Scholars Journal of Dental Sciences
Abbreviated Key Title: Sch J Dent Sci
ISSN 2394-4951 (Print) | ISSN 2394-496X (Online)
Journal homepage: https://saspublishers.com

OPEN ACCESS

Study the Relation between Dietary Intake and Oral Hygiene and Dental Caries during Childhood

Salima Elfagi[1*], Rowaida Abd El.wahab[1], Naima Mustafa[1], Esraa Jamal[1], Faiza Nouh[1], Mariam Omar[1], Ashmisa Eltuhami[1]

[1]Nutrition Department, Faculty of Public Health, University of Benghazi, Benghazi, Libya

DOI: 10.36347/sjds.2021.v08i07.004 | **Received:** 11.05.2021 | **Accepted:** 15.06.2021 | **Published:** 09.07.2021

***Corresponding author**: Salima Elfagi

Abstract **Original Research Article**

Dental caries is the most common disease in children and up to eight times more prevalent than asthma ranked the second among all the common diseases in the world. The food habits and some types of food play an important role in induce dental caries. The objective of this study is to assess the relationship between, dietary intake, dietary habits, oral hygiene practices and dental caries during childhood. A cross-sectional study was conducted on a sample of 150 children that were selected at random from public hospitals in Benghazi, Libya. Data was obtained by using a questionnaire containing information about the number of carious teeth, dietary intake, habits and oral hygiene habits. The relationship between the risk factors and dental caries was modelled using, Statistics Package Social Science (SPSS). There was a significant statistical difference in the average dental caries among children at ($P<0.05$) according to sugar amount consumption ($P=0.02$), as well as to tooth brushing per day ($P= 0.03$). The average dental caries decreased with increase in times of tooth brushing per day. The prevalence of dental caries in children was an average of 3 carious lesions. Socio-demographic factors, dietary and oral hygiene habits were associated with dental caries.

Keywords: Dietary intake, Dietary habits, Oral hygiene, Dental caries, Childhood.

INTRODUCTION

The current definition of oral health involves the ability to speak, smile, smell, taste, touch, chew, swallow and convey a range of emotions through facial expressions with confidence and without pain and discomfort. Dental caries stands out as a highly prevalent oral condition that affects oral health of children in different age groups and socioeconomic strata. Dental caries is a very common and important public health problem in children and oral health can play an important role in nutritional intake and general health status [1, 2]. As dental caries can eventually lead to tooth loss, which in turn impairs the chewing ability, causing avoidance of hard and fibrous foods, including fruits, vegetables and whole grains [3]. Dental caries is the most common disease in children and up to eight times more prevalent than asthma ranked the second among all the common diseases Furthermore, caries have been experienced by about 60–90% of children of school age all around the world. According to the American Dental Association, Early Childhood Caries (ECC), (cavities) is an infectious disease defined as the presence of one or more decayed, missing (due to cavities) or filled tooth surfaces in any primary tooth in a preschool-age child between birth and 71 months of age (5 years and 11 months) [4]. Dietary sugars are a significant cause of caries initiation and development in children. The consumption of some foods, like sweets, ice cream and free sugars which include added sugars and sugars naturally present in honey, syrups and fruit juices which have highly fermentable carbohydrates may lead to an increased risk of dental caries [5, 6]. The association of dental caries to excessive sugar intake has been affirmed by an expert panel of the World Health Organization, whose members reviewed the strength of evidence linking dietary factors to caries in 2003. The panel reported an increased risk of caries associated with frequent and total intake of simple sugars [7]. The WHO in 2013 [8] recommends that both adults and children should reduce the intake of free sugars to less than 10% of total energy intake. In particular, items such as confectionery, cookies/biscuits, cake, sugar-sweetened beverages, and dried fruits are considered to be highly cariogenic. On the other hand, fresh fruit is considered to be low in carcinogenicity and items such as nuts, vegetables, and cheese and other dairy products are considered to be non- cariogenic. According to the WHO [8], the unhealthy dietary messages to children must be limited and prevented

because the advertisements aimed to promote the consumption of sugary foods and beverages play an important role in the increased level of sugar intake in developing countries [9]. Radio and/or television usually broadcast some advertisements promoting unhealthy dietary habits and under the influence of such advertisements people may use an increased level of unhealthy ingredients and food in their children's diet for instance, they may use more sweets for feeding children, and even they may use sweets as rewards. Additionally, people may use more sugar while preparing foods [10, 11].

Moreover, carious lesions are more prevalent in children of school age because they usually do not have proper dietary habits and they do not practice oral hygiene effectively and regularly [7]. Approaches to prevent dental caries include reducing dental plaque levels, correct oral hygiene and changing dietary intake, habits, patterns and frequency. In addition, fluorides are very effective in preventing dental caries, including fluoride toothpaste, water fluoridation, fluoride mouth-rinse and professional topical fluoride application, primarily by inhibiting mineral loss from the tooth. As a general consideration, both fluoridated water and fluoride toothpaste should be recommended. While additional methods such as professional fluoride application and the use of fluoride releasing dental materials can be recommended for patients at a high risk for caries [12, 13]. Also, recent data show that, for dentine, the combination of fluoride toothpaste and topical fluoride application can be more effective than the use of either alone [14]. According to scientific studies, tooth decay is one of the biggest public health problems associated with childhood, and food is one of the main factors that help in its occurrence, as diet and nutrition may interfere with the balance of purification and remineralization in several ways. According to the American Dietetic Association, nutrition is an integral part of oral health as a "synergistic relationship" [15]. From this standpoint, we decided to study the level of correlation between dietary factors, lifestyle and tooth decay to find out the level of awareness among parents in the city of Benghazi and whether it reflects positively or negatively on the health of children's teeth, and whether or not the rate of caries is high or not to come out with nutritional guidelines and circulate them to the community. The significance of this study comes first to find out the prevalence of tooth decay among children in the age group from (2-16 years) in the city of Benghazi, in fact the main goal is not quantitative knowledge, but knowledge of the awareness of parents about this issue and we are in the twentieth century, so we believe at first as an hypothesis that the awareness will be great about the importance and time for children to start brushing their teeth. As through these factors, we will look at the relationship of food with caries, and are they aware of this important factor, as studies have proven. Among the factors that we study is anemia and its close relationship with caries in the hope that there will be cooperation with families in that.

The results of this study will be important in raising nutritional awareness and its relationship to tooth decay, as it is supposed to issue awareness plans in coordination with the Nutrition Department after the completion of this study and circulate its results to the community to benefit from them and clarify the relationships that appeared in the study and pay attention to the quality of food provided to the child and conduct educational courses for parents And children in a clear and smooth way. Dental caries is a complex disease process that afflicts a large proportion of the world's population, regardless of gender, age and ethnicity [15]. It is a major oral health problem in most industrialized countries; the early manifestation of the caries process is a small patch of demineralized (softened) enamel at the tooth surface, often hidden from sight in the fissures (grooves) of teeth or in between the teeth. The destruction spreads into the softer, sensitive part of the tooth beneath the enamel (dentine). The weakened enamel then collapses to form a cavity and the tooth is progressively destroyed. Caries can also attack the roots of teeth should they become exposed by gum recession [15]. Dental caries have been experienced by about 60–90% of children of school age all around the world, and Asian and Latin American countries have reported higher prevalence rates [16] The prevalence of caries is rising in Iran which is similar to the trend observed in other developing countries. During the last 10 years, several studies have been conducted on primary schoolchildren in Iran where the prevalence of caries is about 35–85% in children [17]. In many Arab countries dental caries is increasing over time especially since the relatively recent economic growth, which has resulted in an increased consumption of refined sugar [18, 19], higher than in other developing countries [20]. We found in a previous study a relationship which was evaluated between dietary factors and dental caries among 6–15-years-old children in Qatar. The study concluded that, dental caries is a multifactorial disease. The interplay between biological and social risk factors was highlighted in the study [21], in which the mother's educational level and previous access to dental care services in Qatar were associated with dental caries in a population of Qatari school children residing in Doha and suburban areas. The results of this study indicated that children with mothers with lower educational levels had more caries than children with mothers with higher educational levels [21]; however, these results were statistically nonsignificant. The reported results of this study are in agreement with other previous ones, which showed that the degree of schooling of the child's guardian, especially the level of schooling of the mother, appears to be a risk indicator for dental caries in children [22-24] Diet and nutrition are major multifactorial environmental factors in the etiology and pathogenesis of oral diseases. As they may affect the

