207	196	-1.9	-65.9, 62.11	194	342	0.639
	No	206	221			162	333	
Acidic drinks (g/day)	Yes	183	156	7.16	-42.6, 56.91	165	200	0.966
	No	190	170			137	220	
Acidic fruits (g/day)	Yes	6.69	6.69	1.07	-1.62, 3.77	4.53	11	0.809
	No	7.77	10.11			4.53	12	
Acidic confectionery (g/day)	Yes	10.35	9.66	1.57	-1.59, 4.73	8.02	9.60	0.434
	No	11.92	10.97			9.32	16.69	
Total sugars (g/day)	Yes	93.23	31.02	-5.01	-14.62, 4.60	90.20	44.00	0.167
	No	88.22	32.38			83.49	43.48	
NMES (g/day)	Yes	55.82	24.81	0.07	-7.66, 7.81	50.49	33.27	0.810
	No	55.89	26.17			51.13	31.23	

[1]The 95% CI was presented to help with the visualisation of the distribution of the data [2]Mann-Whitney U test for difference between medians

Table 8.11: Intake of tap, bottled and all waters and daily intake of fluoride from these waters and fluoride concentration: comparison of Libyan children (n=180 subjects, based on 3-day food diary data) with (n=70, 38.9%) and without erosion experience (n= 110, 61.1%) and mean, standard deviation (SD), mean difference, 95% confidence intervals (CI) of the mean difference, median, interquartile range (IQR) and significance of difference (P) between the median daily intakes of these items.

	Experience of erosion (n=180)	Mean	SD	Mean difference	95% CI of the mean difference[1] Lower Upper	Median	IQR	P[2]
Daily fluoride intake from tap water (mg)	Yes	0.21	0.17	0.01	-0.04, 0.07	0.18	0.25	0.843
	No	0.23	0.19			0.19	0.26	
Daily fluoride intake from bottled water (mg)	Yes	0.03	0.06	0.002	-0.02, 0.02	0.00	0.01	0.709
	No	0.03	0.07			0.00	0.02	
Daily fluoride intake from tap and bottled water (mg)	Yes	0.24	0.15	0.02	-0.03, 0.07	0.23	0.22	0.680
	No	0.26	0.17			0.23	0.21	
Daily volume intake of tap water (litre)	Yes	0.33	0.27	0.02	-0.07, 0.09	0.26	0.35	0.699
	No	0.34	0.27			0.30	0.37	
Daily volume intake of bottled water (litre)	Yes	0.09	0.18	0.002	-0.05, 0.06	0.00	0.11	0.699
	No	0.09	0.19			0.00	0.11	
Daily volume intake of tap and bottled water (litre)	Yes	0.42	0.25	0.02	-0.06, 0.09	0.39	0.30	0.399
	No	0.43	0.24			0.42	0.33	
Fluoride concentration of tap water (mg/litre)	Yes	0.57	0.29	-0.04	-0.12, 0.05	0.65	0.18	0.641
	No	0.53	0.29			0.64	0.24	
Fluoride concentration of bottled water (mg/litre)	Yes	0.09	0.17	0.008	-0.04, 0.06	0.00	0.09	0.761
	No	0.09	0.17			0.00	0.15	
Fluoride concentration of tap and bottled water (mg/litre)	Yes	0.58	0.19	-0.02	-0.08, 0.04	0.62	0.21	0.616
	No	0.56	0.21			0.61	0.30	

[1]The 95%CI was presented to help with the visualisation of the distribution of the data [2]Mann-Whitney U test for difference between medians

Table 8.12: Daily total acidic intake, acidic drinks, fruit, confectionery, total sugars and NMES: comparison of Libyan children (n = 180 subjects, based on a 3-day food diary) with (n = 111, 61.7%) and without caries experience (n = 69, 38.3%) and mean, standard deviation (SD), mean difference, 95% Confidence Intervals (CI) of the mean difference, median, interquartile range (IQR) and significance of difference (P) between the median daily intakes of these items.

	Experience of caries (n = 180)	Mean	SD	Mean difference	95% CI of the mean difference[1] Lower Upper	Median	IQR	P
Total acidic intake (g/day)	Yes	202	205	10	-53.24, 75.10	180	336	0.913[2]
	No	213	222			182	347	
Acidic drinks (g/day)	Yes	183	157	12.9	-36.94, 62.79	150	176	0.819[2]
	No	195	176			141	243	
Acidic fruits (g/day)	Yes	7.07	7.49	0.789	-1.91, 3.49	6.39	12.47	0.597[2]
	No	7.83	10.89			4.16	11.06	
Acidic confectionery (g/day)	Yes	12.27	11.43	-2.51	-5.67, 0.64	10.16	16.58	0.270[2]
	No	9.76	8.59			7.58	12.40	
Total sugars (g/day)	Yes	90.07	32.79	0.262	-9.40, 9.93	87.08	50.54	0.957[3]
	No	90.33	30.56			88.08	35.62	
NMES (g/day)	Yes	56.11	25.91	-0.643	-8.40, 7.11	51.26	31.21	0.870[3]
	No	55.47	25.22			48.75	32.22	

[1]The 95% CI was presented to help with the visualisation of the distribution of the data [2]Mann-Whitney U test for difference between medians [3]Linear association exact test

Table 8.13: Intake of tap, bottled and all waters, intake of fluoride from these waters and fluoride concentration: comparison of Libyan children (n = 180 subjects based on 3-day food diary data) with (n = 111, 61.7%) and without caries experience (n = 69, 38.3%) and mean, standard deviation (SD), mean difference, 95% Confidence Interval (CI) of the mean difference, median, Interquartile range (IQR) and significance of difference (P) between the median daily intakes of these items.

	Experience of caries (n = 180)	Mean	SD	Mean difference	95% CI of the mean difference[1] Lower Upper	Median	IQR	P[2]
Daily fluoride intake from tap water (mg)	Yes	0.23	0.18	-0.02	-0.08, 0.03	0.22	0.27	0.344
	No	0.21	0.18			0.00	0.00	
Daily fluoride intake from bottled water (mg)	Yes	0.03	0.07	-0.01	-0.03, 0.005	0.00	0.02	0.044*
	No	0.01	0.05			0.00	0.00	
Daily fluoride intake from tap and bottled water (mg)	Yes	0.26	0.16	-0.04	-0.09, 0.01	0.25	0.22	0.064
	No	0.22	0.17			0.19	0.22	
Daily volume intake of tap water (litre)	Yes	0.34	0.27	-0.02	-0.10, 0.06	0.30	0.36	0.699
	No	0.32	0.26			0.29	0.37	
Daily volume intake of bottled water (litre)	Yes	0.12	0.21	-0.05	-0.11, 0.005	0.00	0.13	0.038*
	No	0.06	0.14			0.00	0.00	
Daily volume intake of tap and bottled water (litre)	Yes	0.46	0.26	-0.07	-0.15, 0.003	0.42	0.35	0.104
	No	0.39	0.23			0.39	0.29	
Fluoride concentration of tap water (mg/litre)	Yes	0.54	0.29	0.0002	-0.09, 0.09	0.64	0.23	0.974
	No	0.54	0.28			0.63	0.24	
Fluoride concentration of bottled water (mg/litre)	Yes	0.07	0.18	-0.042	-0.09, 0.008	0.00	0.18	0.051
	No	0.12	0.14			0.00	0.00	
Fluoride concentration of tap and bottled water (mg/litre)	Yes	0.58	0.19	-0.02	-0.09, 0.04	0.61	0.22	0.951
	No	0.56	0.23			0.63	0.32	

[1]The 95% CI was presented to help with the visualisation of the distribution of the data [2]Mann-Whitney U test for difference between median *Statistically significant at p<0.05

8.6 Discussion

8.6.1 The study sample and the aims

Dietary information was collected from a randomly selected sub-sample of 180 12 year-old Libyan schoolchildren. It was beyond the timescale available for the present study to collect detailed dietary information from the total study sample which was 792 subjects. Undertaking dietary assessment on a sub-sample of 180 children gave a 95% power to detect a correlation coefficient of 0.3 assuming a Type 1 error rate of 5%. Boys represented 51% (92) and the girls 49% (88) of the sub-sample study population.

One of the subsidiary aims of the overall study was to investigate any association between the daily intake of acidic foods and drinks and dental erosion in 12 year-old schoolchildren in the sub-sample in Benghazi, Libya. The aim of the food diary assessment was to estimate the daily intake (g/day) of total intake of acidic foods and drinks. It also aimed to assess the daily total intake of acidic items according to eating events (i.e. with meals or as snacks) and to estimate daily energy intake and total weight of acidic items consumed as meals and snacks, daily intake of total sugars, NMES, IMS, protein, fat, carbohydrate. In addition, the food diary was used to estimate the daily intake (litres) of, and fluoride intake (grams) from the drinking water (tap, bottled and both) and frequency of water consumption and to investigate any gender differences in the daily intake of the above stated macronutrients and acidic items.

8.6.2 Limitations of the study

There is no perfect method of dietary assessment. The three-day dietary diary has its limitations as do other methods used to collect the dietary information, which mainly relate to reduced accuracy in the data collected. The dietary data collected by a 3-day dietary diary is less accurate than dietary data collected by a weighed food diary. Co-operation of the respondent is required, to record the detailed dietary information and not to change the dietary habits during the recording time (Anderson, 1995; Walker *et al.*, 2000; Biro *et al.*, 2002). In addition, it is time consuming for the subjects. On the other hand, the three-day food diary provides a good estimate of the mean intake of a group (Hackett *et al.*, 1983), and this information was needed in the study. The three-day food diary is a relatively low cost method and causes less disturbance to the subjects' daily activities when compared with other methods such as a weighed food diary. However, many studies have recorded the daily frequency of selected foods and drinks consumption using a food frequency questionnaire (FFQ) (Hinds and Gregory, 1995; Walker *et al.*, 2000). The FFQ method gives the estimation of the frequency of foods and drinks for a limited number of food items only, and for this reason, it may not sensitive enough to look at the total daily frequency of foods and drinks intake and it could not give information on time of consumption and whether intakes were associated with meals or snacks. Moreover, the three-dietary dairy provides more accurate information about the frequently, quantity, time and pattern of consumption of foods and drinks and does not rely on memory, as other methods such as the 24 hour dietary recall do (Anderson, 1995).

It was challenging and time consuming in respect of the arrangement for transportation of the water sample tubes from UK to Benghazi, then import these materials to Benghazi and finally, transportation of the water samples from Benghazi to UK and securing the permissions from the Libyan authorities, the Food Standards Agency and Newcastle University in the UK to allow the importation of water samples.

8.6.3 Validation of the dietary data

Overall, the mean physical activity level (PAL) for all the subjects was 1.3, suggesting good or normal reporters. The mean PAL for girls was 1.3, suggesting that they were normal-reporters (Torun *et al.*, 1996), while the mean PAL for boys was 1.2, suggesting that they were under-reporters (Torun *et al.*, 1996). In a repeated UK survey, in 2000, PAL for girls and boys was reported as 1.38 which was still higher than present figure (Fletcher *et al.*, 2004b). However, when comparison was made of mean daily intakes of macronutrients along with the percentage of dietary energy derived from them and the subjects who classified as under-reporters (boys) and good-reporters (girls), found that the mean daily intake of total sugars and NMES, and the main contribution of total sugars and NMES to energy intake were slightly lower in the under-reporters than good-reporters. The mean daily intake of total acidic foods was significantly lower in under-reporters than normal-reporters. A repeated cross-sectional survey which investigated the changes of macronutrient intake and body mass index in 11-12 year-old children in Northumberland for 1980, 1990 and 2000 found, the percentages of boys with PAL below 1.1 were 6%, 15% and 23%, respectively, for girls 3%, 14% and 18%, respectively (Fletcher *et al.*, 2004b).

There are many reasons which may be responsible for the under-reporting. It is difficult to assess the food portion size correctly as the method relies on the participant and they were required to recognise and describe quantities in terms of proportions and units. It is also difficult to record all the dietary details and record the small weight products like sugar in a piece of chewing gum. Co-operation and interest of the subjects are necessary to recall all these small dietary items. Subjects may not record the actual intake from foods especially unhealthy or sugary foods or may purposely omit or not record as consumed as it is known these foods should not be consumed frequently. These subjects were outliers. A UK dietary survey using a weighed food intake diary found that over-reporting was not very common, but under-reporting the intake of NMES was a problem amongst 15-18 year-old girls (Gregory *et al.*, 2000). Under-reporting is more common in overweight than in normal weight subjects (Aeberli *et al.*, 2007). Recording reliability decreases over time and the number of omitted foods increases due to participant fatigue (Anderson, 1995; Biro *et al.*, 2002). In addition, some of the participants may have change of their diet diary intake during the period of recording (Walker *et al.*, 2000). However, there seems to be no reason to believe that under-reporting or over-reporting would have been biased towards subjects with or without erosion.

8.6.4 Dietary interviews

Subjects were interviewed one by one in any available free place within the schools. The use of domestic measures, such as different sizes of plates, cups and spoons helped the subjects to estimate the food portion sizes and give clear dietary information. The subjects were asked if there had been any changes in their dietary habits during the recording period. The most common reason for changing their diet was attendance at parties. When the subjects were asked if they usually had the food diary with them during the 3-day period, majority claimed the food diary was with them all the time and this could be confirmed by different patterns of handwriting and different pens used in the recording in the food diaries which suggested its completion at different times. Some subjects claimed they did not take the food dairy with them out of the house all the time, but they completed it immediately after returning home which may have affected the accuracy of data collected.

8.6.5 Dietary analysis

It is important to highlight that many of the foods and drinks consumed by the Libyan children were the same as those available in the UK. In addition, the pre-existing database available in the UK allowed for the categorisation of foods and drinks according to their acidic content, which was an essential part of the present dietary analysis. The selection of best matches for the Libyan foods within the UK food tables was possible, since the present analysis focused on energy and macronutrients, and did not measure micronutrients intake which may have been different between the foods. A study in the UK considered that definition as a meal required the meeting of at least three of the following criteria: a number of items eaten together and consisting at least three items, making a major contribution to the energy intake for that day, eaten at recognised mealtimes, usually be consumed over a period of more than 15 minutes (Fletcher, 2003). The categorisation of meals and snacks adopted in the present study was similar to this in most aspects, but also considered the general lifestyle of Libyan children in Benghazi. Some subjects skipped breakfast at home and when asked about it, those children said that they did not feel hungry when woke up or they were late at school time and no time to have their breakfast. Schoolchildren attend schools from 8am in the morning, and usually have their breakfast at home (usually a light food intake) and took their meal with them in a lunch box or bought their foods from school canteens. They had their meal at the school break time of 10:30pm. The light food consumed at home was considered as a snack and the food consumed in schools at break time 10:30am was considered as their first meal (breakfast). When they returned home from school between 1 and 3 pm they consumed the main meal of day which was lunch. They consumed dinner between 6 and 9 pm. In the present study no information was collected regarding where the food was consumed. All foods consumed by the subject were considered as consumed at home. Consequently, as a result of the differences in the dietary patterns, the meals and snacks in this study were not only based on the usual mealtimes (breakfast, lunch and dinner) but also the contribution to the daily energy intake from each food and drink consumption.

The analysis of the dental examination data from the present sub-sample seemed to confirm that it was representative of the study sample population. Over one third of the subjects had experience of dental erosion, which was higher amongst girls, whilst approximately two thirds had experience of dental caries, which was also higher amongst girls, following the same trend observed for the whole study population. Comparing the experience of dental erosion and caries in the sub-sample was found, 38.9% of the subjects had experience of dental erosion, whilst the majority 61.7% had experience of dental caries, following the same trend observed for the whole study population. In addition, results from questionnaire support the findings of the estimated food diary.

Obtaining general dietary information from the subjects, which is essential to provide a basis for dietary counselling requires analysis of the macronutrient intake by the subjects and estimate of the daily energy intake. In the present study, the daily energy intake (EI) observed for the sub-sample of 180 children was 1675 kcal/day; 1686 kcal/day (SD± 392.8) for boys and 1663 kcal/day (SD± 342.5) for girls. These figures were lower than the UK Estimated Average Requirement (EAR) for 11-14 year-olds of 2214 kcal/day for boys and 1892 kcal/day for girls (Department of Health, 1991). Similarly, the daily energy intakes found in the present study were lower than those observed for 74 6-14 year-old Swiss boys; 1951 kcal/day, but similar to the 1687 kcal/day, for girls, but it is important to highlight that different methodologies were used to collect dietary information in the two studies, since in the Swiss study, 24-hour recall and one 1-day food record were used and different age groups (Aeberli *et al.*, 2007). In a study carried out to assess the dietary intake for 11-16 year-old children in Switzerland through a 3-day food diary, the mean daily energy intake was 8025 kJ for girls and 9350 kJ for boys (Decarli *et al.*, 2000). These results were also higher than the present study (7011 kJ for girls and 7107 kJ for boys), and again with considering the different age groups used. The mean energy intakes of children in this study were slightly lower than that found for 424 11-12 year-old children in South Northumberland, UK; by means of two 3-day estimated dietary records, boys 8.45 MJ and girls 7.60 MJ (Zohouri *et al.*, 2004). The present results might be due to variability in the subjects' estimation of portion sizes which might have contributed to under-reporting, which is likely to occur when working with dietary assessment (Gregory *et al.*, 2000), or may have been due to the difficulty in accurate measuring of dietary intake, particularly in children (Aeberli *et al.*, 2007), or perhaps they just ate less. However, it has to be considered that the national average included different age groups and variations exist in dietary intakes between ages. In addition, different methodologies were used to collect the dietary data.

The contribution of daily energy intake for the carbohydrates (54%) represented the major source of energy intake for the Libyan children, followed by fat (30.3%) and protein (15.7%). This contribution to energy intake from macronutrients seemed to be in line with the general guidelines for food consumption; for carbohydrate (between 55% and 75%), fat (between 15% and 30%), protein (between 10% and 15%) (WHO, 2003). In the present study, the daily intakes of carbohydrate, fat and protein were for boys; 237 g/day, 59 g/day and 65 g/day respectively, and for girls were 236 g/day, 57 g/day and 64 g/day respectively. When these results were compared with the Swiss study, it found that they were lower than the daily intake of carbohydrate and fat (243 g/day, 77 g/day, respectively), but they were above the daily intake of protein (62 g/day) for Swiss boys. For girls, the results were different; the daily intakes of carbohydrate and protein for Swiss girls (212 g/day, 53 g/day, respectively), were lower than in the present study, but the daily intake of fat (68 g/day) was greater (Aeberli *et al.*, 2007). When the results of the present study were compared with a UK survey in 424 11-12 year-old children in Northumberland who completed two 3-day food diaries higher figures were found for the daily intake of carbohydrate, fat and protein, for boys (277 g/day, 79 g/day and 62.5 g/day) and for girls (249 g/day, 72.7 g/day and 53.6 g/day), respectively (Fletcher *et al.*, 2004b).

The mean daily intake of total sugars in the present study was approximately 90 grams/day which was lower than that reported in a Brazilian study (143 grams/day) of 14 year-olds (Auad, 2006). With highlights the different age groups in both studies but similar methods used. When the contribution to the daily energy intake from sugars was assessed, it was found that the total sugars contributed to 20% of the daily intake amongst 12 year-old Libyan schoolchildren, and this was slightly lower than the 23% found in a UK study (Hackett *et al.*, 1984) and 22.8% found in the Brazilian study (Auad, 2006). The present study showed the mean daily intake of NMES for all subjects to be 56 grams/day. Extrapolation of this figure could produce an estimate of mean NMES intake to be 20.4 kg/year which is higher than the

WHO recommendation of no more than 15 kg/year/person (WHO, 2003). On the other hand, the daily intake of NMES in the present study was lower than figures from a repeated UK survey, 1980 (80g), 1990 (90g) and 2000 (82g) (Fletcher *et al.*, 2004b) and half the intake estimated (111grams) in the Brazilian study (Auad, 2006). The NMES intake in this study was the major contributor to the total sugars consumption amongst Libyan children (12.6%), which was higher than the Dietary Reference Value (DRV) for daily energy intake from NMES (6-10%) (Department of Health, 1991; WHO/FAO, 2003), but it was lower than the 17.7% found in the Brazilian study (Auad, 2006) and lower than the figure 16% in UK survey (Fletcher *et al.*, 2004b). The mean daily intakes of NMES and IMS respectively, in present study, were for the 92 boys, 54 g/day (SD±24) and 35 g/day (SD±19) while for the 88 girls the intakes were 57 g/day (SD±26) and 33 g/day (SD±16), respectively. These intakes were lower than those found in the National Diet and Nutrition Survey (NDNS) of young people aged 4-18 years in which NMES intake was 85 g/day (SD±38) in boys and 69 g/day (SD±29) in girls and the mean contribution to daily energy intake was 17% (Gregory *et al.*, 2000). These differences might be due to the different methodologies used (NDNS used 7-day weighed food diary), the accurate measuring dietary intake is difficult due to under-reporting, and the different number and age of subjects that participated in the studies. In addition, the access to certain foods such as dietary sugars might be easier and less expensive than other constituents of diet. However, it is less interesting to find out that the results of the present study showed children consumed higher than the Dietary Reference Value (DRV) for NMES which is 40-55 g/day and higher than the daily energy intake (6-10%) (Department of Health, 1991; WHO, 2003). On the other hand, it is a cause of concern that the contribution of NMES to daily energy intake of Libyan subjects was higher at snacks times (23%) than at meal times (8%), when this may cause more damaging effects to the teeth surfaces as salivary flow is low and its buffering capacity is reduced between meals.

The median daily total intake of acidic foods and drinks amongst Libyan children was 203 grams/day (IQR 114.5-355.7); half that found amongst 14 year-old Brazilian subjects (400 grams), although this could be partly due to the difference in age of the subjects, since similar methodologies were used to collect dietary information in the two studies (Auad, 2006).

Acidic drinks were the main source of total dietary acids, with a median daily intake of 145 gram/day (IQR 66.7-266.7) in the present study. This figure was also lower than the one observed in the Brazilian subjects (340 grams) (Auad, 2006). Moreover, this intake much lower than UK National Survey amongst 11-14 year-olds (Walker *et al.*, 2000), which found the mean daily intake of carbonated drinks, concentrated and ready to drink soft drinks, and fruit juices were 240 grams, 352 grams and 54 grams, respectively. With highlights different methodologies and age groups. The median daily consumption of acidic confectionery was 11 grams/day (IQR 6.1-18.9) in the present study, which was above the figure in the Brazilian study (8 grams/day) (Auad, 2006). In the present study, the median daily consumption of fresh fruits was only 10 grams/day (IQR 4.5-15.4) (excluding fruit juices), which is far below the current recommendation. Results from the questionnaire (Section 6.4.3) support the findings of the estimated food diary, as only 6% of the Libyan subjects reported the intake of two to four portions of fruits per day (excluding bananas), and this below the current dietary recommendations of at least five portions of fruits and vegetables per day, 400 grams/day (WHO, 2003) for the prevention of chronic diseases such as heart disease, cancer, diabetes and obesity. However, the questionnaire survey did not include questions about the portion number of vegetables consumed per day and perhaps they ate lots of vegetables. This current recommendation does not pose a significant risk for dental erosion as most vegetables and fruits such as bananas are not erosive. In the present study, the daily intake of fruits was very low, but it seems to be in line with dietary pattern observed for young subjects in other studies. Approximately 14% of 418 14 year-old children in Birmingham never consumed fruit (Al-Dlaigan *et al.*, 2001b). The median daily intake of fruits in this study was lower than the 17 grams/day found in the Brazilian study (Auad, 2006) and much lower than the daily fruit intake observed for 11-14 year-olds in the UK which was 36 grams (Walker *et al.*, 2000). However, studies show that diets remain high in NMES and low in fruit and vegetables (Hinds and Gregory, 1995; Gregory *et al.*, 2000). However, it is difficult to compare between the results of different studies due to the use different methodologies in addition to the different sample numbers and age groups.

