CHILDHOOD OBESITY AND DENTAL CARIES IN AN AT-RISK PRESCHOOL POPULATION

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DEDICATION

This thesis is dedicated to my partner, Kathleen Painter, whose love, emotional support, patience, sacrifice, and good cooking made this project and my graduate degree possible. You truly make my life richer. Thank you.

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ABSTRACT

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by

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The occurrence of both childhood obesity and dental caries—which are disproportionately high in low-income families and minority groups in the United States—can have life-long negative consequences for individuals and communities. Previous research aimed at investigating the relationship between obesity and dental caries has been inconclusive, and limited among at-risk pre-school age populations. The purpose of this study was to explore the relationship between body mass index (BMI)-for-age and dental caries within a purposive sample of predominately Hispanic, low-income children enrolled in a Head Start preschool program in South Texas. A purposive sample of 237 children was randomly selected for secondary data analysis. Frequencies, ANOVA, Pearson correlations, and logistic regression analyses were used to describe and analyze the data. The sample consisted of predominately Hispanic (88.2%) children with a mean age of 3.6 years. Prevalence of obesity was 23.2%, and 46.8% had dental caries. Comparison of prevalence of caries (P=0.62), untreated decay (P=0.07), ECC (P=0.38), and dmf (P=0.88) by BMI categories resulted in no significant differences. Pearson correlation analyses found no positive relationship between dmf score and BMI-for-age percentile (r = 0.017), and logistic regression analyses showed no relationship between dmf and obesity (OR=1.00, CI=.05). Increases in children's BMI category classification was associated with a slight decreased likelihood of caries (OR=0.96, CI=.05) and ECC (OR=0.98, CI=.05), but an increased likelihood of untreated decay (OR=1.42, CI=.05). Although childhood obesity and dental caries share some common etiological and facilitating risk factors, this study supports other research that suggests higher rates of both diseases among at-risk populations simply coexists. An interprofessional approach between primary healthcare professionals, dental professionals and health educators can offer a unique opportunity to prevent and treat both prevalent childhood diseases.

Key Words

Childhood obesity; Body Mass Index (BMI); Dental caries; Untreated tooth decay, Early Childhood Caries (ECC); Head Start; Hispanic children; Preschool; Low-income children

CHAPTER I

INTRODUCTION TO THE STUDY

Significance of the Problem

Childhood obesity rates for children aged 2-5 years in the United States (US) more than doubled from 5% in 1976-1980 to 12.1% in 2009-2010 and tripled for all children aged 2-19 years, with nearly 17% classified as obese.[1] Concurrently, dental caries is the most prevalent chronic childhood disease in the US.[2] And while trends indicate the overall prevalence of dental caries has decreased in the US, the National Health and Nutrition Examination Survey (NHANES)[3] data indicated children aged 2-5 years showed a significant increase in caries prevalence from 24% in 1988-1994 to 28% in 1999-2004.

The occurrence of both childhood obesity and dental caries can have life-long negative consequences for individuals and communities.[4,5] Children who are obese during their preschool years are more likely to be obese in adulthood and to develop chronic health conditions such as type II diabetes, hypertension, hyperlipidemia, cardiovascular disease, sleep apnea, asthma, and certain cancers.[5,6] Dental caries in children is also associated with pain, systemic infection, poor speech development, difficulty eating, disrupted sleep, lack of concentration, and school absenteeism.[2,4]

During 2010-2011, more than 1 in 5 children in the US lived in poverty, reflecting the highest rates in recent history.[7] Furthermore, the US Census Bureau's 2010 American Community Survey[8] revealed the poverty rate for Hispanic children was 32.3%, almost double the rate for white children. The 2010 Pediatric Nutrition Surveillance System (PedNSS)[9] data showed obesity prevalence among low-income children aged 2-4 years enrolled in federally funded programs was 14.4%. Similarly, NHANES 1999-2004 data[3] showed 54.3% of children aged 2-11 living below the federal poverty level (FPL) had dental caries, compared to 32.3% of children living at 200% or above the FPL.

Coinciding with the increase in childhood poverty, the Hispanic population in the US grew by 43% between 2000 and 2010, and Mexican Americans accounted for about 75% of this growth.[10] This is an important factor when considering the prevalence of obesity and dental caries among Mexican Americans is high compared to non-Hispanic white children. NHANES 2007-2008 data[11] showed the obesity prevalence of Mexican American children aged 2-5 years was 13.7%, compared to 9.1% among non-Hispanic white children. Likewise, NHANES 1999-2004 data[3] revealed the prevalence of dental caries among Mexican American children aged 2-11 years was 55.4%, compared to 38.6% non-Hispanic white children.

Statement of Purpose

The purpose of this study was to investigate the relationship between Body Mass Index (BMI)-for-age and dental caries within a purposive sample of predominately Hispanic, low-income children enrolled in a Head Start preschool program in South Texas.

Research Questions

The current study asked the following questions:

1. Was there a relationship between BMI-for-age percentile and caries severity (dmf index) among at-risk preschool children?

2. Were there significant differences in caries severity (dmf) or the prevalence of dental caries, untreated decay, and ECC between the four BMI categories (underweight, healthy, overweight, and obese) among this at-risk preschool population?

3. What was the relationship between dental caries, ECC, untreated decay, and obesity among this at-risk population?

Rationale

Obesity and dental caries are multifactorial diseases that share some common etiologic and facilitating risk factors including frequent consumption of sugar-sweetened beverages (SSB),[12-15] parental misperceptions and attitudes,[16-18] and poor eating habits associated with increased television viewing.[19-21] In addition, Hispanic children from low-income families have higher rates obesity and dental caries.[2,3,9] Therefore, it is important to examine the relationship between these diseases within growing at-risk populations.

Implementing prevention and intervention strategies for both diseases during the pre-school years is ideal because the occurrence of obesity or dental caries early in life influences health in adolescence and adulthood.[4,5] An interprofessional approach between primary healthcare professionals and dental professionals can offer a unique opportunity to help prevent and treat these two prevalent childhood diseases. The Surgeon General Report in 2000 stated,[2] “oral health is essential to the general health and well-being of all Americans,” and suggested the need for healthcare practitioners to incorporate oral health into their daily practice. Similarly in 2003, Dovey and colleagues[22] stated in *Pediatrics*, "dental clinics could serve as an important source of health promotion, disease prevention, and screening for non-oral health-related problems." Most recently in 2011, the Institute of Medicine (IOM) published two separate reports, *Early Childhood Obesity Prevention Policies*[23] and *Advancing Oral Health in America,*[24] which recommended a need for increased research and interprofessional training to address both diseases. However, for this approach to be effective, researchers and clinicians need a better understanding of the relationship between childhood obesity, dental caries, and other related factors, particularly among at-risk populations. Evidence-based data could be used to establish interprofessional best practice guidelines for risk assessment tools and diagnosis, as well as education and prevention interventions.

Studies investigating the relationship between obesity and dental caries are inconclusive,[25,26] and limited data are available for children under 5 years, particularly among Hispanic children from low-income families. The current study purposively chose a homogenous population with similar at-risk socioeconomic factors to examine the relationship between childhood obesity and dental caries.

Assumptions

It was assumed a high proportion of Head Start children would receive their BMI and dental assessments within 90 days of each other, and there would not be a meaningful change in participant's BMI or dental status within this time frame.

Delimitations and Limitations

Participants in this study were delimited to include Head Start children from low-income and predominately Hispanic families.

Limitations include:

1. Generalizability is limited because a purposive sample was used.

2. Decayed, missing and filled teeth were used to calculate the dmf indices, which could be overstated if teeth were filled or missing due to reasons other than decay.

3. Dentists determined dmf scores by visual evaluations without radiographs; therefore, dmf scores could be understated.

4. Participating dentists and Head Start health staff received training with defined procedures and criteria, but a calibration study was not conducted.

Definitions

1. At-risk: defined in this study as an increased probability of experiencing obesity and/or dental caries due to socioeconomic factors.

2. Body Mass Index (BMI): a number calculated from a child's weight, height, and age (in months); BMI is a reliable indicator of body fatness for most children.[27]

3. BMI-for-age Percentile: BMI score is plotted on the CDC BMI-for-age growth charts (sex specific) according to the child's age (in quarter years) to obtain the percentile ranking, which "indicates the relative position of the child's BMI number among children of the same sex and age".[27]

4. BMI-for-age Weight Categories (BMI Categories): the percentile ranking on the CDC BMI growth chart determines the child's BMI weight status category, i.e., underweight ($<5^{th}$ percentile), healthy weight (5^{th} - $<85^{th}$ percentile), overweight (85^{th} - $<95^{th}$ percentile), or obese ($\geq 95^{th}$ percentile).[27]

5. Caries Experience: the presence of either untreated or treated tooth decay.[28]

6. Caries Prevalence: defined in this study as the proportion of a population that has dental caries.

7. Dental Caries: a multi-factorial disease process that brings about the demineralization of tooth structure (tooth decay).[28]

8. Decayed, missing, filled (dmf) Index: a common population-based measure of caries severity, which is calculated by the sum number of deciduous (primary) teeth that are decayed, missing, and filled for children aged 3-5 years; the minimum index number for a child is zero, and the maximum number is 20. Note: Missing teeth ("m") were calculated in this study unless it was known that the tooth was missing due to trauma because teeth are fully erupted and have not begun to exfoliate in children aged 3-4 years.[28]

9. Early Childhood Caries (ECC): commonly referred to as "baby bottle tooth decay"; defined in this study as a disease condition in which a child has 1 or more cavitated, missing, or filled smooth surfaces in the primary anterior maxillary teeth.

