

Obesity and dental caries in children and adolescents

Abstract

Objectives: To determine relationship between obesity and dental caries in children and adolescents. Additionally, to explore and report the possible explanations and the underlying causes of the association between obesity and dental caries.

Methods: Databases search for recent papers published between January 2015 and August 2017, inclusive, addressing the association between obesity and dental caries was conducted. Review and critical appraisal of all included studies were performed.

Results: Twenty three studies were included in this review from different populations worldwide. Among them, seven studies assessed the primary dentition, another seven studies conducted on permanent dentition, and nine studies on both dentitions. The studies' results regarding the association between obesity and dental caries were conflicting and inconsistent. Eight studies concluded that there was no relationship between obesity and dental caries. The positive association was reported in five studies, while the inverse association was reported in nine studies. The studies included in this review presented wide variations in methodology and the investigated cofactors. The possible explanations of the controversial association between obesity and dental caries were discussed in this review.

Conclusions: Both obesity and dental caries are multifactorial diseases and their association is far more complex than can be explained by a single common risk factor. This review provides additional evidence for the complexity of this association.

Keywords: Obesity; Dental Caries; Children; Adolescents

INTRODUCTION

A state where unusual and extra fat in adipose tissue of a human body is constantly increasing is known as obesity. This condition normally has an adverse effect on the health of a human. Globally this problem is the fifth most important factor leading to transience of life according to the World Health Organization (WHO). Mainly in the developed countries including the developed countries, obesity have been doubled among the population in the last two decades. It does not have only basic effects on the body but also, it leads to several diseases such as hyperlipidemia, cerebrovascular diseases, hypertension and type 2 diabetes. Furthermore it also leads to some types of Cancers. Since the discovery of oil mainly in the gulf region, there has been a vast productive development in the economy of the countries specifically in the late 70s and 80s. This was the first and the foremost step towards the meteoric social and cultural development in the residents which led to disturbing increase in the rate of obesity. although there are many reasons an individual might become obese but here a drastic change in the type and amount of diets people started to have was the main reason behind obesity. On one hand such oil discovery led to a huge positive economic boom and on the other hand it was having an adverse effect on the way of living of the people. Facts and figures we have, related to the routine of food consumption and dieting are

40 available far more comprehensive as compared to the information we have on the
 41 commonness of obesity rate. there has been a noticeable increase in the use of purified food
 42 and animal products and vegetable and fruits are the opportunity cost for such consumptions.
 43 In the last 20 to 30 years, possibly the most important factor that lead to obesity and
 44 chubbiness in the Saudi people is the changes in diet of the people due to the oil discovery
 45 mentioned earlier (Kantovitz, 2016).

46 Almost whole of the world population becomes the victim of Dental caries disease which has
 47 multiple factors. initial factors of this disease are tooth loss and oral pain and specially among
 48 the young generation's health, this disease is considered as one of the most important
 49 problems and is also the most pervasive oral disease. This disease is now under the lights of
 50 the dental health profession nowadays, due to its high chances of people being diseased. This
 51 disease has spread worldwide irrelative to any gender, age group, socio economic status and
 52 any race. The dental health profession opinionates people on having a strict prevention
 53 against this disease as it discomforts people and people are burdened by this disease. After
 54 Cardiovascular disease, these dental diseases are considered to be the most expensive
 55 diseases when have to be cured, in Australia. Further according to the research it absorbs the
 56 6.2% of total expenditure incurred on health, after hospital services which is 39.3%, medical
 57 services 18.7% and medications 14%. Scientific researchers have been conducted which has
 58 led to a development which observes best ways for curing and preventing dental caries
 59 (Pascon, 2013).

60 In the past few decades the rate at which dental caries was spreading among the people has
 61 been declining in the developed countries but, in various developing countries the awareness
 62 among the people which should be spread and addressed is not meeting the requirement
 63 which is vastly affecting the population overall. In developing countries caries has been
 64 spreading uncontrollably due to several reasons including the consumption of sugary food, no
 65 or limited approach towards oral health services, low economic and social status of most of
 66 the population and no protection from salty water (fluoride). furthermore, the people are not
 67 interested to gain awareness regarding such problems as their lifestyle promotes no hygienic
 68 food and environment. Global Goals for Oral Health 2020 awareness program was held by
 69 the World Health Organization, World Dental Federation and The International Association
 70 in 2003 which provided proper counselling to the policy makers and planners on both local
 71 and national levels so that there could be a good level of improvement in oral health sector of
 72 the population (Rontani, 2009).

73 The most important problem that is increasing worldwide is obesity among the young aged
 74 children. This is basically a disorder led by multiple factors including environmental factors
 75 and genetic reasons. The situation among the young children is that of the energy consumed
 76 by the children nowadays and the level of energy used by them and stored by them. This
 77 storage and expenditure of energy and fat ivy the body of younger children is totally
 78 imbalanced. Thus, it leads to excess amount of fat stored in the body of the children as their
 79 physical activities have been reduced due to their more interest and time consumption in
 80 technological products and gadgets (Silve et at, 2013).

Unhealthy oral health is identified by the beginning state of this disease, dental caries which is the most persistent disease among the young generations. the most dominating causes which lead to this disease are constant use of monosaccharide for example, glucose and fructose and also disaccharide (e.g. sucrose). High quantity of sugar intake shows the paucity of relationship between dental caries and BMI which also results in the growth of Dental Caries, preferably than the acknowledgment of dietary fat as an important influencer of obesity(Nighat, 2016).

