A MULTI-LEVEL EXPLORATION OF OBESITY AND DISPARITIES: THE NEIGHBORHOOD, FAMILY, AND HEALTHCARE SYSTEM

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ABSTRACT

Background: Obesity imposes a significant burden on both the healthcare system and society. Additionally, racial/ethnic and socioeconomic disparities in obesity are well established. Addressing the correlates and consequences of obesity and the disparities observed in obesity is a national priority, but solutions are complex and require multi-level approaches. This dissertation examined the role of contextual factors from three different levels – the neighborhood, the family, and the healthcare system – on the correlates and consequences of obesity and racial/ethnic and socioeconomic disparities in obesity outcomes and quality of care.

Objectives: This dissertation examined factors from the neighborhood, family, and healthcare provider in three separate studies. The objective of Paper 1 was to assess the cross-sectional relationships between obesity-related diet behaviors and weight status outcomes with characteristics of the neighborhood environment in adults stratified by individual race/ethnicity. The objective of Paper 2 was to assess the longitudinal relationship between changes in early childhood obesity-related behaviors and weight status outcomes with changes in the frequency of fathers' child caregiving involvement from age 2 to age 4, and whether family socioeconomic status modified these associations. The objective of Paper 3 was to assess the cross-sectional relationship between parent-reported provider communication quality (outcome) and child obesity status, and whether parent obesity status or child race/ethnicity modified these associations.

Data Sources: Data for Paper 1 came from a representative sample of Californian adults from the 2011 – 2013 California Health Interview Study (CHIS) merged to U.S. Census data, and a commercial business data set (InfoUSA) through census tract identifiers. Paper 2 used data on children collected at age 2 to age 4 from the Early Childhood

Longitudinal Survey – Birth Cohort (ECLS-B), a nationally representative survey of children born in 2001 who were followed from birth until entry into kindergarten. Data for Paper 3 came from parents with children between the ages of 6 and 12 who participated in the nationally representative Medical Expenditures Panel Survey (MEPS) for 2011 – 2013.

Methods: In Paper 1 (neighborhood), I fit race/ethnicity stratified multi-level linear, logistic, and negative-binomial regression models to determine the association between obesity outcomes of obesity-related behaviors (fruit, vegetable and soda consumption) and weight status (BMI and obesity status) and characteristics from three neighborhood environments (sociodemographic, social, built), while controlling for respondent-level characteristics. Racial/ethnic sub-groups in this analysis included: non-Hispanic (NH) Whites, NH African Americans, Hispanics, and NH Asians. For Paper 2, I fit linear and logistic multivariable child fixed-effects models to determine how changes in early childhood obesity-related behaviors (TV viewing and soda consumption) and weight status (BMI z-score, overweight or obesity status, and obesity status) from age 2 to 4 were associated with changes in fathers' child caregiving involvement and decision-making and the modifying effects of family SES. For Paper 3, I fit multivariable logistic regression to examine the association of parent-reported provider communication quality (explaining well, listening carefully, showing respect, and spending enough time) with child obesity status and the modifying effects of parent obesity and child race/ethnicity.

Results: There is evidence that factors from each of the contextual levels examined in this study – neighborhood, family, and health system – were associated with obesity; however these relationships were complex when examined in different race/ethnicity or socioeconomic status groups. Among neighborhood level measures, lower educational attainment was associated with worse obesity-related behavior and weight status outcomes for all race/ethnicity groups. However, more features of the neighborhood

sociodemographic, social, and built environment were associated with obesity behaviors and outcomes among NH Whites than the other race/ethnicity groups. At the family level, increases in paternal caregiving involvement, specifically in the frequency that they took children outside to play (OR = 0.70, p = 0.03) and the number of physical caregiving tasks they performed on a daily basis (OR = 0.67, p = 0.003), were associated with a reduction in odds of childhood obesity from age 2 to age 4. Family socioeconomic status modified few of these relationships. At the healthcare system level, parents of obese children were more likely to report that their child's provider always listened carefully (OR=1.40, p = 0.002) and spent enough time (OR=1.32, p = 0.027) than parents of non-obese children. Among non-obese parents, those with obese children were more likely to report that providers always listened carefully (OR=1.75, p<0.001). Among parents of non-Hispanic (NH) Asian children, those with obese children were more likely to report that providers explained thing well (OR=4.81, p=0.04) compared to those with non-obese children.

Conclusions: While improvements to the neighborhood environment may be promising for reducing obesity, null associations among minority subgroups would suggest that changes to the social and built environments alone may be insufficient to address obesity in these groups. Increases in paternal involvement in caregiving, such as taking children outside and physical caregiving participations, may yield benefits to young children's weight status, regardless of the family's socioeconomic status. Therefore, efforts should be made to encourage father involvement with caregiving and to educate fathers on healthy caregiving. Finally, healthcare providers should continue to communicate effectively to parents of obese children, regardless of parent obesity status.

COMMITTEE

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The long and winding road… -- Paul McCartney

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DISSERTATION ORGANIZATION

This dissertation is organized based on the three-manuscript format, and includes 5 chapters. This chapter provides background information to motivate the problem and the need for more research, research aims and hypotheses, a literature review of the current state of the literature, the conceptual model, and an overview of the data sources used. Chapters 2, 3, and 4 are three separate manuscripts that are intended for submission to peer-reviewed journals. Because each manuscript is expected to stand alone, some information is repeated between chapters. The three manuscripts examine different contextual levels that may influence or be influenced by obesity. Chapter 5 provides a synthesis of findings across the three manuscripts, highlights strengths and limitations of each study, and discusses policy and practice implications of these studies.

CHAPTER 1: INTRODUCTION

Background and significance

Overview of obesity and disparities in obesity prevalence

Obesity is one of the most serious public health concerns in the nation. More than one-third of adults in the United States are obese,[1] which presents a serious challenge to the U.S. healthcare system and society. Overweight and obese individuals have a higher risk for a number of serious chronic diseases, including type II diabetes, cardiovascular disease, and stroke.[2,3] The direct and indirect medical costs of obesity amount to approximately $147 billion dollars each year.[4] Weight gain has implications beyond the healthcare system, including a reduction in worker productivity and national security (e.g., military recruits may be physically unable to perform standard tasks due to their weight).[5,6] Even more concerning, weight gain has increasingly begun at an earlier age. By the time children enter kindergarten (approximately age 5 or 6), 12% are already obese.[7] Furthermore, obesity in early childhood (< 5 years old) tends to persist throughout childhood[7] and into adulthood[8,9] with greater risk of poor health from obesity-related chronic conditions.[10]

Vulnerable populations have even higher rates of obesity, as socioeconomic and racial/ethnic disparities in obesity prevalence are well documented. Among adults, nearly half of non-Hispanic (NH) blacks and 42% of Hispanics are obese, compared to 33% of NH whites.[1] Among children, Hispanics have the highest rate of obesity at 22% compared to 14% of NH whites.[11] Children from low socioeconomic status (SES) families are also significantly more likely to be obese. Among children from age 2 to 19, approximately 20% of boys and girls living in households below 130% of the poverty level are obese, compared to 12% of boys and girls in households that are at or above

350% of the poverty level.[12] Furthermore, approximately 20% of children living in households where the head of the household has less than a college degree were obese, compared to approximately 10% of children living in households where the head of the household holds a college degree.[12]

Correlates and Consequences of Obesity

The causes of obesity are complex. Initial efforts to address obesity focused on modifying individual-level behaviors and characteristics related to diet and physical activity. However, these efforts have proved to be inadequate.[13] There is growing scientific consensus that the rapid increase in the prevalence of obesity over the past 4 decades is caused by factors that extend beyond individual biology and behaviors.[14,15] In recent years, there has been an increasing interest in examining how contextual factors – those beyond the individual – contribute to obesity and disparities,[14] as contextual factors play an important role in shaping individual behaviors including those related to weight, such as diet and exercise.[16]

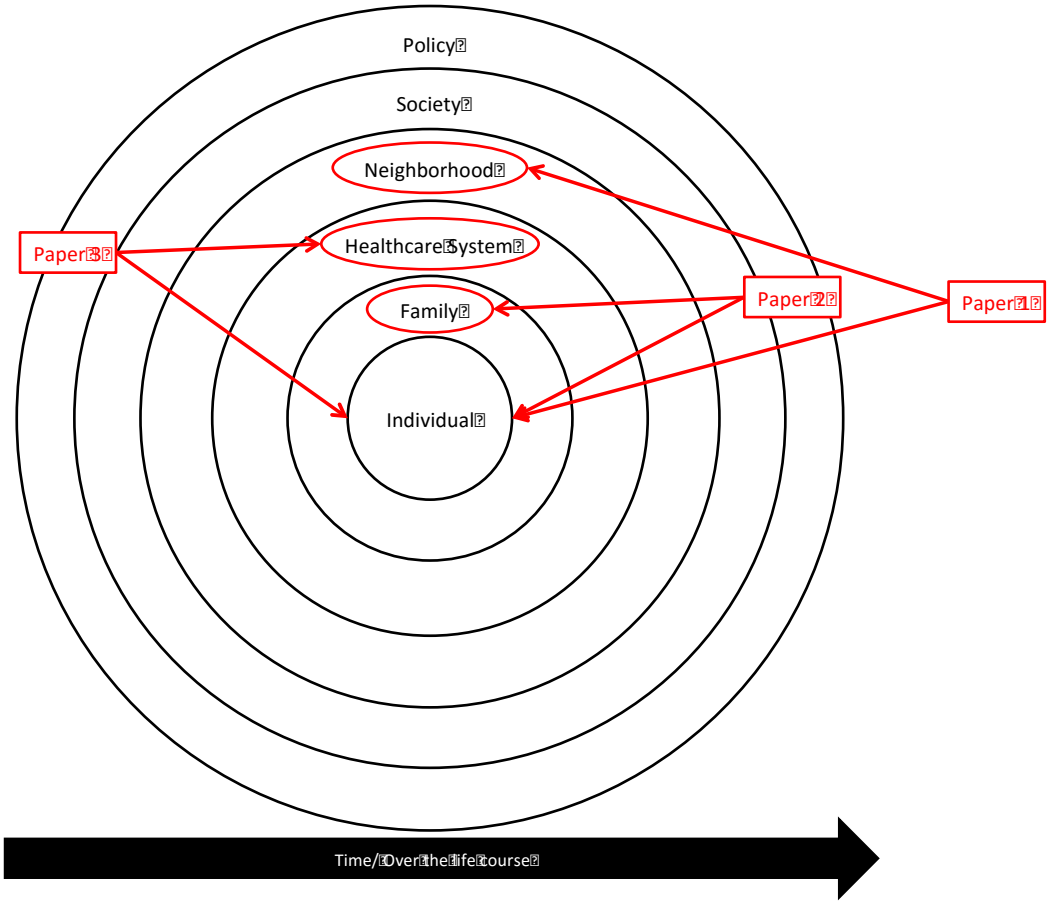
Additionally, a person's weight status affects how he or she interacts with the surrounding environment. Previous studies have documented that overweight and obese individuals experience stigma due to their weight from all levels of society, including employment, education, and healthcare.[17] Weight stigma may result in additional health issues for these individuals such as depression, and lead to them engaging in coping strategies, such as binge eating, that may lead to additional weight gain.[18] In the healthcare system, stigma from healthcare providers is particularly concerning as it can result in obese patients avoiding care and experiencing worse quality of care.[19]

The social-ecological model: a multi-level approach to obesity

The social-ecological model,[20] which emphasizes that different levels of society influence health, is a useful way for researchers to conceptualize, identify, and study the role of various contextual factors on obesity. The social-ecological model recognizes that

individuals are nested within multiple levels of society.[21] These levels extend from those that are most proximal to the individual (e.g., family) to those that are more distal (e.g., neighborhood and work place environments, economic systems, government institutions and policies). Multiple factors from each of these levels can influence an individual's health simultaneously.[21] The relative influence of each of these levels on health will also change through the life course.[20] As an extension to the social-ecological model, it is also possible that an individual's health status can influence how he or she interacts with each of these levels of society.

Figure 1.1. Adaptation of the social-ecological model to illustrate the multi-level relationships for obesity risk and obesity-related care



Based on the social-ecological model in Figure 1.1, there are 3 promising levels for identifying contextual factors that might influence or be influenced by obesity and

disparities in obesity: the neighborhood, the family, and the healthcare system. Factors in the neighborhood level can strongly influence whether individuals are able to access healthy foods and partake in physical activity, and norms and beliefs about healthy lifestyles or acceptable behaviors.[22] Factors in the family level play a crucial role on weight trajectories in young children. For example, parents influence their child's eating behaviors directly through controlling what and how much children eat, and indirectly by shaping appetite, food, and behavioral preferences.[23] Psychosocial stress in the family environment such as maternal depression and low family SES have been associated with elevated risk of childhood obesity.[24] At the same time, person's weight status can simultaneously affect how they interact with and are treated by the healthcare system. Studies have found that obese patients cite physicians and nurses as sources of weight stigma,[17,18] and patient weight may negatively affect the relationship and communication with providers.[25-27] Negative interactions may inhibit obese individuals from successfully losing weight.[19,28]

Contextual factors within these 3 levels can also influence disparities in obesity. Racial/ethnic minorities and lower SES individuals have different life experiences and exposures to contextual factors that can influence their risk of obesity. The role of neighborhood environment on racial/ethnic disparities in obesity has been well studied.[29,30] Due to a long history of institutional racism such as residential redlining, NH Blacks are more likely to live in segregated, disinvested neighborhoods with few health promoting resources, and higher crime.[31-34] Prior research has found that differences in neighborhood physical and social exposures between blacks and whites likely account for a substantial portion of observed black-white disparities in obesity.[30,35] In the family context, observed SES disparities in childhood obesity may be due to differences in maternal risk factors. Obese children from low SES families are more likely to be born to overweight mothers, have mothers with depression, or reduced breastfeeding and early

introduction to solid foods.[36] At the health system level, provider biases towards minority patients and obese patients have been documented, and these negative experiences may potentially be exacerbated among patients who are *both* minorities and obese.

This dissertation takes a multi-level approach to explore the relationships between correlates and consequences of obesity with contextual factors within each of the levels – neighborhood, family, and health system – and whether these relationships vary by individual race/ethnicity and SES. Within the neighborhood level, I will explore the role of built, sociodemographic, and social environments; within the family level, the role of fathers; and within the healthcare system, the quality of parent-pediatric provider communication.

Literature Review

NEIGHBORHOOD LEVEL

Obesity and the neighborhood built, sociodemographic and social environments

Contextual factors within the neighborhood level can potentially influence obesity risk by supporting or inhibiting a healthy diet and physical activity.[37] Understanding the relationship between neighborhoods and obesity requires disentangling the contributions of different aspects of the neighborhood. Recent research has separated the neighborhood into three distinct but potentially related domains that may be relevant to obesity: the built, sociodemographic, and social environments.[38,39]

Most of the research on the neighborhood environment has focused on the built environment.[40-42] The built environment is defined as aspects of the neighborhood which are "man-made or modified, as compared with naturally occurring aspects of the environment".[43] Researchers hypothesize that the built environment can influence caloric consumption through the local food environment (e.g., supermarkets), and caloric expenditure by facilitating or inhibiting physical activity.[40] Despite a strong theoretical

mechanism, studies have yielded mixed results, particularly on the food component of the built environment.[40,43] Among food outlets, prior studies have found evidence of higher or no difference in obesity prevalence in areas with more fast food outlets and convenience stores,[37,40,44,45] while studies on supermarket availability have produced highly mixed relationships.[40,43,45] Supermarket findings may be due to the fact that while supermarkets certainly provide access to fruits and vegetables, they also carry large assortments of unhealthy foods.[37] Research on the physical activity component of the built environment has produced more consistent findings. Being closer to, or having more gyms/recreational facilities,[40,43,46] and living in communities with a low degree of urban sprawl and more variety in land-use mix are generally associated with increased physical activity, and in some instances, reduced BMI.[40,43,47-49]

Studies of sociodemographic environment typically focus on demographic and socioeconomic status (SES) composition of neighborhoods. Common neighborhood SES measures include educational attainment (e.g., % with a high school degree, % with a college degree), median household income, proportion of households living below the poverty line, and proportion of female-headed households.[50] Consistent with findings on other chronic health outcomes,[51] considerable research has found that after accounting for individual SES, lower neighborhood-level SES is associated with higher body mass index (BMI).[46,50,52] These neighborhoods typically have fewer health promoting resources, higher crime that may deter exercising outside, and norms and cues (e.g., advertising) that encourage unhealthy habits.[53]

Neighborhood racial/ethnic composition is a commonly used demographic measure.[54] Some studies have used neighborhood racial/ethnic composition as a proxy for neighborhood SES. Other studies have found that neighborhood racial/ethnic composition is independently associated with obesity after accounting for neighborhood SES.[34,39,55] In neighborhood SES-adjusted analyses, NH Black women living in

neighborhoods that were predominantly black had higher odds of obesity.[34,56] Researchers have hypothesized that neighborhood racial/ethnic composition may influence norms around lifestyle, diet, and body image.[57,58]

Recently, researchers have also begun to assess whether the neighborhood social environment, which is defined as relationships, groups, and social processes that exist between individuals and groups who live and work in a neighborhood is associated with obesity.[38,59] However, compared to the sociodemographic and built environments, the social environment is less well studied.[60] Aspects of the social environment that have been previously examined include perceived safety, social capital and social cohesion, and of these, neighborhood safety has been most extensively studied. While it has been proposed that neighborhood safety likely influences outdoor physical activities, such as walking,[60] studies have yielded mixed results. Some studies found better obesity outcomes (lower obesity prevalence and higher physical activity) in safer neighborhoods as hypothesized, but other studies found no relationship between neighborhood safety and obesity outcomes. Furthermore, several studies have found higher physical activity in neighborhoods with higher crime.[61-63] Research on other aspects of the social environment, including neighborhood social ties, social capital and social cohesion, have found a more consistent relationship between positive social environment (e.g., higher social cohesion) and better obesity-related outcomes, including increased physical activity and lower prevalence of obesity.[38,59,64] Social capital and social cohesion may reinforce positive health norms, and empower communities to work together to improve their neighborhoods to promote healthy lifestyles.[59,65]

The role of neighborhoods in racial/ethnic disparities in obesity

Contextual factors within the neighborhood level may also contribute to the observed differences in obesity prevalence across racial/ethnic subgroups. These

disparities might arise as a result of higher risk groups experiencing different neighborhood exposures from lower risk groups. A significant amount of research has found strong evidence that racial/ethnic differences in neighborhood exposure contribute to observed disparities.[29,34,35,45,66,67] Compared to NH Whites, minorities, especially NH Blacks, are more likely to live in underinvested neighborhoods with fewer educational and employment opportunities, municipal services, and health-promoting resources such as food outlets that carry healthy foods.[45,66,67] These neighborhoods exposures may put these subpopulations at higher risk for developing obesity. Additionally, while nationally, low-SES NH Blacks have a higher prevalence of obesity than their NH White counterparts, recent studies have found that in low-income racially integrated communities, there was no difference in the prevalence of obesity between NH Whites and NH Blacks.[29,35]

It is also possible that associations between obesity and the neighborhood environment vary by race/ethnicity; however, few studies have examined this potential interaction effect.[45] Most of this research has focused on the neighborhood sociodemographic environment, specifically the neighborhood's racial/ethnic composition. These studies have found that the relationship between neighborhood race/ethnic composition and obesity differs by individual race/ethnicity.[68-70] While black neighborhood segregation is associated with worse diet and BMI for NH Blacks,[68] Hispanics and NH Asians who live in predominately Hispanic or Asian neighborhoods, respectively, are more likely to have healthier diets.[69,70] For Hispanics and NH Asians, BMI increased as the concentration of Hispanics and NH Asians, respectively, in the neighborhood decreased.[71] These differences in the relationship between neighborhood segregation and obesity by race/ethnicity may be due to different processes through which segregated neighborhoods arose. Hispanics and NH Asians are more likely to live with others in the same racial/ethnic group in "ethnic enclaves" (geographic areas with

high minority ethnic concentration) while for NH African Americans, segregated neighborhoods resulted from a long history of institutionalized racial discrimination, such as residential redlining.[31-34] Hispanics and Asians may benefit from the "ethnic density effect" where living among a higher concentration of individuals of the same race/ethnicity may be protective of health by fostering social cohesion, protecting cultural norms, and buffering individuals from discrimination.[72] It may also make it easier to preserve their traditional culture, which helps to promote healthier eating practices (e.g., healthier diets and eating meals as a family).[73-75]

Findings from the neighborhood built environment across race/ethnic groups are mixed. Two studies found that supermarkets were more strongly associated with lower weight among NH Blacks compared to NH Whites,[76,77] while another study found that healthful food environment (defined as a composite measure of healthful and unhealthful retail food vendors) is associated with lower obesity in NH Whites, Asians, and Hispanics, but not among NH Blacks.[78] Within the neighborhood sociodemographic environment, one study found that higher neighborhood educational attainment was associated with reduced obesity in NH White and Hispanic women, while higher neighborhood poverty was associated with higher obesity in NH White and NH Black women.[79]

Gaps in the neighborhood level

Despite significant research on the neighborhood environment, it is still unclear which contextual factors within each of these neighborhood environments are most important to addressing the obesity epidemic. Fewer studies have considered the role of the neighborhood social environment.[59] The limited research that has been conducted suggests the neighborhood social environment is a promising way to address obesity. However, more research is needed to identify specific neighborhood social environment

contextual features that are important and may be potential targets for neighborhood interventions.

More research is also needed to examine whether the relationship between obesity and specific features of the neighborhood environment vary by race/ethnicity. With the exception of studies that use neighborhood racial/ethnic composition has a proxy for neighborhood SES, few studies have considered the relationship with obesity for those living among a high concentration of individuals of a *different* racial/ethnic groups.[57] Additionally, there is limited research on racial/ethnic variation in the relationship between obesity and the built and social environments.

FAMILY LEVEL

Role of parents in childhood obesity

While genetics are important determinants of a child's predispositions for weight gain,[80] the family environment, especially parental influences, also exerts an important influence in the development of obesity during early childhood.[81] Parents control what children eat and how children are entertained, and often shape a child's food and behavioral preferences.[82]

For example, parental feeding style can shape a child's eating behavior and their risk for obesity.[82] Prior research has identified responsive, or child-centered, feeding practices that are associated with maintaining a healthy weight, including establishing routines and structure around eating (e.g., eating dinner as a family), and giving children autonomy in food intake (e.g., allowing children to choose food quantity within a range of healthy portions).[83] In contrast, unresponsive or parent-centered feeding practices, such as permissiveness or a lack of rules in food intake, excessive monitoring of children's dietary behaviors, or pressuring children to eat, may negatively affect children's eating behaviors and increase their risk of obesity.[82,83]

Parents can also influence their children by their general parenting styles. Parenting styles fall into four general categories (from most to least controlling): authoritarian, authoritative, permissive, and disengaged. There is general consensus that an authoritative parenting and feeding styles are associated with better diet, more appropriate caloric consumption, reduction in sedentary behavior, and lower childhood obesity.[84] While in some instances, parents employ similar parenting and feeding styles, research suggests that parents often employ different behaviors when feeding compared to their general parenting style.[85] Parenting style also affects other behaviors that can influence obesity risk including physical activity and sedentary activities, such as screen time.[84] Studies have generally found that children with authoritative parents are less likely to be obese compared to authoritarian or permissive parents.[84,86]

Role of fathers in childhood obesity

Much of the research assessing parenting styles were conducted among mothers or used mothers as a proxy for both parents,[87-90] given mothers' traditional role as the primary caregiver. However, in the past four decades, shifts in parental roles and family structure, such as the increase of women in the work force,[91,92] has led to greater involvement of fathers in child cargiving.[93,94] A 2011 U.S. Census report found that fathers provide approximately 20% of primary caregiving to pre-school children.[95] Despite the increased role of fathers, limited research has examined the relationship between paternal caregiving and childhood obesity.[89]

Of the few studies that have explored paternal caregiving involvement and childhood obesity, most have focused on factors specific to child nutrition and exercise, including fathers' parenting styles, knowledge of and behaviors related to nutrition and physical activity, and child feeding habits.[87,96,97] These studies found that fathers' involvement had both positive and negative impacts on child obesity risk. Higher physical activity in fathers was associated with higher physical activity levels in the

child.[97] However, some paternal behaviors, such as lower monitoring of child food intake, were associated with higher child BMI.[87] Additionally, while fathers' had some knowledge about nutrition and mealtime interactions, their understanding was not always accurate, nor did they always act upon their nutritional and feeding knowledge. For example, fathers who knew the appropriate child feeding style may still choose to give into a child's food demands.[96] These studies were also largely limited to well-educated, white fathers who cohabitated with the child's mother.[87]

SES differences in parent influence on childhood obesity

Parent SES characteristics may also influence early childhood obesity risk. These characteristics include maternal employment, parent education, and family structure (i.e., two-parent vs. single-mother household).[88,98-100] Maternal employment has been linked to childhood obesity [99,100], potentially by reducing the amount of time that mothers can spend grocery shopping, cooking, and eating with, playing with, and supervising their children.[101] Children of working mothers are more likely to eat prepared meals, spend more time watching TV, and engage in less vigorous physical activity [88,102]. One study also found that complex relationships emerged between maternal employment and child obesity when interactions with household poverty status, and parent composition were considered.[99] Specifically, children of single mothers living below the poverty line were less likely to be obese when mothers increased their employment.[99] The study authors hypothesized that this might be due to an increase in resources and food provisions that might be protective of obesity.[99] In contrast, they found that maternal employment was detrimental to the child's weight among two-parent families living below the federal poverty line.[99]

Some – although not all – studies have found children of mothers with higher education are less likely to be obese.[88,103] It has been suggested that mothers with lower education may have less nutrition knowledge,[88] may exhibit less control over child

feeding and engage in more emotional feeding.[104] There are far fewer studies examining father feeding behaviors, and most of these studies have been conducted in well-educated, higher SES, white fathers.[87] A recent study assessed feeding behavior in a diverse sample of fathers and found that lower paternal education was not necessarily associated with worse feeding behaviors. While compared to fathers with a college education, fathers without a college education were more likely to let children dictate preferences, less likely to feed on a schedule, and less likely to model healthy practices, they were also more likely to educate children about food.[105]

It is well established that living in a two-parent household has a protective effect on child development in a wide variety of areas including education, behavior, physical health, including obesity, compared to children living in single-mother households.[98,106,107] Two-parent households typically have higher income, which might account for some of these observed benefits. However, studies looking specifically at childhood obesity outcomes have found that after controlling for household income, obesity prevalence is still lower in two-parent compared to single-mother households, which suggests that there are other benefits of living in two-parent households beyond additional gains in income.[98,107]

Gaps in the family level

There is a significant lack of research in the parenting and childhood obesity literature on the role of fathers. A recent systematic review of fathers' representation in observational studies on parenting and childhood obesity noted that only 1% of studies included only fathers compared to more than one-third of studies that included only mothers. Across all eligible studies, fathers represented 17% of participants.[90] Existing research on fathers has been limited to behaviors that are closely linked to the child's nutrition and physical activity (e.g., father feeding, parenting styles). To my knowledge, no study has considered more general paternal participation with caregiving, such as

looking after the child with the mother is not there, or their level of involvement with decision-making. Given the lack of research with fathers, there is a need for more research on their role in childhood obesity, including their general parenting participation.

Furthermore, as children from socioeconomically disadvantaged families are more likely to be obese, it is important to consider the role of fathers in these households. It is possible that fathers may play a more important protective role in low SES families. By helping with child caregiving, they could alleviate maternal stress and depression – which are risk factors for childhood obesity – and provide additional time devoted to child caregiving. Conversely, they may benefit from additional parenting education before they can exert positive influences on their child's obesity risk. However, there is a lack of studies with fathers conducted in more socioeconomically diverse families, to better understand paternal roles in child obesity risk, particularly in low-SES families.

HEALTHCARE SYSTEM LEVEL

Role of parent-provider communication quality and childhood obesity

High quality communication between parents and their child's healthcare provider is generally associated with increased parent/family satisfaction with care, increased adherence to provider recommendations, and improved child health outcomes.[108-112] High quality parent-provider communication is also associated with increased care collaboration between parents and providers as well as parental disclosure of psychosocial issues (e.g., behavioral problems).[109,111,113] For example, a randomized trial of a continuing medical education program that aimed to improve pediatrician asthma therapeutic and communication skills found that pediatricians who participated in the program were more likely to set goals for patients, and their pediatric patients had fewer days of limited activity and fewer emergency department visits.[108]

Obese children typically have greater medical needs as they are more likely to have adverse health conditions as a result of their excess body weight[114] such as dyslipidemia and impaired glucose tolerance.[10] Therefore, high quality provider communication may be especially important for parents of obese children to help them manage their child's weight and related comorbidities. Healthcare providers can make parents aware of their child's weight concerns through weight status assessments and monitoring of BMI, diet, and physical activity; help parents understand the health risks associated with their child's weight gain; and encourage healthy behaviors for weight loss through counseling and development of weight management treatment plan.[115,116] Parents believe that their child's healthcare providers can and should provide counseling on a healthy diet, physical activity, and sedentary behaviors for their child.[117,118]

Influence of patient body weight on communication quality

Obese individuals – both adults and children – commonly face stigma because of their weight.[17,119] Among adults, one source of stigma comes from the healthcare system, including physicians, and to a lesser extent, nurses.[119] It is possible that provider bias against overweight and obese patients, which has been well documented,[17,120,121] may affect how providers interact and communicate with these patients.

Research on the relationship between provider communication and patient weight status has generally focused on adults. Although findings have been mixed, there is evidence to suggests that overweight and obese adult patients experience worse communication, patient-provider relationship quality, and satisfaction with care.[26,27,122] Physicians have less respect for patients with obesity,[123] believe that they lack motivation,[124] and demonstrate less emotional rapport building (e.g., empathy, concern, reassurance, and partnership) with obese patients compared to normal weight patients.[125] However, older obese patients have also reported greater satisfaction with their provider compared to healthy-weight counterparts,[126] although the literature on

patient-provider communication and patient satisfaction has generally found few differences between obese and healthy weight individuals in how they rate relationship quality with their providers[127] and their satisfaction with ambulatory care.[128]

Most of the research on the relationship between child weight status and communication quality between their parents and providers has been examined within the context of weight-related discussions.[116,118,129-132] Parents of overweight and obese children reported feeling that their child's providers blamed them for their child's weight,[129,132] and stigmatized them as being incompetent parents.[133] Some have even avoided consulting their child's provider on weight management because of fear of judgment from their child's provider.[132] While many parents reported negative interactions, including a lack of sympathy, dismissiveness and apathy, hopelessness, and insensitive or offensive comments from providers,[129,131] some parents did note positive experiences where providers listened, were empathetic, and provided helpful advice.[129]

Race/ethnic differences in provider communication quality

Patient-provider communication may also be influenced by providers' biases related to patient race/ethnicity. Prior research among adults has shown that some providers have implicit biases against black patients, associating these patients with being less cooperative, more contentious, and less adherent.[134-136] As a result, black patients may experience less patient-centered communication[137] and report lower levels of trust in providers.[138] Among Hispanic patients, research has found that Spanish-speaking and foreign-born Hispanics are less satisfied with provider communication quality as compared to white, black, English-speaking Hispanics and U.S.-born Hispanics.[139,140] Studies among pediatric patients have found that disparities in parent-provider communication exist primarily for parents of NH Asian and Hispanic children with limited English proficiency.[141-143]

It is possible that patients who are both minorities and obese (e.g., obese and black) may experience even poorer provider communication quality compared to patients who only belong to one of these groups (e.g., obese or black). Two such studies have explored this possibility. A study conducted among a nationally representative sample of adult patients found no differences in patient-reported provider communication quality by patient weight alone, but when both patient weight and race/ethnicity were considered, overweight and obese NH Black patients experienced worse communication quality.[25] A separate study conducted among parents of Latino obese children found that during weight-management conversations, pediatricians frequently used stigmatizing terms like "fat" to describe the child's body and rarely discussed culturally relevant dietary recommendations with parents.[144]

Gaps in the healthcare system level

Although the influence on patient weight on patient-provider interactions is well studied in adults, fewer studies have considered the whether a child's obesity status influences the relationship between parents and their child's health care providers. Furthermore, the studies in children were all conducted during narrowly focused weight counseling sessions. Given the additional health needs of obese children, more research is needed to assess the relationship between parent-provider interactions, such as communication quality, with child obesity status during routine clinical interactions where the child's weight may be discussed but is not necessarily the focus of or reason for these clinical visits. This relationship may also differ based upon other parent and child characteristics. Specifically, the parent's own weight status and the child's race/ethnicity are two potentially important modifiers of the relationship between parent-provider communication quality and child obesity status, given existing research on adult obese patient experiences[26,27,122] and documented differences in communication quality by

child race/ethnicity.[141-143] However, to date, little research has examined the modifying effects of these two characteristics.

Specific aims and Hypotheses

Paper 1 examined the association between obesity related behaviors and weight status **H**outcomes, and three neighborhood environment domains (sociodemographic, social, and built) for four race/ethnicity groups: NH Whites, Hispanics, NH African Americans, and NH Asians. Based on prior research, I hypothesized that neighborhoods with high social support, high neighborhood socioeconomic status, and protective features of the built environment will be associated with better obesity outcomes (behavioral and weight status outcomes) for all race/ethnicity subgroups [38,40,50]. Additionally, more factors within these three neighborhood environments will be associated with obesity outcomes among NH Whites and NH African-Americans than among Hispanics and NH Asians. For the latter two subgroups, Asian and Hispanic cultural influences on dietary habits, even among those not residing in ethnic enclaves, may outweigh neighborhood influences. I further hypothesize that living among others from the same ethnic group will be associated with better obesity outcomes among NH Asians and Hispanics, but worse outcomes among NH African Americans.

Paper 2 aimed to 1) determine whether changes in early childhood obesity-related behaviors and weight status outcomes from age 2 to 4 were longitudinally associated with changes in fathers' child caregiving involvement and decision-making influence, and 2) whether father education, family baseline poverty status, or baseline maternal employment modified these associations. I hypothesized that increasing paternal caregiving involvement and decision-making would be associated with decreases in obesity-related behaviors and weight status outcomes. I further hypothesized that these associations would be stronger among children living in poverty,

whose mothers were employed, and whose fathers had higher education. Among children living in poverty, paternal involvement with caregiving and decision-making may help to alleviate maternal stress, which is associated with childhood obesity[36]. Maternal employment is associated with increased childhood obesity due in part to less time devoted to caregiving[99,100], but increased paternal involvement, particularly with caregiving, may reduce the negative influence of maternal employment. Fathers with higher education may have greater knowledge of healthy behaviors and model behaviors when caring for their child.

Paper 3 aimed to 1) examine the relationship between four domains of parent-reported communication quality (how well providers explained things well, listened carefully, showed respect, and spent enough time) with their child's healthcare provider and child obesity status and 2) whether parent obesity status or child race/ethnicity modified these associations. Given existing research in adult[26,27,122] and among children during weight counseling sessions[129,132], I hypothesized that parents of obese children would report worse communication quality in all four domains. I further hypothesized that if both the parent and child were obese, or if the child were obese and Hispanic, NH Asian, or NH Black, parents would report worse communication quality.

Overview of Methods

Each of the papers involved secondary analysis of a different dataset that was uniquely suited for the research question. This section will describe each of the datasets and their applicability to the research question and method.

