ADIPOSITY AND ORAL HEALTH IN NORTH CAROLINA PRESCHOOL-AGE CHILDREN

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ABSTRACT

Meredith Perdue Davis: Adiposity and Oral Health in North Carolina Preschool-age Children
(Under the direction of Kimon Divaris)

Childhood overweight/obesity (OWOB) and early childhood caries (ECC) are two prevalent conditions that confer significant health and economic impacts on affected individuals and families. This investigation sought to understand the prevalence and risk factors common to OWOB and ECC in a preschool age population in North Carolina. Clinical and questionnaire data was obtained from an epidemiologic study of 3-5 year old children attending public preschool programs in North Carolina. Statistical analyses and Geographic Information System (GIS) –based methods were employed to examine sociodemographic, behavioral, and geographic associations. There was no important clinical association between obesity and ECC in this population of preschool-age children. Hispanic ethnicity, parental education, and dietary behaviors were salient influences in the prevalence of these two conditions. These findings offer valuable insight into which subpopulations are at highest risk and where intervention may be most effective.

This thesis is dedicated to my son, James Ford,
and to all of the children of North Carolina
who we have the privilege and responsibility to care for.

ACKNOWLEDGEMENTS

This project would not have been possible without my advisor and mentor in all things research and pediatric dentistry, Dr. Kimon Divaris. It would be impossible to quantify the number of hours he has dedicated to academic mentorship and I am grateful to be one of the many students who has benefited from the gift of his time and knowledge. In spite of his numerous accomplishments and enduring contributions to the field of pediatric dentistry, he remains gracious and humble. He is someone I will always strive to emulate in my practice of pediatric dentistry.

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Finally, thank you to my family and friends. I am particularly grateful to my mother, Dr. Tamara Perdue, for her general encouragement and expertise in research methodology. Most of all, I am grateful for my husband Bobby, whose unwavering support has sustained me throughout residency and this project.

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LIST OF ABBREVIATIONS

BMI	Body Mass Index
ECC	Early Childhood Caries
ICDAS	International Caries Detection and Assessment System
OWOB	Overweight and Obesity

CHAPTER 1: INTRODUCTION

Dental caries and obesity are two common, complex diseases with serious consequences and high worldwide prevalence. Pediatric dental disease and obesity are particularly troublesome and their health effects extend into adulthood. In the United States, close to one out of every four children ages 2-5 have experienced dental caries, and 2 out of five (42%) are overweight or obese (OWOB).[1,2] Despite encouraging statistics indicating that untreated dental caries has declined in the preschool-age population in recent years, overweight and obesity have increased in this age group.[1,2] Importantly, obesity and dental caries are not “equal-opportunity” diseases, as a disproportionately higher number children of minority race and low income are affected.[3] Early childhood caries (ECC) and childhood OWOB impact the quality of life and confer significant costs on families, the healthcare system, and society as a whole.[4,5]

The causal pathways of caries and obesity are thought to be distinct entities; yet share common risk factors and influences, such as lifestyle habits, genetics, and socioeconomic status. Importantly, both have a nutritional component driving the dysbiotic process that results in disease. Dental caries is a tooth-surface level disease that occurs after repeated exposure to fermentable carbohydrates that encourages the proliferation and selection of cariogenic bacteria in the oral cavity. This microbial imbalance, or dysbiosis, results in the establishment of a biofilm that causes tooth structure breakdown in the presence of specific host and environmental factors.[6] OWOB is influenced by genetic and microbial factors, but is largely the result of an imbalance between energy intake and expenditure, leading to excess weight gain.

In spite of a common nutritional thread, studies attempting to elucidate a causal link between ECC and OWOB have been inconclusive.[7] While some studies have described a positive association between caries in the primary dentition and BMI,[7,8,9,10,11] others have noted an inverse association; suggesting that dental caries is more prevalent in normal weight or underweight children.[7,12,13,14] The majority of published studies have reported no association.[7,15,16] In an updated systematic review by Chen, et al. [2018], the authors emphasize that the inconsistency of results among studies is likely related to differences in methods and categorization used, as well as confounding sociodemographic and behavioral variables.[7] While their meta-analysis did not find any major overall associations, subgroup analyses noted significantly higher caries scores among the OWOB group in high-income countries, but not in low- and middle-income countries, suggesting the presence of population-level influences. Given the inconsistencies across studies, a logical hypothesis is that ECC and OWOB have distinct causal pathways but share predisposing risk factors, including dietary and lifestyle behaviors, biologic and genetic endowment, and socioeconomic status.[11] Common risk factors on an individual- and family-level basis may be exaggerated or attenuated by the upstream influence of the social and environmental context in which a child lives. In Figure 1 we present a conceptual model summarizing our scoping review of multi-level influences on both conditions, including upstream (e.g., access to care) and proximal (e.g., biological) factors.

Geographic area-level influences constitute an emerging area of social determinants of health inquiry that can help inform our understanding of chronic disease burden and risk factors. In the United States, variation on a regional- and state-level affects health care access and utilization. As an example, the state-level differences in breadth of public insurance coverage are influenced by politics and policies, demographics, supply of health care providers, and regional differences in disease burden.[17] Geographic variation also influences health behaviors and lifestyle choices. Recent attention has been directed towards the significance of the food environment. The presence of "food deserts" or "food swamps" impact the ability of an individual to make nutritious choices. Although access to grocery stores is undoubtedly important, a recent study suggests that "food swamps", or communities with a high-density of fast food and junk food establishments, are the bigger culprits in the obesity epidemic.[18] Gordon-Larsen emphasizes that simply increasing access to fresh food stores will not in itself solve the obesity epidemic without efforts to change individual behaviors through education and incentivizing health food choices.[19] Recognizing the role that geography plays in population health outcomes is critical as it can illuminate health disparities and possibly perpetuating factors. Fortunately, recent advances in geographic information systems (GIS) technology have allowed researchers to investigate this influence on public health.[20] The present authors believe that this study will provide a renewed understanding of the risk factors common to ECC and OWOB and will serve to inform and consolidate public health measures to prevent them.

