# Relationship between Adjusted Body Mass Index Percentile and Decayed, Missing, and Filled Primary Teeth

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## ABSTRACT

**Purpose:** The purpose of this study was to determine if there was a significant relationship between adjusted body mass index (BMI) percentiles and the frequency of decayed, missing, and filled primary teeth (dmft) in a retrospective cohort of 3- to 5-year-old children.

**Methods:** Data was collected from 215 3- to 5-year old children with an American Society of Anesthesiologists class I or II physical status who had received dental treatment under general anesthesia at a university hospital between 2007 and 2008. The diagnosis of dental caries and dmft scores were confirmed by oral and radiographic examination.

**Results:** BMI percentile was a statistically significant explanatory variable for dmft after controlling for race, gender, and age ($P<.001$). When BMI percentile increased by 10 units, the dmft score increased by an estimated 1.1 after adjusting for the other covariates.

**Conclusions:** Young children with elevated BMI percentiles who have caries may be at risk for an increased number of carious teeth in the future. Providing nutritional and weight counseling may potentially lower the risk for dental caries in young children while improving their general health. (J Dent Child 2013;80(3):115-20)

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The prevalence of childhood obesity has dramatically increased over the past 20 years.[1] Being overweight is now the most common medical condition of childhood.[2] A decrease in physical activity and changes in dietary and consumption habits have been cited as some of the reasons for this escalation.[3,4] Body mass index (**BMI**) is a measure of body fat based on the height and weight of a person in the form of a standard calculation and can represent an estimate of a healthy or unhealthy weight, assuming an average body composition. According to BMI percentile adjusted for age and gender, children are classified as underweight (<fifth percentile), healthy weight (fifth to <85$^{th}$ percentile), overweight (85$^{th}$ to <95$^{th}$ percentile), and obese (>95$^{th}$ percentile).[5] Processed, energy-dense foods high in sugar/carbohydrates and fats can have unfavorable effects on the general health of children.[1,6] These dietary changes can also have detrimental effects on the dentition.[7,8]

Enamel in the primary dentition is composed of a less dense mineral matrix than in permanent teeth, and oral hygiene is often performed by the untrained hands of the child. The incidence of early childhood caries has been declining, but it continues to be a public health concern, especially among children from lower socioeconomic families in the United States.[9] Ethnic minority children have been found to have a disproportionately higher burden of dental caries.[10]

Interest in the relationship between dental caries and obesity has increased, due in part to the American Academy of Pediatrics reporting that half of all children in the United States will develop caries and some

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will experience severe dental disease.[11] Some studies[12-17] have suggested that a positive association exists between caries and overweight/obesity, while others have reported no association.[18-27]

Documented adverse health effects of obesity include an increased incidence of heart disease, type II diabetes, hypertension, asthma, colon and other cancers, and musculoskeletal disorders.[28] The frequency of these conditions in children is substantially lower than in adults. However, overweight/obese children are affected by other serious consequences, such as high cholesterol, hypertension, orthopedic problems and serious psychological issues due to social discrimination.[29-32] Give the causative relation between refined carbohydrates and both dental caries and weight gain, a few investigators have hypothesized that obesity may be a marker for dental caries in children and possibly another risk factor for caries.[33,34]

The purpose of this retrospective cohort study is to determine if there is a relationship between the BMI percentile and the number of decayed, missing, and filled primary teeth (**dmft**) in a group of three- to five-year-old children who received dental treatment under general anesthesia (**GA**).

## METHODS

This study was approved by the Biomedical Institutional Review Board (**IRB**) of the University of North Carolina (UNC), Chapel Hill, NC. Data was collected from 3- to 5-year-old children who received dental treatment under GA at the UNC Children's Hospital (**UNC-CH**) between 2007 and 2008. Age, weight, physical status, and age-/gender-adjusted BMI for all of the study subjects were collected previously in an IRB-approved study in the School of Medicine, UNC-CH.[35]