10. Head Start: a federally funded program for children living in poverty that promotes comprehensive child development services to preschool-age children and their families in an effort to promote school readiness.[29]

11. On-site: located at a Head Start center.

12. Risk Factor: a factor that increases the probability an individual will experience a disease.[28]

13. Untreated Decay: defined in this study as presence of an untreated obvious carious lesion(s) detected by a dentist using a light source, loupes, and explorer.

CHAPTER II

LITERATURE REVIEW

Purpose

The purpose of this study was to investigate the relationship between Body Mass Index (BMI)-for-age and dental caries within a purposive sample of predominately Hispanic, low-income children enrolled in a Head Start preschool program in South Texas.

Introduction

Childhood obesity and dental caries are diseases that can have life-long negative consequences for individuals and communities.[4,5] Childhood obesity rates in the United States (US) have more than doubled for preschool-aged children and tripled for all children and adolescents in the past 35 years.[1] Additionally, caries prevalence in children aged 2-5 years showed a significant increase from 1988-2004 to 1999-2004.[3] Researchers understand childhood obesity and caries are multifactorial diseases that share some common etiologic and facilitating risk factors.[12-14,17,19,20] Studies focused on how the dietary and socioeconomic changes during the past several decades may be contributing to these increased disease rates are of particular interest. Specifically, changes in dietary habits (related to sugar consumption and television viewing), parental perceptions, and socioeconomic factors were examined in this literature review. A summary of studies that have investigated the relationship between children's weight status and caries were also included in this review.

Childhood Obesity and Dental Caries: Dietary Risk Factors

Although disease mechanisms differ for childhood obesity and dental caries, they share some common dietary etiological risk factors. Specifically, sugar-sweetened foods and beverages and dietary patterns associated with increased television viewing are of particular concern. Consumption of caloric sweeteners peaked in 1999 with the average American consuming 151.3 pounds per year.[30] Since 1999, consumption per capita has decreased to an estimated average of 130.2 pounds in 2011.[31] However, NHANES 2005-2008 data[32] indicated the mean percentage of total kilocalories consumed from sugary drinks (fruit drinks, sodas, energy drinks, sports drinks, and sweetened bottled water) for children and adolescents in low-income households is 8.2%, compared to 6.6% among children in high income households. Additionally, increased television viewing has been associated with increased snacking on sugar-sweetened foods and beverages, as well as overall poor dietary habits.[19]

Childhood Obesity: The Role of Sugar-Sweetened Beverages and Foods. In a systematic review of sugar-sweetened beverages (SSB) effect on weight gain, Malik et al.[15] concluded there is strong overall evidence that consumption of SSB, particularly sodas, has a direct and independent role in promoting weight gain. Similarly, the *Growing Up Today*[33] study, which included followed 11 654 children aged 9-17 years for 3 years, found a significant positive association between consumption of SSB (versus sugared foods) and increased BMI prior to adjusting for total energy intake. The authors concluded SSB probably contribute to weight gain in adolescents due to its effect on total energy intake. Ludwig et al.[34] studied 548 pre-adolescents over a 19 month period and found both baseline consumption of SSB and an increase in SSB consumption independently predicted an increase in BMI. Furthermore, the odds ratio for obesity increased by 60% for each additional serving of SSB consumed. A larger cohort study by Welsh et al.[35] also found that in low-income children aged 2-3 years, consumption of sweet drinks increased the odds of becoming overweight among those at risk for overweight at baseline, and of remaining overweight among children who were already overweight by 60% or more. In contrast to the dose-response rate found by Ludwig and colleagues, Welsh et al. found a threshold of $\geq$ 1 SSB.

Experimental studies investigating the association between SSB beverages and weight gain have primarily been conducted in adult populations and have shown a significant decrease in body weight when there is a decrease in the consumption of SSB.[15] This was also found in a 1-year cluster-randomized control trial on children aged 7-11 years by James et al.[36] in the United Kingdom. Results showed a school-based nutrition education program aimed specifically at reducing soft drinks was successful in decreasing consumption by .6 glasses, which was associated with a .2% decrease in overweight and obesity prevalence. In comparison, the control group showed an increase in soft drinks by .2 glasses, which was associated with a 7.5% increase in overweight and obesity prevalence.

Research discrepancies do exist when examining the relationship between SSB and changes in BMI, particularly when studying preschool-age children. Newby et al.[37] conducted a prospective cohort study of 1345 low-income children aged 2-5 years in North Dakota and did not find an association between SSB and weight change or BMI. However, the duration of follow-up of 6-12 months may have been insufficient to determine a relationship in young children.[15] For example, results from 3 long-term prospective cohort studies in adults suggested replacing SSB or fruit juices with water is associated with lower long-term weight gain.[38] In addition, O'Conner et al.[39] performed a cross-sectional secondary data analysis of 1160 preschool children from the NHANES 1999-2002 and found that although daily total energy intake increased with increased consumption of SSB, the weight status of a child or increase in BMI was not associated SSB.

A 10-year longitudinal study[40] investigated high energy snack foods and beverages in initially non-obese pre-adolescent girls and found soda was the only energy-dense snack significantly related to increased BMI scores. Evidence has suggested this is due to the low satiety of liquids; therefore, there is less energy compensation at subsequent meals with sugary drinks as compared to high energy snack foods.[15,40] Although there is less evidence that high energy snack foods are independently associated with weight gain, a review by Swinburn et al.[14] concluded there was convincing evidence that a high intake of energy-dense, nutrient-poor foods is a risk factor for obesity.

The majority of prospective and experimental studies with adequate sample sizes conclude there is a relationship between consumption of SSB and weight gain.[15] Furthermore, increased consumption of energy-dense snack foods may promote weight gain.[14] Malik et al.[15] discussed the importance of sufficient follow-up time for studies that examine the longitudinal relationship between SSB and weight gain, especially among preschool-age children.

Dental Caries: The Role of Sugar-Sweetened Beverages and Foods. The etiology of dental caries is multi-factorial which requires a susceptible tooth, cariogenic bacteria (*Mutans streptococci* or MS), and specific dietary factors (fermentable carbohydrates).[41] Sucrose, commonly referred to as “table sugar”, has been identified as particularly cariogenic. When MS metabolize sucrose, acids are produced that is ultimately responsible for demineralization of tooth structure. *Mutans streptococci* also require sucrose for production of extracellular glucan. Glucan allows MS to adhere to the tooth structure and also provides energy necessary for MS proliferation.[42] Although sucrose is particularly cariogenic, it is important to note that fermentable carbohydrates include all mono-, di-, and poly-saccharides that can be metabolized by bacteria to produce acids.[43] Additionally, protective factors, such as saliva, fluoride exposure, and good oral hygiene can hasten the cariogenic effect of fermentable carbohydrates.[42]

The relationship between sugar and dental caries has been researched for over 150 years.[12] Classic studies in the 1940’s, 1950’s, and 1960’s, such as the *Vipeholm Dental Caries Study*,[44] the *Hopewood House Study*,[45] and *Turku Sugar Studies*[46] raised awareness of the important role sugar has in the etiology of dental caries. However, a more recent comprehensive review of sugar and dental caries by Anderson et al.,[12] utilizing modern Cochran guidelines revealed only 31 studies published between 1856 and 2007 met the standards for inclusion. Of these, only 6 studies demonstrated a positive relationship of sugar quantity to caries; moreover, 19 studies showed a positive relationship of sugar frequency to dental caries. Anderson and colleagues concluded there is a significant relationship of sugar frequency to dental caries, but there is not enough evidence to support a relationship of sugar quantity to dental caries.

A 10-year prospective study [47] in Finland examined the association of long-term sucrose consumption and caries experience and found children who consumed the highest amount of sucrose had twice the frequency of dental caries as children who consumed the lowest amount of sucrose. The authors also found that children established a high sucrose intake pattern by 2 years of age, suggesting that food habits are adopted very early in childhood. Furthermore, the authors noted both the low and high sucrose groups were similar in all of the following preventive categories: tooth-brushing habits; plaque levels; fluoride exposure; and xylitol exposure. They concluded that one of the most likely causes of the differences in caries is sucrose consumption because protective factors were similar in both groups. Notably, this study did not find differences in total energy intake or weight gain between the two groups.

There have been a number of conflicting studies investigating the caries risk of specific sugar- and starch- containing foods and beverages, as well as, exploring caries risk associated with the timing of exposure, i.e., meals versus snacks.[12,13] A cross-sectional study[48] analyzing data from the 1994-1998 Third National Health and Nutrition Examination Survey (NHANES III) found the only significant associations between soda consumption and caries experience were seen in persons over 25 years of age. The authors concluded this may be due to the cumulative effect of long-term soda consumption. However, a longitudinal study[49] of low-income African-American children and their families found that higher consumption of sodas was a significant predictor of higher caries increment.

Conversely, different results were found in a prospective study[13] of children beginning at 12 months of age, which examined the caries risk associated with intake of specific foods, beverages, and timing of exposure. The authors concluded that sodas and other SSB increased caries risk more than 100% fruit juices, and timing of beverage consumption had minimal impact on caries risk. In addition, timing of food exposures was more associated with caries risk than the risk associated with specific sugar-starch food categories. Sugar exposures during snack time seemed to increase caries risk, while exposures at meals appeared to decrease risk. The authors suggested this may be due to buffering factors in other foods and quicker clearance of carbohydrates during mealtimes. Some evidence for associated caries risk from cariogenic snacks was reported in a longitudinal study[50] which followed children from age 1 through 15 years. This study found approximal caries at 15 years of age was significantly associated with consumption of sweets at ages 1-3 years.