development and integrity of the oral cavity and the progression of oral diseases include dental caries. As stated by the Surgeon General's report Oral Health in America [25]. The interest of dietary effects on dental caries has existed for more than 50 years. A study has been done in 1954 about the effects of high sugar consumption and timing of sugar ingestion showed that the addition of sugar to the diet caused increased caries activity, but the degree was very dependent on the consistency of the sugar [26]. Children generally consume diets which are rich in sugars like sweets, candies, cakes, colas etc. and a lot of awareness has been raised since many years about the ill effects of such food products on teeth has occurred [27]. The relation between diet, nutrition, oral health and disease can best be described as a synergistic 2-way street. Diet has a local effect on oral health, primarily on the integrity of the teeth, pH, and composition of the saliva and plaque. Nutrition, however, has a systemic effect on the integrity of the oral cavity, including teeth, periodontium (supporting structure of the teeth), oral mucosa, and alveolar bone. Alterations in nutrient intake secondary to change in diet intake, absorption, metabolism, or excretion can affect the integrity of the teeth, surrounding tissues, and bone as well as the response to wound healing [28]. Sugars are undoubtedly the most important dietary constituent and the factor studied most often in the development of dental caries. The term 'sugars' refers to all mono and disaccharides while the term 'sugar' only refers to sucrose which is the major dietary factor affecting dental caries prevalence and progression [29] the term 'free sugars' refers to all mono and disaccharides added to foods by manufacturer, cook or consumer, plus sugars naturally present in honey, fruit juices and syrups and the term 'fermentable carbohydrate' refers to free sugars, glucose polymers, fermentable oligosaccharides and highly refined starches [30]. Fresh fruits contain various sugars and may be capable of causing caries under some conditions. Fruits may participate in the caries process, however, as consumed as part of the mixed human diet there is little evidence to show fruit to be an important factor in the development of dental caries and are likely to be much less cariogenic than most sucrose rich snack foods consumed by children. Hence citrus fruits have not been associated with dental caries. Studies have shown that, fresh fruits appear to be of low cariogenicity and citrus fruits have not been associated with dental caries [29]. Fruit juice and flavored drinks, especially aerated beverages like cola have a much greater cariogenic potential because of their high sugar content and the way they are often consumed. They are offered frequently to children because of their high acceptance, low cost, and the belief by parents that they are nutritious [31]. One hundred percent fruit juice has also been associated with caries. Data from children aged 2 to 10 years who participated in National Health and Nutrition Examination Survey (NHANES) suggest that children who consume more than 17 oz 100% juice are more likely to have caries than those who are high water or milk consumers [32]. Conversely, in a cohort of low-income African- American children, 100% fruit juice was found to be protective of caries [33] Given that 100% fruit juice contains about the same amount of sugar as the average sugar sweetened beverages. Dried fruit may potentially be more cariogenic since the drying process breaks down the cellular structure of the fruit, releasing free sugars also dried fruits tend to have a longer oral clearance [34]. Milk is another most frequently consumed food among school children. The sugar found in milk (lactose) is not fermented to the same degree as other sugars [20]. In addition, the high concentrations of calcium, phosphorus and phosphor-proteins in milk will help to prevent dissolution of enamel and other antibacterial factors in milk, principally casein, is likely to be protective as well and may interfere with the oral microbial flora. Starch often is regarded as a relatively low cariogenic carbohydrate. It may be highly refined or consumed in its natural state and sometimes consumed raw (e.g. in fruits and vegetables) but is largely consumed in a cooked form. Human and animal experiments have found that starchy foods such as rice, potatoes, pasta, and bread have very low cariogenicity. However, if starch is finely ground, heat treated, and eaten frequently, it can cause caries, but lesser than sucrose. Additionally, starch that is retained on the teeth long enough to be hydrolyzed by salivary amylase also can be broken down to mono and disaccharides and consequently metabolized by bacteria [35]. Carbohydrates, glucose polymers (glucose syrups and maltodextrins) are increasingly being added to foods in industrialized countries. Evidence on the cariogenicity of these carbohydrates is sparse. Studies suggest that maltodextrins and glucose syrups are cariogenic. Also there is evidence that fructooligosaccharides, which are more widely available in foods, are as acidogenic as sucrose [36]. Sugar alcohols (e.g., sorbitol, mannitol and xylitol) are sweeteners that are metabolized by bacteria at a much slower rate than glucose or sucrose or not at all. Clinical studies have shown that xylitol chewing gum even can reverse initial white spot lesions on teeth [37]. Cheese, evidence exists that certain foods besides milk may be protective against caries. Aged cheese has been shown to be protective because it stimulates salivary flow and raises the calcium, phosphorus, and protein content of plaque [38]. Dietary fluoride principally comes from drinking water, but seafood, coffee, grapes, raisins, potato and tea leaves are also rich sources. Ingested fluoride becomes incorporated into enamel during tooth formation, increasing the resistance of the tooth to decay. This pre-eruptive mode of action affects the primary dentition in utero and the permanent dentition up to the age of 6 years. However, the main protection from dietary fluoride is the lifelong localized intra- oral effect. Fluoride promotes the remineralization of damaged enamel and also inhibits bacterial metabolism of sugars [39]. The benefits to the teeth of exposure to fluoride are therefore life -long. Where natural water

supplies are low in fluoride, it may be added to an optimum concentration of 1 mg/l as a caries preventive measure. Murray et al. 1991 have reviewed the published data on the effect of water fluoridation on caries and have concluded that on average water fluoridation reduces dental caries by 50%. Water fluoridation is a Cost-effective public health measure because it reaches the entire population [40] In a study of 5-year-old children residing in north east England Carmichael et al. 1989, have demonstrated that water fluoridation is effective in reducing dental caries across social classes and, in terms of the number of teeth saved per child, the benefits are greatest in the lower social classes. Fluoride repairs the damage caused by acids produced by plaque bacteria but does not remove the cause of caries, i.e. dietary sugars. [41]. A study conducted in the United Arab Emirates, in four emirates - Abu Dhabi, Dubai, Sharjah and Ajman to assess fluoride concentration in tap water, mineral bottled water and popular cold beverages in the U.A.E. The study concluded that Fluoride levels in drinking water should be within the recommended and accepted levels to prevent dental caries. The less than recommended fluoride level in drinking water (both tap + bottled) as well as beverages poses wider implications for an effective and comprehensive fluoride program for caries prevention in children [42]. Carbohydrates exert their effect in promoting dental caries by serving as a substrate for caries-producing streptococci, it is apparent that for older children as well as for infants that not only the total quantity but the form of the carbohydrate and the frequency of consumption are important. A single piece of sticky candy may adhere to the teeth for almost an hour. In the case of sugars that are not in sticky form, a specified amount consumed at one time is likely to be less conducive to formation of dental caries than the same amount consumed in small portions throughout the day. Considerable evidence exists that between- meal snacks favor development of dental caries [43] Finally, eating frequency, particularly constant grazing or sipping of foods and beverages, is also caries promoting [44]. In a recent study was mentioned by Palmer C et al, 2010 [45] in a diverse sample of children aged 2 to 6 years, eating frequency was associated with severe Early Childhood Caries. The form of the fermentable carbohydrate directly influences the duration of exposure and retention of the food on the teeth. Prolonged oral retention of cariogenic components of food may lead to extended periods of acid production and demineralization and to shortened periods of remineralization [46, 47]. Liquid sugars, such as those found in beverages and milk drinks, pass through the oral cavity quickly with limited contact time to tooth surfaces. However, fluid intake patterns can influence the caries risk. As holding sugar-containing beverages in the oral cavity for a prolonged time or constant sipping of a sugared beverage increases the risk of caries. Whereas long-lasting sources of sugars, such as hard candies, breath mints, and lollipops, have extended exposure time in the oral cavity because the sugars are gradually released during consumption. The longer it takes a food to clear the mouth the longer the drop in pH will remain increasing the risk of caries. However, the adhesiveness or 'stickiness' of a food is not necessarily related to either oral retention time or cariogenic potential. There is evidence to show that the amount and frequency of consumption of high sugar drinks (with low stickiness/oral retention) are associated with increased risk of dental caries [48, 49]. A study conducted in Saudi Arabia on dental caries among primary school children showed that children mixed-fed with both breast milk and powdered milk, and habituated to sleeping with bottle in mouth experienced 4.4-folds higher dental caries compared to children not practicing this habit. In addition, lack of mixed feeding such as less consumption of fresh fruits and frequent consumption of soft drinks and flavored milk, and consuming two or more sugary snack items between meals were predominantly associated with dental caries experience [50]. The frequency of consumption seems to be a significant contributor to the carcinogenicity of the diet as mentioned by Bowen et al., 2012 [51,52-55], and this study concluded that it is not the frequency of ingestion that is related to the development of caries but the time that sugars are available to microorganisms in the mouth. A Libyan study conducted in 2011 to investigate any association between dental caries and potential dietary risk factors in Libyan schoolchildren aged 12 years, showed that (42%) of the subjects who experienced dental caries had a frequent consumption of fruit-based sugared drinks [56]. Higher frequency means more demineralization and less remineralization. The duration of the decrease in pH after intake of a cariogenic food is an important confounder in this relation. Traditionally, and in many educational models, the decrease in pH lasts 30 min, PH telemetry measurements; however, show that after plaque is a few days old, the decrease in pH can last for several hours, unless the site is actually cleared by a stimulated salivary flow or by removal of impacted food [57, 58]. Malnutrition is a multifactorial disease that can have an early onset during the intrauterine life or childhood, or it can occur during an individual's lifetime as a result of poor nutrition. It affects the oral health and a poor oral health in turn, may lead to malnutrition. Malnutrition appears to have multiple effects on the oral tissues and the subsequent oral disease development. It affects the development of the oral cavity and the progression of the oral diseases through an altered tissue homeostasis, a reduced resistance to the microbial biofilms and a reduced tissue repair capacity [59, 60]. The current study aims to determine the nutritional, health statues and the hygiene factors related to the dental caries and also to study the causes for that. Specific Objectives include determining the prevalence and factors contributing to dental caries during childhood, to assess the association between dietary intake and dental caries among Libyan children, to modernize the evidence of