8.6.6 Dental erosion and its association with acidic drinks

There were no statistically significant associations between experience of dental erosion and median total acidic items, acidic drinks, fruits and confectionery intakes. These results confirm the findings of a study conducted in Istanbul showing no association between experience of dental erosion and acidic drinks intake (Caglar *et al.*, 2005) and the finding of a Brazilian study showing no statistically association between erosion and total acidic items, confectionery and fruits intakes (Auad, 2006).

However, the present study was cross-sectional and it was difficult to approximate whether it was representative of a long term dietary pattern, which might contribute to a subjects' experience of dental erosion. In addition, since the study population was not fully exposed to the potential risk factors, as the median acidic foods and drinks intakes were low, the present results do not provide sufficient evidence to eliminate a possible association between the consumption acidic foods and drinks and experience of dental erosion.

8.6.7 Caries and its association with sugared-acidic drinks and foods

There was no statistically significant association between subjects with and without experience of caries and mean total sugars, sugared-acidic drinks, fruit, and confectionery and NMES intakes.

The present results are in agreement with some previous studies. A study conducted in Philippines by Yabao *et al.* (2005) to assess the prevalence of caries and sugar consumption among 6-12 year-old children found no statistically significant relationship between sugar intake and dental caries. Another study showed no statistically significant association between fruit consumption and dental caries (Rugg-Gunn *et al.*, 1984). Several cross-sectional epidemiological studies have reported a weaker association between dietary intake and dental caries than may be expected from theoretical considerations. This might be due to the methods used: dietary data obtained from questionnaire or from diet history, covers only one day to some months, whilst caries data accumulates over years (Sudha *et al.*, 2005). Dental caries takes time to develop so it is the diet served years ago that is responsible for disease levels, not current diet, so cross-sectional study need to be interpreted cautiously.

On the other hand, data reported by a review article stated that sugar intake is an important risk factor for dental caries (Burt and Pai, 2001). Several studies reported a relationship between amount of sugars consumed and dental caries (Sreebny, 1982; Rugg-Gunn *et al.*, 1984; Burt *et al.*, 1988; Miyazaki and Morimoto, 1996; Sudha *et al.*, 2005). Burt *et al.* (1988) investigated the association between sugar intake and dental caries in 499 11-15 year-old children in the USA, and found that children who consumed high proportion of sugars had higher increments of proximal caries. A study investigated dental caries and diet of 405 English adolescents aged 11-12 years reported the consumption of 118g of sugars per day, found a significant association between intake of total sugars and dental caries (Rugg-Gunn *et al.*, 1984).

8.6.8 Water consumption

It is a case of concern that the mean frequency of tap water consumption was 2.5 times a day and 1.8 times a day for bottled water. 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 current prevalence of dental caries and erosion. Fluoride concentration of drinking tap water in Benghazi was 0.66 mg/litre and daily fluoride intake from tap was 0.26 mg, and from bottled water was 0.24 mg. The daily volume intake of tap and bottled water was low (0.43 litres), but it 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 and the average daily plain tap water intake for 11-14 year-olds was 94 ml (0.094 litres) (Gregory *et al.*, 2000); approximately third the mean intake of tap water (340 ml) found in the present study. Moreover, in a study which investigated the change in water intake in 11-12 year-old English children using a 3-day food diary it was found that the mean water intake was 225 ml/day (Zohouri *et al.*, 2004), which was approximately half the mean water intake by children in this study (0.43 litres = 430 ml/day).

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 (Teo *et al.*, 1997; Ganss *et al.*, 2001b; Al-Dosari *et al.*, 2004; Bardsley *et al.*, 2004a; Hughes *et al.*, 2004). Subjects in non-fluoridated areas are 1.5 times more likely to have dental erosion compared with subjects in fluoridated areas (Bardsley *et al.*, 2004a). Subjects with dental erosion have been found to drink acidic drinks more frequently and milk and water less frequently than subjects without dental erosion (O'Sullivan and Curzon, 2000a).

In the present study, there were no statistically significant associations between experience of dental erosion and median of daily fluoride intake from tap, bottled, both waters, and daily volume intake of tap, bottled, both waters. 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 (Harding *et al.*, 2003). Fluoride has an effect on erosion; subjects with erosion have been encouraged to use fluoridation measures to reduce erosion progression or to protect their teeth from dental erosion (Teo *et al.*, 1997; Ganss *et al.*, 2001b; van Rijkom *et al.*, 2003; Bardsley *et al.*, 2004b; Ganss *et al.*, 2004; Hughes *et al.*, 2004).

Given that dental caries is preventable, reduction of the amount and frequency of NMES intake, good oral hygiene and exposure to fluoride are still the main causes to attain optimum benefit in dental caries prevention. Dental caries has multifactorial aetiology, looking at one variable in isolation is challenging. Fluoride defends against caries and reduces dental caries by up to 50% in children (WHO, 1994). In the present study, the prevalence of dental caries was 57% which may show that Libyan children did not have much benefit from fluoride or the fluoride was over whelmed by other exposures to sugars. Another study was conducted in Sudan found no association between the fluoride concentration of water and prevalence of dental caries (Ibrahim *et al.*, 1997). This is because although fluoride increase the teeth resistance to dental caries, it does not remove the cause of dental caries which is dietary sugars (WHO, 2003). In a study which investigated the association between dental caries and fluoride it was reported that exposure to fluoride in the first 12 years of life, reduced dental caries experience (Teo *et al.*, 1997). Fluoride increases teeth resistance to dental caries and reduces the prevalence and severity of caries, but these benefits will not achieve without a reduction in free sugars intake. 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; AlDosari *et al.*, 2004) mainly through topical action. 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).

8.7 Conclusions

The aims of this chapter were achieved. The findings have highlighted a number of important findings which were:

8.7.1 In respect of acidic foods and drinks:

- The median daily intake of total acidic items was 203 grams/day; 145 grams/day of which was from acidic drinks and 58 grams/day from acidic foods.
- The median daily energy intake from acidic drinks was 252 kJ/day.
- The median daily energy intake from acidic foods was 210 kJ/day
- The median daily intake of fruits was 10 grams/day.
- The median daily intake of confectionery was 11grams/day.
- The median daily intake of total acidic items with meals was 104 grams/day, and the median percentage contribution to daily energy intake as meals was 3.3%.
- The daily intake of total acidic items with snacks was 83 grams/day, and the median percentage contribution to daily energy intake as snacks was 2.8%.

8.7.2 In relation to dental erosion and the acidic drinks and foods:

- There was no statistically significant association between experience of dental erosion and acidic foods and drinks intakes. However, it is not possible to assess whether the collected dietary data was representative of a long-term dietary pattern, which would potentially contribute to the experience of dental erosion.

8.7.3 In relation to dental caries and the acidic drinks and foods:

- There was no statistically significant association between experience of dental caries and acidic food and drink intakes. However, it is not possible to assess whether the collected dietary data was representative of a long-term dietary pattern, which would potentially contribute to the experience of dental caries.

The subsidiary aims were achieved:

8.7.4 In relation to dietary data:

In respect of dietary sugars:

- The daily intake of total sugars was 90 grams/day (SD±31). The percentage contribution to daily energy intake from total sugars intake was 20.4%.
- The daily intake of NMES was 56 grams/day (SD±25), which was approximately similar to the dietary reference value (DRV) for NMES which is 40-55 grams/day (WHO, 2003). The percentage contribution to daily energy intake from NMES was 12.6%, which was higher the UK Dietary Reference Value (DRV) and WHO global guidelines for daily energy intake from NMES (6-10%) (Department of Health, 1991; WHO/FAO, 2003).
- The daily intake of IMS was 34 grams/day (SD±18). The percentage contribution to daily energy intake from IMS was 7.8%.
- There no association between dental erosion and caries and daily dietary sugar intakes.

In respect of macronutrients:

- The daily intakes of protein, fat and carbohydrate were 65 grams/day (SD±15.8), 58 grams/day (SD±17.3) and 237 grams/day (SD±51.0), respectively.
- The daily energy intake was 1675 kcal/day (SD±368).
- The percentage contribution to daily energy intake from protein, fat and carbohydrate intakes were 16%, 30% and 54%, respectively, which were in accordance with recommendations for daily energy intake from the macronutrients (WHO, 2003).

In respect to tap and bottled water:

- The daily intake from tap, bottled and both water were 0.34 litres (SD±0.27), 0.09 litres (SD±0.19) and 0.43 litres (SD±0.43), respectively.
- The daily fluoride intake from tap, bottled and both water were 0.26 mg (SD±0.16), 0.08 mg (SD±0.08) and 0.24 mg (SD±0.16), respectively.
- The mean frequency of tap and bottled water intakes were 2.5 times/day (SD±1.49) and 1.8 times/day (SD±1.46) respectively.

8.7.5 In respect to gender:

- There was no statistically significant difference between daily macronutrients consumption and gender except for intake of total acidic items with girls consuming more acidic items than boys (p= 0.015).
- The daily energy intake was 1686 kcal/day ((SD±392) for boys and 1663 kcal/day (SD±342) for girls, these figures were lower than the UK Estimated Average Requirement (EAR) for 11-14 year-olds of 2214 kcal/day for boys and 1892 kcal/day for girls (Department of Health, 1991).

8.7.6 In respect to fluoride exposure from water supplies and dental erosion:

- There no association between dental erosion and daily fluoride intake or volume intake from drinking water.

8.7.7 In respect of the additional aim to assess if the sub-sample was representative:

The sub-sample had similar experiences of dental erosion and dental caries.

- Of 180 subjects, 70 (38.9%) had evidence of dental erosion, which was over one third of the subjects and higher amongst girls than boys, following the same trend observed for the whole study population.
- Of 180 subjects, 111 (61.7%) had dental caries, which was approximately two thirds of the subjects and was also higher amongst girls than boys, following the same trend observed for the whole study population.

Chapter 9
Multivariate analysis of the association between dental erosion and caries and potential risk factors

9.1 Introduction

Data collected through the dental examinations for dental erosion and dental caries and the questionnaire surveys completed by the subjects were analysed in Chapters 6 and 7 respectively, using a process of bivariate analysis, and including 791 subjects who were involved in both the clinical dental examination and questionnaire. Data collected through the dental examinations for dental erosion and dental caries and from food diaries completed with interviews were analysed in Chapter 8, using a process of bivariate analysis, and including a sub-sample of 180 subjects who were involved in dental examination and completed the food dairies with interviews.

The relationships between experience of dental erosion and dietary and non-dietary potential risk factors for dental erosion were investigated. The associations between the experience of dental caries and dietary and non-dietary potential risk factors for dental caries were also investigated. In addition, the association between experience of dental erosion and dental caries was analysed.

Bivariate analysis does not consider the influence of confounding factors in the relationships under study, thus representing a limitation for investigating relationships between an outcome and potential risk factors.

The use of a multivariate analysis process permits for the control of confounding factors. Binary logistic regression analysis is used when the dependent variable (outcome) is dichotomous. The experience of dental erosion (No/Yes) (with no is coded as 0 to indicate that the event has not occurred, while yes is coded as 1 to indicate that the event has occurred) was the dependent variable.

9.2 Aims

The aims were:

9.2.1 To investigate associations between experiences of i) dental erosion; ii) dental caries and the oral health data collected through the questionnaire survey completed by the whole study population (n= 791).

9.2.2 To investigate associations between experiences of i) dental erosion; ii) dental caries and the dietary data collected through the food diaries with interviews completed by the sub-sample (n= 180).

9.3 Methods

To investigate independent associations between the experience of dental erosion and dental caries and the variables under study, two stepwise selection logistic regression models were developed in SPSS 17.0 for Windows.

The first model involved the experience of i) dental erosion and ii) dental caries and information from the questionnaire survey (791 subjects).

The second model included the data from the experience of i) dental erosion and ii) dental caries and the information from food diaries with interviews (180 subjects).

The Hosmer and Lemeshow Goodness of Fit test, available in SPSS 17.0 for Windows, was used to assess the goodness of fit of each model (Hosmer and Lemeshow, 2000), with p-values >0.05, it means that the data fits the model and at an acceptable level.

9.3.1 Dental erosion-first model (n= 791)

Variables which were statistically significantly associated with the experience of dental erosion at 5% level as assessed by the process of bivariate analysis from the clinical examination and questionnaire survey were selected to be included in the logistic regression model. Table 9.1 shows the variables included in the first logistic regression model and their related levels of statistical significance observed through the process of bivariate analysis. This showed that erosion was statistically significantly positively associated with the frequency of consumption of fruit-based sugared drinks and statistically significantly negatively associated with the frequency of consumption of carbonated water and sport drinks.

The bivariate analysis also indicated that experience of erosion (Yes/No) was statistically significantly positively associated with the length of time taken to consume the drink.

A higher proportion of subjects with experience of dental erosion was amongst those who made the drink last up to 15 minutes or more.

The bivariate analysis suggested that a lower proportion of subjects with experience of dental erosion was associated with increasing the frequency of consumption of tea with milk and indicated that experience of erosion was associated with decreasing the frequency of consumption of flavoured milk. A higher proportion of subjects with dental erosion was related to a lower frequency of fruit consumption.

9.3.2 Dental erosion-second model (n= 180)

No dietary data collected through the food diaries with interviews completed by the sub-sample (180 subjects) were statistically significantly associated with dental erosion through the process of bivariate analysis, but it was decided to include them in the final models to test their influence.

Table 9.1: Dental erosion variables included in the first logistic regression model and their corresponding levels of statistical significance in the bivariate analysis for erosion (n=791).

Variable	P	Direction of association +/-
Frequency of consumption of fruit-based sugared drinks	0.006**	+ve
Frequency of consumption of sport drinks	0.004**	-ve
Frequency of consumption of carbonated water	0.048*	-ve
Time taken to consume drinks (1= drink it straight away, 2= ≥ 15 minutes)	0.005**	+ve
Frequency of consumption flavoured milk	0.043*	-ve
Frequency of consumption sugared tea with milk	0.032*	-ve
Frequency of consumption fruit other than bananas	0.002**	-ve

* Statistically significant at p< 0.05 **Statistically significant at p< 0.01

9.3.3 Dental caries-first model (n= 791)

Table 9.2 presents the variables which were included in the first logistic regression model, along with their level of statistical significance observed through the process of bivariate analysis for dental caries.

The bivariate analysis also indicated that experience of caries (Yes/No) was statistically significantly positively associated with the frequency of consumption of fruit-based sugared drinks. In addition, the bivariate analysis showed that experience of dental caries was statistically significantly negatively associated with the level of fathers' education, as fathers' educational level increased, caries experience decreased.

Table 9.2: Dental caries variables included in the first logistic regression model and their corresponding levels of statistical significance (P) in the bivariate analysis for caries (n=791).

Variable	P[1]	Direction of association +/-
Frequency of consumption of fruit-based sugared drinks	0.002**	+ve
Level of fathers' education (1= illiterate, 2= up to secondary schools, 3= college/postgraduate)	0.015*	-ve

[1]Linear Association exact test *Statistically significant at p< 0.05 **Statistically significant at p< 0.01

9.3.4 Dental caries-second model (n= 180)

None of the dietary data collected through the food diaries with interviews completed by the sub-sample (180 subjects) were statistically significantly associated with dental caries through the process of bivariate analysis, but it was decided to include them in the final models to test their influence.

9.3.5 Dental caries-third model (n= 180)

The bivariate analysis indicated that experience of caries (Yes/No) was statistically significantly positively associated with daily fluoride intake from bottled water and volume intake from bottled water (data collected through food diaries by the sub-sample, 180 subjects) (Chapter 8, Table 8.13).

9.4 Results

9.4.1 Dental erosion-first logistic regression model

9.4.1.1 Background to binary logistic regression analysis

In Binary logistic regression, the probability of an event occurring is directly estimated, e.g. whether someone suffers from dental erosion (No/Yes, No= 0, Yes= 1) or from dental carries (No/Yes, No= 0, Yes= 1).

Usually certain risk factors are used to estimate the probability. In the case of dental erosion, the risk factor could be the frequency of drinking fruit-based sugared drinks in a day.

For the case of a single independent variable, the binary logistic regression model can be written as:

$$Prob(event) = \frac{1}{1 + e^{-(b_0 + b_1 x)}}$$

where b_0 and b_1 are coefficients estimated from the data, x is the independent variable, and e is the base of the natural logarithm, approximately 2.718.

For more than one independent variable, the model can be written as

$$Prob(event) = \frac{1}{1 + e^{-z}}$$

where z is the linear combination

$$z = b_0 + b_1 x_1 + b_2 x_2 + \cdots + b_p x_p$$

and p is the number of independent variables.

The probability of the event not occurring is estimated as

$$Prob(no\ event) = 1 - Prob(event)$$

The results of the Hosmer and Lemeshow Goodness of Fit test suggested that the model's estimates fit the data at an acceptable level (p= 0.166).

From the seven variables which were statistically significant in the bivariate analysis and included in the first logistic regression model, six remained in the model (Table 9.3); the frequency of consumption of fruit-based sugared drinks, frequency of consumption fruit other than bananas, frequency of consumption sugared tea with milk, frequency of consumption of sport drinks, time taken to consume drinks and frequency of consumption of flavoured milk.

As Table 9.3 shows, 3 of these variables were statistically significantly positively associated with the experience of dental erosion at a 5% level

From Table 9.3, the binary regression model for dental erosion can now be written as

$$Prob(dental\ erosion) = \frac{1}{1 + e^{-z}}$$

Where:

$$z = -6.17 + 0.30 * FruitSugaredDrinks + 0.91 * SportDrinks + 1.23 * Fruits + 0.13 * DrinksLast + 0.25 * FlavouredMilk + 0.32 * SugaredTeaMilk$$

Table 9.3: Significance of association (Regression Coefficients, P, OR (Odds Ratio) and 95% CI) between the experience of erosion and the variables under study, as explained by the first logistic regression model.

Variable	Un-standardised Coefficients B	Un-standardised Coefficients Std. Error	P	OR	95% CI (Confidence Interval) Lower upper	+/-[1]
Frequency of consumption of fruit-based sugared drinks	0.300	0.152	0.049*	1.349	1.001, 1.819	+ve
Frequency of consumption of fruit other than bananas	1.227	0.497	0.014*	3.411	1.288, 9.030	+ve
Frequency of consumption sugared tea with milk	0.319	0.156	0.041*	1.375	1.013, 1.868	+ve
Frequency of consumption of sport drinks	0.910	0.570	0.111	2.484	0.812, 7.595	+ve
Time taken to consume drinks (1= drink it straight away, 2= ≥ 15 minutes)	0.134	0.129	0.298	1.144	0.888, 1.473	+ve
Frequency of consumption of flavoured milk	0.249	0.208	0.231	1.283	0.853, 1.930	+ve

*Statistically significant at $p< 0.05$ [1]Direction of association

The model can be written in terms of odds of an event occurring (The odds of an event occurring = ratio of the probability that it will occur to the probability that it will not). In terms of the log of the odds (called the logit), the model can be written as:

$$\log\left\{\frac{Prob(dental\ erosion)}{Prob(no\ dental\ erosion)}\right\} = b_0 + b_1x_1 + b_2x_2 + \cdots + b_p x_p$$

The binary logistic regression coefficient can be interpreted as a change in the log odds associated with one-unit change in the independent variable. When the variable was found to have positive regression coefficient, this means the proportional relationship between increased consumption of the questionnaire variable e.g. frequency of consumption of fruit-based sugared drinks were associated with increased dental erosion. From Table 9.3 the coefficient of *frequency of fruit-based sugared drink* is 0.300. This tells us that when *frequency of fruit-based sugared drink* changes from never to <1 a day to ≥ 1 a day and the values of the other independent variables stay the same, the log odds of having dental erosion increase by 0.300.

As it is easier to think of odds instead of log odds, the model equation can be written as

$$\frac{Prob(dental\ erosion)}{Prob(no\ dental\ erosion)} = e^{b_0+b_1x_1+b_2x_2+\cdots+b_px_p} = e^{b_0}e^{b_1x_1}\cdots e^{b_px_p}$$

Then *e* raised to the power b_i is the factor by which the odds change when the i^{th} independent variable increases by one unit. If b_i is positive, this factor will be greater than 1, which means that the odds are increased; if b_i is negative, the factor will be less than 1, which means that the odds are decreased. When b_i is 0, the factor equals 1, which leaves the odds unchanged. For example, when *frequency of fruit-based sugared drink* changes from never to <1 a day to ≥1 a day, the odds are increased by a factor of 1.349, as shown in the *OR* column of Table 9.3.

The model shows positive regression coefficients and significant relationships between the experience of erosion and consumptions of fruit-based sugared drinks, fruits other than banana, and tea with milk. The risk of dental erosion was 1.349 times more when subjects consumed fruit-based sugared drinks once or more than once per day (Odds Ratio 1.349 (p= 0.049, 95% CI 1.001, 1.819)). The consumption of fruit other than bananas (Odds Ratio 3.411 (p= 0.014, 95% CI 1.288, 9.030)). The consumption of tea with milk (Odds Ratio 1.375 (p= 0.041, 95% CI 1.013, 1.868)). The risk of erosion was 1.144 times more likely when time taken to consume drinks up to or more than 15 minutes (Odds Ratio 1.144 (p= 0.298, 95% CI 0.888, 1.473)) (Table 9.3).

9.4.2 Dental erosion-second logistic regression model

The results of the Hosmer and Lemeshow Goodness of Fit test suggested that the model's estimates fit the data at an acceptable level (p= 0.806). There was no statistically significant association between the experience of dental erosion and dietary data collected through the food diaries with interviews completed by the sub-sample (180 subjects) through the process of bivariate analysis. These variables included in the second logistic regression model also found that there was no statistically significant association between dietary data and the experience of dental erosion (Table 9.4).

Table 9.4: Significance of association (Regression Coefficients, P, OR (Odds Ratio) and 95% CI) between the experience of erosion and the dietary data collected through the food diaries with interviews completed by the sub-sample (180 subjects), as explained by the second logistic regression model.

