EXAMINING THE ASSOCIATION BETWEEN MATERNAL AND INFANT DIET AS A BASIS FOR EARLY LIFE OBESITY PREVENTION

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ABSTRACT

Melissa Cunningham Kay: Examining the association between maternal and infant diet as a basis for early life obesity prevention
(Under the direction of Margaret Bentley)

Obesity continues to be a problem in the U.S. Of particular concern is the epidemic of early childhood obesity. Currently, 8.1% of infants and toddlers are considered obese, with rates higher among non-Hispanic black (NHB) compared to non-Hispanic white (NHW) children. Child diet and food preferences are shaped during infancy and evidence indicates infants are consuming foods and beverages associated with obesity. A significant predictor of child diet is maternal diet, but little is known about this relationship during infancy. Observational studies have suggested that infant feeding strategies such as breastfeeding and role modeling can influence infant diet, but few interventions focus on these modifiable practices during infancy.

This study fills a gap in child obesity research by focusing on the development of diet during the first two years of life and uniquely targeting maternal dietary intake as a modifiable factor. Using two unique datasets, this study 1) examines maternal diet and explores predictors of intake; 2) determines the longitudinal association between maternal and infant diet and factors that moderate this relationship; and 3) examines barriers and facilitators to healthy eating during the first two years postpartum among mothers participating in a family-based obesity prevention trial.

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LIST OF ABBREVIATIONS

24HDR	24-hour dietary recall
AAP	American Academy of Pediatrics
BMI	Body Mass Index
CDC	Centers for Disease Control and Prevention
DGAs	*Dietary Guidelines for Americans*
FDA	Food and Drug Administration
FITS	Feeding Infants and Toddlers Study
FGSCS	Food Group Serving Count System
F&V	Fruits and vegetables
MFMU	Maternal Fetal Medicine Unit
NHANES	National Health and Human Examination Survey
NDSR	Nutrient Data System for Research
NHB	Non-Hispanic black
NHW	Non-Hispanic white
NORC	Nutrition Obesity Research Center
SCT	Social Cognitive Theory
SSBs	Sugar-sweetened beverages
UNC	University of North Carolina
U.S.	United States
WLZ	Weight-for-length z-score
WIC	Supplemental Nutrition Program for Women, Infants and Children

CHAPTER I: INTRODUCTION

Overview

Obesity, and childhood obesity in particular, is a major public health concern, disproportionately affecting minority children; rates among non-Hispanic black (NHB) children are consistently higher compared to non-Hispanic white (NHW) children (C. L. Ogden, Carroll, Kit, & Flegal, 2014). In addition, there is growing evidence that infancy is a critical time for obesity prevention efforts. National data document an increase in the prevalence of obesity with age, such that 8.1% of infants ages 0-23 months are classified as obese, as compared to 16.9% of children 2-19 years and 35.1% of adults 20 years and older (Dalenius, Borland, Smith, Polhamus, & Grummer-Strawn, 2012). Obese children are at increased risk of developing chronic conditions during childhood, remaining obese as adults and having more severe forms of chronic conditions during adulthood, including high blood pressure, high cholesterol, type 2 diabetes, asthma, fatty liver disease, depression, behavioral problems, low self-esteem and low quality of life (Baird et al., 2005; Reilly et al., 2005; Taveras et al., 2011).

Dietary behaviors, particularly those associated with obesity among older children and adults such as low intakes of fruits and vegetables (F&V) and high intakes of sugar-sweetened beverages (SSBs), desserts and sweets, emerge during the first two years of life (Saavedra, Deming, Dattilo, & Reidy, 2013; Siega-Riz et al., 2010; A. L. Thompson & Bentley, 2013). These eating behaviors have been shown to track through childhood in that children who consume low amounts of F&V or high amounts of SSBs during infancy are significantly more

likely to continue to do so at age six years (Park, Pan, Sherry, & Li, 2014). Thus, infant dietary intake can have lasting effects on the development of food preferences, which may lead to obesity in adolescence and adulthood and higher risk for chronic diseases.