According to the researches made by different resources it is observed that it has been difficult and a bit complexed to relate obesity and dental caries in children as the studies are of mixed age groups which is obviously be unfair to conclude the statistics of such results as every age group has a unique level of growth and different characteristics in themselves (Chen et al, 2018).

Around more than 50% preschool children experience the disease of dental caries in several countries which shows how common it still is among man childhood diseases. Furthermore, the problem for which the doctors are concerned universally about is that most of the parents whose child is diseased by dental caries ignore its treatment which in long term leads to a negative and declining quality of life and also leads to pain. untreated disease of dental caries leads to have an unfavorable development in young children and their sustenance. prolonging the problems, the health organizations are concerned about is the frequency with which the young children are gaining weight which in short is obesity has been mostly increasing in the developed and industrialized countries where processed foods are more consumed made of oil specifically. This is notified as a global concern (Zhi et al, 2018).

Not only because dental caries and obesity are a huge combined interest for most of the health organizations worldwide, there has also been a growing interest in both of the problems because both of them have similar etiology. It was already proved and agreed by the researchers a long time ago that food, including extrinsic sugars not consisting milk, is of main astrological concern as it helps in the making of the disease dental caries (Ijaz, Croucher&Marinho, 2010).

In recent studies the relationship observed between the disease Dental Caries and adiposity, has always been vague and unclear, with some occurrence of conflicts too. Some take it as a positive whereas; others take it as a negative association between the two. But it seems obvious different reviews have been published based on different ways both are evaluated (Ahmed et al, 2017).

The most common diets that have left its mark over the spreading and vastly increasing obesity are the consumption of the soft drinks and fast-food by almost all type of age groups. On the other hand no exercises and less physical activities due to more technological advancements have provoked the disease of obesity. These soft drinks used by the people worldwide contain a large amount of sugar and the fast-food is all cooked in oil. All these factors combine to create an increment in spreading rate of dental caries and obesity. All these health problems in childhood incline the sickness in the body of adults and leads to deaths before the normal mortality average age. Highly risked factors start to buildup in the

body when growing into an adult lead to diseases such as cancer, orthopedic problems, general poor health, hepatic fatty liver disease, colon, fatty liver, endometrial, cardiovascular and type 2 diabetes etc. according to the study of an Iranian between the age of 7-12 in overweight children, cardiovascular risks start to buildup and increase (Dania, 2013).

A strong relation has been observed between obesity and dental problems as it further leads to caries as discussed above, periodontitis and xerostomia. Highly sugary sources such as fizzy drinks lead to cariogenic potential. Our oral health highly depends on the food and nutrition we have and affects our health generally. World Health Organization has recommended to limit the use of sugar in the food products as well as the drinks to 10% of the total calories in the reaction of the effects observed by the sweetened products to the human body nowadays. A study was done in Scotland where around 150 children were studied, and it was observed that those who were skinny and thin had tooth decay also. Whereas; a study done in Brazil on children aged from 12 to 15 shows that there is no significant link between obesity and dental caries (Rocha et al, 2018).

It is a fact that from age of 2 to 20 the amount of fat in the body changes as the body grows and the rate of change is different in both the genders. When assessment takes place by BMI, such factor of growth of fat in body is highly observed in infants and teenagers as compared to ~~when adults are assessed~~. BMI conducted especially for the children are known as “BMI for age”. Fats in the body are categorized in different age groups including, “underweight”, “normal”, “overweight” and “obese”. But in children which is BMI-for-age does not include “obese” but “at risk of overweight”. Both the dental caries and obesity have become a public problem all around the world. As they are considered as everlasting and highly ramping, they do have multiple factors that increase their conditions. Both have similar conditions when being diagnosed with similar factors shared between both the diseases including factors regarding lifestyle, culture, socioeconomic. Further both of them also have significant biological and genetic factors (Cinar&Murtomaa, 2009).

These are the reasons which prove there is some sense behind the correlation between dental caries and obesity. Studying this relation might lead to the discovery of preventive measures that could be spread publically to reduce and prevent from both.

In every country studies regarding the relation of dental caries and obesity have been carried and done differently and among different group ages also. A wide range of data has been collected which makes it even more difficult for the research groups to finalize and conclude the data as there are many conflicts between the results. Some reported to have given positive results regarding their relation while the other reports gave no positivity regarding the correlation of obesity of dental caries (Giselle et al, 2011).

Different reviews were published between the year 2012 and 2013, which stated different reviews regarding the relation of dental caries and obesity. It was agreed that no specifically single conclusion would be announced or released by the publishers and more detailed studies should be done.

A well-managed and an efficient review was conducted again in 2015, over several countries but unfortunately it was found out that concluding this matter of relation between obesity and

dental caries is not possible as this time too varied results were published by the research groups. Incongruities of types of measurements and settings that have been made by the different groups have led to these uneven results (Honne et al, 2011).

Aims

The main objective to conduct this review is to find out and approve the relation between dental caries and obesity that was released as the result of several studies conducted before. Furthermore, as the relation has been found between the two, the main objective of this review is to make the causes and reasons more concrete to an extent that it can be published as an approved report.

Materials and Methods

Research was conducted which was published in the papers in 2015 and 2017, of Science direct, Google Scholar, Medline/PubMed and Scopus. Every identified paper was there which had lists of references, those lists were added and improvised by the study team themselves by manual searching. Thus, the main items searched were Dental caries and Obesity. The reports that were made after study were properly described in English language and stated the relation between obesity and dental caries in teenagers and ~~as well as~~ young children. Critical analysis was made on the respective reports.