Variable	Un-standardised Coefficients		P	OR	95% CI (Confidence Interval)
	B	Std. Error			Lower Upper
Total acidic intake (g/day)	0.005	0.004	0.242	1.005	0.997, 1.014
Acidic drinks intake (g/day)	-0.005	0.004	0.262	0.995	0.987, 1.004
Fruit intake (g/day)	-0.047	0.036	0.198	0.954	0.888, 1.025
Confectionery intake (g/day)	-0.016	0.016	0.318	0.984	0.954, 1.016

9.4.3 Dental caries-first logistic regression model (n=791)

The results of the Hosmer and Lemeshow Goodness of Fit test suggested that the model's estimates fit the data at an acceptable level (p= 0.240). All variables initially included in the process of bivariate analysis which were statistically significantly associated with the experience of dental caries remained in the logistic regression model. It shows a positive regression coefficient and significant relationship between the experience of dental caries and consumptions of fruit-based sugared drinks and a negative regression coefficient and significant relationship between dental caries and level of fathers' education. As Table 9.5 shows experience of dental caries was statistically significantly positively associated with frequency of consumption of fruit-based sugared drinks, (Odds Ratio 1.368 (p= 0.001, 95% CI 0.468, 1.833)); the risk of dental caries was 1.368 times more when subjects consumed fruit-based sugared drinks once or more than once per day. Dental caries was statistically significantly negatively associated with fathers' education level (Odds Ratio 0.699 (p= 0.008, 95% CI 0.536, 0.912)); the risk of dental caries was 0.699 times less with increasing level of fathers' education (Table 9.5).

Table 9.5: Significance of association (Regression Coefficients, P, OR (Odds Ratio) and 95% CI) between the experience of caries and the variables under study, as explained by the first logistic regression model.

Variables	Un-standardised Coefficients		P	OR	95% CI (Confidence Interval) Lower Upper	+/-[1]
	B	Std. Error				
Frequency of consumption of fruit-based sugared drinks	0.314	0.072	0.001*	1.368	0.468, 1.833	+ve
Level of fathers' education (1= illiterate, 2= up to secondary schools, 3= college/postgraduate)	-0.358	0.136	0.008*	0.699	0.536, 0.912	-ve

*Statistically significant at p< 0.01 [1]Direction of association

9.4.4 Dental caries-second logistic regression model

The results of the Hosmer and Lemeshow Goodness of Fit test suggested that the model's estimates fit the data at an acceptable level (p=0.529). There was no statistically significant association between the experience of dental caries and data collected through food diaries with interviews completed by the sub-sample (180 subjects) through the process of bivariate analysis. When these variables were included in the second logistic regression model, no statistically significant association found (Table 9.6).

Table 9.6: Significance of association (Regression Coefficients, P, OR (Odds Ratio) and 95% CI) between the experience of caries and the dietary data collected through food diaries with interviews completed by the sub-sample (180 subjects), as explained by the second logistic regression model.

Variables	Un-standardised Coefficients		P	OR	95% CI (Confidence Interval) Lower Upper
	B	Std. Error			
Total acidic intake (g/day)	0.008	0.004	0.073	1.008	0.999, 1.017
Acidic drinks intake (g/day)	-0.009	0.005	0.068	0.991	0.982, 1.001
Fruit intake (g/day)	-0.060	0.034	0.082	0.942	0.881, 1.008
Confectionery intake (g/day)	0.029	0.021	0.177	1.029	0.987, 1.073
Total sugar intake (g/day)	-0.004	0.011	0.673	0.996	0.975, 1.016
NME intake (g/day)	0.003	0.017	0.847	1.003	0.970, 1.038

9.4.5 Dental caries-third logistic regression model

The results of the Hosmer and Lemeshow Goodness of Fit test suggested that the model's estimates fit the data at an acceptable level (p= 0.214).

There was a statistically significant positive association between the experience of caries and daily fluoride intake from bottled water and volume intake from bottled water through the process of bivariate analysis (Chapter 8).

When these variables were included in a third logistic regression model, no statistically significant association was found between daily fluoride intake from bottled water or daily intake of bottled water and the experience of dental caries (Table 9.7).

Table 9.7: Significance of association (Regression Coefficients, P, OR (Odds Ratio) and 95% CI) between the experience of caries and the dietary data collected through food diaries completed by the sub-sample (180 subjects), as explained by the third logistic regression model.

Variables	Un-standardised Coefficients		P	OR	95% CI (Confidence Interval)
	B	Std. Error			Lower Upper
Daily intake of fluoride from bottled water (mg)	-1.457	5.155	0.778	0.233	0.000, 5694.418
Daily intake of bottled water (litre)	2.147	1.846	0.245	8.558	0.230, 318.999

9.5 Discussion

9.5.1 Risk factors for dental erosion

In the present study, the dental erosion regression model included the data from the 791 children completing the dental examinations and questionnaire surveys. Information about the frequency of consumption of foods and drinks from the questionnaire survey was based on criteria used in the UK NDNS (Walker *et al.*, 2000).

The first model was developed to assess the association between experience of dental erosion and the oral health questions. Multivariate analysis has been used by previous studies to investigate independent association between the experience of dental erosion or tooth wear and potential risk factors (Walker *et al.*, 2000; Al-Malik *et al.*, 2001b; Al-Majed *et al.*, 2002; Dugmore and Rock, 2004b; Luo *et al.*, 2005; Waterhouse *et al.*, 2008).

In the first logistic regression model, the variables independently positively associated with the experience of dental erosion (No/Yes) at 5% level were frequency of consumption of fruit-based sugared drinks, frequency of consumption of fruit other than bananas and frequency of consumption of sugared tea with milk.

It is important to note that the fruit-based sugared drinks were the most common acidic drinks consumed on a daily basis by 47% of subjects. This is in agreement with the findings of several studies that found significant association between acidic drinks consumption and experience of dental erosion or tooth wear (O'Brien, 1994; Millward *et al.*, 1994a; O'Sullivan and Curzon, 2000a; Al-Dlaigan *et al.*, 2001b; Al-Malik *et al.*, 2001b; Harding *et al.*, 2003; WHO, 2003; Milosevic *et al.*, 2004; Dugmore and Rock, 2004b; El Karim *et al.*, 2007).

In the second logistic regression model, the experience of erosion was not statistically significantly associated with any variables in the food diaries completed by the sub-sample of 180 subjects; there was no association between the experience of erosion and the median recorded frequency of daily consumption of acidic drink. As in the first logistic regression model for erosion, only one type of acidic drink, which was fruit-based drinks, was associated with the experience of erosion.

In the first logistic regression model, the experience of erosion was statistically significantly positively associated with fruit consumption. With highlights that, in the bivariate analysis, there was a statistically significantly negative association between consumption of fruits and experience of dental erosion. This may be due to the bivariate analysis does not consider the influence of confounding factors in the relationships under study but the use of a multivariate analysis process permits for the control of confounding factors. However, 95% of subjects who had dental erosion consumed fruits with frequency of less than one portion per day. Therefore, there was little evidence to consider fruit as a risk factor for dental erosion.

In the second model, there was no statistically significant association between the experience of dental erosion and daily consumption of fresh fruit reported by the sub-sample. This confirms the findings of several studies which have reported no statistical significant association between experience of erosion and fruit consumption (Williams *et al.*, 1999; Walker *et al.*, 2000; Harding *et al.*, 2003; WHO, 2003; Caglar *et al.*, 2005; Waterhouse *et al.*, 2008). In the present study, experience of erosion was statistically significantly positively associated with consumption of sugared tea with milk, contrasting with results from previous studies (O'Sullivan and Curzon, 2000a; Waterhouse *et al.*, 2008). In bivariate analysis the association was statistically significantly negative. As argued before, this may be due to the bivariate analysis not considering the influence of confounding factors in the relationships under study. However, due to the protective effect of fluoride in tea and milk against dental erosion, it has been suggested that tea with milk and milk are not risk factors of dental erosion. Direct comparisons between studies are difficult due to use of different methodologies, different ranges of variables and number of subjects.

It is also important to highlight that the present study is cross-sectional. The dietary data may not be representative of a longer-term diet, which could potentially contribute to the progress of dental erosion.

9.5.2 Risk factors for dental caries

With regard to dental caries, the first logistic regression model showed a statistically significant positive association between the experience of dental caries and frequency consumption of fruit-based sugared drinks, while dental caries experience decreased with increasing fathers' education levels. This confirms the findings of the Walker *et al.* (2000) study which reported that higher parents' educational levels related to oral health improvement. In the second logistic regression model no variables reported through the food diaries completed by the sub-sample were associated experience of dental caries.

When dietary data from the food diaries were analysed, all types of sugared acidic drinks were considered as one group, which may explain some of the lack of association seen in present results.

9.6 Conclusions

9.6.1 Regarding dental erosion and caries and the oral health data collected through questionnaire survey completed by the whole study population:

- The frequency of reported consumption of fruit-based sugared drinks was statistically significantly positively associated with the experience of dental erosion (p= 0.049, OR 1.349).

- Frequency of consumption of fruit other than bananas was statistically significantly positively associated with the experience of dental erosion (p= 0.014, OR 3.411). However, 95% of subjects who had dental erosion consumed fruits with frequency of less than one portion per day. Therefore, there was little evidence to consider fruit as a risk factor for dental erosion.

- Frequency of consumption sugared tea with milk was statistically significantly positively associated with the experience of dental erosion (p= 0.041, OR 1.375). However, because of the protective effect of fluoride against dental erosion, it was suggested not to consider tea with milk as a risk factor for dental erosion.

- There was a statistically significant positive association between the experience of dental caries and frequency consumption of fruit-based sugared drinks (p= 0.001, OR 1.368).

- There was a statistically significant negative association between the experience of dental caries and fathers' education levels. Dental caries experience decreased with increasing fathers' education levels (p= 0.008, OR 0.699).

9.6.2 Regards dental erosion and dental caries and the data collected through the food diaries completed by the sub-sample:

- The experience of dental erosion and dental caries were not statistically significantly associated with any variables in the food diaries completed by the sub-sample of 180 subjects.

Chapter 10
Overall discussion

10.1 Introduction

Dental erosion is defined as irreversible loss of dental hard tissues by a chemical process that does not involve bacteria (Eccles and Jenkins, 1974; Imfeld, 1996; Nunn, 1996; Linnett and Seow, 2001). Dental erosion does not take place in isolation, with attrition and abrasion usually potential compounding processes contributing to the overall tooth surface loss. The literature review (Chapter 2) showed increasing interest in the study of tooth wear and more particularly dental erosion. Several studies offered a better understanding of tooth wear and dental erosion and their potential risk factors. These published studies include *in vitro* and *in situ* studies (Amaechi and Higham, 2001; Fraunhofer and Rogers, 2004; Hemingway *et al.*, 2006; Brown *et al.*, 2007; Kitchens and Owens, 2007; Ehlen *et al.*, 2008; Honório *et al.*, 2008), case-control studies (Milosevic *et al.*, 1997; O'Sullivan and Curzon, 2000a; Sivasithamparam *et al.*, 2002; Al-Dlaigan *et al.*, 2002b), cross-sectional studies (O'Brien, 1994; Walker *et al.*, 2000; Al-Majed *et al.*, 2002; Al-Malik *et al.*, 2002; Árnadóttir *et al.*, 2003; Chadwick and Pendry, 2004; Dugmore and Rock, 2004a; Larsen *et al.*, 2005; Auad *et al.*, 2007) and longitudinal studies (Nunn *et al.*, 2001; Ganss *et al.*, 2001a; Dugmore and Rock, 2003b). The main aims of these studies were assessment of the prevalence of dental erosion or tooth wear and recognition of possible factors associated with its development and progression. The most important factor is diet while other potential risk factors include salivary properties, oral hygiene practices and products, oral habits, lifestyle, general health and socio-demographic characteristics. The relationship between dental erosion and caries has also been tested (Kunzel *et al.*, 2000; Al-Malik *et al.*, 2002; van Rijkom *et al.*, 2002; Dugmore and Rock, 2004a; Dugmore and Rock, 2004b; Truin *et al.*, 2005; Auad *et al.*, 2009).

Aetiological factors for dental erosion in children and adolescents are extrinsic and intrinsic acids. The main contributive process may be more easily recognized when the loss of tooth surface takes place as a result of intrinsic acids; e.g. subjects with gastroesophageal reflux or bulimia (Jarvinen *et al.*, 1988; Gudmundsson *et al.*, 1995; Barron *et al.*, 2003). In contrast, when acids from extrinsic sources are thought to be the main contributors to dental erosion, not only recognition of the potential source of acids but also the evaluation of any interrelating effects of different processes resulting in the tooth surface loss might be challenging.

10.2 The prevalence of dental erosion

Several dental indices have been used to measure tooth wear in general and dental erosion in particular. As a result, dental erosion when measured using different indices and criteria has shown a wide range of prevalence. This wide range of results is not only due to actual differences between populations but also may be due to the absence of a unified approach to assess dental erosion. Several studies have assessed dental erosion (Eccles and Jenkins, 1974; Lussi *et al.*, 1991; O'Brien, 1994; Hind and Gregory, 1995; Kunzel *et al.*, 2000; Larsen *et al.*, 2000; Walker *et al.*, 2000; O'Sullivan and Curzon, 2000a; O'Sullivan, 2000c; Al-Dlaigan *et al.*, 2001a; Al-Malik *et al.*, 2001b; Al-Majed *et al.*, 2002; Chadwick and Pendry, 2004; Wiegand *et al.*, 2006; Auad *et al.*, 2007), whilst some authors have assessed tooth wear (Milosevic *et al.*, 1994; Milosevic *et al.*, 1997; Bartlett *et al.*, 1998; Shaw *et al.*, 1998). There have been a number of studies which have measured dental erosion or tooth wear in different teeth groups and age groups of children and adolescents and reported different prevalence figures (Milosevic *et al.*, 1994; Al-Majed *et al.*, 2002; van Rijkom *et al.*, 2002; Auad *et al.*, 2007). It might be argued that this variety of prevalence figures would potentially reflect the different criteria and indices used rather than true differences between population groups, but this is not clear. The index described by Walker *et al.* (2000), validated in the UK National

Diet and Nutrition Surveys (Walker *et al.*, 2000; Chadwick and Pendry, 2004), and in other epidemiological studies (Al-Majed *et al.*, 2002; Auad *et al.*, 2007) was used in the present study. This index is simple, easy to use and can evaluate severity and affected tooth surface area. It had also been especially designed to assess erosive tooth surface loss in children.

The age of 12 years is a reference age for children for the international measurement of dental caries in the permanent teeth (WHO, 1997). This age was also selected for this study because at this age the index teeth have been present in the mouth for about six years and exposed to potential intrinsic and extrinsic aetiological factors which may cause dental erosion. Since early diagnosis of the erosive process is important it might suggest that oral epidemiological surveys for this age group should also include the assessment of dental erosion. In addition, use of this age group allowed comparison with results from previous studies which have used same age group in different countries.

Dental erosion awareness by individuals and communities is still limited because it is a slowly progressing condition, and to increase awareness it would be necessary that dentists and oral health professionals distribute clear information to the community about dental erosion and its potential risk factors, as well as recommendations and advice for its prevention. This is a challenge to researchers, dental professionals and oral health policy makers.

Although there has been growing concern that the prevalence of erosion has been increasing amongst children (Walker *et al.*, 2000; Al-Dlaigan *et al.*, 2001a; Nunn *et al.*, 2003; Chadwick and Pendry, 2004), there are few longitudinal studies (Milosevic *et al.*, 1997; Nunn *et al.*, 2001; Ganss *et al.*, 2001a; Dugmore and Rock, 2003b), and more are needed so that the true prevalence of the dental erosion might be monitored. Dental erosion severity can range from loss of surface characteristics to loss of tooth tissue with pulp involvement and can require complex and costly treatment and maintenance. Therefore, early diagnosis and prevention of erosion in children and adults is important not only to control erosion and prevent further complications, but also to minimize the costs of the complex extensive treatment. Prevention

and control of dental erosion requires two important approaches; the development of programmes to i) prevent, monitor the erosive process and maintain the effect of preventive programmes and ii) recognise, minimize and modify possible risk factors for dental erosion.
Dental erosion assessment was first included in the UK Children's Dental Health Survey in 1993 and also included in National Diet and Nutrition Surveys (O'Brien, 1994; Walker *et al.*, 2000; Chadwick and Pendry, 2004). The experience obtained in the UK since the first national assessment in 1993 (O'Brien, 1994) could offer important resources for the design and performance for similar practice in other counties.

The literature review showed that a significant percentage of dental erosion was seen to affect enamel only and this might be another factor potentially contributing to the wide variation in prevalence reported (Bartlett *et al.*, 1998; Walker *et al.*, 2000; Al-Majed *et al.*, 2002; Árnadóttir *et al.*, 2003; Dugmore and Rock, 2003b; Chadwick and Pendry, 2004; Dugmore and Rock, 2004a; Caglar *et al.*, 2005; Larsen *et al.*, 2005; Peres *et al.*, 2005a; Auad *et al.*, 2007; Correr *et al.*, 2009). Dental erosion in enamel is difficult to identify (Nunn *et al.*, 2003; Chadwick and Pendry, 2004), but its early detection, recognizing contributory habits putting individuals at risk of developing erosion and identify individuals with risk factors are crucial to stop and prevent for their irreversible tooth surface loss before clinical restorative intervention is required. This highlights the requirement of dental professionals to be able to recognize the clinical features, signs, causes of erosion and how to prevent further progression as well as provide active treatment if necessary (Lussi and Jaeggi, 2008).
In Libya, few dental epidemiological studies have been made and these have been limited to the assessment of prevalence of dental caries, fluorosis and periodontal diseases (Omar and Pitts, 1991; Hawew *et al*., 1996; Al-Sharbati *et al*., 2000; Ingafou *et al*., 2003). No study has published data related to dental erosion in children or adults in Libya and the prevalence and severity of dental erosion in Libya was unknown. Epidemiological studies using a unified approach to determine dental erosion are needed in different regions in Libya. These will

provide a clearer picture regarding the prevalence of dental erosion and to determine if dental erosion a cause of concern in terms of public oral health in Libya. The total Libyan population was about six million in 2005, the majority (88%) of whom live in cities. Benghazi had an estimated 685, 367 inhabitants and the total number of schoolchildren aged 12 years in Benghazi was approximately 7682 according to the General Authority of Information (GAI, 2006). These children were studying at 81 public elementary schools which comprise 90% of the total number of schools in Benghazi (GAI, 2006). Benghazi is the second largest city in Libya after the capital, Tripoli. It is a very good example of a Libyan urban area comprising a population with different socioeconomic, cultural and original backgrounds. Therefore, it is an appropriate site for the study and suitably representative of the Libyan population.

The results of the present study suggest that the prevalence of dental erosion in Benghazi is higher than that observed in other countries such as Brazil (Auad *et al.*, 2007), and closer to the value found in the UK (O'Brien, 1994; Walker *et al.*, 2000; Chadwick and Pendry, 2004) and lower than that found in Saudi Arabia (Al-Majed *et al.*, 2002). These studies used the same index and criteria for dental erosion. The fact that more than third of the subjects in Benghazi had dental erosion emphasizes the importance of effective detection, maintaining and evaluation strategies in the prevention of dental erosion.

10.3 Dental erosion and gender

The findings of several studies of children and adolescents have reported that erosion/tooth wear may be more prevalent in boys (Milosevic *et al.*, 1994; van Rijkom *et al.*, 2002; Árnadóttir *et al.*, 2003; Truin *et al.*, 2005), whilst other studies have reported no significant gender differences (Bartlett *et al.*, 1998; Caglar *et al.*, 2005; Peres *et al.*, 2005a; Peres *et al.*, 2008). In contrast, Kunzel *et al.* (2000) reported that girls were more affected by erosion than boys. This trend was also observed in the present study. The reasons for this may include the fact that girls took statistically significantly longer (15 minutes or more) to consume acidic drinks than boys ($p < 0.01$) also brushed their teeth more frequency than boys, with an association found between dental erosion and high level of oral hygiene (O'Sullivan and Curzon, 2000b). Also boys consumed milk and tea with milk statistically significantly more frequently than girls ($p < 0.05$). In addition, permanent teeth erupt earlier in girls than boys and they are exposed to risk factors for dental erosion for a longer period of time although the differences in eruption times are only a few months which clinically may result in little difference. In addition, the results from the completed food diaries showed a difference in daily total acidic items consumption by gender, with girls consuming statistically significantly more acidic items than boys ($p < 0.05$). However, the association between gender and prevalence of dental erosion and its risk factors is not clear.

10.4 Dental erosion and dietary risk factors

The association between dental erosion and/or tooth wear and acidic foods and drinks has been investigated in several studies (O'Brien, 1994; Millward *et al.*, 1994b; Johansson *et al.*, 1996; Ganss *et al.*, 1999; Shaw and Smith, 1999; Kunzel *et al.*, 2000; Walker *et al.*, 2000; O'Sullivan and Curzon, 2000a; Nunn *et al.*, 2001; Al-Dlaigan *et al.*, 2001b; 2001c; Al-Majed *et al.*, 2002; van Rijkom *et al.*, 2002; Árnadóttir *et al.*, 2003; Harding *et al.*, 2003; Chadwick and Pendry, 2004; Milosevic *et al.*, 2004; Bartlett, 2009). In its report “Diet, Nutrition and the prevention of Chronic Diseases” the WHO stated that there is possible evidence that the intake of acidic drinks is associated with dental erosion (WHO, 2003). Several studies have found a statistically significant relationship between the consumption of acidic drinks and the experience of dental erosion or tooth wear (Eccles and Jenkins, 1974; Lussi *et al.*, 1991; Millward *et al.*, 1994a; O'Sullivan and Curzon, 2000a; Al-Dlaigan *et al.*, 2001b; Al-Malik *et al.*, 2001b; Harding *et al.*, 2003; Milosevic *et al.*, 2004; Dugmore and Rock, 2004b; EI Karim *et al*., 2007). Therefore, it seems reasonable to believe that soft drinks may play an important role in the development of dental erosion in children and adolescents.

The WHO states that the practice of advertising foods and beverages to children should be a potential target for intervention considering its possible evidence of relationship with weight gain and obesity (WHO, 2003). Television advertisements play an important role in the marketing strategies for soft drinks. A qualitative study found that children's choices of drinks were strongly influenced by the appearance of drinks, their cost and accessibility (May and Waterhouse, 2003). These emphasize the importance that effective procedures and specific rules for television advertising be applied and strictly controlled, in order to prevent the encouragement of potentially harmful food items and to encourage the intake of healthy foods and drinks, particularly at children's programming time.

In the present study, dietary data were collected through a questionnaire survey (for the whole study sample) and a three-day food diary with interview (for a randomly selected sub-sample) and 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 erosion and to displace acidic drinks consumption.

In the present study, the frequency of consumption of fruit-based sugared drinks was independently associated ($p = 0.006$) with the experience of erosion. This finding is in agreement with other studies which found a statistically significant relationship between the consumption of acidic drinks and the experience of dental erosion or tooth wear (Harding *et al.*, 2003; Milosevic *et al.*, 2004; Dugmore and Rock, 2004b; El Karim *et al.*, 2007; Waterhouse *et al.*, 2008).

