

# Exploring the Association Between Overweight and Dental Caries Among US Children

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## Abstract

**Purpose:** The purpose of this study was to examine the relationship between age-specific body mass index (BMI-for-age) and dental caries among US children.

**Methods:** Body measures data and oral health data came from the 1999-2002 National Health and Nutrition Examination Survey. Outcome measures for primary and permanent dentitions were: (1) dental caries prevalence; and (2) severity (geometric mean dft and DMFT). Covariates included: (1) age; (2) gender; (3) race/ethnicity; and (4) poverty status. Analysis was limited to children 2 to 17 years old.

**Results:** Approximately 36% of overweight children 2 to 6 years old and 39% of overweight children 6 to 17 years old had dental caries. Geometric mean dental caries scores for overweight children were dft=3.3 and DMFT=2.5 for primary and permanent dentitions, respectively. Controlling for covariates, there was no significant association between BMI-for-age and dental caries prevalence in either dentition. In addition, among children with a positive history of dental caries, BMI-for-age was significantly associated with dental caries severity in the permanent dentition – overweight children had a lower geometric mean DMFT than did normal weight children.

**Conclusions:** Although it was hypothesized that age-specific body mass index would be associated with increased dental caries prevalence and severity, these associations were not found. Rather, overweight was found to be associated with lower geometric mean DMFT. Future studies should address which factors specific to overweight in children might be protective against dental caries in the permanent dentition. Given the importance of overweight as a public health problem, however, clinicians are encouraged to continue providing health education and dietary counseling to their overweight child patients. (*Pediatr Dent* 2006;28:375-380)

**KEYWORDS:** CHILDREN, DENTAL CARIES, OBESITY, OVERWEIGHT, UNITED STATES

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Among children and teenagers 2-20 years old, body fat amounts change as the body grows and are different for boys and girls.<sup>1</sup> Unlike body mass index (BMI) assessments for adults, assessments for children and teenagers take these growth- and gender-specific differences into account. These child-specific BMI values are referred to as “BMI-for-age.” Categories describing amount of body fat for children and teenagers is also different from the categories describing amount of body fat in adults. Among adults, BMI categories include “underweight,” “normal,” “overweight,” and “obese.” Among children and teenagers, BMI-for-age categories include “underweight,” “normal,” “at risk of overweight,” and “overweight.” There is no “obese” category for children and teenagers.

There is a growing epidemic of overweight in the United States among children and teenagers.<sup>2,3</sup> According to 1999-2002 estimates,<sup>4</sup> 16% of US children and teenagers are overweight, compared with only 11% in 1988-1994 estimates and 5% in 1971-1974 estimates. Although overweight is a concern for all Americans, some population segments are particularly at risk. Minority youth are more likely to be overweight than are non-Hispanic Caucasian children and teenagers.<sup>5</sup> Additionally, low socioeconomic status is associated with an overweight condition in children.<sup>6</sup>

The adverse health effects of obesity and overweight in adults have been well documented. Obese adults have an increased risk of premature death compared with those in a healthy weight range.<sup>7</sup> Overweight and obese adults also have an increased risk of: (1) coronary heart disease; (2) type-2 diabetes; (3) endometrial, colon, and other cancers; as well as (4) certain musculoskeletal disorders.<sup>7</sup> Although children and teenagers do not experience the same fre-

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quency of adverse health effects as adults, overweight youth still experience some detrimental health consequences.<sup>8</sup> For instance, overweight youth are more likely to:

1. become overweight or obese adults;
2. develop type 2 diabetes, hypertension, early maturation, and orthopedic problems; and
3. suffer from social ridicule and discrimination.<sup>9,10</sup>

Particular health behaviors lead to overweight children and teenagers, such as living sedentary lifestyles<sup>11-13</sup> and choosing foods high in fats and refined carbohydrates.<sup>14</sup> Given the causative relation between refined carbohydrates and dental caries,<sup>15-18</sup> it is appropriate to hypothesize that overweight might also be a marker for dental caries in children and teenagers.