The children included in this study had been previously examined visually in the dental clinic, without the benefit of oral radiographs, and diagnosed with carious primary teeth by faculty of the Department of Pediatric Dentistry, UNC School of Dentistry. They were referred for comprehensive dental care under GA due to extreme situational anxiety and/or extent of dental needs. The dental diagnosis was confirmed by a pediatric dentist at the time of treatment by an oral examination that was supported by full-mouth dental radiographs. The study included 215 children with an American Society of Anesthesiologists (**ASA**) class I or II physical status. ASA class I describes a patient as normal and in good health, and class II describes a patient with a mild systemic disease with no functional limitations.[36]

The dmft score for each patient was obtained by reviewing the subject's intraoperative dental records, including dental radiographs. A log 10 transformation of the dmft score was used because the dmft scores were highly positively skewed.

Spearman correlation and Kruskal-Wallis tests were used for bivariate analyses assessing the relationship between the potential explanatory variables (age, gender, race, and BMI percentile) and dmft score. Since all subjects had a dmft greater than zero, a zero-truncated Poisson regression was used to test whether BMI percentile, as a predictor, had an effect on the outcome dmft, while controlling for race, gender, and age.[37] The method was implemented in the zero truncated function in R Version 2.14.1 (www.r-project.org). Due to the small sample size (N=12) in the "other" category for race and the substantial difference in BMI percentile median values for the "other" category ("other" median=36) with respect to the other categories of race, subjects in the "other" category for race were not included in the analyses. Females and Caucasians were considered as reference groups. The level of significance was set at 0.05.

## RESULTS

The study subjects were predominantly male and Hispanic (Table 1). The dmft score and the BMI percentile of 215 3- to 5-year-old children varied: the dmft ranged from 3-14, with a median of 8, and the median BMI percentile was 77 (Table 1). There were no statistically significant differences in the average dmft among the race categories ($P$=.22) or between males and females ($P$=.40). There also was no statistically significant difference in average BMI percentile among the race categories ($P$=.18). A significant difference was

**Table 1. Characteristics of Study Patients***

| | N | % | |
|---|---|---|---|
| *Gender* | | | |
| Male | 119 | 55 | |
| Female | 96 | 45 | |
| *ASA classification* | | | |
| I | 138 | 64 | |
| II | 77 | 36 | |
| *Race* | | | |
| African American | 35 | 16 | |
| Caucasian | 71 | 33 | |
| Hispanic | 97 | 45 | |
| Other | 12 | 6 | |
| | $P_{25}$ | Median | $P_{75}$ |
| Age (yrs) | 3.6 | 4.2 | 5 |
| BMI % | 49 | 77 | 92 |
| dmft | 6 | 8 | 10 |
| Height (cm) | 99 | 103 | 109 |
| Weight (kg) | 16 | 17 | 20 |

*$P_{25}$=25th percentile. $P_{75}$=75th percentile. BMI=body mass index. dmft=decayed, missing, and filled primary teeth.

**Table 2. Decayed, Missing, and Filled Primary Teeth (dmft) and Body Mass Index (BMI) Percentile (%) by Race and Gender***

| Variable | | dmft | | | | | BMI % | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | N | $P_{25}$ | Median | $P_{75}$ | *P*-value | $P_{25}$ | Median | $P_{75}$ | *P*-value |
| *Race* | African-American | 35 | 5.00 | 7.00 | 10.00 | .22 | 54 | 75 | 95 | .18 |
| | Caucasian | 71 | 6.00 | 9.00 | 10.00 | | 41 | 76 | 90 | |
| | Hispanic | 97 | 6.00 | 8.00 | 11.00 | | 59 | 81 | 93 | |
| *Gender* | Female | 96 | 6.00 | 8.00 | 9.50 | .40 | 47 | 71 | 85 | .007 |
| | Male | 119 | 5.00 | 8.00 | 11.00 | | 55 | 82 | 96 | |

** $P_{25}$=25th percentile. $P_{75}$75th percentile.*

found between males and females in BMI percentiles (*P*=.007); males had higher median BMI percentiles than females (Table 2). Neither dmft nor BMI percentiles were linearly correlated with age (dmft $r_s$:0.1, *P*=.16; BMI percentiles $r_s$:0.02, *P*=.72). The association between dmft and the BMI percentile, however, was statistically significant ($r_s$:0.56; *P*<.001). The distribution of dmft for children who were underweight/healthy was significantly different (*P*<.001) from those who were overweight/obese. The underweight/healthy children tended to have lower dmft scores (Table 3).