the dietary factors, dietary habits and oral hygiene those cause dental caries during childhood.

METHODOLOGY

A cross-sectional study was conducted in the city of Benghazi, Libya, from November 2019 to February 2020, to determine the relationship between dietary intake, dietary habits, oral hygiene and dental caries in school-aged children. A total of 150 children participated in the study between the age groups of 2 to 16 years. An attempt was made to include equal number of male and female subjects. Out of the 150 children, all of the study subjects were selected randomly from public hospitals including, Benghazi Children Hospital and Benghazi Medical center, as well as the children of friends and relatives. The criteria for selection of the study subjects were that the child should have at least one carious tooth. The subjects were examined standing upright and adequate lighting was used to examine the oral cavity. Examination of the child was done by only one student and recording of data was done by another student. A questionnaire was filled after examination of the child through direct interview by their parents/guardian to collect the subject's personal data, socio-demographic characteristics, anthropometrics, medical history, oral hygiene practices and habits, dietary habits and dietary intake by using a weekly food frequency questionnaire. The subject's weight and height were measured after the completion of the questionnaire using a calibrated weighing machine and a stadiometer respectively. Data analysis was executed using the Statistics Package Social Science (SPSS) program version 20. The data analysed described general information regarding socio-demographic characteristics, BMI, oral hygiene and dietary habits and dietary intake. Data was presented by, Mean, Median, Range, Standard deviation, Frequency distribution tables and column charts that were used to describe and compare variables. A significance testing such as Chi-square test (t test) was used to examine relationships of variables. Significance level: $P \leq 0.05$ was considered to be statistically significant. The ethical clearance for the present study was obtained from the University of Benghazi, Faculty of Public Health, Nutrition Department. The consent from each study subject was taken from their parents/guardian after explaining the nature of the study. First of all, the data was collected by the interview way, which took a long time, and the parents began to get bored, and at the same time there was sometimes refusal to respond frankly and to prevent embarrassment, we avoided confirming the answers. So, it was preferable to use the online method of filling in as an opportunity to answer more accurately and comfort. Secondly, we did not obtain all investigations that required completing the study objectives in the way was planned, where one of the most important goals of this study was to study the relationship of caries to iron deficiency, but we were unable to do so. Thirdly, the majority of children were not taking the supplement, so it was difficult to find any association between taking the supplement and tooth decay.

RESULTS

150 questionnaires out of 150 distributed were filled completely and collected which gives the response rate of 100%. Socio-demographic characteristics details of the children were presented in Table (1). 53.3% of the children were males and females were 46.7%. The majority of the children their fathers' job was an employee, followed by 25.3% of them their fathers' job was a businessman, only 6.7% of the children their fathers' job was a doctor. Whereas, 44.7% of the children their mothers' job was housewife, followed by 40.7% of them their mothers' job was an employee, only 14.7% of the children their mothers' job was doctor or nurse. Most of the children in this study their family income over 500 LD, only 4% of them their family income less 500 LD. The average age of the children was 8.3 years (median = 8 years). The average of dental caries among children was three teeth; with a range from 1 tooth to 10 teeth had caries. The oral hygiene habits and dietary information of the children are presented in Table (2).

Regarding body mass index, seven (4.7%) of the children were less than the 5th percentile, 50% of them were between equal and more than the 5th percentile to less than the 85th percentile. Also, 28% of the children were equal and more than the 85th percentile to less than the 95th percentile, 17.3% of them were equal and more than the 95th percentile. Moreover, 98% of the children eat sweets compare to 2% of them did not. Whereas, 71.3% of the children eat in front of the TV compare to 28.7% of them did not eat in front of the TV. However, regarding to teeth care, 30.0% of the children did not brush their teeth, compared to 49.3% of them brush their teeth once on a day, and 19.3% of the children brush their teeth twice on a day, only 1.3% of the studied children brush their teeth 3 or more times on a day. While, 35.3% of the children brush their teeth before going to sleep compared to 64.7% of them did not brush their teeth before going to sleep. Also, 20.7% of the children rinse their mouths compared to 79.3% of them did not rinse their mouths. As shown in Table (2). The children's distribution according to nutritional status (BMI) is shown in Figure (1). A half percent of children had a healthy weight, followed by 28% of them had overweight; whereas, 17.3% of the children had obesity compare to 4.7% of them had underweight.

Table-1: Socio-demographic characteristics of the children

Socio- demographic char.	No.	%
Gender		
Male	80	53.3%
Female	70	46.7%
Father's job		
doctor	10	6.7%
employee	102	68.0%
business	38	25.3%

Socio- demographic char.	No.	%
Mother's job		
housewife	67	44.7%
doctor & nurse	22	14.7%
Employee	61	40.7%
Income		
<500	6	4.0%
500-1000	76	50.7%
>1000	68	45.3%
Age in years		
Mean ± SD	8.3 ± 3.0	
Median	8.0	
Range	2 -16	
Caries index		
Mean ± SD	2.9 ± 1.7	
Median	3.0	
Range	1-10	

Table-2: Oral hygiene habits and dietary information of the children

	No.	%
BMI		
<5th percentile	7	4.7%
≥ 5 to <85th percentile	75	50.0%
≥85 to<95th percentile	42	28.0%
≥ 95th percentile	26	17.3%
Consume sweets		
Yes	147	98.0%
No	3	2.0%
Eat in front TV		
Yes	107	71.3%
No	43	28.7%
Brush teeth per day		
0	45	30.0%
1x	74	49.3%
2x	29	19.3%
3 or more	2	1.3%
Teeth brushing before sleep		
Yes	53	35.3%
No	97	64.7%
mouth rinse		
Yes	31	20.7%
No	119	79.3%