Statistical analyses

There were different statistics used in these included studies using correlation and regression to investigate the association between obesity and dental caries. Some studies used Pearson's correlation, while others used Spearman's correlation multiple linear regression ~~was employed by some of the studies,~~ while others used Poisson's regression, or logistic regression model. Careful consideration and selection of statistical tests are mandatory to reach a reliable result.

Moreover, both clinical significance and statistical significance should be interpreted carefully. The results of two studies, showed an inverse association between obesity and dental caries, but not statistically significant, thus reached a conclusion of lack of the association. On the contrary, Kottayi et al., reported a positive association between both conditions, which was not statistically significant, led to a conclusion of no association.

Sample size

Disparity of sample size was clear among included studies. The sample size ranged from 100 to 32461 among the 23 studies included, and the median sample size was 433. The majority of sample sizes were less than 1,000 (18/23). Increasing the sample size was recommended by most of the studies, especially to overcome the effect of dividing BMI scores into sub-groups. The technique used in all included studies for diagnosis of dental caries was the direct visual oral examination with no radiograph taken. This caries detection technique would result in underestimation of dental caries prevalence. Another concern is related to the caries indices used in these studies, and the different diagnostic criteria employed.

Most studies used decayed, missing due to caries, filled teeth indices for primary and permanent dentitions (dmft/DMFT) according to the World Health Organization (WHO) criteria. According to the WHO criteria, only the cavitation is inspected and recorded as carious lesion, and the non-cavitation carious lesions are not included. One study used both DMFT and decayed, missing due to caries, filled, surfaces (DMFS). On the other hand, El Qomsan et al., reported the (DFT) of the permanent dentition, and Aluckal et al., measured the (dft) of the primary dentition, where both studies did not include the missing due to caries teeth (mt/MT), hence would alter their results.

The American Academy of Pediatric Dentistry criteria was used to record the severe early childhood caries in children participated in a study by Davidson et al. This criterion includes non-cavitation lesions in the definition of dental caries in young children. The International Caries Detection and Assessment System (ICDAS-II) is used to examine cavitation caries and early enamel caries, and was employed by some of the included studies.

The National Institute of Dental Research (NIDR) criteria employed by Farsi et al., and Elkhodary et al., is an old caries scoring system, which was last updated in 1991, and it is considered as an intentionally conservative system, with only clearly cavitation to be recorded as carious lesion. Studies using different criteria would result in different caries prevalence rates which would alter the results and thus, the relationship with obesity. The analyzed dentition was vary between studies regardless of the target age, especially in the mixed dentition ages. The inclusion of both primary and permanent dentitions at different ages could have skewed the caries prevalence and affected the association between obesity and dental caries.

Anthropometric measures previous studies had various methods of assessing obesity and anthropometric measures. The majority of the previous studies assessed the obesity depended on Body Mass Index (BMI), and did not report other anthropometric outcomes. Additionally, different BMI indices and growth references have been applied in these studies.

Some studies relied on the recommended age and gender specific World Health Organization (WHO) growth references that was expressed as z-score, and categorized into four subgroups as underweight, normal, overweight, and obese. The BMI for Age and gender percentile according to the Centers for Disease Control and Prevention (CDC) was employed by some of the studies. Percentiles are derived from corresponding age and gender adjusted z-scores, and categorized into four subgroups as underweight, normal, risk of overweight, and overweight.

On the other hand, other studies employed the international BMI index recommended by the World Obesity/Policy & Prevention (formerly International Obesity Task Force; IOTF), with only two categories as 'no overweight' and 'overweight'. The age and gender specific international BMI criteria (iso-BMI) is based on IOTF, and have the similar four categories as the WHO criteria. This criteria was applied by Qadri et al.

Moreover, Davidson et al., used both WHO and CDC criteria, and Liang et al., applied all the three criteria; WHO, CDC, and IOTF. The different references that had been applied in these studies might altered the findings and comparison of their results should be made with

caution. Interestingly, a systematic review showed a significant association between obesity and dental caries when the BMI for age and gender percentile (CDC) were reported and non-significant results when z-scores (WHO) were reported.

The BMI thresholds in the included studies were based on different growth and development charts between different countries. For instance, Liang et al., used a Chinese chart, Farsi et al., used a Saudi chart, and Kumar et al., used an Indian growth chart. Consequently, the different classification criteria produce different groups. Furthermore, the methodology for BMI grouping and distribution among the studies were **inconstant**. It is recommended to distribute samples into the full range of BMI categories, for the normality of distribution. While, Americh-Torres et al., grouped the participants into three categories (normal weight, overweight, and obese), Soares et al., combined the overweight and obese groups together, resulted in three groups as underweight, normal and overweight/obesity. Although BMI is an effective screening tool, there is a growing concern on the accuracy of using BMI to precisely detect obesity. As BMI is calculated using the height and weight, these change widely during growth especially for children. Additionally, it has comparative limitations due to inherent differences in body fat percentage between male and female.

Because of the limitations of BMI, some studies evaluated obesity using other diagnostic techniques or a combination of them. Waist circumferences were reported in two of the included studies, as a supplement to the BMI measured **according** CDC percentiles. The longitudinal study by Li et al., in addition **the** BMI, ~~they~~ recorded waist circumferences, waist-to-hip ratio, waist-to-height ratio, and skin fold thickness. These techniques are more precise, accurate and reliable tools.

Confounding factors

Previous studies were conducted in different developed and developing countries. Different communities have different cultures and dietary structures. Also, the different dental and health services and facilities including proper health education and dietary counseling, can alter this relationship. The samples used in some studies included children and adolescents from different social and ethnic backgrounds.