Soft drinks include a wide variety of acidic sugared and non-sugared drinks, such as sugared carbonated drinks, fruit-based sugared drinks, squashes, sport drinks, natural unsweetened fruit juice and non-sugared carbonated drinks. From these, fruit-based sugared drinks were the most common type of drink consumed and were the major single contributor to the intake of an erosive diet by the majority of subjects. The reason behind the high consumption of fruit-based sugared drinks in Libya can be attributed to a number of factors; firstly availability and easy accessibility of these drinks in shops, markets and school canteens. Second is the attractive appearance of these drinks and the marketing of such drinks in a very attractive way. Third is the low-cost of these drinks; the same price as bottled water. Fourth is a lack of awareness and knowledge of the dental hazards of these drinks. Fifth is the hot weather, especially in summer, which encourages children to quench their thirst with these cheap available tasty drinks. The sixth reason is the influence of television advertisements.

In this study, the length of time taken to consume drinks, especially when the drinks lasted up to 15 minutes was statistically significantly positively associated with the experience of erosion. This is in agreement with the findings of Al-Majed *et al.* (2002) and highlights the importance of encouraging children to use a straw since this directs drinks past the anterior teeth and towards the pharynx and reduces the time the drink is in contact with teeth.

In response to the growing concern about the oral impact of acidic drink intake, modified soft drinks to which calcium and/or phosphate supplements, citrate or fluoride are added to reduce dental erosion has been suggested and tested (Imfeld, 1996; West *et al.*, 2003; Davis *et al.*, 2007; Hara and Zero, 2008; Bartlett, 2009). However, it is important to highlight that even if an option of a low erosive drink is available, the intake should not be excessive.

In the present study, the Libyan subjects who reported an intake of one or more than one fruit per day did not have a higher risk of erosion compared with children with low intake. However, fruit consumption was very low and therefore caution is needed when interpreting these results. Only 6% of the Libyan subjects reported an intake of two to four portions of fruits per day (excluding bananas) and this level of fruit intake is below the current dietary recommendations of at least five portions or 400 grams of fruits and vegetables per day (WHO, 2003) for the prevention of chronic diseases such as heart disease, cancer, diabetes and obesity, although the present study did not assess vegetable intake. It is reassuring that this current recommendation does not pose a significant risk for dental erosion as most vegetables and fruits such as bananas are not erosive. Therefore, current dietary recommendations for oral health are not in conflict with that for general health, which stresses increased consumption of fruits (Moynihan, 2005). In view of the low intake of fruit by the children in this study it would be wise to encourage the intake of fruit in this population as they are an essential part of a healthy diet. Also it has been suggested that the intake of fruit has a protective effect in terms of oral cancer (Moynihan and Petersen, 2004).

The consumption of sugared tea with milk and flavoured milk was statistically significantly negatively associated with experience of erosion. This is in agreement with the results of a study in the UK, in which the consumption of tea and milk was significantly lower amongst children with dental erosion (O'Sullivan and Curzon, 2000a) and in a Brazilian study (Waterhouse *et al.*, 2008). This may be due to subjects who consumed sugared tea with milk, milk and flavoured milk more frequently having a lower consumption of acidic drinks. Non-acidic drinks may displace acidic drinks from the diet and may also provide a protective effect of fluoride in tea. This highlights the importance of encouraging children to drink milk and tea with milk as an alternative to acidic drinks.

A healthy and balanced diet has a strong impact in the prevention of oral diseases and general health (Moynihan, 2005). The dietary data collected through the food diaries suggested that the contribution to energy intake from macronutrients was in line with the general guidelines for food consumption; for carbohydrate, fat and protein (WHO, 2003). However, the mean daily intakes of carbohydrate, fat and protein were lower than those found in a UK survey (Fletcher *et al.*, 2004). When the contribution to daily energy intake from sugars was assessed, it was found that the total sugars contributed to 20% of the daily intake amongst Libyan schoolchildren; slightly lower than the 23% found in UK studies (Hackett *et al.*, 1984; Rugg-Gunn *et al.*, 2007). The mean daily intake of non-milk extrinsic sugars (NMES) for subjects was 20.4 kg/year which is higher than the WHO recommendation of no more than 15 kg/year/person (WHO, 2003), but lower than in UK children (Fletcher *et al.*, 2004).

The daily energy intake from NMES was 12.6% which is higher than the Dietary Reference Value (DRV) for daily energy intake from NMES (6-10%) (Department of Health, 1991; WHO/FAO, 2003), but lower than the 16% found in a UK survey (Fletcher *et al.*, 2004). In the present study acidic drinks were the main source of total dietary acids, although the daily intake of acidic drinks was lower than the figures in the UK National Survey (Walker *et al.*, 2000).

The findings of the food diaries showed no statistically significant associations between experience of dental erosion and daily intake of acidic food and drinks. However, the present study was cross-sectional and it was difficult to approximate whether it was representative of a long term dietary pattern, which might contribute to a subjects' experience of dental erosion. It was also possible that subjects identified with erosion had changed their diet and reduced the consumption of acidic drinks, but there was no way to prove this. In addition, the median acidic food and drink intakes were low and food diaries were used to assess the amount but not the frequency of intakes of foods and drinks. The present results do not provide adequate evidence to eliminate an association between the consumption of acidic foods and drinks and experience of dental erosion and this needs further research. The results of the present study emphasize the importance of providing adequate dietary advice to children and parents.

10.5 Dental erosion and non-dietary risk factors

It has been reported that family attitudes are influenced by economic status and/or educational level of parents which have an impact in the dental health of their children. In Libya, there is no governmental classification of areas based upon socioeconomic information. For this reason, the parents' education level was used to assess the socioeconomic status of the subjects. Children whose parents' level of education was high have been found to have a higher experience of dental erosion (Walker *et al.*, 2000; van Rijkom *et al.*, 2002; Bardsley *et al.*, 2004; Luo *et al.*, 2005; Auad *et al.*, 2007; Mangueira *et al.*, 2009). This aspect was also observed in the present study, but the association was not statistically significant. It is suggested that the reason might be that parents with higher education levels spend more time away from home which might influence dietary habit with increased frequency of consumption of fast food and carbonated drinks (Mangueira *et al.*, 2009). A significantly higher prevalence of dental erosion was also found in Chinese children whose parents had a higher education level (Luo *et al.*, 2005). The author suggested that the reason may be parents with high educational level had adopted a more Western style diet for their children such as carbonated soft drinks and fruit juices, while parents with low educational level may choose traditional drinks such as tea for their children for economic reasons as well as a cultural choice.

These findings suggest that the association between dental erosion and economic status and/or parents' educational level is still not clear and needs more research. They also highlight the importance of educating parents in relation to dental erosion and its potential risk factors, so that they can include healthy practices in their family on a daily basis. It might be argued that parental influence and control on children's food selection seem to reduce as children grow up (May and Waterhouse, 2003).

In relation to general health and medication and its influence on dental erosion, it has been suggested that there has been an increase in the prevalence of eating disorders (Morandé *et al.*, 1999), and the presence of dental erosion on the palatal surfaces of upper anterior teeth and buccal surfaces of upper canines, premolars and upper incisors could clinically characterise bulimia nervosa (Jones and Cleaton-Jones, 1989). In addition, approximately 35-

40% of the adults in the Western world suffer from gastroesophageal reflux disease (Farrokhi and Vaezi, 2007). The higher prevalence of erosion among asthmatic adolescents might be related to the acidity of the medication used to control asthma. Also, the medication could reduce the salivary flow and as a result asthmatic children could have a higher intake of drinks because of a relatively dry mouth (Shaw *et al*., 2000). Studies have also reported that consumption of vitamin C supplements was associated with dental erosion (Al-Dlaigan *et al.*, 2001b; Al-Malik *et al.*, 2001b). As a complication of medication for chronic diseases, regurgitation or a dry mouth are possible reasons for increased prevalence of dental erosion (Johansson *et al.*, 2008).

In relation to oral hygiene practices, one cross-sectional observational study reported an association between dental erosion and high level of oral hygiene (O'Sullivan and Curzon, 2000b). In addition, an *in vitro* study which investigated the association between dental erosion and toothbrushing, found the abrasiveness of toothbrushing added a physical effect on the demineralization with resulting increased tooth wear in people with a high standard of oral hygiene (Attin *et al.*, 2001). On other hand, several studies have reported no statistically significant association between dental erosion and frequency of toothbrushing (Al-Malik *et al.*, 2001b; Al-Majed *et al.*, 2002; Milosevic *et al.*, 2004; Rafeek *et al.*, 2006), and a similar finding was observed for the present study. However, the presence of calculus appears to reduce the chance of dental erosion occurring. When data from oral examination at age 14 was associated with data collected at age 12, it was found that presence of calculus at age 12 reduced the chance of dental erosion at age 14 (Dugmore and Rock, 2004b). Children should be instructed not to brush their teeth immediately after an erosive challenge (e.g. acidic food/drink intake and vomiting) to reduce risk of abrasion/abrosion (Zero, 1996; Lussi and Hellwig, 2006). However, different findings have been reported in epidemiological studies and still the association between dental erosion and oral hygiene practice is not clear. However, the impact of delaying toothbrushing on dental caries should be considered. It might be argued that toothbrushing could be carried out before meals, but it may remove the protective salivary pellicle, thus leaving enamel more vulnerable to an acid attack (Attin *et al.*, 2001). The literature suggests that dental erosion does not occur in isolation and assumes that neither attrition nor abrasion would have significant impact in tooth surface loss in children and adolescents, if not preceded by an acidic attack from non-bacterial origin. Advice with regard to toothbrushing should consider all these aspects and be individualized and not given to prevent only one specific condition.

10.6 Dental erosion and dental caries

In the present study, the prevalence of dental caries was higher in Libyan children than the prevalence of dental erosion and there was no statistically significant association between the dental erosion and caries. Despite the fact that the prevalence of dental caries has declined in developed countries during the last 30 years (Petersson and Bratthall, 1996; Petersen, 2005) it remains a significant dental disease and a major public health challenge. Significant proportions of children and adults are also affected by caries in developing countries (Abid, 2004; AlDosari *et al.,* 2004; Yabao *et al.,* 2005; Auad *et al.,* 2009). Although the nature of dental erosion and caries is very different, it has been reported that the two processes may have common risk factors such as sugared acidic drinks (Al-Malik *et al.*, 2002), however it is still unclear if a group of children more affected by dental caries may also be at higher risk for dental erosion. Several studies have investigated the relationship between dental erosion and dental caries (Kunzel *et al.*, 2000; Al-Malik *et al.*, 2002; van Rijkom *et al.*, 2002; Dugmore and Rock, 2004a; 2004b; Truin *et al.,* 2005; Auad *et al.,* 2009). Of these Al-Malik *et al.* (2002), Dugmore and Rock, (2004a) and Dugmore and Rock, (2004b), reported a statistically significant association, whilst others did not (Kunzel *et al.*, 2000; van Rijkom *et al.*, 2002; Truin *et al.*, 2005; Auad *et al.*, 2009). Consequently, it is important that more research be carried out to provide a clearer picture of this relationship.

In the present study, a similar pattern for the prevalence of dental caries was found; girls having a higher caries experience than boys and this is in agreement with that reported by other studies (Misra and Shee, 1979; Saimbi *et al.*, 1983; Singh *et al.*, 1985; Kiwanuka *et al.*, 2006; Auad *et al.*, 2009). As previously argued, this may be due to the fact that girls took statistically significantly longer (15 minutes or more) to consume acidic drinks than boys ($p < 0.01$) and boys consumed milk and tea with milk statistically significantly more frequently than girls ($p < 0.05$). In addition, permanent teeth erupt earlier in girls than boys and they are exposed to risk factors for dental caries for a longer period of time. In addition, the results from the completed food diaries showed a difference in daily total acidic items consumption by gender, with girls consuming statistically significantly more sugared acidic items than boys ($p < 0.05$).

In the present study, the frequency of consumption of fruit-based sugared drinks was independently associated ($p = 0.002$) with the experience of dental caries. This is in agreement with the evidence from different studies reporting that dietary sugars play an important role in the aetiology of dental caries (Al-Khateeb *et al.*, 1991; Rugg-Gunn and Hackett, 1993; Sheiham, 2001; Moynihan, 2002; WHO, 2003; AlDosari *et al.*, 2004; Moynihan and Petersen, 2004; Sudha *et al.*, 2005; Yabao *et al.*, 2005). It seems, however to suggest that consumption of fruit-based sugared drinks may have contributed to the high experience of dental caries observed amongst the Libyan children.

In the present study the highest proportion without caries experience however, was observed among children whose fathers' were educated to higher level and this negative association was statistically significant. This confirms the findings of a previous Libyan study (Baccush and Nayak, 1991) and Ajman study (Hashim *et al.*, 2006). These finding suggest that the association between caries and economic status and/or parents' educational level is still not clear and more research is required.

The present study was cross-sectional and therefore has its limitations and it was difficult to approximate whether it was representative of a long term dietary pattern, which might contribute to a subjects' experience of dental erosion. A significant proportion of children in Benghazi, Libya were affected by dental erosion which emphasizes the importance of preventive measures needed to control the erosive process, before the need for invasive involvement to restore eroded teeth. Therefore, this study provided a base-line for future assessments of dental erosion in this population and presented vital information to suggest recommendations and to identify potential areas for future work.

Chapter 11

Conclusions, recommendations and future work

11.1 Conclusions with regard to main aim

To determine the prevalence and severity of dental erosion amongst 12 year-old schoolchildren in Benghazi, Libya.

- Over a third of the 971 12 year-old Libyan subjects; 323 (40.8%) had experience of dental erosion based on depth and on area, which was seen mainly in enamel (258 subjects, 32.5%) and affected more than two thirds of the surfaces. Erosion into dentine was uncommon (63 subjects, 8%) and into pulp was rare (2 subjects, 0.3%).
- Dental erosion was more prevalent in girls 184 (46.7%) than boys 139 (35%); this difference was statistically significant (p= 0.001).
- Of the 791 subjects, 25% of subjects had evidence of dental erosion, with one or more labial or palatal surfaces of the incisors examined scoring >0 for depth or for area.
- Of the sample, 23% of subjects had evidence of dental erosion (score >0 for depth or for area) affecting the occlusal surface of at least one of the first permanent molars examined.
- In total, 6328 upper permanent incisors and upper and lower first permanent molars were evaluated. Among these teeth, 1372 (21.7%) had evidence of erosion.
- In total, 9492 tooth surfaces of upper permanent incisors and upper and lower first permanent molars were evaluated. Of these surfaces, 2128 (22.4%) surfaces had evidence of erosion. Dental erosion was symmetrical across the midline.
- In total, 3164 incisors were evaluated. Among these teeth, 756 (23.9%) incisors had evidence of erosion on their labial surfaces, while 775 (24.5%) on palatal surfaces.

- Of the 3164 maxillary and mandibular first permanent molars examined, 597 molars (18.9%) had evidence of erosion.

11.2 Conclusions with regard to subsidiary aims

11.2.1 with regard to subsidiary aim 3.2.1;

- From all dietary variables included in the questionnaire survey, the only variables statistically associated with the experience of dental erosion in the bivariate analysis were: the frequency of consumption of fruit-based sugared drinks, the frequency of consumption of sugared tea with milk, length of time taken to consume drinks and frequencies of consumption of sport drinks, carbonated water and fruit.
- The frequency of consumption of fruit-based sugared drinks was statistically significantly positively associated with the experience of dental erosion (p= 0.006).
- The frequencies of consumption of sugared tea with milk (p= 0.032) and flavoured milk (p= 0.043) were statistically significantly negatively associated with the experience of dental erosion.
- The experience of erosion increased with increasing the length of time taken to consume drinks, especially when the drinks lasted up to 15 minutes. This was a statistically significantly positive association (p= 0.005).
- The frequencies of consumption of sport drinks (p= 0.004), carbonated water (p= 0.048) and fruit other than bananas (p=0.002) were statistically significantly negatively associated with the experience of dental erosion. However, since the majority of the subjects (89%, 84%) never consumed sport drinks and carbonated water, respectively, it is possible that the results have been influenced by the impact of this low frequency of intakes of these drinks and the fruit.
- The frequency of consumption of fruit-based sugared drinks was also statistically significantly positively associated with the experience of dental erosion in the

multivariate analysis. Subjects who daily consumed fruit-based sugared drinks were most likely to have dental erosion (Odds Ratio 1.349, p= 0.049, 95% CI 1.001, 1.819).

- The frequency of consumption of fruit other than bananas was statistically significantly positively associated with the experience of dental erosion in the multivariate analysis (p= 0.014, OR 3.411, 95% CI 1.288, 9.030). In this study, fruits other than bananas were consumed by only 6% of the Libyan subjects with a frequency of two to four portions per day, the majority of subjects consuming one or less than one portion per day. Therefore, the present findings suggest excluding the association between the consumption of fruits and experience of erosion.
- The frequency of consumption of sugared tea with milk was statistically significantly positively associated with the experience of dental erosion in the multivariate analysis (p= 0.041, OR 1.375, 95% CI 1.013, 1.868).
- Consumption of acidic drinks at bedtime, brushing after consuming acidic drinks, chewing gum, frequency of toothbrushing and parents' education were not associated with experience of dental erosion.
- There was no statistically significant association between experience of dental erosion and dietary data collected from the sub-sample (n= 180) through three-food diaries with interviews. However, it is not possible to assess whether the collected dietary data was representative of a long-term dietary pattern, which could potentially contribute to the experience of dental erosion.

11.2.2 Conclusion with regard to subsidiary aim 3.2.2;

- There was no statistically significant association between fluoride exposure from water supplies and experience of dental erosion.

11.2.3 Conclusions with regard to subsidiary aim 3.2.3;

- Over half of the subjects (57.8%) had experience of dental caries. The mean DMFT and DMFS indices were 1.68 (SD± 1.86) and 2.39 (SD± 3.05) for all 791 subjects.

Considering only subjects with caries experience (457), the mean DMFT and DMFS indices were 2.90 (SD± 1.56) and 4.14 (SD± 2.97), respectively.

- The Decay index was 95.2%, Missing index was 3% and Care index was 1.8%. The D (decayed) component (1.60, SD± 1.79) comprised the greatest proportion of the caries experience seen. The F (filled) component (0.03, SD± 0.28) comprised the lowest of all components of the indices. The M (missing teeth due to dental caries) component was (0.05, SD± 0.24).
- The mean DMFT and DMFS were higher in girls (1.88 and 2.71) than boys (1.48 and 2.08), respectively ($p= 0.002$).
- The mean DMFT for this study (1.68) was higher than the WHO goal for 2020; a mean DMFT ≤ 1.5 for the same age group (Petersen, 2003).
- There was a statistically significant positive association between the experience of dental caries and frequency of consumption of fruit-based sugared drinks ($p=0.001$, OR 1.368, 95% CI 0.468, 1. 83). There was a statistically significant negative association between the experience of dental caries and fathers' education levels ($p=0.008$, OR 0.699, 95% CI 0.536, 0.912).

11.2.4 Conclusion with regard to subsidiary aim 3.2.4;

- The experience of dental erosion was not statistically associated with experience of dental caries.

11.3 Null hypotheses testing

The following null hypotheses were tested in the present study:

11.3.1 There is no difference in the prevalence and severity of dental erosion in 12 year-old children in Benghazi, Libya compared with European children.

- There was no difference in the prevalence and severity of dental erosion in 12 year-old children in Benghazi, Libya and European children and the null hypothesis was accepted. The prevalence (40.8%) and severity (erosion into enamel only was the most common finding) of dental erosion in 12 year-old children in Benghazi, Libya was in agreement with data reported for the prevalence and severity of dental erosion in European children; the 52% found in the UK NDNS (Walker *et al.*, 2000) and 33% found in the 2003 UK CDH Survey (Chadwick and Pendry, 2004); both these studies reported the majority of children had erosion in enamel only.

11.3.2 There is no relationship between dental erosion and caries in 12 year-old children.

- There is no relationship between dental erosion and dental caries in 12 year-old children in Benghazi, Libya and the null hypothesis was accepted. The experience and severity of dental erosion was not statistically significantly associated with the experience of caries.

11.3.3 There is no relationship between the prevalence and severity of dental erosion and the amount and frequency of consumption of acidic dietary items.

- The null hypothesis was rejected. The experience of dental erosion was statistically significantly positively associated with frequency of consumption of fruit-based sugared drinks. The experience of dental erosion was statistically significantly positively associated with frequency of consumption of fruits, but it is possible that the results have been influenced by the impact of the low frequency of consumption of fruits by a majority of the subjects.

11.3.4 There is no relationship between the prevalence and severity of dental erosion and exposure to other risk factors for dental erosion.

- The null hypothesis was rejected. The experience of dental erosion was statistically significantly positively associated the length of time taken to consume drinks.

11.4 Recommendations

Taking into account the aspects included in the present study, it is recommended that:

- Children and parents' awareness about dental erosion and potential risk factors for its development should be increased. Advice for its prevention also should be increased. Educational information about dental erosion should be distributed using easy and accessible messages to be understood by all people.
- Children and adolescents should be included as target groups in education and prevention programmes about dental erosion.
- A unified approach between different countries using a common criterion-referenced index and specific reference ages for the assessment of dental erosion should be defined to allow comparison of dental erosion in terms of prevalence and severity in epidemiological studies.
- Development of longitudinal studies should be emphasized to monitor trends in the prevalence of dental erosion.
- Sufficient training of dentists and dental professionals should be carried out to enable them to recognize the early stages of dental erosion in order to prevent further progression of this condition and minimize the expense of treatment.
- The consumption of tap water should be encouraged as part of a healthy diet and as a good alternative to soft drinks. 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.
- The consumption of acidic drinks should be discouraged and sales of these drinks should be restricted at school canteens. As an alternative, sales of healthy foods and drinks such as fruits, milk and water should be encouraged. Taxes on acidic drinks

should be increased. The consumption of fruits should be encouraged as part of a healthy diet.

- Television advertisements should be controlled, in order to prevent the promotion of unhealthy foods and drinks and to encourage a healthy diet, particularly at children's programming time. Participation of dentists in television health programmes is needed in order to explain to people the potential risk factors for dental erosion and its prevention.
- Government, community representatives and schools should be involved in programmes to educate people about dietary practices and general health. Health visits to schools are needed in order raise awareness and describe to the schoolchildren the risk of food habits, such as the frequent consumption of carbonated drinks, to health in general and to oral health in particular.
- Researchers and manufacturers should continue to research and develop modified food and drinks in order to minimize dental erosion.

11.5 Further work

The present study has identified the following aspects of this area of research warranting further work:

- The evaluation of people and dental professionals' awareness about dental erosion and its potential risk factors is needed. Assessment of knowledge, behaviour and attitudes using focus groups of schoolchildren, parents, dentists and public health planners about dental erosion and its potential risk factors should be undertaken in order to facilitate decisions on future plans and programmes for education and awareness.

