ORIGINAL RESEARCH

Excess Weight and Dental Caries throughout Childhood and Adolescence: Systematic Review of Longitudinal Studies

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Abstract

Objective: The aim of the present study was to analyze existing scientific evidence on the longitudinal association between overweight/obesity and dental caries in children and adolescents and indicate possible gaps in the literature to guide future studies.

Study design: A systematic search of the literature was performed for the identification of longitudinal studies on this issue. The search strategy included words related to the outcome (dental caries), exposure (overweight/obesity), population (children and adolescents), and study design (longitudinal) of interest. Searches were performed in the PubMed, Web of Science, and Latin American and Caribbean Health Sciences Literature (LILACS) databases. The risk of bias in the studies was appraised using the tool for the critical analysis of cohort studies proposed by the Joanna Briggs Institute.

Results: Among the 400 studies retrieved from the databases, only seven met the inclusion criteria and were selected to compose the present review. Five of the studies had a low risk of bias, but all had methodological flaws. As the studies reported different findings, the association between obesity and dental caries continues to be undefined. Moreover, there is a lack of well-designed studies on this issue with standardized methods to enable comparisons.

Conclusion: Future studies should consider longitudinal designs, more precise diagnostic methods for obesity and dental caries, as well as the rigorous control of confounding factors and effect modifiers.

Keywords: Adolescent, Child, Dental caries, Longitudinal studies, Obesity.

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Introduction

Obesity and dental caries are important public health problems. Both conditions are higher prevalent, have a multifactor etiology, and exert significant, lasting impacts on the lives of children and adolescents.[1,2]

According to the Global Burden of Disease Study conducted in 2016, oral problems affect 3.5 billion people, and untreated dental caries is among the most prevalent noncommunicable diseases.[3] There is also a growing number of young individuals with excess weight. According to estimates from the World Health Organization (WHO), >340 million children and adolescents from 5 to 19 years of age were overweight or obese in 2016. The prevalence of overweight and obesity in this age group increased dramatically from 4% in 1975 to >18% in 2016.[4]

Dental caries and excess weight share common risk factors, including behavioral and socioeconomic characteristics. The high consumption of fermentable carbohydrates is a characteristic of the diet of individuals with overweight/obesity and an etiological factor of dental caries. Socioeconomic aspects affect the quality of foods consumed and therefore exert an influence on the development of both obesity and dental caries.[5]

Although widely discussed in the literature, the association between obesity and the occurrence of caries is not well established. Recent systematic reviews point to the inconsistency of the results found in existing studies[6,7] and the need for well-designed investigations with robust statistical models involving ample control of possible confounding factors.[8] There is also a need for longitudinal studies to examine the association between these variables throughout life,[7] as such studies are fundamental to the inference of causality.

To the best of our knowledge, only one systematic review of longitudinal studies analyzed the association between anthropometric measures and dental caries.[9] The authors found that the evidence is conflicting and remains inconclusive. However, the study included studies published up to February 2014, and diverse anthropometric measures were considered, which were not necessarily related to excess weight.

The clarification of the association between obesity and dental caries could contribute to the development of public policies directed at the prevention of both conditions, especially in children and adolescents, as health behaviors and risk behaviors acquired in childhood and adolescence tend to be perpetuated in adulthood and have consequences for the quality of life.[10]

Therefore, the present study aimed to analyze existing scientific evidence on the longitudinal association between

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overweight/obesity and dental caries in children and adolescents and indicate possible gaps in the literature to guide the conduction of future studies.

Materials and Methods

The present literature review was conducted to answer the following question: "Is there scientific evidence of the association between overweight/obesity and dental caries in children and adolescents over time?"

The search strategy involved words related to the outcome (dental caries), exposure (overweight/obesity), population (children and adolescents), and study design (longitudinal) of interest. Searches were performed in the PubMed, Web of Science, and LILACS databases in June 2020. The search key is displayed in Table 1.