The purpose of this study was to determine whether age-specific body mass index might be associated with dental caries in US children, controlling for relevant demographic and socioeconomic status (SES) factors.

## Methods

Data from the National Health and Nutrition Examination Survey (NHANES) for survey years 1999-2002 were used. NHANES is a cross-sectional survey of the health, illness, and nutritional status of the nation. The following groups were oversampled so that estimates for each would be reliable: (1) 12- to 19-year-old adolescents; (2) adults at least 60 years old; (3) Mexican Americans; (4) African Americans; (5) low-income persons; and (6) pregnant women. Data are representative of the civilian, noninstitutionalized US population. Survey data from the *Body Measures* and *Oral Health* (dentition section) components were merged for this analysis. A detailed description of sampling and data collection methodology are available at the NHANES Web site.<sup>19</sup>

Outcome variables included: (1) measures of dental caries prevalence; and (2) severity for the primary and permanent dentitions. Caries prevalence was represented by the proportion of children with a positive dental caries history—sum of decayed and filled teeth (dft) greater than 0 for the primary dentition, and sum of decayed, missing, and filled teeth (DMFT) greater than 0 for the permanent dentition. Dental caries severity was represented by geometric mean dft and geometric mean DMFT. Geometric means were derived from the antilog of the log<sup>10</sup> transformations of dft and DMFT, and were used because dft and DMFT distributions are highly positively skewed, which violates statistical assumptions of normality in linear regression analysis. Geometric means are always smaller than or equal to the arithmetic mean of a distribution. Although arithmetic mean dft and DMFT values are sometimes used in linear regression, geometric mean values are more statistically appropriate and compensate for the high frequency of values at the low end of the distribution.

BMI-for-age percentiles, representing eating habits in children and teenagers, were used. BMI-for-age (weight in kilograms/height in meters<sup>2</sup>) percentiles are dependent on

gender- and age-specific weight for height curves for those 2 to 20 years old.<sup>20,21</sup> According to these curves:

1. “underweight” is defined as BMI-for-age less than the fifth percentile;
2. “normal” is defined as BMI-for-age greater than or equal to the fifth percentile and less than the 85<sup>th</sup> percentile;
3. “at risk of overweight” is defined as BMI-for-age greater than or equal to the 85<sup>th</sup> percentile and less than the 95<sup>th</sup> percentile; and
4. “overweight” is defined as BMI-for-age greater than the 95<sup>th</sup> percentile.

Covariates for this analysis included:

1. age (2-5 years, 6-17 years);
2. sex;
3. race/ethnicity (non-Hispanic white, non-Hispanic black, Mexican American, and other); and
4. poverty status (less than 100% of the federal poverty level [FPL], 100%-199% FPL, 200% FPL or higher, and unknown).

Multiple logistic regression was used to examine BMI-for-age percentile as a predictor of dental caries prevalence. Multiple linear regression was used to examine BMI-for-age percentile as a predictor of dental caries severity. For the multiple logistic regression analysis, the authors used adjusted odds ratios. These defined whether the odds of having dental caries for one level of obesity was higher/lower than the reference level of obesity (normal body mass), controlling for covariates. For the multiple linear regression analysis, model parameter estimates defined whether the geometric mean dft or DMFT for one level of obesity was higher/lower than the reference level, controlling for covariates.  $P < .05$  was considered to be statistically significant. SUDAAN statistical software (Research Triangle Institute, Cary, NC) was used for all analyses.<sup>22</sup>

This secondary analysis of public-use data was reviewed and approved (as exempt) by the Institutional Review Board of the University of Maryland, Baltimore, Md.

## Results

According to 1999-2002 NHANES data, 4.6 million children (4%) 2 to 17 years old were underweight, 19 million (15%) were at risk for overweight, and 19.8 million (15%) were overweight. Approximately 83 million (63%) had a normal BMI-for-age percentile. The 1999-2002 NHANES data also showed that 8.1 million (28%) children 2 to 5 years old had a positive dental caries history in the primary dentition and 17.7 million (38%) children 6 to 17 years old had a positive dental caries history in the permanent dentition.