The home environment is key to understanding the development of child diet and food preferences. Young children consume 71% of their daily energy intake at home and numerous studies among older children have documented associations between maternal diet and child diet (Howard, Mallan, Byrne, Magarey, & Daniels, 2012; Poti & Popkin, 2011; Wen, Simpson, Rissel, & Baur, 2013). Maternal diet influences the foods available and offered to children in the home and mothers also serve as role models, communicating through their behavior what is "good" to eat. Despite its established importance to the diet of older children, few studies have examined the influence of maternal diet during infancy. This dissertation addresses this gap through three primary aims: Aim 1 examines maternal diet between 3 to 18 months postpartum in a sample of NHB first-time mothers and compares their consumption of key food groups to recommended serving sizes from the 2015-2020 *Dietary for Americans* (DGAs); Aim 2 determines the longitudinal association between maternal and infant intake of key food groups and tests for factors that may moderate the relationship; and Aim 3 uses in-depth qualitative research methods to investigate barriers and facilitators to healthy eating during the first two years postpartum among a sample of mothers participating in a family-based obesity prevention trial, to guide future interventions that aim to improve maternal diet for the purpose of establishing healthy infant dietary habits.

Specific Aims

Aim 1: Explore maternal diet during the postpartum period.

a. Examine maternal consumption of key food groups at 3, 6, 9, 12 and 18 months postpartum.
b. Determine factors that predict intake of key food groups among first-time non-Hispanic black mothers.
c. Compare maternal consumption of key food groups to recommended serving sizes from the 2015-2020 *Dietary Guidelines for Americans*.

Aim 2: Examine the association between maternal and infant intake of key food groups at 6, 9, 12 and 18 months.

a. Explore maternal and infant consumption of key food groups from 6 to 18 months.
b. Identify predictors of maternal and infant consumption of key food groups.
c. Determine the longitudinal association between maternal and infant consumption of key food groups and factors that moderate the relationship.

Aim 3: Explore barriers and facilitators to healthy eating during the postpartum period through in-depth interviews with participants of *Mothers and Others: Family-based Obesity Prevention for Infants and Toddlers*.

CHAPTER II: LITERATURE REVIEW

Risk for obesity starts early

Childhood obesity continues to be a major public health concern, affecting even the youngest age group of infants and toddlers (C. L. Ogden et al., 2014). Currently, 8.1% of infants and toddlers are considered obese (weights-for-length $\geq 95^{th}$ percentile) with rates higher among non-Hispanic black (NHB) children compared to non-Hispanic white children (NHW) (Dalenius et al., 2012; Freedman, 2011). Being overweight in the first 2 years of life is associated with obesity and higher risk for chronic diseases in adolescence and adulthood (Baird et al., 2005; Nader et al., 2006; Reilly et al., 2005; Skilton et al., 2013; Stocks et al., 2011; Taveras et al., 2011). This is concerning, for as children age it becomes more difficult to prevent and treat obesity (Dattilo et al., 2012). With the onset of obesity occurring earlier and racial disparities in weight status becoming apparent by preschool, minorities at the earliest stages of life are a priority population for interventions. Yet, few published interventions focus on the prevention of obesity during infancy and this age group remains an understudied population (Birch & Ventura, 2009; Ciampa et al., 2010; Dattilo et al., 2012; Hesketh & Campbell, 2010; Janicke et al., 2014; Waters et al., 2011).

Dietary habits set during infancy

Child diet and food preferences are shaped early in life. Eating patterns that emerge during infancy track through childhood and have lasting effects on the development of food

preferences and control of intake later in life (Golley et al., 2013; North & Emmett, 2000; Northstone & Emmett, 2005; Skinner, Carruth, Bounds, Ziegler, & Reidy, 2002). The Infant Feeding and Practices study, a longitudinal analysis of U.S. children, looked at how food-related experiences before age 2 predict intake at age 6. They found that any consumption of sugar-sweetened beverages (SSBs) during infancy was associated with higher odds for consuming them at least once per day at age 6 (Park et al., 2014). They also found that children who had infrequent fruit or vegetable intake during infancy had higher odds of infrequently consuming them at age 6.

Why focus on sugar-sweetened beverages, desserts, sweets, fruits and vegetables?