Based on the zero-truncated Poisson regression, neither race (Figure 1) nor gender (Figure 2) was statistically significant predictors of dmft after controlling for BMI percentile. BMI percentile, however, was a statistically significant explanatory variable for dmft after controlling for race, gender, and age (*P*<.001). Given the positive slope for BMI percentile, when BMI percentile increased by 10 units, the dmft score would increase by an estimated 1.1, after adjusting for the other covariates (Table 4).

**Table 3. Distribution of Decayed, Missing, and Filled Primary Teeth (dfmt) for Underweight/Normal and Overweight/Obese Children**

| dfmt | 3-6 N (%) | 7-10 N (%) | >10 N (%) | Total subjects |
|---|---|---|---|---|
| Underweight/normal | 62 (47) | 58 (44) | 12 (9) | 132 |
| Overweight/obese | 5 (6) | 44 (53) | 34 (41) | 83 |

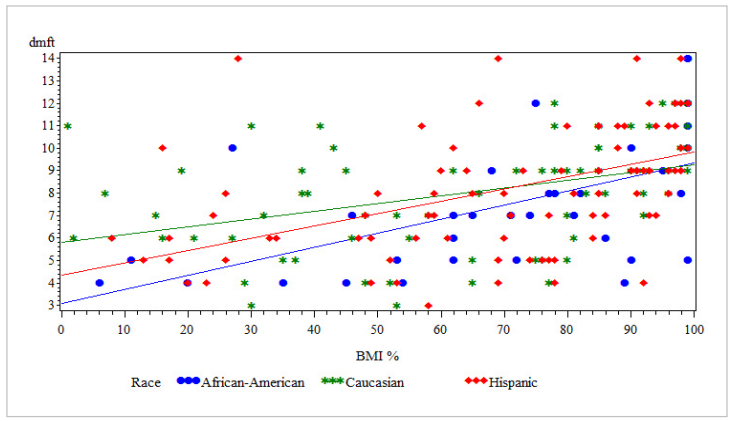


*Figure 1. Decayed, missing, and filled primary teeth (dmft) vs. body mass index (BMI) percentile (%) by race.*

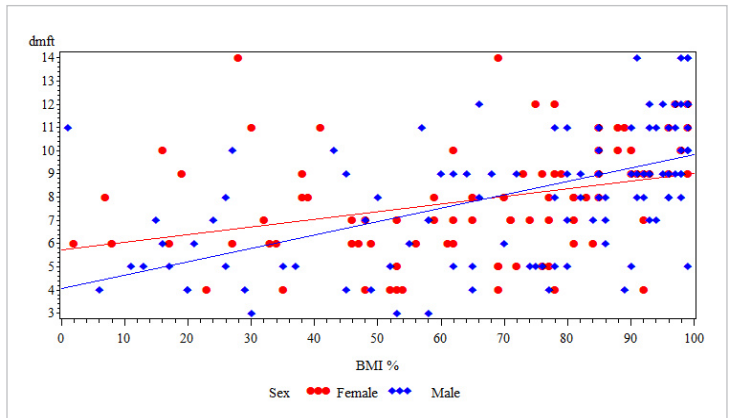


*Figure 2. Decayed, missing, and filled primary teeth (dmft) vs. body mass index (BMI) percentile (%) by gender.*

## DISCUSSION

Most of the children had a BMI percentile in the healthy range, but approximately 12 percent were considered overweight/obese. After controlling for age, race, and gender, the relationship between BMI percentile and dmft was statistically significant, with higher BMI percentiles associated with higher dmft. Other measures may need to be included, such as socioeconomic status, to further investigate this positive association, as the UNC Department of Pediatric Dentistry cares for a culturally diverse pediatric population. This makes our study complex, in that many factors may influence the relationship between BMI percentile and the number of dmft.