Regarding the primary dentition, overweight children had a higher dental caries prevalence value than did normal children and underweight children had a lower prevalence value than did normal children (Table 1). These differences, however, were not statistically significant. Regarding the permanent dentition, overweight children had only a

**Table 1. Weighted Prevalence of Dental Caries Among Children 2 to 17 Years Old, by Body Mass Index and Dentition: United States, 1999-2002\***

Characteristic	Primary dentition (2-5 ys old; n=1,719)	Permanent dentition (6-17 ys old; n=5,898)
	dft>0	DMFT>0
Percentage±SE		
Overall†	27.5±1.7	37.8±1.2
Body mass index (BMI)		
Underweight	18.0±5.2	31.7±6.3
Overweight	36.1±6.4	38.8±1.7
At risk of overweight	26.9±5.0	38.1±2.3
Normal	28.1±1.8	37.8±1.4

\*National Health and Nutrition Examination Survey data, 1999-2002. Differences between prevalence values are not statistically significant.

†Includes children with unknown body mass index (BMI).

**Table 2. Adjusted Odds of Having Dental Caries Among 2- to 17-year-old Children, by Selected Characteristics and Dentition: United States, 1999-2002\***

Characteristic	Primary dentition (2-5 ys old; n=1,719)		Permanent dentition (6-17 ys old; n=5,898)	
	dft>0	DMFT>0	Adjusted OR (95% CI)†	P value
Body mass index (BMI)				
Underweight	0.6 (0.3-1.3)	.17	0.9 (0.5-1.7)	.73
Overweight	1.0 (0.5-1.7)	.95	1.1 (0.9-1.3)	.54
At risk of overweight	0.8 (0.5-1.3)	.38	1.0 (0.8-1.4)	.69
Normal	Reference	---	Reference	---

\*Source=National Health and Nutrition Examination Survey, 1999-2000.

†Controlling for age, gender, race/ethnicity, and poverty status. OR=odds ratio; CI=confidence interval.

slightly higher dental caries prevalence value than did normal children. Underweight children had a lower prevalence than did normal children (Table 1). Again, these differences were not statistically significant. Controlling for age, gender, race/ethnicity, and poverty status (AGRP), multiple logistic regression models also showed that there was no statistically significant association between BMI-for-age and dental caries prevalence for either the primary or permanent dentitions (Table 2).

Among children who had a positive history of dental caries in the primary dentition, the geometric mean number of decayed and filled teeth was 2.9. Underweight and overweight children had a slightly higher geometric mean dft than reference children (Table 3), however these associations were not statistically significant. Among those who had a positive history of dental caries in the permanent dentition, the geometric mean number of decayed, missing, and filled teeth was 2.8. Underweight children had a higher geometric mean DMFT value than the reference children. Overweight children, conversely, had a slightly lower geometric mean DMFT value than the reference children (Table 3). Once again, these differences were not statistically significant.

Controlling for AGRP, multiple linear regression models showed that there was no statistically significant association between BMI-for-age and dental caries severity for the primary dentition (Table 4). There was, however, a statistically significant association between BMI-for-age and dental caries severity for the permanent dentition. Controlling for AGRP, overweight children had a significantly lower geometric mean DMFT than did reference children (Table 4).

## Discussion

Testing the association between BMI-for-age and oral health outcomes has not received much attention in the literature. Reid and colleagues<sup>23</sup> included BMI in a study of the relation between behavioral factors and untreated dental caries among adults, although BMI was grouped together with other behavioral factors such as: (1) marital status; (2) tobacco use; (3) alcohol use; and (4) social support. Wood and colleagues<sup>24</sup> reported a positive correlation between BMI and the incidence and severity of periodontitis, likely due to similarities between periodontitis and other obesity-related systemic conditions. Al-Zahrani and colleagues<sup>25</sup> reported similar results in young adults. In a study of children, Chen and colleagues<sup>26</sup> reported no association between BMI-for-age and dental caries among 3-year-old Chinese children. The current analysis represents the first to test the association between BMI-for-age and dental caries in a representative sample of US children.