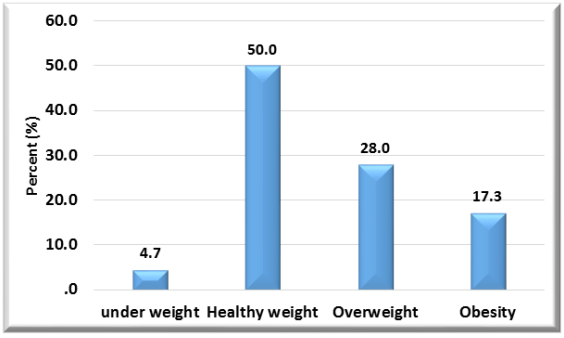

Fig-1: The children's distribution according to nutritional status (BMI)

A comparison of socio-demographic characteristics among children with dental caries is presented in Table (3). There was no significant statistical difference in the average dental caries between males and females (P= 0.7); in both males and females had three teeth as the average dental caries. Whereas, there was a significant statistical difference in the average dental caries among age groups (P= 0.02); in which the average dental caries are increased in older children. The children aged between (2-4 years) had two teeth as the average dental caries; while about four teeth as the average dental caries in the children aged between (11 or more). There was a significant statistical difference in the average dental caries among the type of fathers' job with (P= 0.000) and among the type of mothers' job with (P = 0.006). Where the children who their fathers or their mothers work as doctors or nurses, had fewer dental caries with average (mean = 2 teeth) while others jobs, the children had three or more teeth as the average dental caries. There was a significant statistical difference among children regarding family income levels (P=0.01), in which two teeth were the average dental caries among children whose family income is under 500 LD; while average teeth caries were three or more among children whose family income more than 500 LD. Comparison of oral hygiene habits and dietary information of the children with dental caries is presented in Table (4). There was a significant statistical difference in the average dental caries among the children according to their BMI percentiles (P = 0.01). Average dental caries were two among children who had fewer than 5% of body mass index percentile (underweight); while average dental caries were three teeth or more among children who had 5% or more of body mass index percentiles. Whereas, there was no significant statistical difference in the average dental caries among the children according to consume sweets (P=0.3) or children eat in front of the TV with (P=0.1). About three teeth were average dental caries among children who consume sweets or nor. Similar results are also observed among children who eat in front of the TV or not. However, there was a significant statistical difference in the average dental caries among the children according to brush their teeth per day (P= 0.03). The average dental caries decreased with the increase times to brush their teeth per day. But, there was no significant statistical difference in the average dental caries among the children according to brush their teeth before sleep (P=0.1) or to rinse their mouths (P=0.6). In which three teeth were average dental caries among children who brush their teeth before sleep or not.

A comparison of dietary intake among children with dental caries is presented in Table (5). There was a significant statistical difference in the average dental caries among the children according to their meal pattern (P= 0.007). Average dental caries were two among children who had regular meal patterns; while average dental caries were three teeth among children who had irregular meal patterns. Also, there was a significant statistical difference in the average dental caries among the children according to snack number (P=0.04). About two teeth were average dental caries among children who eat one snack per day; while average dental caries increased with snack number per

day increase. There was a significant statistical difference in the average dental caries among the children according to eat junk food (P= 0.003). Where the average dental caries were two teeth among the children who did not like junk food, but, the average dental caries were about three teeth among the children who like junk food. As well, the supplement has a significant statistical difference in the average dental caries among the children. The average dental caries were two teeth among the children who take the supplement compare to three teeth among the children who did not take the supplement. There was a significant statistical difference in the average dental caries among the children according to sugar amount consumption (P=0.02). The average dental caries were two teeth among the children who consume one spoon of sugar. About three teeth were the average dental caries among the children who consume two or more spoon of sugar, in which the average dental caries increase with the increase in consumption of sugar. However, there was no significant statistical difference in the average dental caries among the children according to drink milk before sleep. About three teeth were the average dental caries among the children who drink milk before sleep or not. Similar results are also observed among children who drink one cup of juice or more (P= 0.5). The average dental caries were about three teeth among the children who drink one cup of juice or more. As shown in Table (5). Figure (2) shows the distribution of the average dental caries according to children's age groups who take the supplement. There was no significant statistical difference in the average dental caries among the children according to the children's age group who take the supplement (P=0.2). About two teeth were the average dental caries among children aged group 1-5 years and 6-10 years. While the average dental caries was one tooth among children aged group 11-15 years. Figure (3) shows the distribution of children according to the common snack liked. About 25% of the children like to eat cake as a snack; followed by 17.3% of the children like to eat a sandwich as a snack. From 6% to about 9% of the children like to eat French fries, Pizza, aside, and pastries.

Table-3: Comparison of socio-demographic characteristics among children with dental caries

Socio- demographic char.	Mean ± DS	P value
Gender		P=0.7
Male	2.98 ±1.8	
Female	2.90 ± 1.5	
Age in years		**P = 0.02***
2-4	2 ± 1.1	
5-7	2.8 ± 1.7	
8-10	3.3 ± 1.9	
11 or more	3.5 ± 1.3	
Father's job		**P = 0.000***
doctor	2 ± 0.9	
employee	2.7 ± 1.5	
business	3.8 ± 1.9	
Mother's job		**P = 0.006***
housewife	3.4 ± 1.8	
doctor & nurse	2.2 ± 1.2	
employee	2.6 ± 1.5	
Income		**P = 0.01***
<500	2.1 ± 1.4	
500-1000	3.5 ± 1.7	
>1000	2.7 ± 1.5	

Table-4: Comparison of oral hygiene habits and dietary information of the children with dental caries

	Mean ± DS	P value
BMI percentiles		**P = 0.01***
<5th percentile	1.8 ± 0.8	
≥ 5 to <85th percentile	3 ± 1.5	
≥85 to<95th percentile	2.8 ± 1.6	
≥ 95th percentile	3.7 ± 2.1	
Consume sweets		P = 0.3
Yes	3.0 ± 1.3	
No	2.5 ± 1.1	
Eat in front of TV		
Yes	3.1 ± 1.6	P = 0.1
No	2.7 ± 1.9	

	Mean ± DS	P value
Brush teeth per day		
0	3.6 ± 1.9	**P = 0.03***
1x	2.8 ± 1.6	
2x	2.7 ± 1.4	
3 or more	2.0 ± 0.1	
Teeth brushing before sleep		
Yes	2.8 ± 1.5	P = 0.1
No	3 ± 1.7	
mouth rinse		
Yes	2.8 ± 1.3	P = 0.6
No	2.9 ± 1.7	

Table-5: Comparison of dietary intake among children with dental caries

	Mean ± DS	P value
Meal pattern		**P = 0.007***
regular	**2.4 ± 1.4**	
irregular	**3.3 ± 1.8**	
Snack number		**P = 0.04***
1	**2.4 ± 1.7**	
2	**2.9 ± 1.5**	
3	**3.3 ± 1.8**	
More than 3	**4.5 ± 1.7**	
Junk food		
Yes	**3.3 ± 1.6**	**P = 0.003***
No	**2.3 ± 1.7**	
Supplement		
Yes	**2.0 ± 1.1**	**P = 0.008***
No	**3.1 ± 1.7**	
Sugar amount		
1	**2.3 ± 1.2**	**P = 0.02***
2	**2.8 ± 1.7**	
3	**3.2 ± 1.6**	
Drink milk before sleep		
Yes	**3.1 ± 1.7**	**P = 0.4**
No	**2.8 ± 1.6**	
Juice amount		
1	**2.8 ± 1.9**	**P = 0.5**
2	**3.2 ± 1.5**	
More than 2	**2.7 ± 1.0**	