Additionally, it was **noted a wide variation** between the studies regarding the assessment and control of potential confounding factors. These **factors related** to age, gender, life styles, dietary habits, oral hygiene, socioeconomic status, race/ethnicity, physical activity level, and even type of schools. Each study controlled few of these confounding factors, but other potential confounding factors were not assessed. All of these uncontrolled confounders could have biased the results. The challenge in exploring the association lies in measuring possible confounding factors. Future researches should incorporate validated measures of these potential confounding factors to better understand this association.

Results

From around the world twenty-three studies were performed by the teams and were also reviewed. In table 1 summary of those studies has been provided.

Among those twenty-three studies, primary dentition and permanent dentitions were assessed in seven studies each. Whereas, the rest nine studies were made on both the dentitions.

Results of those studies were still not specific to the extent of result and were inconsistent. Eight out of those total studies stated that no significant relation has been found between dental caries and Obesity. While five stated that there is a positive correlation between the two, and nine reported that there is an inverse association.

One stimulating thing in these studies was that only one studies out of the total stated that dental caries is more than obesity in underweight children as well as obese children. That is a positive association in the two directions.

Almost all the studies were made on a specific age groups and only three were made on a different age groups, which were made on permanent dentition and ~~resulted to have~~ stated positive relation. A single study was designed for a specific case and was performed on primary dentition which also resulted in positive association. ~~For defining obesity levels.~~

The inconsistent associations reported between obesity and dental caries could be due to methodologic limitations. This discrepancy may have been due to differences in the study designs. The majority of the included studies were cross-sectional studies. Cross-sectional studies have a potential limitation which is that definitive information about cause and effect relationships cannot be determined. These type of studies cannot identify risk factors and often miss many of the confounding factors that influence a particular problem over time. When studying chronic diseases such as obesity and dental caries. Distinguishing between the contributions of a confounding factor in an observational study is difficult.

For future researches, longitudinal studies are necessary to determine whether there is a cause and effect relationship between obesity and dental caries, and will be helpful in understanding and determining the course, mechanism and consequences of this association. Longitudinal studies would benefit from adequate adjustment for confounding variables and from the use of continuous outcomes. Thus, may be more effective in developing a more realistic model for predicting such chronic conditions. The relationship between obesity and dental caries in children and adolescents is far more complex than can be explained by a particular risk factor.

Limitations and future considerations

The heterogeneities between studies and the inconsistent associations could be due to methodologic limitations, and might be attributed to the following. The differences among the reports might be related to diversity of the study subjects' age. While some studies investigated the association between obesity and dental caries in narrow or wide age ranges, one study investigated children in a single age group (8 years old). The widest age range among the included studies was noted in da Silva et al., who included 3 to 15 years old participants. It is possible that caries is an age related cumulative condition and thus older group is more likely to exhibit higher prevalence of dental caries. However, in younger age children, dental caries values may decrease with increasing age as a result of primary teeth exfoliation (Wakaguri et al, 2011).

Furthermore, the relatively wide age range, may exhibit entirely different dietary habits and lifestyles. Children and adolescents become more independent in food choice with increasing ~~their~~ age, thus influencing the dietary factors in regard to this association. Older children who are overweight or obese often have dietary lifestyles involving frequent eating and so are more likely to experience dental caries ~~as a result~~. The gender differences may be attributed to the difference in the diet and eating pattern, physical activity, as well as the difference in the time of tooth eruption in both genders (Bowler et al, 2013).

Moreover, the gender differences in the amount of body **fat due** to differences in the growth milestones, body structure and hormonal effects. These may influence the prevalence of obesity and dental caries, and thus their correlation. The majority of the included studies attempted similar distribution between male and female participants in their samples. However, **Bhayat et al.**, studied the association between obesity and dental caries on a sample **comprised only** boys. While some studies reported more dental caries in boys, Quadri et al. had found more dental caries in girls. In contrast, some studies had reached a conclusion of no difference in dental caries between both genders. With regard to obesity, girls were likely to have higher obesity prevalence. As a consequence, the similar gender distribution is important ~~to consider~~ to avoid any misleading conclusions (Dongru et al, 2018).

DISCUSSION

A latest study held in Sweden showed that there is a good relation between the dental caries and BMI as it showed that children of young age having more snacks have a risk of dental caries at a young age. Our research was conducted over the adult population in Saudi Arabia, and it was observed that besides oily food and sugary drinks, smoking has also high risk factor of dental caries. Thus, a positive correlation was found between commonness and BMI. To the extent of our knowledge we only have one productive and proper way of reviewing the relation between dental caries and obesity. This review **consists** of seven studies ~~made and~~ published till the early 2000s. ~~among~~ those seven, five of them only had a pediatric sample. In a sample of around 800 children aged from 6 to 11 years, positivity was found between BMI and dental caries. But when a study was ~~made~~ on 3000 infants, of around 3yr old, no connection was found. Whereas, the third research made on 500 children aged between 5 to 13 years couldn't find any prediction on future dental caries. After this research was published, till today there has been almost no evaluation or study made on the relation of dental caries and BMI in all over Saudi Arabia and specifically in the city of Tail (Nahan, 2011).