For Paper 1, individual level data and data on the neighborhood social environment from the 2011 – 2013 California Health Interview Survey (CHIS) was linked to area-level data from the US Census and InfoUSA, which provided information about the neighborhood sociodemographic and built environments, respectively. The CHIS is a

cross-sectional survey that collects information about the health of Californians. The CHIS is ideally suited for studying the relationship between obesity and the neighborhood environment by racial/ethnic subgroups for a number of reasons. First, the CHIS, which captures the racial/ethnic diversity of the state of California, is designed to provide population estimates for California's major race/ethnic groups by oversampling individuals from California's major racial/ethnic groups. This sampling strategy provides sufficient sample size for race/ethnicity-stratified analyses including those for NH Asians, which typically cannot be analyzed as a separate subgroup with other national surveys due to insufficient number of observations. Second, the CHIS includes a census tract identifier for each survey respondent, which allowed area-level data from the US Census and InfoUSA (a business listing data set) that provided information about the neighborhood sociodemographic and built environments to be merged to the CHIS. Third, while information about the neighborhood built and sociodemographic environments are readily available in area-level data sources such as the US Census and commercially available business listing data sources, data about the social environment are more challenging to ascertain and often require surveying respondents. The CHIS includes a series of questions that specifically asks respondents about their neighborhood social environment, such as whether they can trust their neighbors.

I used race/ethnicity stratified multi-level linear, logistic, and negative binomial models that controlled for individual characteristics to assess the relationship between obesity-related behaviors (fruit, vegetable, and soda consumption) and weight status outcomes (BMI and obesity prevalence) with three neighborhood environments (sociodemographic, social, and built) for NH Whites, Hispanics, NH African Americans, and NH Asians. By providing census tract identifiers, the CHIS allows for multi-level modeling, which allows for appropriate accounting of the clustering of data within neighborhoods for unbiased inferences.

Paper 2 used data from the Early Childhood Longitudinal Study – Birth Cohort (ECLS-B). This survey collected data from a nationally representative sample of children at various time points from birth until entry into 1st grade. The ECLS-B has a number of strengths for studying the association between early childhood obesity and father involvement with caregiving and decision-making. The ECLS-B is intended to collect detailed information about factors that influence early childhood development, particularly the family and home environment. To achieve this, the ECLS-B administered surveys to a variety of individuals who play an important role in the child's life, including a *separate* survey administered to fathers. Collecting information directly from fathers is important to have a comprehensive understanding of their involvement with their child's upbringing, but many surveys only collect information from the primary caregiver – typically the mother.

Another strength of the ECLS-B is that it collected longitudinal information on the child's development. Paper 2 analyses took advantage of the longitudinal data to assess the association between changes in early childhood obesity-related behaviors (TV viewing and soda consumption) and weight status (BMI z-score and obesity status) with changes in father involvement with child caregiving (meal preparation, taking child outside for walk or play, looking after child, and physical caregiving participation) and decision-making on nutrition, health, discipline and childcare. Fixed-effects linear and logistic regressions compared each child to him or herself over time, such that each child serves as his or her own control. This method controls for all observed and unobserved time-invariant variables that may confound the relationship between child obesity and father's involvement, thus providing better inferences of causality than typical cross-sectional models.

Paper 3 pooled data from the 2011 – 2013 Medical Expenditure Panel Survey (MEPS), a nationally representative survey that collects data on the health services used

by Americans, including types of services used, source of payment, access to and satisfaction with care. It is appropriate for examining whether parent-reported communication quality with their child's provider is associated with their child's obesity status for several reasons. First, included within the MEPS are questions that have previously been validated to assess patient- and parent-reported provider communication quality[145]. Second, the MEPS also collect information about demographic, household, and health care access and utilization characteristics, which will be examined as confounders or modifiers. Having access to this information allows for examination of additional relationships or factors that might mask the central relationship between parent-reported communication quality and child obesity status. In this paper, logistic models were fit to assess the relationship between parent-reported provider communication quality and child obesity status, and modifying effects of parent obesity status and child-race/ethnicity.

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CHAPTER 2: Manuscript 1

The Neighborhood Environment and Obesity: Understanding Variation by Race/Ethnicity

Research highlights:

- Relationships between neighborhood environments and obesity vary by race/ethnicity
- Neighborhood educational attainment is associated with lower BMI in all sub-groups
- More features of the neighborhood environment were associated with obesity among NH Whites

Key Words: obesity, race/ethnicity, neighborhood environment, California Health Interview Survey

Abstract

Neighborhood characteristics have been associated with obesity-related behaviors and weight status, but whether these relationships vary by race/ethnic subgroups remain unclear. This study examined the relationship between obesity-related behaviors and weight status with neighborhood sociodemographic, social, and built environments separately by race/ethnicity. We merged cross-sectional data from the 2011 – 2013 California Health Interview Survey (CHIS) (n = 62,396), U.S. Census data, and a commercial business data set (InfoUSA) using census tract identifiers. Dependent variables included behavioral (fruit, vegetable, and soda consumption) and weight status (body mass index (BMI), and obesity status) outcomes. Main independent variables were measures of three neighborhood environments: social environment (cohesion and safety), sociodemographic environment (median household income, education, and race/ethnic composition), and built environment (grocery stores, fast food, convenience stores, and fitness centers). We fit multi-level linear, logistic, and negative binominal regression models, stratified by individual race/ethnicity (NH Whites, NH African Americans, Hispanics, and NH Asians) and controlled for respondent-level characteristics, to estimate contextual effects of the neighborhood sociodemographic,

social and built environment on obesity-related behaviors and weight status. Lower neighborhood educational attainment and more positive social environment characteristics were associated with better obesity outcomes in all racial/ethnic groups. We found fewer significant associations among NH African Americans and NH Asians, especially in the built environment. Our results suggest that there are disproportionately more associations between obesity-related behaviors and weight status with the neighborhood environment among NH Whites. While improvements to the neighborhood environment may be promising to reduce obesity, our null associations among minority subgroups suggest that changes, particularly to the built environments, may be insufficient to address obesity in these groups.

Introduction

Although recent trends in obesity prevalence suggest that obesity is stabilizing in the United States [1], certain race/ethnicity groups, particularly non-Hispanic (NH) African Americans and Hispanics, remain disproportionately affected [2]. While obesity prevalence is lowest among NH Asians, the rate of obesity continues to increase in this group, especially among younger generations [3].

There is growing scientific consensus that the recent increase in obesity and documented disparities are caused by factors that extend beyond individuals' biology and behaviors and result through complex interaction between individuals and the context in which they live [4]. The socioecological model, which recognizes that different levels of society influence individual health [5], has been a promising framework for examining the role of contextual factors on disparities in obesity. One area that has received significant interest is the neighborhood environment. Various neighborhood environment characteristics have been associated with obesity outcomes [4,6,7], but whether these relationships vary by race/ethnic subgroups remain unclear.

Neighborhood environment and obesity

Understanding the relationship between neighborhoods and obesity requires disentangling the contributions of different aspects of the neighborhood. Recent research has separated the neighborhood into three distinct but potentially related domains that may be relevant to obesity: the built, sociodemographic, and social environments [8,9].

The built environment is defined as aspects of the neighborhood which are "man-made or modified, as compared with naturally occurring aspects of the environment" [10]. Much of the research on neighborhood factors has focused in this area [6,11,12].

Researchers hypothesize that the built environment influences caloric consumption through the local food environment (e.g., supermarkets), and caloric expenditure by facilitating or inhibiting physical activity [6]. Despite a strong theoretical mechanism, studies have yielded mixed results, particularly on the food component of the built environment [6,10]. Studies on the physical activity component of the built environment, such as access to fitness centers and land use mix, have produced more consistent findings that these features are associated with lower obesity prevalence [6,13,14].

The sociodemographic environment is defined as individual and collective demographic and economic composition of neighborhoods and includes both neighborhood socioeconomic status (SES) measures, such as education and household income, and neighborhood demographic measures of racial/ethnic composition [15]. Considerable research has found that even after accounting for individual SES, lower neighborhood-level SES is associated with higher body mass index (BMI) [16-18]. These neighborhoods typically have fewer health promoting resources, higher crime that may deter exercising outside, and norms and cues (e.g., advertising) that encourage unhealthy habits [19]. Some studies have used neighborhood racial/ethnic composition as a proxy for neighborhood SES. Other studies suggest an independent relationship between neighborhood racial/ethnic composition and obesity after accounting for neighborhood SES [9,20,21]. Researchers hypothesize that racial/ethnic composition may influence norms around lifestyle, diet, and body image [20,22].

The neighborhood social environment is defined as relationships, groups, and social processes that exist between individuals and groups who live and work in a neighborhood [8] and includes measures like perceived safety, social capital and social cohesion. Of these measures, neighborhood safety has been most extensively studied. Studies have yielded mixed results of negative or no association between neighborhood safety and obesity [23]. Research on other aspects of the social environment, including

social capital and social cohesion, suggest associations with reduced obesity prevalence [8,24]. It has been hypothesized that social capital and social cohesion reinforce positive health norms, and empower communities to work together to improve their neighborhoods to promote healthy lifestyle [24,25].

Neighborhoods and racial/ethnic disparities in obesity

The neighborhood environment may contribute to the observed differences in the obesity prevalence across racial/ethnic subgroups. Compared to NH Whites, minorities, especially NH African Americans, are more likely to live in underinvested neighborhoods that have fewer educational and employment opportunities, municipal services, and health promoting resources, including food stores, such as supermarkets, that carry healthy foods [26-28]. These neighborhood exposures may put these subpopulations at higher risk for obesity. Recent studies found no difference in the prevalence of obesity comparing low-income NH African Americans and NH Whites living in racially integrated communities [29,30].

It is also possible that the neighborhood environment features associated with obesity differ by race/ethnic subgroups; some features of the neighborhood may matter for some but not all subgroups. Few studies to date, have examined these relationships stratified by race/ethnicity[26]. Most of this research has focused on the neighborhood's racial/ethnic composition. While neighborhood segregation is associated with worse diet and BMI in NH African Americans [31], the opposite seems to be true for Hispanics and NH Asians. Hispanics and NH Asians who live in neighborhoods with a large portion of other co-ethnics are more likely to have healthier diets [32,33]. These two subgroups may benefit from the "ethnic density effect", where living in areas with a higher concentration of individuals of their same race/ethnicity is protective of health, potentially through

fostering social cohesion, protecting cultural norms, and buffering individuals from discrimination [34].

Race/ethnic differences in neighborhood segregation-obesity relationship may be due to different processes through which these segregated neighborhoods arose. Hispanics and NH Asians are more likely to live with others in the same racial/ethnic group in "ethnic enclaves" (geographic areas with high minority ethnic concentration) while for NH African Americans, segregated neighborhoods resulted from a long history of institutionalized discrimination, such as residential redlining [21,35]. Living in ethnic enclaves allows Asians and Hispanics to preserve their traditional culture, which helps to promote healthier eating practices (e.g., healthier diets and eating meals as a family) [36-38]. Even among those who do not live in ethnic enclaves, the preservation of traditional cultural diets among these subgroups that immigrated to the U.S. more recently may act as a buffer against neighborhood influences, allowing them to maintain a healthier lifestyle regardless of their neighborhood environment.

A limited number of studies have considered how the relationship between other aspects of the neighborhood, primarily within the built environment, and obesity varies by race/ethnicity. Two studies found that supermarkets were more strongly associated with lower weight and better diet among NH African Americans compared to Whites [39,40]. Conversely, another study found that healthful food environments (defined by a composite measure of healthful and unhealthful retail food vendors) were associated with lower obesity in NH Whites, Asians, and Hispanics, but not among NH African Americans [41]. In a study conducted in southeastern Pennsylvania, higher neighborhood educational attainment was associated with reduced obesity in NH White and Hispanic women, and higher neighborhood poverty was associated with higher obesity in NH White and NH African American women [42].

Current Investigation

This study examined the associations between obesity-related behaviors (soda, fruit and vegetable consumption) and weight status (BMI and obesity prevalence) with distinct neighborhood environments (the built, socioeconomic, and social environments) stratified by race/ethnicity subgroups, after controlling for individual-level confounders. Using data that is representative of California's racially/ethnically diverse population, we considered the following racial/ethnic subgroups: NH Whites, Hispanics, NH African Americans, and NH Asians.

This study adds to limited research on how the obesity-neighborhood relationships vary by race/ethnicity. Failure to consider whether these three neighborhoods environments have a stronger effect on certain subpopulations may mask potentially important relationships that can address these disparities. To our knowledge, few studies have considered race/ethnicity variation in the association between obesity and the built and sociodemographic environments [22,42], and none for the social environment.

We hypothesize that neighborhoods with high social support, high neighborhood socioeconomic status, and protective built environment features will be associated with better obesity behavioral and weight status for all race/ethnicity subgroups, [6,8,16], but more features of the neighborhood will be associated with obesity outcomes for NH Whites and NH African-Americans. For Hispanics and NH Asians, cultural influences on dietary habits, even among those not residing in ethnic enclaves, may outweigh neighborhood influences. We further hypothesize that living among others from the same ethnic group will be associated with better obesity outcomes among NH Asians and Hispanics, but worse outcomes among NH African Americans.

Materials and methods

Data and sample

Individual level and social environment data came from the 2011 – 2013 California Health Interview Survey (CHIS) California Health Interview [43]. The CHIS, representative of California's non-institutionalized population, employed a complex survey design and was designed to provide population estimates for California's major race/ethnic groups. Our study sample consists of adults, age ≥ 18 (n = 62,396, representing 27,066,497 persons), excluding pregnant women, underweight individuals, and individuals in the "other" race/ethnicity category (n = 3,285 representing 738,911 persons). We excluded pregnant women since pregnancy weight gain affects weight status classification, underweight individuals because their weight status may be due to varying underlying health conditions, and individuals in the "other" race/ethnicity category due to significant heterogeneity.

Neighborhoods were defined by census tracts. We merge data from 2011 – 2013 InfoUSA [44], and 2009 – 2013 5-year U.S. Census's American Community Survey U.S. Census [45] to the CHIS though census tract identifiers to provide information about the built and sociodemographic environments, respectively. InfoUSA is a commercially available database that obtains data about businesses from a variety of sources including Yellow Page directories, business filings, corporate websites, and user-generated feedback [44].

Measures

Dependent Variables: We examined both obesity-related behaviors and weight status. Behavioral outcomes included self-reported consumption of fruits and vegetables, and soda consumption given strong evidence that these behaviors are associated with

obesity [46,47]. Based on respondent self-reports, we created a continuous measure of the total number of fruits and vegetables consumed in the past week and a dichotomous variable to indicate whether individuals drank any soda (i.e., 1 or more) in the previous week vs. none. The latter is consistent with prior research that characterizes consumption of at least 1 soda per week as "frequent" consumption [48].

Weight status outcomes included a continuous measure of body mass index (BMI), and a dichotomized indicator of obese or non-obese using WHO definitions [49]. BMI was calculated from self-reported height and weight.

Main Independent Variables: Neighborhood sociodemographic, social, and built environments are represented by three different sets of variables. The sociodemographic environment is represented by census-tract level measures of SES (household income: median household income, and educational attainment: percent with a high school degree or less) and demographic composition (percent Hispanic, NH African American, and NH Asian). All sociodemographic environment variables were modeled as continuous measures. Median household income was scaled by $10,000 increments. Other sociodemographic measures were scaled by 10 percentage point increments.

A neighborhood's social environment was assessed by 4 CHIS questions asked of all adult respondents. We conducted factor analyses, with an oblique rotation, with these questions to identify distinct aspects of neighborhood social environment. We obtained two measures of neighborhood social environment – social cohesion and safety – which corresponded with the theoretical understanding of the neighborhood social environment [50]. Social cohesion was based on three questions: whether respondents perceived their neighbors as willing to help each other out, can be trusted, and watched out for the safety of children in the neighborhood. Responses to each of these questions were on a 4-point scale of strongly disagree (=0), disagree (=1), agree

(=2), or strongly agree (=3). We summed the responses across the 3 questions to create a single continuous measure ranging from 0 (low social cohesion) to 9 (high social cohesion). Neighborhood safety was based on a single question of how often (all, most, some, and none of the time) respondents felt safe in their neighborhood, and dichotomize into safe (all the time) vs. not safe (< all of the time) as has been done previously [51]

We used North American industry Classification System (NAICS) codes to identify the following business establishments relevant to the neighborhood built environment. We included separate measures of the number of convenience stores, supermarkets/ grocery stores, fast food outlets (limited service restaurants and pizza restaurants), and fitness and recreational sports centers within each census tract.

Potential confounding variables: We controlled for respondent-level characteristics that we believe to be potential confounders, including demographic characteristics (age, sex, education), health behaviors (current smoking status), residential characteristics (urban/rural, years at current residential address), and acculturation. Acculturation included a measure of English proficiency and a 5-level composite variable of nativity/generational status/time in U.S.: U.S. born, both parents born in the U.S.; U.S. born, one parent born in the U.S., U.S. born, neither parent born in the U.S.; foreign born, > 15 years in the U.S.; and foreign born, <15 years in the U.S.

Statistical Analysis

We accounted for CHIS's complex survey design to calculate summary statistics of means or proportions for all variables of interest stratified by the following racial/ethnic groups: NH White, NH African American, Hispanics, and NH Asians.

The data represent multi-level data with persons (level-1 units) nested within census tract (level-2 units). To assess the relationship between the obesity-related behaviors and weight status with the neighborhood environments for NH White,

Hispanic, NH African American, and NH Asian subgroups, we ran multi-level linear, logistic, and negative binomial regression models separately for each neighborhood environment, stratified by race/ethnicity subgroup. The models included a random intercept to account for the potential within-neighborhood correlation of the behavioral and weight status [52]. We used negative binomial random intercept models for the number of fruits and vegetables consumed per week, linear random intercept models for BMI, and logistic random intercept models for obesity prevalence and soda consumption.

We included the CHIS survey weights to account for the complex survey design, as a comparison of the weighted and unweighted analyses suggested that the survey design is informative. In the weighted analysis, we compared the regression results based on 2 different methods of scaling level 1 weights (scale level 1 weights to the cluster sample size within each race/ethnicity group, and scale level 1 to the effective cluster size within each race/ethnicity group) [53]. Because we found few differences in inferences between both scaling methods, we reported findings from the analysis using weights scaled to the cluster sample size as this is preferred when the point estimates are of substantive interest [53].

For each outcome, we built separate regression models for each neighborhood environment. Each model adjusted for *a priori* selected *potential* respondent-level and census tract-level confounding variables; the *a priori* selected census tract-level potential confounding variables were selected for each neighborhood environment. For the sociodemographic environment, we included only the respondent-level potential confounding variables. For the built and social environments, we also included 2 measures of neighborhood SES: median household income and percent in the census tract with a high school degree or less. We chose to control for these variables since

neighborhood SES may be a confounder of the relationship between obesity behavioral and weight status and neighborhood built and social environments [54,55].

Sensitivity Analysis: We conducted a sensitivity analyses for the built environment measures by including stores within a 1) 0.5 mile and b) 1 mile radius buffer around of the census tract.

All analyses were conducted using Stata 14 (College Station, TX). The Johns Hopkins School of Public Health Institutional Review Board reviewed and determined that this project was non-human subjects research.

Results

Sample Characteristics

The data represent 27,066,497 adults (age ≥ 18), excluding pregnant women, underweight individuals, and individuals identifying as "other" race/ethnicity in the CHIS, of which 45.4, 35.1, 5.8, and 13.7% identified as NH White, Hispanic, NH African American and NH Asian, respectively (Table 2.1). Hispanics were least likely to have a college degree. More than 80% of each subgroup lived in an urban area. Hispanics and Asians were more likely to be foreign born and were less likely to speak only English.

Hispanics and NH African Americans lived in neighborhoods with lower median household income, fewer high school graduates, and had a larger proportion of Hispanics. Social cohesion was similar for all groups (Table 2.1). NH Whites were more likely to report high levels of safety. Hispanics lived in neighborhoods with the highest number of grocery stores/supermarkets, but the fewest number of fitness centers. The number of neighborhood convenience stores and fast food outlets available was similar across all subgroups.

Table 2.2 summarizes the outcomes for each race/ethnicity subgroup. NH Whites and NH Asians report higher average consumption of fruits and vegetables within the last week (16.4 and 15.1, respectively) compared to Hispanic and NH African Americans (13.1 and 12.7, respectively). A larger proportion of Hispanics and NH African Americans reported consuming any soda (56.1% and 48.3%, respectively) compared to NH Asians and NH Whites (34.2% and 33.3%, respectively. BMI was highest for NH African Americans (29.3kg/m^2) and lowest for NH Asians (24.8kg/m^2). Among respondents, 22% of NH Whites, 33% of Hispanics, 37% of NH African Americans, and 10% of NH Asians were obese.

Table 2.3 presents adjusted associations between each of the neighborhood environments and obesity-related behaviors and weight status by race/ethnicity.

NH Whites: In adjusted models, obesity-related behaviors were associated with all three neighborhood environments. Higher neighborhood social cohesion was associated with increased fruit and vegetable consumption (IRR:1.03, 95%CI: 1.02, 1.04) and lower odds of soda consumption (OR: 0.95, 95%CI: 0.93, 0.98). Higher median household income, and more grocery stores/supermarkets were associated with increased fruit and vegetable consumption (income IRR:1.01, 95%CI: 1.00, 1.01; grocery stores/supermarkets IRR:1.01, 95%CI: 1.00, 1.02). Fitness centers were associated with reduced odds of soda consumption (OR: 0.96, 95%CI: 0.93, 1.00). Lower neighborhood educational attainment (i.e., % with a high school degree or less) and more fast food restaurants were associated with lower fruit and vegetable consumption (education IRR:0.97, 95%CI: 0.96, 0.99; fast food IRR:0.99, 95%CI: 0.99, 1.00) and higher odds of soda consumption (education OR: 1.13, 95%CI: 1.07, 1.18).

Weight status was associated with all three neighborhood environments. Higher neighborhood social cohesion and more grocery stores/supermarkets were associated

with decreased BMI (social cohesion: -0.17, 95%CI: -0.22, -0.12; grocery stores: -0.11, 95%CI: -0.17, -0.05) and reduced odds of obesity (social cohesion: OR:0.93, 95%CI: 0.90, 0.95; grocery stores: OR:0.94, 95%CI: 0.92, 0.97). Fitness centers were associated with lower BMI (-0.07, 95%CI: -0.13, -0.01). Safe neighborhoods were associated with lower odds of obesity (OR: 0.89, 95% CI: 0.82, 0.97). Conversely, lower neighborhood educational attainment was associated with increased BMI (0.55, 95%CI: 0.45, 0.65) and higher odds of obesity (OR:1.27, 95%CI: 1.27, 1.33). A larger proportion of NH Asians and more fast food restaurants were both associated with increased BMI (%Asian: 0.09, 95%CI: 0.02, 0.15; fast food: 0.03, 95%CI: 0.00, 0.06).

Hispanics: Neighborhood social cohesion was associated with increased fruit and vegetable consumption (IRR: 1.03, 95%CI: 1.02, 1.04). No other neighborhood measure was associated with obesity-related behaviors.

The neighborhood sociodemographic and built environments were associated with weight outcomes. Neighborhoods with higher median household income, were safe, and had more fitness centers were associated with lower BMI (income: -0.09, 95%CI: -0.19, -0.00; safe: -0.1, 95% CI: -0.20, -0.00; fitness centers: -0.16, 95%CI: -0.27, -0.04). Lower neighborhood educational attainment was associated with higher BMI (0.28, 95%CI: 0.10, 0.46) and higher odds of obesity (OR:1.08, 95%CI: 1.01, 1.16).

NH African Americans: Both the built and sociodemographic environments were associated with obesity-related behaviors for NH African Americans. A greater number of fast food outlets were associated with decreased fruit and vegetable consumption (IRR: 0.99, 95%CI: 0.97, 1.00). Lower neighborhood educational attainment was associated with increased soda consumption (OR:1.14, 95%CI: 1.00, 1.31). For weight status, only the social environment was associated with weight status. Safe neighborhoods were associated with lower BMI (-0.59 (95% CI: -1.13, -0.06).

NH Asians: Only the social environment was associated with obesity-related behaviors. Neighborhood safety was associated with increased with increased fruit and vegetable consumption (IRR:1.09 95% CI: 1.04, 1.15). Sociodemographic and built environments were associated with weight status. A high proportion of Asians was associated with lower odds of obesity (OR: 0.87, 95%CI: 0.79, 0.96). Neighborhoods with more fitness centers were also associated with lower BMI (-0.10, 95%CI: -0.20, -0.00).

Sensitivity Analysis: Results from both sensitivity analyses of the neighborhood boundaries of the built environment were largely similar with a few notable differences (results available upon request). Contrary to the main analysis, both buffer distances yielded no association between fast food restaurants and fruit and vegetable consumption among NH African Americans or between fitness centers and BMI among NH Asians. However, for NH Asians, fitness centers became associated with lower odds of soda consumption for the 1-mile buffer. Among Hispanics, we found additional associations between grocery stores/supermarkets with reduced odds of obesity for both buffer distances, and with BMI for the 1-mile buffer. Fitness centers were associated with reduced odds of obesity at the 0.5-mile buffer, and fast food restaurants were associated with higher BMI at the 1-mile buffer.

Discussion

We found that more features of the neighborhood sociodemographic, social and built environment were associated with obesity-related behaviors and outcomes – in the expected direction – for NH Whites compared to other subgroups. Few built environment measures features were associated with obesity outcomes in the other race/ethnicity subgroups.

Lower neighborhood educational attainment was associated with better obesity-related behaviors and outcomes in all race/ethnicity groups. This is consistent with a

large body of evidence that neighborhood deprivation is associated with obesity-related behaviors and weight status [16-18]. While prior studies have assessed neighborhood deprivation through both income and education, we found few subgroup associations with neighborhood income. This suggests that neighborhood education may be more relevant to obesity outcomes.

Features of the social environment were associated with better obesity outcomes in all race/ethnicity groups. These findings build upon the growing evidence of the importance of the neighborhood social environment on obesity outcomes, and further suggest that the social environment is important in all 4 racial/ethnic groups. However, it is important to note that the exact relationships differed by race/ethnicity. There may be racial/ethnic differences in how the social environment might influence obesity outcomes.

For NH Whites, multiple measures from all three neighborhood environments were significantly associated with dietary behaviors and BMI/obesity. However, the magnitude of the associations for fruit and vegetable consumption with the built and sociodemographic environments was small and may not have practical significance. Most of these associations were in the expected direction and consistent with prior reports that higher neighborhood SES, greater social cohesion, and safety are associated with improved obesity outcomes [16,23,24]. Additionally, we found associations between some (fast food outlets, grocery stores, fitness center), but not all, built environment features and obesity outcomes. We did not find associations with convenience stores. These results provide additional evidence of a relationship between obesity and certain built environment elements in the expected direction among NH Whites.

For Hispanics, social cohesion was associated with both better diet and lower BMI. This is consistent with existing evidence of obesity-related benefits of more

cohesive neighborhoods beyond neighborhood SES [24]. Social cohesion may encourage more culturally traditional, healthful diets, resulting in lower BMI [24]. Among built environment measures, only fitness centers were associated with better obesity outcomes.

For NH Asians, our finding that living among a higher concentration of Asians had reduced obesity prevalence is consistent with the "ethnic density effect" theory [34]. [56]. In the social environment, neighborhood safety was associated with improved diet. It is possible that safer neighborhoods may support more positive food retail environments [57], making it easier to access fruits and vegetables. Fitness centers were the only built environment feature associated with better obesity outcomes. We believe that this is the first study to assess the relationship between fitness centers and obesity among NH Asians.

Among, NH African Americans, neighborhood safety was associated with lower BMI. Neighborhood safety may be particularly important to this subgroup because they are more likely to live in neighborhoods perceived as unsafe [58]. The only built characteristic associated with obesity-related behaviors was fast food restaurant availability. Our study is the first to find an association between more fast food outlets and worse diet among NH African Americans. We did not find an association with grocery stores/supermarkets, which were found in some [39,40], but not all, prior studies [41].

In our sensitivity analyses of the neighborhood boundaries, we found a few key differences: for Hispanics, extending the boundaries to both 0.5 and 1-mile buffers around the census tract resulted in additional associations – all in the hypothesized directions – between weight status and several built environment features (grocery stores/supermarkets, fitness centers, and fast food); however, for NH African Americans, the built environment was no longer associated with obesity outcomes. It is possible that relevant neighborhood boundaries might vary by race/ethnicity, as prior research

suggest that neighborhood boundaries differ by individual-level characteristics [59]. NH African Americans are more likely to live in metropolitan areas [60], so smaller boundaries – such as census tracts – might be appropriate, while larger neighborhood boundaries might be more appropriate for Hispanics, particularly if they live in rural, agricultural communities and may have to travel further to Hispanic grocery stores.

Our findings have several implications for policy and research. Recently, there has been significant interest in built environment interventions to curb the obesity epidemic and address disparities. For example, policies to improve the built food environment, such as Pennsylvania's Fresh Food Financing Initiative, have provided financial incentives for supermarkets to open in low-income neighborhoods [61]. Prior studies have found that NH African Americans tend to live in neighborhoods with fewer healthy food stores, such as supermarkets [28], suggesting that these built food environment improvements may also address racial/ethnic disparities in obesity. However, numerous null associations between the built environment and obesity among minority subgroups in our study would suggest that changes to the built environment alone may be insufficient to address obesity in these groups. Should changes to the built environment disproportionately benefit NH Whites, they could unintentionally exacerbate existing race/ethnic disparities in obesity outcomes. Race/ethnic groups may face numerous barriers –at the individual and the neighborhood levels – that may hinder them from benefitting built environment improvements to address obesity [62]. For example, neighborhoods may be unsafe, lack social cohesion, and lack grocery stores, or individuals may have limited financial resources that preclude them from taking advantage of changes to their built environment. Reducing race/ethnic disparities in obesity, particularly in high-risk minority groups, may require a more tailored approach that addresses multiple neighborhood and individual level factors and a better understanding of what these factors are for each group.

We did, though, find that neighborhood educational attainment and the neighborhood social environment were associated with better obesity outcomes in all race/ethnicity groups. Greater investment in the educational system to increase individual and neighborhood educational attainment, and policies that promote mixed income communities, which would improve neighborhood educational attainment for low-SES individual, could be potential avenues to reduce obesity among all race/ethnicity groups. However, because our study did not assess causality, future studies should assess causality between neighborhood educational attainment and obesity-related behaviors and weight status within minority subgroups. The social environment may be a potentially promising target for neighborhood-level obesity reduction interventions, but likely require efforts tailor to specific subgroups. Preserving or increasing social cohesion among Hispanics, such as through investment in Spanish-speaking community centers and policy collaborations with Hispanic organizations and churches, and promoting neighborhood safety initiatives, particularly in predominately NH African American communities, may potentially improve obesity outcomes. Future research should also examine underlying mechanisms of how the social environment can promote health by race/ethnicity. Sensitivity analyses results for Hispanics highlights the need for additional research on how the relevant neighborhood boundaries might vary by race/ethnicity.

This study had several limitations. Using cross-sectional data limited our ability to infer causality. This analysis, though, is an important exploratory step that examined less studied neighborhood characteristics, such as social cohesion, and can inform future studies. Our study relied on self-reported height and weight, which likely underestimates BMI [63]. We defined neighborhoods by census tracts, but it is possible that this may not accurately capture neighborhood boundaries relevant to obesity and dietary behaviors. Because car ownership is high in California, the neighborhood definition for the built environment may extend beyond census tracts. Our sensitivity analyses suggest that

larger boundaries might be appropriate for Hispanics. We used a commercial database to create our built environment measures, but there may be issues with data accuracy [64].

Our study findings suggest that associations between features of the neighborhood environment and obesity-related outcomes vary by race/ethnicity. Efforts to intervene on the neighborhood built environments might not benefit all racial/ethnic subgroups equally. Future research should explore potential pathways to better understand the relationship between obesity outcomes and the neighborhood environment in different race/ethnicity groups, particularly in high-risk minority groups.