Dye et al.[51] analyzed NHANES 1988-1994 data to examine the relationship between healthy eating habits and dental caries in children aged 2-5 years. The authors found children with poor eating habits were more like to have caries, and that poverty and being Mexican American were significant effect modifiers in this relationship. The findings also showed that healthful eating practices were more significantly associated with caries than BMI measures after adjusting for known caries risk factors, such as race/ethnicity and dental visit utilization.

Overall, the majority of prospective research on dental caries among preschool children supports the hypothesis that increased frequency of sugar-sweetened beverages and snacks is associated with increased caries risk.[12,13,42] Trends of children’s increased sugar consumption and snacking, particularly sodas and its effect on dental caries, should continue to be investigated.

Dietary Habits Related to Television Viewing. Daily in the US, the average child under 6 years of age watches approximately 80 minutes of television and is exposed to nearly 4 hours of background television.[52] The Framingham Children's Study [20] offered important evidence that television watching is an important independent predictor for changes in body fat. The 7-year prospective study repeatedly measured television viewing and anthropometry of 106 children aged 4-11 years. Unlike previous studies, researchers controlled for body fat of both parents and the child's body fat at baseline. Researchers found at baseline (4 years of age) there was no apparent association between BMI, body fatness and television viewing habits. However, as the children aged, the children who watched more television (>3.0 hours/day) had significantly higher mean BMIs and skin-folds than children whose watched less television (<1.75 hours/day).

Researchers have hypothesized the dramatic increase of childhood obesity is associated with increased television viewing due to one or more of the following[21]: (1) reduced physical activity (2) decreased resting metabolic rate and/or (3) increased dietary intake while watching television or from the effect of food commercials. When investigating the relationship between childhood obesity and dental caries, it is important to examine the associated dietary habits related to television viewing, specifically consumption of sugared foods and beverages and total energy intake.

Several important studies have concluded that television viewing affects children's dietary consumption and total energy intake. The GENESIS Study[53] sampled 2374 children aged 1-5 years in Greece and found that even after adjusting for confounders, children who spent more than 2 hours per day watching television had a significantly higher intake of fat, simple carbohydrates (sweets, sodas, etc.), and total energy, compared to children who watched fewer than 2 hours of television per day. Additionally, data from the Longitudinal Study of Child Development[54] in Quebec, which followed children from 5 months through 5 years of age, showed an association between children who consumed snacks while watching television daily and higher BMI. These children also consumed more carbohydrates, sodas, fat, and consumed fewer fruits and vegetables. Data collected from the World Health Organization's 2001-2002 Health Behaviour in School-Aged Children Survey[19] — which included 162 305 European and North American children aged 11, 13, and 15 years — found a significant relationship between increased television viewing and higher intakes of sweets and sodas. In addition, the authors found that in the majority of countries, including the US, increased television viewing was associated with less consumption of fruits and vegetables and lower socioeconomic status.

Television commercials have an effect on children's food preferences. In a randomized controlled trial,[55] researchers found one, 30-second food advertisement can significantly affect preschool children's food preferences. Additionally, results of a prospective observational study[56] of middle school students showed an increase of 1 hour of television viewing per day was associated with increased consumption of foods commonly advertised, as well as an additional 167 kilocalories. In New Zealand, data analysis of a cross-sectional survey[57] of 3275 children aged 5-14 years showed children with the highest television viewing were significantly more likely to consume commonly advertised foods. Specifically, children who watched more than 2 hours of television per day were more than twice as likely to consume ≥5 sodas per week.

Thompson et al.[58] analyzed the content of food and drink commercials aired after school on 2 Spanish-language television stations in the US. They found that 2.5 food and drink commercials aired per hour, which were predominately fast foods and sugared drinks advertisements. They concluded advertisements on Spanish-language television may play a role in the high risk of overweight Latino children.

Evidence from multiple studies have indicated children with increased television viewing tend to have higher daily intakes of sugar, fat, and total energy.[19,53,54] Food advertisements on television have been associated with the unhealthy food preferences of children.[55-57] Consequently, children who watch more television tend to have higher BMI scores than children who watch less television.[20,54] In addition, frequent consumption of sugared foods and beverages increase the risk for dental caries.[12]

Childhood Obesity and Dental Caries: Parental Perceptions and Attitudes

Parental perceptions and attitudes related to childhood obesity and dental caries affects parents' ability to establish preventive habits at-home, identify signs of disease, and seek treatment. Therefore, it is important to investigate current parental perceptions and attitudes, particularly the parents of young children because health habits are usually formed during early childhood.[16-18] Furthermore, understanding the perceptions and attitudes of groups where disease rates are the highest is vital, so health professionals and health educators can be more effective in implementing prevention strategies with parents.[17,59]

Parental Perceptions and Attitudes Related to Childhood Obesity. Obese preschool children are more likely to be obese throughout childhood and adulthood.[5,18] Parents' perception and awareness of their child's weight status is vital to successful obesity prevention.[18,60] Therefore, it is important to investigate parental perceptions of weight status while the child is preschool-age or even younger because parental beliefs can shape feeding practices.[18,61]

There is consistent research demonstrating parents of overweight or obese children tend to have misperceptions of their child's weight status.[61,62] Results from a cross-sectional survey[18] of mothers with children aged 2-5 years from diverse socioeconomic backgrounds found 95% of the obese mothers perceived themselves as overweight. However, only 21% of the mothers of overweight children perceived their child to be overweight; and just 29% of the mothers of obese children believed their child to be overweight. Low maternal education was the only factor found to be statistically associated with this misperception after adjusting for income, age of the child, age of the mother, smoking status, maternal obesity, race and sex. Another survey[60] administered to parents of predominately white children aged 4-8 years showed parents of overweight children did not differ from parents of children in other weight categories in their concern for the health risks of excess weight, or in their knowledge of healthy eating habits. However, parents of overweight children significantly differed in their accuracy of the perceived weight of their child. Only 10.5% of parents of overweight children accurately perceived their child's weight, compared to 59.4% of other parents.

Hispanic children are disproportionately affected by childhood obesity, with one of the highest prevalence rate in the US.[5,9] A purposive survey[63] of 200 predominately low-income Hispanic parents of obese children aged 2-5 years revealed 78% of parents were knowledgeable of the cardiovascular risk of obesity; however, 35.5% of the parents of obese children did not perceive their child as being overweight. When parents were asked what they had done to control the child's weight, 37% responded they had done nothing; 48% said they tried to reduce snacks high in fat and sugar; 3.5% attempted to give fewer sodas, juice, or Kool Aid; and 5% considered exercise.

Qualitative research has also been conducted to determine Hispanic parental perceptions of overweight children. One such study[62] recruited 11 acculturated Mexican American immigrant parents of preschool-aged children to participate in a focus group. The purpose of the study was to explore how participants perceived the meaning of excess weight in childhood and its relationship to health. The authors found the parents associated excess weight to poor health, which is contrary to earlier studies which suggested Mexican Americans view excess child weight as a sign of health. Participants attributed the causes of overweight or obesity to "poor self-care" as a result of "poor self-esteem", and believed that prevention was the parents' responsibility. However, many parents demonstrated uncertainty on how to "know" or determine if their own child was overweight. Participants attributed cultural differences and abundant lifestyles in the US to excess weight in the Mexican immigrant population. Ironically, the parents in this study felt pressure to work longer hours (leaving their children unsupervised), and to provide US abundances commonly associated with obesity (snack foods, fast food, television, and video games).

In comparison, a qualitative study[59] of low-income Latina mothers and grandmothers of preschool-age children in California revealed they also had difficulty acknowledging their children were overweight, but did not associate weight status with poor health. In fact, when viewing pictures of children who were thin to very heavy, the participants often identified heavier children as looking the healthiest because their hair was "healthy and shining", their skin was "full of life", and they had a "very happy expressions." Other themes which emerged from the focus group included the following: (1) participants identified overweight as a condition that caused children to be tired, sick, or teased by peers; (2) they believed overweight young children will "grow out of it"; (3) genetics determines a young child's weight; and (4) mothers are hesitant to label their child as overweight despite it being suggested.

While parental recognition of children becoming overweight is vital to prevention of childhood obesity, research demonstrates that parental perception is often inaccurate, especially among under-educated, ethnic minorities.[18,59,63] Healthcare professionals and health educators need to learn effective and culturally competent education strategies for counseling parents on how to recognize the signs and consequences of childhood obesity in at-risk population.[62]

Parental Perceptions and Attitudes Related to Dental Caries. Parental perceptions and attitudes of their children's oral health affect implementation of caries prevention at-home and utilization professional dental services.[16] This is especially true for young children who are often unable to verbalize discomfort and are dependent on parental care.[16] The research available on how parental perceptions of their children's oral health also tend to be related to socioeconomic disparities.[49,64]

The 2003 National Survey of Children's Health (NSCH)[64] revealed stepwise disparities in parental perceptions of their children's oral health status by race/ethnicity and income. The percentages of parents who report their children's teeth to be in "excellent or very good condition" are as follows: 76.4% of white parents; 61.1% of African-American parents; and 46.7% of Hispanic parents. In addition, 48.8% of low-income parents perceived their children's teeth in "excellent or very good condition," compared to 82.8% of high-income parents. Accurate parental perceptions of the condition of their children's teeth tended to be slightly better than parental perceptions of their children's weight status. Fifty-five percent of children whose parents reported their child's teeth to be in "fair or poor condition" actually had cavities.