Nutritive consumption habits do play a vital role to increase obesity in the body and symptoms of dental caries. There has been difference in the pattern in today's eating patterns of the people as compared to before where people are now consuming more sugary soft drinks and fast foods have now increased the danger of obesity and dental caries. As it has been proved with evidences that both the obesity and dental caries are greatly correlated with the dietary plans an individual observes during his life which has changed now with time and thus, is acceptable to observe such disease and its links biologically. Children nowadays, while using gadgets and watching TV tend to eat more snacks and other food that are high on oil and sugar which doesn't only increase the level of calorie they take but also leads to tooth

decay with time. Tooth decay ~~in~~ specifically increases in young age ~~is~~ because the contact of food with teeth is more frequent and its durability is more (Ligeng et al, 2013).

It is observed that the mean DFT indices in the overweighed children are much more than in the normal weighted children. Conjecturing that the dental caries would be associated with the increased rate of dental caries, it was almost impossible to find any relation between BMI-for-age and DFT indices ($R < 0.07$). Dental caries cannot be stated a disease solely dependent on the nutrition as it does not consist of a single factor. Its factors can be saliva, oral flora, oral hygiene and available nutrients. BMI index and dft score was examined by Chen et al among the 3 year old children. Their results were a bit different to what others observed as they say that there is no figurative difference between dft score among the different BMI children. Further they stated that there is no correlation between such decayed teeth and over weighed children. Kantovitz et al is said to have stated in an organized review that only a single study with high level of evidence disclosed the direct relation between dental caries and obesity. Macek&Mitola are also stated to have determined that according to their calculations and observations, there is no relation between BMI-for-age and dental caries frequency for the children who had a good history of their teeth conditions and children who are weighty. It is observed that the children who are overweight from the age of 6 to 17 do not have rigorousness in their dental caries as compared to those who have a normal BMI-for-age (Mahvi et al, 2017).

Obviously it is not possible that such studies bring the same outcomes, thus the consequences of this study also have some divergence to others studies done earlier. Hilgers et al found out that with increasing BMI, the average rate of caries in lasting molars also rises. They also stated that increased case of permanent molar interproximal caries also is related with the accumulating BMI. It was reported by Burt and Pay that children with normal or overweight birth do not have much higher rate of having dental caries as compared to the children who are born underweight in their primary dentition. Such occurrence of dental caries as mentioned by them is because of the social factors the children are deprived of when their primary dentition is developing. Willerhausen et al made a study in Germany on over a thousand children in different schools and found out that the correlation between dental caries and obesity in children is very weak. One more study states that there is a strong relation between the rate of recurrence of caries and BMI even after the adjustment of the age of children. An experiment was held on over 500 children from the age of when they are born to the age of 12 and weighted them to predict their experience of caries (DMFT/daft). The observes stated that obesity cannot be a good indicator to predict the caries in a child (Liang et al, 2008).

Today's study shows a considerable connection between caries free ($P = 0.0001$) and BMI-for-age. It is considerably linked with the results of Willerhausen et al who stated that the number of healthy teeth decreases along with the increasing age and BMI. Specialists in Sweden observed and studied about the relation between the factors that would lead to atherosclerosis and dental caries. Further they concluded that caries free children have comparatively lower BMI-for-age values to those have higher DMFT score of greater than 9 (Hooley et al, 2012).

According to Glik, although obesity would indirectly affect the oral conditions, it cannot be solely justified to be the main factor and to get concerned. This should be our strong and honest desire and willingness to make a positive difference on the general health of the patient. Such conflicts in different studies shows that more observations should be made and facts should be collected with pure results to find out a perfect result that whether there is any correlation between dental caries and BMI for age or not. Certain protective measures are to be found against the dental caries specifically o overweight children. Proper strategies should be made and published in future preventive programs when conducted for diet and nutrition control to avoid obesity and also dental caries (Dean et al, 1992).

With low evidence, it can be obvious that more studies on obesity and dental caries association tend to show that young children with dental caries in the primary dentition are underweight compared to children without caries; an inverse association. Older children and adolescents who are obese are more likely to have dental caries in their permanent teeth; a positive association. However, the contradictory conclusions were reported in other investigations.

Multiple studies have demonstrated that both conditions share common risk factors, which would support a positive association. The possible explanations of this positive association is summarized in the following points. The role of diet is significant in the development of both conditions. Both obesity and dental caries share some common risk factors related to diet which influence the incidence of both obesity and dental caries. These diet factors include poor food choices, dietary habits, frequency and high consumption of fermentable carbohydrates, consumption of sweetened junk foods and highly caloric and cariogenic diets. Some studies have highly supported that frequent and excessive intake of fermentable sugars is the critical shared predisposing factor of both obesity and dental caries (Kim et al, 2016).

Obesity may make changes in the body system so, increase the dental caries. The association between different biological indicators of obesity and dental caries had been investigated. Lower stimulated salivary secretion rates, a higher concentrations of secretory immunoglobulin, and different oral microbial profiles were reported in the obesity group. Some authors suggest that obesity may lead to changes in concentrations of free sialic acid, total protein, and phosphate as well as peroxidase activity in stimulated saliva, which may promote dental caries. However, there was inability to confirm whether the association is due to systemic changes or due to possible other factors such as diet and oral hygiene habits (Ismail et al, 1987).

Some studies supported that the positive association between obesity and dental caries was because of other shared contributing factors such as life style issues. Life style issues that might be responsible for occurrence of both obesity and dental caries included changes in physical activity and food characters with more snacks and increased time spent on TV and new multimedia technologies. Additionally, it was reported that both conditions were more in some specific communities because of unhealthy food, less parents' education and inability to obtain sufficient health care and services. In contrast to the studies reported a positive association between obesity and dental caries, a number of studies had shown an inverse

association and that more caries experience was associated with being underweight, Table 1. Some theories may explain this inverse relationship (Bruce et al, 2004).