- Development of further prevalence studies on dental erosion in urban and rural environments in Libya are essential, in order to assess if dental erosion is a major dental health problem in the country as a whole.
- Further international prevalence studies and longitudinal studies on dental erosion are needed, so that trends in its prevalence can be observed and prevention strategies reviewed.
- Further studies to test the relationship between dental erosion and caries are needed, in order to identify the potential risk factors for the two conditions and to assess if conflicting preventive methods for the two conditions exist.
- Laboratory investigations are needed to identify the potential risk factors for dental erosion and to verify the erosivity of different foods and drinks consumed by Libyan children and adolescents.
- Further questionnaire based studies are needed to compare the dietary habits of children in urban and rural areas in Libya.
- Further dietary studies using food diary analysis with interviews are needed to test the relationship between frequency and amount of acidic food items and dental erosion.
- A derived score was used in the present study to measure the severity of dental erosion by Area x Depth. This score provided a greater range of values and was used as a proxy for the volume loss due to erosion on each tooth surface. Similar results were found when dental erosion by Area x Depth score was compared with separate Depth and Area scores. But Area x Depth provided a wider range of scores which may help to predict need for dental treatment and manage it clinically. This derived score needs to be validated.

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LIBYA
Mediterranean Sea
Tunisia
Tripoli
Leptis Magna
Nalut
Nafusa Mountains
Cyrene
Jebel Akhdar
Benghazi
To Cairo (400km)
Berdi
Gulf of Sirte
Surt
Ajdabiya
Brega
Ghadhames
Sawda Mountains
Houn
Jalu
Jaghbub
EGYPT
Ubari Sand Sea
Ubari
Brak
Sebha
ALGERIA
Great Sand Sea
Waw Namus (538m)
Tazerbo
Ghat
Acacus Mountains
Murzuk Sand Sea
Qatroun
Buseima
Kufra
Ribiana Sand Sea
Tummu
NIGER
Tibesti
CHAD
SUDAN
0 300 km
0 180 miles

Number of the schools and 12 year-old schoolchildren in each school in each District in Benghazi

Name of schools	No. of 12 year-old children	No. of schools
Al Bayan Alawal district, name of schools:		
1. Al Qudis	129	
2. Yousif Buraheel	110	
3. Al Karam	111	6
4. Al Nahda	109	
5. Al Mujahid	103	
6. Imhamed Al Mugaryaf	108	
	Σ 670	
Sidi Hussain district, name of schools:		
7. Asma	94	
8. Al Andulus	95	4
9. Uzu	100	
10. Jameyat alkafeef	92	
	Σ 381	
Al Sabri–West district, name of schools:		
11. 23 Youlyou	85	
12. Al Antifada	80	5
13. Palestine	82	
14. Al wahda Al arbia	83	
15. Omar Almukhtar	70	
	Σ 400	
Al Sabri-East district, name of schools:		
16. Rabaah Al Adawayh	49	
17. Sama	50	7
18. Al Qumayah Al Ambia	48	
19. Omar Al farouq	51	
20. Al Sawaed	47	
21. Al Thamaa	42	
22. Shuhada Alsabri	64	
	Σ 351	
Al Mukhtar district, name of schools:		
23. Al Hasan Ben Ali	101	
24. Almanar	120	5
25. Jaber Ben Hayan	105	
26. Al Qadeesaya	110	
27. Osama Ben Zaid	109	
	Σ 545	
Al Salmani East district, name of Schools:		
28. Ali Ben IbiTalib	52	
29. Amenah Bint wahb	51	7
30. Ashbal Al Fateh	59	
31. Thorat Al Hijara	56	
32. Fatat al Thora	50	
33. Al Yarmouk	52	
34. Shuhada Al Aghylaa	50	
	Σ 370	
Al Salmani West district, name of schools:		
35. Bilal Ben Rabah	82	
36. Baraam al Thora	84	5
37. Jeel Al Mistaqbal	84	
38. Al Shura	80	
39. Al Feedai Alarabi	70	
	Σ400	
Dawood North district, name of schools:		
40. Taraq Ben Zayad	109	
41. Al Shaheeda Sama	101	4
42. Al resalah Al muqadasa	120	
43. Tagrafit	120	
	Σ 450	
Dawood West district, name of Schools:		
44. Al Fakr Al rayid	81	
45. Al maseera Al Kubra	80	8
46. Shabab Al Fatch	89	
47. Khalid Ben Waleed	80	
48. Al Sadiq Balaa	82	
49. Baraam Al Nasser	78	
50. Shuhada Jandouba	81	
51. Al Amal Al kabeer	79	
	Σ 650	
Khalid Ben Walid district, name of Schools:		
52. Zaharat Al Mustaqbal	99	
53. Ibn Sina	100	6
54. Al Bashayir	100	
55. Ibn Ibi KHaab	101	
56. Al Fayha	103	
57. Khleej Al Tahadi	97	
	Σ 600	
Dawood South district, name of schools:		
58. Badr Al Kubrah	87	
59. Ahmed Al Shareef	88	8
60. Al Nahr Al Synai	83	
61. AlSaydah Zaynab	84	
62. Al Gardabyiah	90	
63. Al Noor	80	
64. Mishal al wahda	86	
65. Qurtaba	102	
	Σ 700	
Al Jazeera district, Name of schools:		
66. Fajar Al horayah	84	
67. Jeel Al Thora	87	3
68. Shuhada Al Jazeera	81	
	Σ 252	
Garyounis district, name of Schools:		
69. Al Amal al akhdar	112	
70. Ibn Khaldoon	100	3
71. Garyounis	125	
	Σ 337	
Al Fuwayhat West district, name of Schools:		
72. Amragaa Al Bargathi	160	
73. Al Etihahd	155	4
74. Baraam Al Tahdi	157	
75. Al Najah	159	
	Σ 631	
Benghazi Al Jadidah district, name of schools:		
76. Al Wafa	170	
77. Al Majd	157	6
78. Al Eid Al dahabi	150	
79. 12 Rabe'ah Al awal	160	
80. Al Sulta ash shabia	156	
81. Al Abbas Ben Abdulmutalib	152	
	Σ 945	
Total	**7682**	**81**

ORAL HEALTH ASSESSMENT FORM

NAME ____

IDENTIFICATION No [ ][ ][ ]   DATE OF EXAM [ ][ ][ ][ ]
Day Month

SCHOOL No [ ][ ]

GENDER (1= M, 2=F) [ ]   DATE OF BIRTH [ ][ ][ ][ ][ ][ ]
Day Month Year

EXAM (ORIGINAL = 1, DUPLICATE = 2) [ ]

DENTAL EROSION

Right UPPER ← Left

	6	2		1		1		2		6
	O	L	P	L	P	L	P	L	P	O
Depth										
Area										

	6		6
	O		O
Depth		LOWER	
Area			

CRITERIA

DEPTH

Normal	0
Enamel only	1
Enamel and dentine	2
Enamel, dentine and pulp	3
Assessment cannot be made	9

AREA

Normal	0
< 1/3 surface	1
1/3 < 2/3 surface	2
> 2/3 surface	3
Assessment cannot be made	9

DENTITION STATUS

Right								UPPER							Left	
8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8	SURF.
																D
																O
																M
																B
																P

Right								LOWER							Left	
8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8	
																D
																O
																M
																B
																L

CRITERIA

STATUS	CROWN (SURFACE)
Sound	0
Decayed	1
Filled, with decay	2
Filled, with no decay	3
Missing, as a result of caries	4
Missing, any other reason	5
Fissure sealant	6
Bridge abutment, special crown or veneer / implant	7
Unerupted tooth, (crown) / unexposed root	8
Trauma (fracture)	T
Not recorded	9

The conduct of the examination and criteria for the assessments

1 Tooth Condition by WHO, 1997

Teeth will be examined in the following order:
Upper left - upper right - lower right - lower left.
In the first instance the tooth will be identified and coded. In cases where both the primary tooth and its permanent successor are present further details will be recorded for the permanent tooth only. Code only the permanent tooth.

Tooth surfaces

If a tooth is present, each surface will be examined, coded and called in the following order: Distal – occlusal – mesial – buccal – lingual. In the cases of anterior teeth' occlusal' is omitted. Obscured surfaces (e.g. by an orthodontic band) will be assumed to be sound unless there is clear evidences to the contrary.

The surface coding is as follows:

Code 0 Present and sound.

Code 0 (zero) is used for all surfaces that are present and have no caries experience. A surface is recorded as 'sound' if it shows no evidence of treatment or untreated clinical caries up to the 'caries into dentine' diagnostic threshold. The stages of caries that precede cavitations, as well as other condition similar to the early stages of caries, are excluded because they cannot be reliably diagnosed. Thus, a crown with the following defects, in the absence of other positive criteria, should be coded as sound:

- White or chalky spots
- Discoloured or rough spots that are not soft to touch with a metal CPI probe
- Stained pits or fissures in the enamel that do not have visual signs of undermined enamel or softening of the floor or walls detectable with a CPI probe
- Dark, shiny, hard, pitted areas of enamel in a tooth showing signs of moderate to severe fluorosis
- Lesions that, on the basis of their distribution or history, or visual/tactile examination, appear to be due to abrasion.

Code 1 Decayed crown

Caries is recorded as present when a lesion in a pit or fissure, or on a smooth tooth surface, has an unmistakable cavity, undermined enamel, or a detectably softened floor or wall. A tooth with a temporary filling or which is sealed (code 6) but also decayed, should also be included in this category. The CPI probe should be used to confirm visual evidence of caries on the occlusal, buccal and lingual surfaces. Where any doubt exists, caries should not be recorded as present.

Code 2 Filled crown, with decay

A crown is considered filled, with decay, when it has one or more permanent restorations and one or more areas that are decayed. No distinction is made between primary and secondary caries (i.e. the same code applies whether or not the carious lesions are in physical association with the restoration).

Code 3 Filled crown, with no decay

A crown is considered filled, without decay, when one or more permanent restorations are present and there is no caries anywhere on the crown. A tooth that has been crowned because of previous decay is recoded in this category. A tooth that has been crowned for reason other than decay, e.g. a bridge abutment, is coded 7.

Code 4 Missing tooth, as a result of caries
This code is used for teeth that have been extracted because of caries and is recorded under coronal status. In some age groups, it may difficult to distinguish between unerupted teeth (code 8) and missing teeth (codes 4 or 5). Basic knowledge of tooth eruption patterns, the appearance of the alveolar ridge in the area of the tooth space in question, and the caries status of other teeth in the mouth may provide helpful clues in making a differential diagnosis between unerupted and extracted teeth. Code 4 should not be used for teeth judged to be missing for any reason other than caries.

Code 5 Permanent tooth missing, for any other reason
This code is used for permanent teeth judged to be absent congenitally, or extracted for orthodontic reasons or because of periodontal disease, trauma.

Code 6 Fissure sealant
This code is used for teeth in which a fissure sealant has been placed on the occlusal surface; or for teeth in which the occlusal fissure has been enlarged and a composite material placed. If a tooth with a sealant has decay, it should be coded 1.

Code 7 Bridge abutment, special crown or veneer
This code is used under coronal status to indicate that a tooth forms part of a fixed bridge, i.e. is a bridge abutment. This code can also be used for crowns placed for reasons other than caries and for veneers or laminates covering the labial surface of a tooth on which there is no evidence of caries or a restoration. Missing teeth replaced by bridge pontics are coded 4 or 5

Code 8 Unerupted crowns
This classification is restricted to permanent teeth and used only for a tooth space with an unerupted permanent tooth with or without a primary tooth. Teeth scored as unerupted are excluded from all calculations concerning dental caries. This category does not include congenitally missing teeth, or teeth lost as a result of trauma.

Code T Trauma (fracture)
A crown is scored as fractured when some of its surface is missing as a result of trauma and there is no evidence of caries.

Code 9 Not recorded
This code is used for any erupted permanent tooth that cannot be examined for any reason (e.g. because of orthodontic bands, severe hypoplasia, etc.).

Where doubt exists in the diffenentiation between the categories, the less severe category should always be called.

2 Dental erosion by Walker et al., 2000

The occlusal surfaces of the molar teeth and the labial and palatal surfaces of the incisor teeth will be assessed for loss of surface enamel characteristics, and/or exposure of dentine or pulp. The incisal edge will not be coded.
The examination will be carried out on the upper and lower first permanent molars and on the upper permanent incisors.

Assess the Depth and Area of loss of tooth tissue for each surface using the following criteria:
Depth:
Code 0 Normal

Code 1 Enamel Only
On incisor teeth there is loss of developmental ridges resulting in a smooth, glazed or 'ground glass' appearance. On occlusal surfaces the cusps appear rounded and there may be depressions producing 'cupping'.

Code 2 Enamel and dentine
There is loss of enamel exposing dentine. On incisors this may resemble a 'shoulder preparation' parallel to the crest of the gingivae, particularly on palatal surfaces. The incisors may appear shorter and there may be chipping of the incisal edges. On occlusal surfaces 'cupping and rounding-off of cusps is evident. Restoration may be raised above the level of the adjacent tooth surface.

Code 3 Enamel, dentine and pulp
Loss of enamel and dentine resulting in pulpal exposure.

Code 9 Assessment cannot be made.

Erosion should be distinguished from attrition and abrasion on the basis of the following:
Attrition usually occurs on occlusal surfaces, incisal edges, the palatal surfaces of upper anterior teeth and the labial surfaces of lower anterior teeth. The teeth appear faceted and the location of these facets can be elated to functional movements of the dentition. Occlusal surfaces may be flattened with an even loss of tooth substance from the marginal ridges as well as the remainder of the surface.

Abrasion is characterised by a rounded or v-shaped groove between the gingivae and the enamel at the necks of teeth. The depth of these lesions may exceed their breadth, unlike erosion lesions in the cervical area where breadth greatly exceeds depth.

Area:

For each affected surface assess by area:
Code 0 Normal.
Code 1 Less than one third of surface involved.
Code 2 One third – up to two thirds of surfaces involved.
Code 3 Two thirds or more of surface involved.
Code 9 Assessment cannot be made.

Schoolchildren's Questionnaire

Please do not write in this box

Identification number

Name: ________

Gender: _____Male (1) _____Female (2)

School No: _______

Date of birth:

Date you completed the questionnaire:

Dear pupil

This questionnaire was developed to get information about you. There are no right or wrong answers. What is important is that you carefully read the instructions before you start to answer the questionnaire.

I will keep your name and your answers confidential, so you do not need to be concerned about any information you provide. Please answer the questions as honestly as you can (in the way that best reflects what you do day by day).

Thank you for your help with this study!

Instructions to help you to answer the questionnaire

Please read the following instructions before starting the questionnaire:

1- Read each question carefully before answering it.

2- Please use a pen to complete this questionnaire.

3- The questions can be answered by putting a number by the answer that best applies to you in the column to the right of the sheet.

4- If you cannot remember, or do not know, or are unable to answer a particular question, please write that in.

5- Take your time to answer this questionnaire. You will not need any help from your classmates, since it is about you. Who else knows you better than yourself?!

Example

Do you drink fizzy drinks?

1) More than 2 per day -----

2) More than 1 per day -----

3) Once per day -----

4) Less than 1 per day -----

3

A-Do you drink fizzy drinks?
1) More than 2 per day -----
2) More than 1 per day -----
3) Once per day -----
4) Less than 1 per day -----
5) Never -----

B-Do you drink sugar free fizzy drinks?
1) More than 2 per day -----
2) More than 1 per day -----
3) Once per day -----
4) Less than 1 per day -----
5) Never -----

C-Do you drink sports drinks?
1) More than 2 per day -----
2) More than 1 per day -----
3) Once per day -----
4) Less than 1 per day -----
5) Never -----

D-Do you drink squash?
1) More than 2 per day -----
2) More than 1 per day -----
3) Once per day -----
4) Less than 1 per day -----
5) Never -----

E-Do you drink natural unsweetened fruit juices?
1) More than 2 per day -----
2) More than 1 per day -----
3) Once per day -----
4) Less than 1 per day -----
5) Never -----

F-Do you drink fruit-based sugared drinks?
1) More than 2 per day -----
2) More than 1 per day -----
3) Once per day -----
4) Less than 1 per day -----
5) Never -----

G-Do you drink milk?
1) More than two times per day -----
2) More than one time per day -----
3) One time per day -----
4) Never -----

H-Do you drink flavoured milk (including milk with chocolate)?
1) More than 2 per day -----
2) More than 1 per day -----
3) Once per day -----
4) Less than 1 per day -----
5) Never -----

I-Do you drink tea with milk?
1) More than 2 per day -----
2) More than 1 per day -----
3) Once per day -----
4) Less than 1 per day -----
5) Never -----

J-Do you drink tap or bottled water or both?
1) Tap water -----
2) Bottled water -----
3) Both tap and bottled water -----

K-Do you drink fizzy water?
1) More than 2 per day -----
2) More than 1 per day -----
3) Once per day -----
4) Less than 1 per day -----
5) Never -----

L-How often do you eat fruits other than bananas per day?
1) More than 4 per day -----
2) 2-4 per day -----
3) More than 1 per day -----
4) Once per day -----
5) Less than 1 per day -----

M-Do usually drink any of the following at bed time: fizzy drinks, squashes, fruit juices.
1) Yes -----
2) No -----

N-About how long do you usually make the drink last?
1) Drink it straight away -----
2) Up to 15 minutes -----
3) Between 15 and 30 minutes -----
4) Longer than 30 minutes -----

O-Do you chew gum?
1) No -----
2) Yes, I usually chew sugared gum -----
3) Yes, I usually chew sugar free gum -----

P-If you chew gum, how often?
1) Once a day -----
2) More than once a day -----

Q-How often do you brush your teeth?
1) More than two times a day -----
2) Twice a day -----
3) Once a day -----
4) Less than once a day -----

R-Do you know the brand of the toothpaste you are using at this moment?
1) Yes -----
2) No -----

S-Do you ever brush your teeth after consuming the following: fizzy drinks, squashes, fruit juices?
1) Yes -----
2) No -----

T-Do you usually use any of: fluoride mouthwash, fluoride tablets?
1) Yes -----
2) No -----

U-Do you regularly suffer from?

1) Asthma Yes ----- No -----
2) Diabetes Yes ----- No -----
3) Acid taste in the mouth Yes ----- No -----
4) Heart burn yes ----- No -----
5) Regular Stomach upsets yes ----- No -----

V-Do you usually take vitamin C?

1) Yes -----
2) No -----

W-If yes are they

1) Swallowed whole -----
2) Chewable -----
3) Liquid -----

X-Have you ever gone to a dentist?

1) No -----
2) Yes -----

Y-Would you say that:

1) I do not clench or grind my teeth -----
2) I do not know if I clench or grind my teeth -----
3) I clench and grind my teeth -----

Z-What is the level of education of your mother?

1) Not reading or writing -----
2) Elementary school -----
3) Intermediate school -----
4) Secondary school -----
5) College -----
6) Postgraduate degrees -----

AA-What is the level of education of your father?

1) Not reading or writing -----
2) Elementary school -----
3) Intermediate school -----
4) Secondary school -----
5) College -----
6) Postgraduate degrees -----

Thank you very much for your cooperation!

ID Number

Food diary for

Thursday ___

Friday ___

Saturday ___

Food Diary

Name: ______________________

Weight: _____

School: ______________________

School year: ______________________

Date: _____/_____/_____

Dear pupil

I know it can be difficult finding some time to write down everything you eat and drink for three days, but it is the best way of recording your true diet. This information is very important for our project. Therefore, I would like to ask you to complete this diary in the best way you can.

It would help if you had your diary close to you during these three days, so that you do not forget to take note of any food or drink. But if you have a meal but do not have your diary at the time you eat, you can complete it later. It is important that you remember to record your intake of any food and drink during the following consecutive three days: Thursday, Friday and Saturday. You are going to find some instructions, please take time to read them carefully, as they will help you on how to complete the diary.

If you have any questions about filling this diary in please phone Rasmia on Tel: 0926221056

I would like to thank you once more for your help with this project!

Instructions to the participants

Please read the instruction before starting the diary

- Do not forget to write down your name, school and date you start to complete this diary in the front page.

- This diary should be completed over three consecutive days: Thursday, Friday and Saturday, Please do not complete it on any other days.
- Write down everything you eat and drink, including water. Use one entry for each food or drink. Remember to give information about the portions of each type of food or drink. If you have any query about how to do it, just follow the example provided.
- Write down everything, even if it is a snack or a very small portion, for example, one sweet. Do not forget to write down the time you eat or drink anything, including; sweets, chewing gum.
- Try to be as much detailed as you can. For example, if you drink a low calorie fizzy drink, write it down. Try not to write only 'fizzy drink'. For example, you can also give the brand of the food or drink, like 'Diet Coke'.
- If you take any medicine (for example: tablets or inhalers) during any of the three consecutive days, remember to write it down.
- Remember to include any snacks you have between meals and before going to bed. Please write down the time you go to bed. Please leave the last column on the right blank.

Thank you for your help

Example

Saturday (Breakfast, lunch, dinner and snacks)

Time	Food or Drink or medicine	Portion size	Rasmia's column Please leave blank
07.30	Tea with milk and 1 spoon of sugar	1 cup	
07.30	White bread	2 slices	
07.30	Butter	1 tea spoon	
08.00	Medicine-antibiotics	1 tablet with 1 glass of milk	
09.15	Tap water	1 glass	
10 20	coke	1 can	
11.15	Chewing gum with sugar	1	
12.15	Rice	3 spoon	
12.15	Fried egg	1	
12.15	Salad(tomato and lettuce)	1 dish	
12.15	Orange juice with sugar	1 glass	
13.40	Strawberry sweets	3	
15.00	Orange squash	1 glass	
15.00	Chocolate digestive biscuits	3	
18.10	White bread	3 slices toasted	
18.10	Grape juice with sugar	1 glass	
18.10	Chicken	2 slices	
19.20	coke	1 slice	

I went to bed at 10 pm on Saturday

Thursday (Breakfast, lunch, dinner and snacks and drinks)

Time	Food or drink or medicine	Portion size	Rasmia's column please leave blank

Time	Food or drink or medicine	Portion size	Rasmia's column please leave blank

Time	Food or drink or medicine	Portion size	Rasmia's column please leave blank

Time	Food or drink or medicine	Portion size	Rasmia's column please leave blank

I went to bed at _______ on Thursday.

Friday (Breakfast, lunch, dinner and snacks and drinks)

Time	Food or drink or medicine	Portion size	Rasmia's column please leave blank

Time	Food or drink or medicine	Portion size	Rasmia's column please leave blank

Time	Food or drink or medicine	Portion size	Rasmia's column please leave blank

Time	Food or drink or medicine	Portion size	Rasmia's column please leave blank

I went to bed at _______ on Friday.

Saturday (Breakfast, lunch, dinner and snacks and drinks)

Time	Food or drink or medicine	Portion size	Rasmia's column please leave blank

Time	Food or drink or medicine	Portion size	Rasmia's column please leave blank

Time	Food or drink or medicine	Portion size	Rasmia's column please leave blank

Time	Food or drink or medicine	Portion size	Rasmia's column please leave blank

I went to bed at ______ on Saturday.

Would you like to make any comment about what you ate during these three days?

____

____

Would you say that during these three days you have eaten as you usually do or would you that you have changed it?

____

____

Notes and recipes

Standard Laboratory Operating Procedure

DIRECT FLUORIDE ANALYSES

1. Purpose
The purpose of this Standard Operating Procedure (SOP) is to describe the direct analysis for determination of fluoride in non-dairy beverage, water and urine samples

2. Scope
The scope of this Standard Operating Procedure is to describe the Direct Analysis procedures for determining the fluoride (F) concentration. The SOP describes terms and definitions, equipment and supplies, preparation of reagents and standards, processing of samples for analysis, potentiometer use for analysis and the use of the Microsoft *'Excel'* software program for calculating results.