Data from NSCH[64] also suggested the majority of parents were unaware of the professional recommendation that children should receive preventive dental services no later than 12 month of age. In 2003, 10.1% of 1 year-olds, 23.8% of 2 year-olds, and 50.5% of 3year-olds visited the dentists within the past year; however, only .9%, 2.1%, and 4.3% (respectively) had parents who reported their child needing a preventive dental visit but did not receive it. Additionally, parents reported the most common reason they did not access dental care for their children was related to cost.

It is important to investigate parental perceptions and attitudes of oral health as they relate to different ethnic and socio-economic groups to better understand how to educate and motivate parents on establishing good oral health behavior for their children.[17] A cross-sectional, international study[17] of children aged 3-4 years and their parents examined this phenomenon. Specifically, this study investigated if parental attitudes towards tooth brushing twice daily and sugared snacks were associated with these behaviors being established by their children. The authors found parental attitudes did influence behaviors, and the strength of attitudes varied between different ethnic groups. The majority of parents viewed tooth decay as a serious condition for children and intended to establish healthy oral health behaviors. However, the authors found a key predictor of healthy behavior occurring was parental efficacy (how effective parents believed they would be in consistently implementing the behavior). Furthermore, parental attitudes towards prevention were least likely to predict brushing twice daily. The authors concluded that while parents accept preventive messages, it may be more important for health professionals to help families implement behaviors.

The rate of untreated dental decay for Mexican American preschool children is almost double the rate for white preschool children.[65] Yet there has been little research on Mexican American parental perceptions of oral health. One qualitative study[66] investigated how rural Mexican immigrant parents interpret children's dental symptoms and what motivates them to seek dental treatment for their child. The following themes emerged: 1) parents defined "healthy" teeth as "white", "clean", and free of pain; 2) parents perceived cavities as "stains" that could be removed by "cleanings"; therefore, many delayed seeking help; 3) parents' decision to seek treatment was dependent on visible signs of a "problem" and children's complaints of pain; however, children's complaints often had to be verified by parents seeing visible signs. The authors noted most of the parents did not experience dental decay when they were children living in rural Mexico (due to non-cariogenic diets) and this may have influenced their lack of understanding and misinterpretations of dental decay. The authors concluded that rural Mexican immigrants need to be educated on the increased importance of dental care and prevention in industrialized countries with cariogenic diets.

Another parental misperception of dental caries is dental fatalism, which can be defined as the belief that most children will develop cavities regardless of efforts to prevent them.[49] In a longitudinal study[49] of low-income African-American children and their families, researchers found that dental fatalism was a significant predictor of higher caries increment.

Disparities by race, ethnicity, and income are evident in how parents perceive the oral health status of their children.[64] Parents tend to be uneducated regarding the recommendation that children receive routine preventive dental care by 12 months of age.[64] Research suggests parents tend to view tooth decay in children as a serious problem; however, correct identification of the signs of disease and dental utilization may be related to race/ethnicity, cost, insurance status, and their own personal experiences.[17,66] Furthermore, parental self-efficacy toward implementing preventive oral health behaviors seems to be an important factor for parents establishing good oral health behaviors with their children.[16,17]

Childhood Obesity and Dental Caries: Socioeconomic Risk Factors

The percentage of children living in poverty has steadily increased over the past several years in the US. In 2010, the US Census Bureau's American Community Survey (ACS) revealed 21.6%, or 15.7 million, of US children lived in poverty, compared to 16.9% of children in 2001.[7] The Hispanic population is the fastest growing population in the US, increasing 43% between 2000 and 2010.[10] The ACS also showed the poverty rate among Hispanic children was 32.3%, almost double the rate among non-Hispanic white children.[7] This is important when considering Hispanic children from low-income families have higher rates obesity and dental caries.[3,9] Therefore, it is important to examine the relationship of both diseases within this growing at-risk population.

The 2010 Pediatric Nutrition Surveillance System (PedNSS) data[9] showed obesity prevalence among low-income children aged 2-4 years enrolled in federally funded programs was 14.4%, compared to 12.1% of all US children aged 2-5 years in NHANES 2009-2010.[1] Similarly, NHANES1999-2004 data[3] showed 54% of poor children aged 2-

11 had dental caries, compared to 32% of children from high incomes. Furthermore, NHANES 2009-2010 data[67] showed 25.1% of children aged 3-5 years living below the Federal Poverty Level (FPL) had untreated decay, compared to 10.5% living above the FPL.

NHANES 2009-2010 data[1] showed the obesity prevalence of Mexican American children aged 2-5 years was 23.8%, compared to 16.1% among non-Hispanic white children. Likewise, NHANES 1999-2004 data[3] revealed the prevalence of dental caries among Mexican American children aged 2-11 years was 55.4%, compared to 38.6% non-Hispanic white children. Furthermore in 1999-2002, 39.1% of Mexican American children aged 2-5 years living 100% or below the FPL had untreated dental caries, compared to 19.3% of all children aged 2-5 years.[65]

There is evidence that childhood poverty, particularly during early childhood, is associated with poorer health outcomes, including childhood obesity and dental caries.[2,68,69] An 11-year longitudinal study by Marshall et al.[70] found that obesity and dental caries coexisted in children of low socioeconomic status (i.e., they had an increased risk for both obesity and caries). Researchers have hypothesized this association is related to lower parent education, children exposed to fewer role models of people with healthy behaviors, and less access to healthcare and stores that sell healthy foods.[68,71]

Studies Investigating the Relationship between Childhood Obesity and Dental Caries

Studies investigating the relationship between body mass and dental caries are inconclusive.[25,26] Furthermore, there are limited studies that have investigated this relationship among preschool children in at-risk populations.[26] In 2006, a systematic review by Kantovitz et al.[26] found only 7 papers that met the inclusion criteria. Three of the studies provided a high level of evidence, "Grade A", which had conflicting results. The authors concluded there is a need for additional well-designed randomized studies to determine the relationship between obesity and dental caries.

Several studies, predominately conducted outside of the US, have demonstrated a positive association between overweight or obesity and dental caries in children. A study among German elementary school children by Willerhausen et al.[72] in 2004, which was classified as "Grade A" by Kantoviz et al.,[26] found that children with BMI scores in the healthy category had significantly fewer caries in their primary and permanent teeth than overweight children. This significance was not found with the obese children. Similar results were found in a later study by Willerhausen et al.[73] of 1290 German children aged 6 to 11 years, which found that BMI was an independent risk factor for caries frequency in the primary and permanent dentition. Notably, the daily consumption of sweets, age, and gender also showed a significant correlation to dental caries. However, the Willerhausen et al. studies used BMI scores which are not as meaningful as BMI age percentiles in growing children and adolescence.[74]

A study[75] of 500 children aged 8-12 years in India investigated the relationship between BMI, caries experience, and dietary preference. The results showed obese and overweight children to have a significantly higher prevalence of caries than healthy or underweight children in the primary dentition. In the permanent dentition, obese and overweight children continued to have a significantly higher prevalence of dental caries than healthy weight children; however, underweight children had the highest prevalence of caries. The authors suggested this may be due to malnutrition during tooth development in early childhood. This study also found obese and overweight children preferred sweet and fatty foods significantly more frequently than healthy weight children. The authors concluded that increased frequency of sweet and fatty foods was related to increased weight, which therefore had a positive relationship to caries prevalence in children. Another study by Alm et al.[50] of 15 year-old adolescents in Sweden showed obese individuals had more than double the amount of approximal carious lesions and fillings compared with low- and healthy- weight individuals. The authors also found frequent consumption of cariogenic snacks during early childhood was significantly associated with caries at 15 years.

There are limited data available for young children, particularly among minority children from low-income families. One study[76] investigating the relationship between obesity and dental caries among 104 low-income Mexican American children aged 12 to 24 months found children with higher caries experience tended to have higher BMI scores than those with less caries. However, there were several limitations in this study, including the dental exams were performed by non-dental health professionals and the authors created their own weighted scoring system to determine caries experience. A study of 1160 Mexican preschool children aged 4-5 years by Vazquez-Nava et al.[77] did find a significant association between overweight and obese children and dental caries in the primary dentition. When the authors compared overweight and obese children to normal weight children, they found overweight children had 1.94 times greater risk of caries and obese children had 1.95 times greater risk. Another study[49] that followed low-income African-American children from birth to 5 years for 2 years found greater weight-for-age was one of the significant predictors of higher caries increment, but the authors noted the association was inconsistent and did not demonstrate a clear dose-response relationship. Finally, a longitudinal study by Marshall et al.[70] followed a diverse socio-demographic group of children from birth to 11 years found overweight children had significantly higher caries rates than healthy or obese children. Stepwise logistic regression models showed the two variables which predicted caries experience were overweight status and mother's education. The studies by Vazquez-Nava et al. and Marshall et al. did not include children who were underweight.

Conversely, several cross-sectional studies have not found a significant association between obesity and dental caries in children. A cross-sectional data analysis of children aged 2-18 years from the NHANES III (1988-1994) and NHANES 1999-2002 by Kopycka-Kedzierawski et al.[78] showed no evidence to support that overweight or obese children have an increased risk of dental caries after controlling for potential confounding variables. In fact, the NHANES III data analysis suggested obese children may be associated with decreased caries risk in older children. Macek et al.[79] also analyzed BMI-for-age and dental caries data of children 2-17 years old from the NHANES 1999-2002 and did not find an association between BMI-for-age and caries prevalence; however, the authors did find that caries severity (geometric DMFT) was significantly less severe in the permanent dentition among overweight children than in normal weight children. Hong et al.[80] examined NHANES 1999-2002 data of 1507 young children aged 2-6 years. The authors only found a significant association between obesity and caries in the 5-6 year olds when they stratified by age and ethnicity. They also found significant associations in the Hispanic and Black strata when they compared overweight children to healthy weight children in the same age group. However, no association was found between obesity and caries after controlling for age, race, and income status. More recently, a cross-sectional study[81] of 200 patients aged 8 or younger who were treated a New Zealand dental school showed no significant association between BMI and caries experience.