Although sugar is one accepted risk factor for both obesity and dental caries, the inverse relationship may be attributed to the dietary patterns. Obese children and adolescents might consume more fatty foods, fried foods, and unrefined carbohydrates, but not necessarily more foods high in sugar and refined carbohydrates. This could increase the obesity but not necessarily have a direct link to dental caries (Thylstrup&Poulsen, 1976).

Additionally, some studies have suggested that dental caries is associated with poor nutrition. Nutrients such as vitamins A and D, calcium and phosphate have an effect on the morphology, chemical composition and tooth eruption patterns, which in turn determine the susceptibility of teeth to dental caries. Another explanation for the inverse association might be that children with untreated caries may experience pain and infection, thus preventing them from consuming adequate nutrition, and can affect their quality of life including ability to sleep, which in turn may lead to malnutrition and growth impairment. It was reported in the literature, that underweight children gained more weight after receiving dental treatment (Nur, 2014).

However, this possible explanation is more apparent in populations with high proportion of severe and untreated dental caries. Saliva production another possible explanation is that saliva production increases due to increased food consumption in obese groups. The protective effect of saliva as a mechanical cleanser, and buffering the low pH and hence reducing the incidence of dental caries. Another possible indirect link, is the compromised immune system due to either dental caries and chronic dental infection, or malnutrition and impaired growth in underweight children. Infected dental pulp may affect immunity and erythropoiesis, which may result in anemia, and influence sleep pattern and food intake due to pain and infection, which may lead to impairment of growth hormone secretion (Masami, 1991).

Many authors suggested that both underweight and caries are due to poverty and low socioeconomic status. Also, families with obese children may take greater care of their children's diet and provide them with less sweets and desserts, resulting in low caries prevalence. Some investigators had found no correlation between obesity and dental caries. The following could be possible explanation for the lack of association between both conditions. Both obesity and dental caries are multifactorial in etiology and various genetic and environmental factors have an impact on them. Thus, due to the many confounding factors in addition to age, gender, and life style, these might affect the final conclusion (Mei et al, 2017).

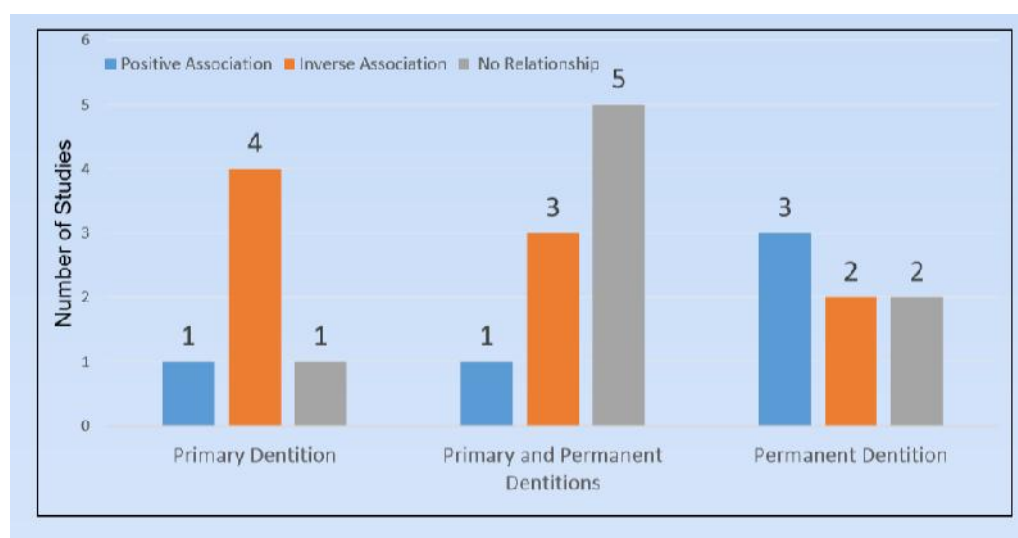
Dietary factors, oral hygiene practice and socioeconomic status are more responsible factors for dental caries than obesity. As stated previously, obesity can be due to an increased intake of dietary fats, which has less influence on the development of dental caries than a diet high in sugar. Where proper oral hygiene is maintained with proper fluoride exposure, dental caries prevalence has decreased despite increases in sugar consumption (Zhang et al, 2017).

Table 1: Summary of the included studies.

Investigated dentition	Association between obesity and dental caries			
	Author [Country, Sample size, Age]			
	Positive	Inverse	No relationship	Positive in two directions
Primary	Davidson <i>et al</i> 2016 [Canada, 235, 2 to 6]*	Soares <i>et al</i> 2017 [Brazil, 285, 3 to 5] Elkhodary <i>et al</i> 2017 [KSA, 820, 3 to 6] Bafli <i>et al</i> 2015 [Iran, 1482, 3 to 6] Liang <i>et al</i> 2016 [China, 32461, 7 to 9]	de Jong-Lenters <i>et al</i> 2015 [Netherlands, 230, 5 to 8]	Aluckal <i>et al</i> 2016 [India, 433, 2 to 6]
Primary and permanent	El Qomshan <i>et al</i> 2017 [KSA, 386, 6 to 12]	Quadri <i>et al</i> 2017 [KSA, 360, 6 to 15] Farsi <i>et al</i> 2016 [KSA, 915, 7 to 10] Yang <i>et al</i> 2015 [China, 744, 8 to 8.5]	Mitrakul <i>et al</i> 2016 [Thailand, 100, 6 to 12] da Silva <i>et al</i> 2016 [Brazil, 237, 3 to 15] Araujo <i>et al</i> 2016 [Brazil, 313, 8 to 10] Münevveroglu <i>et al</i> 2017 [Turkey, 856, 6 to 12] Almerich-Torres <i>et al</i> 2016 [Spain, 1326, 6/12/15]	-
Permanent	Li <i>et al</i> 2017 [Hong Kong, 282, 12/15/18]** Qadri <i>et al</i> 2015 [Germany, 694, 9 to 12]** Basha <i>et al</i> 2017 [India, 785, 13 +3years]**	Bhayat <i>et al</i> 2016 [KSA, 402, 12 to 14] Chauhan <i>et al</i> 2016 [India, 275, 6 to 15]	Kottayi <i>et al</i> 2016 [India, 2000, 12 to 15] Kumar <i>et al</i> 2017 [India, 1092, 11 to 14]	-