Given the link between refined carbohydrate consumption and dental caries and the link between dietary intake and overweight among children, it was somewhat surprising to find that overweight was not associated with increased prevalence of dental caries in either dentition or with dental severity in the primary dentition. It was even more surprising to find that overweight children 6 to 17 years old had a significantly lower dental caries severity than did children of normal BMI-for-age.

Perhaps these findings illustrate that the relationship between overweight and dental caries in children is far more complex than can be explained by carbohydrate consumption alone. These findings might also show that more research should be conducted to address what factors specific to overweight in children might be protective

**Table 3. Weighted Geometric Mean Dental Caries Score Among 2- to 17-year-old Children With a History of Dental Caries, by Body Mass Index and Dentition: United States, 1999-2002\***

Characteristic	Primary dentition (2-5 ys old; n=486)	Permanent dentition (6-17 ys old; n=1,431)
	Geometric mean dft	Geometric mean DMFT
Geometric mean (95% confidence interval)		
Overall†	2.9 (2.6-3.2)	2.8 (2.7-2.9)
Body mass index (BMI)		
Underweight	3.1 (2.1-4.6)	4.3 (2.6-7.0)
Overweight	3.3 (2.5-4.3)	2.5 (2.1-2.8)
At risk of overweight	2.6 (1.9-3.5)	2.8 (2.5-3.2)
Normal	2.8 (2.4-3.2)	2.8 (2.6-3.1)

\*Source: National Health and Nutrition Examination Survey, 1999-2002. Differences between geometric mean values are not statistically significant.

†Includes children with unknown body mass index (BMI).

**Table 4. Weighted Multiple Linear Regression for Geometric Mean Dental Caries Scores among 2- to 17-year-old Children With a History of Dental Caries, by Selected Characteristics and Dentition: United States, 1999-2002\***

Characteristic	Primary dentition (2-5 ys old; n=486)		Permanent dentition (6-17 ys old; n=2,496)	
	Regression coefficient	P value	Regression coefficient	P value
Body mass index (BMI)				
Underweight	0.03	.80	0.17	.10
Overweight	0.07	.26	-0.06	.05
At risk of overweight	-0.06	.42	-0.00	.92
Normal	Reference	---	Reference	---

\*Source: National Health and Nutrition Examination Survey, 1999-2002. Controlling for age, gender, race/ethnicity, and poverty status.

against dental caries in the permanent dentition (regarding the multiple linear regression results).

Although this analysis did not show that overweight was significantly associated with increased dental caries prevalence or severity, dental professionals are reminded that they still have an important role in influencing eating habits and food choices. As a framework for developing effective interventions, in 2001 the Surgeon General pub-

lished a call to action to decrease and prevent obesity and overweight.<sup>27</sup> Among key actions relevant to the health care setting were:

1. informing and educating the health care community about the importance of healthful eating and physical activity;
2. educating health care providers and administrators to identify and reduce barriers involving patients' lack of access to effective nutrition counseling and physical activity programs;
3. educating health care providers on effective ways to promote and support breastfeeding; and
4. encouraging partnerships between health care providers, schools, faith-based groups, and other community organizations in prevention and efforts targeted at the causes of overweight.

Clinicians are also reminded that dietary and physical activity counseling may be administered effectively in an oral health care setting. The US Department of Agriculture (USDA) recommends that all Americans consume a variety of nutrient-dense foods and beverages and limit their intake of: (1) saturated and "trans" fats; (2) cholesterol; (3) added sugars; and (4) salt.<sup>28</sup>

More specifically, the USDA recommends that:

1. all children and teenagers should consume whole-grain products frequently (at least half of all grains should be whole grains);
2. children 2 to 8 years old should consume 2 cups per day of fat-free or low-fat milk or equivalent milk products;
3. children 9 years old or older should consume 3 cups per day of fat-free or low-fat milk or milk equivalent products; and
4. children and teenagers engage in 60 minutes or more of physical activity on most (preferably all) days of the week.

These messages should be given to all youngsters, particularly overweight children and those at risk of overweight.