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Tables

Table 2.1. Percentages and means (SD) for respondent-level and neighborhood environment characteristics

	NH White (n = 38466)	Hispanic (n = 13466)	NH African American (n = 2943)	NH Asian (n = 5499)
RESPONDENT-LEVEL				
Demographic Characteristics				
Gender (%)				
Female	50.5	49.8	53.4	52.0
Age, years	50.4 (21.8)	40.5 (12.4)	46.6 (16.1)	43.0 (13.9)
Education (%)				
Less than HS	4.9	34.4	10.0	8.4
HS degree	37.8	42.3	48.8	28.7
College/Associates degree or trade school	57.3	23.4	41.2	62.8
Heath Behaviors				
Current smoker (%)	14.5	11.9	20.3	10.4
Residential Characteristics				
Urban/rural (%)				
Urban	82.1	89.5	96.3	96.3
Time at residential address, year	12.5 (14.7)	8.7 (7.3)	9.6 (10.7)	9.0 (7.6)
US Acculturation Characteristics				
Nativity, generational status/time in US (%)				
US born, both parents US born	78.8	16.9	87.1	4.4
US born, one parent US born	7.8	9	2.3	3.1
US born, no parent US born	3.6	19.3	1.8	21.8
Foreign born, ≥15 years in US	7.2	38.6	5.3	45.4
Foreign born, <15 years in US	2.5	16.1	3.2	25.4
English proficiency (%)				
Speaks only English	88.0	19.6	90.6	24.3
Speaks English very well/well	11.7	43.7	9.1	57.5
Not well/not at all	0.3	36.8	0.3	18.2
NEIGHBORHOOD ENVIRONMENT				
Sociodemographic environment				
Median household income (mean $)	74,938 (37,772)	54,960 (18,974)	57,087 (23,875)	76,468 (27,225)
High school graduate or less (%)	31.6	52.8	45.3	34.5
Hispanic (%)	25.5	55.2	40.3	28.5
Black (%)	4.0	6.1	19.5	5.3
Asia (%)	11.1	10.3	11.6	27.7
Social Environment				
Social cohesion[1] (mean)	6.4 (2.0)	5.6 (1.4)	5.6 (1.7)	6.0 (1.2)
Perceived safety (%)				
All the time	93.53	79.29	81.31	85.95
< all the time	6.47	20.71	18.69	14.05
Built environment[2]				
Grocery stores/supermarkets	1.4 (2.0)	1.9 (1.6)	1.7 (1.7)	1.6 (1.5)
Convenience stores	0.5 (0.9)	0.5 (0.6)	0.5 (0.7)	0.4 (0.6)
Fast food outlets	2.6 (4.1)	2.4 (2.6)	2.4 (3.1)	2.7 (2.9)
Fitness centers	1.1 (1.9)	0.7 (1.0)	0.8 (1.3)	1.0 (1.3)
Notes: 1 – measured on a scale from 0 (low) to 9 (high); 2 – mean counts per census tract				

Table 2.2. Percentages and means (SD) for sample obesity-related behaviors and weight status

	NH White (n = 38466)	Hispanic (n = 13466)	NH African American (n = 2943)	NH Asian (n = 5499)
Behaviors				
Number of fruits & vegetables consumed/week	16.4 (13.2)	13.1 (8.7)	12.7 (9.3)	15.1 (8.4)
Consumed at least 1 soda/week, %	33.3	56.1	48.3	34.2
Weight status				
BMI, kg/m^2	26.99 (6.4)	28.8 (5.4)	29.3 (5.8)	24.8 (4.0)
Obese, %	22.1	32.8	37.3	9.6

Table 2.3. Adjusted associations between obesity-related behaviors and weight status with neighborhood sociodemographic, social, and built environments

	Behaviors				Weight Status			
	Number of fruits/vegetables consumed/week		Soda consumption		BMI		Obese	
	IRR	95% CI	OR	95% CI	Estimate	95% CI	OR	95% CI
NEIGHBORHOOD SOCIODEMOGRAPHIC ENVIRONMENT[1]								
Median HH income[2]								
NH White	**1.01**	**(1.00, 1.01)***	0.99	(0.97, 1.01)	0.00	(-0.03, 0.03)	1.00	(0.98, 1.02)
Hispanic	1.01	(0.98, 1.02)	0.97	(0.94, 1.00)	**-0.09**	**(-0.19, -0.00)***	0.98	(0.94, 1.01)
NH African American	1.00	(0.98, 1.02)	1.03	(0.97, 1.09)	0.00	(-0.12, 0.13)	0.99	(0.93, 1.06)
NH Asian	1.00	(0.99, 1.01)	0.98	(0.94, 1.03)	0.04	(-0.03, 0.11)	1.01	(0.95 1.08)
% with HS degree or less								
NH White	**0.97**	**(0.96, 0.99)***	**1.13**	**(1.07, 1.18)***	**0.55**	**(0.45, 0.65)***	**1.27**	**(1.21, 1.33)***
Hispanic	1.04	(0.97, 1.12)	1.06	(0.97, 1.12)	**0.28**	**(0.10, 0.46)***	**1.08**	**(1.01, 1.16)***
NH African American	0.99	(0.95, 1.04)	**1.14**	**(1.00, 1.31)***	0.30	(-0.01, 0.61)	1.12	(0.97, 1.30)
NH Asian	0.98	(0.96, 1.01)	1.03	(0.91, 1.16)	**0.23**	**(0.04, 0.43)***	1.14	(0.96, 1.36)
% Hispanic								
NH White	1.00	(0.99, 1.01)	1.00	(0.97, 1.04)	-0.04	(-0.11, 0.03)	0.97	(0.94, 1.00)
Hispanic	0.97	(0.94, 1.01)	1.03	(0.98, 1.08)	-0.02	(-0.13, 0.10)	1.02	(0.97, 1.07)
NH African American	0.97	(0.94, 1.01)	0.98	(0.88, 1.08)	-0.5	(-0.27, 0.18)	0.97	(0.87, 1.08)
NH Asian	1.00	(0.98, 1.02)	1.01	(0.92, 1.11)	0.03	(-0.10, 0.16)	1.01	(0.88, 1.15)
% Black								
NH White	1.00	(0.98, 1.02)	0.97	(0.90, 1.05)	0.12	(-0.03, 0.27)	1.06	(0.99, 1.13)
Hispanic	0.99	(0.96, 1.01)	1.06	(0.99, 1.14)	0.10	(-0.08, 0.27)	1.04	(0.98, 1.11)
NH African American	1.00	(0.98, 1.02)	1.04	(0.97, 1.11)	0.04	(-0.12, 0.21)	0.99	(0.92, 1.07)
NH Asian	0.99	(0.95, 1.03)	1.05	(0.90, 1.23)	-0.01	(-0.10, 0.16)	0.97	(0.79, 1.19)
% Asian								
NH White	0.99	(0.98, 1.00)	1.00	(0.97, 1.04)	**0.09**	**(0.02, 0.15)***	1.06	(1.00, 1.07)
Hispanic	0.99	(0.97, 1.01)	1.00	(0.95, 1.05)	0.08	(-0.06, 0.22)	0.99	(0.94, 1.04)
NH African American	1.00	(0.97, 1.04)	1.06	(0.96, 1.17)	-0.13	(-0.34, 0.08)	0.94	(0.85, 1.05)
NH Asian	0.99	(0.98, 1.01)	0.94	(0.88, 1.00)	-0.08	(-0.17, 0.00)	**0.87**	**(0.79, 0.96)***
NEIGHBORHOOD SOCIAL ENVIRONMENT[3]								
Social Cohesion								
NH White	**1.03**	**(1.02, 1.04)***	**0.95**	**(0.93, 0.98)***	**-0.17**	**(-0.22, -0.12)***	**0.93**	**(0.91, 0.96)***
Hispanic	**1.03**	**(1.02, 1.05)***	0.99	(0.94, 1.03)	**-0.10**	**(-0.20, -0.00)***	0.97	(0.94, 1.01)
NH African American	1.01	(0.99, 1.03)	1.04	(0.97, 1.11)	-0.01	(-0.16, 0.14)	0.97	(0.90, 1.04)
NH Asian	1.01	(1.00, 1.03)	0.98	(0.90, 1.06)	0.08	(-0.02, 0.18)	1.01	(0.90, 1.14)

	Behaviors				Weight Status			
	Number of fruits/vegetables consumed/week		Soda consumption		BMI		Obese	
	IRR	95% CI	OR	95% CI	Estimate	95% CI	OR	95% CI
Safety								
NH White	1.01	(0.99, 1.04)	0.95	(0.87, 1.03)	-0.20	(-0.36, -0.04)	**0.89**	**(0.82, 0.97)***
Hispanic	1.01	(0.97, 1.06)	0.96	(0.85, 1.09)	0.23	(-0.09, 0.55)	1.10	(0.97, 1.25)
NH African American	1.06	(0.98, 1.16)	0.79	(0.61, 1.01)	**-0.59**	**(-1.13, -0.06)***	0.82	(0.64, 1.07)
NH Asian	**1.09**	**(1.04, 1.15)***	1.00	(0.78, 1.23)	0.16	(-0.23, 0.46)	1.11	(0.78, 1.59)
NEIGHBORHOOD BUILT ENVIRONMENT[3]								
Grocery stores/supermarkets								
NH White	**1.01**	**(1.00, 1.02)***	1.00	(0.96. 1.03)	**-0.11**	**(-0.17, -0.05)***	**0.94**	**(0.92, 0.97)***
Hispanic	1.01	(1.00, 1.02)	0.99	(0.95, 1.02)	-0.00	(-0.09, 0.08)	0.99	(0.95, 1.02)
NH African American	1.01	(0.99, 1.04)	0.99	(0.93, 1.06)	0.03	(-0.14, 0.21)	1.03	(0.95, 1.10)
NH Asian	1.00	(0.99, 1.02)	1.05	(0.98, 1.13)	-0.03	(-0.12, 0.06)	0.93	(0.84, 1.02)
Convenience Stores								
NH White	1.00	(0.98, 1.02)	0.97	(0.92, 1.04)	0.10	(-0.04, 0.23)	1.02	(0.96, 1.08)
Hispanic	1.00	(0.97, 1.03)	0.98	(0.91, 1.06)	0.08	(-0.12, 0.28)	1.03	(0.95, 1.11)
NH African American	1.05	(1.00, 1.10)	0.99	(0.85, 1.16)	0.14	(-0.24, 0.52)	1.06	(0.90, 1.24)
NH Asian	0.97	(0.94, 1.01)	1.05	(0.89, 1.23)	0.12	(-0.12, 0.35)	0.92	(0.73, 1.16)
Fast Food restaurants								
NH White	**0.99**	**(0.99, 1.00)***	**1.02**	**(1.01, 1.04)***	**0.03**	**(0.00, 0.06)***	1.01	(1.00, 1.03)
Hispanic	1.00	(0.99, 1.00)	0.99	(0.97, 1.01)	0.05	(-0.00, 0.11)	1.01	(0.99, 1.03)
NH African American	**0.99**	**(0.97, 1.00)***	1.00	(0.95, 1.04)	0.06	(-0.05, 0.17)	1.04	(0.99, 1.08)
NH Asian	0.99	(0.98, 1.00)	0.97	(0.94, 1.01)	0.03	(-0.02, 0.08)	1.06	(1.00, 1.12)
Fitness Centers								
NH White	1.00	(0.99, 1.01)	**0.96**	**(0.93, 1.00)***	**-0.07**	**(-0.13, -0.01)***	0.98	(0.95, 1.01)
Hispanic	1.00	(0.99, 1.02)	1.00	(0.95, 1.05)	**-0.16**	**(-0.27, -0.04)***	0.96	(0.91, 1.03)
NH African American	0.99	(0.96, 1.02)	0.97	(0.88, 1.07)	-0.13	(-0.37, 0.11)	0.91	(0.82, 1.01)
NH Asian	1.01	(0.99, 1.03)	0.97	(0.90, 1.06)	**-0.10**	**(-0.20, -0.00)***	0.93	(0.83, 1.05)

Note:
* Denotes statistical significance at p<0.05
1 – Controlled for respondent-level confounders (gender, age, education, current smoking status, urban/rural, time at residential address, nativity, English proficiency)
2 – per $10,000
3 – Controlled for respondent-level confounders (gender, age, education, current smoking status, urban/rural, time at residential address, nativity, English proficiency) and neighborhood SES (household income and % HS degree or less)

Appendix Tables

Table A2.1. Built environment sensitivity analysis: 0.5-mile buffer: Association between obesity-related behaviors and weight status by neighborhood built environment

	Behaviors				Weight status			
	Fruit and vegetable consumption/week		Soda Consumption (≥1/week)		BMI		Obesity	
	IRR	95% CI	OR	95% CI	Estimate	95% CI	OR	95% CI
Markets/Grocery stores								
NH White	1.00	(1.00, 1.00)	1.00	(0.99, 1.01)	**-0.04**	**(-0.5, -0.3)***	**0.98**	**(0.97, 0.99)***
Hispanic	1.00	(1.00, 1.00)	1.00	(0.99, 1.01)	-0.02	(-0.04, 0.00)	**0.99**	**(0.98, 1.00)***
NH African American	1.00	(1.00, 1.01)	0.99	(0.98, 1.01)	0.01	(-0.03, 0.04)	1.00	(0.98, 1.02)
NH Asian	1.00	(1.00, 1.00)	1.00	(0.99, 1.02)	-0.01	(-0.03, 0.01)	0.99	(0.96, 1.01)
Convenience Stores								
NH White	1.00	(0.99,1.01)	1.01	(0.99, 1.04)	0.05	(-0.01, 0.10)	1.02	(0.99, 1.05)
Hispanic	1.00	(0.99, 1.02)	1.00	(0.96, 1.03)	0.00	(-0.09, 0.09)	1.03	(0.99, 1.06)
NH African American	1.01	(0.99, 1.03)	0.96	(0.90, 1.02)	0.04	(-0.10, 0.19)	1.00	(0.94, 1.07)
NH Asian	1.00	(0.98,1.01)	0.98	(0.91, 1.04)	-0.01	(-0.11, 0.09)	0.94	(0.86, 1.04)
Fast Food restaurants								
NH White	**1.00**	**(1.00, 1.00)***	1.00	(0.99, 1.01)	**0.02**	**(0.01, 0.04)***	1.01	(1.00, 1.01)
Hispanic	1.00	(0.99,1.00)	1.00	(0.99, 1.01)	0.02	(-0.00, 0.05)	1.00	(0.99, 1.01)
NH African American	1.00	(0.99, 1.00)	1.01	(0.99, 1.03)	0.01	(-0.03, 0.06)	1.01	(0.99, 1.03)
NH Asian	1.00	(0.99, 1.00)	1.00	(0.98, 1.02)	0.01	(-0.01, 0.04)	1.01	(0.99, 1.04)
Fitness Centers								
NH White	1.00	(1.00, 1.01)	**0.98**	**(0.97, 1.00)***	**-0.07**	**(-0.09, -0.04)***	**0.98**	**(0.96, 0.99)***
Hispanic	1.00	(1.00, 1.01)	0.98	(0.96, 1.01)	**-0.06**	**(-0.12, -0.01)***	**0.87**	**(0.95, 1.00)***
NH African American	1.00	(0.99, 1.02)	0.98	(0.94, 1.02)	-0.06	(-0.15, 0.03)	0.96	(0.92, 1.00)
NH Asian	1.01	(1.00, 1.01)	0.97	(0.93, 1.00)	-0.03	(-0.08, 0.01)	0.98	(0.93, 1.03)

Notes:

* denotes statistical significance at p< 0.05

Models controlled for respondent-level confounders (gender, age, education, current smoking status, urban/rural, time at residential address, nativity, English proficiency) and neighborhood SES (household income and % ≤HS degree)

Table A2.2. Built environment sensitivity analysis: 1.0-mile buffer: Association between obesity-related behaviors and weight status by neighborhood built environment

	Behaviors				Weight status			
	Fruit and vegetable consumption/week		Soda Consumption (≥1/week)		BMI		Obesity	
	IRR	95% CI	OR	95% CI	Estimate	95% CI	OR	95% CI
Markets/Grocery stores								
NH White	**1.00**	**(1.00, 1.00)***	1.00	(1.00, 1.00)	**-0.02**	**(-0.02, -0.01)***	**0.99**	**(0.99, 1.00)***
Hispanic	1.00	(1.00, 1.00)	1.00	(1.00, 1.01)	**-0.01**	**(-0.02, -0.00)***	**0.99**	**(0.99, 1.00)***
NH African American	1.00	(1.00, 1.00)	1.00	(0.99, 1.00)	-0.01	(-0.02, 0.01)	1.00	(0.99, 1.01)
NH Asian	1.00	(1.00, 1.00)	1.01	(1.00, 1.02)	-0.01	(-0.02, 0.00)	0.99	(0.97, 1.00)
Convenience Stores								
NH White	1.00	(1.00, 1.01)	1.00	(0.99, 1.03)	0.02	(-0.01, 0.06)	1.01	(0.99, 1.03)
Hispanic	1.00	(0.99, 1.00)	0.99	(0.97, 1.02)	0.01	(-0.05, 0.07)	1.01	(0.99, 1.03)
NH African American	1.00	(0.99, 1.02)	0.98	(0.94, 1.02)	0.05	(-0.04, 0.15)	0.99	(0.94, 1.03)
NH Asian	1.00	(0.99, 1.01)	0.98	(0.94 1.03)	0.02	(-0.05, 0.09)	0.99	(0.93, 1.06)
Fast Food restaurants								
NH White	**1.00**	**(1.00, 1.00)***	1.00	(1.00, 1.01)	**0.01**	**(0.00, 0.02)***	**1.01**	**(1.00, 1.01)***
Hispanic	1.00	(1.00, 1.00)	1.00	(0.99, 1.01)	**0.02**	**(0.00, 0.04)***	1.00	(0.99, 1.01)
NH African American	1.00	(0.99, 1.00)	1.01	(1.00, 1.02)	0.00	(-0.03, 0.04)	1.01	(0.99, 1.02)
NH Asian	1.00	(1.00, 1.00)	1.00	(0.99, 1.01)	0.01	(-0.01, 0.02)	1.01	(0.99, 1.02)
Fitness Centers								
NH White	1.00	(1.00, 1.00)	**0.99**	**(0.98, 1.00)***	**-0.04**	**(-0.05, -0.02)***	**0.98**	**(0.97, 0.99)***
Hispanic	1.00	(1.00, 1.01)	0.99	(0.97, 1.00)	**-0.05**	**(-0.08, -0.02)***	0.99	(0.98, 1.00)
NH African American	1.00	(0.99, 1.01)	0.98	(0.96, 1.00)	-0.02	(-0.08, 0.03)	0.99	(0.96, 1.01)
NH Asian	1.000	(1.00, 1.01)	**0.98**	**(0.95, 1.00)***	-0.01	(-0.04, 0.01)	1.00	(0.97, 1.03)

Notes:
* denotes statistical significance at p< 0.05
Models controlled for respondent-level confounders (gender, age, education, current smoking status, urban/rural, time at residential address, nativity, English proficiency) and neighborhood SES (household income and % ≤HS degree)

Table A2.3. Mean and distribution of neighborhood sociodemographic and built environment characteristics among census tracts

	Overall	NH White	Hispanic	NH African American	NH Asian
SOCIODEMOGRAPHIC ENVIRONMENT					
Median Household Income, mean $ (SD)	66,440 (31,246)	7.36 (3.23)	5.21 (2.28)	5.40 (2.52)	7.38 (3.35)
% HS degree or less, mean % (SD)	40.24 (20.75)	3.26 (1.70)	5.57 (1.99)	4.70 (1.93)	3.69 (1.97)
% Hispanic, mean % (SD)	36.60 (26.39)	2.65 (1.99)	5.94 (2.66)	4.12 (2.32)	3.02 (2.21)
% Black, mean % (SD)	5.91 (9.45)	0.43 (0.63)	0.59 (0.85)	2.06 (2.04)	0.56 (0.75)
% Asian, mean % (SD)	12.96 (14.95)	1.16 (1.30)	0.95 (1.17)	1.10 (.32)	2.89 (2.11)
BUILD ENVIORNMENT					
Markets, mean (SD)	1.50 (1.71)	1.33 (1.55)	1.83 (1.86)	1.67 (2.05)	1.42 (1.74)
Convenience stores, mean (SD)	0.44 (0.72)	0.44 (0.71)	0.49 (0.76)	0.41 (0.71)	0.39 (0.70)
Fast food, mean (SD)	2.26 (3.08)	2.37 (3.19)	2.12 (2.94)	1.92 (2.62)	2.24 (3.09)
Fitness centers, mean (SD)	0.83 (1.39)	0.99 (1.51)	0.56 (1.15)	0.61 (1.04)	0.83 (1.35)

Note: Means and standard deviations calculated at the census-tract level (not at the individual-level). Race/ethnicity stratified means and standard deviations calculated based on census tracts that had at least one individual of the specified race/ethnicity

CHAPTER 3: Manuscript 2
The longitudinal Association between early childhood obesity and fathers' involvement in caregiving and decision-making

Abstract

Objective: Fathers are playing an increasing role in caregiving; however, there is a lack of research on their role in childhood obesity. This study assessed the longitudinal association between changes in obesity among children aged 2 to age 4 and changes in father involvement in caregiving and influence on decision-making.

Methods: Using longitudinal data from the Early Childhood Longitudinal Study-Birth Cohort (ECLS-B), we conducted child fixed-effects linear and logistic regression to assess the association between changes in childhood obesity-related outcomes (sugar sweetened beverage consumption, TV watching, BMI z-score, overweight/obesity, obesity) with measures of fathers' involvement with caregiving and decision-making. We also examined modifying effects of family poverty, father education, and maternal employment.

Results: Children whose fathers increased their frequency of taking children outside and number of physical caregiving tasks experienced a decrease in their odds of obesity from age 2 to age 4.

Conclusion: Increases in paternal involvement in caregiving appear to be associated with lower odds of childhood obesity.

Policy Implications: Policies for flexible work schedules and initiatives that encourage paternal child caregiving norms may yield child weight benefits.

Introduction

Preventing obesity in young children is essential to addressing the current obesity epidemic. Young children who have a high BMI by age 6 are more likely to become an obese adult,[1] and experience poorer health from obesity-related chronic conditions.[2]

Parents play an important role in helping young children maintain a healthy weight. Parents control what children eat and how children are entertained, and shape a child's food and behavioral preferences.[3] To date, most of the research on parental influences has focused on maternal risk factors for childhood obesity,[4] since mothers have traditionally been the child's primary care giver.

However, in the past four decades, changes to parental roles and the increase of women in the work force,[5,6] has led to greater involvement of fathers in child caregiving.[7,8] A 2011 U.S. Census report found that fathers provide approximately 20% of primary caregiving to pre-school children.[9] Despite the increased role of fathers, fathers are significantly underrepresented in research on childhood obesity.[4]

Of the few studies that have explored paternal child caregiving involvement and childhood obesity, most have focused on factors related to child nutrition and exercise, including fathers' parenting styles, knowledge of and behaviors related to nutrition and physical activity, and child feeding habits.[10,11] These studies found that some paternal behaviors, such as lower monitoring of child food intake, were associated with higher child BMI.[10,11] Additionally, fathers' nutritional knowledge was not always accurate[10]. Prior studies have also noted some differences in father feeding behaviors based upon father characteristics such as education and resident status.[12]

It is also important to consider the role that fathers play in other aspects of caregiving that are not directly related to child nutrition and exercise. For example, by

helping children bathe or looking after the child while mothers do other things, fathers may alleviate maternal stress, which has been found to be associated with increased child BMI,[13] and increase the quality of care provided by both parents. Paternal involvement may be particularly important for children who have other risk factors for obesity, including living in poverty or maternal employment.[14-16] To our knowledge, no study has considered broader measures of paternal caregiving involvement that are not directly related to child physical activity or nutrition, such as helping the child bathe or involvement with caregiving decisions, nor the relationship between the amount of paternal caregiving involvement and childhood obesity. Additionally, studies that have assessed paternal feeding behavior and knowledge were primarily cross-sectional or qualitative and none have examined these relationships longitudinally.

In our study, we sought to 1) examine the longitudinal association between changes in obesity-related behaviors (SSB (sugar sweetened beverage) consumption and TV-viewing) and weight status (BMI z-score and obesity) with changes in paternal involvement in both child caregiving and decision-making from age 2 to age 4, and 2) determine whether father's education, family poverty status, and maternal employment modified this association. We hypothesized that increasing paternal involvement with caregiving and decision-making would be associated with decreases in SSB consumption, TV-viewing, BMI z-score, and the odds of overweight/obesity and obesity. We further hypothesized that these relationships would be stronger in children living in poverty, children whose mothers are employed, and children of fathers with higher education.

Methods

Data and study sample

Our analysis used longitudinal data from the Early Childhood Longitudinal Study – Birth Cohort (ECLS-B), which followed a nationally representative cohort of ~10,700 children (rounded to the nearest 50 to comply with ECLS-B's restricted-use data reporting guidelines) born in 2001 from birth through first grade. Sponsored by the US Department of Education, the ECLS-B was designed to collect information on child, home, and family influences on the child's development during the first 6 years of life, with a particular focus on the role of parents and families.[17] The ECLS-B included separate surveys administered to the primary caregiver (biological mothers responded to 95% of parent/guardian surveys) and to resident and non-resident fathers. Fathers responded to self-administered questionnaires.

Our study used data collected from children at age 2 and age 4. Our study sample included children whose fathers lived with them, but was not the primary caregiver, and had completed the resident father survey at both time points (n ~4500). We excluded children with missing BMI z-scores (n ~ 550), implausibly large BMI z-scores (< -5 or > 5 standard deviations) at either time point (n ~ 50), or an implausibly large change in BMI z-score (> 5 standard deviations) from age 2 to age 4 (n ~50) as these observations may have unreliable data on BMI. Our final analytic sample of ~3,900 children was comparable to the full sample of children with resident fathers, with minor differences in child and father race/ethnicity, family poverty, and father educational attainment (Table A3.1). Appendix Figure A3.1 shows how we created the analytic sample.

Study Measures

Dependent Variables: Study outcomes included obesity-related health behaviors and weight status. Measures of obesity-related behaviors included: 1) the number of hours each day that children spends watching TV during weekdays; and 2) sugar sweetened

beverage consumption (regular=1 vs. infrequent/never=0). Regular SSB consumption at age 2 was defined as "usually" consuming SSBs with either meals or snacks, and at age 4, as drinking ≥ 1 SSB per day. Soda, <100% fruit drinks, and sports drinks were considered SSBs. This classification is consistent with previous research on SSB consumption among young children.[18]

For weight status, we included a continuous measure of BMI z-score, an indicator of overweight or obesity status (overweight/obese = 1; not overweight/obese = 0), and obesity status (obese =1; not obese = 0). These outcomes were based on measured weight and height data collected by trained ECLS-B staff. We calculated a child's z-score from BMI (weight divided by recumbent length or standing height squared) using sex-specific BMI-for-age World Health Organization (WHO) child growth standards, which is appropriate for children from birth to age 5.[19] We defined overweight/obesity as being >2 standard deviations above the WHO growth standard mean for all children, and obesity as being >3 standard deviations about the WHO mean.[20]

Main Independent variables: Our independent variables of interest were paternal involvement in two key domains – caregiving and parental decision-making. Our first set of independent variables assessed fathers' involvement in child caregiving. These included how often, in the past month, fathers: 1) prepared meals for child, 2) took their child outside for walks or play, 3) looked after child when the mother did other things, and 4) performed physical caregiving tasks (helped children to bed, brush teeth, get dressed, and bathe child). Frequency for meal preparation and taking children outside to play responses included rarely/never (=0), a few times a month (=1), a few times a week (=2), about once a day (=3), and more than once a day (=4). Frequency of looking after the child responses included never (=0) once or twice (=1), a few times a month (=2), a

few times a week (=3) and every day or almost every day (=4). Frequency of performing physical caregiving tasks was assess through a combined measure, ranging from 0 to 4, where fathers received one point for each physical caregiving task (helped children to bed, brush teeth, get dressed, and bathe child) performed on at least a daily basis (i.e., once a day or more than once a day).

Our second set of independent variables assessed father's influence on parental decision-making on: 1) child nutrition, 2) child healthcare, 3) discipline, and 4) childcare decisions. Response to the individual decision measures were on a 3 point Likert scale of no influence (=0), some influence (=1), and a great deal of influence (=2).

Although, frequency response categories were ordinal, we chose to model both sets of independent variables as continuous measures to facilitate interpretation from fixed effects models.

Effect modifiers and potential confounding variables: We examined father education (high school degree or less=0 versus greater than high school degree=1), baseline maternal employment status (not employed=0 versus employed=1), and baseline poverty status at age 2 (below federal poverty line (FPL)=0 versus at or above FPL=1) as potential effect modifiers.[21-24]

We controlled for time-varying variables that may be potential confounders, including child age (continuous, in months), paternal employment (continuous, # hours/week), maternal employment (continuous, # hours/week), and poverty status (< 100% FPL or ≥100% FPL) at each time point. Because we used child fixed effects regression models, we did not need to explicitly control for time-invariant potential confounders (e.g., child sex) in our analysis, as these models control for all observed and unobserved characteristics that do not change over time.

Statistical Analysis

We calculated descriptive statistics on all key variables for the study sample at age 2 and age 4. We then used fixed effects linear and logistic regression models to assess the relationship between changes in obesity-related behaviors and weight status with changes in paternal caregiving and decision-making from age 2 to age 4. Similar to a pre-post test, these fixed effects models compared children to themselves overtime between the two time points, and therefore automatically control for attributes that do not change over time.[25] Thus, we only control for potential confounders that do change over time. Fixed effects models estimate within-unit (in this case, child) effects and in the two-period case with continuous outcomes, are equivalent to a first difference model. For each outcome, we ran separate models for each of the 4 paternal caregiving and 4 decision-making measures, while controlling for specified time-varying confounders.

To test whether father education, baseline maternal employment, and baseline poverty status modified the association between changes in paternal caregiving and decision-making with changes in early childhood obesity-related outcomes, we also ran separate fixed effect models for each potential modifier that included an interaction term between the modifier and the paternal caregiving or decision-making variable. The interaction was deemed statistically significant if the interaction term was found to have a p-value < 0.05. Then, we estimated the association between changes in childhood obesity behaviors and outcomes and changes in paternal caregiving and decision-making, stratified by each modifier. For all descriptive and statistical analyses, we used the ECLS-B provided survey weights, strata, and variance for the resident father survey at age 4 to also account for survey non-response during the age 2 survey. Statistical analyses were performed in Stata/ID 14.1 (College Station, TX).

This secondary analysis of the restricted use ECLS-B data was determined to be non-human subject research by the Johns Hopkins Institutional Review Board.

Results

The data represent 2,608,286 children in the U.S. More than half of the children (64%) and fathers (67%) were (Non-Hispanic) NH White (Table 3.1). Families living below the poverty line increased slightly from age 2 to age 4 (14% to 15%). Fifty-six percent of fathers had more than a high school degree. On average, mothers worked part-time (18 hours/week at age 2 and 19 hours/week at age 4), while fathers worked full-time (46 hours/week at both age 2 and age 4).

Mean BMI z-scores decreased from 1.1 (SD: 1.2) to 0.7 (SD: 1.1), the proportion overweight decreased from 20.6% to 12.0%, and proportion obese decreased from 6.4% to 4.4% from age 2 to age 4 (Table 3.1). From age 2 to age 4, TV viewing (2.3 hours to 2.1 hours) and SSB consumption (23.0% to 24.4%) were similar. On average, fathers' frequency of participation in each of the following tasks decreased from age 2 to age 4: meal preparation, taking children outside for walk or play, and performing physical caregiving tasks. However, 58% of children experienced an increase in father participation in *at least one* caregiving measure from age 2 to age 4. Children experienced an increase in fathers' influence on nutrition (great deal of influence: 42.3% vs. 48.5%), health (great deal of influence: 61.9% vs. 65.9%) and discipline (great deal of influence: 74.4% vs. 78.1%) from age 2 to age 4.

Table 3.2 presented results from our adjusted fixed effects models. We found that a child's odds of becoming obese decreased when paternal involvement in caregiving increased from age 2 to age 4. Specifically, a one-category increase in the frequency that fathers took the child out for walks or play was associated with a 30% decrease in the odds of childhood obesity (OR = 0.70, 95% CI: 0.5, 0.97). Similarly, each additional physical caregiving task performed by fathers on a daily basis was associated with a 33% decrease in the odds of childhood obesity (OR = 0.67, 95% CI: 0.52, 0.88).

Although not statistically significant, we also observed relationships in the same direction between decreases in the odds of childhood obesity with increases in the frequency of paternal involvement with meal preparation (OR = 0.73, 95% CI: 0.51, 1.03), and looking after the child (OR = 0.75, 95% CI: 0.55, 1.03). These relationships were significant at $p<0.1$. Father involvement with caregiving was not associated with other obesity outcomes.

Father influence on decision-making was not associated with childhood obesity behaviors or weight status outcomes. However, each level increase of father's influence on childcare decisions approached statistical significance with decreases in odds of regular SSB consumption (OR = 0.74, 95% CI: 0.52, 1.06) and of obesity (OR = 0.56, 95% CI: 0.29, 1.09).

We also examined whether these associations varied by father's education, baseline family poverty status, and baseline maternal employment. The tests of whether each of these variables modified the associations between each childhood obesity outcome and each measure of father's involvement with caregiving and decision-making indicated that, generally, these relationships were not modified by any of these variables (results available upon request). However, there were a few exceptions. Increases in the frequency that fathers took their children outside to walk or play was associated with decreases in the child's BMI z-score (-0.07, 95% CI: -0.13, -0.01) among children above the FPL, but not among children living below the FPL (0.10, 95% CI: -0.07, 0.27) (Interaction p = 0.048). Among children with more educated fathers, an increase in paternal physical caregiving participation was associated with an increase in the odds of regular SSB consumption (OR = 1.39, 95% CI: 1.09, 1.76), but not among children with less educated fathers (OR = 0.93, 95% CI: 0.74, 1.16) (Interaction p = 0.013). Conversely, increases in paternal physical caregiving tasks was associated with

decreases in the odds of obesity among children with less educated fathers (OR = 0.58, 95% CI: 0.41, 0.80), but not among more educated fathers (OR = 0.93, 95% CI: 0.64, 1.36) (interaction p = 0.043). None of the relationships varied by baseline maternal employment.

Discussion

This study used a nationally representative sample of children to examine the longitudinal association between changes in early childhood obesity-related behaviors and weight status outcomes and changes in paternal involvement in caregiving and influence in decision-making. By comparing children to themselves over time, we were able to control for all potential time-invariant variables, including unobserved confounding variables that may not be accounted for in cross-sectional studies. We found that for children living in two-parent households, increases in paternal caregiving involvement in child-related decision-making from age 2 to age 4 was associated with decreases in a child's odds of obesity from age 2 to age 4. Although we did not find an association between increases in paternal caregiving involvement measures and changes in BMI, our significant findings for decreased odds of childhood obesity from age 2 to age 4 are important because becoming obese during this developmentally important period poses substantial health risks in later life.[26] While BMI z-scores decreased in this cohort, children at the highest end of the BMI range at this early age are at a particularly high risk for adult adiposity.[1]

There is strong consensus on the importance of paternal involvement during early childhood for child social, behavioral, and cognitive development.[27-31] Our study suggests a relationship between paternal involvement with general child caregiving can also improved child physical health, specifically child obesity outcomes. We found that children whose fathers increased their participation in physical caregiving tasks, such as

bathing and dressing children, from age 2 to age 4 had a reduction in odds of obesity. To our knowledge, this study, conducted with a nationally representative sample of young children, is the first to consider how paternal involvement in general caregiving, beyond caregiving tasks directly related to nutrition or physical activity, is associated with better childhood obesity outcomes. Prior research has found that fathers are more likely to play with children and less likely to perform physical caregiving tasks, while mothers devote a larger portion of their caregiving time to physical caregiving tasks.[24] In recent years, though, fathers have increased their involvement – although still unequal – in physical caregiving.[32] Continued increases in fathers' involvement in physical caregiving tasks may potentially be protective of childhood obesity. It is possible that their increased participation in general child caregiving may provide additional support to the mother and augment the time and quality of care provided to children compared to if they did not help with these tasks.[33]

We also found that fathers taking children outside to play was associated with reduced odds of early childhood obesity. Prior research has found that fathers may play a unique role in their child's health and wellbeing.[34,35] Because fathers are more likely to engage in "roughhousing" play with their children,[35] children may be more physically active when father take children outside than when mothers do so. Fathers may also play a compensatory role in taking children outside to play: since mothers still shoulder the majority of caregiving, they may not have sufficient time or energy to take children outside to play.

Few studies have considered the role of fathers' influence on child-related decision-making on child health as mothers are often primarily responsible for planning and managing caregiving.[24] In our study, we did not find any relationship between fathers' influence on decision-making with childhood obesity outcomes. However, our

null findings may be due to fathers' both positively and negatively influencing on child-related decisions. For example, fathers may encourage child physical activity through more active play,[35] but also more permissive feeding.[11] More research is needed to explore the role of fathers in decision-making influence.

We also explored whether family poverty, father education, and maternal employment modified the relationship between childhood obesity outcomes with paternal caregiving involvement and influence on decision-making, but clear patterns in these relationships did not emerge. This might point to the benefits of paternal involvement in general caregiving on maintaining a healthy weight for children regardless of family poverty, father education, and maternal employment.

Limitations

Our study had a number of limitations. First, due to the lack of precision provided by the measures of paternal involvement with caregiving and influence on decision-making, and the challenges of modeling categorical exposures in fixed-effects models, we modeled these measures as continuous variables despite the fact that they had ordinal response categories. Fixed effects models the relationship of changing *into* a response category, and thus coefficients for the middle categories include both individuals who increased and decreased into that category and become inappropriate for this assessment. This prevented us from making meaningful inferences about specific changes in the odds of obesity associated with each unit change in paternal involvement or influence. However, our goal was to understand the direction of the relationship between child obesity outcomes and paternal involvement and influence more generally and the underlying data provided in these questions are adequate for this purpose. Second, we did not have external validation of father-reported involvement with caregiving and influence on decision-making. Some studies have found that fathers may

overestimate their involvement with caregiving,[36] while others have found agreement between paternal and maternal report.[37] Third, while our use of fixed-effects models accounts for all time-invariant maternal characteristics, there may be other important time-varying confounders that we have not included in our analysis. In particular, we could not control for changes in maternal involvement in caregiving and decision-making (i.e., time-varying measures of maternal involvement), as the ECLS-B did not survey mothers on this. Thus, we cannot ascertain whether paternal involvement is uniquely related to the child's obesity status or how paternal involvement supplements care provided by mothers. Because fixed-effects models are powered by changes in the outcome measures, it is possible that we were underpowered to detect significant interactions. Finally, we limited our sample to two-parent heterosexual families, so our results may not be generalizable to single-parent households or children of same-sex couples.

Policy implications

Our study highlights the importance of paternal participation in caregiving for young children across a spectrum of activities, including those not directly related to child nutrition and physical activity, on preventing childhood obesity. There are several implications of our research. First, efforts should be made to make it more convenient and feasible for fathers to participate in caregiving, especially during these developmentally important early years. Employment is a significant barrier to fathers' taking on more caregiving responsibilities.[38] Paternal participation in caregiving decreases as fathers work more hours.[39] Employer policies for *both* mothers and fathers could allow for greater flexibility to take care of young children. These policies might include allowing for flexible schedules and teleworking for *both* parents of young children.