The article selection process was conducted by two independent reviewers based on the previously determined inclusion and exclusion criteria (Table 2). The first step consisted of a reading of the titles identified in the databases. The second step was the reading of the abstracts of potentially eligible articles, and the third step was the full-text analysis of the articles selected in the previous stage. Cases of a divergence of opinion between the reviewers were decided by consensus with the participation of a third reviewer.

The risk of bias in the studies selected was appraised using the tool for the critical analysis of cohort studies proposed by the Joanna Briggs Institute, Adelaide, Australia.[11] Two reviewers independently appraised each study considering the domains that compose this analysis tool. Cases of a divergence of opinion between the reviewers were discussed. If a consensus was not reached, a third reviewer was consulted to make the final decision. The risk of bias was classified as high, moderate, or low, depending on the percentage of positive answers to the questions on the assessment tool. Studies that obtained up to 49% of "yes" answers were considered to have a high risk of bias, those with 50–69% "yes" answers were considered to have moderate risk, and those with a 70% or higher rate of "yes" answers were considered to have a low risk of bias.

The following information was extracted from the studies selected for the present review: author, year of publication, country, sample size, the age range of the participants, the measure of overweight/obesity, criteria for diagnosis of overweight/obesity, the measure of dental caries, criteria for diagnosis of dental caries, adjustment for confounding factors, variables considered confounding factors, main results, and classification of the risk of bias.

Results

The searches of the databases led to the retrieval of 465 records: 374 in PubMed, 88 in Web of Science, and three in LILACS. After the removal of duplicates, 400 studies were submitted to analysis, 358 of which were excluded based on the title, 24 were excluded after the reading of the abstracts, and 11 were excluded after the full-text analysis. Thus, seven articles met the inclusion criteria and composed the present systematic review. The reference lists of the seven articles were hand-searched in an attempt to locate relevant articles that were not identified in the databases, but no additional studies were found that could be included in the review. The flowchart of the article selection process and the reasons for exclusion are displayed in Flowchart 1. A summary of the characteristics of the studies is presented in Table 3.

The seven studies were conducted in different countries: two in Brazil and one each in China, Chile, Australia, Sweden, and Mexico. All articles were published between 2010 and 2019. In six of the seven studies, the sample was composed of children and adolescents between 12 months and 18 years of age. In one study, the follow-up was extended to 20 years of age.[12] The studies had two to four follow-up evaluations, and the sample size ranged from 88 to 4,149 individuals.

Dental caries was the main outcome in all studies. Regarding the type of instrument used to measure the presence of caries, six studies used widely known indices—decayed, missing, and filled teeth (dmft/DMFT) index, decayed, missing, and filled surfaces (dmfs/DMFS), decayed, extraction indicated, and filled teeth (deft) index, and decayed, extraction indicated, and filled surfaces (defs).[12–17] One study used reported dental caries experience.[18] Regarding the diagnosis of caries, four studies used the WHO criteria,[14–17] one failed to describe the criteria used,[13] one used the criteria of the authors of the study, which involved clinical and radiographic exams,[12] and one did not use established criteria, as data on dental caries were collected based on reports by the participants.[18]

The main exposure was overweight/obesity in all seven studies. The body mass index (BMI) was the main anthropometric measure used to determine the nutritional status of the individuals–mentioned in six studies. One study failed to indicate the parameter used in the analysis.[16] Besides BMI, one study evaluated waist circumference;[18] one study evaluated waist circumference, waist/hip ratio, waist/height ratio, and thickness of the triceps skinfold;[14] and one study used the *Z*-score of weight for age at one of the follow-up evaluations.[15]

Regarding the criteria for the classification of BMI, among the six studies that used this index, three classified it based on the criteria of the International Obesity Task Force (IOTF);[12,14,18] two used the WHO criteria,[13,15] and one used the criteria proposed by the Centers for Disease Control and Prevention (CDC).[17] One study did not indicate the anthropometric measure but reported that nutritional status was determined by the WHO reference values.[16]