Clinicians should be aware that influencing patient behavior is very challenging. Dentists and dental hygienists should provide consistent messages repeatedly over multiple appointments for change to take place.<sup>29</sup> Personal barriers, coping mechanisms, social support, and other factors specific to patients and their parent caregivers should be identified and incorporated into behavior-changing strategies. Motivational interviewing may also provide a framework for influencing dietary behaviors and physical activity.<sup>30</sup> Clinicians who are not familiar with theoretical models and effective strategies are encouraged to seek additional training.

This analysis had one limitation. Given that NHANES is a cross-sectional survey providing BMI data at one point in time, it is possible that a youngster's BMI could have changed over his or her lifetime without being captured in the survey. Such misclassification, although possible, probably did not bias results appreciably.

Despite this limitation, the authors' analysis exhibited some important strengths. For example, it represented one of the few studies in the United States or elsewhere to test the link between BMI-for-age and dental caries. It also used the most currently available national data and it provided estimates that were representative of a wide variety of demographic and SES groups. Finally, it controlled for relevant covariates, eliminating these sources of potential confounding from the results.

### Conclusions

Based on this study's results, the following conclusions can be made:

1. Controlling for confounders, there is no statistically significant association between BMI-for-age and dental caries prevalence for children in either dentition. There is also no statistically significant association between BMI-for-age and dental caries severity for children in the primary dentition.
2. Overweight children with a positive history of dental caries in the permanent dentition exhibit fewer decayed, missing, and filled teeth than do their normal-weight peers.

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## Abstract of the Scientific Literature



### The DOCS Sedation Scale

Studies of pediatric sedation practice have suffered from the lack of an objective scale that would allow for a comparison of the effectiveness and safety of sedation provided by various providers and techniques. The purpose of this paper was to present the Dartmouth Operative Conditions Scale (DOCS), which is designed as a research tool to codify the appropriateness of the procedural conditions provided by various sedation interventions.

To begin, human factors methodology was used to develop a model of the pediatric sedation process and to define the criteria for measuring a patient's condition during a procedure (DOCS). To accomplish validation, 70 video clips (each 30 seconds long) were then selected from more than 300 hours of procedural video tape for testing/grading purposes. Inter-rater reliability was tested by comparing the score for each video clip among 10 different raters. Intrarater reliability was evaluated by retesting all of the raters 1 year after their initial rating. Construct validity was confirmed by analyzing the change in DOCS scores relative to the time that sedation intervention was undertaken. Criterion validity was tested by comparing the DOCS to a modified COMFORT score.

The DOCS was completed with excellent inter-rater ( $k=0.84$ ) and intrarater ( $k=0.91$ ) agreement by 10 health care providers with various backgrounds during the 1-year study period. Criterion validity was supported by the close correlation between the DOCS and the modified COMFORT scores for 20 distinct video clips (Spearman rank correlation coefficient=0.98;  $P<.001$ ). The distribution of DOCS scores 20 minutes after the anesthetic induction was significantly lower than the scores before initiation of sedation. Also, scores after emergence were consistently higher than those 20 minutes after sedation ( $P<.001$ ), thus confirming construct validity of the scale.

The DOCS is a validated research tool, when used with video data, for comparing the effectiveness and safety of pediatric sedation service, regardless of the technique used for decreasing anxiety or pain during a procedure.

**Comments:** Sedation studies in pediatric dentistry have been criticized by many outside of dentistry for their lack of reproducibility and an inability to compare and contrast sedation techniques. This paper describes the exhaustive and novel process utilized in the development of DOCS, which was designed specifically to codify the appropriateness of the conditions during medical procedures for children facilitated by various sedation/analgesia techniques. The scale is intended for research purposes and is designed to be simple and flexible enough to allow for comparison between providers, pharmacologic interventions, and nonpharmacologic techniques. This paper showed that DOCS is a valid measure for qualifying the state of a patient during a sedation or distraction intervention. Perhaps collaborative sedation research by pediatric dentists and the authors who developed DOCS will provide solid evidence for the validity of our patient management techniques. **ARM**

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