The primary objective of this study was to examine the prevalence and association between ECC and childhood OWOB in a community-based sample of preschool-age children. Secondarily, we sought to contribute to the knowledge base of common risk factors for both diseases, including social, demographic, and behavioral risk factors. In an effort to elucidate the complex postulated relationships between ECC and OWOB, we introduce a conceptual model that summarizes these multi-level influences.

CHAPTER 2: METHODS

Section 2.1: Study Design:

This descriptive investigation used data collected in the ZOE 2.0 study, a community-based, epidemiologic study of early childhood oral health in North Carolina that enrolled 8,059 public preschool-attending children ages 3-5 between 2016-2019. The study received ethics approval by the University of North Carolina Institutional Review Board (#14-1992). The study overview, clinical and survey procedures, as well as descriptive cohort profile have been presented in detail elsewhere.[21,22,23]

Section 2.2: Study Sample:

The present study's analytical sample comprised 6,357 preschool-age (age range: 36-71, mean: 54 months) children attending public preschools (Head Start Program) in North Carolina with complete dental and anthropometric data. There was an approximately equal number of males and females.

Section 2.3: Data Collection:

Questionnaires in English or Spanish-language were administered to participants' caregivers to assess sociodemographic characteristics and oral health-related behaviors. Behavioral questions included frequency and parental involvement in tooth brushing, daily consumption of sugar-containing foods and beverages, and whether the child had ever been put to bed with a bottle. Anthropometric measurements were obtained at time of examination and included weight, using a calibrated portable digital scale (Doran® Remote Indicator Scale), and height, obtained using a calibrated stadiometer (seca®). Height was recorded in inches (in.) and weight in pounds (lbs.) by two examiners for quality assurance. BMI Z-scores (normalized scores) were calculated using Stata's *zanthro* program (StataCorp LP, College Station, TX) and percentiles based on CDC reference tables. BMI percentile classifications are underweight (0-5th percentile), normal weight (5-85th percentile), overweight (85-95th percentile), and obese (>95th percentile). For Z-scores, overweight is defined as a BMI Z-score between 1.05-1.63, and obesity is defined as BMI Z-score >1.64.[24,25]

Clinical dental examinations were completed by 10 trained and calibrated oral health professionals using International Caries Detection and Assessment System (ICDAS) modified visual diagnostic criteria to determine presence and severity of dental disease.[26] Caries lesions were diagnosed and recorded at the tooth-surface level; each of 88 primary tooth surfaces were diagnosed as caries-free (ICDAS code: 0), early-stage caries lesion (ICDAS codes: 1-2) or established/severe stage (ICDAS codes: 3-6). A dmfs (decayed, missing due to caries and filled/restored primary tooth surfaces) index was calculated as the sum of all individual tooth surface codes with a range 0-88. For the purposes of this study, a caries case was defined at the "severe/established" threshold, which is the presence of one or more established caries lesions (≥ICDAS 3), restored, crowned, and/or missing tooth surfaces due to caries.[22] To enable geographic and area-level inferences, participants' residential addresses were encoded into latitude and longitude coordinates and carried forward to GIS analyses using ArcGIS software.[21]

Section 2.4: Statistical Approach:

The primary outcome measures were BMI Z-score and ECC prevalence (i.e., case status) and severity (i.e., dmfs index). Bivariate analyses (X^2, non-parametric trend tests or ANOVA) were performed to evaluate associations between clinical findings of OWOB or ECC and sociodemographic and behavioral factors. All analyses accounted for the clustered nature of data (i.e., participation in 34 public preschool programs) using Stata 16.1. Spatial "hotspot" analyses relied upon the Getis-Ord Gi* and the Local Moran's I statistics.

CHAPTER 3: RESULTS

Section 3.1: Characteristics of Study Population:

Our study population consisted of 6,357 children with complete clinical, demographic, and anthropometric data. Characteristics of the population are summarized in Table 1. Participating children were of mixed racial/ethnic background, with the most-represented race being non-Hispanic black (48%), followed by Hispanic (20%), non-Hispanic white (18%), and others including Asian and >1 race (14%). Approximately one out of every four children (23%) were classified as overweight or obese based on their BMI Z-score. The majority (68%) were normal weight, and 9% were underweight. In terms of caries experience, 54% had experienced ECC with a mean of 8 affected tooth surfaces. Hotspots of pediatric underweight and ECC were identified in counties with high poverty, food insecurity, and low access to dental care, as displayed in Figures 2 and 3.

Caries experience and BMI categories according to sociodemographic characteristics are presented in Tables 2 and 3. The prevalence of OWOB was not evenly distributed across racial groups, with Hispanic children being significantly more likely to be overweight or obese than any other group. Twenty-seven percent of Hispanic children were OWOB compared to 22% of non-Hispanic white children. In terms of caries experience among racial groups, Hispanic children were also more likely to have dental caries compared to non-Hispanic black and non-Hispanic white children (61% versus 52%). There was a significant inverse association between parent or guardian's educational attainment and prevalence of ECC and OWOB. Children with caregivers who had not attained at least a high school-diploma level of education had a higher prevalence of caries and more affected tooth surfaces. For example, 65% of children whose parents did not graduate from high school or obtain a GED had dental caries, compared to 45% of children whose parents had a college education. This subpopulation of children with less educated parents was also more likely to be overweight or obese than children whose parents had achieved a higher level of education.