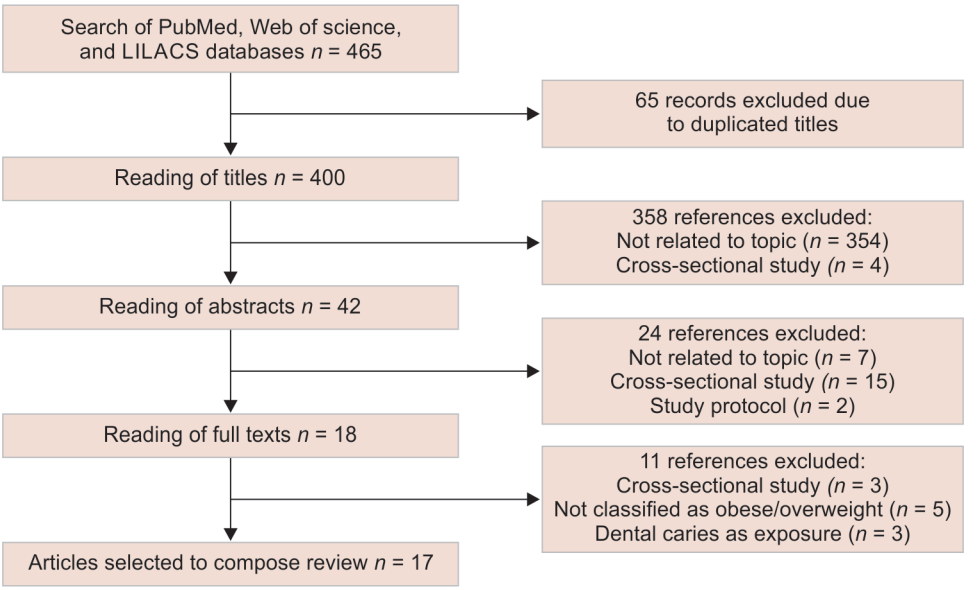
Table 1: Search strategy employed; 2021

Search	*Descriptors*
#1	(Overweight OR obes* OR underweight OR BMI OR "body mass" OR adiposity OR weight OR "body size" OR waist OR hip OR skinfold* OR Maln* OR "fat mass")
#2	(Caries OR "dental health" OR "oral health" OR decay OR cavities)
#3	(Child* OR preschool OR pediatr* OR paediatr* OR minor OR pupil* OR Toddler* OR adolesc* OR teen* OR "young person" OR "young people" OR youth)
#4	("Longitudinal study" OR "cohort studies" OR "case-control")
#5	#1 AND #2 AND #3 AND #4

Table 2: Inclusion and exclusion criteria; 2021

Inclusion criteria	• Evaluation of dental caries as the outcome (any diagnostic criteria in any dentition). • Evaluation of overweight/obesity as exposure (any diagnostic criteria). • Evaluation of the association between overweight/obesity and dental caries. • Longitudinal studies (at least two evaluation periods of caries and overweight/obesity in the same sample).
Exclusion criteria	• Population older than 18 years of age. • Literature reviews, case reports, protocol studies, letters, and editorials.

Flowchart 1: Flowchart of studies selection according to PRISMA statement; 2021



Among the seven articles selected for the present review, only one did not have an analysis adjusted for possible confounding factors in the association between obesity and dental caries. In the studies that included confounding factors in the model, the most frequent were sex, socioeconomic status, and oral health behaviors.

The results found on the association between obesity and dental caries were not conclusive. In the two studies that only considered the permanent dentition, one found no association,[14] and the other found an inverse association between the two conditions.[13] In the two studies that only considered primary dentition, both found a positive association between obesity and dental caries.[15,16] In the three studies that considered both dentitions, one found a positive association between the conditions,[18] another found no association at 3 years of age but a positive association at 6 and 15 years of age,[12] and one found a negative association in the primary dentition and no association in the permanent dentition.[17]

Among the seven studies included in the present review, five were considered to have a low risk of bias,[13–15,17,18] one had moderate risk,[16] and one had high risk.[12] All studies had some methodological flaws. The most common problems were the fact that the sample was not free of the outcome at the onset of the study and the lack of an analysis of losses to follow-up. These problems were found in six of the seven studies.