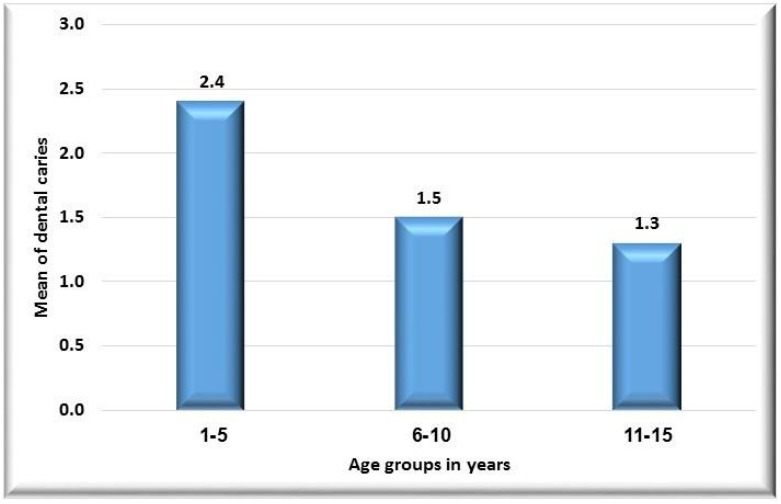

Fig-2: Distribution of the average dental caries according to children's age groups who take the supplement

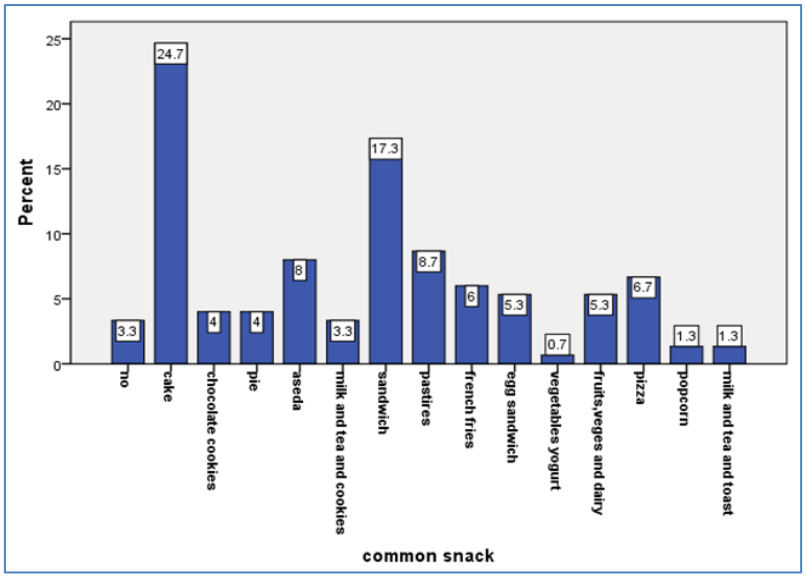

Fig-3: The distribution of children according to the common snack liked

DISCUSSION

Gender-wise, proportion of males was slightly higher than females in this study, although the difference in caries number between the two groups was not statistically significant. A study was conducted in Benghazi, Libya in the early 1990's to assess the oral health practices and dental caries among pupils, also found that the prevalence of dental caries was slightly higher in boys than girls, however the difference was not statistically significant [69]. Another study was conducted in Northern Appalachia to assess sex disparities in dental caries, found that young girls experienced greater protection compared to boys. Informal evidence from oral health professionals indicates that greater cultural importance is placed on girl's dental aesthetics, which is consistent with the significantly lower caries indices observed in girls [70]. While another Libyan study was conducted in Tripoli, in 2019 to observe the prevalence of decayed teeth in relation to different socio-demographic variables, found that there was a significant difference in the prevalence of dental caries according to sex of children which was higher in girls than boys [71]. Since parents play an important role in the formation of their children's oral hygiene habits, socio-economic factors, like parental occupational status, parental educational levels, and family income influence likelihood of dental caries in children. In the present study, parents who did not have a higher educational and occupational attainment, their children had the highest number of caries. Children who have parents with a higher occupational status presented the lowest caries. A cross-sectional study in Switzerland showed that parental occupations with higher professional level were significantly inversely associated with the prevalence of caries in children aged 36 to 71 months [72]. In a study conducted among Egyptian children, there was an inverse significant correlation between parental educational level and dental caries in children [73]. Studies have found that uneducated, unemployed or low income mothers feed their children since they were infants either too much or frequently which lead to establishing bad future eating patterns in children hence leading to early childhood caries. Marshall et al. reported that caries exists in young children of low socio-economic status, and that both mother's education and occupation were closely associated with caries experience in children [74], which is in agreement with a study conducted among preschool children in Saudi Arabia which found that mother's educational level appeared to have higher association with caries prevalence in their children even than the father's educational level [75]. These studies explain the findings in our results which demonstrate an increased awareness of health practices in children of occupied, highly educated mothers. On the other hand, no association was observed between maternal employment and dental caries in Japanese, Brazilian, South African, Mongolian, preschool children [76-79]. There was a higher prevalence of dental caries among children of high and middle income families, while a low prevalence was found among children of low income families. Studies have found a significant relationship between dietary patterns and socio-economic indicators where consumption of 'healthier' dietary pattern were associated with children from the lower income group and consumption of 'unhealthy' dietary patterns was more among the higher income and higher education group [80]. In another study it was found that children of lower socioeconomic status had less diverse diets but ate less snack foods than children of higher socioeconomic status [80]. The reason for more frequent consumption of unhealthy diets such sweets, cakes, colas and others among children from the rich socio-economic status group may be due to its easy availability they being able to afford it when compared to children from the poor socio-economic group. However, Barker and colleagues found that lower income and socioeconomic status in general was associated with less fruit and vegetable consumption

compared to high fat sugary foods that are often associated with caries risk in children [81]. Another study demonstrated the opposite findings in which children of higher socioeconomic group were at a lower risk of caries however, children from lower socioeconomic status family showed a greater risk for developing dental caries [82]. In our study there was a significant difference in dental caries experience according to age groups, in which the number of caries increased in older children. In this study, the number of dental caries was lower in younger children which gradually increased with age to be higher in older children. This finding might be justified by considering the fact that as children grow into their adolescent years, they become more responsible for their own nutrition and what they choose to eat, their influenced by their peer's diet as well as unhealthy food advocates on social media and parents might as well have less control on what foods and drinks they are consuming whether their children are eating inside or outside the house, and hence they obtain more access to junk and fast foods, refined carbohydrates, sweets and sugary foods, high sugar drinks like juice and sodas increasing their chance of dental caries. A study conducted in Lebanon on preschool children reported similar results in which the prevalence of proximal caries seems to be higher in older children within the sample, and it could be explained by the changes in diet that accompany the child's growth; a child capable of accepting or rejecting certain foods, may indulge in a more cariogenic diet than a younger child ingesting a parent chosen menu [83]. In 2015, epidemiology program for England reported evidence on the relationship between dental caries and obesity [84]. Over consumption of sugar in its refined state is associated with dental caries, overweight and obesity [85] Marshall, in 2007, reported the highest proportion of tooth caries found in obese children, and this is what our study has found, that there is a relationship between dental caries and BMI, and that overweight and obese children are more susceptible to dental caries. In 2015, the WHO recommended that ideally, added sugar consumption should be add no more than 5% of total energy intake [86]. Several studies have reported that the stickiness of food is the primary factor in the initiation of dental caries. [87]. In the present study there was no relationship between frequent sweet consumption and dental caries because cavities depend on the type of sweets, for example, if it contains caramel sticking to the teeth, it may cause cavities, and if it is just a cake that doesn't contain sticky substances, it will not stick for a long period on the teeth's surface and will not cause cavities. The National Diet and Nutrition Survey (NDNS) reported that children who brush their teeth twice a day have significantly less caries than brushing less frequently [88]. Tooth brushing is related with markedly reduced risk of caries [89]. As less brushed away, plaque can build up on the teeth. A buildup of plaque is a key factor in the development of tooth decay which is similar to the study's results. Washing teeth before sleep has no direct relationship to tooth decay, perhaps because dental hygiene depends on the whole day, and not just before sleep. As we found in the results of previous studies regarding tooth brushing that those who brush more than twice a day aren't exposed to caries. American Dental Association has recommended that children must limit eating between meals and when they must snack, give a preference to nutritious foods identified by the US Department of Agriculture (USDA) Dietary Guidelines [90]. In our study irregular meal patterns showed a relationship with dental caries, which means that the child returns to other foods between the basic meals, hence an indicator of snacking. Consumption of sugar and refined carbohydrates frequently between meals will increase risk of caries. Sugar is classified into several types including, monosaccharides, out of which the most common are glucose, fructose, and sucrose [91] Sucrose is called arch criminal of dental caries and is the most common form of added sugar, as it plays a major role in dental caries [92] Sucrose produces a substance called glucan, which forms a major component of antimicrobial matrix of plaque [93] This is demonstrated in our study, in which the addition of two or more tea-spoons of sugar had a relationship with dental caries. The Research Committee of the Canadian Dental Association reported that milk consumption was linked with risk reduction of caries [94]. Cow's milk contains lactose, but lactose is the least cariogenic of the common dietary sugars [95], in addition milk contains another substance including calcium phosphate and casein that have an important role in preventing caries Therefore, we concluded that there is no relationship between drinking milk before bed and dental caries, rather, milk protects against caries. There was no significant association between dental caries and intake of supplements, which might indicate that dental caries development is normally a slow process with several years of delay before the activity is observed, for example, the level of serum [25(oH) D] at time of caries scoring may or may not be representative of the period when caries symptoms are developed [96]. In other studies relationships between 25(OH) D and CYP2R1, DHCR7 and GC were replicated [97, 98] When combined these SNPS were confirmed as a strong genetic instrument for 25(OH) D, with per allele changes of a clinically relevant magnitude. This genetic instrument showed no association with factors potentially confounding the vitamin D dental caries relationship. Therefore, in the absence of coordinated vitamin D and outcome data this genetic instrument was used to model a life-course difference in vitamin D exposure for use in MR analysis. MR analysis has not given substantive evidence for an association between caries experience and vitamin D [99]. There is an association between dental caries and snacks, in which an increased number of snacks leads to increase in average of dental caries in children this is because Ph drop on the teeth surface from carbohydrate fermentation by dental biofilm bacteria is etiologic to