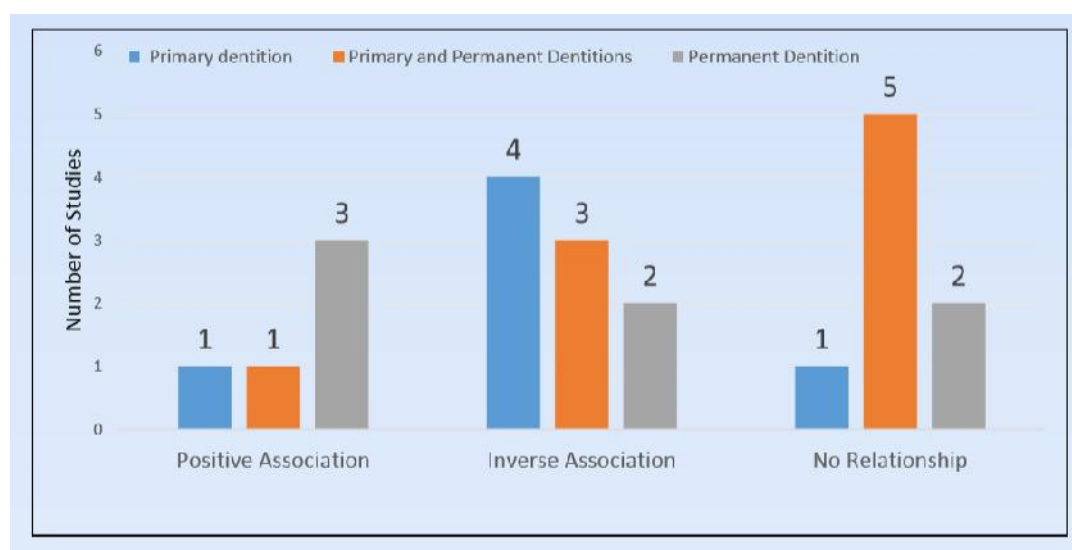
* Case-control study. ** Longitudinal study.

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Conclusion

Both obesity and dental caries are multifactorial diseases and it is complex to assess all the associated risk factors simultaneously. The association is far more complex than can be explained by diet habits alone or a single common risk factor. Presence of multiple confounding factors resulted in an inability to express a firm opinion regarding the association. This review provides additional evidence for the complexity of this association (Gibson et al, 2000).

REFERENCES

Ahmed, S., Sudhir, K., Reddy, V., Kumar, R. and Srinivasulu, G. (2017). Green Tea in the Prevention of Dental Caries-A Systematic Review. *International Archives of BioMedical and Clinical Research*, 3(1).

Al Agili, D. (2013). A systematic review of population-based dental caries studies among children in Saudi Arabia. *The Saudi Dental Journal*, 25(1), pp.3-11.

Chen, D., Zhi, Q., Zhou, Y., Tao, Y., Wu, L. and Lin, H. (2018). Association between Dental Caries and BMI in Children: A Systematic Review and Meta-Analysis. *Caries Research*, pp.230-245.

~~Chen, D., Zhi, Q., Zhou, Y., Tao, Y., Wu, L. and Lin, H. (2018). Association between Dental Caries and BMI in Children: A Systematic Review and Meta-Analysis. *Caries Research*, pp.230-245.~~

Childhood dental caries and obesity. (2009). *Dental Abstracts*, 54(3), p.159.

Cinar, A. and Murtomaa, H. (2009). A holistic food labelling strategy for preventing obesity and dental caries. *Obesity Reviews*, 10(3), pp.357-361.

Correlation of Obesity and Dental Caries. (2016). *International Journal of Science and Research (IJSR)*, 5(6), pp.273-274.

D'MELLO, G., CHIA, L., HAMILTON, S., THOMSON, W. and DRUMMON, B. (2011). Childhood obesity and dental caries among paediatric dental clinic attenders. *International Journal of Paediatric Dentistry*, 21(3), pp.217-222.

Honne, T., Pentapati, K., Kumar, N. and Acharya, S. (2011). Relationship between obesity/overweight status, sugar consumption and dental caries among adolescents in South India. *International Journal of Dental Hygiene*, 10(4), pp.240-244.

Ijaz, S., Croucher, R. and Marinho, V. (2010). Systematic Reviews of Topical Fluorides for Dental Caries: A Review of Reporting Practice. *Caries Research*, 44(6), pp.579-592.