Discussion

Obesity and dental caries are highly prevalent conditions that affect millions of individuals throughout the world. Numerous studies have been conducted to determine a possible association between these variables, but the majority have had a cross-sectional design, which does not enable the inference of causality. The present systematic review united updated information on the association between these two conditions through a critical analysis of seven longitudinal studies published since 2010. Analyzing the results of studies with this type of design is the most appropriate way to clarify this unresolved issue, as such studies provide data on samples studied over time. However, longitudinal studies are methodologically complex and expensive to conduct, which may be the reason why few such studies were identified to compose the present review.

The results found on the association between obesity and dental caries were inconclusive. Previous systematic reviews, which included cross-sectional studies, have also pointed out this inconsistency in the literature.[6,7] In the present review, although five of the studies had a low risk of bias, different results were described among the articles. One found no association,[14] two found a positive association,[15,18] and one found an inverse association[13] between obesity and dental caries. Moreover, the results can vary within the same study depending on the dentition evaluated. Sánchez-Pérez et al.[17] found an inverse association in the primary dentition and no association in the permanent dentition,[17] indicating that age is an important confounding variable, which agrees with results described in a meta-analysis on this topic.[19]

The DMFT/DMFS and dmft/dmfs are the most widely used indices and are recommended by the WHO to measure dental caries experience at the population level.[20] However, not all studies that employ these indices consider the diagnostic criteria proposed by the WHO. This was the case of two studies included in the present review: one failed to mention the criteria used, and the authors of the other study adopted their diagnostic criteria. This lack of standardization may have exerted an influence on the inclusive results encountered. Among the studies that employed the WHO criteria, one found no association,[14] two found a direct association between obesity and dental caries,[15,16] and one found an inverse association only in the primary dentition.[17] The study in which the authors used their criteria for the diagnosis of caries, which included radiographic exams, also found a direct association between the two conditions.[12] The study that failed to mention the diagnostic criteria found an inverse association between obesity and dental caries.[13]

Nutritional status was assessed using the BMI in all seven studies, but the classification criteria differed, with different studies using the criteria proposed by the IOTF, CDC, and WHO. BMI is a widely used indicator of nutritional status due to the ease of measurement and low cost. However, it is not capable of precisely differentiating the components of body weight. In contrast to modern imaging exams, which are used little in population-based studies due

Table 3: Summary of articles selected for present review; 2021

Author	*Year*	*Country*	*Sample size and age*	*Anthropometric measures*	*Measures of dental caries*	*Control of confounding factors*	*Main results*	*Risk of bias*
Lock et al.	2019	Brazil	1st follow-up: 1528 12-year-old adolescents. 2nd follow-up: 801 adolescents after 2.5 years.	BMI measured at 1st follow-up–*Z*-scores for age, classified according to cutoff points recommended by WHO. • Normal weight [*Z*-score of BMI for age ≤ +1 standard deviation (SD)]. • Overweight (*Z*-score of BMI for age > +1 SD to ≤ +2 SD). • Obese (*Z*-score of BMI for age > +2 SD).	DMFS measured at first and second follow-up. Criteria: not informed.	Yes Variables: Sex, socioeconomic status, type of school (public or private), consumption of sweetened soft drinks, and brushing frequency.	Obese adolescents had lower ΔDMFS (difference between baseline and follow-up) compared to those with normal weight ($p < 0.05$). No significant association between weight status categories and ΔDMFS in the adjusted model [overweight incidence rate ratio (IRR) = 0.92; $p = 0.54$/ obesity IRR = 0.75; $p = 0.16$]. U-shaped inverted association found using the multivariable fractional polynomial model: ΔDMFS diminished with an increase in BMI ($p < 0.05$).	Low
Li et al.	2017	China	1st follow-up: 668 12-year-old adolescents. 2nd follow-up: 436 15-year-old adolescents. 3rd follow-up: 383 18-year-old adolescents. 282 participated in three follow-ups.	BMI, waist circumference, waist/hip ratio, waist/ height ratio, and triceps skinfold. Measured at three follow-ups. BMI–classified using cutoff points recommended by IOTF, divided into two groups. • Low weight/normal weight. • Overweight/obesity.	DMFT measured at three follow-ups Criteria: WHO	Yes Variables: Sex, socioeconomic status, and oral health-related behavior.	No association between obesity indices at 12 years and DMFT at 15 years. A significant association was found only between waist/ hip ratio at 15 years and DMFT at 18 years (adjusted for sex $p = 0.019$/ adjusted for sex and socioeconomic status $p = 0.027$/ adjusted for oral health behaviors, sex, and socioeconomic status $p = 0.028$). No association between other obesity indices at 15 and DMFT at 18 years.	Low