3. Terms and Definitions

- **Direct Analysis**
- for fluoride involves direct measurement of fluoride by determining fluoride ion concentration through the use of an ion specific electrode.

- **Slope** is the change in millivolt potential for a unit change in the logarithm of the fluoride concentration. In accordance to Nernst equation, the logarithm of the concentration plotted against the millivolt potential results in a straight line with a change of approximately 59 mV per decade, when the fluoride concentration, is above 0.1ppm at a temperature of 25°C.

4. Equipment and Supplies

4.1 Equipment and Supplies

Adjustable Pipetman
Combination Fluoride-Specific Electrode
Computer
'IBM' compatible (Pentium II or higher)

Computer Software
Computer operating system Microsoft Windows 98 or higher
Microsoft *'Excel'* software version 2000 or higher

Disposable Pipette Tips
- 200-1000 µL   1-5 ml

pH/ion Meter
Scintillation Vials
Wipes

4.2 Chemicals

Deionized Water (DiH_20)

Double Distilled Water (DDiH2O)

Electrode, Equitransfer Filling Solution
(*'Orion'*, # 900001)
Standard Fluoride Solution, 100 ppm
(*'Orion'*, # 940907)
Total Ionic Strength Adjusting Buffer (TISAB) I, II or III
(*'Orion'*, # 040906, 040907, 040908, 940909 and 940911)

5. Preparation of Reagents and Standards

All reagents and standards must be prepared with double distilled water (DDiH_2O).

Label the containers of the stock standard fluoride solutions with identity, concentration and date of preparation.

Note:

To avoid contamination, aliquots must never be pipetted directly from stock solutions. When standard F solutions are used, *'working'* amount of each standard must be transferred from these stock solutions into pre-labeled containers and subsequently used from these containers.

Table 1

Standard	Volume of Stock Standard	+	DDiH_2O
20 ppm F	2 ml of 100 ppm F standard	+	8 ml
10 ppm F	1 ml of 100 ppm F standard	+	9 ml
5 ppm F	5 ml of 10 ppm F standard	+	5 ml
2 ppm F	1 ml of 20 ppm F standard	+	9 ml
1 ppm F	1 ml of 10 ppm F standard	+	9 ml
0.5 ppm F	5 ml of 1 ppm F standard	+	5 ml
0.3 ppm F	3 ml of 1 ppm F standard	+	7 ml
0.2 ppm F	1 ml of 2 ppm F standard	+	9 ml
0.1 ppm F	1 ml of 1 ppm F standard	+	9 ml
0.05 ppm F	1 ml of 0.5 ppm F standard	+	9 ml
0.02 ppm F	1 ml of 0.2 ppm F standard	+	9 ml
0.01 ppm F	1 ml of 0.1 ppm F standard	+	9 ml

6. Processing Samples for Analysis

1. Place an aliquot of each beverage or pooled beverages samples in a vial and label with the sample number (or if coded, use an assigned random number), and the date.

2. Use a **1.0** ml aliquot for fluoride analysis.

7. Fluoride Analyses

Every time a new set of analyses are performed:

1 A new group of standards must be analyzed.

2 **The tested standards must cover the expected range of F concentrations in the samples to be analyzed:**

a. At least three (3) standards should be prepared and analyzed.

b. Construct a standard curve using the *'Excel'* program as described in Section 10 *'Regression Data Analysis for Fluoride Standard Solutions'*.

NOTE: When analyzing standards to construct a curve, standards should be analyzed from lowest to highest concentration.

3. The slope of the fluoride electrode should be 58 - 60 (=-1/m) calculated inverting the slope of the Linear Regression Equation for the F standard solutions with the F concentrations ranging from 0.1 to 100 ppm F. The slope is an indicator as how well the F electrode is performing. If the number is below 58, new standards should be analyzed before the electrode is replaced.

8. Direct Analysis

1. Mix each **standard or sample 1:1**(v/v) with TISAB I, II; or, mix each **standard or sample 10:1** (v/v) with TISAB III buffer in a scintillation vial labeled with the concentration of the standard or with the specimen number if the sample is being analyzed.

2. Measure the mV readings of the standards or samples.
   a) Take the electrode out of the storage solution.
   b) Hold a beaker around the electrode and rinse the electrode thoroughly with deionized water.

   c) Blot the electrode dry with a wipe.

   d) Place the electrode in the standard or sample making sure the solution being analyzed 'wets' the entire end of the electrode.

   e) Verify the meter is in the **mV mode.**

   f) Allow the electrode to stabilize.

   g) Record the millivolt reading for standards and samples in a data book or on a data sheet.

   h) Remove the standard or sample.

   i) Hold a beaker around the electrode and rinse the electrode thoroughly with deionized water.

   j) Dry the electrode with a wipe.

   k) Repeat steps **d-j** for the remainder of the standards and samples.

4. To convert millivolt readings into concentration, refer to Section 10 to construct a regression line or curve and calculate the equation using the *'Excel'* program.

(Note: It is recommended to run low concentration standard samples alongside each series of analyses to check for a possible drift in the electrode, if the drift in the electro is higher than 4-7 mV for the lowest standard, and then repeat the reading of the standard curve)

9.Calculations

Definitions: μg/ml = mg/l = parts per million (ppm)
μg/g = mg/Kg = parts per million (ppm)

10.Regression Data Analysis for Fluoride Standard Solutions

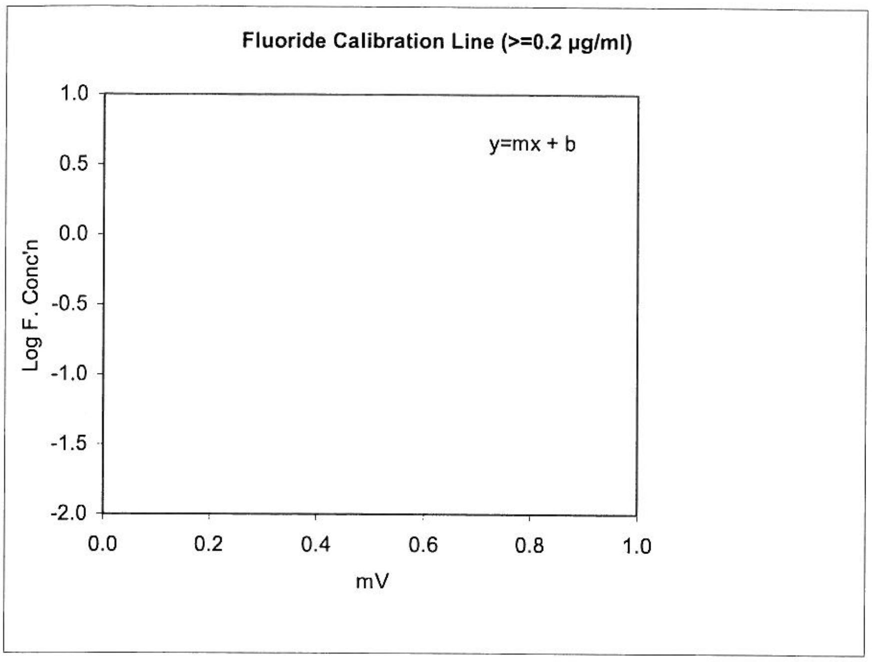
10.1 Constructing the Regression Line or Curve and Calculating the Equation

1. Open the beverage analysis Excel spreadsheet and type the date of analysis, study name/number, temperature at time of analysis and technician's initials.
2. Fill in the blanks of the table with the following values and calculations (See Table 2):
   - Fluoride standards concentration (μg/ml)
   - Volume of standards (ml)
   - Millivolts mV (X)

Table 2: Regression Data for Fluoride Standard Solutions

F stds (Fluoride standards concentration)	Volume (Volume of standards)	log F std (Logarithm of fluoride standards concentration)	mv	Calc'd log F (Calculation of logarithm of fluoride standards concentration)	Cal'd F (Calculation of fluoride standards concentration for linear regression)
µg/ml	ml	(µg/ml) Y	X	Y=mX+b	µg/ml
		#NUM!		0.00	1.00
		#NUM!		0.00	1.00
		#NUM!		0.00	1.00
		#NUM!		0.00	1.00
		#NUM!		0.00	1.00
		#NUM!		0.00	1.00
		#NUM!		0.00	1.00

3. Obtain m and b values from the equation in the self-calculating graph. (See figure)



10.2 Calculation of the Fluoride Concentration for Unknown Samples

1. In the same Excel spreadsheet, go to table with the following values and calculations
   (See Table 3). Fill in the following blanks:
   - Sample number
   - Volume of sample analyzed (ml)
   - Millivolt mV (Y)

2. The self-calculating spread sheet will give you the following data:
   - Logarithm of fluoride content in sample (μg)
   - Fluoride concentration (μg/ml)
   - Fluoride standards concentration
   - Standard use to check fro electrode drift

Table 4: Regression Data for Fluoride Concentration for Unknown Samples

Sample #	Volume (ml)	millivolt (mV) Reading	Calc'd log F	F- Content (µg/ml)

11. References

- Microsoft Excel on-line manual
- pH/ion meter manuals
- Electrode manual

The time table for field work in Benghazi, Libya.

Period	Task	Length of time
10 Sep-14 Sep. 2007	Obtain Permission from Ministry of Education. Obtain Permission from Ministry of Health. Obtain Permission from Dental School in Benghazi.	3 days
15 Sep-17 Sep.	Obtain Permission from the randomly selected schools.	3 days
18 Sep-28 Sep.	Permission from parents. Permission from children.	14 days
29 Sep-20 Oct.	Preparatory visits schools. Training an assistant. Printing and photocopy the required number of: Oral Health Assessment Forms. Food Dairy Forms. Questionnaire. Preparing the materials needed in dental examinations. Randomization: List of 12 year-old girls and list of 12 year-old boys will be made alphabetically and then assign them consecutive numbers. Using a list of randomly generated numbers to pick the samples of 11 boys or 11 girls that is required which are 22 from each school. Then, using the same method randomly selected 7 children from the 22 as a sub-sample for 3-day food dairy and randomly selection of 6 subjects for intra oral photography. Water Sampling Procedure: Eight water samples will be taken from each subject in the sub-sample (175 subjects) and will be collected by the subject. Two samples; one in the morning and one in the afternoon of the first day and two samples in the morning and afternoon in the third day of food dairy (from tap water at home). Another four water samples for the bottled water or any water may the subject drink outside the house. Labelling of sampling: each container should be labelled before give it to the subject. Each container should be labelled as follows: Type of water; tap (T), bottled (B), other source (O). The code of the subject similar to that on food dairy. Time of collection, morning (M) or afternoon (A). Day of collection, the first day (1), or third day (3) of the food diary. Four samples will be collected by the researcher; one in the morning and one in afternoon in the first and third day of food dairy from each school. Labelling of the school samples: Type of water; from school (S). Number of school. Time of collection; morning (M) or afternoon (A). Day of collection, the first day (1), or third day (3) of food diary.	17 days
3 Oct-11 Oct.	Food diaries delivered to a sub-sample of schoolchildren on Wednesday. 7 children in schools 1, 2 and 3 to complete it on Thursday, Friday and Saturday. Dietary interviews at schools and collection of water samples on Sunday. Questionnaire survey completed by 22 children at school in schools 1, 2 and 3 on Monday. Dental examination to the 22 children in schools 1, 2 and 3 on Tuesday, Wednesday and Thursday. 3 Intra oral photographic photos/child for 6 children in each school. Re-examine 2 subjects from each school.	9 days

10 Oct-18 Oct.	Food diaries delivered to a sub-sample of schoolchildren on Wednesday. 7 children in schools 4, 5 and 6 to complete it on Thursday, Friday and Saturday. Dietary interviews at schools and collection of water samples on Sunday. Questionnaire survey completed by 22 children at school in schools 4, 5 and 6 on Monday. Dental examination to 22 children in schools 4, 5 and 6 on Tuesday, Wednesday and Thursday. 3 Intra oral photographic photos/child for 6 children in each school. Re-examine 2 subjects from each school.	9 days
17 Oct-25 Oct.	Food diaries delivered to a sub-sample of schoolchildren on Wednesday. 7 children in schools 7, 8 and 9 to complete it on Thursday, Friday and Saturday. Dietary interviews at schools and collection of water samples on Sunday. Questionnaire survey completed by 22 children at school in schools 7, 8 and 9 on Monday. Dental examination to 22 children in schools 7, 8 and 9 on Tuesday, Wednesday and Thursday. 3 Intra oral photographic photos/child for 6 children in each school. Re-examine 2 subjects from each school.	9 days
24 Oct-1 Nov.	Food diaries delivered to a sub-sample of schoolchildren on Wednesday. 7 children in schools 10, 11 and 12 to complete it on Thursday, Friday and Saturday. Dietary interviews at schools and collection of water samples on Sunday. Questionnaire survey completed by 22 children at school in school 10, 11 and 12 on Monday. Dental examination to 22 children in schools 10, 11 and 12 on Tuesday, Wednesday and Thursday. 3 Intra oral photographic photos/child for 6 children in each school. Re-examine 2 subjects from each school.	9 days
31 Oct-8 Nov.	Food diaries delivered to a sub-sample of schoolchildren on Wednesday. 7 children in schools 13, 14 and 15 to complete it on Thursday, Friday and Saturday. Dietary interviews at schools and collection of water samples on Sunday. Questionnaire survey completed by 22 children at school in schools 13, 14 and 15 on Monday. Dental examination to 22 children in schools 13, 14 and 15 on Tuesday, Wednesday and Thursday. 3 Intra oral photographic photos/child for 6 children in each school. Re-examine 2 subjects from each school.	9 days
14Nov-22Nov.	Food diaries delivered to a sub-sample of schoolchildren on Wednesday. 7 children in schools 16, 17 and 18 to complete it on Thursday, Friday and Saturday. Dietary interviews at schools and collection of water samples on Sunday. Questionnaire survey completed by 22 children at school in schools 16, 17 and 18 on Monday. Dental examination to 22 children in schools 16, 17 and 18 on Tuesday, Wednesday and Thursday. 3 Intra oral photographic photos/child for only 6 children in each school. Re-examine 2 subjects from each school.	9 days
21Nov-29Nov.	Food diaries delivered to a sub-sample of schoolchildren on Wednesday. 7 children in schools 19, 20 and 21 to complete it on Thursday, Friday and Saturday. Dietary interviews at school and collection of water samples on Sunday. Questionnaire survey completed by 22 children at schools in schools 19, 20 and 21 on Monday. Dental examination to 22 children in schools 19, 20 and 21 on Tuesday, Wednesday and Thursday. 3 Intra oral photographic photos/child for 6 children in each school. Re-examine 2 subjects from each school.	9 days

28 Nov-6 Dec.	Food diaries delivered to a sub-sample of schoolchildren on Wednesday. 7 children in schools 22, 23 and 24 to complete it on Thursday, Friday and Saturday. Dietary interviews at school and collection of water samples on Sunday. Questionnaire survey completed by 22 children at school in schools 22, 23 and 24 on Monday. Dental examination to 22 children in schools 22, 23 and 24 on Tuesday, Wednesday and Thursday. 3 Intra oral photographic photos/child for 6 children in each school. Re-examine 2 subjects from each school.	9 days
5 Dec-13 Dec.	Food diaries delivered to a sub-sample of schoolchildren on Wednesday. 7 children in schools 25, 26 and 27 to complete it on Thursday, Friday and Saturday. Dietary interviews at schools and collection of water samples on Sunday. Questionnaire survey completed by 22 children at school in schools 25, 26 and 27 on Monday. Dental examination to 22 children in school 25, 26 and 27 on Tuesday, Wednesday and Thursday. 3 Intra oral photographic photos/child for 6 children in each school. Re-examine 2 subjects from each school.	9 days
19Dec-27 Dec.	Food diaries delivered to a sub-sample of schoolchildren on Wednesday. 7 children in schools 28, 29 and 30 to complete it on Thursday, Friday and Saturday. Dietary interviews at schools and collection of water samples on Sunday. Questionnaire survey completed by 22 children at school in schools 28, 29 and 30 on Monday. Dental examination to 22 children in schools 28, 29 and 30 on Tuesday, Wednesday and Thursday. 3 Intra oral photographic photos/child for 6 children in each school. Re-examine 2 subjects from each school.	9 days
26 Dec-3 Jan.	Food diaries delivered to a sub-sample of schoolchildren on Wednesday. 7 children in schools 31, 32 and 33 to complete it on Thursday, Friday and Saturday. Dietary interviews at schools and collection of water samples on Sunday. Questionnaire survey completed by 22 children at school in schools 31, 32 and 33 on Monday. Dental examination to 22 children in schools 31, 32 and 33 on Tuesday, Wednesday and Thursday. 3 Intra oral photographic photos/child for 6 children in each school. Re-examine 2 subjects from each school.	9days
2 Jan.-10 Jan.	Food diaries delivered to a sub-sample of schoolchildren on Wednesday. 7 children in both schools 34 and 35 to complete it on Thursday, Friday and Saturday. Dietary interviews at schools and collection of water samples on Sunday. Questionnaire survey completed by 22 children at school in both schools 34 and 35 on Monday Dental examination to 22 children in both schools 34 and 35 on Tuesday, Wednesday and Thursday. 3 Intra oral photographic photos/child for 6 children in each school. Re-examine 2 subjects from each school.	9 days
11 Jan-30 Jan.	Complete any unfinished work. Photocopying the written documents as backup (oral health assessment forms, questionnaires, food diaries). Shipping the written documents and drinking water samples to Newcastle upon Tyne. The return to Newcastle to process the collected data.	20 days

UNIVERSITY OF
NEWCASTLE UPON TYNE

School of Dental Sciences
University of Newcastle upon Tyne
Framlington Place
NE2 4BW

Libyan Cultural Affairs Department
Libyan Embassy
61-62 Ennismore Gardens
London
SW7 1NH

8-07-07

Dear Sir/Madam

Field work in Benghazi, Libya for PhD project: Dental erosion and its association with fluoride exposure and risk factors for erosion, in 12 year old schoolchildren in Benghazi, Libya.

I write to seek your agreement for Rasmia Huew (RH), who is a registered postgraduate (PhD) student in the School of Dental Sciences, Newcastle University, to carry out the field work for her study in Benghazi, Libya. She will determine the prevalence and the severity of dental erosion in schoolchildren in Benghazi and its association with dental caries and risk factors for dental erosion. This field work is part of the original design of her study, has been planned since the inception of the project and is essential for her PhD studies.

No study has published data relating to dental erosion in Libya. This is despite the growing concern regarding the prevalence and severity of dental erosion especially amongst children in developed counties.

The study will help to determine the prevalence of dental erosion in schoolchildren in Benghazi and provide strategies for prevention and treatment.

The fieldwork schedule has been prepared by Mrs Huew at Newcastle University and the protocol requires the dentist (RH) to dentally exam 12 year old children in 35 selected schools in Benghazi and collect dietary information using a 3 day food diary. She will need 5 months in Libya to undertake recruitment of schools and pupils, undertake a dental examination of 770 12 year-old schoolchildren along with a self-completion questionnaire. In addition, in a sub-sample of 175 children she would collect three day estimated food diaries, carry out a post-diary interview and collect drinking water samples to measure fluoride concentration. The fieldwork would take place according to the schools' calendar, during the first semester of the next academic year (from September 2007). The data collection sheets, food diaries and water samples would then be returned to the UK for analysis.

Accompanying this letter are the Title, Aims, Objectives and brief overview of the study. Should you require any further information regarding the protocol or have any queries regarding the proposed study, I would be very happy to answer them and can be contacted at the above address.

Yours sincerely

Dr Anne Maguire, Senior Clinical Lecturer in Child Dental Health

Switchboard · 0191 222 6000
www.ncl.ac.uk/dental

الجماهيرية العربية الليبية الشعبية الاشتراكية العظمى
المكتب الشعبي - لندن
الشئون الثقافية

إن العلاقات الدائمة بين الشعوب وليست بين الحكومات

التاريخ:

الرقم الإشاري:

التاريخ : 12/07/2007
الرقم الاشاري: 489-07-07
رقم الملف : 4990

قرار الايفاد : 00
بداية الصرف: 01/09/2006
نهاية الصرف: 31/08/2010
أشهر المنحة: 48

اسم الطالب : رسمية محمد ابرهيم احويو
الدرجة العلمية : دكتوراه طب
التخصص : طب اسنان

الأخ/ مدير إدارة البعثات والتعاون الفني

بعد التحية،،،

الموضوع :دراسة حقلية

تقدمت الينا المعنية بطلب لموافقتكم على اجراء دراسة حقلية في الجماهيرية ولمدة 4 اشهر، لجمع البيانات المتعلقة بدراستها وذلك حسب رسالة الاستاذ المشرف المرفقة.

نأمل منكم موافاتنا بالخصوص.

والسلام عليكم ورحمة الله وبركاته ،،،

عياد محمد مقتوق
الملحق الثقافي المكلف
المكتب الشعبي الليبي - لندن

المكتب الشعبي للجماهيرية العربية الليبية الشعبية الاشتراكية العظمى
لندن
الشئون الثقافية
Cultural Affairs
LONDON
The People's Bureau of the Great Socialist People's Libyan Arab Jamahiriya

صورة لملف الطالب 4990

صورة للملف الدوري العام

المعرفة حق طبيعي لكل انسان

الجماهيرية العربية الليبية الشعبية الاشتراكية العظمى
اللجنة الشعبية لشعبية بنغازى

امانة اللجنة الشعبية للتعليم

الرقم الاشاري : ت.ت.ع. ح.م. 14. 263. 975.

التاريخ : / /

الموافق : 10 / 9 / 2007 م

الأخـوة / مدراء المؤسسات التعليمية للتعليم الأساسي

بعــد التحيــة ،،،

بنـــــــاءً ... علي الطلب المقــدم من الطالبة في مجال طب الأسنان رسميـــة محمـــد حويـــو حيــثُ ستقــوم بدراســـة علي طلبة الصـــف الســـادس العمـــر 12 ســـنة .

عليـــــــه ... نأمل منكم مساعدتها في إجراء فحوصات علي الطلبة بالإضـــافة إلي ملءْ استبيان غذائي

نأمل تعاونكم ولكم خالص الشكر والتقدير

والســـلام عليكـــم ،،،،،

فتحي عبد المجيد البدري

مـــدير مكتب التعليـــم الأساســـي

باللجنة الشعبية للتعليم شعبية بنغازي

/ للأخ / أمين اللجنة الشعبية للتعليم شعبية بنغازي
الحفـــــــــــــــــظ
الشهوبي . س. الأوجلي

2228403 : - 2229306 - 2226444 :

الجماهيرية العربية الليبية الشعبية الإشتراكية العظمى

أمانة اللجنة الشعبية للصحة والضمان الإجتماعي - شعبية بنغازي

لاديمقراطية بدون مؤتمرات شعبية

الصحة للجميع وبالجميع

الرقم : ص ٣٠٢٠ مدرسية/44/07

التاريخ : / /

الموافق : 12/9/2007

الأخوة / مدراء مدارس التعليم الأساسي .