Section 3.2: Behavioral Associations:

Dietary and oral health-related behavioral associations are depicted in Tables 4-7. A positive history of being put to bed with a bottle containing something other than water was significantly associated with both ECC and OWOB in this study population. Sixty-percent of children who had been put to bed with a bottle of something other than water were ECC cases and 25% presented with overweight or obesity. Consumption of sugar-containing beverages and snacks in between meals was associated with increased prevalence of ECC, but not with OWOB.

In terms of oral health and hygiene measures, not having a dental home or having a positive history of a toothache or dental pain were significantly associated with all measures of ECC but not with OWOB. When clinical measures of oral health were compared against BMI, there were no major associations, with the exception of a small-in-magnitude, but statistically significant, inverse relationship between unrestored ECC (caries-affected and non-restored tooth surfaces) and underweight children. Underweight children had an average of one additional untreated carious surface compared to children that were not classified as underweight. This data is shown in Table 8.

We further examined the characteristics of two sub-populations that were of particular interest due to the scope of this study. First, the subset of children with obesity and ECC (n=305) and second, the subset of children who were underweight and had non-restored dental caries (n=229). In comparison to the entire sample, the latter were more likely to be African American (53% vs 48%), more likely to have a child-reported score of "fair/poor" oral health (30% vs 15%), and more likely to have experienced dental pain (21% vs 12%). Compared to the entire sample, the ECC-affected obese children were more likely to be female (56% vs 50%), Hispanic (29% vs 20%), have parents with a lower level of education (28% vs 19% not having completed high school), and more likely to have been put to bed with a bottle containing something other than water (30% vs 25%).

Section 3.3: Geographic Associations:

Geographical distribution of the primary outcomes ECC and BMI are displayed in Figures 2 and 3. A cursory glance shows relatively heterogenous distribution across the state; however, spatial analysis using Hot Spot Analysis (Getis-Ord Gi*) was employed to evaluate for "clusters", or statistically significant non-random groups of children with these clinical conditions. Significant clustering of high values (dark red) defined a hot spot, and that of low values (deep blue) defined a cold spot (95% CI). These maps are shown in Figures 2 and 3. In terms of BMI categories, there was one cold spot of low values, or underweight children, in Bladen county in southeastern North Carolina. Clustering of ECC cases was more varied. There were hot spots in various counties in southeastern North Carolina and Western North Carolina, and two cold clusters in Alamance county and Nash-Edgecombe counties.

CHAPTER 4: DISCUSSION

Section 4.1: General Discussion:

In this large community-based sample of preschool-age children, dental caries and OWOB were relatively common conditions. Based on publicly available data collected by the National Health and Nutrition Examination Survey (NHANES), ECC prevalence in our study population was more than twice the national average for children ages 2-5 (23%).[1] A possible explanation for this marked difference is the relative income heterogeneity of the NHANES sample population compared to our sample, who were all classified as low income based on their enrollment in the Head Start Program. Low income has been established as an important risk factor for ECC.[27,28] In terms of BMI, the majority of children in our sample population had a BMI classified as normal; however, almost one in four (23%) were classified as overweight or obese. This figure is lower than national data,[2] which is an interesting finding.

Our results offer evidence for sociodemographic risk factors common to the development of these two chronic conditions in childhood. It has been previously established that children with certain sociodemographic characteristics are at higher risk for development of caries and OWOB.[1,2,29] After stratifying by sociodemographic factors, this study found that prevalence of ECC and OWOB was highest in Hispanic children and in children with less formally-educated caregivers. Caregiver's education level, a measure of SES, influences knowledge of appropriate food choices and health behaviors, and contributes to overall health literacy and ability to navigate the healthcare system.

Only one dietary risk factor was assessed in this study, the frequency of in-between meal sugar-containing snacks and beverages. Interestingly, we found that it was positively associated with dental caries but not with OWOB in this population, even though frequent snacking has been implicated in OWOB in the literature.[30] On the other hand, a positive history of being put to bed with a bottle of something other than water was associated with both conditions. Although consumption of sugar-sweetened beverages was not specifically investigated in this study, there is a possibility that this group of children was also being exposed to sugar-containing beverages frequently throughout the day, which is a well-established risk factor for both conditions.[30,31,32] Consumption of sugar-containing beverages at least weekly was associated with more than double the odds of severe obesity in kindergartners in a study by Flores, et al.[32] Our study's finding of the association between both conditions and the behavior of going to bed with a bottle is important as it is a modifiable risk factor that could be mitigated by increased awareness and education.

There were no major associations between clinical measures of caries status and BMI with the exception of a small-in-magnitude, but statistically significant, association between underweight children and untreated dental caries. This finding warrants additional discussion. One possible explanation is that these children have a history of oral pain related to untreated caries that results in anorexia and eventual underweight status. Another theory is that these children may be experiencing geographical or social isolation which creates a barrier to food and/or healthcare access. Aside from this slight association, our overall finding of no major clinical association between dental caries experience and OWOB aligns with the inconclusive relationship found in the literature.