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Author	*Year*	*Country*	*Sample size and age*	*Anthropometric measures*	*Measures of dental caries*	*Control of confounding factors*	*Main results*	*Risk of bias*
Ribeiro et al.	2017	Brazil	1st follow-up: 388 children at 12 months—data from patient charts. 2nd follow-up: 388 children at 24 to 71 months clinical evaluation.	Nutritional status at 12 months—*Z*-score of weight for age. Nutritional status at 24–71 months—*Z*-scores of BMI for age, classified according to cut-off points recommended by WHO. • Overweight or obese (*Z*-score of BMI for age > +2 SD). • Thin or very thin (*Z*-score of BMI for age <1 SD). • Ideal range (*Z*-score of BMI for age 1 ≥ SD <2).	dmfs measured at the second follow-up. Criteria: WHO.	Yes Variables: Mother's schooling, income, birthweight, nutritional status at 12 months, and sugar intake frequency.	A significant association between overweight/obesity and early childhood caries [IR = 1.52; 95% confidence interval (CI): 1.03–2.22].	Low
Zaror et al.	2014	Chile	196 2-year-old children, follow-up annually until 5 years of age.	Nutritional status was determined according to WHO reference values for children <6 years of age. Evaluated annually until 5 years of age. • Normal weight. • Overweight. • Obese.	Ceod is evaluated annually until 5 years of age. Criteria: WHO.	Yes. Variables: Sex, socioeconomic status, history of caries, duration of breastfeeding, and oral hygiene.	Incidence of early childhood caries is higher among children with overweight compared to those with normal weight ($p = 0.022$). The likelihood of developing new carious lesions is 1.4-fold greater among children with overweight or obese in comparison to those with adequate weight for size (RR = 1.4; 95% CI: 1.044–1.878).	Moderate
Hooley et al.	2012	Australia	4,149 children evaluated at three follow-ups. 1st follow-up with a mean age of 4.79 years. 2nd follow-up with a mean age of 6.87 years. 3rd follow-up with a mean age of 8.84 years.	BMI and waist circumference were measured at three follow-ups. BMI (specific for age and sex) is classified using criteria recommended by IOTF. • Underweight. • Normal weight. • Overweight. • Obesity.	Caries experience was collected at second and third follow-up. Criteria: reported caries experience (yes or no).	Yes. Variables: Child—age, sex, breastfeeding, and brushing frequency; mother—BMI, age, smoking, and alcohol intake during pregnancy; Socioeconomic status, number of smokers in the home, and ethnicity.	The likelihood of having dental problems at 8 years of age increased by 70% in children in the underweight category (OR = 1.70; $p = 0.006$) and 26% in those in the overweight/obesity category (OR = 1.26; $p = 0.04$) at 6 years of age compared to those in the normal weight category.	Low