dental caries or in other words increase number of snack intake leads to frequently decrease in the salivary ph below the critical demineralization level which leads to a suitable environment for dental caries, the results of our study and another study agreed that snacking on starchy food is associated with caries in children [100].

CONCLUSION

In conclusion, the present study reported on childhood dental caries, prevalence and risk factors in Benghazi, Libya. The prevalence of dental caries in children was an average of 3 carious lesions. Socio-demographic factors, parental education, occupation, and income, oral hygiene practices and, dietary intake and habits were positively associated with dental caries each play a role in initiating or increasing a child's exposure to dental caries. Supplement intake during childhood, however did not prevent caries later on in children.

REFERENCES

1. Glick, M., Williams, D. M., Kleinman, D. V., Vujicic, M., Watt, R. G., & Weyant, R. J. (2016). A new definition for oral health developed by the FDI World Dental Federation opens the door to a universal definition of oral health. British dental journal, 221(12), 792-793.
2. Feldens, C. A., Ardenghi, T. M., Dullius, A. I. D. S., Vargas-Ferreira, F., Hernandez, P. A. G., & Kramer, P. F. (2016). Clarifying the impact of untreated and treated dental caries on oral health-related quality of life among adolescents. Caries research, 50(4), 414-421.
3. Benzian, H., Monse, B., Heinrich-Weltzien, R., Hobdell, M., Mulder, J., & van Palenstein Helderman, W. (2011). Untreated severe dental decay: a neglected determinant of low Body Mass Index in 12-year-old Filipino children. BMC public health, 11(1), 1-10.
4. Moynihan, P. J. (2005). The role of diet and nutrition in the etiology and prevention of oral diseases. Bulletin of the World Health Organization, 83, 694-699.
5. United States. Public Health Service. Office of the Surgeon General, National Institute of Dental, & Craniofacial Research (US). (2000). Oral health in America: a report of the Surgeon General. US Public Health Service, Department of Health and Human Services.
6. Çolak, H., Dülgergil, Ç. T., Dalli, M., & Hamidi, M. M. (2013). Early childhood caries update: A review of causes, diagnoses, and treatments. Journal of natural science, biology, and medicine, 4(1), 29.
7. World Health Organization. (2003). The world health report 2003: shaping the future. World Health Organization.
8. World Health Organization. (2013). The world health report 2013: shaping the future. World Health Organization.
9. Vadiakas, G. (2008). Case definition, aetiology and risk assessment of early childhood caries (ECC): a revisited review. European archives of paediatric dentistry, 9(3), 114-125.
10. Johansson, I., Holgerson, P. L., Kressin, N. R., Nunn, M. E., & Tanner, A. C. (2010). Snacking habits and caries in young children. Caries research, 44(5), 421-430.
11. Hawkes, C. (2006). Uneven dietary development: linking the policies and processes of globalization with the nutrition transition, obesity and diet-related chronic diseases. Globalization and health, 2(1), 1-18.
12. Kumarihamy, S. L., Subasinghe, L. D., Jayasekara, P., Kularatna, S. M., & Palipana, P. D. (2011). The prevalence of Early Childhood Caries in 1-2 yrs olds in a semi-urban area of Sri Lanka. BMC research notes, 4(1), 1-6.
13. Wamani, H., Åstrøm, A. N., Peterson, S., Tylleskär, T., & Tumwine, J. K. (2005). Infant and young child feeding in western Uganda: knowledge, practices and socio-economic correlates. Journal of tropical pediatrics, 51(6), 356-361.
14. Kemparaj, U., Chavan, S., & Shetty, N. L. (2014). Caries risk assessment among school children in davangere city using cariogram. International journal of preventive medicine, 5(5), 664.
15. Tenuta, L. M. A., & Cury, J. A. (2005). Fluoreto na prática de promoção de saúde individual e coletiva. Rio de Janeiro: ABOPREV.
16. Moysés, S. T. (2012). Recomendações do Ministério da Saúde para o uso de dentifrícios fluoretados. Revista da Faculdade de Odontologia de Porto Alegre, 53(3), 32-35.
17. Vale, G. C., Tabchoury, C. P. M., Del Bel Cury, A. A., Tenuta, L. M. A., Ten Cate, J. M., & Cury, J. A. (2011). APF and dentifrice effect on root dentin demineralization and biofilm. Journal of dental research, 90(1), 77-81.
18. American Dietetic Association. (2003). American Dietetic Association Position Paper: Nutrition and Oral Health. Journal of the American Dietetic Association, 103(5), 615-625.
19. Hicks, J., Garcia-Godoy, F., & Flaitz, C. (2004). Biological factors in dental caries: role of saliva and dental plaque in the dynamic process of demineralization and remineralization (part 1). Journal of Clinical Pediatric Dentistry, 28(1), 47-52.
20. Petersen, P. E., Bourgeois, D., Ogawa, H., Estupinan-Day, S., & Ndiaye, C. (2005). The global burden of oral diseases and risks to oral health. Bulletin of the World Health Organization, 83, 661-669.
21. Vadiakas, G. (2008). Case definition, aetiology and risk assessment of early childhood caries (ECC): a revisited review. European archives of paediatric dentistry, 9(3), 114-125.