Second, outreach and educational efforts can potentially change norms around the role of fathers to support their involvement in caregiving involvement and decision-making. Specifically, positive social norms can make it socially acceptable – and even expected – for fathers to take on greater responsibility with caregiving and decision-making. Outreach efforts might include expanding early childhood parent interventions to actively include fathers, child health care providers who actively engage with fathers during their child's healthcare visits, and campaigns that encourage fathers to increase their involvement in all aspects of caregiving. To date, most childhood parent interventions target mothers[40] and fathers have noted feeling neglected during visits with their child's pediatricians.[41] Outreach and education efforts may also have the additional benefit of educating fathers on parenting practices that support a healthy weight for their children.

Conclusion

Although fathers are participating more in caregiving, the effects of their increased involvement on childhood obesity are understudied. We find evidence that increases in paternal involvement in caregiving is associated with lower odds of childhood obesity. Future studies can utilize more precise information on both maternal and paternal caregiving involvement and influence, such as through time-use data, to allow for more definitive estimates of these relationships. Information on maternal involvement can also help elucidate pathways through which paternal involvement and influence might confer child weight benefits.

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Tables

Table 3.1. Sample Characteristics at child age 2 and age 4

	Age 2	Age 4
Child Characteristics		
Age, months (SD)	24.26 (1.04)	52.29 (4.02)
Sex, %		
Female	48.69%	48.69%
Race/ethnicity, %		
NH White	63.69%	63.69%
NH Black	5.33%	5.33%
Hispanic	16.46%	16.46%
NH Asian	7.80%	7.80%
NH Other	6.72%	6.72%
Family Characteristics		
Poverty		
Below Poverty	13.72%	15.08%
Father Race/ethnicity		
NH White	66.78%	66.78%
NH Black	6.06%	6.06%
Hispanic	22.02%	22.02%
NH Asian	3.12%	3.12%
NH Other	2.01%	2.01%
Father education		
HS degree or less	43.83%	43.83%
More than a high school degree	56.17%	56.17%
Maternal employment, hours/week (SD)	17.81 (19.07)	19.06 (19.61)
Paternal employment, hours/week (SD)	45.95 (11.44)	46.47 (11.07)
Father involvement with caregiving		
Meal Preparation		
More than once a day	22.34%	16.31%
Once a day	24.40%	22.17%
A few times a week	30.17%	35.56%
A few times a month	13.52%	14.95%
Rarely/never	9.58%	11.01%
Takes child outside for walks/play		
More than once a day	10.90%	6.07%
Once a day	22.26%	17.43%
A few times a week	44.04%	46.06%
A few times a month	18.19%	24.94%
Rarely/never	4.61%	5.51%
Physical caregiving tasks[1]	1.71 (1.38)	1.44 (1.38)

Frequency looks after child		
Everyday or almost every day	36.29%	34.67%
A few times a week	38.95%	39.53%
A few times a month	18.65%	19.32%
Once or twice	5.13%	5.73%
Never/usually does not take care of child	0.99%	0.75%
Father influence on decision-making		
Influence on Nutrition		
No influence	6.36%	4.78%
Some influence	51.32%	46.73%
A great deal of influence	42.32%	48.49%
Influence on health		
No influence	3.92%	4.02%
Some influence	34.14%	30.09%
A great deal of influence	61.94%	65.88%
Influence on discipline		
No influence	0.71%	1.02%
Some influence	24.87%	20.87%
A great deal of influence	74.42%	78.11%
Influence on childcare		
No influence	4.44%	4.34%
Some influence	33.53%	32.35%
A great deal of influence	62.03%	63.31%
Child obesity-related behaviors and weight status		
TV watching, weekday hours/day (SD)	2.28 (2.15)	2.13 (2.04)
Regular SSB consumption (%)	7.69	24.41
BMI z-score	1.05 (1.28)	0.74 (1.13)
Weight Status		
Overweight	13.71%	7.59%
Obese	6.93%	4.37%

Notes:
Calculated using ECLS-B survey weights
1. Scale from 0 - 4: father's daily involvement (more once a day or daily) in the following tasks: help child get dressed, help child to bed, help child brush teeth, and bathe child
2. Scale from 0 - 4: fathers have a great deal of influence on child nutrition, health, discipline, and childcare decisions
Overweight defined as > 2 SD and ≤ 3 SD based on WHO growth standards
Obese defined as >3 SD based on WHO growth standards

Table 3.2. Adjusted associations between changes in child behaviors and weight status and changes in fathers' involvement in child caregiving and influence on decision-making

	TV-watching (hours)		**Regular SSB consumption**		**BMI z-score**		**Overweight or obese**		**Obese**	
	Estimated change	95% CI	OR	95% CI	Estimated change	95% CI	OR	95% CI	OR	95% CI
Father Involvement in child care										
Meal preparation[1]	0.01	(-0.09, 0.12)	1.02	(0.82, 1.27)	-0.03	(-0.08, 0.03)	0.92	(0.76, 1.12)	0.73	(0.52, 1.03)
Takes child outside for walks/play[1]	-0.08	(-0.19, 0.03)	1.07	(0.87, 1.32)	-0.05	(-0.11, 0.02)	0.87	(0.68, 1.12)	**0.70**	**(0.50. 0.97)**
Physical caregiving tasks[2]	0.00	(-0.10 0.10)	1.10	(0.93, 1.30)	-0.02	(-0.07, 0.02)	0.98	(0.81, 1.17)	**0.67**	**(0.52, 0.88)**
Frequency of looking after child[1]	0.08	(-0.04, 0.20)	0.87	(0.69, 1.10)	-0.01	(-0.07, 0.04)	0.98	(0.76, 1.26)	0.75	(0.55, 1.03)
Father influence on decision-making										
Influence on child nutrition[3]	-0.09	(-0.30, 0.11)	0.73	(0.49, 1.09)	-0.05	(-0.14, 0.04)	0.80	(0.56, 1.14)	0.68	(0.37, 1.25)
Influence on child health[3]	0.03	(-0.17, 0.22)	0.76	(0.53, 1.10)	0.03	(-0.04, 0.11)	1.15	(0.80, 1.66)	1.48	(0.76, 2.92)
Influence on discipline[3]	0.09	(-0.19, 0.36)	0.96	(0.53, 1.73)	0.02	(-0.10, 0.13)	0.96	(0.59, 1.56)	0.70	(0.33, 1.51)
Influence on childcare[3]	0.01	(-0.16, 0.18)	0.74	(0.52, 1.06)	0.02	(-0.06, 0.10)	0.96	(0.64, 1.45)	0.56	(0.29, 1.09)

Note:
Bolded text denotes statistical significance at $p < 0.05$
1 - Per one unit increase in the frequency in paternal involvement
2 - Per increase in one of the following tasks (help child get dressed, help child to bed, help child brush teeth, and bathe child) on at least a daily basis (daily or more than once a day)
3 - Per one unit increase in the level of decision-making influence
Calculated using survey weights
Models controlled for the following time-varying potential confounders: child age (in months), paternal employment (# hours/week), maternal employment (# hours/week), and poverty status (<100% FPL)
Overweight or obese defined as > 2 SD based on WHO growth standards
Obese defined as >3 SD based on WHO growth standards

Appendix Tables

Table A3.1. Comparison of analytic sample (fathers answered both survey questions) with full sample of fathers who were eligible for resident father survey

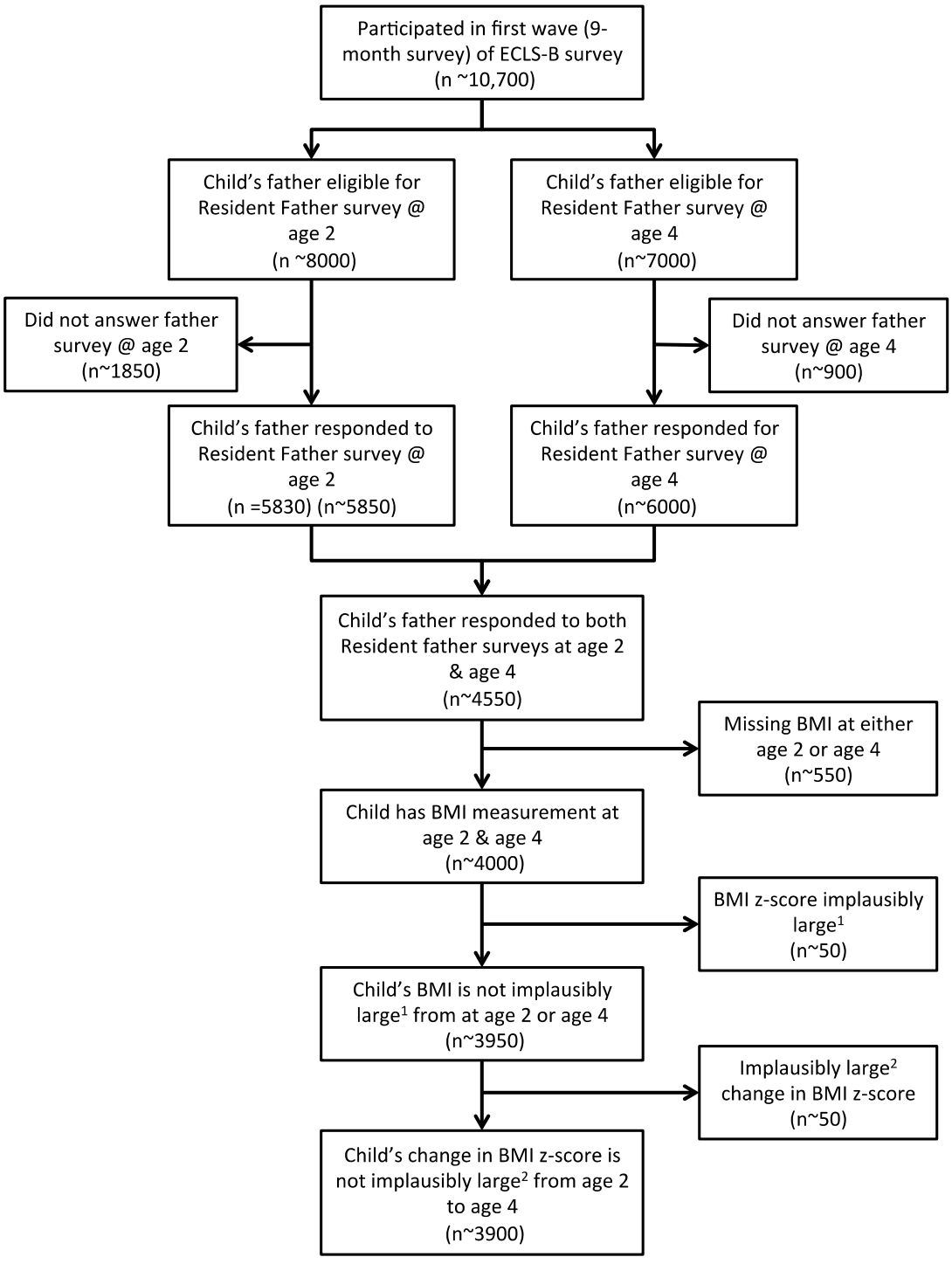
	Age 2			Age 4		
	Full sample (n ~ 4,550)	Analytic sample (n ~ 3,900)	p-value	Full sample (n ~ 5,000)	Analytic sample (n ~ 3,900)	p-value
Child Characteristics						
Age, months (SD)	24.27 (1.00)	24.26 (1.04)	0.669	52.35 (4.02)	52.29 (4.02)	0.482
Sex, %						
Female	49.57%	48.69%	0.543	48.89%	48.69%	0.850
Race/ethnicity, %						
NH White	62.24%	63.69%	0.079	60.44%	63.69%	**< 0.001**
NH Black	6.98%	5.33%		7.42%	5.33%	
Hispanic	16.33%	16.46%		16.74%	16.46%	
NH Asian	7.74%	7.80%		8.44%	7.80%	
NH Other	6.71%	6.72%		6.95%	6.72%	
Family and Household Characteristics						
Poverty, %						
Below Poverty	15.12%	13.72%	**0.019**	17.41%	15.08%	**< 0.001**
Father Race/ethnicity, %						
NH White	65.38%	66.78%	**0.049**	63.51%	66.78%	0.076
NH Black	7.79%	6.06%		8.58%	6.06%	
Hispanic	21.81%	22.02%		22.76%	22.02%	
NH Asian	3.08%	3.12%		3.21%	3.12%	
NH Other	1.93%	2.01%		1.93%	2.01%	
Father education, %						
HS degree or less	44.74%	43.83%	**0.004**	45.99%	43.83%	**0.006**
> high school degree	55.26%	56.17%		54.01%	56.17%	
Maternal employment, hours/week (SD)	18.26 (19.24)	17.81 (19.07)	0.569	19.62 (19.75)	19.06 (19.61)	0.519
Paternal employment, hours/week (SD)	45.74 (11.76)	45.95 (11.44)	0.644	46.53 (11.21)	46.47 (11.07)	0.852
Father involvement in caregiving						
Meal Preparation						
More than once a day	23.98%	22.34%	0.202	17.84%	16.31%	0.263
Once a day	23.36%	24.40%		21.89%	22.17%	

	Age 2			Age 4		
	Full sample (n ~ 4,550)	Analytic sample (n ~ 3,900)	p-value	Full sample (n ~ 5,000)	Analytic sample (n ~ 3,900)	p-value
A few times a week	29.89%	30.17%		34.56%	35.56%	
A few times a month	12.90%	13.52%		14.27%	14.95%	
Rarely/never	9.87%	9.58%		11.44%	11.01%	
Takes child outside for walks/play						
More than once a day	11.53%	10.90%	0.458	6.41%	6.07%	0.799
Once a day	21.92%	22.26%		17.80%	17.43%	
A few times a week	43.91%	44.04%		45.29%	46.06%	
A few times a month	17.80%	18.19%		24.86%	24.94%	
Rarely/never	4.85%	4.61%		5.65%	5.51%	
Frequency looks after child						
Everyday/almost every day	36.20%	36.29%	0.672	35.30%	34.67%	0.296
A few times a week	38.96%	38.95%		37.97%	39.53%	
A few times a month	18.10%	18.65%		19.32%	19.32%	
Once or twice	5.46%	5.13%		6.26%	5.73%	
Never/usually does not	1.28%	0.99%		1.16%	0.75%	
Physical caregiving tasks[1]	1.74 (1.39)	1.71 (1.38)	0.312	1.44 (1.40)	1.44 (1.38)	0.9839
Father Influence on decision-making						
Influence on Nutrition						
No influence	6.02%	6.36%	0.724	4.93%	4.78%	0.891
Some influence	51.20%	51.32%		46.81%	46.73%	
A great deal of influence	42.78%	42.32%		48.27%	48.49%	
Influence on health						
No influence	4.10%	3.92%	0.906	4.74%	4.02%	0.520
Some influence	34.66%	34.14%		30.63%	30.09%	
A great deal of influence	61.25%	61.94%		64.64%	65.88%	
Influence on discipline						
No influence	0.69%	0.71%	0.912	1.27%	1.02%	0.666
Some influence	25.44%	24.87%		21.54%	20.87%	
A great deal of influence	73.87%	74.42%		77.18%	78.11%	

	Age 2			Age 4		
	Full sample (n ~ 4,550)	Analytic sample (n ~ 3,900)	p-value	Full sample (n ~ 5,000)	Analytic sample (n ~ 3,900)	p-value
Influence on childcare						
No influence	4.51%	4.44%	0.832	4.64%	4.34%	0.699
Some influence	33.62%	33.53%		33.60%	32.35%	
A great deal of influence	61.87%	62.03%		61.76%	63.31%	
Child Obesity behaviors and weight status outcomes						
TV watching, hours/day during weekdays (SD)	2.29 (2.15)	2.28 (2.15)	0.645	2.21 (2.20)	2.13 (2.04)	**0.035**
Regular SSB consumption (%)	23.86%	22.95%	0.297	26.73%	24.41%	**0.022**
BMI z-score	1.05 (1.28)	1.05 (1.28)	0.820	0.79 (1.14)	0.74 (1.13)	0.104
Overweight	20.78%	20.64%	0.672	12.70%	11.96%	0.278
Obese	6.54%	6.93%	0.986	4.76%	4.37%	0.524

Note:
p-values compare full sample with analytic sample for each age group
Bold denotes statistically significant differences at $p < 0.05$
Overweight defined as > 2 SD and ≤ 3 SD based on WHO growth standards
Obese defined as >3 SD based on WHO growth standards

Figure A3-1. Flow chart inclusion/exclusion criteria for final analytic sample



Note:
All sample sizes rounded to nearest 50 as required by the ECLS-B to maintain confidentiality
1 – BMI z-score > 5DS or < -5SD
2 – change in BMI z-score greater than 5 SD

CHAPTER 4: Manuscript 3

The association between parent-reported provider communication quality and child obesity status: variation by parent obesity and child race/ethnicity

Abstract

Background:

High quality communication between parents and their child's healthcare provider is associated with increased parent satisfaction and improved child health outcomes, and may be particularly important for obese children who have higher medical needs. Research in adults has found that patient characteristics, such as weight and race, can influence provider communication. However, it is not known whether similar relationships would be found in pediatric settings.

Objective:

To examine the association between parent report of provider communication quality during routine office visit and child obesity status, and whether parent obesity status or child race/ethnicity modify this association.

Methods:

Using pooled data from the 2011 – 2013 Medical Expenditures Panel Survey, we conducted a cross-sectional study of parents with children aged 6-12 (n = 5,390). We used multivariable logistic regression, to examine the association of parent-reported provider communication quality (explaining well, listening carefully, showing respect, and spending enough time) with child obesity status and the modifying effects of parent obesity status and child race/ethnicity.

Results:

Parents of obese children were more likely to report that their child's provider always listened carefully (OR=1.40, p = 0.002) and spent enough time (OR=1.32, p = 0.027) than parents of non-obese children. When stratified by parent obesity status, among

non-obese parents, those with obese children were more likely to report that providers listened carefully compared to those with non-obese children (OR= 1.75, p <0.001), but there were no differences by child obesity status among obese parents (OR = 1.06, p = 0.707) (interaction p = 0.025). When stratified by child race/ethnicity, among parents of non-Hispanic (NH) Asian children, those with obese children were more likely to report that providers explained things well (OR=4.81, p=0.04) compared to those with non-obese children, but there were no differences in other race/ethnicity groups (interaction p = 0.033).

Conclusion:

Provider communication quality does not appear to be negatively associated with child obesity status. Parents of obese children experienced better communication compared to parents of non-obese children, particularly if parents were non-obese or children were NH Asian.

Practice implications:

Providers should communicate effectively to parents of obese children regardless of parent obesity status.

Keywords: parent-reported pediatric provider communication; obesity; health disparities

1. Introduction

High quality communication between parents and their child's healthcare provider is generally associated with increased parent/family satisfaction with care, increased adherence to provider recommendations, and improved child health outcomes [1-4]. Additionally, the quality of parent-provider communication is associated with increased care collaboration between parents and providers as well as parental disclosure of psychosocial issues (e.g., behavioral problems) [2,4,5].

In the last few decades, rates of childhood obesity have increased substantially. Approximately 18% of elementary school aged children (age 6 to 11) are now obese [6], compared to 7% in 1980 [7]. Obese children typically have greater medical needs as they are more likely to have adverse health conditions as a result of their excess body weight [8] such as dyslipidemia and impaired glucose tolerance [9]. Additionally, providers play an important role in preventing and managing child weight gain [10]. Because parents often underestimate their child's weight status [11], providers can play an instrumental role in helping parents identify and understand the risks of their child's weight [12]. Given these important healthcare provider roles for children with obesity, high-quality communication is particularly important; however, few studies have examined provider communication quality during routine office visits.

Most research on the relationship between child weight status and parent-provider communication quality has predominantly focused on weight-related discussions [13-18]. Parents of overweight and obese children have reported feeling that their child's providers blamed them for their child's weight [13,18], and stigmatized them as incompetent parents [19]. Some have even avoided consulting their child's provider on weight

management because of fear of judgment from their child's provider [18]. Many parents report negative interactions, including a lack of sympathy, dismissiveness and apathy, hopelessness, and insensitive or offensive comments from providers [13,17]. However, some parents have noted positive experiences where providers listened, were empathetic, and provided helpful advice [13]. These mixed results may be due, in part, to other child or parent factors that have not been accounted for in previous studies, such as weight status of the parent or race/ethnicity of the child.

Stigma and negative provider interactions may be exacerbated if parents are themselves overweight or obese. Prior research among adults suggests that patients' body weight may negatively affect the relationship and communication with their own providers. Some studies have found that physicians and nurses can be sources of weight stigma [20,21], and obese adults frequently report having negative interactions with providers [22-24]. Pediatric healthcare providers may have similar weight-related biases towards obese parents that may affect how they communicate with parents about their child. Because parent behaviors towards food consumption and physical activity influences their child's weight and behaviors in these same areas [25-27], providers may perceive parents to be more responsible or at fault for their child's weight if they are themselves obese. To date, little research has examined how a parent's own weight may influence the provider relationship.

Given significant disparities in childhood obesity for Hispanic and non-Hispanic (NH) Black children [6], it is important to consider whether parent-provider communication is also influenced by child race/ethnicity and child weight. One study found differences in patient-provider communication quality among adults when both patient weight and race/ethnicity were considered, where overweight/obese NH Black patients experienced

worse communication quality [28]. Similarly, parents of obese minority children may experience poor provider communication quality. Studies among pediatric patients have found that disparities in parent-provider communication are primarily among parents of NH Asian and Hispanic children with limited English proficiency [29-31]. To our knowledge, only one study has examined the provider communication experiences of parents of obese minority children during weight management conversations. This study found that pediatricians frequently used stigmatizing terms like “fat” to describe the child’s body and rarely discussed culturally relevant dietary recommendations with Latino parents [32]. However, little is known about whether parent-provider communication varies by weight-race/ethnicity groups in routine clinical interactions.

Our primary objective was to examine the association between four domains of parent-provider communication quality (how frequently providers explained things well, listened carefully, showed respect, and spent enough time) experienced during routine pediatric care with child obesity status among parents of children 6 to 12 years of age. We hypothesized that parents of obese children would be less likely to report high quality communication with their child’s provider in all four domains compared to parents of non-obese children. We had 2 secondary objectives. First, we aimed to determine whether parent obesity status modified the association between child weight and parent-provider communication quality. We hypothesized that the deficit in communication quality between obese and non-obese children will be larger among obese parents than non-obese parents. Second, we aimed to determine whether child race/ethnicity modified the association between child weight and parent-provider communication quality. We hypothesized that the deficit in communication quality between obese and non-obese children will be larger for parents of minority children than for parents of NH White children.

2. Methods

2.1 Data Source

We pooled 2011 to 2013 data from the Medical Expenditure Panel Survey's (MEPS) Household Component to increase power in our cross-sectional study, particularly for the subgroup analyses. MEPS, which is conducted by the Agency for Healthcare Research and Quality (AHRQ), collects data from a nationally representative sample of U.S. non-institutionalized and non-military families and individuals. Our study sample included parents with a child aged 6-12 who had at least one visit with their healthcare provider in the past 12 months (n =5,390, representing 44,342,823 individuals). We limited our study sample to parents of pre-adolescents, as providers direct more of their communication towards parents of younger children, while they may communicate more directly with adolescent pediatric patients [33]. We excluded parents of underweight children from our analysis due to significant heterogeneity in the underlying reason for their child's weight status (e.g., underweight due to illness) (n=693, representing 5,340,047 individuals).

2.2 Measures

Our dependent variables were four validated measures of parent-provider communication quality from the health plan version of the Consumer Assessment of Healthcare Providers and Systems (CAHPS) survey. CAHPS is a family of AHRQ-sponsored survey instruments designed to measure patient perspectives on the quality of their health care. These questions asked parents, "In the past 12 months, how often did [your child's] doctor or other health provider 1) explained things in a way that was easy to understand, 2) listened carefully to you, 3) show respect for what you had to say, and 4) spent enough time with you/[your child]". Responses were on a 4-point scale of

never, sometimes, usually, and always. We dichotomized the responses to each question into always versus less than always, which is consistent with public reports of other CAHPS measures [34].

Our primary independent variable was child obesity status. Body mass index (BMI) was calculated from parent-report of child's height and weight. We classified children as being obese if they were at or above the 95th percentile among children of the same age and sex, as defined by Center for Disease Control and Prevention [35].

Two effect modifiers, parent obesity status and child race/ethnicity, were examined. Parents were classified as being obese or not obese based on BMI calculated from their self-reported height and weight, which we classified according to standard NIH categories; parents were considered obese if their BMI was 30kg/m^2 or above [36]. Parent-reported child race/ethnicity was categorized as NH White, NH Black, Hispanic, NH Asian, and NH other.

In our primary analysis, we controlled for the confounding effects of several child characteristics: age (continuous), sex (male vs. female), race/ethnicity (NH White, NH Black, Hispanic, NH Asian, or NH other), insurance coverage (any private, public, or uninsured), number of visits in the past 12 months (1, 2, 3, 4, 5-9, or 10+), perceived health status (excellent/very good, good, or fair/poor), usual source of care (yes vs. no), and geographic region (northeast, midwest, south, or west) during multivariable regression analyses. We also controlled for parent characteristics including: obesity status (not obese vs. obese), educational attainment (<high school degree, high school or GED degree, or College degree or higher), household income (continuous), and parent birth status (born in US vs. outside of US) the language that parents reported as

being most commonly spoken at home (English, Spanish, or other). In our secondary analyses, we did not control for child race/ethnicity and adult obesity status, respectively, as we were interested in exploring their role as effect modifiers. However, we controlled for all remaining child and parent characteristics from our primary analysis. Parent race/ethnicity demonstrated high concordance with child race/ethnicity (percent agreement = 89%) and was excluded from these analyses.

2.3 Statistical Analysis:

We calculated summary statistics of means or proportions for all variables of interest for our study population and stratified by child obesity status. We also conducted statistical tests to determine whether these summary statistics differed between obese and non-obese children.

For our primary objective, we conducted bivariate and multivariable logistic regression to examine the association between each of the four provider communication quality domains and child obesity status, controlling for child and parent confounders. Our reference group for these analyses was parents of non-obese children.

For our secondary objectives, we examined whether parent obesity and child race/ethnicity modified the associations between parent-provider communication quality and child obesity status by including interaction terms between child obesity status and parent obesity status, and child obesity status and child race/ethnicity, in separate models. These models controlled for all remaining parent and child confounders listed above. For each level of the potential effect modifier, we estimated the association between parent-reported provider communication quality and child obesity status.

In all analyses, we accounted for the MEPS's complex survey design by using specified survey weights and strata, and adjusted survey weights provided from each year of the MEPS data accordingly, to produce nationally representative estimates of the 2011 – 2013 U.S. non-institutionalized civilian population. All analyses were conducted in Stata/IC 14.1 (College Station, TX).

3. Results

Our study sample represents 44,342,823 parents of children age 6 to 12 who had a visit with their healthcare provider in the past 12 months, excluding parents of underweight children. Table 4.1 presents sample characteristics overall and stratified by child obesity status. Twenty-five percent of the study sample was parents of obese children (representing 11,173,290 individuals). The mean age for all children was 9.3 years. Non-obese children were more likely to be NH White (64 vs 49% for non-obese vs. obese, respectively), have excellent or very good health (84 vs. 76%) and have private health insurance (70 vs. 54%) compared to obese children. Approximately one-third of all parents were obese. While 70% of non-obese children had non-obese parents, only 54% of obese children had non-obese parents. Parents of obese children were less educated (college degree or higher: 28% vs. 43%), had a lower household income ($64,400 vs. $84,700), were less likely to be born in the U.S. (77% vs. 82%), and were less likely to report English as the most commonly spoken language at home (83% vs. 90%).

A large majority of parents reported "always" on provider communication quality, ranging from 76% for providers spending enough time to 83% for showing respect to parents. The proportion of parents responding that they always experienced high quality provider

communication was similar for obese and non-obese children across all 4 communication domains.

Table 4.2 presents unadjusted and adjusted associations between parent-reported communication quality and child obesity status, parent obesity status, and child race/ethnicity for the entire study sample. In unadjusted analysis, we did not find statistically significant associations between any of the parent-reported provider communication domains and child obesity status. After controlling for parent and child confounders, among all study participants, parents of obese children had statistically significantly greater odds of reporting that their providers always listened carefully (OR = 1.40, 95% CI: 1.14, 1.73) and spent enough time with them (OR = 1.32, 95% CI: 1.03, 1.69) compared to parents of non-obese children. We also found that parents of obese children had greater odds of reporting that providers always explained things well (OR = 1.11, 95% CI: 0.88, 1.39) and showed respect (OR = 1.09, 95% CI: 0.87, 1.36), although these differences did not reach statistical significance. Full results of associations between parent-reported communication quality and all covariates are available in Appendix Table A4.1.

Figure 4.1 presents adjusted associations between parent-reported provider communication quality and child obesity status stratified by parent obesity status. Among non-obese parents, those with obese children had statistically significantly greater odds of reporting that providers always listened carefully to them than those with non-obese children (OR: 1.75 95% CI: 1.32, 2.32). In contrast, among obese parents, those with obese children were not significantly different from those with non-obese children in reporting that providers always listened carefully (OR: 1.06, 95%CI: 0.77, 1.47). This difference in the estimated odds ratios when stratified by parent obesity status was

statistically significant (interaction p = 0.025). Among non-obese parents, those with obese children had statistically significantly greater odds of reporting that providers always spent enough time with them (OR: 1.46 95%CI: 1.10, 1.94), while the odds ratio among obese parents was higher but did not reach statistical significance (OR: 1.16, 95%CI: 0.79, 1.69). However, this difference in estimated odds ratios when stratified by parent obesity status was not statistically significant (interaction p = 0.311). We did not find statistically significant differences for the other two communication domains.

Figure 4.2 presents adjusted associations between parent-reported provider communication quality and child obesity status stratified by child race/ethnicity. In the domain of providers explaining well, we found that among parents of NH Asian children, those with obese children were significantly more likely to report that providers always explained thing well compared to those with non-obese children (OR: 4.81 95% CI: 1.82, 12.73). We did not observe statistically significant differences in this domain between parents of obese children compared to non-obese children within other race/ethnicity groups. This difference in estimated odds ratios when stratified by child race/ethnicity was statistically significant (interaction p = 0.033). In the domains of listening carefully and showing respect, we found that among parents of NH Black children, those with obese children had greater odds of reporting that providers always listened carefully (OR: 1.71, 95% CI: 1.14, 2.58), and showed respect (OR: 1.55, 95% CI: 1.04, 2.33) compared to those with non-obese children. We did not find significant associations in these 2 communication domains for the other child race/ethnicity groups. These differences in the estimated odds ratios when stratified by child race/ethnicity were not statistically significant (listen: interaction p = 0.484, respect: interaction p = 0.213). In the domain of spending enough time, we found that among parents of NH Black children and NH Asian children, those with obese children were more likely to report that

providers spent enough time with them (NH Black OR: 1.60, 95%CI: 1.07, 2.41; NH Asian OR: 2.81, 95%CI: 1.10, 7.17). This relationship was not significant in the other 2 race/ethnicity groups. The differences in the estimates odds ratio when stratified by child race/ethnicity was not significant in this communication domain (interaction p = 0.254).

4. Discussion and Conclusion

4.1 Discussion

To our knowledge, our study is the first to use a nationally representative dataset to examine whether a child's obesity status is associated with parent-provider communication quality during routine pediatric care. Contrary to our hypothesis, we found that parents with obese children reported better communication quality with their child's provider in the domains of providers listening carefully and spending enough time during general pediatric encounters. These results suggest that the relationship between obesity status and provider communication quality may differ for pediatric and adults patients. Research among adults has found that the communication and relationships of obese patients with their providers were either similar [28,37], or worse when compared to their healthy weight counterparts [20,23,38,39]. Our findings also differ from experiences documented between parents of overweight or obese children specifically within the context of pediatric weight-related discussions. Although previous studies have found that some parents experience positive and helpful interactions with their providers during these encounters, most report negative experiences [13,17,18]. The poor experiences during weight loss conversations might stem from provider discomfort with weight management discussions, rather than being driven by provider bias against these parents. Previous studies have often documented providers' limited training and confidence in delivering

weight loss counseling [40,41]. In contrast, our study, which examined general clinical interactions between parents and their child's providers, suggest that these negative experiences may occur less frequently in routine encounters compared to weight-counseling interactions. In fact, providers may actually be more conscious of how they communicate with parents of obese children, resulting in these parents reporting comparable or better communication quality compared to parents of non-obese children.

However, when we examined whether parent obesity status modified the association between provider communication quality and child obesity status, a more complex relationship emerged. The relationship between parent-reported provider communication quality within the domain of listening carefully and child obesity status differed based upon parent obesity status. Specifically, among non-obese parents, a greater proportion reported that providers always listened carefully if the child was obese compared to non-obese children. However, among obese parents, there was no difference in communication quality based upon the child's obesity status. This finding suggests both child and parent obesity can factor into how parents rate whether providers always listen carefully. While parents of obese children appear to experience better communication quality if they are themselves not obese, for obese parents, the experience of providers listening carefully was similar to parents of non-obese children. It is possible that providers are more sympathetic towards non-obese parents of obese children, because they perceive these parents as less likely to engage in obesity-promoting behaviors, and less culpable for their child's weight gain.

We are encouraged by our results that overall, parents of obese children were more likely to report that providers always spent enough time with them, and that this relationship did not differ based upon parent obesity status or child race/ethnicity.

Because obese children are at increased risk for physical and psychological problems [9], their healthcare visits likely require additional time to address all of these health concerns. Our finding is consistent with research among adults that has similarly found that providers are more likely to spend time with obese patients in efforts to help these patients manage their multiple comorbidities [42,43].

When examining differences by race/ethnicity, we found that among parents of NH Asian, those who had obese children were more likely to report that their providers explained things well compared to those with non-obese children. These findings are surprising. Prior research on differences in parent-provider interactions by child race/ethnicity has consistently found that parents of NH Asian children with limited English proficiency report worse interactions with their child's provider, while English proficient parents of NH Asian children reported similar experiences compared to parents of NH White children [29-31]. However, as we controlled for language spoken at home in our adjusted analyses, disparities in provider communication among parents of NH Asian children may disappear. Additionally, since NH Asian children have the lowest prevalence of obesity [6], when providers encounter an obese child in this subpopulation, they may be more inclined to explain things well to their parents. Given the complicated relationships among language, child obesity status, and parent-provider interactions in this subgroup, more research on parent-provider communication among NH Asians is needed.

Our findings that parents of obese NH Black children were more likely to report that providers always listened carefully and parents of obese NH Black and NH Asian children were more likely to report that provider spent enough time with them compared to parents of non-obese children is likely driven by high quality provider communication

in this domain among all obese children rather than by specific race/ethnicity differences as we did not find evidence that child race/ethnicity modified these relationships. This finding differs from a previous study among adults, which found that obese NH Black patients experienced worse communication quality than non-obese NH Whites [28]. Taken together, these findings suggest that relationships among race, weight, and provider communication quality differ in pediatric and adult patient populations. While providers may have biases against NH Black overweight and obese adult patients, resulting in these patients experiencing worse provider communication quality, NH Black race does not seem to have a negative impact on provider communication in pediatric populations. We are encouraged by this finding because NH Black children are at a higher risk for childhood obesity [6], and obesity-related chronic diseases in adulthood [44]. High quality communication with these pediatric patients can yield significant future health benefits.