The 2015-2020 *Dietary Guidelines for Americans* (DGA) recommend increased consumption of fruits, vegetables and whole grains, particularly in place of foods high in added sugar, refined grains and saturated fat, as they provide important under consumed nutrients and help reduce the risk of heart disease, stroke and some cancers as well as help manage weight (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015). Despite their importance, only 40% of children (aged 2-18) consume recommended amounts of fruit and 7% consume recommended amounts of vegetables (Kim et al., 2014). The DGA also include a discretionary calorie allowance, which provides caloric limits for excess energy from consumption of food groups beyond recommended amounts as well as solid fats, alcoholic beverages, and added sugars. These "empty calories", or sources of energy with little to no nutritional value, are contributing more than the recommended amount in children's diets. In 2005-2006 they contributed nearly 40% of total caloric intake (433 kcal from solid fat and 365 kcal from added sugars) for 2-18 year olds (Reedy & Krebs-Smith, 2010). Grain-based desserts

and SSBs were among the top sources of energy amounting to 138 kcal/day and 173 kcal/day, respectively. Increasing evidence suggests that consuming energy dense foods like desserts, sweets and SSBs in place of nutrient- and fiber-rich foods such as F&V contributes to unhealthy eating patterns and weight gain (Houchins et al., 2012; Leahy, Birch, & Rolls, 2008; Rolls, Ello-Martin, & Tohill, 2004). Additionally, diets characterized by higher consumption of desserts and sweets during infancy have been associated with lower IQ scores (Smithers et al., 2012). Furthermore, consumption of SSBs has been positively associated with overweight in toddler and preschool age children while conversely high consumption of F&V have been associated with a more desirable body weight in this age group (Dattilo et al., 2012).

What are children eating during infancy?

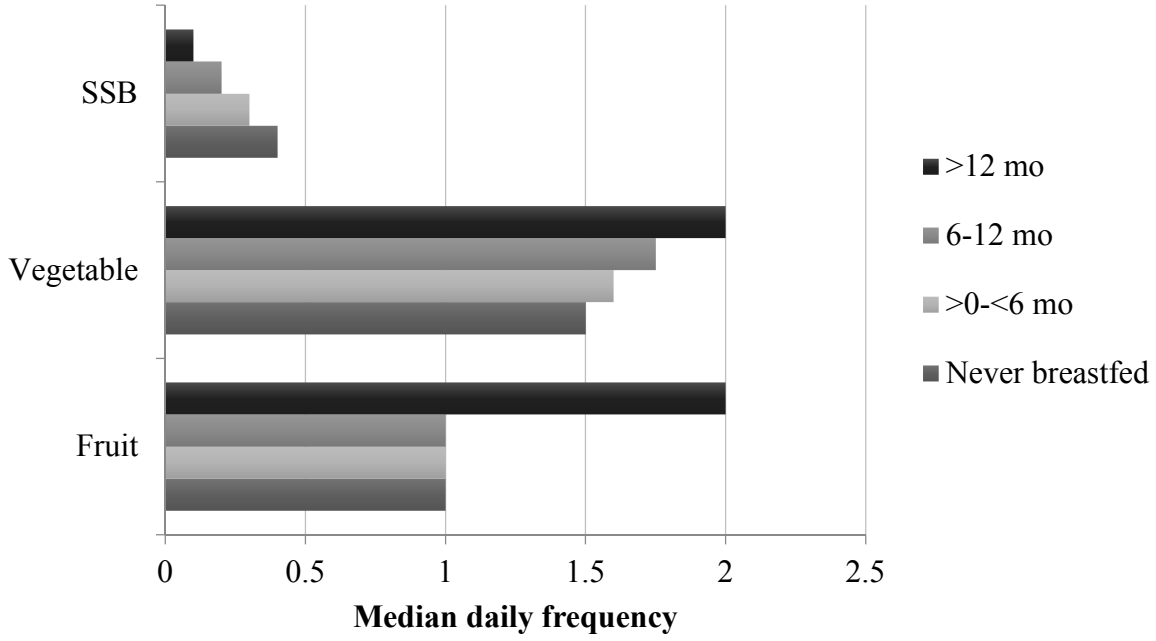
Dietary exposures such as early introduction to solid foods and delayed introduction of textured foods are associated with poorer diets, infant weight gain and obesity later in life (Baker, Michaelsen, Rasmussen, & Sorensen, 2004; Golley et al., 2013; Schack-Nielsen, Sorensen, Mortensen, & Michaelsen, 2010). The American Academy of Pediatrics (AAP) recommends delaying introduction of complementary foods until 6 months (American Academy of Pediatrics, 2014). Yet, obesogenic (i.e. energy-dense/nutrient poor) diets are emerging early with infants being fed SSBs and energy dense foods such as desserts and sweets before 6 months (Saavedra et al., 2013; A. L. Thompson & Bentley, 2013). Data from the 2008 Feeding Infants and Toddler Study (FITS) show that by the age of 9–11 months 43% of infants consume some type of dessert, sweet or SSB at least once in a day and this percentage increases to 72% at 12-23 months (Saavedra et al., 2013; Siega-Riz et al., 2010). Furthermore, substantial proportions of infants do not consume any fruit or vegetable in a given day; approximately 30% of older infants