22. Kazerouni, K., Mohammadi, N., ANSARI, G. H., & Kamali, Z. (2005). The effects of socio-economic status on dental caries incidence in a group of primary school children, Tehran-2000.
23. Sadeghi, M., Lynch, C. D., & Arsalan, A. (2011). Is there a correlation between dental caries and body mass index-for-age among adolescents in Iran?. Community dental health, 28(2), 174.
24. Sheiham, A. (1984). Changing trends in dental caries. International Journal of Epidemiology, 13(2), 142-147.
25. World Health Organization. (1984). Prevention methods and programmes for oral diseases: report of a WHO expert committee [meeting held in Geneva from 12 to 16 September 1983]. World Health Organization.
26. Gustafsson, B. E., Quensel, C. E., Lanke, L. S., Lundqvist, C., Grahnen, H., Bonow, B. E., & Krasse, B. O. (1953). The effect of different levels of carbohydrate intake on caries activity in 436 individuals observed for five years. Acta Odontologica Scandinavica, 11(3-4), 232-364.
27. Bener, A., Al Darwish, M. S., Tewfik, I., & Hoffmann, G. F. (2013). The impact of dietary and lifestyle factors on the risk of dental caries among young children in Qatar. The Journal Of The Egyptian Public Health Association, 88(2), 67-73.
28. Zahara, A. M., Fashihah, M. H., & Nurul, A. Y. (2010). Relationship between frequency of sugary food and drink consumption with occurrence of dental caries among preschool children in Titiwangsa, Kuala Lumpur. Malays J Nutr, 16(1), 83-90.
29. Feldens, C. A., Giugliani, E. R. J., Duncan, B. B., Drachler, M. D. L., & Vítolo, M. R. (2010). Long-term effectiveness of a nutritional program in reducing early childhood caries: a randomized trial. Community dentistry and oral epidemiology, 38(4), 324-332.
30. Rugg-Gunn, A. J. (2001). Nutrition, diet and oral health. Journal of the Royal College of Surgeons of Edinburgh, 46(6), 320-328.
31. Keys, P. H. (1963). Factor influencing the initiation, transmission and inhibition of dental caries. Mechanism of hard tissue destruction.
32. Sohn, W., Burt, B. A., & Sowers, M. R. (2006). Carbonated soft drinks and dental caries in the primary dentition. Journal of dental research, 85(3), 262-266.
33. Gustafsson, B. E., Quensel, C. E., Lanke, L. S., Lundqvist, C., Grahnen, H., Bonow, B. E., & Krasse, B. O. (1953). The effect of different levels of carbohydrate intake on caries activity in 436 individuals observed for five years. Acta Odontologica Scandinavica, 11(3-4), 232-364.
34. Harris, R. (1963). Biology of the children of Hopewood House, Bowral, Australia. 4. Observations on dental-caries experience extending over five years (1957-61). Journal of Dental Research, 42(6), 1387-1399.
35. Lineback, D. R., & Jones, J. M. (2003). Sugars and health workshop: summary and conclusions. The American journal of clinical nutrition, 78(4), 893S-897S.
36. Moynihan, P., & Petersen, P. E. (2004). Diet, nutrition and the prevention of dental diseases. Public health nutrition, 7(1a), 201-226.
37. Moynihan, P. (2005). The interrelationship between diet and oral health. Proceedings of the Nutrition Society, 64(4), 571-580.
38. Nobigrot, T., Chasalow, F. I., & Lifshitz, F. (1997). Carbohydrate absorption from one serving of fruit juice in young children: age and carbohydrate composition effects. Journal of the American College of Nutrition, 16(2), 152-158.
39. Sohn, W., Burt, B. A., & Sowers, M. R. (2006). Carbonated soft drinks and dental caries in the primary dentition. Journal of dental research, 85(3), 262-266.
40. Murray, J. J., Rugg-Gunn, A. J., & Jenkins, G. N. (1991). Health and water fluoridation. Fluorides in caries prevention. 3rd edition Oxford: Butterworth-Heinemann, 337-346.
41. Carmichael, C. L., Rugg-Gunn, A. J., & Ferrell, R. S. (1989). The relationship between fluoridation, social class and caries experience in 5-year-old children in Newcastle and Northumberland in 1987. British Dental Journal, 167(2), 57-61.
42. Walia, T., Fanas, S. A., Akbar, M., Eddin, J., & Adnan, M. (2017). Estimation of fluoride concentration in drinking water and common beverages in United Arab Emirates (UAE). The Saudi dental journal, 29(3), 117-122.
43. Weiss, R. L., & Trithart, A. H. (1960). Between-meal eating habits and dental caries experience in preschool children. American Journal of Public Health and the Nations Health, 50(8), 1097-1104.
44. Burt, B. A., Eklund, S. A., Morgan, K. J., Larkin, F. E., Guire, K. E., Brown, L. O., & Weintraub, J. A. (1988). The effects of sugars intake and frequency of ingestion on dental caries increment in a three-year longitudinal study. Journal of Dental Research, 67(11), 1422-1429.
45. Palmer, C. A., Kent Jr, R., Loo, C. Y., Hughes, C. V., Stutius, E., Pradhan, N., ... & Tanner, A. C. R. (2010). Diet and caries-associated bacteria in severe early childhood caries. Journal of dental research, 89(11), 1224-1229.
46. Lingstrom, P., Van Houte, J., & Kashket, Y. S. (2000). Food starches and dental caries. Critical Reviews in Oral Biology & Medicine, 11(3), 366-380.
47. Kashket, S., Van Houte, J., Lopez, L. R., & Stocks, S. (1991). Lack of correlation between food retention on the human dentition and consumer perception of food stickiness. Journal of Dental Research, 70(10), 1314-1319.
48. Jamel, H., Sheiham, A., Watt, R. G., & Cowell, C. R. (1997). Sweet preference, consumption of sweet tea and dental caries; studies in urban and rural

Iraqi populations. International dental journal, 47(4), 213-217.
49. Ismail, A. I., Burt, B. A., & Eklund, S. A. (1984). The cariogenicity of soft drinks in the United States. The Journal of the American Dental Association, 109(2), 241-245.
50. Alhabdan, Y. A., Albeshr, A. G., Yenugadhati, N., & Jradi, H. (2018). Prevalence of dental caries and associated factors among primary school children: a population-based cross-sectional study in Riyadh, Saudi Arabia. Environmental health and preventive medicine, 23(1), 1-14.
51. König, K. G., & Navia, J. M. (1995). Nutritional role of sugars in oral health. The American journal of clinical nutrition, 62(1), 275S-282S.
52. Gustafsson, B. E., Quensel, C. E., Lanke, L. S., Lundqvist, C., Grahnen, H., Bonow, B. E., & Krasse, B. O. (1953). The effect of different levels of carbohydrate intake on caries activity in 436 individuals observed for five years. Acta Odontologica Scandinavica, 11(3-4), 232-364.
53. König, K. G., Schmid, P., & Schmid, R. (1968). An apparatus for frequency-controlled feeding of small rodents and its use in dental caries experiments. Archives of Oral Biology, 13(1), 13-IN7.
54. Firestone, A. R., Schmid, R., & Mühlemann, H. R. (1982). Cariogenic effects of cooked wheat starch alone or with sucrose and frequency-controlled feedings in rats. Archives of Oral Biology, 27(9), 759-763.
55. Bowen, W. H., Amsbaugh, S. M., Monell-Torrens, S. M., & Brunelle, J. (1983). Effects of varying intervals between meals on dental caries in rats. Caries research, 17(5), 466-471.
56. Huew, R., Waterhouse, P. J., Moynihan, P. J., Kometa, S., & Maguire, A. (2011). Dental erosion and its association with diet in Libyan schoolchildren. European Archives of Paediatric Dentistry, 12(5), 234-240.
57. Stephan, R. M., & Miller, B. F. (1943). A quantitative method for evaluating physical and chemical agents which modify production of acids in bacterial plaques on human teeth. Journal of Dental Research, 22(1), 45-51.
58. Imfeld, T. N. (1983). Identification of low caries risk dietary components. Karger Publishers.
59. Ehizele, A. O., Ojehanon, P. I., & Akhionbare, O. (2009). Nutrition and oral health. Benin Journal of Postgraduate Medicine, 11(1).
60. Alvarez, J., Lewis, C. A., Saman, C., Caceda, J., Montalvo, J., Figueroa, M. L., ... & Navia, J. M. (1988). Chronic malnutrition, dental caries, and tooth exfoliation in Peruvian children aged 3–9 years. The American journal of clinical nutrition, 48(2), 368-372.
61. Loesche, W. J., Hockett, R. N., & Syed, S. A. (1972). The predominant cultivable flora of tooth surface plaque removed from institutionalized subjects. Archives of Oral Biology, 17(9), 1311-1325.
62. Al-Shahrani, M. A. (2019). Microbiology of dental caries: A literature review. Annals of Medical and Health Sciences Research.
63. Berkowitz, R. J. (2003). Acquisition and transmission of mutans streptococci. CDA, 31(2), 135-138.
64. Hawkes, C. (2006). Uneven dietary development: linking the policies and processes of globalization with the nutrition transition, obesity and diet-related chronic diseases. Globalization and health, 2(1), 1-18.
65. Marsh, P. D. (2003). Are dental diseases examples of ecological catastrophes?. Microbiology, 149(2), 279-294.
66. Hannigan, A., O'Mullane, D. M., Barry, D., Schäfer, F., & Roberts, A. J. (2000). A caries susceptibility classification of tooth surfaces by survival time. Caries research, 34(2), 103-108.
67. Stenlund, H., Mejàre, I., & Källestål, C. (2003). Caries incidence rates in Swedish adolescents and young adults with particular reference to adjacent approximal tooth surfaces: a methodological study. Community dentistry and oral epidemiology, 31(5), 361-367.
68. Carlos, J. P., & Gittelsohn, A. M. (1965). Longitudinal studies of the natural history of caries—II: A life-table study of caries incidence in the permanent teeth. Archives of Oral Biology, 10(5), 739-751.
69. Al Sharbati, M. M., Meidan, T. M., & Sudani, O. (2000). Oral health practices and dental caries among Libyan pupils, Benghazi [1993-1994]. EMHJ-Eastern Mediterranean Health Journal, 6 (5-6), 997-1004, 2000.
70. Shaffer, J. R., Leslie, E. J., Feingold, E., Govil, M., McNeil, D. W., Crout, R. J., ... & Marazita, M. L. (2015). Caries experience differs between females and males across age groups in Northern Appalachia. International journal of dentistry, 2015.
71. Kabar, A. M., Elzahaf, R. A., & Shakhatreh, F. M. (2019). Scholars Journal of Dental Sciences.
72. Baggio, S., Abarca, M., Bodenmann, P., Gehri, M., & Madrid, C. (2015). Early childhood caries in Switzerland: a marker of social inequalities. BMC Oral Health, 15(1), 1-9.
73. Abbass, M. M., Mahmoud, S. A., El Moshy, S., Rady, D., AbuBakr, N., Radwan, I. A., ... & Al Jawaldeh, A. (2019). The prevalence of dental caries among Egyptian children and adolescences and its association with age, socioeconomic status, dietary habits and other risk factors. A cross-sectional study. F1000Research, 8.
74. Marshall, T. A., Eichenberger- Gilmore, J. M., Broffitt, B. A., Warren, J. J., & Levy, S. M. (2007). Dental caries and childhood obesity: roles of diet and socioeconomic status. Community dentistry and oral epidemiology, 35(6), 449-458.