The maps in Figures 4 and 5 display hot-spot analyses for both primary outcomes overlaid with county-level measures suggestive of social vulnerability and/or barriers to care. In Figure 4, both food insecurity and poverty levels are depicted by county. The cluster of low weight children in Bladen county are living in an environment that has both a high level of food insecurity and poverty. The percentage of people living below poverty in Bladen county is estimated to be between 25-30%, and those experiencing food insecurity is between 21-26%.[33] A possible explanation is that this cluster of underweight children speaks to the overall social vulnerability of this county, as being underweight can be a physical manifestation of social-economic distress.[34] Cluster analyses for ECC are overlaid with two county-level measures in Figure 5: dentist to population ratio and access to grocery store by county. While there are some exceptions, the hot spots for ECC are generally found in counties with low dentist to population ratio (Duplin, Sampson, Columbus, Harnett, Robeson, Yancey, Graham and Cherokee). These counties have less than 4 dentists per 10,000 population.[35] Having poor access to food stores is defined as living >1 mile (urban area) or >10 miles (rural area) from a grocery store or supermarket.[36] Interestingly, the majority of the hot spots for ECC are located in counties where overall the population does not have difficulty with store access. This finding supports the realization that simply having access to healthy food does not mean that it is affordable or that people have the education required to make the best choices for their health.[19]

Section 4.2: Limitations:

A strength of this study lies in the large, state-wide, multi-ethnic population of preschoolers sampled, as well as its uniform and standardized clinical examination protocol for both ECC and anthropometry. The main limitation of the study is its cross-sectional character—ECC, anthropometry, and all postulated risk factors were measured contemporaneously. This not only prevents investigators from making causal inferences but also ignores the time-dependent variability in some important behaviors (e.g., diet patterns can and do change over time). Another limitation of the study is the relative homogeneity in terms of income in the studied population, as enrollment in Head Start programs has a maximum limit (e.g. $26,200 for a 4-person household in North Carolina).[37] As low income is an important risk factor for chronic health conditions as well as education and access to health services, the studied population is at high risk and carries a higher burden of disease compared to general population, which must be taken into consideration. Finally, assessment of oral health-related and dietary behaviors was done by survey, which is inherently subject to limitations including self-reporting bias. Responding parents may have been led to provide socially desirable answers out of concern for perceived judgment or repercussions for "less-acceptable" answers.[38]

Section 4.3: Anticipated Impact and Future Directions:

The findings of this study illuminate the frank disease burden and geographic distribution of early childhood caries and obesity in the state of North Carolina in a high-risk population of preschool-age children. This knowledge is valuable as it allows elected government officials, healthcare providers, and other interested stakeholders to have a "pulse" on chronic health issues afflicting this particular vulnerable subset of North Carolina's children. Furthermore, the identification of dietary and health related risk factors provides insight into where intervention and prevention may be most necessary and effective. This study did not find an important clinical association between the conditions of ECC and OWOB; however, additional large-scale population studies in older children would be informative, as the prevalence of both conditions increases with age.

CHAPTER 5: CONCLUSIONS

In this population-based, epidemiologic study we described the prevalence and association between childhood caries and OWOB in a low-income population of children in North Carolina. We confirmed the presence of shared demographic characteristics and behavioral risk factors that increase a child's risk of succumbing to one of these chronic diseases. Children and adolescents with caries and obesity are more likely to become adults with these conditions, which makes this study timely and significant. The understanding of these common risk factors should influence the development of precision policy-making and focused preventive efforts on a state and national-level to improve the health of our nation's children.

APPENDIX 1: FIGURES

Figure 1. A Conceptual Model of Common Influences between Early Childhood Caries and Childhood Overweight/Obesity

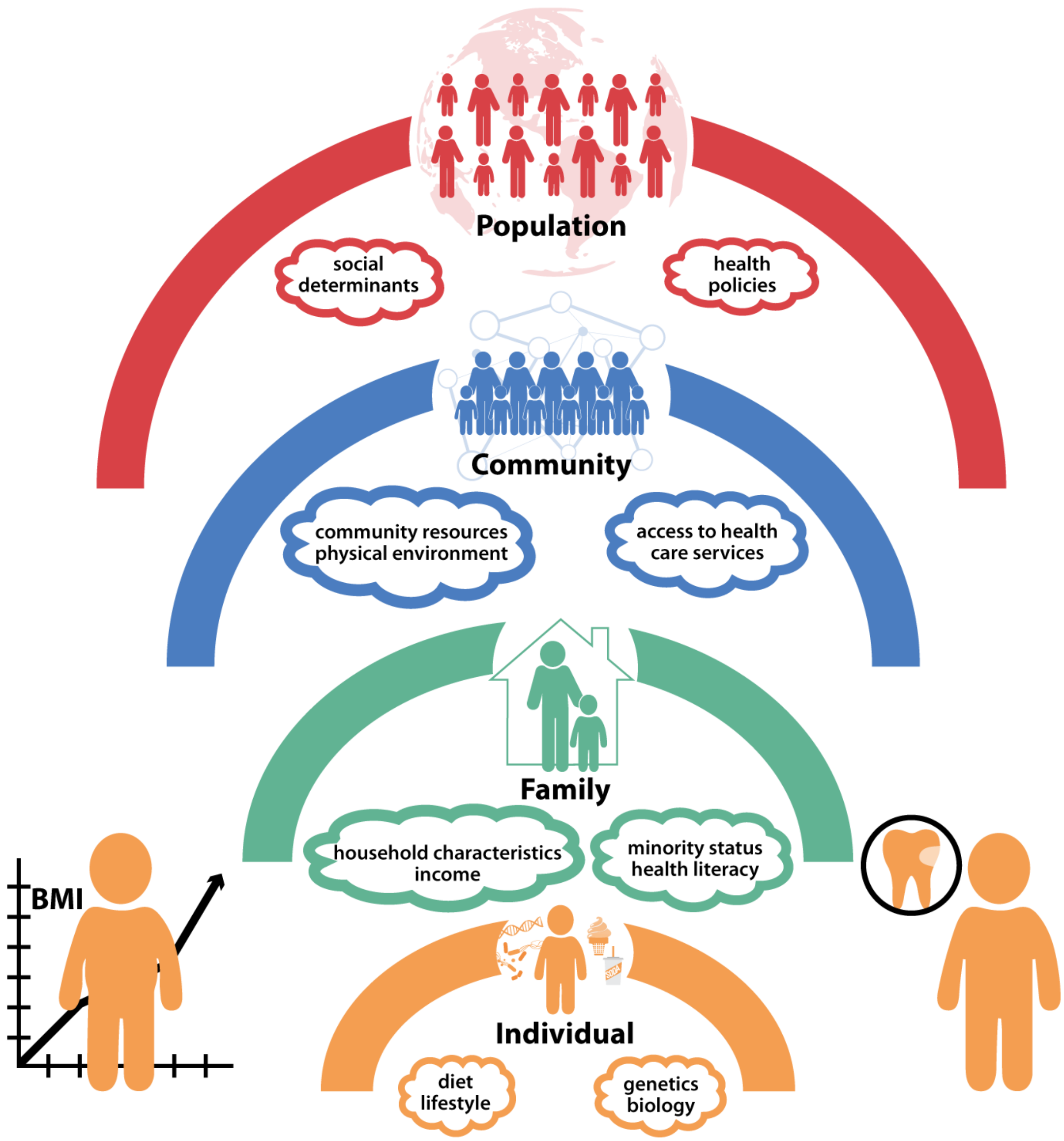
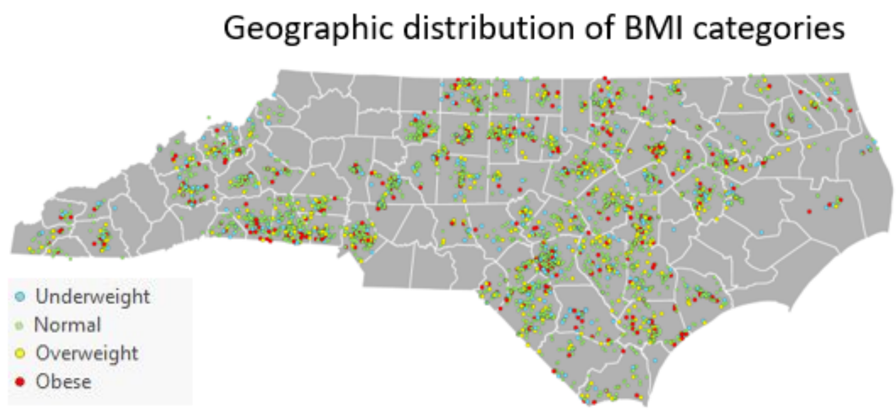