did not consume vegetables and 25% did not consume fruit. French fries are introduced as early as 6 months and were among the top 5 most commonly consumed vegetables at 12-23 months. High intake of SSBs, desserts and sweets and low intake of F&V is associated with rapid infant growth and increased risk for obesity (Dattilo et al., 2012). Offering foods such as desserts, sweets and SSBs during the weaning period sets up a predisposition for unhealthy foods, yet few interventions focus on diet quality in this critical phase.

Maternal diet shapes infant food preferences through breastfeeding and flavor exposure

One of the first opportunities to intervene on infant diet is the mother's decision to breastfeed or not. Formula-fed infants are exposed to a single flavor, where breastfed infants are exposed to a multitude of flavors contingent on the mother's diet through her milk. For breastfeeding moms, what they eat can influence infant palate and acceptance of solid foods during the weaning process as well as taste preferences later in life (Birch & Fisher, 1998; Savage, Fisher, & Birch, 2007). The length of time exposed to breast milk is also important in that shorter durations of breastfeeding have been associated with poorer diets, including more frequent SSB consumption and less frequent F&V consumption during childhood, as well as obesity later in life (Figure 1) (Golley et al., 2013; Perrine, Galuska, Thompson, & Scanlon, 2014). Breastfeeding exclusivity and continuation remain below targeted levels, particularly among NHB mothers, suggesting a need to intervene (Centers for Disease & Prevention, 2010, 2014; McDowell, Wang, & Kennedy-Stephenson, 2008). Although observational studies have demonstrated the relationship between breast milk and infant food preferences, interventions considering breast milk as a predictor of infant diet are lacking (Mennella, Jagnow, & Beauchamp, 2001).

Figure 1. Median daily frequency of intake of various foods and beverages at 6 y, by breastfeeding duration. IFPS II, 2005–2007 and Y6FU (Perrine et al., 2014).



Maternal diet is a significant contributor to the quality of infant diet

In addition to shaping preferences through breast milk, maternal diet is a key determinant of infant diet (Howard et al., 2012; Wen et al., 2013). Maternal diet influences foods available in the home and consequently those offered during weaning. As infants make this significant dietary transition from a milk-based diet to foods indicative of their adult, cultural diet, they learn what, when and how much to eat from those around them. Observing the eating behaviors of others, specifically their mother, heavily influences child diet and food preferences (Papas, Hurley, Quigg, Oberlander, & Black, 2009; Robinson et al., 2007). Studies show a child's preferences and eating patterns are related to their mothers (Fisher & Birch, 1995; Saavedra et al., 2013) and that toddlers eat more readily when following the example of their mother (Birch & Fisher, 1998). Infants of mothers who meet dietary recommendations for fruits, vegetables and whole grains are more likely to have comparable diets where infants of mothers who eat energy