Our findings that parents of obese children are more likely to report that providers always listen carefully and spend enough time are heartening. Since obese children are more likely to have suboptimal health [8], these patients can benefit from consistent high quality of care, including effective communication in all domains. This is especially important for obese children whose parents are also obese. Since parental behaviors can strongly influence child weight status [25-27], providers may need to foster stronger partnerships with these parents to address behavior changes for both child and parents. Care should be taken to ensure that providers provide high quality communication with parents of obese children, regardless of parent weight. Gaps still exist, though, in the communication experienced by obese children and their parents. Studies among parents of overweight Latino children and during sick-child visits, have noted that during weight-management sessions, parents would like providers to give specific, easy-to-follow guidance on healthy diet and family lifestyle changes and clearly explain weight-related

health-issues [45,46]. Furthermore, other gaps in quality of care for obese children remain, including a failure to diagnose obesity [47], and the need for consistent follow-up [45].

Our study had a number of limitations. Our analysis relied upon parent-reported height and weight for their child and themselves, which may underestimate both child [48] and parent BMI [49]. Our analysis was cross-sectional, making us unable to make conclusions about causality. We were also unable to control for provider characteristics that have previously been found to influence provider communication quality, such as provider weight and race/ethnicity [50-52]. The MEPS asked parents to consider communication with their child's provider over the course of the previous 12 months when answering each of the 4 communication questions, but if the children saw multiple providers during this time frame, parents may have experienced different communication quality among providers. In this case, we could not determine which providers parents considered when rating communication quality. Our analysis only considered parent reported experiences of communication. However, previous studies in adults have found that providers and patients may differ in their expectations for quality of care, including communication [53]. Our analysis was only conducted among parents of children age 6 to 12, and our results may not be generalizable to parents of children in other age groups.

4.2 Conclusion

Our analysis of a large nationally representative dataset of the U.S. suggests that parents of obese children experience better communication quality, specifically in providers listening carefully and spending enough time with them. However, these benefits for parents of obese children were higher when parents themselves were not obese. Contrary to the adult literature, we did not find impaired provider communication

among parents of obese minority children; in fact among parents of NH Asian and NH Black children, those with obese children were more likely to report better communication compared to those with non-obese children.

4.3 Practice Implications

High quality communication between parents and their child's provider is important for maintaining a strong relationship with parents, achieving high quality patient care, and improving parent satisfaction. Providers should continue to maintain high quality communication with parents of obese children, be cognizant of potential biases towards obese parents, and aim to communicate effectively with all parents regardless of parent obesity status. Providers should also focus on effective communication with obese parents of obese children, as this group likely requires strong collaboration with parents to manage the child's weight and obesity-related comorbidities. Future research should examine why communication quality differs by parental obesity status among parents of obese children, and the complex relationships between child race/ethnicity, child weight, and parent-provider communication.

I confirm all patient/personal identifiers have been removed or disguised so the patient/person(s) described are not identifiable and cannot be identified through the details of the story.

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Conflict of Interest

Authors have no conflicts of interest to disclose.

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Tables and Figures

Table 4.1. Sample characteristics by child obesity status

	Overall (n = 5,390)	Not obese (n = 3,736)	Obese (n = 1,654)	p-value
Child Characteristics				
Age in years, mean (SD)	9.3 (2.0)	9.4 (1.9)	8.9 (2.1)	< 0.001
Gender, %				
Female	49.3	50.3	46.6	0.109
Race/ethnicity, %				
NH White	60.6	64.6	48.7	
NH Black	11.8	10.1	17.0	
Hispanic	18.1	15.6	25.6	
NH Asian	4.5	4.6	4.3	
NH Other	5.0	5.2	4.5	< 0.001
Insurance Coverage , %				
Any private	66.0	70.2	53.7	
Public	31.1	27.1	43.1	
Uninsured	2.9	2.8	3.2	< 0.001
Number of visits in the past 12 months, %				
1	37.0	36.2	39.4	
2	24.9	25.2	24.0	
3	14.7	14.9	14.2	
4	8.0	8.6	6.4	
5 - 9	10.7	10.3	11.7	
10+	4.7	4.8	4.3	0.278
Perceived health status, %				
Excellent/very good	81.6	83.5	76.1	
Good	16.0	14.7	20.1	
Fair/poor	2.4	1.9	3.9	< 0.001
Has usual source of care, %	96.0	95.9	96.2	0.699
Region, %				
Northeast	19.9	20.1	19.2	
Midwest	22.4	22.5	22.0	
South	37.9	37.0	40.6	
West	19.8	20.4	18.3	0.500
Parent Characteristics				
Obesity status, %				
Not obese	66.3	70.4	53.8	
Obese	33.8	29.6	46.2	< 0.001
Educational attainment, %				
< HS degree	9.3	7.4	15.0	
HS or GED degree	51.5	49.8	56.7	
College degree or higher	39.2	42.8	28.3	< 0.001
HH income, mean (SD)	81,100 (63,500)	84,700 (63,720)	64,400 (56,800)	< 0.001
US born, %	80.9	82.3	76.6	< 0.001

	Overall (n = 5,390)	Not obese (n = 3,736)	Obese (n = 1,654)	p-value
Language most commonly spoken at home, %				
English	87.8	89.6	82.5	
Spanish	10.0	8.6	14.0	
Other	2.2	1.8	3.5	< 0.001
Parent-Reported Provider Communication Quality				
Explain Well				
< Always	19.9	19.8	20.0	
Always	80.2	80.2	80.0	0.876
Listen Carefully				
< Always	19.6	20.3	17.7	
Always	80.4	79.7	82.3	0.094
Shows Respect				
< Always	16.9	16.6	17.8	
Always	83.1	83.4	82.2	0.446
Enough Time				
< Always	23.6	24.2	22.1	
Always	76.4	75.9	77.9	0.290

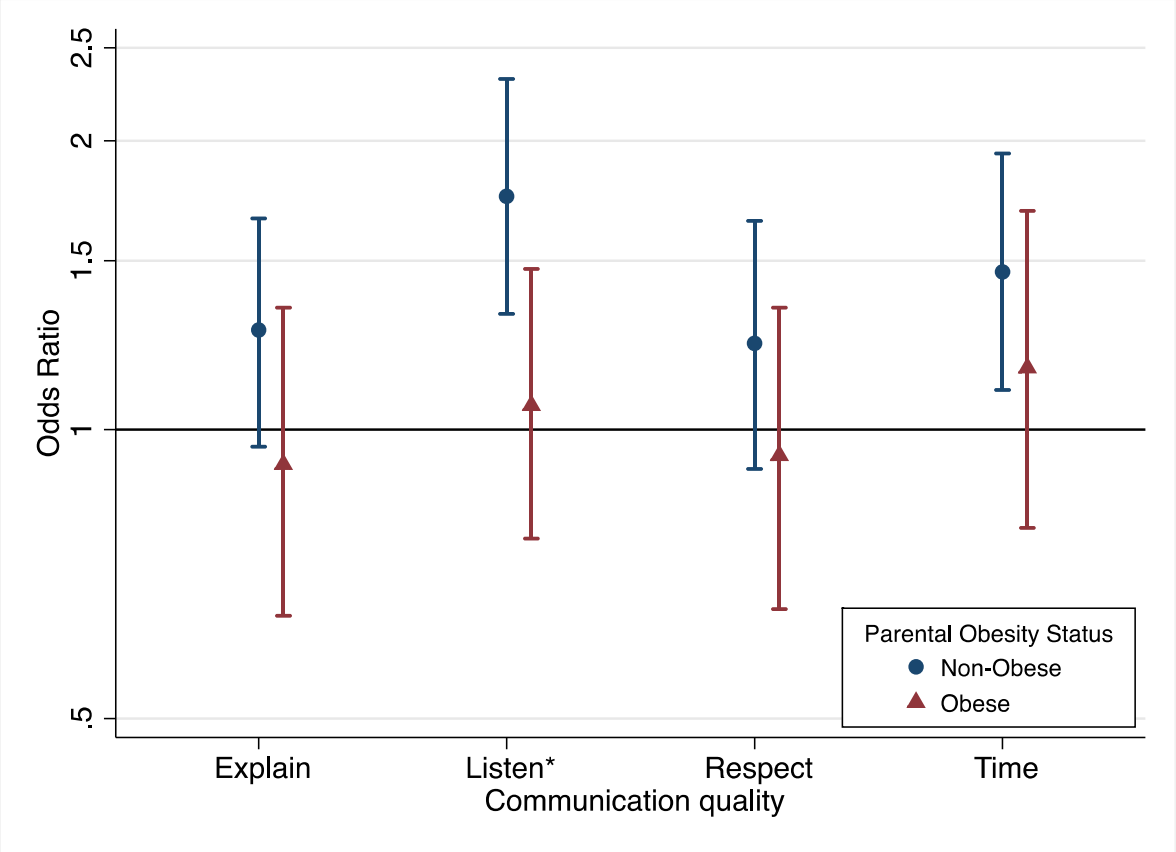
Notes:
Estimates calculated using survey weights.
Obese: at or above the 95th percentile among children of the same age and sex; Not obese: less than the 95th percentile among children of the same age and sex
Other race includes: Pacific Islander, American Indian, Aleut, Eskimo

Table 4.2. Adjusted associations between parent-reported communication quality and child obesity status, parent obesity status, and child race/ethnicity

	Explain				Listen				Respect				Time			
	Unadjusted		Adjusted		Unadjusted		Adjusted		Unadjusted		Adjusted		Unadjusted		Adjusted	
	OR	95% CI	OR	95% CI	OR	95%CI	OR	95%CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Child Weight Status																
Not obese	Ref		Ref		Ref		Ref		Ref		Ref		Ref		Ref	
Obese	1.00	(0.81, 1.23)	1.11	(0.88,1.39)	1.2	(0.98, 1.47)	**1.40**	**(1.14,1.73)**	0.96	(0.77, 1.19)	1.09	(0.87,1.36)	1.1	(0.89, 1.37)	**1.32**	**(1.03,1.69)**
Parent Weight Status																
Not obese			Ref				Ref				Ref				Ref	
Obese			1.00	(0.78,1.28)			**0.93**	**(0.74,1.17)**			0.91	(0.71,1.15)			**0.97**	**(0.75,1.24)**
Child race/ethnicity																
NH White			Ref				Ref				Ref				Ref	
NH Black			0.93	(0.69,1.25)			0.93	(0.70,1.23)			1.08	(0.79,1.49)			0.94	(0.71,1.25)
Hispanic			0.97	(0.68,1.36)			1.01	(0.74,1.36)			1.11	(0.78,1.57)			0.92	(0.66,1.28)
NH Asian			0.72	(0.38,1.36)			0.63	(0.36,1.11)			0.59	(0.32,1.08)			0.66	(0.38,1.15)
NH Other			0.84	(0.52,1.37)			1.12	(0.61,2.06)			0.87	(0.52,1.46)			0.82	(0.47,1.43)

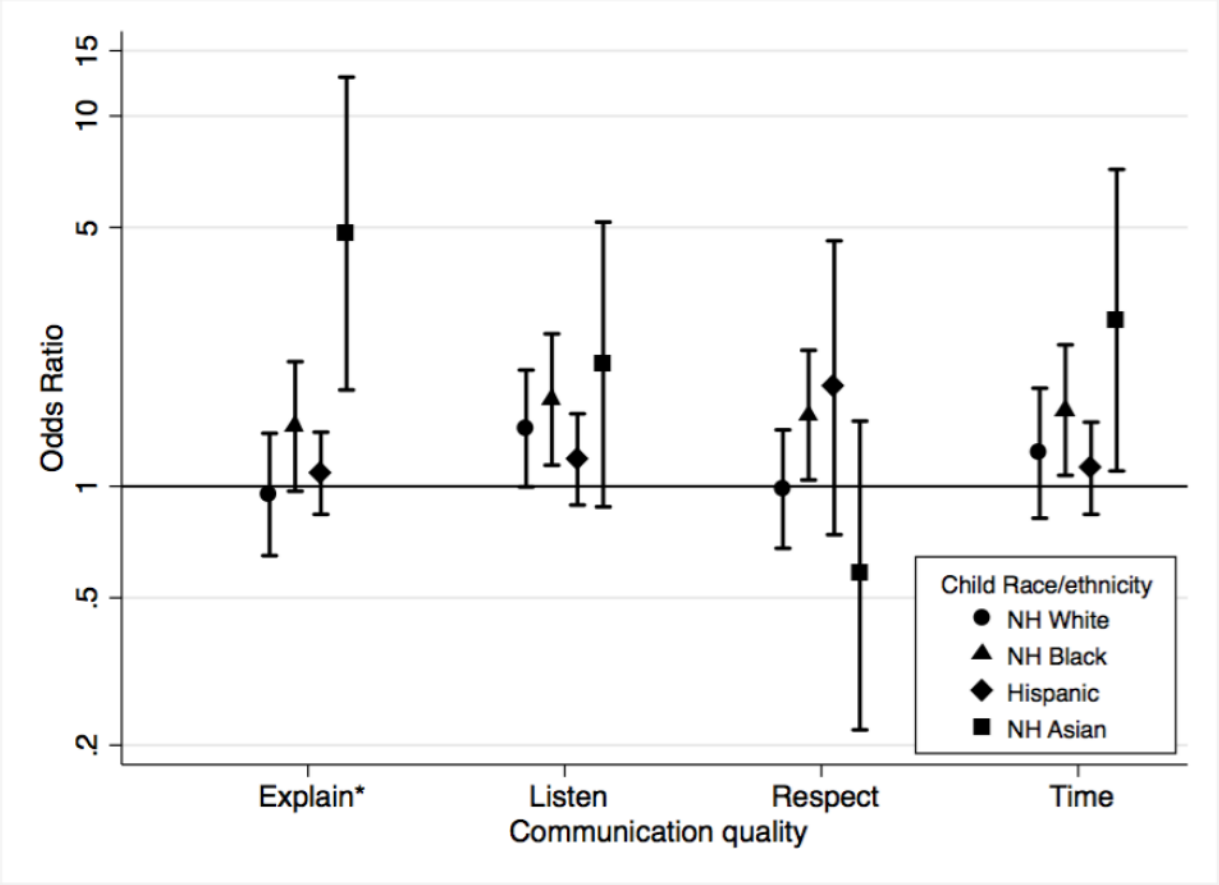
Notes:
Bole text indicates significance at p<0.05
ORs calculated using multivariate logistic regression. Model controls for child variables (age, sex, race/ethnicity, insurance coverage, # of visits to the doctor in past year, health status, geographic region), parent variables (educational attainment, race/ethnicity, obesity status, house hold income, US born, and language spoken at home), and survey year. Full results for all covariates are available in Appendix Table A1
Estimates calculated using survey weights.
Child Obese: at or above 95th percentile among children of the same age and sex. Child non-obese: less than 95th percentile among children of the same age and sex.
Parent Obese: BMI ≥ 30 kg/m^2. Parent non-obese: BMI < 30 kg/m^2
Other race includes: Pacific Islander, American Indian, Aleut, Eskimo.

Figure 4.1. Adjusted odds ratios of parent-reported provider communication quality, stratified by parent obesity status



Note:
* denotes statistically significant interaction between child obesity status and parent obesity status p-value for interaction between child obesity status and parent obesity status: Explain: 0.18, Listen: 0.025, Respect: 0.266, Time: 0.311.
Models controlled for child variables (age, sex, race/ethnicity, insurance coverage, # of visits to the doctor in the past year, health status, and geographic region), parent variables (educational attainment, household income, US born status, and language spoken at home), and survey year. Estimates calculated using survey weights.

Figure 4.2. Adjusted odds ratios of parent-reported provider communication quality, stratified by child race/ethnicity



Note:
* denotes statistically significant interaction between child obesity status and child race/ethnicity p-values for interaction between child obesity status and child race/ethnicity: Explain: 0.033, Listen: 0.484, Respect: 0.213, Time 0.254.
Results from NH Other race/ethnicity group not shown due to significant heterogeneity in this group.
Models controlled for child variables (age, sex, insurance coverage, # of visits to the doctor in the past year, health status, and geographic region), parent variables (obesity status, educational attainment, household income, US born status, and language spoken at home), and survey year.
Estimates calculated using survey weights.

Appendix Tables

Table A4.1. Full results of adjusted associations for parents reporting high quality provider communication by child adjusted status adjusted for all covariates

	Explain Well		Listen Carefully		Show Respect		Enough Time	
	OR	95% CI	OR	95%CI	OR	95% CI	OR	95% CI
Child Obesity Status								
Not obese	Ref	--	Ref	--	Ref	--	Ref	--
Obese	1.11	(0.88,1.39)	**1.40**	**(1.14,1.73)**	1.09	(0.87,1.36)	**1.32**	**(1.03,1.69)**
Parent Obesity Status								
Not obese	Ref	--	Ref	--	Ref	--	Ref	--
Obese	1.00	(0.78,1.28)	0.93	(0.74,1.17)	0.91	(0.71,1.15)	0.97	(0.75,1.24)
Child race/ethnicity								
NH White	Ref	--	Ref	--	Ref	--	Ref	--
NH Black	0.93	(0.69,1.25)	0.93	(0.70,1.23)	1.08	(0.79,1.49)	0.94	(0.71,1.25)
Hispanic	0.97	(0.68,1.36)	1.01	(0.74,1.36)	1.11	(0.78,1.57)	0.92	(0.66,1.28)
NH Asian	0.72	(0.38,1.36)	0.63	(0.36,1.11)	0.59	(0.32,1.08)	0.66	(0.38,1.15)
NH Other	0.84	(0.52,1.37)	1.12	(0.61,2.06)	0.87	(0.52,1.46)	0.82	(0.47,1.43)
Child age	0.99	(0.94,1.04)	**1.05**	**(1.00,1.11)**	1.02	(0.97,1.07)	1.03	(0.99,1.07)
Child sex								
Male	Ref	--	Ref	--	Ref	--	Ref	--
Female	1.08	(0.88,1.32)	0.86	(0.71,1.04)	0.96	(0.78,1.19)	0.97	(0.79,1.19)
Child Insurance Status								
Any private	Ref	--	Ref	--	Ref	--	Ref	--
Public	1.03	(0.77,1.39)	0.98	(0.74,1.31)	1.02	(0.74,1.41)	0.87	(0.63,1.21)
Uninsured	1.82	(0.96,3.46)	1.53	(0.88,2.69)	**2.04**	**(1.05,3.95)**	1.21	(0.64,2.28)
Number of visits in the past 12 months								
1	Ref	--	Ref	--	Ref	--	Ref	--
2	0.96	(0.75,1.22)	0.89	(0.70,1.13)	0.84	(0.67,1.06)	**0.78**	**(0.62,0.98)**
3	**0.62**	**(0.46,0.82)**	0.74	(0.54,1.02)	**0.72**	**(0.53,0.98)**	**0.65**	**(0.49,0.85)**
4	0.73	(0.51,1.04)	0.77	(0.53,1.12)	0.81	(0.55,1.21)	0.78	(0.55,1.12)
5 - 9	**0.59**	**(0.39,0.88)**	**0.55**	**(0.38,0.79)**	**0.48**	**(0.32,0.74)**	**0.61**	**(0.41,0.91)**
10+	0.39	(0.23,0.67)	**0.41**	**(0.26,0.66)**	**0.34**	**(0.19,0.58)**	**0.39**	**(0.22,0.68)**
Perceived Health Status								
Excellent/very good	Ref	--	Ref	--	Ref	--	Ref	--
Good	**0.66**	**(0.51,0.84)**	**0.57**	**(0.44,0.74)**	**0.58**	**(0.46,0.73)**	**0.55**	**(0.44,0.70)**
Fair/poor	**0.55**	**(0.32,0.92)**	0.51	(0.31,0.83)	**0.48**	**(0.28,0.82)**	**0.59**	**(0.35,1.00)**
Has usual source of care								
Yes	Ref	--	Ref	--	Ref	--	Ref	--
No	**0.50**	**(0.29,0.84)**	**0.41**	**(0.20,0.84)**	**0.47**	**(0.27,0.83)**	0.54	(0.26,1.14)
Region								
Northeast	Ref	--	Ref	--	Ref	--	Ref	--
Midwest	1.14	(0.78,1.66)	0.98	(0.69,1.39)	1.11	(0.75,1.65)	1.17	(0.80,1.71)
South	1.10	(0.73,1.68)	1.27	(0.86,1.88)	0.98	(0.66,1.46)	1.35	(0.91,1.99)
West	0.92	(0.66,1.30)	0.93	(0.66,1.31)	0.78	(0.56,1.09)	0.93	(0.66,1.31)

Parent Educational Attainment								
< HS degree	Ref	--	Ref	--	Ref	--	Ref	--
HS or GED degree	1.01	(0.73,1.39)	0.95	(0.73,1.24)	0.89	(0.66,1.21)	1.13	(0.86,1.50)
College degree or higher	1.02	(0.63,1.64)	0.94	(0.61,1.45)	0.97	(0.59,1.58)	1.07	(0.70,1.65)
HH income, mean (SD)	1.02	(1.00, 1.05)	1.02	(0.99, 1.05)	**1.05**	**(1.02, 1.08)**	1.01	(0.99, 1.04)
Parent US Birth status								
Born in US	Ref	--	Ref	--	Ref	--	Ref	--
Born outside of US	0.70	(0.39,1.26)	0.65	(0.40,1.07)	0.73	(0.43,1.22)	0.76	(0.48,1.18)
Parent report of language most commonly spoken at home								
English	Ref	--	Ref	--	Ref	--	Ref	--
Spanish	0.85	(0.54,1.35)	0.82	(0.54,1.25)	0.88	(0.56,1.41)	0.89	(0.58,1.36)
Other	0.80	(0.40,1.58)	1.10	(0.58,2.12)	1.05	(0.52,2.12)	0.96	(0.54,1.71)
Year								
2011	Ref	--	Ref	--	Ref	--	Ref	--
2012	1.12	(0.86, 1.47)	1.25	(0.96, 1.64)	1.2	(0.91, 1.58)	**1.38**	**(1.09, 1.74)**
2013	**1.36**	**(1.02, 1.82)**	**1.45**	**(1.11, 2.12)**	**1.55**	**(1.12, 2.15)**	**1.54**	**(1.18, 2.02)**

Notes:
Bold text indicates significance at $p<0.05$.
ORs calculated using multivariate logistic regression. Model controls for child variables (age, sex, race/ethnicity, insurance coverage, # of visits to the doctor in past year, health status, geographic region), parent variables (educational attainment, race/ethnicity, obesity status, house hold income, US born, and language spoken at home), and survey year. Estimates calculated using survey weights.
Child Obese: at or above 95th percentile among children of the same age and sex. Child non-obese: less than 95th percentile among children of the same age and sex.
Parent Obese: BMI ≥ 30 kg/m2. Parent non-obese: BMI < 30 kg/m2
Other race includes: Pacific Islander, American Indian, Aleut, Eskimo.

CHAPTER 5: DISCUSSION

Summary of findings

Guided by the social-ecological model, this dissertation takes a multi-level approach to examining the correlates and consequences of obesity, and whether factors from different levels are related to SES and racial/ethnic disparities in obesity. The studies undertaken in this dissertation found that factors from all 3 contextual levels examined – the neighborhood, family, and healthcare system – were associated with obesity behaviors and weight status outcomes, although not always in the expected direction. Additionally, results from this dissertation provide stronger evidence of a relationship between contextual factors within the neighborhood level, specifically the built environment, and obesity disparities compared to the family or healthcare system levels. Results from these three studies underscore the complexity of understanding the obesity epidemic and the SES and racial/ethnic disparities in obesity outcomes, and the need for multi-level approaches to addressing these problems.

Identifying key contextual factors of the neighborhood, family, and healthcare system levels

Paper 1 found that lower neighborhood educational attainment was associated with worse obesity behaviors and weight status outcomes in all 4 race/ethnic groups included in this analysis (NH Whites, Hispanics, NH African Americans, and NH Asians). This finding is consistent with a large body of evidence that neighborhood SES is associated with obesity.[1-3] Interestingly, though prior studies have assessed neighborhood SES through both neighborhood level measures of income and education, there was mixed evidence of an association between obesity outcomes and neighborhood income in this study. One thing to note is that lower neighborhood educational attainment was associated with higher BMI in all groups except for NH

African Americans. For NH African Americans, higher neighborhood educational attainment was associated with obesity-related behaviors, specifically higher odds of regular soda consumption. Despite the lack of association with weight status outcomes in this subpopulation, this finding is still important because there is strong evidence that, in addition to weight gain, soda consumption increases the risk of other chronic health conditions including type 2 diabetes, metabolic syndrome, and cardiovascular disease.[4] It is possible that in these neighborhoods, there may be fewer societal cues, such as soda beverage advertisements, that encourage soda consumption, and may have food stores that are of the same category but of different quality from those in neighborhoods with lower educational attainment (e.g., grocery stores that focus on organic and healthy food product vs. large chain grocery stores).

Features of the neighborhood social environment were also associated with obesity outcomes for all racial/ethnic groups. These findings build upon the growing evidence of the importance of neighborhood social environment – including social cohesion, social connectivity, social capital – on obesity outcomes,[5-7] and further indicate that the social environment is important in all 4 racial/ethnic groups. However, the specific relationships differed by race/ethnicity. For NH Whites, both higher social cohesion and always feeling safe were associated better obesity outcomes. For Hispanics, only higher social cohesion was associated with obesity outcomes. Social cohesion may help Hispanics maintain traditional – healthier – diets.[8] For NH Asians and NH African Americans, high neighborhood safety was associated with better obesity outcomes. Although I did not examine physical activity outcomes, neighborhood safety may encourage greater outdoor physical activity, such as walking.[9] This might suggest that there are racial/ethnic differences in how the social environment might influence obesity outcomes.

There is limited existing research on paternal influences on childhood obesity[10]. Paper 2 is the first to consider how father involvement in general caregiving – beyond activities directly related to nutrition or physical activity (e.g., feeding behaviors, nutrition and sedentary behavior knowledge) – is associated with early childhood obesity, and points to the importance of the father's influence on childhood obesity through a wide variety of care giving roles. In this study, I found that, as hypothesized, increases in the frequency of paternal involvement with caregiving were associated with a reduction in the odds of childhood obesity. Specifically, children whose fathers increased the frequency of taking children outside for walk or play and their participation in physical caregiving tasks, such as bathing and dressing child, from age 2 to age 4 had a reduction in odds of obesity by 30% and 33%, respectively. Additionally, although not statistically significant, I found relationships in the same direction between decreases in the odds of obesity among children whose fathers increased the frequency of involvement with meal preparation and looking after the child. This finding of the benefits of fathers' involvement is consistent with a large body of evidence of the importance of fathers in early childhood for child social, behavioral, and cognitive development.[11-15] These results add to the existing research by indicating that father involvement also has benefits for the child's physical health, specifically obesity.

I also hypothesized that increased father influence on decision-making would be associated with better obesity-outcomes; however, my results did not support this hypothesis. I did not find any significant relationships between increases in the level of father influence child-related decision-making and childhood obesity outcomes. Few studies have considered the role of fathers' influence on family decision-making on child health as mothers are often primarily responsible for planning and managing the care of children.[16] These null findings might be due to the fact that fathers may sometimes have positive and negative influences on child-related decisions. For example, compared to

mothers fathers may encourage more physical activity through more active play,[17] but may also be less likely to monitor child food intake.[18] More research is needed to explore the role of fathers in child decision-making, including the processes and allocation of decision-making power between both parents, and the level of influence that fathers have.

Although provider biases towards adult patients have been well-studied, there is less research on provider biases in pediatric settings and is generally limited to weight-related discussions. Paper 3 is the first to assess the relationship between provider communication and child weight status during general pediatric care interactions. I hypothesized that that parents of obese children would experience worse communication quality. However, results from this study found the opposite to be true: parents of obese children were 40% more likely to report that their child's provider always listened to them and 32% more likely to always spend enough time with them compared to parents of non-obese children. This finding is surprising and differs from prior research that documented negative experiences between parents of overweight or obese children and their child's providers specifically within the context of pediatric weight-related discussion.[19-21] One reason for this difference may be that this study evaluated communication quality in the context of routine clinical interactions where weight – if discussed – was not necessarily the focus while previous studies specifically evaluated interactions in the context of weight counseling. The poor experiences during weight loss conversations might stem from provider discomfort with weight management discussions, rather than being driven by provider bias against these parents. Previous studies have often documented providers' limited training and confidence in delivering weight loss counseling.[22,23] This study suggests that during routine clinical encounters, providers may actually be more conscious of how they communicate with parents of

obese children, resulting in these parents reporting comparable or better communication quality compared to parents of non-obese children.

There is also limited knowledge on the role of parent weight status on communication quality with the child's provider. The hypothesis that if both the parent and child were obese, parents would report worse communication was partially confirmed by results from this study. Among non-obese parents, a greater proportion reported that providers always listened carefully if the child was obese compared to non-obese children. However, among obese parents, there was no significant difference in communication quality based upon the child's obesity status. These results suggest that both parent and child obesity status can factor into how parents rate whether providers always listen carefully, such that parents of obese children only experience better communication if they themselves are not obese. It is possible that providers are more sympathetic towards non-obese parents of obese children, because they perceive these parents as less likely to engage in obesity-promoting behaviors, and less culpable for their child's weight gain.

Multi-level contribution to disparities in obesity outcomes

Despite numerous studies on the relationship between neighborhood – particularly the built environment – and obesity,[24] Paper 1 is one of the few studies that has analyzed these relationships stratified by individual race/ethnicity, which has important implications for how neighborhoods can potentially address race/ethnicity disparities. Overall, more features of the neighborhood environment were associated with obesity outcomes among NH Whites, in the expected direction than in other race/ethnicity groups. This finding partially confirmed my hypotheses that more aspects of these three neighborhood environments would be associated with obesity among NH Whites and NH African-Americans than among Hispanics and NH Asians. Most of the

differences in these associations emerged in the built environment. For NH Whites, more grocery stores and fitness centers were both associated with better obesity outcomes, and more fast food restaurants were associated with worse obesity outcomes. However, for NH African Americans, contrary to the hypothesis, the only significant association was between fast food restaurants and a reduction in fruit and vegetable consumption. My study did not find an association with supermarkets, which were observed in some,[25,26] but not all, prior studies.[27] For both Hispanics and NH Asians, the only significant association was between fitness centers and lower BMI. This finding differs from a previous study that found that for NH Asians and Hispanics, more healthful food environments (defined by a composite measure of healthful and unhealthful retail food vendors) were associated with lower obesity.[27] These results suggest that improvements to the neighborhood's built environment alone may not yield comparable benefits across all race/ethnicity groups. For NH African Americans and Hispanics, who both have a disproportionately risk of obesity, factors at other contextual levels (e.g., high food prices, lack of individual resources) may also contribute to obesity.

In the sociodemographic environment, for NH Asians, living in neighborhoods with a higher concentration Asians was associated with lower odds of obesity, which is consistent with the ethnic density effect.[67,68] However, this study did not find evidence of the ethnic density effect among Hispanics as evidence by the lack of associations between obesity outcomes and neighborhood concentration of Hispanics. Additionally, to my knowledge, only one other study has considered the relationship between obesity outcomes and neighborhood concentration of individuals from other race/ethnic groups. This study found that for NH Whites, living in neighborhoods with a higher concentration of NH Asians was associated with higher BMI. This finding differs from a previous study that found that for NH Whites, living in a neighborhood with a high concentration of NH Asians (≥25%) was associated with reduced odds for obesity and lower BMI.[28] While this

study was conducted specifically in California, the other study was conducted using national data. It is possible that the divergent findings arise from differences between California and the U.S as a whole.

Paper 2 explored SES disparities in childhood obesity at the family level, and hypothesized that these relationships would be stronger in children living in poverty, children whose mothers were employed, and children of fathers with higher education. However, I found little evidence that these associations varied by family SES. There were few significant interactions between SES measures of family poverty, father education, and maternal employment and measures of fathers' involvement with caregiving and decision-making. Among those interactions that were significant, clear patterns did not emerge. This study suggests that increases in paternal involvement with caregiving giving may be beneficial to the child's weight trajectory early in life for all children regardless of their family's SES status.

Paper 3 explored racial/ethnic disparities in the health system level, specifically with parent-provider communication quality by child obesity status. Contrary to the hypothesis that the deficit in communication quality between obese and non-obese children will be larger for parents of minority children than for parents of NH White children, results from this study provide evidence that parents of minority children, specifically NH Black and NH Asian children, may in fact experience better communication with their child's provider if their child is also obese. Among parents of NH Asian, those who had obese children were more likely to report that their providers explained things well compared to those with non-obese children. These findings are surprising, given prior research that has consistently found that parents of NH Asian children with limited English proficiency report worse interactions with their child's provider, while English proficient parents of NH Asian children reported similar experiences compared to parents of NH White children.[29-31] However, the lack of

disparities among NH Asian children in this study compared to previous studies may be due to the fact that this study controlled for language spoken at home in the adjusted analyses, disparities in provider communication among parents of NH Asian children may disappear. Additionally, since NH Asian children have the lowest prevalence of obesity,[32] when providers encounter an obese child in this subpopulation, they may be more inclined to explain things well to their parents.

Paper 3 also found that parents of obese NH Black children were more likely to report that providers always listened carefully and spent enough time with them compared to parents of non-obese children. This result is likely driven by high quality provider communication in this domain among all obese children rather than by specific race/ethnicity differences as there was no evidence that child race/ethnicity modified these relationships. Contrary to previous research in adults that found weight-related biases among providers towards their obese NH black patients,[33] parents of obese NH Black children actually experience better communication with their child's provider compared to their non-obese counterpart. Taken together, these findings suggest that relationships among race, weight, and provider communication quality differ in pediatric and adult patient populations. The findings of better communication among parents of obese NH Black children is encouraging because NH Black children are at a higher risk for childhood obesity,[32] and obesity-related chronic diseases in adulthood.[34] High quality communication with these pediatric patients can yield significant future health benefits.

Study limitations and strengths

This research has several limitations that should be considered when interpreting the results. Limitations for each of the papers are discussed here as well as limitations for the overall study.

The results of these studies may have limited generalizability. Paper 1's analyses were conducted in a representative sample of adults in California from 2011 to 2013, but these findings may not be generalizable to the rest of the United States. Paper 2's analyses were conducted in a nationally representative sample of children from age 2 to age 4, who lived in heterosexual two-parent households, so these findings may not be generalizable to other age groups or children living in households with other family structures (e.g., single-parent or same-sex two-parent households). Paper 3's analyses were also conducted in a nationally representative of children between the ages of 6 and 12, and may not be generalizable to parents of children in other age groups.

Both paper 1 and paper 3 may be subject to reporting bias of BMI and overweight or obesity prevalence. Both papers used datasets that relied upon self-reported height and weight. It has been noted that adults tend to underestimate their own weight[35] or the weight of their child.[36]

Another limitation of both paper 1 and paper 3 was the used a cross-sectional study design, which limited the ability to infer causality. Results from both of these papers provide information about associations, but the direction of the association cannot be determined. Reverse causality is a common concern for neighborhood environment studies, such as paper 1. While I hypothesized that neighborhoods can influence obesity-related behaviors outcomes, it is also plausible that people self-select into living in certain neighborhoods in a systematic way that can affect their weight status. For example, individuals who want to have a healthy diet may choose to live in neighborhoods with nice parks and better grocery stores. Thus the lower prevalence of obesity is not due to neighborhood influence, but rather, reflect preferences for certain neighborhood characteristics.