- 522 K, N. (2016). Herbs and Dental Caries- A Review. *Journal of Medical Science And clinical*
523 *Research*.
- 524 Nisar, N. (2015). Role of Mothers in Prevention of Dental Caries: A Systematic Review.
525 *Journal of Dental Health, Oral Disorders & Therapy*, (3).
- 526 Obesity and dental caries in children: a systematic review and meta-analysis. (2013). *British*
527 *Dental Journal*, 214(3), pp.113-113.
- 528 Rocha, J., Arima, L., Werneck, R., Moysés, S. and Baldani, M. (2018). Determinants of
529 Dental Care Attendance during Pregnancy: A Systematic Review. *Caries Research*, 52(1-2),
530 pp.139-152.
- 531 Silva, A., Menezes, A., Demarco, F., Vargas-Ferreira, F. and Peres, M. (2013). Obesity and
532 dental caries: systematic review. *Revista de Saúde Pública*, 47(4), pp.799-812.
- 533 Dean, H., Jr., F. and Elvove, E. (1942). Domestic Water and Dental Caries: V. Additional
534 Studies of the Relation of Fluoride Domestic Waters to Dental Caries Experience in 4,425
535 White Children, Aged 12 to 14 Years, of 13 Cities in 4 States. *Public Health Reports (1896-*
536 *1970)*, 57(32), p.1155.
- 537 DYE, B., SHENKIN, J., OGDEN, C., MARSHALL, T., LEVY, S. and KANELIS, M.
538 (2004). The relationship between healthful eating practices and dental caries in children aged
539 2–5 years in the United States, 1988–1994. *The Journal of the American Dental Association*,
540 135(1), pp.55-66.
- 541 Gibson, S. (2000). Breakfast cereal consumption in young children: associations with non-
542 milk extrinsic sugars and caries experience: further analysis of data from the UK National
543 Diet and Nutrition Survey of children aged 1.5–4.5 years. *Public Health Nutrition*, 3(02).
- 544 Hong, L., Ahmed, A., McCunniff, M., Overman, P. and Mathew, M. (2008). Obesity and
545 Dental Caries in Children Aged 2-6 Years in the United States: National Health and Nutrition
546 Examination Survey 1999-2002. *Journal of Public Health Dentistry*, 68(4), pp.227-233.
- 547 Hooley, M., Skouteris, H. and Millar, L. (2012). The relationship between childhood weight,
548 dental caries and eating practices in children aged 4-8 years in Australia, 2004-2008.
549 *Pediatric Obesity*, 7(6), pp.461-470.
- 550 Ismail, A., Burt, B. and Brunelle, J. (1987). Prevalence of dental caries and periodontal
551 disease in Mexican American children aged 5 to 17 years: results from southwestern
552 HHANES, 1982-83. National Health and Nutrition Examination Survey. *American Journal of*
553 *Public Health*, 77(8), pp.967-970.
- 554 Kim, J., Choi, Y., Park, S., Kim, J., Lee, T., Cho, K. and Park, E. (2016). Disparities in the
555 experience and treatment of dental caries among children aged 9–18 years: the cross-sectional

- 556 study of Korean National Health and Nutrition Examination Survey (2012–2013).
557 *International Journal for Equity in Health*, 1(1).
- 558 Lin, M., Zhang, X., Holt, J., Robison, V., Li, C. and Griffin, S. (2017). Multilevel model to
559 estimate county-level untreated dental caries among US children aged 6–9 years using the
560 National Health and Nutrition Examination Survey. *Preventive Medicine*.
- 561 ~~Lin, M., Zhang, X., Holt, J., Robison, V., Li, C. and Griffin, S. (2017). Multilevel model to~~
562 ~~estimate county level untreated dental caries among US children aged 6–9 years using the~~
563 ~~National Health and Nutrition Examination Survey. *Preventive Medicine*.~~
- 564 Mahvi, A., Goodarzi, F., Hosseini, M., Nodehi, R., Kharazifard, M. and Parvizishad, M.
565 (2017). Prevalence of dental caries and fluoride concentration of drinking water: A
566 systematic review. *Dental Research Journal*, 14(3), p.163.
- 567 Thylstrup, A. and Poulsen, S. (1976). Dental caries in Faeroese children aged 5-13 years.
568 *Community Dentistry and Oral Epidemiology*, 4(3), pp.115-120.
- 569 Wakaguri, S., Aida, J., Osaka, K., Morita, M. and Ando, Y. (2011). Association between
570 Caregiver Behaviours to Prevent Vertical Transmission and Dental Caries in Their 3-Year-
571 Old Children. *Caries Research*, 45(3), pp.281-286.
- 572 Widayati, N. (2014). Factors associated with dental caries in children aged 4-6 years old.
573 *Jurnal Berkala Epidemiologi*, 2(2), p.196.
- 574 Wu, L., Chang, R., Mu, Y., Deng, X., Wu, F., Zhang, S. and Zhou, D. (2013). Association
575 between Obesity and Dental Caries in Chinese Children. *Caries Research*, 47(2), pp.171-176.
- 576 YONEMITSU, M. (1991). A comparative study of caries experience among Scottish,
577 Nigerian and Japanese children aged 5 years. *JOURNAL OF DENTAL HEALTH*, 41(2),
578 pp.231-233.
- 579 Chen, D., Zhi, Q., Zhou, Y., Tao, Y., Wu, L. and Lin, H. (2018). Association between Dental
580 Caries and BMI in Children: A Systematic Review and Meta-Analysis. *Caries Research*,
581 pp.230-245.
- 582 Obesity and dental caries in children: a systematic review and meta-analysis. (2013). *British*
583 *Dental Journal*, 214(3), pp.113-113.