بعد التحية ،،،،

في إطار التعاون المستمر بيننا خدمة لأبنائنا الطلبة نأمل منكم السماح للأخت / د. رسمية محمد حويو إجراء فحص طبي لطلبة المدارس في مجال خدمات الأسنان .

شاكرين حسن تعاونكم معنا

والســـــلامــ عليـــــكمـــ،،،،،

"أ. محمد عبد الحميد نجم "
رئيس قسم الصحة المدرسية
بمكتب الرعاية الصحية الأولية
وصحة المجتمع

الأخ / منير مكتب الرعاية الصـــــحية الأولية
الأخ/ رئيس قسم النشاط المدرسي بأمانة التعليم
للحـــــــــــــــفظ

نحم // المقصبي

هاتف : 13-9090011 / 9099176 / 9092027 ص.ب : 2464 بنغازى بريد مصور / 9098836

الجماهيرية العربية الليبية الشعبية الاشتراكية العظمى
جامعة العرب للعلوم الطبية
كلية طب وجراحة الفم والأسنان
بنغـــازي

التطور العلمي مكسب للإنسانية

الرقم الإشاري XV
التاريخ ....
الموافق .... 16 . 9 . 2007 ف

الى /من يهمه الأمـــــــــر.

بعد التحية ؛؛ ؛؛

تفيدكم كلية طب وجراحة الفم والأسنان -جامعة العرب للعلوم الطبية بأن الأخت الطبيبة /**رسمية محمد أبرهيم حويو** ، عضو هيئة التدريس بقسم طب أسنان الأطفال بالكلية ، تقوم حاليا بدراسة التخصص الدقيق (**الدكتوراه**) فى جامعة نيوكاسل ببريطانيا وتقوم فى جزء من دراستها على أجراء فحوصات على أسنان طلبة المدارس ومنها ملىء بعض الأستبيانات الغذائية .

نأمل من الجميع مساعدتها فى أداء مهمتها الدراسية .

ولكم فائق التقدير والأحترام

والسلام عليكم ،، ،،

(د.مفتاح على أسعيد)
أمين اللجنة الشعبية بالكلية

أ-ف.الوحيشى*

الجماهيرية العربية الليبية الشعبية الاشتراكية العظمى
جامعة العرب للعلوم الطبية
كلية طب وجراحة الفم والأسنان
بنغـــازي

الرقم الإشاري ....
التاريخ ....
الموافق 26 .. 12 .. 2007

التطور العلمي مكسب للإنسانية

إلى / من يهمه الأمـــــــــــــــــــر.

بعد التحية ،، ،،

تفيدكم كلية طب وجراحة الفم والأسنان –جامعة العرب للعلوم الطبية بأن الدكتورة/ **رسمية محمد حويو** ، عضو هيأة التدريس بقسم طب أسنان الأطفال ، تقوم حالياً بدراسة التخصص الدقيق (الدكتوراه) فى جامعة نيوكاسل ببريطانيا وتقوم فى جزء من دراستها بجمع عينات من مياه الشرب وذلك لتحليل محتواها من عنصر الفلور المقاوم لتسوس الأسنان .

فى الوقت الذى نحيطكم علماً نود منكم السماح لها بنقل العينات إلى بريطانيا لإتمام عملية التحليل والدراسة.

ولكم فائق الأحترام والتقدير.

والسلام عليكم ،، ،،

(د. مفتاح على أستيته)
أمين اللجنة الشعبية بالكلية

.ف الوحيشي

هاتف 45-9096046 - 9092239- 9092219 بريد مصور 00218 60 9093771 ص. ب 9504 بريد عبدالمنعم رياض
بريد الإلكتروني E-mail: fdgu@Lttnet.net

LETTERS TO HEAD TEACHERS

School name
Address
Date

Dear Mr/Mrs

It is a pleasure to contact you about the development of our project in your school after your receiving the permission from the Ministry of Education.

I should be grateful if you would kindly provide the list of pupils who will be 12-year-olds in the first semester of 2007 It would be very useful if this list included the name, date of birth, and school-year of the pupils.

It is important to emphasise that the contact with the pupils will be made throughout the school. I will send letters to parents, explaining the aims of the project and asking for their permission to include their children in the study. However, if there is any constraint in sending this information, would you please inform the precise number of pupils at this age in your school?

I also would like to ask you information about the school's calendar for 2007 and 2008, with the predicted holidays and examinations dates, when the involvement with my project would not be recommended.

I would be most grateful if this information could be given as soon as possible, in order to prepare the letters and send them to the parents.

Once more, I would like to thank you for your willing co-operation with this study and hope to see you soon.

Yours Sincerely
Dr Rasmia Huew
Dental Researcher
PhD student at University of Newcastle

Dear Parents/Guardians

My name is Rasmia. I am a dentist working on a project about dental decay and dental erosion at Newcastle University in England. Dental erosion is the wearing-away of teeth. It is different from dental decay, and happens as a result of the presence of acids in the mouth. There is growing concern amongst dentists in Europe, since the number of people developing dental erosion seems to be increasing, especially in adolescents. However, we do not know if it is also happening in Libya. Therefore, I aim to develop a project about dental erosion among adolescents in our country. An important part of this project will be developed in the schools of Benghazi. The project will include an oral examination to see if your child has this type of tooth wear. This examination will be conducted at school, but will be arranged, to cause minimum disturbance in school activities. It will be only a dental examination. All the dental instruments will be sterilised. You will receive a letter from me explaining what was found and, if appropriate, advice on whether to contact a dentist for a check-up. I will also advise your child on how to prevent dental erosion.

To evaluate the factors that could cause dental erosion, your child will be asked to complete a questionnaire with information about his/her general and oral health and medicine intake, together with dietary and tooth brushing habits. The questionnaire will be answered at school and is confidential. It is possible that your child can also be selected to complete a three-day-dietary record. It is a simple procedure and he/she will be explained how to complete the dietary diary form. I will check the information with your child. This project was approved by the Office of Education and by the Deans of all schools. It is important to note that your personal, family and children's identity will not be divulged. Only the research team will have access to the information collected and it will be stored securely. Therefore, I can assure you that all the information will be kept confidential.

I should be most grateful for your consent to include your child in this study. If you are willing to co-operate, please would you complete and sign the written consent form attached to this letter. Your child may also sign the form if he/she wishes. Your child will not be included in this project without your authorisation. Therefore, it is necessary that you return the completed consent form if you wish your child to take part. In this way, your child will have the chance to be dentally examined. Your child may withdraw from the study at any time, without prejudice.

Finally, it can be necessary to take some photographs of your child's teeth. It is important for you to know that the identity of your child will be preserved when the picture is showed. It means that no one will be able to recognize your child from that picture. However, if you want to collaborate but prefer that no photograph be taken from your child, please tick this option in the written consent form. If you have any queries about this project, you can contact the telephone number 0926221056 to discuss any queries.

Thank you very much for taking the time to read this letter.
I hope to meet your child soon.
Yours faithfully
Dr Rasmia Huew
PhD student at Newcastle University

A study of dental erosion and consumption of acidic dietary items in children

WRITTEN CONSENT FORM

Please sign and return this form to school as soon as possible and keep one copy for your records

Full name of the parent/guardian:____

Full name of the child:____

- I have read the information contained in the enclosed letter. I know that the dentist will examine the teeth of my child at school. I also know that my child will be asked to answer a questionnaire at school and that this questionnaire is confidential. I know that my child may be asked to complete a diary record.
- I know that my child will not be included in this study without my written permission. I understand that participation in this study is not compulsory.
- I affirm that my participation and my consent to my child inclusion are voluntary. I consent to my child being examined and completing the questionnaire and the dietary record.
- I know that my child can withdraw from the study at any time, without giving a reason and without prejudice.
- In relation to photographs of my child's teeth:
  I consent that the dentist can take photographs of my child's mouth ____
  I do not consent that the dentist can take photographs of my child's mouth ____

Parent/Guardian's signature:________________________
Date________________

WRITTEN CONSENT FORM FOR THE CHILD

- I have read the information contained in the enclosed letter.
- I know that the dentist will examine me at school. I also know that I will be asked to answer a questionnaire at school and that this questionnaire is confidential. My parents, family or friends will not know my answers. I know that I may be asked to complete a dietary record. I affirm that my participation is voluntary. I know that I can withdraw from the study at any time, without giving reason.
-

Child's signature:__________________
Date_________________

LETTER TO PUPILS

Dear Pupil

My name is Rasmia. I am a dentist working on a project about dental erosion and dental decay in Newcastle University in England. There is growing concern among dentists in Europe, since the number of people developing dental erosion which is a type of wear of tooth surfaces seems to be increasing, especially in adolescents, However, we do not know if it is also happening in Libya. Therefore, I aim to develop a project about dental erosion among people of your age in our country. An important part of this project will be developed in the schools of Benghazi. The project will include a dental check-up to see if you have dental erosion. This check-up will take place at school. Information from your check-up would be used in my research. However, I will also send a letter to your parents/guardians to let them know what I found, and whether you would need to be seen by a dentist. I will also advise you on how to prevent dental erosion.

You will also be asked to answer a questionnaire about your health, the foods and drinks you eat and your tooth brushing habits. The questionnaire will be answered at school and should only take about half an hour. It is not a test and there are no right and wrong answers. I just want to know about you and your opinions. Your parents, family, teachers or friends will not be shown or told your answers. Therefore, you do not need to worry about any information you provide, as it will only be seen by me and other members of the research team in England. You may also be selected to complete a dietary record. It is a simple procedure and I will explain to you how to complete the questionnaire. I would be most grateful if you agree to take part in this study. I need to get written permission from your parents or guardians for you to take part and have sent them a letter too. There is a space on the consent form where you can sign as well. Ask your parents/guardians if you wish to sign it. It is also important for you to know that you may withdraw from the study at any time.
I would be thankful if you could remind your parents to fill in the form and give it back to you. As soon as you have the document back, would you please return it to school and deliver it to the same person that first gave it to you?

Thank you very much for taking the time to read this letter. I hope to see you soon at school.

Yours faithfully
Dr Rasmia Huew
Dental Researcher
PhD student at Newcastle University

Newcastle University

Dental erosion in schoolchildren and its association with risk factors in Benghazi

Letter to Parents after dental examination

Dear parents/Guardians of ______________________

Thank you for your consent to include your child in this study. Dental examination has been undertaken for your child.

Your child needs to see by dentist due to presence of dental caries/eroded teeth /need advice dental health and oral hygiene.________

Your child does not need to see by dentist ________

Thank you again for your cooperation

Yours truly

Dr Rasmia Huew

Principal researcher

CERTIFICATE FOR PUPILS

Newcastle University

CERTIFICATE

This is to confirm that

____

Participated in the project entitled 'A study about dental caries and dental erosion and consumption of acidic dietary items in schoolchildren in Benghazi'

Thank you very much for your important cooperation!

Dr Rasmia Huew

RE: Benghazi fieldtrip 2

Anne Maguire

Sent: 24 September 2007 11:41

To: Rasmia Huew; P J Waterhouse; P J Moynihan

Dear Rasmia
Thanks for the update of 14th and 21st September.
Glad to hear things are progressing OK

It looks like you are on target for your first 3 periods up to 29th September so that you should have received permissions from parents and children by the end of September.
Please can you confirm briefly in your next report how you randomly selected the schools.

Thanks

Anne

From: Rasmia Huew
Sent: 21 September 2007 16:26
To: Anne Maguire; P J Waterhouse; P J Moynihan
Subject: Benghazi fieldtrip 2

Dear All

The permission of the dental examination for pupils had been graned by the head teachers of the randomly selected schools, after they received official letters from the Ministry of Education and lettres explaining the protocol and the the importance of the study. I have visited each of the randomly selected 35 schools for a preparatory visit to assess the visibility of the study implementation in the schools and the availability of a room suitable for dental examination and to secure cooperation of the shool officials.
I have sent letters to the Parents/Gurdians and the pupils seeking their permissions, providing information about the aims and methods of the study.
Next step will be:

Training an assistant.
Preparing the materials needed for the dental examination.
Arrangement for dental equipment sterilization.

Note

Please note that some times I face technical problems in sending you e-mails via the university e-mail but I can read the university e-mail easily so if I find difficulity I'll send you e-mails via Yahoo.

Thank you.

Best wishes
Rasmia Huew

RE: Benghazi field trip 5

Anne Maguire

Sent: 29 October 2007 09:51

To: Rasmia Huew

Cc: P J Waterhouse; P J Moynihan

Hi Rasmia
How's it going; looking forward to an update
Thanks
Anne

-----Original Message-----
From: Rasmia Huew
Sent: 11 October 2007 13:44
To: Anne Maguire; P J Waterhouse; P J Moynihan
Subject: Benghazi field trip 5

Dear all

Visits to school 1, school 2, and school 3 done as we arranged in the field work time table. Starting day was Wed. 3/10/07. Food dairies delivered to the sub sample in schools 4, 5, 6 in Wed. 10/10/07 and the interviews will be on Sunday 14/10/07. Eid celebration will be on Friday and Saturday and children back to schools on Sunday.

Many Thanks
Rasmia Huew

The variation in diagnosis between the first and second examination of code 1 (dental erosion into enamel only) for labial surface of incisors by depth.

Number of surfaces First Examination Code 1 (n =75)	Number of surfaces Second Examination Code 1 (n =75)					Total
	0	1	2	3	4	
0	63	0	0	0	1	64
1	0	0	0	0	0	0
2	0	0	1	0	0	1
3	0	0	0	0	0	0
4	1	0	0	0	9	10
Total	64	0	1	0	10	75

Measure of agreement; Kappa: 0.89

The variation in diagnosis between the first and second examination of code 1 (dental erosion into enamel only) for palatal surface of incisors by depth.

Number of surfaces First Examination Code 1 (n =75)	Number of surfaces Second Examination Code 1 (n =75)					Total
	0	1	2	3	4	
0	60	0	0	0	0	60
1	0	0	0	0	0	0
2	0	0	1	0	0	1
3	0	0	0	0	0	0
4	0	0	2	0	12	14
Total	60	0	3	0	12	75

Measure of agreement; Kappa: 0.91

The variation in diagnosis between the first and second examination of code 1 (dental erosion into enamel only) for occlusal surface of molars by depth.

Number of surfaces First Examination Code 1 (n =75)	Number of surfaces Second Examination Code 1 (n =75)					Total
	0	1	2	3	4	
0	70	1	0	0	0	71
1	0	0	1	0	0	1
2	0	0	1	0	0	1
3	0	0	0	0	0	0
4	0	0	0	0	2	2
Total	70	1	2	0	2	75

Measure of agreement; Kappa: 0.77

Tooth prevalence of dental erosion on all index teeth; permanent maxillary incisors and maxillary and mandibular first permanent molars.

Tooth	Number of all teeth						
	No. of teeth assessed	No. with Erosion		No. without erosion		No. of teeth not assessed	
		N	%	N	%	N	%
Index teeth	6328	1372	21.7	4784	75.6	172	2.7

Tooth prevalence of dental erosion for all index teeth surfaces (> code 0 for area or depth) in 791 children.

Groups of teeth	No. of surfaces examined	No. of surfaces with erosion		No. of surfaces without erosion		No. of surfaces not assessed	
		N	%	N	%	N	%
All index teeth surfaces	9492	2128	22.4	7155	75.4	209	2.2

Tooth prevalence of dental erosion for labial and palatal surfaces of maxillary incisors (> code 0 for area or depth) in 791 children

Groups of teeth	No. of surfaces examined	No. of surfaces with erosion		No. of surfaces without erosion		No. of surfaces not assessed	
		N	%	N	%	N	%
Incisor surfaces	6328	1531	24.2	4727	74.7	70	1.1

The variation in diagnosis between the first and second examination for DMFT.

		Second Examination DMFT (n = 75)						Total
		0.0	1.0	2.0	3.0	4.0	5.0	
First Examination DMFT (n = 75)	0.0	34	1	0	0	0	0	35
	1.0	0	11	0	0	0	0	11
	2.0	0	2	9	0	0	0	11
	3.0	0	0	0	6	0	0	6
	4.0	0	0	0	0	9	0	9
	5.0	0	0	0	0	0	3	3
Total		34	14	9	6	9	3	75

Measure of agreement; Kappa: 0.95

The variation in diagnosis between the first and second examination for DMFS.

		Second Examination DMFS (n = 75)												Total
		0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	10.0	11.0	13.0	
First Exam DMFS (n =75)	0.0	34	1	0	0	0	0	0	0	0	0	0	0	35
	1.0	0	8	0	0	0	0	0	0	0	0	0	0	8
	2.0	0	2	6	0	0	0	0	0	0	0	0	0	8
	3.0	0	0	0	3	0	0	0	0	0	0	0	0	3
	4.0	0	0	0	0	7	1	0	0	0	0	0	0	8
	5.0	0	0	0	0	0	4	0	0	0	0	0	0	4
	6.0	0	0	0	0	0	0	3	0	0	0	0	0	3
	7.0	0	0	0	0	0	0	0	2	0	0	0	0	2
	8.0	0	0	0	0	0	0	0	0	1	0	0	0	1
	10.0	0	0	0	0	0	0	0	0	0	1	0	0	1
	11.0	0	0	0	0	0	0	0	0	0	0	1	0	1
	13.0	0	0	0	0	0	0	0	0	0	0	0	1	1
Total		34	11	6	3	7	5	3	2	1	1	1	1	75

Measure of agreement; Kappa: 0.93

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.

Water consumption	Experience of erosion		Total	P (Pearson Chi-Square)
	Yes N (%)	No N (%)	N	
Tap water	97 (30.0)	138 (29.5)	235	0.091
Bottled water	57 (17.6)	58 (12.4)	115	
Both	169 (52.3)	272 (58.1)	441	
Total	323 (100)	468 (100)	791	

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	P (Pearson Chi-Square)
	Yes N (%)	No N (%)	N	
Tap water	133 (29.1)	102 (30.5)	235	0.146
Bottled water	58 (12.7)	57 (17.1)	115	
Both	266 (58.2)	175 (52.4)	441	
Total	457 (100)	334 (100)	791	

Significance of the association (P, OR and 95% CI) between the number (N) and proportion (%) of subjects with and without experience of caries and habit of having bedtime sugared-acidic drinks

Habit of having bedtime sugared-acidic drinks	Experience of caries			P (Fisher's exact test)	OR (Odds Ratio)	95% CI (Confidence Interval)
	Yes	No	Total			
	N (%)	N (%)	N			Lower-Upper
Yes	114 (24.9)	86 (25.7)	200	0.804	1.043	0.755, 1.443
No	343 (75.1)	248 (74.3)	591			
Total	457 (100)	334 (100)	791			

Significance of the association (P) between the number (N) and proportion (%) of subjects with and without experience of dental caries and the frequency of toothbrushing.

Frequency of toothbrushing	Experience of dental caries		Total	P (Linear Association exact test)
	Yes N (%)	No N (%)	N	
≥2/day	252 (55.1)	171 (51.2)	423	0.251
1/day	88 (19.3)	67 (20.1)	155	
<1/day	117 (25.6)	96 (28.7)	213	
Total	457 (100)	334 (100)	791	

استبانــــــه لطلبــــــة المــــــدارس

أرجو عدم الكتابة في هذه الخانة: الرقم

اسم الطالب :..

الجنس :   ذكر (1) أنثى (2)

رقم المدرسة :

تاريخ الميلاد :

تاريخ تعبئة الاستمارة :

عزيــــزي الطـــــالب :

هذا الاستبيان عمل من أجلك ولا يوجد إجابات صحيحة أو غير صحيحة ولهذا أرجو قراءة الأسئلة جيداً قبل الإجابة وستكون الاجابات سرية.

إرشـــادات عن كيفيـــة تعبئـــة الاستبيـــان :

1- أقرأ الأسئلة جيداً قبل الإجابة.
2- استعمل قلم الحبر الجاف للإجابة.
3- الإجابة تكون بوضع الرقم المناسب في المربع الذي يوجد أمام كل سؤال كما هو موضح في المثال.
4- إذا لم تعرف الاجابة أرجو كتابة ذلك أمام السؤال.
5- خذ وقتك للإجابة فأنت لا تحتاج لمساعدة أحد في الإجابة لأن الأسئلة عنك شخصياً.

مثـــال :

هل تشرب المشروبات الغازية؟

1- أكثر من مرتين في اليوم الواحد.
2- أكثر من مرة في اليوم الواحد.
3- مرة واحدة في اليوم.   3
4- ليس كل يوم.

أشكركم على حسن تعاونك

A) هل تشرب المشروبات الغازية ؟
1- أكثر من مرتين في اليوم.
2- أكثر من مرة في اليوم.
3- مرة واحدة في اليوم.
4- ليس كل يوم.
5- لا أشربها.

B) هل تشرب مشروبات غازية بدون سكر ؟
1- أكثر من مرتين في اليوم.
2- أكثر من مرة في اليوم.
3- مرة واحدة في اليوم.
4- ليس كل يوم.
5- لا أشربها.

C) هل تشرب مشروبات رياضية ؟
1- أكثر من مرتين في اليوم.
2- أكثر من مرة في اليوم.
3- مرة واحدة في اليوم.
4- ليس كل يوم.
5- لا أشربها.

D) هل تشرب العصائر المركزة ؟
1- أكثر من مرتين في اليوم.
2- أكثر من مرة في اليوم.
3- مرة واحدة في اليوم.
4- ليس كل يوم.
5- لا أشربها.

E) هل تشرب عصير الفواكه الطبيعية بدون سكر ؟
1- أكثر من مرتين في اليوم.
2- أكثر من مرة في اليوم.
3- مرة واحدة في اليوم.
4- ليس كل يوم.
5- لا أشربها.

F) هل تشرب عصير الفواكه المحلى (بالسكر)؟
1- أكثر من مرتين يومياً.
2- أكثر من مرة يومياً.
3- مرة واحدة في اليوم.
4- ليس كل يوم.
5- لا أشربها.

G) هل تشرب الحليب ؟
1- أكثر من مرتين في اليوم.

2- أكثر من مرة في اليوم.
3- مرة واحدة في اليوم.
4- ليس كل يوم.
5- لا أشربه.

H) هل تشرب الحليب بالنكهات أو الشوكولاته ؟
1- أكثر من مرتين في اليوم.
2- أكثر من مرة في اليوم.
3- مرة واحدة في اليوم.
4- ليس كل يوم.
5- لا أشربه.

I) هل تشرب الشاي مع الحليب ؟
1- أكثر من مرتين في اليوم
2- أكثر من مرة في اليوم.
3- مرة واحدة في اليوم.
4- ليس كل يوم.
5- لا أشربه.

J) هل تشرب ماء الحنفية أو الماء المعدني (المياه الطبيعية) أو كليهما ؟
1- ماء الحنفية.
2- المياه المعدنية.
3- أشرب النوعين.

K) هل تشرب المياه الغازية ؟
1- اكثر من مرتين في اليوم.
2- أكثر من مرة في اليوم.
3- مرة في اليوم.
4- ليس كل يوم.
5- لا أشربها.