Figure 2. Geographic distribution of study participants' BMI and hot-spot analysis of zBMI score



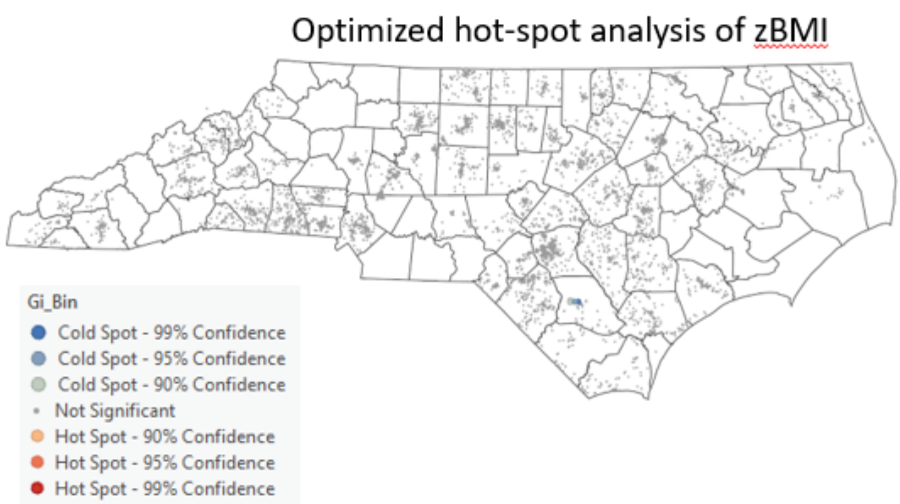
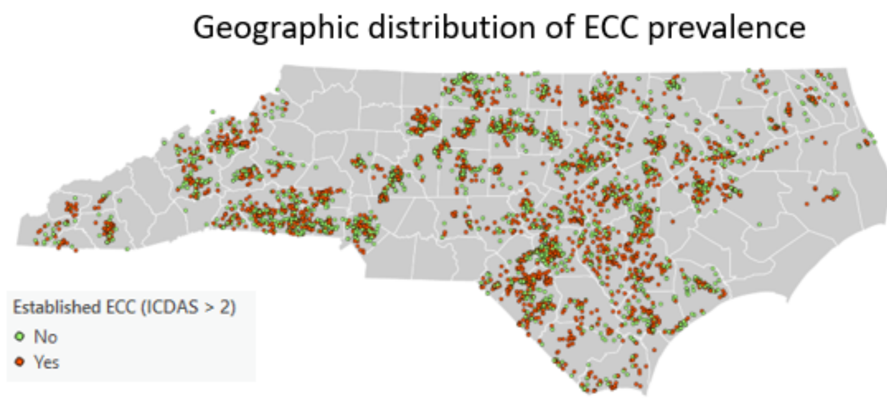


Figure 3. Geographic distribution of study participants' ECC experience and hot spot analysis of dmfs index