Omitted variable bias is a potential limitation of all three studies. In paper 1, potential omitted variables include the cost and quality of food available in the

neighborhood, and how long stores have been open. Although paper 2 used fixed effects regression models, which automatically accounted for all time-invariant confounders, I still needed to explicitly include time-varying variables that I believe to be potential confounders in my model. Potential time-varying confounders that I was unable to control for include maternal involvement and parental BMI or obesity status. Maternal involvement is a particularly important variable to consider because it can help us better understand the mechanism by which father involvement may yield health benefits. Controlling for maternal involvement can provide insight into the amount of total caregiving time that both parents devote and provide some insight into the potential mechanism through which paternal involvement influences obesity outcomes. For example, it is possible that fathers may increase their caregiving involvement in response to mothers decreasing their caregiving involvement. In this case, children potentially receive the same amount of caregiving between age 2 and 4, and this would suggest that paternal involvement confers different benefits to children from maternal involvement. However, it is also possible that maternal participation may stay the same or increase over the same period. In this case, increases in paternal participation in caregiving would increase the total amount of time devote to caregiving from both parents, suggesting that benefits from increased paternal participation arise from an increase in the total amount of time devoted to caregiving across a range of caregiving tasks rather than from something unique to the father's involvement. A recent analysis that compared time use survey data from 1965 to 2011 found that mothers have also increased the amount of time they spend with children[37], which might point to the latter scenario. In paper 3, potential omitted variables include provider characteristics that have previously been found to influence provider communication quality, such as provider weight and race/ethnicity.[38-40]

A data limitation of paper 2 was that the ECLS-B did not have precise estimates of the frequency of caregiving involvement, and instead only provided approximate ordinal responses of involvement. In fixed effects logistic models, ordinal independent variables would be modeled as changing *to* that category, which precluded modeling the these variables as categorical dummies as is typically done in cross-sectional analyses. As a result, although the frequency of father involvement with meal preparation, taking children outside for walk or play, and looking after the child were ordinal variables, I modeled these as continuous variables in in my analyses. A similar approach was used to model changes in fathers' influence on decision-making, as the response categories for these variables were also categorical. As a result of this, the beta coefficients cannot be interpreted as precise estimates for changing from one category specific category to another (e.g., reduction in BMI among children whose fathers increased their involvement from a few times a month to a few times a week), but rather provide general estimates of the effect of increasing or decreasing father caregiving involvement and influence on decision-making.

Despite these limitations, this study still had numerous strengths. Paper 1 used the CHIS, which is ideally suited to answer the questions posed. First, paper 1 took advantage of the fact that the CHIS captured the racial/ethnic diversity of California and, importantly, oversampled California's major racial/ethnic groups. This provided sufficient sample size for subgroup analyses of these racial/ethnic groups. Another strength was that the CHIS oversampled NH Asians, which allowed us to analyze NH Asians as a separate racial/ethnic category. This typically is not possible with large national surveys, as NH Asians may not be included as a separate racial/ethnic category or, if they are, the sample size is too small for subgroup analyses. Third, one of the challenges of studying the neighborhood social environment compared to the other two neighborhood domains is the lack of data. While information about the neighborhood built environment

can be obtained rather easily – and is commonly done – through the use of commercial datasets such as InfoUSA or Business Analyst and sociodemographic information can be obtained easily through census data, social environment data requires specifically collecting this data through surveys. While many of the nationally representative surveys do not include neighborhood social environment measures, the CHIS does collect this information.

One of the main strengths of Paper 2 is that it used a dataset, the ECLS-B, that collected information about fathers, from the fathers themselves. Most of the existing parenting research use data collected from mothers to represent the collective influence of parents. Additionally, if information about fathers is collected, it may be mothers who are reporting this information. Another strength of this paper is the use of longitudinal data collected by the ECLS-B to conduct fixed-effects regression. Use of child fixed-effects compare children to themselves over time, such that each child serves as his or her own control. In doing so, fixed-effects models automatically controls for all potential time-invariant confounders (e.g., child sex, birth weight, parent educational attainment), which have to be explicitly modeled in cross-sectional analyses. Compared to cross-sectional models, fixed-effects models better estimate causality. A third strength of this study is that the results are generalizable across race/ethnicity and SES lines. In contrast to most of the existing studies on the father's influence on childhood obesity that were largely conducted in small samples of white, well-educated fathers – and thus, have limited generalizability – this analyses used a diverse, nationally-representative study sample.

One strength of Paper 3 is that it relied upon validated measures of provider communication quality from the Consumer Assessment of Healthcare Providers and Systems (CAHPS) surveys, which is commonly used to assess quality of care.[41] Another strength is that this analysis was based on a large nationally representative sample,

making the findings generalizable to all parents in the US of children between the age of 6 and 12 who had a visit with a healthcare provider in the 12 months prior to being surveyed. The large sample size also sufficiently powered the effect modification analyses. Finally, the dataset used in this analysis (MEPS) included information on a number of important potentially confounding variables.

Implications

Implications for Policy and Practice

Addressing the obesity epidemic and eradicating health disparities are both goals of Health People 2020.[42,43] Healthy People 2020 emphasizes that efforts to prevent and manage obesity must occur throughout the life course and examine contextual factors beyond the individual, such as those within the neighborhood and family. Additionally, overweight and obese individuals cite the healthcare system as a source of weight-related stigma,[44,45] which may lead to patients avoiding care and being less adherence, and may negatively impact the quality of care that they receive.[46] Findings from these three papers have important policy implications for addressing the correlates and consequences of obesity, and obesity disparities at the neighborhood, family, and healthcare system levels.

Neighborhood Environment

At the neighborhood level, efforts to increase neighborhood educational attainment is a potential avenue to reduce obesity prevalence among all race/ethnicity groups. Additionally, increasing both individual and neighborhood educational attainment should enhance overall human capital and yield longer-term economic and health benefits. Policies to increase neighborhood educational attainment could directly target the school system such as initiatives to improve and increase resources provided to

schools, particularly in resource-limited communities with large minority populations. Other initiatives might be more community oriented, such as through the creation of mentorship programs that encourage youth to complete high school and continue on to college. Community initiatives might also include creating more mixed-income communities. Although neighborhood household income was not associated with obesity outcomes in all race/ethnic groups in this study, mixed-income communities also likely have residents with a range of educational attainment, resulting in higher neighborhood education for low-SES individuals. The Moving to Opportunity study found that among low SES families who sought federal housing assistance, those who randomly received vouchers to move to higher income communities had a reduction in obesity.[47] Making higher education more attainable is also an important component of increasing neighborhood educational attainment. The financial burden of high education is a common barrier, especially for low SES individuals and minorities. Federal and state efforts to reduce the cost of higher education and by providing interest-free loans or scholarships can help to make higher education more attainable.

Recently, there has been significant interest in built environment interventions to curb the obesity epidemic and address disparities. For example, polices to improve the built food environment, such as Pennsylvania's Fresh Food Financing Initiative, have provided financial incentives for supermarkets to open in low-income neighborhoods [48]. Prior studies have found that NH African Americans tend to live in neighborhoods with fewer healthy food stores, such as supermarkets,[49] suggesting that these built food environment improvements may also address racial/ethnic disparities in obesity. However, numerous null associations in this study between the built environment and obesity among all minority subgroups – although not causal – would suggest that changes to the built environment alone may be insufficient for addressing obesity in vulnerable populations. Should changes to the built environment disproportionately

benefit NH Whites, they could unintentionally exacerbate existing race/ethnic disparities in obesity and obesity-related behaviors. Race/ethnic groups may face numerous barriers – both at the individual and the neighborhood levels – that may hinder them from benefitting built environment improvements to address obesity.[50] Neighborhoods may be deprived at numerous levels or individuals may have limited resources that preclude them from taking advantage of changes to their built environment. For example, NH African Americans may be more likely to live in neighborhoods that are less safe, have lower levels of social cohesion, and have fewer supermarkets but more fast food restaurants. Built environment initiatives that only target a single facet (e.g., incentives to open more supermarkets) may be insufficient, as these residents still fact barriers in other aspects of the neighborhood. Additionally, even in neighborhoods with ample supermarkets and gyms, residents may not have the time to grocery shop and cook, or workout, nor income to afford a gym membership. Reducing race/ethnic disparities in obesity, particularly in high-risk minority groups, may require a more tailored approach that addresses multiple neighborhood and individual level factors simultaneously, such as more comprehensive neighborhood improvement efforts and providing affordable and culturally appropriate resources.

Family Environment

Paternal participation in caregiving for young children across a spectrum of activities – including more general child caregiving activities that may not be directly related to child nutrition and physical activity can play an important role in helping to prevent childhood obesity. Importantly, increased paternal participation should be encouraged for all children regardless of their family's SES.

More efforts should be made to make it feasible and more convenient for fathers to participate in caregiving, especially during these developmentally important early years. Employment is a significant barrier to fathers' taking on more caregiving

responsibilities[51] with paternal participation in caregiving decreasing as fathers work more hours.[52] However, employers can make it easier for fathers to assume more child caregiving by allowing for more flexible work schedules. Among fathers who are salaried workers, employers can extend family-friendly work policies, such as allowing for flexible work schedules, telecommuting options, and child-friendly work environments, to *both* mothers and fathers, and for a longer duration beyond just the first few months or year of the child's life. Employers can also offer on-site day care, even in more "male-dominated" fields and companies (e.g., the financial sector). This not only provides parents with additional childcare options, but also allows fathers to drop off and pick up their children from childcare, and even check-in on the child during the day. Employers of fathers who are shift or hourly workers can allow fathers to take shifts or hours that accommodate caregiving (e.g., earlier or later hours) or split shifts, and flexibility in breaks and overtime.

Increasing paternal participation in caregiving also requires changing norms around the role of fathers. Although this study was unable to determine whether father participation added to the time mothers spent resulting in an overall increase in the time devoted to caregiving or if they substituted some of the time that mothers would normally spend on caregiving, general trends have found that both parents have increased the amount of time they devote to caregiving[37]. Since 1965, fathers have more than tripled the amount of time they spend with their children.[37] However, this is still less than mothers, in part due to entrenched cultural beliefs about mothers as the primary caregiver and traditional allocation of caregiving responsibilities. Outreach and educational efforts can potentially change these norms around the role of fathers to urge them to increase their involvement in child caregiving. These efforts might include national and local campaigns to encourage fathers to play a more active role in caregiving. President Obama has spoken openly about the importance of fatherhood,

particularly for Black men, which has helped to shape the conversation about the evolving role of fathers. Currently, the Obama administration has made responsible fatherhood one of the Office of Faith-Based and Neighborhood Partnerships' four key priorities, started a National Conversation on Responsible Fatherhood and Strong Communities, and created the President's Fatherhood and Mentoring Initiative to promote responsible fatherhood across the country[53]. While these campaigns have focused on getting fathers to be present in the lives of their children and have targeted minority men (especially Black men) or those who do not live with their children, as a next step, these campaigns could expand their message to include fathers of all race/ethnicities, including those who live with their children. These campaigns may also include messages about specific ways that fathers can be involved, and encourage men, particularly those in 2-parent households, to increase their involvement with child caregiving.

Other opportunities to engage and educated fathers in child caregiving and decision-making might occur during child healthcare provider encounters and by including fathers in family-focused interventions. Fathers have noted feeling neglecting during visits with their child's pediatricians as most of the conversations were directed towards the child's mother [54]. If both parents are present during child healthcare visits, providers should make the effort to address and engage both mothers and fathers. Healthcare providers should made aware of and be educated on the need to engage fathers and recognize them as active participants in their child's health and healthcare. To date, the majority of family-based interventions for childhood obesity have targeted and been tailored to mothers [55,56]. Greater efforts can be made to enroll fathers in family-based interventions. Interventions can also be geared specifically towards fathers. Father-specific interventions might include healthy lifestyle educational or behavior change programs or interventions specifically geared to increasing their caregiving

participation. A recent community randomized control trial evaluated the effectiveness of the "Healthy Dads, Healthy Kids" lifestyle program that specifically targeted overweight fathers to help them lose weight and model positive behaviors for their children. Results from this program found that fathers in the intervention arm not only lost more weight but their children also had lower BMI and increased physical activity levels.[57,58] Including fathers in such studies ensures that when fathers participate in caregiving, such as when they look after their children or prepare meals, they support healthy lifestyles for their children. This may have the additional benefit of increasing fathers' involvement. Some studies have found that programs aimed to increase paternal participation in general caregiving successfully did so[59] and yielded positive child educational outcomes[60], but to my knowledge, the effect of these programs on child weight status have not been evaluated.

Healthcare providers

High quality communication between parents and their child's provider is important for maintaining a strong relationship with parents, achieving high quality patient care, and improving parent satisfaction. While this should be a priority regardless of the child's obesity status, high quality communication may be even more important for parents of obese children who are more likely to have greater medical need due to adverse health conditions associated with their excess body weight[61] such as dyslipidemia and impaired glucose tolerance.[62] Providers should continue to maintain high quality communication with parents of obese children.

Additionally, I find that providers may potentially have biases towards obese parents of obese children compared to non-obese parents of obese children. Providers should be made cognizant of these potential biases towards obese parents, and work to communicate effectively with all parents of obese children, regardless of parent obesity status. In fact, obese parents of obese children may require even more attention and

stronger collaboration with parents to make the changes within the entire family that are necessary to manage the child's weight and obesity-related comorbidities.

Because Hispanic and NH Black children have an increased risk of obesity, providers can potentially help to address the disparity through strong partnership with parents of these children. High-quality, culturally competent communication is an important component of creating partnerships. I found that overall parent satisfaction with provider communication was quite high. Parents of NH Black obese children were actually more likely to report that providers always listened carefully compared to parents of non-obese NH White children, but providers should work to maintain high quality communication in all domains for parents of this high-risk subpopulation. Additionally, providers should also aim to achieve high quality communication with parents of obese Hispanic children. I did not find differences in communication quality by child obesity status in this subpopulation, but given that Hispanic children have the highest prevalence of obesity, these children might benefit from providers making additional effort to provide high quality communication to their parents. Providers should also ensure that they provide culturally competent communication to this subpopulation.

Research Implications

Neighborhood Level

This study adds to the limited research on the neighborhood social environment,[6] and is the first to examine associations between obesity and the neighborhood social environment by racial/ethnic subgroups. Findings from this study point not only to the fact that the neighborhood social environment was associated with obesity outcomes in all race/ethnic groups, but that these relationships differed by race/ethnicity, which underscores the need for more research in the social environment by racial/ethnic subgroup. Future studies might consider exploring whether other aspects of the social

environment, such as social capital and social connectivity, are associated with obesity, especially among high-risk racial/ethnic subpopulations.

While this study found that neighborhood safety was associated with obesity outcomes among NH Asians and NH African Americans, it relied upon relied upon a single self-reported measure of neighborhood safety. Neighborhood safety, though, is a multi-faceted concept that may include actual measures of crime, perceived crime, street lighting, vandalism (e.g., graffiti and broken windows), and litter[63]. Future research might take a more detailed examining of different aspects of neighborhood safety and whether there are racial/ethnic differences in how neighborhood safety is conceptualized. This can inform more targeted neighborhood safety improvement efforts that are tailored to the subpopulations at highest risk. Future studies might also consider whether acculturation status of racial/ethnic subpopulations that immigrated to the United States more recently (e.g., Hispanics and Asians) might modify the associations between obesity and various aspects of the social environment.

Additionally, future research can explore potential pathways between obesity outcomes and the neighborhood environment, and whether these pathways differ by race/ethnicity. This might include investigating how factors within the neighborhood social environment might influence obesity. Social network analyses might be a valuable way to examine the types of social connections that individuals have with their community and how individuals utilize their social connections within their neighborhood in ways that utilize their health. This might also include further examining the pathways that neighborhood education confers health benefit. The finding that more features of the built environment were associated with obesity outcomes among NH Whites compared to other race/ethnicity groups warrant further investigation into how different neighborhood built environment factors influence obesity outcomes for different race/ethnic subgroups.

Given the lack of studies that have considered the association between obesity outcomes and living in neighborhoods with a high concentration of individuals of a *different* race/ethnicity and divergent results in this study from a previous study for NH Whites living in high concentration Asian neighborhoods[28], future studies can further examine this relationships, including potential geographic and regional differences, such as in areas with different levels of urbanicity and levels of acculturation of the neighborhood minority residents (e.g., NH White individual living in an Asian ethnic enclave vs. living in a community with a large proportion of highly acculturate and assimilated NH Asians) . Additionally, my finding that the relationship between obesity outcomes and neighborhood concentration of NH Asians was beneficial for NH Asians but detrimental for NH Whites warrants additional research on how the underlying pathways between the neighborhood concentration of NH Asians and health outcomes varies for NH Asians and non-Asians, particularly NH Whites.

Given the lack of consistent findings in the existing research and my finding of differences by race/ethnicity, it is possible that *other* individual-characteristics might be masking important subgroup variation in the relationship between obesity outcomes and the neighborhood environment. Future studies can consider other potential subgroup analyses, such as differences in immigration status, further considering racial/ethnic subgroups (e.g., within Hispanics, differences among Mexicans, Puerto Ricans, etc).

Family Environment

The generalizability of findings from this study were limited to young children between the ages of 2 and 4, who lived in two parent households where the father lived with them but was not the primary caregiver. Future studies can examine the role of father involvement on childhood obesity among older children, such as elementary school children, and other family structures (e.g., single-parent households, father

primary caregiver, or same-sex parent households). Involvement from fathers may in fact be more important for children living in single-parent households, as these children have a significantly higher risk of obesity[64], and the primary care giver (most likely the mother) may have additional parental stress. Given the recent increase in the number of households where fathers are the primary caregivers, research can also consider how parental involvement varies based upon the gender of the primary caregiver and whether this has implications for the child's obesity-related behaviors and outcomes.

Although I found evidence that increases in father caregiving participation was associated with decreased childhood obesity, I do not know the mechanism through which father caregiving confers benefits. For example, increases in father caregiving participation may yield child weight benefits because it increases the overall time that *both* parents devote to caregiving. Alternatively, it may be that fathers increase their caregiving in response to mothers decreasing their involvement, and the reduction in obesity observed in this study was due to the fact that father child caregiving confers unique benefits to the child's weight status. Future studies could examine potential mechanisms for the observed relationship between increases in father involvement in child caregiving and decreases in early childhood obesity. This might include analyzing time-use data for mothers and fathers to compare changes in the amount of time devoted to caregiving by both parents, and to understand the types of activities that each parent partakes in. Time-use data can also address the data limitations from this study by providing more precise information about father participation. Additionally qualitative studies with both mothers and fathers – particularly with fathers – could help researchers better understand differences in the quality and type of care provided by each parent, even when both perform the same types of tasks (e.g., differences in the types of meals that mothers and fathers prepare for the child).

The lack of consistent findings between early childhood obesity outcomes and father's involvement with decision-making in this study emphasizes the need to understand the dynamics between mothers and fathers in child-related decision-making processes and the specific ways that that fathers engage in these decisions. For example, it is possible that fathers can sometimes have a positive influence, while other times they may have a negative influence. Future research can also examine potential father characteristics, such as race/ethnicity, weight status, or resident status, and mother-father dynamics that might modify the relationship between childhood obesity and fathers' decision-making influence. In some families, mothers may act as the gate keeper for all child-related decisions, while in other families, mothers and fathers may try to share decision-making responsibilities more equally, such that both parents are involved with all decisions[65,66]. Understanding these complex dynamics between how parents share responsibilities can better elucidate the role of fathers' decision-making on their child's health.

Healthcare providers

While this research focused on parent-reported experience, future research might consider exploring provider perspectives and behaviors. For example, research could solicit provider opinions of parents and children based upon the child's weight status. Self-reported measures may be subject to recall bias and social desirability bias – the latter may be particularly true for provider responses – so future research can also analyze audio record interactions during pediatric visits. This would allow researchers to objectively assess provider-patient interactions, and examine the types of communication (e.g., biomedical, psychosocial/lifestyle, and rapport building) that providers use with parents of obese vs. non-obese children, as was previously done in a sample of adult patients[67].

While this study considered children between the age of 6 to 12, future studies can examine whether parent-provider communication quality varies by child weight status for parents of children in different age groups. Providers might view parents to be even more responsible for the child's weight among younger children. In older children and adolescents, additional research might consider direct interactions between provider and children, because providers are more likely to communicate directly with older children, and view these children as being more responsible for their weight status.

Finally, this study provided evidence that child and parent characteristics, including parent obesity status and child race/ethnicity modified the association between parent-reported provider communication quality and child obesity status. Future research should examine why communication quality differs by parental obesity status among parents of obese children, and the complex relationships between child race/ethnicity, weight, and parent-provider communication. Future research can also consider whether other child and parent characteristics, such as generational status and English proficiency, are potential modifiers of these relationships. Due to data limitations, I was unable to include provider characteristics, but studies in adult populations have found that provider characteristics, such as race and gender, can influence interactions with patients [38-40]. Additional studies might consider including provider characteristics, both controlling for them as potential confounders or as potential modifiers.

Conclusion

Curbing the obesity epidemic is one of the biggest public health challenges that the United States currently faces. Obesity has serious health and societal consequences. A substantial proportion of Americans – both children and adults – are obese. Additionally, there are significant racial/ethnic minorities and socioeconomic disparities in obesity. Healthy People 2020 has made it a national priority not only to

address obesity, but also to work towards eliminating health disparities. Researchers, policy makers, and practitioners, are increasingly considering factors beyond the individual to reverse this epidemic.

These studies used the social-ecological model to explore the relationship between factors from 3 levels of the social-ecological model (neighborhood environment, family environment, and healthcare system) and obesity and obesity disparities. The first two studies assessed potential causes of obesity within the neighborhood and family environments, while the third study assess how obesity status might influence patient experiences with the healthcare system. The studies found evidence of associations between factors from each of these levels and obesity. Higher neighborhood educational attainment and more positive neighborhood social environments (safety and social cohesion) were associated with more positive obesity outcomes in race/ethnicity groups. However, the lack of associations in the built environment for minority individuals suggests that enhancement of neighborhood's built environment might benefit some, but not all race/ethnicity subgroups. In contrast, for the family environment, increased father involvement in caregiving tasks was associated with decreased in obesity in all children, regardless of their SES. This suggests that children across the entire SES may benefit from policies and efforts to increase paternal involvement in caregiving. Finally, at the healthcare level, these studies found that parents of obese children actually reported better communication with their child's healthcare provider compared to parents of non-obese children. However, this seems to be limited to parents who are themselves not obese. Providers should be made aware of potential biases towards obese parents of obese children. Additionally, contrary to research among research among adults, this research on pediatric encounters found that parents of obese minority children, specifically NH Black and NH Asian children, do not experience worse communication and in fact, actually reported better quality in some communication domains.

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SUPPLEMENTAL APPENDICES

Paper 1: Full covariate tables

Full covariates from sociodemographic environment model for NH Whites

	Fruit and Vegetable Consumption		Soda consumption		BMI		Obesity	
	IRR	95% CI	OR	95% CI	Estimate	95% CI	OR	95% CI
Neighborhood Characteristics								
Median Household Income	**1.01**	**(1.00, 1.01)**	0.99	(0.97, 1.07)	0.00	(-0.03, 0.03)	1.00	(0.98, 1.02)
% HS degree or less	**0.97**	**(0.96, 0.99)**	1.13	(1.07, 1.18)	**0.55**	**(0.45, 0.65)**	**1.27**	**(1.21, 1.33)**
% Hispanic	1.00	(0.99, 1.01)	1.00	(0.97, 1.04)	-0.04	(-0.11, 0.03)	0.97	(0.94, 1.00)
% Black	1.00	(0.98, 1.02)	0.97	(0.90, 1.05)	0.12	(-0.03, 0.27)	1.06	(0.99, 1.13)
% Asian	**0.99**	**(0.98. 1.00)**	1.00	(0.97, 1.04)	**0.09**	**(0.02, 0.15)**	**1.03**	**(1.00, 1.07)**
Individual Characteristics								
Age	**1.00**	**(1.00, 1.00)**	**0.97**	**(0.96, 0.97)**	**0.02**	**(0.02, 0.03)**	**1.00**	**(1.00, 1.01)**
Sex								
Male	Ref	--	Ref	--	Ref	--	Ref	--
Female	**1.28**	**(1.25, 1.31)**	**0.41**	**(0.38, 0.44)**	**-1.05**	**(-1.20, -0.91)**	**0.82**	**(0.77, 0.89)**
Educational Attainment								
< HS degree	Ref	--	Ref	--	Ref	--	Ref	--
HS degree	**1.13**	**(1.07, 1.20)**	**0.76**	**(0.63, 0.92)**	**-0.56**	**(-1.00, -0.11)**	0.86	(0.72, 1.04)
College +	**1.35**	**(1.27, 1.43)**	**0.52**	**(0.43, 0.63)**	**-1.04**	**(-1.48, -0.60)**	**0.70**	**(0.58, 0.84)**
Smoking Status								
Not current smoker	Ref	--	Ref	--	Ref	--	Ref	--
Current smoker	**0.78**	**(0.75, 0.82)**	2.06	(1.84, 2.31)	**-0.70**	**(-0.94, 0.46)**	**0.83**	**(0.72, 0.94)**
Urban/rural								

	Fruit and Vegetable Consumption		Soda consumption		BMI		Obesity	
	IRR	95% CI	OR	95% CI	Estimate	95% CI	OR	95% CI
Rural	Ref	--	Ref	--	Ref	--	Ref	--
Urban	**1.03**	**(1.00, 1.06)**	1.06	(0.94, 1.18))	**-0.29**	**(-0.51, -0.08)**	**0.87**	**(0.78, 0.97)**
Time at current address	**1.00**	**(1.00, 1.00)**	1.00	(1.00, 1.00)	**-0.01**	**(-0.02, -0.01)**	**1.00**	**(0.99, 1.00)**
Nativity/Acculturation status								
US born, both parents born in US	Ref	--	Ref	--	Ref	--	Ref	--
US born, 1 parent born in US	1.04	(1.00, 1.08)	0.91	(0.78, 1.05)	**-0.38**	**(-0.65, -0.12)**	**0.84**	**(0.73, 0.97)**
US born, Neither parent born in US	0.98	(0.93, 1.04)	0.82	(0.66, 1.01)	**-0.69**	**(-1.02, -0.37)**	0.82	(0.67, 1.00)
Foreign born>= 15 years in US	1.02	(0.98, 1.06)	**0.75**	**(0.63, 0.89)**	**-0.44**	**(-0.73, -0.16)**	**0.81**	**(0.68, 0.95)**
Foreign born, < 15 years in US	0.98	(0.90, 1.06)	0.97	(0.70, 1.35)	**-1.22**	**(-1.82, -0.62)**	**0.50**	**(0.33, 0.78)**
English proficiency								
Speaks only English	Ref		Ref	--	Ref	--	Ref	--
Very well/well	**1.08**	**(1.03, 1.13)**	0.98	(0.84, 1.13)	-0.12	(-0.38, 0.14)	0.87	(0.75, 1.01)
Not well/not at all	1.24	(1.01, 1.52)	0.79	(0.34, 1.82)	0.58	(-0.70, 1.85)	1.25	(0.66, 2.35)
Year								
2011	Ref	--	Ref	--	Ref	--	Ref	--
2012	**0.98**	**(0.96, 1.00)**	1.02	(0.93, 1.12)	**-0.18**	**(-0.36, -0.00)**	0.94	(0.86, 1..03)
2013	--	--	**0.84**	**(0.77, 0.93)**	**-0.23**	**(-0.41, -0.05)**	0.91	(0.83, 1.00)
Intercept	**10.74**	**(9.66, 11.94)**	**3.87**	**(2.66, 5.62)**	**26.17**	**(25.44, 26.91)**	**0.18**	**(0.12, 0.25)**
Random effect	0.07	(0.07, 0.08)	1.11	(1.01, 1.22)	4.14	(3.67, 4.68)	0.90	(0.82, 0.99)

Full covariates from social environment models for NH Whites

	Fruit and Vegetable consumption		Soda		BMI		Obesity	
	IRR	95% CI	OR	95% CI	Estimate	95% CI	OR	95% CI
Neighborhood Characteristics								
Social Cohesion	**1.03**	**(1.02, 1.04)**	**0.95**	**(0.93, 0.98)**	**-0.17**	**(-0.22, -0.12)**	**0.93**	**(0.91, 0.96)**
Safety								
< Always Safe	Ref		Ref		Ref		Ref	
Always Safe	1.01	(0.99, 1.04)	0.95	(0.87, 1.03)	**-0.20**	**(-0.36, -0.04)**	**0.89**	**(0.82, 0.97)**
Median Household income	1.00	(1.00, 1.00)	1.00	(1.00, 1.00)	0.00	(0.00, 0.00)	1.00	(1.00, 1.00)
% HS or less	**0.97**	**(0.96, 0.98)**	**1.13**	**(1.09, 1.17)**	**0.46**	**(0.39, 0.53)**	**1.20**	**(1.16, 1.25)**
Age	**1.00**	**(1.00, 1.00)**	**0.96**	**(0.96, 0.97)**	**0.03**	**(0.03, 0.04)**	**1.01**	**(1.01, 1.01)**
Sex								
Male	Ref		Ref		Ref		Ref	
Female	**1.29**	**(1.26, 1.32)**	**0.39**	**(0.36, 0.43)**	**-1.08**	**(-1.23, -0.93)**	**0.82**	**(0.75, 0.88))**
Individual Characteristics								
Education								
< HS degree	Ref		Ref		Ref		Ref	
HS degree	**1.13**	**(1.06, 1.20)**	**0.77**	**(0.62, 0.95)**	-0.61	(-1.09, -0.13)	0.85	(0.69, 1.04)
College+	**1.33**	**(1.25, 1.42)**	**0.53**	**(0.42, 0.65)**	**-1.08**	**(-1.56, -0.60)**	**0.68**	**(0.55, 0.84)**
Smoking status								
Not current smoker	Ref		Ref		Ref		Ref	
Current smoker	**0.78**	**(0.75, 0.81)**	**2.10**	**(1.86, 2.38)**	**-0.73**	**(-0.98, -0.48)**	**0.81**	**(0.71, 0.93)**
Urban/rural								
Rural	Ref		Ref		Ref		Ref	
Urban	1.03	(1.00, 1.06)	**1.12**	**(1.01, 1.24)**	-0.29	(-0.49, -0.09)	**0.89**	**(0.80, 0.98)**
Time at current address	**1.00**	**(1.00, 1.00)**	1.00	((1.00, 1.01)	**-0.02**	**(-0.02, -0.01)**	**1.00**	**(0.99, 1.00)**
Nativity/acculturation								

US born, both parents born in US	Ref		Ref		Ref		Ref	
US born, 1 parent born in US	1.04	(1.00, 1.08)	1.01	(0.92, 1.12)	**-0.40**	**(-0.68, -0.11)**	**0.82**	**(0.71, 0.96)**
US born, neither parent born in US	0.99	(0.93, 1.05)	**0.85**	**(0.77, 0.94)**	**-0.61**	**(-0.96, -0.25)**	0.85	(0.68, 1.06)
Foreign forn>= 15 yrs in US	1.01	(0.97, 1.06)	0.91	(0.78, 1.07)	**-0.37**	**(-0.68, -0.06)**	**0.81**	**(0.68, 0.97)**
Foreign born, < 15 yrs in US	0.98	(0.90, 1.06)	0.82	(0.65, 1.04)	**-1.17**	**(-1.79, -0.55)**	**0.49**	**(0.31, 0.77)**
English Proficiency					| \			
Only speaks English	Ref		Ref		Ref		Ref	
Very well/well	**1.09**	**(1.04, 1.14)**	**0.80**	**(0.67, 0.97)**	**-0.12**	(-0.04, 0.15)	0.85	(0.73, 1.00)
Not well/not at all	1.24	(0.99, 1.54)	0.95	(0.67, 1.34)	0.69	(-0.66, 2.04)	1.29	(0.66, 2.52)
Year								
2011	Ref		Ref		Ref		Ref	
2012	0.98	(0.96, 1.00)	0.97	(0.83 ,1.14)	**-0.23**	**(-0.42, -0.05)**	0.91	(0.71, 0.96)
2013	1 (empty)\		0.82	(0.34, 2.01)	**-0.27**	**(-0.46, -0.09)**	**0.90**	**(0.81, 0.99)**
Intercept	**8.99**	**(7.98, 10.14)**	**4.88**	**(3.21, 7.43)**	**27.33**	**(26.51, 28.15)**	**0.29**	**(0.19, 0.43)**
Random Intercept	0.08	(0.00, 0.09)	1.30	(1.18, 1.42)	4.59	(4.07, 5.18)	1.06	(0.05, 1.16)

Full covariates from built environment models for NH Whites

	Fruit and Vegetable Consumption		Soda Consumption		BMI		Obesity	
	IRR	95% CI	OR	95% CI	Estimate	95% CI	OR	95% CI
Neighborhood characteristics								
Market	**1.01**	(1.00, 1.02)	1.00	(0.96, 1.03)	**-0.11**	**(-0.17, -0.05)**	**0.94**	**(0.92, 0.97)**
Conveience Stores	1.00	(0.98, 1.02)	0.97	(0.92, 1.04)	0.09	(-0.04, 0.23)	1.02	(0.96, 1.08)
Fast Food	**0.99**	**(0.99, 1.00)**	**1.02**	**(1.01, 1.04)**	0.03	(0.00, 0.06)	1.01	(1.00, 1.03)
Fitness Center	1.00	(0.99, 1.01)	**0.96**	**(0.93, 1.00)**	**-0.07**	**(-0.13, -0.00)**	0.98	(0.95, 1.01)
Medican HH income	**1.00**	**(1.00, 1.00)**	**1.00**	**(1.00, 1.00)**	0.00	(0.00, 0.00)	1.00	(1.00, 1.00)
% HS or less	**0.97**	**(0.96, 0.98)**	**1.12**	**(1.08, 1.16)**	**0.50**	**(0.44, 0.57)**	**1.23**	**(1.19, 1.27)**
Individual Characteristics								
age	**1.00**	**(1.00, 1.00)**	**0.97**	**(0.96, 0.97)**	**0.02**	**(0.02, 0.03)**	**1.00**	**(1.00, 1.01)**
Sex								
Male	Ref		Ref		Ref		Ref	
Female	**1.28**	**(1.25, 1.31)**	**0.41**	**(0.38, 0.44)**	**-1.05**	**(-1.20, -091)**	**0.82**	**(0.77, 0.89)**
Education								
< HS	Ref		Ref		Ref		Ref	
HS degree	**1.13**	**(1.07, 1.20)**	**0.76**	**(0.63, 0.92)**	**-0.55**	**(-1.00, -0.11)**	0.86	(0.72, 1.04)
College+	**1.35**	**(1.27, 1.43)**	**0.52**	**(0.43, 0.63)**	**-1.03**	**(-1.47, -0.59)**	**0.70**	**(0.58, 0.84)**
Smoking status								
Not current smoker	Ref		Ref		Ref		Ref	
current smoker	**0.78**	**(0.75, 0.82)**	**2.06**	**(1.84, 2.31)**	**-0.70**	**(-0.94, -0.46)**	**0.83**	**(0.73, 0.94)**
Urban/rural								
Rural	Ref		Ref		Ref		Ref	
Urban	**1.04**	**(1.01, 1.07)**	1.08	(0.98, 1.19)	**-0.31**	**(-0.51, -0.12)**	**0.88**	**(0.80, 0.97)**
Time at current address	**1.00**	**(1.00, 1.00)**	1.00	(1.00, 1.00)	**-0.01**	**(-0.02, -0.01)**	**1.00**	**(0.99, 1.00)**
Nativity/acculturation								