L) كم مرة تأكل الفواكه (غير الموز) في اليوم ؟
1- أكثر من أربع فواكه في اليوم.
2- من 2-4 فواكه في اليوم.
3- أكثر من فاكهة واحدة في اليوم.
4- فاكهة واحدة في اليوم.
5- ليس كل يوم.

M) هل تشرب أحدى هذه المشروبات عند النوم: المشروبات الغازية العصائر المركزة ، عصير الفواكه ؟
1- نعم
2- لا

N) كم من الزمن يستغرق شرب المشروب ؟
1- تشرب المشروب دفعة واحدة.
2- يستغرق شربه 15 دقيقة.

3- يستغرق شربه بين 15 إلى 30 دقيقة.
4- أكثر من 30 دقيقة.

O) هل تمضغ العلكة (المستكة)؟
1- لا .
2- نعم ، أمضغ العلكة المحلاة بالسكر.
3- نعم ، أمضغ العلكة الغير محلاة بالسكر.

P) لو تمضغ العلكة، كم مرة ؟.
1- مرة واحدة في اليوم.
2- أكثر من مرة في اليوم.

Q) كم مرة تنظف أسنانك ؟
1- أكثر من مرتين في اليوم.
2- مرتين في اليوم.
3- مرة واحدة في اليوم.
4- ليس كل يوم.

R) هل تعرف اسم معجون الأسنان الذي تستعمله الآن ؟
1- نعم.
2- لا.
S) هل تغسل أسنانك بعد شربك لأحد هذه المشروبات: المشروبات الغازية ، المشروبات المركزة ، عصير الفواكه ؟
1- نعم.
2- لا.

T) هل عادةً تستعمل مضمضة الفم بالفلور أو تأخذ حبوب الفلور؟
1- نعم.
2- لا.

هل تعاني من أحدى الأمراض الآتية :

1- الربو	(1) نعم	(2) لا
2- السكر	(1) نعم	(2) لا
3- وجود طعم حامض في الفم	(1) نعم	(2) لا
4- الحموضة	(1) نعم	(2) لا
5- نوبات من اضطراب الهضم	(1) نعم	(2) لا

U) هل تأخذ عادة فيتامين C ؟
1- نعم.
2- لا.

V) لو كنت تأخذ فيتامين C هل هو :
1- حبوب.
2- مضغ.
3- سائل.

W) هل ذهبت يوماً إلى طبيب الأسنان ؟
1- لا.
2- نعم.

X) هل تقول عن نفسك :
1- أنا لا أصر (أضغط) على أسناني.
2- لا أعلم.
3- أنا أصر (أضغط) على أسناني.

Y) ما هو مستوى تعليم الوالدة ؟
1- لا تعرف القراءة والكتابة.
2- تعليم ابتدائي.
3- تعليم اعدادي.
4- تعليم ثانوي.
5- جامعي / كلية.

6- ماجستير / دكتوراه.

Z) ما هو مستوى تعليم الوالد ؟
1- لا يعرف القراءة والكتابة.
2- تعليم ابتدائي.
3- تعليم إعدادي.
4- تعليم ثانوي.
5- جامعي / كلية.
6- ماجستير / دكتوراه.

أشكركم على حسن تعاونكم !

المفكــــــرة الغذائيــــــة

الاسم : ____________________

الوزن : ____________________

المدرسة : ____________________

السنة الدراسية : ____________________

التاريخ : ____________________

الرقـــم

مفكــرة يوميــة لغــذاء

____

الخميس ______

الجمعة ______

السبت ______

عزيـــزي الطالـــب :

أعلم أنه من الصعب كتابة كل طعام أو شراب تتناوله خلال ثلاث أيام ولكنهـا الطريقـة الوحيدة لمعرفة نوعية الطعام والشراب الذي تتناوله.

هذه المعلومات الغذائية مهمة في دراستي ولهذا أرجوا كتابتها بعناية وأرجو أصحاب هذه المذكرة معك دائماً كتابة كل ما تأكله وتشربه في حينه ولكن إذا نسيت كتابة شيء في وقته بمكنك كتابته بعد ذلك.

أرجو كتابة هذه المعلومات الغذائية في ثلاث أيام فقط وهي الخميس والجمعة والسبت.

توجد إرشادات قد تساعدك في تكملة المفكرة الغذائية وكذلك مثال إذا وجدتم أي صـعوبة أرجو الاتصال بالباحثة.

إرشـــادات :

- أرجو قراءة هذه الارشادات قبل البدء بكتابة هذه المفكرة الغذائية.
- اكتب اسمك واسم مدرستك والسنة الدراسية وتاريخ كتابة هذه المفكرة.
- أرجو تعبئة المفكرة فقط في ثلاث أيام متتابعة وهي الخميس والجمعة والسبت.
- أرجو كتابة كل شيء تأكله أو تشربه ويتضمن ذلك أيضاً ماء الشرب والدواء وكمية كـل منها وزمن تناولها إذا وجدت صعوبة اتبع المثال المعطي.
- أرجو كتابة ما تتناوله بالتفصيل وبالشرح لمكوناته الغذائية.
- في حالة تناولك للدواء أذكر إذا ما كان سائل أو حبوب أو بخاخ.
- أرجو أيضـاً كتابة الوجبات الخفيفة بين الوجبات الرئيسية وأي شيء تأكله أو تشربه مهما كان صغيراً حتى لو كان علكة (مستكة) أو قطعة حلوة صغيرة.
- وأرجو كتابة وقت ذهابك للنوم.
- أرجو عدم الكتابة في العمود الخاص بالباحثة.

أشكركم على حسن تعاونكم !

مثـــــال :

السبـــت (الفطور، الغذاء، العشاء، الوجبات الخفيفة)

الزمن	الطعام أو الشراب أو الدواء	كمية الغذاء أو الشراب	خاص بالباحثة أرجو عدم الكتابة في هذا العمود
07:30	شاي بالحليب مع ملعقة 1 سكر	1 كوب	
07:30	خبزة بيضاء	قطعتين	
07:30	زبده	1 ملعقة شاي صغيرة	
08:00	دواء مضاد حيوي	1 حبة مع كوب من الحليب	
09:15	ماء من الحنفية	1 كوب	
10:20	مشروب غازي (قازوزة)	1 علبة	
11:15	علكة بالسكر	1	
12:15	أرز	20 ملعقة	
12:15	بيضة مقلية	1	
12:15	سلاطه وطماطم	1 طبق	
12:15	عصير البرتقال بالسكر	1 كوب	
13:40	حلوة الفراولة	3	
15:00	عصير برتقال مركز	1 كوب	
15:00	بسكويت بالشوكولاته	3	
18:10	خبزة بيضاء	½ قطعة	
18:10	عصير عنب بالسكر	1 كوب	
18:10	دجاج	قطعتين	

ذهبت إلى النوم الساعة الـ10 مساءا.

الزمن	الطعام أو الشراب أو الدواء	كمية الغذاء أو الشراب	خاص بالباحثة أرجو عدم الكتابة في هذا العمود

الخميس (الفطور، الغذاء، العشاء، الوجبات الخفيفة)

الزمن	الطعام أو الشراب أو الدواء	كمية الغذاء أو الشراب	خاص بالباحثة أرجو عدم الكتابة في هذا العمود

خاص بالباحثة أرجو عدم الكتابة في هذا العمود	كمية الغذاء أو الشراب	الطعام أو الشراب أو الدواء	الزمن

ذهبت إلى النوم الساعة الـ............... مساءً.

خاص بالباحثة أرجو عدم الكتابة في هذا العمود	كمية الغذاء أو الشراب	الطعام أو الشراب أو الدواء	الزمن

الزمن	الطعام أو الشراب أو الدواء	كمية الغذاء أو الشراب	خاص بالباحثة أرجو عدم الكتابة في هذا العمود

الجمعة (الفطور، الغذاء، العشاء، الوجبات الخفيفة)

الزمن	الطعام أو الشراب أو الدواء	كمية الغذاء أو الشراب	خاص بالباحثة أرجو عدم الكتابة في هذا العمود

الزمن	الطعام أو الشراب أو الدواء	كمية الغذاء أو الشراب	خاص بالباحثة أرجو عدم الكتابة في هذا العمود

ذهبت الى النوم الساعة الـ............ مساءاً

الزمن	الطعام أو الشراب أو الدواء	كمية الغذاء أو الشراب	خاص بالباحثة أرجو عدم الكتابة في هذا العمود

الزمن	الطعام أو الشراب أو الدواء	كمية الغذاء أو الشراب	خاص بالباحثة أرجو عدم الكتابة في هذا العمود

السبت (الفطور، الغذاء، العشاء، الوجبات الخفيفة)

الزمن	الطعام أو الشراب أو الدواء	كمية الغذاء أو الشراب	خاص بالباحثة أرجو عدم الكتابة في هذا العمود

خاص بالباحثة أرجو عدم الكتابة في هذا العمود	كمية الغذاء أو الشراب	الطعام أو الشراب أو الدواء	الزمن

ذهبت إلى النوم الساعة الـ............... مساءا.

خاص بالباحثة أرجو عدم الكتابة في هذا العمود	كمية الغذاء أو الشراب	الطعام أو الشراب أو الدواء	الزمن

ملاحظات ووصفات غذائية

هل لديك أي تعليق على وجباتك الغذائية خلال هذه الأيام الثلاث ؟

هل كانت نوعية أكلك في هذه الأيام الثلاث كالمعتاد أو هناك بعض التغيير ؟

رسالة إلى مديري المدارس

اسم المدرسة ___________________

العنوان ___________________

التاريخ ___________________

السيد المدير / المديرة

تحية طيبة

إنه لمن دواعي سروري الاتصال بكم لتطبيق بحثي في مدرستكم, بعد حصولي على الموافقة من أمانة التعليم على إجراء هذه الدراسة .

أنا طبيبة أسنان, اعمل الآن في بحث علمي عن ذوبان الطبقة الخارجية للأسنان و التسوس,في جامعة نيوكسل في بريطانيا, و يهدف هذا البحث العلمي إلى دراسة مشكلة ذوبان الطبقة الخارجية للأسنان و التسوس في طلبة المدارس في مدينة بنغازي.

عليه أرجو منكم تزويدي بأسماء الطلبة الدارسين في مدرستكم الذين أعمارهم تبلغ 12 سنة في الفصل الدراسي الأول لسنة 2007 , كما أرجو إعطائي أيضاً تاريخ ميلادهم و السنة الدراسية, و سوف يتم اختيار عينة عشوائية من بين هؤلاء الطلبة, و إرسال رسائل إلى أوليا أمورهم لشرح أهداف الدراسة, و الحصول منهم على الموافقة لمشاركة أبنائهم و بناهم في هذه الدراسة.

الرجاء إعطائي مواعيد الامتحانات و العطلات التي يفضل فيها عدم إجراء الكشف

شكراً جزيلاً لحسن تعاونكم

د. رسمية محمد حويو

طالبة دكتوراه , جامعة نيوكسل – بريطانيا

رسالة إلى ولي أمر الطالب

السيد ولي أمر الطالب/ الطالبة

تحية طيبة

اسمي رسمية محمد حويو, مهنتي طبيبة أسنان, في الوقت الحالي أعمل في بحث ميداني عن ذوبان الطبقة الخارجية للأسنان و التسوس في جامعة نيوكسل – بريطانيا, و نظراً لوجود اهتمام كبير بهذه المشكلة المتعلقة بصحة الأسنان في الدول الأوروبية, سيكون بحثي على طلبة المدارس في بنغازي لمعرفة مدى انتشار هذه المشكلة الصحية في بلادنا, البحث يتطلب فحصاً لأسنان ابنكم / ابنتكم و سيكون في المدرسة, و الأدوات المستخدمة معقمة, و بعد انتهاء الفحص ستصلك رسالة مـــني توضح الحالة الصحيـــة لأسنـــان ابنكم / ابنتكم, و هل يحتاج / تحتاج لزيارة طبيب الأسنان, و لمعرفة أسباب ذوبان الطبقة الخارجية للأسنان سوف يكمل ابنكم / ابنتكم استبيان في المدرسة و يمكن أيضا اختياره لملء استبيان غذائي, لمدة ثلاثة أيام في البيـــت و سوف أقـــوم بشـــرح مفـــصل لأبنكم / لأبنتكم عن كيفية ملء الاستبيان.

أود أن أعلمكم بأنني تحصلت على موافقة أمانتي التعليم و الصحة و مديري المدارس على هذه الدراسة, و أعلمكم أيضاً أن إجابات ابنكم / ابنتكم سوف تكون سرية لا يطلع عليها أحد.

أرجو منكم الموافقة على مشاركة أبنكم / أبنتكم في هذا البحث و التوقيع على نموذج الموافقة المرفق مع هذه الرسالة مع توقيع ابنكم / ابنتكم عليها. سوف لن يتم فحص ابنكم ابنتكم إلا بعد موافقتكم و اعلموا أن ابنكم / ابنتكم يستطيع الانسحاب متى شاء من المشاركة في هذا البحث دون ذكر الأسباب . و أخيراً ربما احتاج لالتقاط صور فوتوغرافية لأسنان ابنكم / ابنتكم, فإذا كنت تفضل عدم التصوير اشر لذلك في نموذج الموافقة .

إذا كان لديكم استفسارات, أرجو ألا تترددوا في الاتصال بإدارة المدرسة أو الاتصال بي على الرقم التالي

0926221056

شكراً جزيلاً لحسن تعاونكم

د. رسمية محمد حويو

طالبة دكتوراه , جامعة نيوكسل – بريطانيا

دراسة عن ذوبان الطبقة الخارجية للأسنان في طلبة المدارس

نموذج الموافقة

نموذج موافقة ولي أمر الطالب

أسم ولي الأمر ______________________

أسم الطالب ______________________

لقد اطلعت و قرأت أهداف هذه الدراسة و كيفيتها , و أعلم أن طبيبة الأسنان سوف تقوم بفحص أسنان أبني / ابنتي في المدرسة, و أنه سيقوم بملء استبيان و أن إجاباته سوف تكون سريةً, و أنه يمكن اختياره لملء استبيان غذائي لمدة ثلاثة أيام . و أعلمكم أنني أوفق على مشاركة أبني / ابنتي في هذه الدراسة و أعلم أن ابني / ابنتي تستطيع الانسحاب من هذه الدراسة دون ذكر الأسباب في أي وقت.

فإنني موافق : و فيما يتعلق بالتقاط بعض الصور الفوتوغرافية لأسنان ابني / ابنتي

على التقاط الصور لفم ابني / ابنتي ____________ .

أنا لا أوافق على التقاط صور لفم ابني / ابنتي ____________ .

اسم ولي الأمر ______________________

توقيع ولي الأمر ______________________

التاريخ ______________________

نموذج موافقة الطالب

اطلعت و قرأت أهداف و كيفية هذه الدراسة و أعلم أن طبيبة الأسنان سوف تفحص أسناني في المدرسة و سوف يطلب مني ملء استبيان عن هذه الدراسة في المدرسة و إجاباتي سوف تكون سرية و ربما أيضا يطلب مني ملء استبيان غذائي مدته ثلاثة أيام .

أوكد موافقتي الطوعية للمشاركة في هذه الدراسة, و أعلم أنه يمكنني الانسحاب في أي وقت دون ذكر الأسباب .

اسم الطالب ______________________

توقيع الطالب______________________

التاريخ ______________________

رسالة إلى الطلبة

عزيزي الطالب / الطلبة

أنا طبيبة أسنان و أعمل الآن في بحث علمي عن ذوبان الطبقة الخارجية للأسنان والتسوس في جامعة نيوكسل في بريطانيا, و نظراً لأهمية هذا البحث في الدول الأوربية و اهتمام أطباء الأسنان بهذه المشكلة في أوربا, أردنا معرفة ما إذا كان طلبة المدارس في مدينة بنغازي يعانون من هذه المشكلة الصحية.

هذا البحث يتطلب فحصاً لأسنانك و سوف يكون هذا الفحص في مدرستك, و سوف أبين لك حقيقة حالة أسنانك الصحية وهل أنت بحاجة لمراجعة طبيب أسنان, و سيكون هناك استبيان عن حالتك الصحية, و عاداتك في اختيار الطعام و الشراب , و تنظيف الأسنان, وهو ليس امتحانا ستحاسب عليه و لا توجد إجابات صحيحة أو خاطئة. و ستحفظ الإجابات بسرية تامة.و ربما يتم اختيارك أيضاً لملء استبيان غذائي لمدة ثلاثة أيام في البيت, أو لالتقاط صور فوتوغرافية لأسنانك فقط.

أرجو موافقتك على نموذج الموافقة المرفق, و أعلمك أنه يمكنك الانسحاب من المشاركة متى شئت دون ذكر الأسباب .

شكراً جزيلاً لحسن تعاونكم

د. رسمية محمد حويو

طالبة دكتوراه , جامعة نيوكسل – بريطانيا

ذوبان الطبقة الخارجية للأسنان في طلبة المدارس و علاقته بالتسوس و العوامل المؤثرة الأخرى في مدينة بنغازي – ليبيا

رسالة إلى أوليا أمور الطلبة المفحوصين بعد الانتهاء من فحص الأسنان

السيد ولي أمر الطالب /الطالبة ______________________________

أشكركم على موافقتكم على مشاركة ابنكم/ابنتكم في هذه الدراسة, نعلمكم أنه قد تم فحص ابنكم /ابنتكم و لوحظ عليه الأتي:

ابنكم/ابنتكم بحاجة إلى مراجعة طبيب الأسنان و ذلك لوجود تسوس في الاسنان / ذوبان في الأسنان / يحتاج إلى تلقي إرشادات و نصائح عن صحة أسنانه و نظافة الفم.

ابنكم / ابنتكم لا يحتج إلى مراجعة طبيب الأسنان حالياً.

شكراً جزيلاً لحسن تعاونكم

د. رسمية محمد حويو

طالبة دكتوراه , جامعة نيوكسل – بريطانيا

شهادة استكمال فحص الأسنان

الطالب / الطالبة ________________________________

شارك الطالب المذكور في المشروع العلمي الموسوم بـــ : دراسة حول التسوس و ذوبان الطبقة الخارجية للأسنان و علاقتـــه بالتـــسوس و العوامـــل المـــؤثرة الأخرى على طلبة المدارس في مدينة بنغازي.

شكراً جزيلاً لحسن تعاونكم

د. رسمية محمد حويو

طالبة دكتوراه , جامعة نيوكسل – بريطانيا

BSDR - 2009

GLASGOW SCOTLAND

British Society for Dental Research (BSDR)
Scientific Meeting

Glasgow Caledonian University
Glasgow, Scotland, UK

1st - 4th September 2009

British Society for Dental Research

British Division of the International Association for Dental Research

Registered Charity No 264173

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139 Prevalence of Dental Erosion in 12 year-old Libyan Schoolchildren

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Location: Refectory Extension (Glasgow Caledonian University)

***R. HUEW**, School of Dental sciences, Newcastle University, Newcastle upon Tyne, United Kingdom, **P.J. WATERHOUSE**, School of Dental Sciences, Newcastle University, Newcastle Upon Tyne, United Kingdom, **P.J. MOYNIHAN**, School of Dental Sciences/ Institute for Ageing and Health, Newcastle University, Newcastle upon Tyne, United Kingdom, and **A. MAGUIRE**, School of Dental Sciences, Newcastle University, Newcastle upon Tyne, United Kingdom*

Introduction: Dental erosion appears to be affecting a growing number of children but there are no data on its prevalence in Libya. Objectives: To assess the prevalence and severity of dental erosion in a sample of 12 year-old children in Benghazi, Libya. Methods: A random sample of 791 12 year-old children (397 boys and 394 girls) attending 36 elementary schools in Benghazi was dentally examined for dental erosion using UK National Diet and Nutrition Survey(2000) criteria. This index assesses the area and depth of dental erosion affecting the labial and palatal surfaces of the upper permanent incisors and occlusal surfaces of the first permanent molars. Results: Dental erosion was observed in 40.8% of subjects; erosion into enamel affecting 32.5%, into dentine affecting 8% and erosion into pulp affecting 0.3% of subjects. Of the 9480 tooth surfaces examined, 2116 surfaces (22.3%) had dental erosion. Girls had more experience of erosion than boys, this difference was statistically significant (P= 0.001). Conclusion: It is concluded that in a cohort of 12 year-old Libyan schoolchildren, more than one third of children examined showed dental erosion, requiring clinical preventive counselling. Significantly more erosion occurred in girls than boys.

This study was supported by the Libyan Government.

See more of: Clinical Research
See more of: Scientific Groups

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IADR GENERAL SESSION
BARCELONA, SPAIN • JULY 14-17, 2010

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132391 Dental Erosion and its Association with Diet in Libyan Schoolchildren

Thursday, July 15, 2010: 3 p.m. - 4:15 p.m.
Location: Exhibit Hall (CCIB)

R. HUEW[1]*, P. WATERHOUSE*[1]*, P. MOYNIHAN*[1]*, S. KOMETA*[1]*, and A. MAGUIRE*[2]*,* [1]*University of Newcastle-upon-Tyne, Newcastle upon Tyne, United Kingdom,* [2]*Newcastle University, Newcastle upon Tyne, United Kingdom*

Objectives: The aim of this study was to investigate any association between the experience of dental erosion and potential dietary risk factors in a group of schoolchildren in Benghazi, Libya. The objective was to collect data, by means of a dietary questionnaire on frequency of consumption of acidic foods and drinks and associated habits in a sample of schoolchildren. This questionnaire was based on the one previously used in the UK National Diet and Nutrition Survey (2000). The null hypothesis was that there was no relationship between experience of dental erosion and the frequency and pattern of consumption of acidic foods and drinks. Methods: Using a cross-sectional observational study a random sample of 791 12 year-old schoolchildren in 36 randomly selected schools completed a questionnaire to provide dietary data and underwent clinical dental examination. Dental erosion was assessed using UK National Diet and Nutrition Survey (2000) criteria. Associations between dental erosion and dietary variables under study were investigated through processes of bivariate and multivariate analyses. The statistical significance level was set at 5%. Results: Of 791 schoolchildren, 40.8% had dental erosion; erosion into enamel affecting 32.5%, into dentine affecting 8% and into pulp affecting 0.3% of subjects. The frequency of intake of fruit-based sugared drinks was statistically significantly positively associated with erosion ($p=0.006$, Odds Ratio 1.498, 95% CI 1.124,1.996) as was the length of time taken to consume acidic drinks,especially when the drinks lasted up to 15 minutes ($p=0.005$, Odds Ratio 1.593, 95% CI 1.161,2.186). Conclusions: The null hypothesis was rejected. In this group of schoolchildren the frequency of consumption of fruit-based sugared drinks and length of time taken to consume acidic drinks were statistically significant positive risk factors for dental erosion.

This study was supported by the Libyan Government

See more of: International Prevention Programs
See more of: Oral Health Research

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North East Postgraduate Conference 2009

Certificate of attendance

Awarded to

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On behalf of the NEPG 2009 organising committee
23rd October 2009

Best Student Abstract Award

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2010
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Nutrition Research Scientific Group

OHIO STATE UNIVERSITY COLLEGE OF DENTISTRY