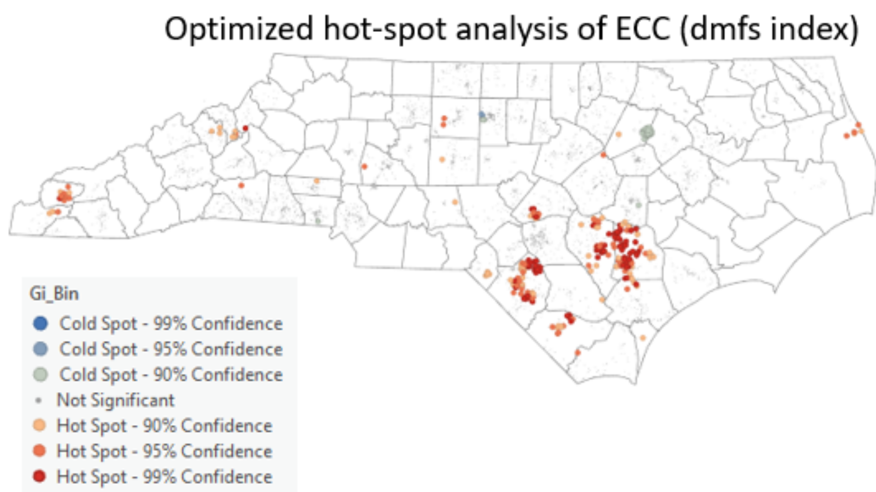
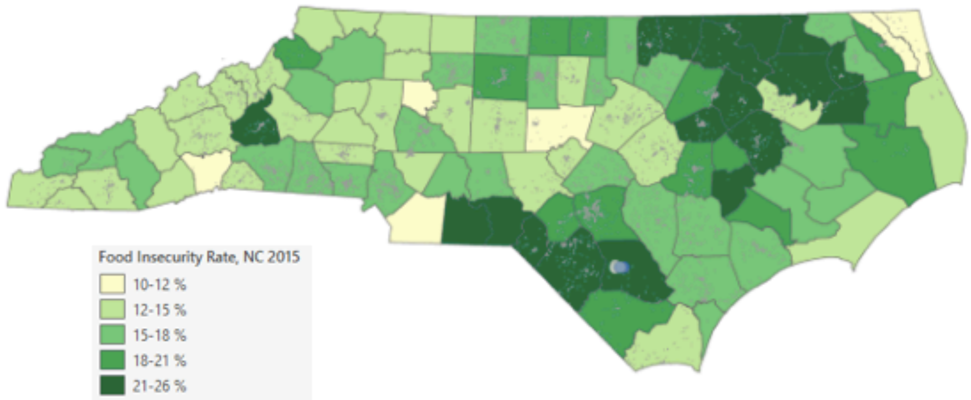


Figure 4. Hot spot analysis of study participants' zBMI and county-level measures of social distress

North Carolina county-level estimates of food insecurity in 2015



North Carolina county-level estimates of poverty in 2015

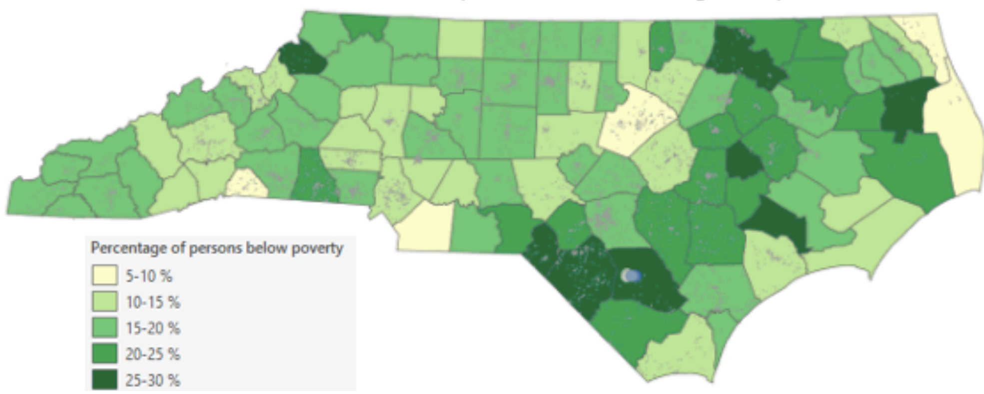
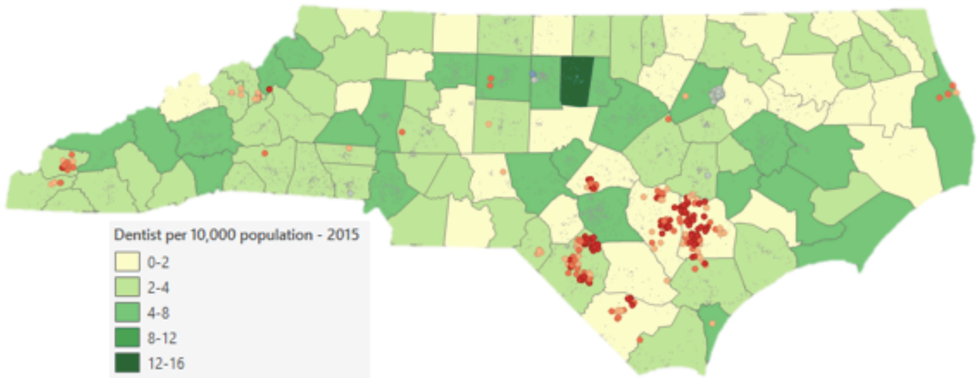
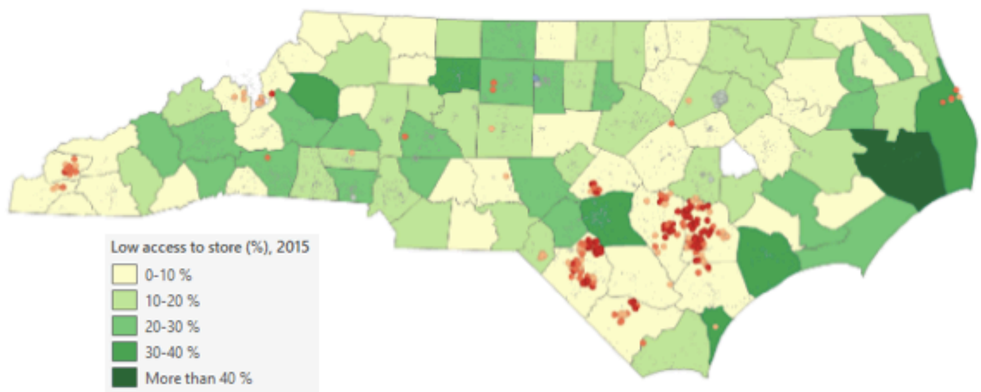