A few studies have been conducted within specific populations in the US with varying results. A recent secondary data analysis by Sheau-Huey et al.[82] of predominately African-American (64%) children aged 2-17 years living in a homeless shelter found that as BMI increased, caries did as well; however, the positive association was not statistically significant (P =0.08). This positive association was not found among a cohort of 135 predominately African-American patients (mean age 8.7 years) at an urban dental school in Pennsylvania. Pinto et al.[83] found no correlation between caries in obese or non-obese children (p = .99). Additionally, a retrospective case study by Sheller et al.[84] of 293 children aged 2-5 years with Severe Early Childhood Caries did not show a correlation between BMI percentiles or caries experience. Similar to the Sheller and colleagues study, a retrospective case-control analysis of children aged 3-6 years by Vania et al.[85] did not show a typical weight distribution among children with caries when compared to caries-free children. However, they did find there were significantly more children in the caries groups that were underweight than in the caries-free group (10% vs. 4.94%). Werner et al.[74] found comparable results in a 3-year retrospective review of patients aged 6-9 years at a dental school in North Carolina. The authors found overweight and obese children had significantly fewer caries in the primary teeth than underweight/healthy weight children.

There is inconclusive evidence to support a relationship between childhood obesity and dental caries. Some research suggests if a relationship exist, it is closely linked to dietary habits during early childhood and other socio-demographic factors.[13,49,51,70] The majority of evidence which does not support an association between children's weight status and dental caries comes from cross-sectional secondary data analysis among diverse populations.[51,78] Kantovitz et al.[26] suggested conflicting results may also be due to differing methodologies used in individual studies, while Dye et al.[3] suggested most studies fail to control for dietary confounding variables. A limited number of studies have investigated this relationship among specific at-risk populations; therefore, additional studies are needed in order to determine if a relationship exists among these groups.

Summary

Childhood obesity and dental caries are complex, mulitfactorial diseases that share some common etiological and socio-demographic risk factors. Dietary habits, specifically frequent consumption of sugar-sweetened foods and beverages, play an important role in the occurrence of both diseases. Kantovitz et al. stated,[26] "the triangular relationship of sugar, dental caries, and obesity needs to be further explored." Increased television viewing has been associated with unhealthy dietary habits, namely, increased intake of sugared foods and beverages.[21] In addition, minority children from low-income families have higher rates of both diseases. National trends of increased sugar consumption, increased television viewing, increased rates of childhood poverty, and an increased Hispanic population in the US should prompt particular investigation of how these factors affect the relationship between childhood obesity and caries. Parental perceptions and attitudes among at-risk groups should be examined more closely in order for health professionals to develop effective prevention and intervention strategies for parents. Finally, there is inconclusive evidence on the relationship between childhood obesity and dental caries, with limited data on low-income, Hispanic preschool-aged children in the US. Further research is needed to determine if there is a clear relationship, especially among at-risk populations.

CHAPTER III

METHODS

The purpose of this study was to investigate the relationship between Body Mass Index (BMI)-for-age and dental caries within a purposive sample of predominately Hispanic, low-income children enrolled in a Head Start preschool program in South Texas. This was accomplished through secondary data analysis of 237 randomly selected participants. The dental assessments were performed on-site by dentists from the local health department, and the height and weight measurements were obtained by Head Start health staff. BMI-for-age scores and percentiles were calculated by the Head Start database (Child Plus). Dentists determined each child's decayed, missing, and filled (dmf) index, as well as caries experience, and presence of untreated decay or Early Childhood Caries (ECC). Data were analyzed using IBM SPSS (version 20). The methods for collecting and analyzing the data are covered in this chapter and were approved Texas State University's Institutional Review Board prior to conducting the study.

Participants

The participants were children aged 3-5 years enrolled in a Head Start program in South Texas. The program was comprised of 88 centers located within a large urban area. The Head Start population was socioeconomically homogeneous with the following characteristics: 87% were Hispanic or Latino, and 95% were living in households at or below the Federal Poverty Level (FPL). A proportionate sample based on age was randomly selected from a population of 7574 children enrolled in the Head Start program for at least 1 day throughout the school-year. The participants were randomly selected using an online random numbers generator. To achieve a representative sample, from this homogeneous group, 237 participants were selected.[86] Eligibility of the participants was based on the following criteria for each child: complete demographic, dental assessment, and BMI data were available; each child's dental assessment and BMI assessment were completed within 90 days of each other; and the dental assessment was completed by a dentist from the local health department.

The study was approved by the Texas State University's Institutional Review Board prior to data collection. Parents completed socioeconomic and demographic information during the application process prior to a child's enrollment. Written parental consent was obtained for release of medical information to the Head Start program. In addition, parental consent was required for all on-site dental examinations. Data collected during a child's Head Start enrollment, including demographic, health, and dental information were collected in the Head Start program's password protected database and anonymous raw data were reported to US Department of Health and Human Services (HHS). The raw data are classified a public record and available upon request.

Measures

BMI-for-age. The BMI score was determined from children's height, weight, and date of birth. This study utilized the Centers for Disease Control and Prevention (CDC) BMI-for-age percentile ranking to describe the "relative position of a child's BMI score among children of the same sex and age" (in quarter years).[27] The BMI weight category definitions were used for underweight (< 5th percentile), healthy weight (5th - < 85th percentiles), overweight (85th - < 95th percentile), and obese (≥ 95th percentile).[27]

Caries Severity, Prevalence, ECC, and Untreated Decay. The dmf index was used to measure dental caries severity because the preschool-age children's primary teeth were fully erupted and had not begun to exfoliate.[28] The dmf was determined by dentists from the local health department and reflects the sum of each child's decayed, missing, and filled teeth. Each tooth was counted once, therefore the maximum dmf score was 20. The score may be overstated if teeth were extracted or filled due to reasons other than decay.[28] A child was determined to have caries if their dmf > 0. The dental assessment also measured Early Childhood Caries (ECC), defined in this study as presence of a disease condition in which a child has 1 or more cavitated or filled smooth surfaces in the primary anterior maxillary. A child with a missing primary anterior maxillary tooth was also considered to have ECC unless it was known that the tooth was missing due to trauma. In addition, presence of untreated decay was also recorded.

Procedures and Study Examiners

Dental assessments and height and weight measurements were conducted between late-August and mid-November, 2011. Nine dentists from the local health department performed the dental assessments on-site within the first 90 calendar days of the fall semester. The dentist received standardized procedural training, and examined each child with a light source, loupes, and explorer (used only to remove debris in the occlusal pits and fissures). The Head Start program's health staff obtained each child's height and weight measurements on-site utilizing electronic digital scales and measuring tape attached to the wall. Weight was measured to the nearest 1/4 pound, and height was measured to the 1/8 inch.

Height/weight and socio-demographic data of the children were entered into the Head Start program's password protected database (Child Plus) by trained Head Start staff. The database calculated the each child's BMI score and BMI for- age percentile using the CDC calculation for children and teens. Note: Because children grow rapidly within 1 year, the BMI calculation for children is based on a child's date of birth (in months), and is plotted on the CDC growth chart in quarter years to determine the percentile ranking. The Head Start Health Content Manager exported the following data into a password protected Excel spreadsheet: database identification number, date of birth, sex, race, ethnicity, date of height and weight measurement, BMI for-age percentile, and date of dental assessment. The principal investigator (PI) determined the BMI category for each participant based on his/her BMI percentile ranking and added these data to the spreadsheet. The age of each participant at the time of his/her height and weight measurement was calculated from his/her date of birth (in whole years) using an Excel formula. Dental assessment data were also added to the spreadsheet by the PI, including date of dental exam, dmf index score, presence of ECC, and presence of untreated decay. Arbitrary subject numbers were assigned to each participant and the database identification numbers were deleted. The following data sets for each participant were then exported into IBM SPSS (version 20):

- subject number;
- age at the time of BMI assessment (in whole years);
- sex;

- race/ethnicity;
- BMI percentile;
- BMI category;
- dmf index (caries severity);
- caries experience, i.e., dmf >0 (yes/no);
- presence of ECC (yes/no);
- and presence of untreated decay (yes/no).

Data Analysis

Data analyses were performed by IBM SPSS, version 20. Frequency tables and cross-tabulations were used to describe the sample, and to determine central tendency and variability of dmf; BMI measures; and prevalence of caries, untreated decay, and ECC. Pearson r correlations were used to investigate the relationship between BMI-for-age percentiles and caries severity (dmf). Analysis of variance (ANOVA) was used to compare prevalence of dental caries, untreated decay, and ECC by BMI weight categories. Finally, logistic regression analyses were used to determine the relationships between BMI measures and dental caries, ECC, or untreated decay.