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Author	*Year*	*Country*	*Sample size and age*	*Anthropometric measures*	*Measures of dental caries*	*Control of confounding factors*	*Main results*	*Risk of bias*
Alm et al.	2011	Sweden	1st follow-up: 525 children at 3 years of age. 2nd follow-up: 506 children at 6 years of age. 3rd follow-up: 402 adolescents at 15 years of age. 4th follow-up: 491 young adults at 20 years of age.	BMI at 3, 6, and 15 years–international childhood obesity classification system recommended by IOTF (BMI adjusted for age and sex; denominated isoBMI in the article). • Low-normal weight (isoBMI <25). • Overweight (isoBMI 25–29.9). • Obesity (isoBMI ≥30). • BMI at 20 years—classified into four categories. • Low weight (BMI <18.5). • Normal weight (BMI 18.5–24.9). • Overweight (BMI 25–29.9). • Obesity (BMI ≥30).	At 3 and 6 years: total dmfs. (including initial lesions on enamel) and manifested dmfs (only cavitated lesions extending to dentine). At 15 and 20 years: total DMFT. (including initial lesions on enamel) and manifested DMFT (only cavitated lesions extending to dentine). Criteria: authors' own–radiographic exams performed at all follow-ups.	No.	At 3 years, no significant difference in the prevalence of dental caries between children with normal weight and those with overweight/obesity. At 6 years, odds (OR) of having caries and fillings were 2.5-fold higher in obese children compared to those with low-normal weight ($p = 0.04$). At 15 years, odds (OR) of having proximal caries and fillings 2.8-fold higher in obese adolescents compared to those with low-normal weight ($p =$ 0,04). At 20 years, odds (OR) of having caries and restorations 3.1-fold higher in obese adults compared to those with normal weight ($p = 0.01$).	High
Sanchez-Pérez et al.	2010	Mexico	88 children completed 4 years of follow-up, with mean age of 7.1 years at onset of study.	BMI measured annually–classified using CDC criteria. Overweight (BMI for age and sex ≥95th percentile). • Risk of overweight (BMI for age and sex ≥85th percentile and <95th percentile). • Normal weight (BMI for age and sex ≥50th percentile and <85). • Thin (BMI for age and sex <50th percentile and higher than 5th percentile). • Underweight (BMI for age and sex <5th percentile).	dmft/dmfs and DMFT/DMFS measured annually. Criteria: WHO	Yes. Variables: Age at onset of study, sex, socioeconomic status, and number of teeth present.	Children with high BMI had lower levels of dental caries in primary dentition ($p < 0.01$). Longitudinal effect showed that children in higher BMI categories had lower risk of dental caries in primary dentition (overweight $p = 0.032$/obesity $p = 0.035$). No association detected between BMI and DMFT score ($p > 0.05$).	Low

to the high cost, the BMI has limitations about estimating fat mass and lean mass on the individual level.[21] Moreover, studies have shown the prevalence of overweight/obesity differs when different BMI classification criteria are used.[22,23] This variation in the form of classifying BMI may contribute to the inconsistency in the results found on the association between caries and obesity in the literature.

Behavioral and socioeconomic characteristics are risk factors for both obesity and dental caries and therefore need to be collected and included in the adjustment of the analysis model when investigating this association. There seems to be a consensus on the need to control for socioeconomic and behavioral factors related to oral health. All six studies that controlled for possible confounding factors analyzed these characteristics. However, only two evaluated behavioral factors related to eating habits–one through an investigation of sugar intake,[15] and the other through an investigation of the consumption of sweetened soft drinks.[13] Indeed, the high consumption of sugar-rich foods is the most widely explored mechanism to explain the higher prevalence of dental caries in obese individuals, as the excessive consumption of sweetened foods is a characteristic of the diet of obese individuals,[1] and a well-established etiological factor for dental caries.[2] It is, therefore, fundamental to investigate eating habits, as this may be the main link between obesity and dental caries.

Among the studies identified in the literature to compose the present review, meta-analysis was not possible due to the heterogeneity of the results. Pooling results from heterogeneous studies can lead to erroneous conclusions. Another aspect is that none of the seven studies scored positively on all domains of the assessment tool for the risk of bias. All had methodological flaws, which may have affected the estimate of the association between obesity and dental caries. Therefore, caution should be exercised in the interpretation of the results from the different studies included in the present review.

The association between obesity and dental caries remains undefined. There is a lack of well-designed studies on this issue with methodological standardization to enable comparisons. Future studies should be developed to clarify this complex association and generate consistent evidence capable of guiding health-related decisions. For such, longitudinal studies are needed with precise diagnostic methods for both obesity and dental caries, as well as the rigorous control of confounding factors and effect modifiers. Moreover, the eating habits of the participants, which have been explored little, need to be investigated.

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