Figure 5. Hot spot analysis of study participants' ECC status and county-level measures of access to dental care and food stores

North Carolina county-level dentist to population estimates in 2015



North Carolina county-level estimates of low access to stores in 2015



APPENDIX 2: TABLES

Table 1. Sociodemographic and clinical characteristics of sample population

	n (%)
Total	6,357 (100)
Sex	
Male	3,163 (50)
Female	3,194 (50)
Age (years)	
3	1,484 (23)
4	3,324 (52)
5	1,549 (24)
Race/ethnicity	
Non-Hispanic black	3,032 (48)
Hispanic	1,283 (20)
Non-Hispanic white	1,125 (18)
>1 race	654 (10)
Asian/Alaska Native/American Indian/Other	259 (4)
Body mass index (BMI)	
Underweight	584 (9)
Normal weight	4,334 (68)
Overweight	863 (14)
Obese	576 (9)
Dental caries	
Established definition (ICDAS ≥3)	3,441 (54)
Untreated disease (ICDAS ≥3)	2,287 (36)
Parent/guardian education level	
Some elementary	320 (5)
Some high school	867 (14)
High school diploma or GED	2,345 (38)
Some technical school or community college	1,786 (29)
College education or higher	882 (14)

Table 2. Participants' demographic characteristics according to anthropometric classification

	underweight	normal weight	overweight	obese	Z-BMI
	n (row %)	n (row %)	n (row %)	n (row %)	P
	584 (9)	4,334 (68)	863 (14)	576 (9)	
Sex					0.53
boy	271 (9)	2,239 (71)	399 (13)	254 (8)	
girl	313 (10)	2,095 (66)	464 (15)	322 (10)	
Age (years)					<0.0005
3	156 (11)	1,059 (71)	177 (12)	92 (6)	
4	327 (10)	2,237 (67)	451 (14)	309 (9)	
5	101 (7)	1,038 (67)	235 (15)	175 (11)	
age months mean (SD)	52.4 (7.0)	53.4 (7.4)	54.1 (7.3)	55.2 (7.0)	<0.0005
Race/ethnicity					<0.0005
African American (Non-Hispanic Black)	302 (10)	2,065 (68)	389 (13)	276 (9)	
Hispanic	86 (7)	850 (66)	202 (16)	145 (11)	
Non-Hispanic White	96 (9)	784 (70)	152 (14)	93 (8)	
>1 race	74 (11)	445 (68)	86 (13)	49 (7)	
Asian/AN/AI/Other	26 (10)	186 (72)	34 (13)	13 (5)	
Guardian's education					<0.0005
Some elementary	20 (6)	208 (65)	52 (16)	40 (13)	
Some high school	64 (7)	578 (67)	138 (16)	87 (10)	
High school diploma or GED	226 (10)	1,599 (68)	299 (13)	221 (9)	
Some technical school or community college	162 (9)	1,266 (71)	213 (12)	145 (8)	
College education or more	94 (11)	583 (66)	136 (15)	69 (8)	

Table 3. Participants' demographic characteristics according to early childhood caries measures

	ECC (ICDAS≥3 threshold)			**Untreated disease** (ICDAS≥3 threshold)		
	cases n (column %)	dmfs mean (se)	P	cases n (column %)	ds mean (se)	P
Sex			0.02			0.02
boy	1,732 (55)	8 (0.52)		1,167 (37)	2 (0.20)	
girl	1,709 (54)	8 (0.66)		1,120 (35)	2 (0.17)	
Age (years)			<0.0005			0.22
3	661 (45)	5 (0.34)		499 (34)	2 (0.16)	
4	1,828 (55)	8 (0.63)		1,227 (37)	2 (0.18)	
5	952 (61)	11 (0.80)		561 (36)	2 (0.24)	
age months mean (SD)	54.4 (7.1)		<0.0005	53.7 (7.2)		0.15
Race			<0.0005			0.18
African American (Non-Hispanic Black)	1,589 (52)	7 (0.50)		1,137 (37)	2 (0.25)	
Hispanic	783 (61)	11 (1.0)		448 (35)	2 (0.17)	
Non-Hispanic White	584 (52)	8 (0.59)		376 (33)	2 (0.16)	
>1 race	328 (50)	6 (0.60)		225 (34)	2 (0.18)	
Asian/AN/AI/ Other	154 (59)	12 (1.8)		98 (38)	3 (0.48)	
Guardian's education			<0.0005			<0.0005
Some elementary	224 (70)	13 (2.0)		124 (39)	2 (0.26)	
Some high school	549 (63)	11 (0.79)		357 (41)	3 (0.34)	
High school diploma or GED	1,297 (55)	8 (0.64)		884 (38)	2 (0.25)	
Some technical school or community college	884 (50)	7 (0.52)		613 (34)	2 (0.15)	
College education or more	398 (45)	6 (0.48)		256 (29)	2 (0.19)	

Table 4. Association between reported dietary behaviors and participants' anthropometric classification

	entire sample	underweight	normal weight	overweight	obese	Z-BMI
	n (column %)	n (row %)	n (row %)	n (row %)	n (row %)	P
	6,357 (100)	584 (9)	4,334 (68)	863 (14)	576 (9)	
Daily snacks and drinks containing sugar consumed between meals						0.87
0-1	1,788 (28)	166 (9)	1,238 (69)	237 (13)	147 (8)	
2-3	4,221 (67)	387 (9)	2,862 (68)	570 (13)	402 (10)	
4 or more	315 (5)	30 (10)	211 (67)	50 (16)	24 (8)	
Child has ever been put to bed with a bottle containing something other than water						0.005
no	4,664 (75)	436 (9)	3,206 (69)	626 (13)	396 (8)	
yes	1,561 (25)	135 (9)	1,035 (66)	225 (14)	166 (11)	