	Fruit and Vegetable Consumption		Soda Consumption		BMI		Obesity	
	IRR	95% CI	OR	95% CI	Estimate	95% CI	OR	95% CI
US born, both parents born in US	Ref		Ref		Ref		Ref	
US born, 1 parent born in US	1.04	(1.00, 1.08)	0.91	(0.78, 1.05)	**-0.38**	**(-0.64, -0.11)**	**0.84**	**(0.73, 0.97)**
US bornneither parent born in US	0.98	(0.93, 1.04)	0.82	(0.66, 1.02)	**-0.68**	**(-1.01, -0.35)**	0.83	(0.68, 1.01)
Foreign born, >= 15 yrs in US	1.02	(0.98, 1.06)	**0.75**	**(0.63, 0.90)**	**-1.19**	**(-1.79, -0.59)**	**0.81**	**(0.69, 0.96()**
Foreign born, < 15 yrs in US	0.98	(0.90, 1.06)	0.96	(0.69, 1.34)	**-0.43**	**(-0.71, -0.14)**	**0.51**	**(0.33, 0.79)**
English Proficiency								
Only speaks English	Ref		Ref		Ref		Ref	
Very well/well	**1.08**	**(1.03, 1.13)**	0.98	(0.84, 1.13)	-0.11	(-0.37, 0.15)	0.87	(0.75, 1.01)
Not well/not at all	**1.23**	**(1.01, 1.51)**	0.79	(0.34, 1.81)	0.58	(-0.70, 1.85)	1.24	(0.66, 2.35)
Year								
2011	Ref		Ref		Ref		Ref	
2012	**0.98**	**(0.96, 1.00)**	1.02	(0.93, 1.12)	-0.16	(-0.34, 0.02)	0.95	(0.87, 1.04)
2013			**0.84**	**(0.77, 0.93)**	-0.22	(-0.40, -0.05)	0.92	(0.83, 1.00)
Intercept	**10.65**	**(9.58, 11.83)**	**3.75**	**(2.58, 5.45)**	**26.53**	**(25.79, 27.27)**	**0.21**	**(0.14, 0.30)**
Random Intercept	0.07	(0.07, 0.08)	1.10	(1.00, 1.21)	4.13	(3.66, 4.66)	0.90	(0.82, 0.99)

Full covariates from sociodemographic environment model for Hispanics

	Fruit and Vegetable Consumption		Soda Consumption		BMI		Obesity	
	IRR	95% CI	OR	95% CI	Estimate	95% CI	OR	95% CI
Neighborhood Characteristics								
Median Household Income	1.01	(1.00, 1.02)	0.97	(0.94, 1.00)	**-0.09**	**(-0.19, -0.00)**	0.98	(0.94, 1.01)
% HS degree or less	1.00	(0.98, 1.02)	1.04	(0.97, 1.12)	**0.28**	**(0.10, 0.46)**	**1.08**	**(1.01, 1.16)**
% Hispanic	0.99	(0.97, 1.00)	1.03	(0.98, 1.08)	-0.02	(-0.13, 0.10)	1.02	(0.97, 1.07)
% Black	0.99	(0.96, 1.01)	1.06	(0.99, 1.14)	0.10	(-0.08, 0.27)	1.04	(0.98, 1.11)
% Asian	0.99	(0.97, 1.01)	1.00	(0.95, 1.05)	0.08	(-0.06, 0.22)	0.99	(0.94, 1.04)
Individual Covariates								
Age	**1.00**	**(1.00, 1.00)**	**0.96**	**(0.96, 0.97)**	**0.05**	**(0.04, 0.06)**	**1.02**	**(1.01, 1.02)**
Sex								
Male	Ref		Ref		Ref		Ref	
Female	**1.31**	**(1.26, 1.36)**	**0.46**	**(0.41, 0.52)**	0.05	(-0.22, 0.33)	1.01	(0.91, 1.13)
Educational Attainment								
< HS degree	Ref		Ref		Ref		Ref	
HS degree	1.05	(1.00, 1.11)	0.89	(0.76, 1.04)	**-0.71**	**(-1.09, -0.33)**	**0.83**	**(0.71, 0.97)**
College +	**1.20**	**(1.12, 1.27)**	**0.67**	**(0.56, 0.81)**	**-1.04**	**(-1.47, -0.62)**	**0.68**	**(0.57, 0.81)**
Smoking status								
Not current smoker	Ref		Ref		Ref		Ref	
Current smoker	**0.83**	**(0.78, 0.89)**	**2.00**	**(1.65, 2.41)**	0.33	(-0.7, 0.82)	1.11	(0.92,1.33)
Urban rural								
Rural	Ref		Ref		Ref		Ref	
Urban	1.05	(0.99, 1.11)	1.17	(0.98, 1.40)	0.03	(-0.41, 0.46)	1.06	(0.89, 1.27)
Time at current address	1.00	(1.00, 1.00)	1.00	(0.99, 1.00)	**-0.03**	**(-0.04, -0.01)**	**0.99**	**(0.98, 1.00)**

	Fruit and Vegetable Consumption		Soda Consumption		BMI		Obesity	
	IRR	95% CI	OR	95% CI	Estimate	95% CI	OR	95% CI
Nativity/Acculturation status								
US born, both parents born in US	Ref		Ref		Ref		Ref	
US born, 1 parent born in US	1.01	(0.93, 1.09)	1.00	(0.78, 1.28)	-0.33	(-0.89, 0.22)	0.93	(0.73, 1.17)
Foreign born, Neither parent born in US	1.01	(0.93, 1.09)	1.25	(1.00, 1.57)	**-1.27**	**(-1.77, -0.76)**	**0.71**	**(0.57, 0.89)**
Foreign born, >= 15 years in US	1.04	(0.96, 1.13)	**1.29**	**(1.04, 1.60)**	**-1.19**	**(-1.67, -0.71)**	**0.67**	**(0.54, 0.85)**
Foreign born, < 15 years in US	1.03	(0.93, 1.13)	1.61	(1.23, 2.10)	**-1.79**	**(-2.41, -1.16)**	**0.53**	**(0.40, 0.70)**
English proficiency								
Speaks only English	Ref		Ref		Ref		Ref	
very well/well	1.05	(0.99, 1.12)	0.98	(0.82, 1.18)	0.25	**(-0.17, 0.66)**	1.02	**(0.84, 1.24)**
not well/not at all	1.02	(0.94, 1.10)	1.16	(0.91, 1.47)	**1.11**	**(0.54, 1.69)**	1.18	**(0.93, 1.51)**
Year								
2011	Ref		Ref		Ref		Ref	
2012	**1.06**	**(1.02, 1.10)**	0.94	(0.82, 1.07)	0.04	(-0.29, 0.36)	1.05	(0.92, 1.20)
2013			**0.80**	**(0.69, 0.92)**	-0.10	(-0.43, 0.24)	0.96	(0.83, 1.11)
Intercept	**7.89**	**(6.58 ,9.46)**	**5.79**	**(3.35, 10.02)**	**26.96**	**(25.57, 28.35)**	**0.21**	**(0.12, 0.36)**
random effect	0.13	(0.11, 0.14)	1.32	(1.14, 1.53)	8.01	(6.28, 10.21)	1.18	(1.02, 1.37)

Full covariates for social environment models for Hispanics

	Fruit and Vegetable		Soda Consumption		BMI		Obesity	
	IRR	95% CI	OR	95% CI	Estimate	95% CI	OR	95% CI
Neighborhood Characteristics								
Social Cohesion	**1.03**	**(1.02, 1.05)**	0.99	(0.95, 1.03)	**-0.10**	**(-0.20, -0.00)**	0.97	(0.94, 1.01)
Neighborhood Safety								
< always safe	Ref		Ref		Ref		Ref	
Always safe	1.01	(0.97, 1.06)	0.96	(0.85, 1.09)	0.23	(-0.09, 0.55)	1.10	(0.97, 1.25)
Median Household income	1.00	(1.00, 1.00)	**1.00**	**(0.99, 1.00)**	-0.01	(-0.02, -0.00)	1.00	(0.99, 1.00)
% HS degree or less	0.99	(0.98, 1.01)	**1.07**	**(1.02,1.12)**	**0.25**	**(0.14,0.36)**	**1.11**	**(1.06, 1.16)**
Individual Characteristics								
age	**1.00**	**(1.00,1.00)**	**0.96**	**(0.96, 0.97)**	**0.06**	**(0.05, 0.07)**	**1.02**	**(1.02, 1.02)**
Sex								
Male	Ref		Ref		Ref		Ref	
Female	**1.32**	**(1.27, 1.37)**	**0.46**	**(0.41, 0.52)**	0.04	(-0.24, 0.32)	1.02	(0.91, 1.14)
Education								
< HS degree	Ref		Ref		Ref		Ref	
HS degree	1.05	(1.00,1.16)	0.86	(0.73, 1.02)	**-0.70**	**(-1.09, -0.31)**	**0.83**	**(0.71, 0.97)**
College+	**1.18**	**(1.11, 1.26)**	**0.64**	**(0.53, 0.77)**	**-1.07**	**(-1.51, -0.62)**	**0.66**	**(0.55, 0.80)**
Smoking Status								
Not a current smoker	Ref		Ref		Ref		Ref	
Current smoker	**0.83**	**(0.78, 0.89)**	**2.02**	**(1.66, 2.45)**	0.28	(-0.23, 0.78)	1.11	(0.92, 1.34)
Urban/rural								
Rural	Ref		Ref		Ref		Ref	
Urban	**1.05**	**(1.00, 1.11)**	1.11	(0.94, 1.31)	-0.11	(-0.48, 0.27)	1.02	(0.86, 1.20)
Time at current address	1.00	(1.00,1.00)	1.00	(0.99, 1.00)	**-0.03**	**(-0.05, -0.01)**	**0.99**	**(0.98, 1.00)**
Nativity/acculturation								

US born, both parents born in the US	Ref		Ref		Ref		Ref	
US born, 1 parent born in US	1.01	(0.93,1.10)	0.99	(0.76, 1.28)	-0.30	(-0.87, 0.27)	0.94	(0.74, 1.20)
US born,neither parent born in US	1.02	(0.94,1.11)	1.24	(0.98, 1.57)	**-1.13**	**(-1.65, -0.61)**	**0.75**	**(0.59, 0.94)**
Foreign born, >= 15 yrs in US	1.05	(0.96, 1.14)	**1.26**	**(1.01, 1.59)**	**-1.26**	**(-1.76, -0.76)**	**0.66**	**(0.52, 0.84))**
Foreign born, < 15 yrs in US	1.03	(0.93, 1.15)	**1.56**	**(1.18,2.06)**	**-1.74**	**(-2.38, -1.10)**	**0.54**	**(0.40, 0.71)**
English proficiency								
Speaks only English	Ref		Ref		Ref		Ref	
very well/well	1.05	(0.99, 1.12)	1.00	(0.83, 1.21)	0.21	(-0.22, 0.64)	1.00	**(0.82, 1.22)**
not well/not at all	1.02	(0.93, 1.11)	1.17	(0.91,1.51)	**0.95**	**(0.36, 1.55)**	1.11	**(0.86, 1.44)**
Year								
2011	Ref		Ref		Ref		Ref	
2012	**1.06**	**(1.02, 1.10)**	0.94	(0.82,1.08)	0.09	(-0.24, 0.43)	1.07	(0.94, 1.23)
2013			**0.81**	**(0.69, 0.94)**	-0.10	(-0.44, 0.24)	0.96	(0.83, 1.11)
Intercept	6.24	(5.15, 7.56)	**7.49**	**(4.21, 13.31)**	**27.59**	**(26.26, 28.91)**	**0.23**	**(0.13, 0.40)**
Random Intercept	0.13	(0.11, 0.15)	1.40	(1.21,1.62)	8.07	(6.34, 10.28)	1.28	(1.10, 1.48)

Full covariates from built environment models for Hispanics

	Fruit and Veg consumption		Soda consumption		BMI		Obesity	
	IRR	95% CI	OR	95% CI	Estimate	95% CI	OR	95% CI
Neighborhood Characteristics								
Market	1.01	(1.00, 1.02)	0.99	(0.95, 1.02)	0.00	(-0.09, 0.08)	0.99	(0.95, 1.02)
Convenience Stores	1.00	(0.97, 1.03)	0.98	(9.91, 1.06)	0.08	(-0.12, 0.28)	1.03	(0.95, 1.11)
Fast Food Restaurants	1.00	(0.99, 1.00)	0.99	(0.97, 1.01)	0.05	(0.00, 0.11)	1.01	(0.99, 1.03)
Fitness Centers	1.00	(0.99, 1.02)	1.00	(0.95, 1.05)	**-0.16**	**(-0.27, -0.04)**	0.96	(0.91, 1.01)
Median HH income	1.00	(1.00, 1.00)	**1.00**	**(0.99, 1.00)**	**-0.01**	**(-0.02, -0.00)**	1.00	(0.99, 1.00)
% HS degree of less	0.99	(0.97, 1.00)	**1.07**	**(1.03, 1.12)**	**0.23**	**(0.11, 0.35)**	**1.10**	**(1.05, 1.15)**
Individual Characteristics								
age	**1.00**	**(1.00, 1.00)**	**0.96**	**(0.96, 0.97)**	**0.05**	**(0.04, 0.06)**	**1.02**	**(1.01, 1.02)**
Sex								
Male	Ref		Ref		Ref		Ref	
Female	**1.31**	**(1.26, 1.36)**	**0.46**	**(0.41, 0.52)**	0.06	(-0.22, 0.33)	1.01	(0.91, 1.4)
Education								
< HS	Ref		Ref		Ref		Ref	
HS degree	1.05	(1.00, 1.11)	0.89	(0.76, 1.04)	**-0.70**	**(-1.08, -0.32)**	**0.83**	**(0.71, 0.97)**
College+	**1.19**	**(1.12, 1.27)**	**0.67**	**(0.56, 0.81)**	**-1.04**	**(-1.47, -0.61)**	**0.68**	**(0.57, 0.81)**
Smoking Status								
Not current smoker	Ref		Ref		Ref		Ref	
Current smoker	**0.83**	**(0.78, 0.89)**	**2.00**	**(1.66, 2.41)**	0.32	(-0.17, 0.81)	1.11	(0.92, 1.33)
Urban/rural								
Rural	Ref		Ref		Ref		Ref	
Urban	**1.07**	**(1.02, 1.13)**	1.12	(0.95, 1.31)	-0.03	(-0.41, 0.35)	1.05	(0.89, 1.23)
Time at current address	1.00	(1.00, 1.00)	1.00	(0.99, 1.00)	**-0.03**	**(-0.04, -0.01)**	**0.99**	**(0.98, 1.00)**

	Fruit and Veg consumption		Soda consumption		BMI		Obesity	
	IRR	95% CI	OR	95% CI	Estimate	95% CI	OR	95% CI
Nativity/acculturation								
US born, both parents born in US	Ref		Ref		Ref		Ref	
US born, 1 parent born in US	1.01	(0.93, 1.09)	1.00	(0.78, 1.28)	-0.33	(-0.88, 0.22)	0.93	(0.73, 1.17)
US born, either parent born in US	1.00	(0.93 1.09)	**1.26**	**(1.01, 1.57)**	**-1.25**	**(-1.76, -0.75)**	**0.71**	**(0.57, 0.90)**
foreign born, >= 15 yrs in US	1.04	(0.96, 1.13)	**1.29**	**(1.04, 1.61)**	**-1.17**	**(-1.65, -0.69)**	**0.68**	**(0.54, 0.85)**
Foreign born, < 15 yrs in US	1.02	(0.93, 1.13)	**1.61**	**(1.23, 2.10)**	**-1.75**	**(-2.38, -1.12)**	**0.53**	**(0.41, 0.70)**
English Proficiency								
Speaks only English	Ref		Ref		Ref		Ref	
Very well/well	1.05	(0.99, 1.12)	0.99	(0.82, 1.18)	0.24	(-0.18, 0.65)	1.02	(0.85, 1.24)
Not well/not at all	1.01	(0.93, 1.10)	1.16	(0.92, 1.48)	**1.10**	**(0.53, 1.68)**	1.19	(0.93, 1.52)
Year								
2011	Ref		Ref		Ref		Ref	
2012	**1.06**	**(1.02, 1.10)**	0.94	(0.82, 1.07)	0.03	(-0.30, 0.37)	1.05	(0.92, 1.20)
2013			**0.80**	**(0.69, 0.92)**	-0.10	(-0.44, 0.24)	0.96	(0.84, 1.11)
Intercept	**7.61**	**(6.36, 9.09)**	**7.03**	**(4.11, 12.05)**	**27.32**	**(25.99, 28.65)**	**0.23**	**(0.14, 0.39)**
Random Intercept	0.13	(0.11, 0.14)	1.32	(1.14, 1.53)	7.96	(6.22, 10.18)	1.18	(1.02, 1.37)

Full covariates from sociodemographic environment model for NH African Americans

	Fruit and Vegetable Consumption		Soda Consumption		BMI		Obesity	
	IRR	95% CI	OR	95% CI	Estimate	95% CI	OR	95% CI
Neighborhood Characteristics								
Median Household Income	1.00	(0.98, 1.02)	1.03	(0.97, 1.09)	0.00	(-0.12, 0.13)	0.99	(0.93, 1.06)
% HS degree or less	0.99	(0.95, 1.04)	**1.15**	**(1.00, 1.31)**	0.30	(-0.01, 0.61)	1.12	(0.97,1.30)
% Hispanic	0.97	(0.94, 1.01)	0.98	(0.88, 1.08)	-0.05	(-0.27, 0.18)	0.97	(0.87, 1.08)
% Black	1.00	(0.98, 1.02)	1.04	(0.97, 1.11)	0.04	(-0.12, 0.21)	0.99	(0.92, 1.07)
% Asian	1.00	(0.97, 1.04)	1.06	(0.96, 1.17)	-0.13	(-0.34, 0.08)	0.94	(0.85, 1.05)
Individual Covariates								
Age	**1.01**	**(1.00, 1.01)**	**0.98**	**(0.97, 0.98)**	0.01	(-0.01, 0.02)	1.00	(1.00, 1.01)
Sex								
Male	Ref		Ref		Ref		Ref	
Female	**1.30**	**(1.20, 1.41)**	**0.68**	**(0.54, 0.86)**	0.50	(-0.00, 1.01)	**1.31**	**(1.04, 1.67)**
Educational Attainment								
< HS degree	Ref		Ref		Ref		Ref	
HS degree	**1.27**	**(1.06, 1.52)**	**0.61**	**(0.40, 0.94)**	-0.42	(-1.42, 0.59)	0.79	(0.52, 1.21)
College +	**1.45**	**(1.21, 1.75)**	**0.50**	**(0.32, 0.78)**	-0.80	(-1.80, 0.20)	0.73	(0.47, 1.12)
Smoking Status								
Not current smoker	Ref		Ref		Ref		Ref	
Current smoker	**0.78**	**(0.70, 0.86)**	**1.68**	**(1.24, 2.28)**	**-1.22**	**(-1.86, -0.59)**	0.74	(0.54, 1.01)
Urban/rural status								
Rural	Ref		Ref		Ref		Ref	
Urban	1.05	(0.89, 1.23)	1.02	(0.63, 1.66)	-0.55	(-1.64, 0.53)	0.76	(0.46, 1.26)
Time at current address	1.00	(0.99, 1.00)	0.99	(0.98, 1.00)	**-0.03**	**(-0.05, -0.01)**	0.99	(0.98, 1.00)
Nativity/Acculturation status								

	Fruit and Vegetable Consumption		Soda Consumption		BMI		Obesity	
	IRR	95% CI	OR	95% CI	Estimate	95% CI	OR	95% CI
Both parents born in US	Ref		Ref		Ref		Ref	
1 parent born in US	1.06	(0.79, 1.41)	0.66	(0.30, 1.46)	-1.04	(-2.75, 0.68)	0.64	(0.28, 1.44)
Neither parent born in US	0.81	(0.49, 1.33)	0.30	(0.09, 1.02)	-0.55	(-3.43,2.33)	1.51	(0.44, 5.25)
Foreign born, >= 15 years in US	0.90	(0.76, 1.08)	**0.80**	**(0.48, 1.32)**	**-1.14**	**(-2.11, -0.17)**	0.62	(0.37, 1.04)
Foreign born, < 15 years in US	1.07	(0.81, 1.42))	**1.18**	**(0.50, 2.78)**	**-2.99**	**(-4.66, -1.31)**	**0.33**	**(0.12, 0.87)**
English proficiency								
Speaks only English	Ref		Ref		Ref		Ref	
very well/well	**1.21**	**(1.02, 1.43)**	**0.58**	**(0.37, 0.93)**	-0.86	(--1.78, 0.07)	0.72	(0.45, 1.15)
not well/not at all	1.19	(0.42, 3.42)	12.03	**(0.44, 331.52)**	**-2.83**	**(-4.56, -1.10)**	1.00	--
Year								
2011	Ref		Ref		Ref		Ref	
2012	0.99	(0.91, 1.06)	0.91	(0.70, 1.20)	-0.18	(-0.78, 0.42)	0.96	(0.72, 1.27)
2013			0.83	(0.63, 1.08)	-0.02	(-0.62, 0.57)	1.04	(0.79, 1.37)
constant	**6.30**	**(4.24, 9.37)**	2.66	(0.88, 8.09)	**29.52**	**(27.07, 31.97)**	0.63	(0.20, 1.95)
random effect	0.15	(0.11, 0.20)	1.50	(1.07, 2.12)	8.94	(6.37, 12.54)	1.92	(1.43, 2.59)

Full covariates from social environment models among NH African Americans

	Fruit and Vegetable consumption		Soda consumption		BMI		Obesity	
	IRR	95% CI	OR	95% CI	Estimate	95% CI	OR	95% CI
Neighborhood Characteristics								
Social Cohesion	1.01	(0.99, 1.03)	1.04	(0.97, 1.11)	**-0.10**	**(-0.20, -0.00)**	0.97	(0.90, 1.04)
Safety								
< always safe	Ref		Ref		Ref		Ref	
Always safe	1.06	(0.98, 1.16)	0.79	(0.61, 1.01)	0.23	(-0.09, 0.55)	0.82	(0.64, 1.07)
Median household income	1.00	(1.00, 1.00)	1.00	(1.00, 1.01)	**-0.01**	**(-0.02, -0.00)**	1.00	(0.99, 1.01)
% HS or less	**0.96**	**(0.94, 0.99)**	**1.10**	**(1.01, 1.20)**	**0.25**	**(0.14, 0.36)**	**1.11**	**(1.01, 1.22)**
Individual Characteristics								
age	**1.01**	**(1.00, 1.01)**	**0.98**	**(0.97, 0.98)**	**0.06**	**(0.05, 0.07)**	1.01	(1.00, 1.01)
Sex								
Male	Ref		Ref		Ref		Ref	
Female	**1.31**	**(1.20, 1.42)**	**0.64**	**(0.50,0.82)**	0.04	(-0.24, 0.32)	1.25	(0.97, 1.60)
Education								
< HS degree	Ref		Ref		Ref		Ref	
HS degree	**1.33**	**(1.09, 1.63)**	**0.61**	**(0.399, 0.98)**	**-0.70**	**(-1.09, -0.31)**	0.78	(0.49, 1.22)
College+	**1.52**	**(1.24, 1.86)**	**0.48**	**(0.30, 0.78)**	**-1.07**	**(-1.51, -0.62)**	0.71	(0.44, 1.13)
Smoking Status								
not a current smoker	Ref		Ref		Ref		Ref	
current smoker	**0.77**	**(0.69, 0.86)**	**1.69**	**(1.23, 2.33)**	0.28	(-0.23, 0.78)	0.74	(0.53, 1.02)
Urban/rural								
rural	Ref		Ref		Ref		Ref	
urban	1.05	(0.90, 1.23)	1.00	(0.61, 1.64)	-0.11	(-0.48, 0.27)	0.86	(0.51, 1.45)
current_addy	1.00	(0.99, 1.00)	1.00	(0.99, 1.01)	**-0.03**	**(-0.05, -0.01)**	0.99	(0.98, 1.00)
Nativity								

	Fruit and Vegetable consumption		Soda consumption		BMI		Obesity	
	IRR	95% CI	OR	95% CI	Estimate	95% CI	OR	95% CI
US born, both parents born in US	Ref		Ref		Ref		Ref	
US born, 1 parent born in US	1.01	(0.74, 1.36)	0.57	(0.26, 1.25)	-0.30	(-0.87, 0.27)	0.64	(0.27, 1.55)
US born, neither parent born in US	0.83	(0.50, 1.35)	0.31	(0.09, 1.10)	**-1.13**	**(-1.65, -0.61)**	1.32	(0.35, 4.92)
Foreign born, >= 15 yrs in US	0.92	(0.77, 1.10)	0.76	(0.45, 1.28)	**-1.26**	**(-1.76, -0.76)**	**0.54**	**(0.31, 0.95))**
Foreign born, <15 yrs in US	1.14	(0.86, 1.51)	1.09	(0.45, 2.01)	**-1.74**	**(-2.38, -1.10)**	**0.34**	**(0.12, 0.93)**
English Proficiency								
Speaks only English	Ref		Ref		Ref		Ref	
very well/well	1.18	(0.98, 1.41)	**0.59**	**(0.36, 0.96)**	0.21	(-0.22, 0.64)	0.70	(0.42, 1.71)
not well/not at all	**0.58**	**(0.43, 0.79)**	1.00		0.95	(0.36, 1.55)	1.00	
Year								
2011	Ref		Ref		Ref		Ref	
2012	1.00	(0.92, 1.08)	0.87	(0.65, 1.16)	0.09	(-0.24, 0.43)	0.98	(0.73, 1.31)
2013			0.80	(0.61, 1.07)	-0.10	(-0.44, 0.24)	1.01	(0.76, 1.36)
Intercept	**5.75**	**(3.79, 8.73)**	**3.55**	**(1.11, 11.27)**	**27.59**	**(26.26, 28.91)**	0.51	(0.16, 1.66)
Random intercept	0.17	-0.13	1.64	(1.16, 2.33)	0.99	(6.34, 10.28)	2.14	(1.58, 2.90)

Full covariates from built environment models for NH African Americans

	Fruit and Vegetable Consumption		Soda consumption		BMI		Obesity	
	IRR	95% CI	OR	95% CI	Estimate	95% CI	OR	95% CI
Neighbrhood Characteristics								
Market	1.01	(0.99, 1.04)	0.99	(0.93, 1.06)	0.03	(-0.14, 0.21)	1.03	(0.95, 1.10)
Convenience Store	1.05	(1.00, 1.10)	0.99	(0.85, 1.16)	0.14	(-0.24, 0.52)	1.06	(0.90, 1.24)
Fast Food	**0.99**	**(0.97, 1.00)**	1.00	(0.95, 1.04)	0.06	(-0.05, 0.17)	1.04	(0.99, 1.08)
Fitness Center	0.99	(0.96, 1.02)	0.97	(0.88, 1.07)	-0.13	(-0.37, 0.11)	0.91	(0.82, 1.01)
Median HH Income	1.00	(1.00, 1.00)	1.00	(1.00, 1.01)	0.00	(-0.01, 0.01)	1.00	(0.99, 1.01)
% HS or less	**0.96**	**(0.93, 0.98)**	**1.09**	**(1.00, 1.19)**	**0.24**	**(0.05, 0.44)**	1.08	(0.99, 1.18)
Individual Characteristics								
age	**1.01**	**(1.00, 1.01)**	**0.98**	**(0.87, 0.99)**	0.01	(-0.01, 0.02)	1.00	(1.00, 1.01)
Sex								
Male	Ref		Ref		Ref		Ref	
Female	**1.30**	**(1.20, 1.41)**	**0.69**	**(0.55, 0.87)**	0.50	(0.00, 1.01)	**1.31**	**(1.04, 1.65)**
Education								
< HS	Ref		Ref		Ref		Ref	
HS degree	**1.27**	**(1.06, 1.52)**	**0.62**	**(0.40, 0.94)**	-0.42	(-1.43, 0.59)	0.79	(0.52, 1.21)
College+	**1.46**	**(1.21, 1.76)**	**0.50**	**(0.32, 0.78)**	-0.81	(-1.81, 0.19)	0.72	(0.47, 1.12)
Smoking Status								
Not current smoker	Ref		Ref		Ref		Ref	
Current smoker	**0.77**	**(0.69, 0.86)**	**1.68**	**(1.24, 2.28)**	**-1.20**	**(-1.84, -0.56)**	0.75	(0.55, 1.03)
Urban/Rural								
Rural	Ref		Ref		Ref		Ref	
Urban	1.06	(0.92, 1.23)	0.96	(0.62, 1.50)	-0.44	(-1.47, 0.58)	0.84	(0.52, 1.34)
Time at current address	1.00	(0.99, 1.00)	0.99	(0.98, 1.00)	**-0.03**	**(-0.05, -0.01)**	0.99	(0.98, 1.00)
Nativity/acculturation								

	Fruit and Vegetable Consumption		Soda consumption		BMI		Obesity	
	IRR	95% CI	OR	95% CI	Estimate	95% CI	OR	95% CI
US born, both parents born in US	Ref		Ref		Ref		Ref	
US born, 1 parent born in US	1.08	(0.81, 1.44)	0.66	(0.30, 1.48)	-1.02	(-2.74, 0.69)	0.65	(0.29, 1.46)
US born, neither parent born in US	0.81	(0.49, 1.33)	0.29	(0.09, 1.01)	-0.58	(-3.48 2.31)	1.48	(0.43, 5.09)
Foreign born, >= 15 yrs in US	0.91	(0.76, 1.08)	0.80	(0.48, 1.32)	**-1.16**	**(-2.13, -0.18)**	0.62	(0.37, 1.04)
Foreign born, < 15 yrs in US	1.06	(0.80, 1.40)	1.18	(0.50, 2.79)	**-3.03**	**(-4.69, -1.36)**	**0.33**	**(0.12, 0.87)**
English proficiency								
Speaks only English	Ref		Ref		Ref		Ref	
very well/well	**1.20**	**(1.02, 1.43)**	**0.58**	**(0.37, 0.92)**	-0.86	(-1.78, 0.05)	0.72	(0.45, 1.16)
not well/not at all	1.21	(0.44, 3.37)	13.26	(0.45 392.57)	**-3.19**	**(-4.85, -1.53)**		
Year								
2011	Ref		Ref		Ref		Ref	
2012	0.99	(0.92, 1.07)	0.92	(0.70, 1.20)	-0.17	(-0.77, 0.43)	0.96	(0.73, 1.27)
2013			0.83	(0.64, 1.09)	-0.04	(-0.64, 0.55)	1.04	(0.79, 1.36)
Intercept	**6.42**	**(4.36, 9.46)**	**3.96**	**(1.38, 11.37)**	**29.27**	**(26.98, 31.56)**	0.49	(0.17, 1.43)
Random Intercept	0.15	(0.11, 0.20)	1.51	(1.08, 2.12)	8.84	(6.29, 12.43)	1.88	(1.39, 2.53)

Full covariates from sociodemographic environment model for NH Asian

	Fruit and Vegetable Consumption		Soda Consumption		BMI		Obesity	
	IRR	95% CI	OR	95% CI	Estimate		OR	95% CI
Neighborhood Characteristics								
Median Household Income	1.00	(0.99, 1.01)	0.98	(0.94, 1.03)	0.04	(-0.03, 0.11)	1.01	
% HS degree or less	0.98	(0.96, 1.01)	1.03	(0.91, 1.16)	0.23	(0.04, 0.43)	1.14	(0.96, 1.36)
% Hispanic	1.00	(0.98, 1.02)	1.01	(0.92, 1.11)	0.03	(-0.10, 0.16)	1.01	(0.88, 1.15)
% Black	0.99	(0.95, 1.03)	1.05	(0.90, 1.23)	-0.01	(-0.21, 0.18)	0.97	(0.79,1.19)
% Asian	0.99	(0.98, 1.01)	0.94	(0.88, 1.00)	-0.08	(-0.17, 0.00)	**0.87**	**(0.79, 0.96)**
Individual Covariates								
Age	**1.00**	**(1.00, 1.01)**	**0.96**	**(0.95, 0.97)**	**0.02**	**(0.01, 0.03)**	1.01	(1.00, 1.02)
Sex								
Male	Ref		Ref		Ref		Ref	
Female	**1.23**	**(1.18 ,1.28)**	**0.31**	**(0.25, 0.39)**	**-1.32**	**(-1.65, -1.00)**	**0.69**	(0.51, 0.95)
Educational Attainment								
< HS degree	Ref		Ref		Ref		Ref	
HS degree	1.02	(0.94, 1.11)	**1.71**	**(1.10, 2.66)**	**-0.91**	**(-1.70, -0.12)**	**0.44**	(0.26, 0.74)
College +	**1.14**	**(1..05, 1.24)**	**1.67**	**(1.07, 2.60)**	-1.08	(-1.86, -0.31)	**0.34**	**(0.20, 0.60)**
Smoking Status								
Not current smoker	Ref		Ref		Ref		Ref	
Current smoker	0.80	(0.73, 0.89)	**1.69**	**(1.17, 2.44)**	0.03	(-0.48, 0.55)	0.88	(0.52, 1.48)
Urban/rural								
Rural	Ref		Ref		Ref		Ref	
Urban	1.02	(0.93, 1.13)	0.96	(0.59, 1.57)	-0.03	(-0.60, 0.55)	0.93	(0.49, 1.79)
Time at current address	1.00	(1.00, 1.00)	1.01	(0.99, 1.02)	0.00	(-0.02, 0.01)	0.99	(0.97, 1.01)

	Fruit and Vegetable Consumption		Soda Consumption		BMI		Obesity	
	IRR	95% CI	OR	95% CI	Estimate		OR	95% CI
Nativity/Acculturation status								
both parents born in US	Ref		Ref		Ref		Ref	
1 parent born in US	**1.19**	**(1.02, 1.38)**	1.32	(0.66, 2.62)	-0.31	(-1.28, 0.66)	**0.38**	(0.16, 0.89)
Neither parent born in US	1.12	(1.00, 1.26)	1.49	(0.85, 2.61)	**-1.10**	**(-1.81, -0.39)**	**0.42**	(0.23, 0.78)
Foreign born, >= 15 years in US	**1.15**	**(1.03, 1.29)**	1.23	(0.72, 2.11)	**-1.30**	**(-1.99, -0.61)**	**0.27**	(0.15, 0.50)
Foreign born, < 15 years in US	1.12	(0.99, 1.27)	1.30	(0.71, 2.38)	-1.16	(-1.96, -0.35)	**0.23**	(0.12, 0.47)
English proficiency								
Speaks only English	Ref		Ref		Ref		Ref	
very well/well	1.05	(0.98, 1.12)	0.75	(0.55, 1.01)	-0.47	(-0.83, -0.11)	0.67	(0.42, 1.06)
not well/not at all	0.97	(0.89, 1.05)	**0.53**	**(0.36, 0.80)**	-0.40	(-0.97, 0.18)	**0.49**	(0.27, 0.88)
Year								
2011	Ref		Ref		Ref		Ref	
2012	**0.94**	**(0.90, 0.99)**	0.82	(0.65, 1.05)	-0.13	(-0.52, 0.27)	0.79	(0.79, 1.14)
2013			**0.68**	(0.51, 0.90)	0.09	(-0.32, 0.51)	0.77	(0.53, 1.12)
Intercept	**9.31**	**(7.33, 11.83)**	2.59	(0.81, 8.27)	**25.94**	**(24.34, 27.55)**	0.27	(0.06, 1.22)
random effect	0.12	(0.10, 0.14)	2.71	(2.16, 3.38)	6.66	(3.98, 1.15)	3.85	(2.99, 4.97)