CHAPTER IV

MANUSCRIPT

Introduction

Childhood obesity rates for children aged 2-5 years in the United States (US) have more than doubled from 5% in 1976-1980 to 12.1% in 2009-2010 and tripled for all children aged 2-19 years, with nearly 17% classified as obese.[1] Concurrently, dental caries is the most prevalent chronic childhood disease in the US.[2] And while trends indicate that the overall prevalence of dental caries has decreased in the US, the most recent National Health and Nutrition Examination Survey (NHANES)[3] data indicated children aged 2-5 years showed a significant increase in caries prevalence from 24% in 1988-1994 to 28% in 1999-2004.

Children who are obese during their preschool years are more likely to be obese in adolescence and adulthood and to develop chronic health conditions such as type II diabetes, hypertension, hyperlipidemia, cardiovascular disease, sleep apnea, asthma, and certain cancers.[5,6] Dental caries in children is also associated with pain, systemic infection, poor speech development, difficulty eating, disrupted sleep, and a lack of concentration, and school absenteeism.[2,4]

During 2010 and 2011, more than 1 in 5 children in the US lived in poverty, reflecting the highest rates in recent history.[7] Furthermore, the US Census Bureau

2010 American Community Survey[8] revealed the poverty rate for Hispanic children was 32.3%, almost double the rate for white children. The 2010 Pediatric Nutrition Surveillance System (PedNSS)[9] data showed obesity prevalence among low-income children aged 2-4 years enrolled in federally funded programs was 14.4%. Similarly, NHANES 1999-2004 data[3] showed 54% of children aged 2-11 living below the federal poverty level (FPL) had dental caries, compared to 32% of children living at 200% or above the FPL.

Coinciding with the increase in childhood poverty, the US Hispanic population grew by 43% between 2000 and 2010, and Mexican Americans accounted for about 75% of this growth.[10] This is an important factor when considering the prevalence of obesity and dental caries among Mexican Americans is high compared to non-Hispanic white children. NHANES 2007-2008 data[11] showed the obesity prevalence of Mexican American children aged 2-5 years was 13.7%, compared to 9.1% among non-Hispanic white children. Likewise, NHANES 1999-2004 data[3] revealed the prevalence of dental caries among Mexican American children aged 2-11 years was 55.4%, compared to 38.6% non-Hispanic white children. Note: The NHANES 1999-2004 and 2007-2008 over sampled Mexican American children in comparison to the general US Hispanic population. Additionally, CDC has not released NHANES 2009-2010 racial and ethnic comparative data on obesity and caries prevalence for preschool age children.

Obesity and dental caries are multifactorial diseases that share some common etiologic and facilitating risk factors including frequent consumption of sugar-sweetened beverages (SSB),[12-15] parental misperceptions and attitudes among at-risk populations,[16-18] and poor eating habits associated with increased television viewing.[19-21] In addition, Hispanic children from low-income families have higher rates obesity[9] and dental caries.[2,3] Therefore, it is important to examine the relationship of both diseases within growing at-risk populations.

Literature Review of the Relationship between Childhood Obesity and Dental Caries

The relationship between obesity and dental caries, based on current literature, is inconclusive.[25,26]. In a systematic review by Kantovitz et al.[26] in 2006 — which focused on obesity and dental caries studies among all age groups — found only 7 papers that met the inclusion criteria. Of these, one study by Willerhausen et al.[72] in 2004 was found to have a high level of evidence demonstrating an increase in caries was associated with high weight among German children aged 6-11. Similar results were found by Willerhausen et al.[73] in 2007, which showed BMI was an independent risk factor for caries frequency in the primary and permanent dentition of German children aged 6-11 years. However, the Willerhausen et al. studies[72,73] used BMI scores which are not as meaningful as BMI-for-age percentiles in growing children and adolescence.[74]

Several additional studies have shown a positive relationship between obese or overweight children and dental caries. A study[75] of 500 children aged 8 to 12 years in India showed obese and overweight children to have a significantly higher prevalence of caries than healthy or underweight children in the primary dentition. The authors concluded that increased frequency of sweet and fatty foods was related to increased weight, which therefore had a positive relationship to caries prevalence in children. Additionally, a study[50] of 15 year-old adolescents in Sweden showed obese individuals had more than double the amount of approximal carious lesions and fillings compared with low- and healthy- weight individuals. The authors also found frequent consumption of cariogenic snacks during early childhood was significantly associated with caries at 15 years.

There are limited data available for young children, particularly among minority children from low-income families. One such study of 1160 Mexican preschool children aged 4-5 years by Vazquez-Nava et al.[77] did find a significant association between overweight and obese children and dental caries in the primary dentition. When the authors compared overweight and obese children to normal weight children, they found overweight children had 1.94 times greater risk of caries and obese children had 1.95 times greater risk of caries. Another study[49] followed low-income African-American children birth to 5 years for two years and found greater weight-for-age was one of the significant predictors of higher caries increment. However, the authors noted that the association was inconsistent and did not demonstrate a clear dose-response relationship. Finally, a longitudinal study by Marshall et al.[70] followed a diverse socio-demographic group of children from birth to 11 years found overweight children had significantly higher caries rates than healthy or obese children. Stepwise logistic regression models showed the two variables which predicted caries experience were overweight status and mother's education. The studies by Vazquez-Nava et al. and Marshall et al. did not include children who were underweight.

Conversely, several cross-sectional studies among diverse populations have not found a significant association between obesity and dental caries in children. A cross-sectional data analysis of children aged 2-18 years from the NHANES III (1988-1994) and NHANES 1999-2002 by Kopycka-Kedzierawski et al.[78] showed no evidence to support that overweight or obese children have an increased risk of dental caries after controlling for potential confounding variables. In fact, the NHANES III data analysis suggested obese children may be associated with decreased caries risk in older children. Macek et al.[79] also analyzed BMI-for-age and dental caries data of children 2-17 years old from the NHANES 1999-2002 and did not find an association between BMI-for-age and caries prevalence; however, the authors did find that caries severity (geometric DMFT) was significantly less severe in the permanent dentition among overweight children than in normal weight children. Hong et al.[80] examined NHANES 1999-2002 data of 1507 young children aged 2-6 years. The authors only found a significant association between obesity and caries in the 5-6 year olds when they stratified by age and ethnicity. They also found significant associations in the Hispanic and Black strata when they compared overweight children to healthy weight children in the same age group. However, no association was found between obesity and caries after controlling for age, race, and income status. More recently, a cross-sectional study[81] of 200 patients aged 8 or younger who were treated a New Zealand dental school showed no significant association between BMI and caries experience.

A few studies have been conducted within specific populations in the US with varying results. A recent secondary data analysis by Sheau-Huey et al.[82] of predominately African-American (64%) children aged 2-17 years living in a homeless shelter found that as BMI increased, caries did as well; however, the positive association was not statistically significant ($p = .08$). This positive association was not found among a cohort[83] of 135 predominately African-American patients (mean age 8.7 years) at an urban dental school in Pennsylvania by Pinto et al.,[83] which found no correlation between caries in obese or non-obese children ($p = .99$). Additionally, a retrospective case study by Sheller et al.[84] of 293 children aged 2-5 years with Severe Early Childhood Caries did not show a correlation between BMI percentiles or caries experience. Similar to the Sheller and colleagues study, a retrospective case-control analysis of children aged 3-6 years by Vania et al.[85] did not show a typical weight distribution among children with caries when compared to caries-free children. However, they did find there were significantly more children in the caries groups that were underweight than in the caries-free group (10% vs. 4.94%). Werner et al.[74] found comparable results in a 3- year retrospective review of patients aged 6-9 years at a dental school in North Carolina. The authors found overweight and obese children had significantly less caries in the primary teeth than underweight/healthy weight children.

Research Questions

The purpose of this study was to investigate the relationship between BMI-for-age and dental caries within a purposive sample of predominately Hispanic, low-income Head Start children living in an urban area located 160 miles from the US and Mexico border. Because little is known about these relationships among this population, the current study was exploratory in nature, and was guided by the following research questions:

1. Was there a relationship between BMI-for-age percentile and caries severity (dmf index) among this at-risk preschool population?
2. Were there significant differences in caries severity (dmf) or the prevalence of dental caries, untreated decay, and ECC between the four BMI categories (underweight, healthy, overweight, and obese) among this at-risk preschool population?

3. What was the relationship between dental caries, ECC, untreated decay, and obesity among this at-risk population?

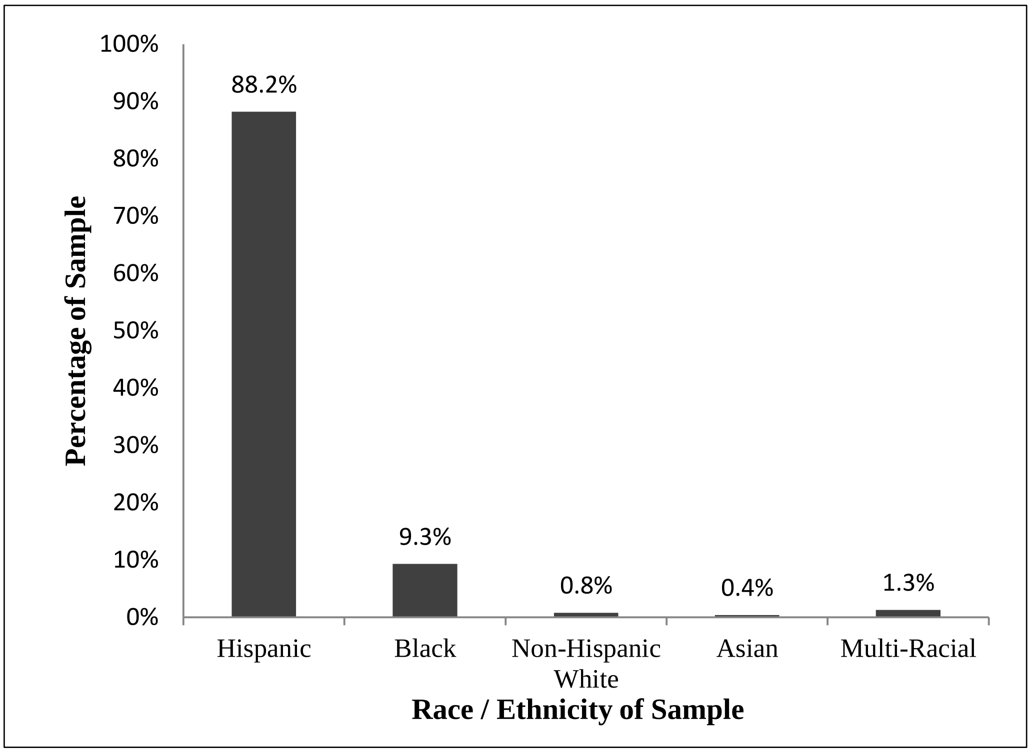
Methods

Sampling Strategy. The participants were children aged 3-5 years enrolled in a Head Start program in South Texas. The program was comprised of 88 centers located within a large urban area. The population was socioeconomically homogeneous with the following characteristics: 87% were Hispanic or Latino, and 95% were living in households at or below the Federal Poverty Level (FPL).