Table 5. Association between reported dietary behaviors and early childhood caries measures

	ECC (ICDAS≥3 threshold)			Untreated disease (ICDAS≥3 threshold)		
	cases n (column %)	dmfs mean (se)	P	cases n (column %)	ds mean (se)	P
Daily snacks and drinks containing sugar consumed between meals			<0.0005			<0.0005
0-1	853 (48)	7 (0.54)		555 (31)	2 (0.14)	
2-3	2,366 (56)	9 (0.63)		1,573 (37)	2 (0.20)	
4 or more	199 (63)	9 (0.93)		149 (47)	3 (0.34)	
Child has ever been put to bed with a bottle containing something other than water			<0.0005			<0.0005
no	2,437 (52)	7 (0.56)		1,617 (35)	2 (0.15)	
yes	930 (60)	10 (0.65)		633 (41)	3 (0.27)	

Table 6. Association between reported child oral health-related behaviors and status and anthropometric classification

	entire sample	underweight	normal weight	overweight	obese	Z-BMI
	n (column %)	n (row %)	n (row %)	n (row %)	n (row %)	P
	6,357 (100)	584 (9)	4,334 (68)	863 (14)	576 (9)	
Brushing ≥2 times/day						0.06
yes	3,950 (62)	365 (9)	2,662 (67)	543 (18)	380 (10)	
no	2,379 (38)	218 (9)	1,652 (69)	314 (13)	195 (8)	
Adult involvement in brushing teeth						0.14
yes	3,822 (60)	376 (10)	2,594 (68)	521 (14)	331 (9)	
no	2,513 (40)	207 (8)	1,723 (69)	340 (14)	243 (10)	
Use of fluoride toothpaste						0.81
yes	4,858 (77)	441 (9)	3,303 (68)	674 (14)	440 (9)	
no	654 (10)	60 (9)	466 (71)	67 (10)	61 (9)	
unknown	774 (12)	77 (10)	516 (67)	114 (15)	67 (9)	
Reported dental home						0.89
yes	5,239 (92)	482 (9)	3,574 (68)	710 (14)	473 (9)	
no	445 (8)	39 (9)	305 (69)	55 (12)	46 (10)	
Reported child oral health status						0.03
excellent/v. good/good	5,330 (85)	475 (9)	3,637 (68)	730 (14)	488 (9)	
fair/poor	951 (15)	103 (11)	640 (67)	126 (13)	82 (9)	
Child had toothache or dental pain						0.88
no/unknown	5,539 (88)	507 (9)	3,795 (69)	745 (13)	492 (9)	
yes	750 (12)	72 (10)	499 (67)	105 (14)	74 (10)	

Table 7. Association between reported child oral health-related behaviors and status and early childhood caries (ECC) measures

	ECC (ICDAS≥3 threshold)			**Untreated disease** (ICDAS≥3 threshold)		
	cases n (column %)	dmfs mean (se)	P	cases n (column %)	ds mean (se)	P
Brushing ≥2 times/day			0.25			<0.0005
yes	2,137 (54)	8 (0.65)		1,359 (34)	2 (0.18)	
no	1,287 (54)	8 (0.48)		919 (39)	2 (0.18)	
Adult involvement in brushing teeth			0.11			0.59
yes	2,044 (53)	8 (0.63)		1,366 (36)	2 (0.15)	
no	1,382 (55)	8 (0.56)		916 (36)	2 (0.24)	
Use of fluoride toothpaste			0.003			0.30
yes	2,667 (55)	8 (0.58)		1,751 (36)	2 (0.17)	
no	312 (48)	6 (0.62)		227 (35)	2 (0.26)	
unknown	419 (54)	8 (0.81)		291 (38)	2 (0.24)	
Reported dental home			<0.0005			<0.0005
yes	2,793 (53)	8 (0.59)		1,790 (34)	2 (0.17)	
no	330 (74)	16 (1.3)		225 (51)	5 (0.50)	
Reported child oral health status			<0.0005			<0.0005
excellent/v. good/good	2,555 (48)	6 (0.50)		1,672 (31)	1 (0.11)	
fair/poor	828 (87)	19 (0.93)		582 (61)	6 (0.46)	
Child had toothache or dental pain			<0.0005			<0.0005
no/unknown	2,740 (49)	6 (0.49)		1,872 (34)	2 (0.16)	
yes	665 (89)	22 (1.0)		393 (52)	4 (0.31)	

Table 8. Association between clinically determined children's oral health status and anthropometric classification

	entire sample	underweight	normal weight	overweight	obese	Z-BMI
	n (column %)	n (row %)	n (row %)	n (row %)	n (row %)	P
ECC (ICDAS≥3 threshold)						0.66
case	3,441 (54)	319 (9)	2,356 (68)	461 (13)	305 (9)	
not case	2,916 (46)	265 (9)	1,978 (68)	402 (14)	271 (9)	
dmfs, mean (se)	8 (0.57)	8 (0.92)	8 (0.60)	8 (0.77)	8 (0.57)	0.95
Non-restored caries (ICDAS≥3 threshold)						0.16
no non-restored caries	4,070 (64)	355 (9)	2,757 (68)	568 (14)	390 (10)	
non-restored caries	2,287 (36)	229 (10)	1,577 (69)	295 (13)	186 (8)	
ds, mean (se)	2 (0.17)	3 (0.30)	2 (0.19)	2 (0.19)	2 (0.22)	0.03

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