Biological, genetic, environmental, and behavioral factors influence BMI percentile and dmft individually and collectively. Previous studies have

*Table 4. Estimates and Values from the Zero-truncated Poisson Regression*

| Covariate | Estimate* | 95% confidence interval | Z-value | *P*-value |
|---|---|---|---|---|
| Gender (male vs. female) | 1.001 | 0.906, 1.106 | 0.020 | >.98 |
| Race (African-American vs. Caucasian) | 0.896 | 0.773, 1.038 | -1.461 | >.14 |
| Race (Hispanic vs. Caucasian) | 0.989 | 0.888, 1.102 | -0.207 | <.84 |
| Age | 1.039 | 0.979, 1.102 | 1.258 | <.21 |
| BMI %† | 1.006 | 1.004, 1.008 | 6.237 | <.001 |

** 1.001=ratio of the dmft for males to females; 1.006=dmft increases 1.006 for a 1-unit increase in body mass index (BMI) percentile; 1.006=dmft increases 1.006 for 10-unit increase in BMI percentile.*

*† BMI=body mass index.*

presented controversial data suggesting that the relationship between caries and weight is complex and multifactorial. In a prospective study, Marshall et al.[38] suggested that obesity does not increase the risk of caries, nor does caries increase the risk for obesity; rather, a common risk factor increases the likelihood of both diseases. Macek and Mitola[25] found no significant association between BMI for age and dental caries prevalence in either the primary or permanent dentition.

In a dental school pediatric dental clinic, Werner et al.[26] found that a smaller proportion of obese and overweight children presented with primary tooth caries than healthy/underweight children in the mixed dentition. Caries prevalence and incidence were assessed using decayed primary teeth and decayed permanent teeth; only 46 percent of the subjects had active primary tooth caries, while 12 percent had active permanent tooth caries. Age- and gender-adjusted BMI percentiles rather than BMI were used in this study to assess obesity, as it is more meaningful in growing children. This is an important distinction and may explain differences reported in other study results, as BMI is not adjusted for gender during periods of growth/maturity. Pinto et al.[24] found no relationship between carious surfaces on both primary and permanent teeth and weight as measured by BMI.

Willerhausen et al.,[13] however, found that normal weight children had significantly fewer caries in their primary and permanent teeth than did the overweight children and speculated that the association of poor oral health with obesity was likely due to diet quality. A positive correlation was also found between dental caries experience in primary and permanent dentitions and BMI, rather than BMI percentile in a study of German children.[14]

In a study by Larsson et al.[15] that used bitewing radiographs to diagnosis interproximal lesions, the proportion of adolescents with a BMI greater than 26 had increased caries scores. Trikaliotis et al.[17] found that overweight Greek preschool children were at higher risk of dental caries. Unlike many previous studies, the current investigation was unique in that all of the subjects had active dental caries.

Strategies to prevent and reduce obesity and dental caries must focus on changing dietary habits while encouraging increased physical activity and improved dental hygiene.[39] The current study suggests that there is a common risk factor for dental caries in primary teeth and being overweight. This is significant because the consequences associated with a high BMI percentile, such as cardiovascular disease, hypertension, and possibly diabetes, are chronic conditions. Dental caries, on the other hand, can be identified early and managed with proper nutrition, good oral hygiene, and the appropriate use of topical and systemic fluorides. Children and their parents should be educated to the importance of maintaining good oral health and a healthy BMI percentile in preventing overweight-associated systemic diseases.

The current study is limited by its retrospective nature and the fact that the clinical caries diagnosis was made by several uncalibrated pediatric dentistry faculty. One calibrated investigator read all of the radiographs. Further studies are recommended to investigate whether the association between childhood obesity (as defined by age- and gender-corrected BMI) and caries is the same for children with no caries and those with caries. The inclusion of the socioeconomic status of the patient would be appropriate in future studies, as it was found to be significantly related to caries and childhood obesity in a previous study.[34]

## CONCLUSIONS

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

1. Controlling for age, race, and gender, there was a significant association between BMI percentile and dmft in children with existing caries.
2. Overweight children had a higher prevalence of dental caries value than normal or underweight children.

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