75. Al-Meedani, L. A., & Al-Dlaigan, Y. H. (2016). Prevalence of dental caries and associated social risk factors among preschool children in Riyadh, Saudi Arabia. Pakistan journal of medical sciences, 32(2), 452.
76. Tanaka, K., Miyake, Y., Sasaki, S., & Hirota, Y. (2013). Socioeconomic status and risk of dental caries in Japanese preschool children: the O saka M aternal and C hild H ealth S tudy. Journal of Public Health Dentistry, 73(3), 217-223.
77. Piovesan, C., Mendes, F. M., Ferreira, F. V., Guedes, R. S., & Ardenghi, T. M. (2010). Socioeconomic inequalities in the distribution of dental caries in Brazilian preschool children. Journal of public health dentistry, 70(4), 319-326.
78. Khan, M. N., & Cleaton- Jones, P. E. (1998). Dental caries in African preschool children: social factors as disease markers. Journal of public health dentistry, 58(1), 7-11.
79. Jigjid, B., Ueno, M., Shinada, K., & Kawaguchi, Y. (2009). Early childhood caries and related risk factors in Mongolian children. Community dental health, 26(2), 121-128.
80. Mirajkar, S. G. (2014). The relationship between diet and dental caries among school children in the city of Chennai, India.
81. Barker, M., Lawrence, W., Woadden, J., Crozier, S. R., & Skinner, T. C. (2008). Women of lower educational attainment have lower food involvement and eat less fruit and vegetables. Appetite, 50(2-3), 464-468.
82. Gokhale, N., & Nuvvula, S. (2016). Influence of socioeconomic and working status of the parents on the incidence of their children's dental caries. Journal of natural science, biology, and medicine, 7(2), 127.
83. Chedid, N. R., Bourgeois, D., Kaloustian, H., Baba, N. Z., & Pilipili, C. (2011). Caries prevalence and caries risk in a sample of Lebanese preschool children. Odonto Stomatologie Tropicale, 34(134), 31.
84. D'Aiuto, F., Gable, D., Syed, Z., Allen, Y., Wanyonyi, K. L., White, S., & Gallagher, J. E. (2017). Evidence summary: The relationship between oral diseases and diabetes. British dental journal, 222(12), 944.
85. Kopycka- Kedzierawski, D. T., Auinger, P., Billings, R. J., & Weitzman, M. (2008). Caries status and overweight in 2- to 18- year- old US children: findings from national surveys. Community dentistry and oral epidemiology, 36(2), 157-167.
86. Marshall, T. A., Eichenberger- Gilmore, J. M., Broffitt, B. A., Warren, J. J., & Levy, S. M. (2007). Dental caries and childhood obesity: roles of diet and socioeconomic status. Community dentistry and oral epidemiology, 35(6), 449-458.
87. World Health Organization. (2015). World Health Organization Guideline: Sugars Intake for Adults and Children. Geneva: WHO.
88. Gustafsson, B. E., Quensel, C. E., Lanke, L. S., Lundqvist, C., Grahnen, H., Bonow, B. E., & Krasse, B. O. (1953). The effect of different levels of carbohydrate intake on caries activity in 436 individuals observed for five years. Acta Odontologica Scandinavica, 11(3-4), 232-364.
89. Gregory, J. R., Collins, D. L., Davies, P. S. W., Hughes, J. M., & Clarke, P. C. (1995). National Diet and Nutrition Survey: children aged 1.5 to 4.5 years. HMSO Publications Centre.
90. Dummer, P. M. H., Oliver, S. J., Hicks, R., Kingdon, A., Kingdon, R., Addyt, M., & Shaw, W. C. (1990). Factors influencing the caries experience of a group of children at the ages of 11–12 and 15–16 years: Results from an ongoing epidemiological survey. Journal of dentistry, 18(1), 37-48.
91. Punitha, V. C., Amudhan, A., Sivaprakasam, P., & Rathanaprabu, V. (2015). Role of dietary habits and diet in caries occurrence and severity among urban adolescent school children. Journal of pharmacy & bioallied sciences, 7(Suppl 1), S296.
92. Moynihan, P. J. (1998). Update on the nomenclature of carbohydrates and their dental effects. Journal of Dentistry, 26(3), 209-218.
93. Newbrun, E. (1969). Sucrose, the arch criminal of dental caries. ASDC journal of dentistry for children, 36(4), 239-248.
94. Guggenheim, B. (1970). Extracellular polysaccharides and microbial plaque. International dental journal, 20(4), 657-678.
95. Bánóczy, J., Rugg-Gunn, A., & Woodward, M. (2013). Milk fluoridation for the prevention of dental caries. Acta medica academica, 42(2), 156.
96. Rugg-Gunn, A. J. (1993). Nutrition, diet and dental public health. Community dental health, 10, 47-47.
97. Schroth, R. J., Rabbani, R., Loewen, G., & Moffatt, M. E. (2016). Vitamin D and dental caries in children. Journal of dental research, 95(2), 173-179.
98. Ahn, J., Yu, K., Stolzenberg-Solomon, R., Simon, K. C., McCullough, M. L., Gallicchio, L., ... & Albanes, D. (2010). Genome-wide association study of circulating vitamin D levels. Human molecular genetics, 19(13), 2739-2745.
99. Wang, T. J., Zhang, F., Richards, J. B., Kestenbaum, B., Van Meurs, J. B., Berry, D., ... & Spector, T. D. (2010). Common genetic determinants of vitamin D insufficiency: a genome-wide association study. The Lancet, 376(9736), 180-188.
100. Johansson, I., Holgerson, P. L., Kressin, N. R., Nunn, M. E., & Tanner, A. C. (2010). Snacking habits and caries in young children. Caries research, 44(5), 421-430.