A proportionate sample based on age was randomly selected from a population of 7574 children enrolled in the Head Start program for at least 1 day throughout the school-year. The participants were randomly selected using an online random numbers generator (www.random.org). To achieve a representative sample from this homogeneous group, 237 participants were selected.[86] Eligibility of the participants was based on the following criteria for each child: complete demographic, dental assessment, and BMI data were available; each child's dental assessment and BMI assessment were completed within 90 days of each other; and the dental assessment was completed by a dentist from the local health department. The sample was predominantly Hispanic (Figure 1), 4 years of age (Table 1) at the time of their assessments (mean age 3.7 years), and there were slightly more females than males (Table 2).

The study was approved by the Texas State University's Institutional Review Board prior to data collection. Parents completed socioeconomic and demographic information during the application process prior to a child's enrollment. Written parental consent was obtained for release of medical information to the Head Start program. In addition, parental consent was required for all on-site dental examinations. Data collected during a child's Head Start enrollment, including demographic, health, and dental information were collected in the Head Start program's password protected database and anonymous raw data were reported to US Department of Health and Human Services (HHS). The raw data are classified a public record and available upon request.

Figure 1: Race / Ethnicity of Sample



Measures for BMI-for-age. The BMI score was determined from children's height, weight, and date of birth. This study utilized the Centers for Disease Control and Prevention (CDC) BMI-for-age percentile ranking to describe the "relative position of a child's BMI score among children of the same sex and age" (in quarter years). [27] The BMI weight category definitions[27] were used for underweight (< 5th percentile), healthy weight (5th - < 85th percentiles), overweight (85th - < 95th percentile), and obese (≥ 95th percentile).

Measures for Caries Severity, Prevalence, ECC, and Untreated Decay. The dmf index was used to measure dental caries severity because the preschool-age children's primary teeth were fully erupted and had not begun to exfoliate.[28] The dmf score was determined by dentists from the local health department and reflects the sum of each child's decayed, missing, and filled teeth. Each tooth was counted once, therefore the maximum possible dmf score was 20. The score may be overstated if teeth were extracted or filled due to reasons other than decay.[28] A child was determined to have caries if their dmf > 0. The dental assessment also measured Early Childhood Caries (ECC), defined in this study as presence of a disease condition in which a child has 1or more cavitated or filled smooth surfaces in the primary anterior maxillary teeth. A child with a missing primary anterior maxillary tooth was also considered to have ECC unless it was known that the tooth was missing due to trauma. In addition, presence of untreated decay was also recorded.

Procedures and Study Examiners. Dental assessments and height and weight measurements were conducted between late-August and mid-November, 2011. Nine dentists from the local health department performed the dental assessments on-site within the first 90 calendar days of the fall semester. Each dentist received standardized procedural training, and performed the dental assessments using a light source, loupes, and explorer (used only to remove debris in the occlusal pits and fissures). The Head Start program's health staff obtained each child's height and weight measurements on-site utilizing electronic digital scales and measuring tape attached to the wall. Weight was measured to the nearest 1/4 pound, and height was measured to the 1/8 inch.

Height/weight and socio-demographic data of the children were entered into the Head Start program's password protected database (Child Plus) by trained Head Start staff. The database calculated the each child's BMI score and BMI for- age percentile using the CDC calculation for children and teens. Note: Because children grow rapidly within 1 year, the BMI calculation for children is based on a child's date of birth (in months), and is plotted on the CDC growth chart in quarter years to determine the percentile ranking. The Head Start Health Content Manager exported the following data into a password protected Excel spreadsheet: database identification number, date of birth, sex, race, ethnicity, date of height and weight measurement, BMI for-age percentile, and date of dental assessment. The principal investigator (PI) determined the BMI category for each participant based on their BMI percentile and added this data to the spreadsheet. The age of each participant at the time of their height and weight measurement was calculated (in whole years) using an Excel formula. Dental assessment data were also added to the spreadsheet by the PI, including date of dental exam, dmf index score, presence of ECC, and presence of untreated decay. Arbitrary subject numbers were assigned to each participant and the database identification numbers were deleted. The following data sets for each participant were then exported into IBM SPSS (version 20): subject number, age at the time of BMI assessment, sex, race/ethnicity, BMI percentile, BMI category, dmf score, caries experience, presence of ECC, and presence of untreated decay.

Results

A total of 326 potential participants were randomly drawn from the Head Start population before the final sample of 237 met the inclusion criteria. The population included every child that attended at least 1 day of Head Start during 2011-2012 school-year. The Head Start program had 90 days from the first day a child's enrollment to obtain the BMI and dental assessments. Eighty-nine children initially selected were not included in the final sample for the following reasons: incomplete data because they withdrew from the program prior to receiving both assessments; the dates of their dental assessment and height and weight measurement were not within 90 days of each other; they did not have parental consent for the health department to perform the on-site dental assessment; or had missing dental or BMI information due to absenteeism.

Demographics. Dental caries prevalence for the sample was 46.8%, and the mean dmf score was 2.44 (SD 3.65). Both caries prevalence and the severity of caries (dmf) increased with age; however, the prevalence of untreated decreased with age (Table 1). Comparison of prevalence of caries (*P*=0.36), untreated decay (*P*=0.58), and dmf scores (*P*=0.69) by age groups resulted in no significant differences. Logistic regression models showed an increased likelihood of caries (OR=1.42, CI=0.05) but a decreased likelihood of untreated decay (OR=0.76, CI=0.05) with increased age. There were no statistically significant differences in prevalence of caries (*P*=0.43), untreated decay (*P*=0.14), and dmf scores (*P*=0.71) by sex; however, all three measures were higher among the boys (Table 2). Logistic regression analyses showed boys were more likely to have caries (OR=1.27, CI=0.05), and almost twice as likely to have untreated decay (OR=1.86, CI=0.05). There were no significant differences found for prevalence of ECC by age (*P=0*.43) or by sex (*P=0*.86).

The prevalence of obesity among the overall sample was 23.2%, and the mean BMI-for-age percentile score was 60.6 (SD 33.49). Table 1 summarizes obesity prevalence by age groups, and Table 2 summarizes obesity by sex. Comparison of BMI categories by age groups resulted in no significant differences (*P*=0.45); however, logistic regression analyses showed decreased likelihood of obesity with increased age (OR=0.85, CI=.05). The average BMI category was significantly higher for girls (*P*=0.04), and logistic regression analyses showed girls had an increased likelihood of being in a higher BMI category (OR= 1.31, CI=.05) when compared to boys.

Table 1: Description of Sample by Age

Age	n (%)	Caries Severity (mean dmf)	Caries Prevalence (%)	Untreated Decay Prevalence (%)	ECC Prevalence (%)	Obesity Prevalence (%)
3 years	87 (36.7%)	2.28 (SD 3.59)	41.4	20.7	28.7	26.4
4 years	140 (59.1%)	2.49 (SD 3.6)	49.3	16.4	29.3	20.7
5 years	10 (4.2%)	3.30 (SD 5.01)	60.0	10.0	10.0	30.0
Total	237 (100%)	2.44 (SD 3.65)	46.8	17.7	28.3	23.2

Table 2: Description of Sample by Sex

Sex	n (%)	Caries Severity (mean dmf)	Caries Prevalence (%)	Untreated Decay Prevalence (%)	ECC Prevalence (%)	Obesity Prevalence (%)
Female	126 (53.2%)	2.36 (SD 3.51)	44.4	14.3	27.8	27.8
Male	111 (46.8%)	2.53 (SD 3.82)	49.6	21.6	28.8	18.0
Total	237 (100%)	2.44 (SD 3.65)	46.8	17.7	28.3	23.2

Dental Caries and BMI Prevalence of caries, untreated decay, ECC, and mean dmf scores are summarized in Table 3 by BMI category. Underweight children had the highest average dmf score, and prevalence of caries and ECC. Obese children had the highest prevalence of untreated decay. The distribution of dmf scores by BMI category is summarized in Table 4. The highest proportion of children in all BMI categories had a dmf = 0, with underweight children having the lowest proportion with no decay and healthy weight children having the highest proportions with no decay. The maximum dmf score was 15. Obese children did not have the most severe decay (dmf = 13-15). Comparison of prevalence of caries (P=0.62), untreated decay (P=0.07), ECC (P=0.38), and dmf (P=0.88) by BMI categories resulted in no significant differences. Pearson correlation analyses found no positive relationship between dmf score and BMI-for-age percentile (r = 0.017), and logistic regression analyses also showed no relationship between dmf and obesity (OR=1.00, CI=.05) Increases in children's BMI category classification were associated with a slight decreased likelihood of caries (OR=0.96, CI=.05) and ECC (OR=0.98, CI=.05), but an increased likelihood of untreated decay (OR=1.42, CI=.05).