Full covariates from social environment model for NH Asian

	Fruit and Vegetable Consumption		Soda consumption		BMI		Obesity	
	IRR	95% CI	OR	95% CI	Estimate	95%CI	OR	95% CI
Neighborhood Characteristics								
Social Cohesion	1.01	(1.00, 1.03)	0.98	(0.90, 1.06)	0.08	(-0.02, 0.18)	1.01	(0.90, 1.14)
Safety								
< always safe	Ref		Ref		Ref		Ref	
Always safe	**1.09**	**(1.04, 1.15)**	1.00	(0.78, 1.28)	0.12	(-0.23, 0.46)	1.11	(0.78, 1.59)
Median HH income	1.00	(1.00, 1.00)	1.00	(0.99, 1.00)	0.00	(0.00, 0.01)	1.00	(0.99, 1.01)
% HS or less	0.99	(0.97, 1.01)	1.06	(0.97, 1.16)	**0.28**	**(0.13, 0.43)**	**1.19**	**(1.04, 1.36)**
Individual Characteristics								
age	**1.00**	**(1.00, 1.01)**	**0.96**	**(0.95, 0.97)**	**0.03**	**(0.01, 0.04)**	**1.01**	**(1.00, 1.03)**
Sex								
Male	Ref		Ref		Ref		Ref	
Female	**1.26**	**(1.21, 1.32)**	**0.29**	**(0.23, 0.27)**	**-1.38**	**(-1.71, -1.04)**	**0.65**	**(0.46, 0.92)**
Education								
< HS degree	Ref		Ref		Ref		Ref	
HS degree	1.02	(0.93, 1.13)	**2.01**	**(1.21, 3.33)**	-0.51	(-1.43, 0.40)	0.52	**(0.27, 1.01)**
College+	**1.15**	**(1..05, 1.27)**	**1.90**	**(1.14, 3.15)**	-0.73	(-1.63, 0.17)	**0.39**	**(0.20, 0.77)**
Smoke status								
Not current smoker	Ref		Ref		Ref		Ref	
Current smoker	**0.82**	**(0.74, 0.91)**	**1.52**	**(1.03, 2.25)**	0.07	(-0.44, 0.59)	0.87	(0.49, 1.55)
Urban/rural								
Rural	Ref		Ref		Ref		Ref	
Urban	1.03	(0.93, 1.13)	1.10	**(0.67, 1.81)**	0.18	(-0.39, 0.74)	1.34	(0.69, 2.61)
Time at current address	1.00	**(1.00, 1.00)**	1.01	**(0.99, 1.02)**	0.00	(-0.02,0.02)	0.99	(0.97, 1.01)
Nativity								

	Fruit and Vegetable Consumption		Soda consumption		BMI		Obesity	
	IRR	95% CI	OR	95% CI	Estimate	95%CI	OR	95% CI
US born, both parents born in US	Ref		Ref		Ref		Ref	
US, 1 parent born in US	1.16	(0.99, 1.35)	1.53	**(0.74, 3.16)**	-0.18	(-1.18, 0.83)	**0.37**	**(0.14, 0.97)**
US, neither parent born in US	1.08	(0.95, 1.22)	1.62	**(0.89, 2.95)**	**-0.90**	**(-1.63, -0.17)**	**0.44**	**(0.23, 0.86)**
Foreign born, >= 15 yrs in US	1.11	(0.99, 1.25)	1.39	**(0.78, 2.48)**	**-1.17**	**(-1.87, -0.46)**	**0.26**	**(0.13, 0.51)**
Foreign born, < 15 yrs in US	1.07	(0.94, 1.21)	1.42	**(0.74, 2.72)**	**-0.87**	**(-1.72, -0.03)**	**0.26**	**(0.12, 0.57)**
English proficiency								
Speaks only English	Ref		Ref		Ref		Ref	
very well/well	1.06	(0.98, 1.13)	**0.71**	**(0.52, 0.97)**	**-0.49**	**(-0.87, -0.11)**	0.61	**(0.37, 1.00)**
not well/not at all	0.99	(0.90, 1.08)	**0.52**	**(0.34, 0.80)**	-0.42	(-1.05, 0.22)	**0.35**	**(0.18, 0.70)**
Year								
2011	Ref		Ref		Ref		Ref	
2012	0.96	(0.91, 1.00)	0.82	(0.63, 1.07)	-0.19	(-0.61, 0.23)	0.75	(0.51, 1.12)
2013			**0.64**	**(0.48, 0.86)**	0.05	(-0.38, 0.48)	0.74	(0.49, 1.12)
Intercept	**8.09**	**(6.23, 10.50)**	1.86	(0.52, 6.68)	**24.41**	**(22.70, 26.12)**	**0.07**	**(0.01, 0.41)**
Random Intercept	0.13	(0.11, 0.15)	3.05	(2.42, 3.84)	7.84	(4.42, 13.89)	4.82	(3.67, 6.33)

Full covariates from built environment model for NH Asian

	Fruit and Vegetable Consumption		Soda consumption		BMI		Obese	
	IRR	95% CI	OR	95% CI	Estimate	95% CI	OR	95% CI
Neighborhood Characteristics								
Market	1.00	(0.99, 1.02)	1.05	(0.98, 1.13)	-0.03	(-0.12, 0.06)	0.93	(0.84, 1.02)
Convenience Store	0.97	(0.94, 1.01)	1.05	(0.89, 1.23)	0.12	(-0.12, 0.35)	0.92	(0.73, 1.16)
Fast Food	0.99	(0.98, 1.00)	0.97	(0.94, 1.01)	0.03	(-0.02, 0.08)	1.06	(1.00, 1.12)
Fitness Center	1.01	(0.99, 1.03)	0.97	(0.90, 1.06)	**-0.10**	**(-0.20, 0.00)**	0.93	(0.83, 1.05)
Median HH Income	1.00	(1.00, 1.00)	1.00	(0.99, 1.00)	0.00	(0.00, 0.01)	1.00	(0.99, 1.01)
% HS degree or less	**0.98**	**(0.96, 1.00)**	1.02	(0.94, 1.12)	0.25	(0.10, 0.40)	1.16	(1.03, 1.32)
Individual Characteristics								
Age	**1.00**	**(1.00, 1.01)**	**0.96**	**(0.95, 0.97)**	**0.02**	**(0.01, 0.03)**	**1.01**	**(1.00, 1.02)**
Sex								
Male	Ref		Ref		Ref		Ref	
Female	**1.23**	**(1.18, 1.29)**	**0.31**	**(0.25, 0.39)**	**-1.32**	**(-1.64, -1.00)**	**0.70**	**(0.51, 0.95)**
Education								
< HS degree								
HS degree	1.03	(0.95, 1.11)	**1.73**	**(1.12, 2.69)**	**-0.89**	**(-1.68, -0.10)**	**0.45**	**(0.26, 0.76)**
College+	**1.15**	**(1.06, 1.24)**	**1.69**	**(1.09, 2.63)**	**-1.07**	**(-1.84, -0.30)**	**0.35**	**(0.20, 0.61)**
Smoker status								
Not a current smoker	Ref		Ref		Ref		Ref	
Current smoker	**0.81**	**(0.73, 0.89)**	**1.70**	**(1.18, 2.46)**	0.05	(-0.47, 0.56)	0.88	(0.51, 1.50)
Urban/rural								
Rural	Ref		Ref		Ref		Ref	
Urban	1.04	(0.94, 1.14)	1.03	(0.63, 1.64)	0.15	(-0.38, 0.68)	1.27	(0.68, 2.37)
Time at current residence	1.00	(1.00, 1.00)	1.00	(0.99, 1.02)	0.00	(-0.02, 0.01)	0.99	(0.97, 1.01)
Nativity/acculturation								

	Fruit and Vegetable Consumption		Soda consumption		BMI		Obese	
	IRR	95% CI	OR	95% CI	Estimate	95% CI	OR	95% CI
US born, both parents born in US	Ref		Ref		Ref		Ref	
US born, 1 parent born in US	**1.19**	**(1.03, 1.39)**	1.31	(0.66, 2.61)	-0.29	(-1.26, 0.68)	**0.38**	**(0.16, 0.89)**
US born, neither parent born in US	1.12	(1.00, 1.26)	1.46	(0.83, 2.56)	**-1.11**	**(-1.82, -0.40)**	**0.41**	**(0.22, 0.76)**
Foreign born, >= 15 yrs in US	**1.15**	**(1.03, 1.29)**	1.20	(0.70, 2.06)	**-1.31**	**(-2.00, -0.62)**	**0.26**	**(0.14, 0.48)**
Foreign born, < 15 yrs in US	1.12	(0.99, 1.27)	1.27	(0.69, 2.33)	**-1.17**	**(-1.99, -0.36)**	**0.22**	**(0.11, 0.45)**
English proficiency								
Speaks only English	Ref		Ref		Ref		Ref	
very well/well	1.04	(0.97, 1.12)	**0.73**	**(0.54, 0.99)**	**-0.50**	**(-0.86, -0.14)**	**0.63**	**(0.40, 1.00)**
not well/not at all	0.96	(0.89, 1.05)	**0.51**	**(0.34, 0.76)**	-0.46	(-1.03, 0.11)	**0.44**	**(0.24, 0.79)**
Year								
2011	Ref		Ref		Ref		Ref	
2012	**0.94**	**(0.90, 0.99)**	0.82	(0.65, 1.05)	-0.12	(-0.51, 0.27)	0.80	(0.56, 1.15)
2013			**0.68**	**(0.51, 0.90)**	0.11	(-0.31, 0.53)	0.78	(0.53, 1.14)
Intercept	**9.26**	**(0.734, 11.68)**	2.41	(0.79, 7.38)	**25.66**	**(24.07, 27.25)**	**0.15**	**(0.04, 0.65)**
Random intercept	0.12	(0.10, 0.14)	2.75	(2.20, 3.44)	6.69	(4.02, 11.14)	4.11	**(3.21, 5.27)**

Paper 2. Associations stratified by baseline family poverty, father education, and baseline maternal employment

Association between obesity-related behaviors and father involvement in caregiving and decision-making, stratified by baseline family poverty

	TV watching					Soda					
	Below poverty		Above poverty		Interaction p-value	Below Poverty		Above poverty			Interaction p-value
	Estimated change	95% CI	Estimated Change	95% CI		OR	95% CI	OR	95% CI	p-value	
Meal preparation[1]	0.05	(-0.30, 0.40)	0.01	(-0.08, 0.09)	0.811	0.99	(0.70, 1.40)	1.04	(0.77, 1.40)	0.819	0.864
Takes child outside for walks/play[1]	0.04	(-0.32, 0.39)	-0.10	(-0.21, 0.01)	0.467	0.95	(0.65, 1.40)	1.12	(0.88, 1.42)	0.358	0.473
Physical caregiving tasks[1]	0.05	(-0.30, 0.39)	-0.01	(-0.12, 0.10)	0.767	0.81	(0.60, 1.10)	1.17	(0.95, 1.44)	0.137	0.071
Frequency of looking after child[1]	0.01	(-0.50, 0.53)	0.09	(-0.02, 0.20)	0.763	0.89	(0.56, 1.41)	0.86	(0.68, 1.09)	0.221	0.887
Influence on child nutrition[3]	-0.51	(-1.08, 0.06)	-0.02	(-0.26, 0.22)	0.13	0.75	(0.27, 2.03)	0.73	(0.47, 1.14)	0.169	0.969
Influence on child health[3]	-0.16	(-0.71, 0.40)	0.06	(-0.15, 0.27)	0.469	0.80	(0.31, 2.11)	0.75	(0.51, 1.10)	0.146	0.899
Influence on discipline[3]	0.02	(-0.85, 0.89)	0.10	(-0.18, 0.38)	0.864	0.85	(0.20, 3.67)	0.99	(0.52, 1.87)	0.98	0.849
Influence on childcare[3]	-0.37	(-1.04, 0.31)	0.07	(-0.10, 0.24)	0.224	1.12	(0.51, 2.50)	**0.66**	**(0.44, 0.99)**	**0.047**	0.252

Note:
Bolded text denotes statistically significant at p< 0.05
1 - Per one unit increase in the frequency in paternal involvement
2 - Per increase in one of the following tasks (help child get dressed, help child to bed, help child brush teeth, and bathe child) on at least a daily basis (daily or more than once a day)
3 - Per one unit increase in the level of decision-making influence
Calculated using survey weights
Models controlled for the following time-varying potential confounders from age 2 and age 4: child age (in months), paternal employment (# hours/week), maternal employment (# hours/week), and poverty status (<100% FPL)

Association between weight status and father involvement in caregiving and decision-making, stratified by baseline family poverty

	BMI z-score					Overweight					Obese				
	Below Poverty		Above poverty		Interaction p-value	Below Poverty		Above poverty		Interaction p-value	Below Poverty		Above poverty		Interaction p-value
	Est. change	95% CI	Est change	95% CI		OR	95% CI	OR	95% CI		OR	95% CI	OR	95% CI	
Meal preparation[1]	-0.03	(-0.14, 0.09)	-0.03	(-0.08, 0.03)	0.999	0.81	(0.46, 1.42)	0.97	(0.80, 1.19)	0.566	0.82	(0.37, 1.80)	**0.70**	**(0.70, 0.97)**	0.709
Takes child outside for walks/play[1]	0.10	(-0.07, 0.27)	**-0.07**	**(-0.13, -0.01)**	**0.048**	1.01	(0.54, 1.90)	0.82	(0.62, 1.07)	0.528	0.93	(0.46, 1.90)	**0.64**	**(0.43, 0.94)**	0.36
Physical caregiving tasks[1]	-0.02	(-0.16, 0.12)	-0.02	(-0.06, 0.02)	0.994	0.99	(0.60, 1.62)	0.97	(0.81, 1.17)	0.953	0.70	(0.36, 1.34)	**0.67**	**(0.48, 0.93)**	0.915
Frequency of looking after child[1]	0.04	(-0.14, 0.21)	-0.02	(-0.08, 0.04)	0.546	1.35	(0.84, 2.16)	0.88	(0.68, 1.15)	0.118	0.89	(0.44, 1.81)	**0.71**	**(0.52, 0.95)**	0.544
Influence on child nutrition[3]	-0.01	(-0.23, 0.21)	-0.06	(-0.15, 0.03)	0.627	0.76	(0.39, 1.47)	0.81	(0.54, 1.21)	0.874	0.73	(0.26, 2.05)	0.67	(0.25, 1.29)	0.87
Influence on child health[3]	0.09	(-0.17, 0.35)	0.02	(-0.05, 0.10)	0.638	0.73	(0.35, 1.54)	1.33	(0.89, 1.98)	0.152	0.84	(0.27, 2.63)	1.87	(0.92, 3.97)	0.209
Influence on discipline[3]	0.16	(-0.16, 0.48)	-0.02	(-0.13, 0.10)	0.296	1.10	(0.43, 2.80)	0.91	(0.55, 1.51)	0.697	0.40	(0.13, 1.21)	0.89	(0.34, 2.34)	0.281
Influence on childcare[3]	0.10	(-0.16, 0.35)	0.01	(-0.08, 0.10)	0.533	0.73	(0.27, 1.92)	1.02	(0.64, 1.63)	0.535	0.70	(0.14, 3.65)	0.53	(0.26, 1.10)	0.762

Note:
Bolded text denotes statistically significant at p< 0.05
"Est. change" abbreviation for estimated change
1 - Per one unit increase in the frequency in paternal involvement
2 - Per increase in one of the following tasks (help child get dressed, help child to bed, help child brush teeth, and bathe child) on at least a daily basis (daily or more than once a day)
3 - Per one unit increase in the level of decision-making influence
Calculated using survey weights
Models controlled for the following time-varying potential confounders from age 2 and age 4: child age (in months), paternal employment (# hours/week), maternal employment (# hours/week), and poverty status (<100% FPL)
Overweight or obese defined as > 2 SD based on WHO growth standards. Obese defined as >3 SD based on WHO growth standards

Association between obesity-related behaviors and father involvement in caregiving and decision-making, stratified by father education

	TV watching					Soda				
	HS degree or less		> HS degree		Interaction p-value	HS degree or less		> HS degree		Interaction p-value
	Estimated change	95% CI	Estimated change	95% CI		OR	95% CI	OR	95% CI	
Meal preparation[1]	0.00	(-0.18, 0.17)	0.04	(-0.07, 0.15)	0.689	0.87	(0.74, 1.04)	1.33	(0.81, 2.19)	0.12
Takes child outside for walks/play[1]	-0.07	(-0.24, 0.10)	-0.09	(-0.22, 0.05)	0.906	0.96	(0.74, 1.25)	1.31	(0.95, 1.79)	0.115
Physical caregiving tasks[2]	0.06	(-0.12, 0.24)	-0.05	(-0.17, 0.06)	0.281	0.93	(0.74, 1.16)	**1.39**	**(1.09, 1.76)**	**0.013**
Frequency of looking after child[1]	-0.01	(-0.21, 0.20)	**0.15**	**(0.01, 0.30)**	0.227	0.90	(0.72, 1.13)	0.84	(0.57, 1.23)	0.682
Influence on child nutrition[3]	-0.24	(-0.61, 0.12)	0.04	(-0.16, 0.24)	0.173	0.92	(0.54, 1.57)	**0.53**	**(0.29, 0.96)**	0.201
Influence on child health[3]	-0.07	(-0.41, 0.27)	0.13	(-0.06, 0.32)	0.313	0.88	(0.57, 1.37)	0.57	(0.29, 1.12)	0.312
Influence on discipline[3]	-0.04	(-0.54, 0.45)	0.23	(0.00, 0.47)	0.328	1.12	(0.54, 2.32)	0.71	(0.28, 1.82)	0.438
Influence on childcare[3]	-0.14	(-0.43, 0.15)	0.14	(-0.07, 0.35)	0.142	0.92	(0.60, 1.42)	0.51	(0.26, 1.03)	0.185

Note:
Bolded text denotes statistically significant at p< 0.05
1 - Per one unit increase in the frequency in paternal involvement
2 - Per increase in one of the following tasks (help child get dressed, help child to bed, help child brush teeth, and bathe child) on at least a daily basis (daily or more than once a day)
3 - Per one unit increase in the level of decision-making influence
Calculated using survey weights
Models controlled for the following time-varying potential confounders from age 2 and age 4: child age (in months), paternal employment (# hours/week), maternal employment (# hours/week), and poverty status (<100% FPL)

Association between weight status and father involvement in caregiving and decision-making, stratified by father education level

	BMI z-score					Overweight					Obese				
	HS degree or less		> HS degree		Interaction p-value	HS degree or less		> HS degree		Interaction p-value	HS degree or less		> HS degree		Interaction p-value
	Est change	95% CI	Est change	95% CI		OR	95% CI	OR	95% CI		OR	95% CI	OR	95% CI	
Meal preparation[1]	-0.01	(-0.08, 0.06)	-0.04	(-0.11, 0.02)	0.41	1.03	(0.76, 1.40)	0.81	(0.65, 1.00)	0.204	0.76	(0.50, 1.15)	0.69	(0.44, 1.07)	0.749
Takes child outside for walks/play[1]	-0.04	(-0.14, 0.05)	-0.05	(-0.12, 0.02)	0.915	0.82	(0.57, 1.17)	0.91	(0.65, 1.27)	0.671	0.71	(0.47, 1.06)	0.69	(0.44, 1.09)	0.947
Physical caregiving tasks[2]	-0.05	(-0.12, 0.03)	0.00	(-0.04, 0.05)	0.222	0.89	(0.68, 1.17)	1.1	(0.9, 1.3)	0.27	**0.58**	**(0.41, 0.80)**	0.93	(0.64, 1.36)	**0.043**
Frequency of looking after child[1]	0.02	(-0.07, 0.10)	-0.04	(-0.11, 0.02)	0.317	1.22	(0.87, 1.73)	0.76	(0.55, 1.05)	**0.041**	0.79	(0.53, 1.19)	**0.62**	**(0.39, 1.00)**	0.451
Influence on child nutrition[3]	-0.08	(-0.20, 0.04)	-0.03	(-0.14, 0.08)	0.475	0.84	(0.54, 1.32)	0.75	(0.45, 1.25)	0.714	0.66	(0.30, 1.42)	0.78	(0.37, 1.67)	0.724
Influence on child health[3]	0.05	(-0.08, 0.18)	0.02	(-0.06, 0.11)	0.756	1.13	(0.67, 1.92)	1.17	(0.75, 1.84)	0.923	1.50	(0.65, 3.49)	1.63	(0.70, 3.83)	0.884
Influence on discipline[3]	0.01	(-0.17, 0.19)	0.02	(-0.12, 0.16)	0.906	1.25	(0.68, 2.32)	0.66	(0.33, 1.30)	0.149	0.50	(0.20, 1.27)	1.56	(0.46, 5.24)	0.141
influence on childcare[3]	0.07	(-0.07, 0.21)	-0.02	(-0.12, 0.08)	0.335	1.20	(0.75, 1.91)	0.76	(0.39, 1.47)	0.251	0.49	(0.17, 1.42)	0.71	(0.22, 2.30)	0.694

Note:
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"Est. change" abbreviation for estimated change
1 - Per one unit increase in the frequency in paternal involvement
2 - Per increase in one of the following tasks (help child get dressed, help child to bed, help child brush teeth, and bathe child) on at least a daily basis (daily or more than once a day)
3 - Per one unit increase in the level of decision-making influence
Calculated using survey weights
Models controlled for the following time-varying potential confounders from age 2 and age 4: child age (in months), paternal employment (# hours/week), maternal employment (# hours/week), and poverty status (<100% FPL)
Overweight or obese defined as > 2 SD based on WHO growth standards. Obese defined as >3 SD based on WHO growth standards

Association between obesity-related behaviors and father involvement in caregiving and decision-making, stratified by baseline maternal employment status

	TV watching					Soda				
	Mother unemployed		Mother employed		Interaction p-value	Mother unemployed		Mother employed		Interaction p-value
	Estimated change	95% CI	Estimated change	95% CI		OR	95% CI	OR	95% CI	
Meal preparation[1]	0.00	(-0.16, 0.16)	0.03	(-0.08, 0.14)	0.764	1.02	(0.83, 1.25)	1.03	(0.73, 1.46)	0.918
Takes child outside for walks/play[1]	-0.10	(-0.29, 0.09)	-0.06	(-0.18, 0.06)	0.764	0.97	(0.72, 1.32)	1.18	(0.91, 1.52)	0.334
Physical caregiving tasks[2]	-0.03	(-0.19, 0.13)	0.02	(-0.11, 0.15)	0.865	1.07	(0.86, 1.33)	1.13	(0.88, 1.44)	0.75
Frequency of looking after child[1]	0.06	(-0.14, 0.26)	0.10	(-0.02, 0.23)	0.75	0.94	(0.65, 1.34)	**0.76**	**(0.60, 0.97)**	0.391
Influence on child nutrition[3]	-0.13	(-0.45, 0.18)	-0.06	(-0.37, 0.26)	0.74	0.99	(0.56, 1.75)	**0.56**	**(0.33, 0.96)**	0.153
Influence on child health[3]	0.05	(-0.26, 0.36)	0.01	(-0.25, 0.26)	0.832	0.82	(0.46, 1.46)	0.71	(0.46, 1.10)	0.683
Influence on discipline[3]	0.19	(-0.22, 0.59)	-0.03	(-0.40, 0.34)	0.445	1.07	(0.53, 2.19)	0.84	(0.32, 2.18)	0.682
Influence on childcare[3]	0.02	(-0.21, 0.25)	-0.01	(-0.27, 0.26)	0.894	0.77	(0.50, 1.19)	0.70	(0.43, 1.16)	0.762

Note:
Bolded text denotes statistically significant at p< 0.05
1 - Per one unit increase in the frequency in paternal involvement
2 - Per increase in one of the following tasks (help child get dressed, help child to bed, help child brush teeth, and bathe child) on at least a daily basis (daily or more than once a day)
3 - Per one unit increase in the level of decision-making influence
Calculated using survey weights
Models controlled for the following time-varying potential confounders from age 2 and age 4: child age (in months), paternal employment (# hours/week), maternal employment (# hours/week), and poverty status (<100% FPL)

Association between weight status and father involvement in caregiving and decision-making, stratified by baseline maternal employment

	BMI z-score					Overweight or obese					Obese				
	Mother unemployed		Mother employed			Mother unemployed		Mother employed			Mother unemployed		Mother employed		
	Est. Change	95% CI	Est. change	95% CI	Interaction p-value	OR	95% CI	OR	95% CI	Interaction p-value	OR	95% CI	OR	95% CI	Interaction p-value
Meal preparation[1]	-0.04	(-0.11, 0.02)	-0.01	(-0.08, 0.07)	0.426	0.82	(0.62, 1.09)	1.04	(0.80, 1.34)	0.22	0.73	(0.46, 1.14)	0.74	(0.48, 1.14)	0.961
Takes child outside for walks/play[1]	-0.04	(-0.13, 0.04)	-0.05	(-0.12, 0.03)	0.946	0.93	(0.69, 1.26)	0.79	(0.56, 1.13)	0.461	0.70	(0.42, 1.15)	0.70	(0.47, 1.05)	0.974
Physical caregiving tasks[2]	-0.03	(-0.10, 0.03)	-0.01	(-0.06, 0.04)	0.534	1.01	(0.81, 1.27)	0.96	(0.76, 1.20)	0.704	0.80	(0.56, 1.14)	**0.59**	**(0.43, 0.82)**	0.172
Frequency of looking after child[1]	-0.03	(-0.12, 0.05)	0.01	(-0.06, 0.08)	0.395	1.09	(0.79, 1.48)	0.86	(0.60, 1.23)	0.32	0.73	(0.42, 1.25)	0.79	(0.51, 1.21)	0.835
Influence on child nutrition[3]	0.72	(-0.16, 0.08)	-0.07	(-0.20, 0.06)	0.754	0.63	(0.38, 1.04)	0.94	(0.59, 1.51)	0.219	0.92	(0.42, 2.03)	0.54	(0.20, 1.14)	0.265
Influence on child health[3]	0.02	(-0.09, 0.14)	0.04	(-0.06, 0.15)	0.801	0.84	(0.53, 1.32)	1.64	(0.88, 3.03)	0.078	1.43	(0.55, 3.77)	1.52	(0.64, 3.61)	0.924
Influence on discipline[3]	0.03	(-0.11, 0.16)	0.01	(-0.17, 0.18)	0.857	0.65	(0.39, 1.08)	1.41	(0.66, 3.03)	0.075	0.52	(0.18, 1.52)	0.95	(0.34, 2.66)	0.407
Influence on childcare[3]	0.01	(-0.09, 0.11)	0.03	(-0.10, 0.17)	0.751	0.84	(0.53, 1.35)	1.07	(0.57, 2.01)	0.54	0.77	(0.30, 2.01)	0.44	(0.17, 1.10)	0.381

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Overweight or obese defined as > 2 SD based on WHO growth standards. Obese defined as >3 SD based on WHO growth standards

CURRICULUM VITALE

Michelle Wong

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EDUCATION

Johns Hopkins Bloomberg School of Public Health, Baltimore, MD Expected Graduation: May 2017
Doctorate of Philosophy Candidate
Department of Health Policy and Management, Health and Public Policy track
Research interest: obesity prevention, social determinants of health, health disparities, healthcare provider biases
Dissertation: "A multi-level exploration of obesity and disparities: The neighborhood, family, and healthcare system"

Yale University, New Haven, CT 2004 – 2008
Bachelor of Science, Molecular Biochemistry & Biophysics

PROFESSIONAL EXPERIENCE

RESEARCH

Research Assistant for Dr. Craig Pollack May 2016 – present
Welch Center for Prevention Epidemiology, and Clinical Research, Johns Hopkins School of Medicine, Baltimore, MD

- Conduct data analysis and drafted manuscript for a study that assessed racial differences when comparing patient-reported and GIS-calculated travel times to prostate cancer specialist offices

Research Assistant for Dr. Sandra Newman April 2015 – August 2015
Department of Health Policy and Management, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD

- Conducted literature reviews on the effect of the "boom and bust" economic cycle of the 2000s on young adult living arrangement, educational attainment, and earnings

Research Assistant for Dr. Kimberly A. Gudzune June 2015 – present
Welch Center for Prevention Epidemiology, and Clinical Research, *Johns Hopkins School of Medicine*, Baltimore, MD

- Conduct geospatial analyses and draft the manuscript for a study that compared the validity of three commonly used geospatial data sources on the food retail environment
- Conduct geospatial analyses of the density of food retailers and physical activity resources available to residents living in public housing communities
- Assist with an internal evaluation of the Johns Hopkins Medical Institution's 2016 Community Health and Needs Assessment process
- Assist with the redesign of the survey instrument for the Johns Hopkins Medical Institution's Community Health and Needs Assessment

Research Assistant for the Global Obesity Prevention Center February 2014 – March 2017
Johns Hopkins Bloomberg School of Public Health, Baltimore, MD

- Develop a probability outcomes model and drafted manuscript for a study that assessed how product placement of beverages in Baltimore corner stores could "nudge" adolescent beverage purchasing behavior
- Develop an agent based model and drafting manuscript for a study that examined the relationship between neighborhood crime and leisure-time physical activity among African American women

POLICY AND PRACTICE

The Agency for Healthcare Research and Quality, Rockville, MD June 2013 – August 2013
Summer Service Fellow in the Center for Quality and Patient Safety

- Developed presentations on healthcare disparities among Asian and Pacific Islander Americans, and Hispanics

The Brookings Institution, Washington, DC July 2010 – July 2012
Research Assistant at the Engelberg Center for Health Care Reform

- Helped to convene stakeholder meetings for the U.S. Food and Drug Administration (FDA) to explore policy issues related to the development of FDA's Sentinel Initiative for post-market drug safety surveillance
- Developed pre-meeting briefing documents and meeting summaries

IMS Health Consulting, New York, NY July 2008 – July 2010 &
Analyst with the Pricing and Market Access Consulting Practice June 2014 – September 2014

- Developed pricing, market access strategies for pharmaceutical company clients, including a new pharmaceutical product for obesity
- Conducted in-depth interviews with health care payers and physicians in Australia, Canada, and the US
- Presented strategic recommendations to clients

PEER-REVIEWED PUBLICATIONS

Wong, MS, Peyton JM, Shields TM, Curriero FC, and Gudzune KA, Comparing the accuracy of food outlet databases in an urban environment. Geospatial Health *[In-press]*

Wong MS, Showell NN, Bleich SN, Gudzune KA and Chan KS The association between parent-reported provider communication quality and child obesity status: variation by parent obesity and child race/ethnicity. Patient education and counseling *[In-press]*

Wong MS, Nau C, Kharmats AY, Vedovato GM, Cheskin LJ, Gittelsohn J, & Lee BY (2015). Using a computational model to quantify the potential impact of changing the placement of healthy beverages in stores as an intervention to "Nudge" adolescent behavior choice. BMC public health, 15(1), 1.

Wong, MS, Gudzune KA, & Bleich SN (2015). Provider communication quality: Influence of patients' weight and race. Patient education and counseling, 98(4), 492-498.

PUBLICATIONS UNDER REVIEW

Wong MS, Grande D, Mitra N, Radhakrishnan A, Branas C, Ward K, Pollack C, Racial differences in the validity of GIS-calculated travel time

Wong MS, Jones-Smith J, Colantuoni E, Bleich SN, Thorpe R, and Chan KS. The longitudinal association between early childhood obesity and fathers' involvement in childcare and decision-making

Nau C, Kumanyika S, Gittelsohn J, Adam A, **Wong MS**, Mui Y, Lee BY, Identifying financially sustainable pricing interventions to promote healthier beverage purchases in small neighborhood stores

Lee BY, Adam A, Zenkov E, Hertenstein D, Ferguson M, **Wong MS**, Wedlock P, Nyathi S, Gittelsohn J, Fallah-Fini S, Bartsch SM, Cheskin LJ, Brown ST, Economic and health impact of increasing children's physical activity in the united states

MANUSCRIPTS IN PRODUCTION

Wong MS, Chan KS, Jones-Smith J, Colantuoni E, Thrope R, and Bleich SN. The neighborhood environment and obesity: understanding variation by race/ethnicity

PRESENTATIONS

Wong, M.S., Jones-Smith, J., Bleich, S. N., Colantouni E., Thorpe, R., and Chan, K.S., "The longitudinal association between fathers' childcare involvement and obesity in young children". Oral Presentation, The Obesity Society's Obesity Week, New Orleans, LA. November 2016.

Wong, M.S., Jones-Smith, J., Colantouni E., Bleich, S.N., "Obesity Prevalence and the Neighborhood: Variation by Race/Ethnicity." Poster Presentation, AcademyHealth Annual Research Meeting, Boston, MA. June 2016.

Wong, M.S., Arredondo, V., Covington, S., Fonseca-Becker. F., "Early Prevention of CVD risk among elementary school children in Clark County, NV through a school-based garden and healthy lifestyle promotion program." Poster Presentation, American Heart Association Scientific Sessions, Orlando, FL. November 2015.

Wong, M. S., Arredondo, V., Covington, S., and Fonseca-Becker, F., "Promoting healthy lifestyles for the prevention of childhood overweight and obesity among a Latino Population in Clark County, NV: Using an Innovative program to assess the effectiveness of a school based garden program." Poster Presentation, American Public Health Association Annual Meeting, Chicago, IL. November 2015.

HONORS AND AWARDS

Barbara Starfield Scholarship Recipient	2016 – 2017
AcademyHealth Annual Student Competition winner	2016
CareFirst's Hal Cohen Memorial Scholarship Recipient	2015 – 2016
Clinical Research and Epidemiology in Diabetes and Endocrinology pre-doctoral Training grant recipient (T32)	2014 – Present
Center for a Livable Future Doctor Fellowship Award	2013 – 2014
Agency for Healthcare Research and Quality (AHRQ's) National Research Service Award (NRSA) Pre-doctoral Training grant recipient	2012 - 2014

PUBLIC HEALTH EXTRACURRICULAR ACTIVITIES

Johnson & Johnson Community Healthcare Program, Baltimore, MD March 2013 – May 2016
Community Health Scholar

- Provided training and technical assistance to the American Heart Association of Las Vegas to build their in-house capacity to monitor and evaluate their School Garden program to encourage a healthy lifestyle and reduce childhood obesity

American Heart Association's Recess Baltimore, Baltimore, MD February 2013 – June 2013*Community Health Ambassador*

- Provided nutrition and physical activity education to children 5 – 11 years old as part of an after-school program

Real Food Farm, Baltimore, MD September 2012 – June 2013
Farm Volunteer

The Neighborhood Farm Initiative, Washington, DC August 2010 – July 2012
Fundraising Coordinator and Volunteer

OTHER LEADERSHIP & SERVICE ACTIVITIES

HPM Student Coordinating Council, Baltimore, MD — August 2013 – May 2014
Health Policy and Management Department, Johns Hopkins Bloomberg School of Public Health
Co-chair

The Vagina Monologues, Baltimore, MD — February 2013 & February 2014
Johns Hopkins Schools of Public Health, Medicine, and Nursing
Co-organizer and Cast Member

Yale Global Day of Service, Washington, DC — May 2012
Volunteer Site-Coordinator

IMS Consulting Community Service Committee, New York, NY — May 2010
Community Service Committee Chair

TEACHING EXPERIENCE

Johns Hopkins School of Public Health, Baltimore, MD
Teaching Assistant

- Health Policy I: Social and Economic Determinants of Health (Professor: Dr. Tom LaVeist)
- Public Health Policy (Professor: Dr. Gerry Anderson)
- Spatial Analysis and GIS I (Professors: Dr. Frank Curriero and Mr. Tim Shields)
- Health Services Research & Policy Student Seminar (Professors: Dr. Kitty Chan and Dr. Albert Wu)

Transcend Academy, Washington, DC — September 2010 – July 2012
Senior Educational Advisor for SAT and SAT II subject tests

- Tutored high school students in SAT and SAT II subject tests
- Provided guidance on college admission essays

Griffon Prep, Washington, DC — June 2013 – August 2013
GRE and LSAT tutor

PROFESSIONAL ORGANIZATIONS

The Obesity Society student member	2016 – Present
AcademyHealth student member	2013 – Present
American Public Health Association student member	2015 – 2016
American Heart Association student member	2015 – 2016

SKILLS

Computer skills: Stata, ArcGIS, Epi Info, Microsoft Office
Analytical skills: Multi-level modeling, Longitudinal data analysis, Causal inference, Spatial statistics
Languages: Cantonese