Table 3: Description of Sample by BMI Category

BMI Category	n (%)	Caries Severity (mean dmf)	Caries Prevalence (%)	Untreated Decay Prevalence (%)	ECC Prevalence (%)
Underweight	19 (8%)	3.05 (SD 4.27)	57.9	21.1	42.1
Healthy Weight	139 (56.6%)	2.33 (SD 3.61)	43.9	13.7	25.2
Overweight	24 (10.1%)	2.54 (SD 4.00)	45.8	12.5	25.0
Obese	55 (23.3%)	2.45 (SD 3.43)	50.9	29.1	32.7
Total	237 (99.9%)	2.44 (SD 3.65)	46.8	17.7	28.3

Table 4: BMI Category and dmf Cross Tabulation

	dmf (n / %)						
BMI Category	0	1-3	4-6	7-9	10-12	13-15	Total
Underweight	8 (42%)	5 (26%)	2 (11%)	3 (16%)	0	1 (5%)	19
Healthy Weight	78 (56%)	23 (17%)	18 (13%)	11 (8%)	6 (4%)	3 (2%)	139
Overweight	13 (54%)	3 (13%)	5 (21%)	1 (4%)	0	2 (8%)	24
Obese	27 (49%)	13 (24%)	8 (15%)	3 (5%)	4 (7%)	0	55

Discussion

It was hypothesized that a positive relationship between BMI-for-age and caries (dmf) would be found in this sample, because both diseases share some common risk factors in this at-risk population; however, results did not support this hypothesis. The results may be partially explained by its cross-sectional design and the young age of the participants. It may take longer for etiological or facilitating factors to result in clinical signs of obesity or caries.[39,50] For instance, there is sufficient evidence to support an association between consumption of sugar-sweetened beverages (SSB) and weight gain over time[14,15]; however, O'Connor[39] and colleagues' cross-sectional secondary data analysis of preschool children from NHANES 1999-2002 did not support a relationship between weight status and SSB.

The results may also be partly explained by examining the etiological role of diet in both diseases. In a review of dietary causes of obesity, Swinburn et al.[14] concluded that there was convincing evidence that high intake of energy-dense foods was a risk factor for obesity, but there was little evidence that higher frequency of eating (eating more times throughout the day) was associated with obesity. The opposite relationship seems to be true for dental caries. In a review of the literature on the relationship between quantity and frequency of sugar and dental caries, Anderson et al.[12] found no sufficient evidence to support a relationship between the quantity of sugar intake; however, moderately significant evidence to support the relationship between sugar frequency (or exposure) and dental caries was found. Kantovitz et al.[26] stated, "the triangular relationship of sugar, dental caries, and obesity needs to be further explored."

There is inconclusive evidence in the literature to support a relationship between childhood obesity and dental caries.[79] Some research suggests if a relationship exist, it is closely linked to dietary habits during early childhood and other socio-demographic factors.[13,49,51,70] The majority of evidence that does not supporting an association between childhood obesity and dental caries comes from cross-sectional secondary data analysis among diverse populations.[51,78] Kantovitz et al.[26] suggest conflicting results may also be due to differing methodologies used in individual studies, while Dye et al.[3] suggest most studies fail to control for dietary confounding variables.

The current study did show obese children to have the highest proportion of untreated decay, which may have some practical implications regarding the important role parents play in the prevention of both diseases. Previous research has demonstrated that under-educated, Hispanic/Latina mothers often have difficulty in recognizing their children as overweight or obese.[18,59,62,63] Similarly, there is some evidence to suggest correct identification of the signs of dental caries and dental utilization by parents may be related to race/ethnicity, cost, insurance status, and their own personal experiences.[17,66] There is insufficient research on Mexican American parental perceptions of oral health, but Horton and Barker[66] investigated how rural Mexican immigrant parents in the US interpret children's dental symptoms and what motivates them to seek dental treatment for their child. The following themes emerged: 1) parents defined "healthy" teeth as "white", "clean", and free of pain; 2) parents perceived cavities as "stains" that could be removed by "cleanings", so many delayed seeking help; 3) parents' decision to seek treatment was dependent on visible signs of a "problem" and children's complaints of pain; however, children's complaints often had to be verified by parents seeing visible signs. The authors noted most of the parents did not experience dental decay when they were children living in rural Mexico (primarily due to non-cariogenic diets) and this may have influenced their lack of understanding and misinterpretations of dental decay. Healthcare professionals need to learn effective and culturally competent education strategies for counseling parents on how to recognize the signs and consequences of childhood obesity and dental caries in at-risk populations.[62,66]

The prevalence of obesity and dental caries in the current study are both well above Healthy People 2020 baseline and target goals.[87] As previously discussed, both diseases do share some common risk factors; however, they also have unique confounding variables that may play a more important role in determining disease manifestation.[14,41] For example, lack of exercise or sleep, and high-fat diets may be more closely associated with childhood obesity than sugar intake.[14,23] Similarly, fluoride exposure, good oral hygiene, and access to dental care are important factors in preventing dental caries that are not closely related to the etiological factors for childhood obesity.[42]

In the current study, the average BMI weight category was significantly higher for girls. This finding was not consistent with NHANES 2009-2010 data[1] for children aged 2-5 years, which showed boys to have an increased prevalence of obesity (14.4%) compared to 9.6% of the girls. Similarly, NHANES 2007-2008 data[11] for Hispanic children aged 2-5 years showed obesity prevalence in boys was 17.8% compared to 10.4% in girls.

This study was delimited to a purposive sample of low income predominately Hispanic children enrolled in a Head Start program; therefore, the results are not generalizable to other populations. There were several other limitations to the study. First, dentists determined dmf scores by visual evaluations without radiographs; therefore, dmf scores could be understated. Second, dentists and Head Start health staff received training with defined procedures and criteria, but a calibration study was not conducted for the dental assessments or height and weight measurements. Finally, decayed, missing and filled teeth were used to calculate dmf scores, which could be overstated if teeth were filled or missing due to reasons other than decay.

Conclusion

The current study supports the research by Marshall et al.,[70] and suggests increased rates of childhood obesity and dental caries among at-risk populations simply coexist. There is a need for additional well-designed prospective cohort studies to examine the relationship among at-risk populations over time.[39]

Implementing prevention and intervention strategies for both diseases during the pre-school years is ideal because the occurrence of obesity or dental caries early in life influences health in adolescence and adulthood.[4,5] In 2011, the Institute of Medicine (IOM) published two reports, *Early Childhood Obesity Prevention Policies*[23] and *Advancing Oral Health in America,*[24] which recommended a need for increased research and interprofessional training to address both diseases. An interprofessional approach between primary healthcare professionals, dental professionals, and health educators would offer a unique opportunity to help prevent and treat these prevalent childhood diseases. Furthermore, additional research is needed to investigate effective and culturally competent education and prevention strategies for both diseases in at-risk populations.[62,66]

CHAPTER V

CONCLUSION AND RECOMMENDATIONS

Conclusion

The purpose of this study was to investigate the relationship between Body Mass Index (BMI)-for-age and dental caries within a purposive sample of predominately Hispanic, low-income children enrolled in a Head Start preschool program in South Texas. It was hypothesized that a positive relationship between BMI-for-age and caries (dmf) would be found because both diseases share some common risk factors in this at-risk population. Obesity and dental caries prevalence found among the sample were well above Healthy People 2020 baselines and target goals[87]; however, a positive relationship was found between the two diseases. The current study supports the other research[70] that suggests increased rates of childhood obesity and dental caries among at-risk populations simply coexist.

Recommendations

The results of the current study may be partially explained by its cross-sectional design and the young age of the participants. It may take longer for etiological or facilitating factors to result in clinical signs of obesity or caries.[39,50] Therefore, additional well-designed, prospective, cohort studies are need to examine the relationship among at-risk populations over time.[39]

The results may also be partly explained by examining the etiological role of sugar in the diet (quantity versus frequency) for both diseases more closely. Kantovitz et al.[26] stated, "the triangular relationship of sugar, dental caries, and obesity needs to be further explored."

Interestingly, the current study did show obese children to have the highest proportion of untreated decay, which may have some practical implications. Parental misperceptions of obesity and dental caries in at-risk populations may offer some explanation. Previous research has demonstrated that under-educated, Hispanic/Latina mothers often have difficulty in recognizing their children are overweight or obese.[18,59,62,63] Similarly, there is some evidence to suggest correct identification of the signs of dental caries and dental utilization by parents may be related to race/ethnicity, cost, insurance status, and their own personal experiences.[17,66] Additional research is needed to investigate effective and culturally competent education and prevention strategies for both diseases in at-risk populations.[62,66]

Implementing prevention and intervention strategies for both diseases during the pre-school years is ideal because the occurrence of obesity or dental caries early in life influences health in adolescence and adulthood.[4,5] An interprofessional approach between primary healthcare professionals, dental professionals, and health educators would offer a unique opportunity to help prevent and treat these prevalent childhood diseases.

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