dense/nutrient poor foods are more likely to have similar dietary patterns (Robinson et al., 2007). Role modeling healthy food choices (e.g., F&V and foods low in added sugar and fats) is an important component to shaping a healthy diet in children. However, for many women, diet quality is suboptimal, particularly in the postpartum period (Durham, Lovelady, Brouwer, Krause, & Ostbye, 2011; Fowles & Walker, 2006; G.C. George, Hanss-Nuss, Milani, & Freeland-Graves, 2005; Wiltheiss et al., 2013). Nonetheless, few interventions aim to change maternal diet directly (G.C. George et al., 2005; Havas et al., 1998; Lioret et al., 2012; Ostbye et al., 2012). Thus, an important and often overlooked behavioral target for intervening on infant diet is maternal diet as it can influence the types of complementary foods available and subsequently offered.

Postpartum maternal diets

Although some women adopt healthier eating patterns during pregnancy, many discontinue these habits postpartum. In a sample of low-income women, F&V consumption declined while intake of added sugars increased at 6 months postpartum (G.C. George et al., 2005). At 12 months <25% complied with the DGAs for grains, F&V and dairy (G. C. George, Milani, Hanss-Nuss, & Freeland-Graves, 2005). Among a sample of overweight and obese women 6-9 weeks postpartum, intake of F&V, whole grains, dairy, meats and beans and fat were below recommended levels and mothers consumed on average 2.5 servings of SSBs per day (Durham et al., 2011). Studies show that diet quality for women is suboptimal, particularly during the postpartum period. Yet, a prospective and comprehensive examination of food choices beyond 12 months postpartum is limited. One study looked at postpartum diets at 6, 12 and 24 months and found that less than 43% consumed ≥3 servings of F&V per day. However, this

study included limited outcomes and was conducted in 1997 on a predominately white (96%) sample (Olson, 2005).

Non-Hispanic black families are a priority population

Different behavioral patterns and feeding practices have been observed in NHB families compared to other races/ethnicities such as greater likelihood for early introduction of inappropriate foods (A. L. Thompson & Bentley, 2013) and breastfeeding rates that lag far behind that of white and Hispanic women (Centers for Disease & Prevention, 2010). Thus, combined with evidence regarding early learning of food preferences and obesogenic patterns currently in existence, particularly in disparate populations, there exists a need for studies focused on infant diet in NHB families.

Summary

Children are consuming foods associated with obesity early in life, yet few studies focus on the impressionable time period of 0-2 years. Given the early emergence of diet-related diseases such as obesity, infancy is an opportune time to intervene, for that is when food preferences and diet begin to form. In addition, the effects maternal dietary behaviors can have on consumption patterns is not well understood in infants**.** Observational studies have demonstrated that both maternal diet and infant feeding strategies can influence infant diet. The impact these maternal behaviors can have on infants should not be ignored given the implications role modeling and breastfeeding can have on a child's dietary habits and food preferences. Growing evidence on modifiable factors associated with infant feeding and diet lend insight to potential opportunities to intervene. Therefore, investigation into the relationship between

maternal and infant intake is warranted with the goal of uncovering effective intervention targets to prevent early obesogenic patterns from being adopted.

This study fills am important gap in child obesity research by focusing on infant diet before the age of 2 and uniquely targeting maternal diet as a modifiable factor. As noted by a recent review, few published results exist from interventions focused on modifiable feeding and related practices in infants, particularly in NHB families (Dattilo et al., 2012). This study is one of the first to focus on infant diet in a minority population. Although recognized as having a distinct association with infant diet (Hart, Raynor, Jelalian, & Drotar, 2010; S. L. Hoerr, Lee, Schiffman, Horodynski, & McKelvey, 2006; Lee, Hoerr, & Schiffman, 2005; Papas et al., 2009; Robinson et al., 2007), maternal diet has yet to be the primary target of an intervention aimed at influencing infant diet in the home (Hartman, Hosper, & Stronks, 2011).

CHAPTER III: METHODS

Research Designs and Methods

This study explores the relationship between maternal and infant diet in order to develop targeted intervention strategies for preventing infant overweight and obesity. Aim 1 investigates maternal diet and compares intake of key foods groups to the recommended amounts from the 2015-2020 DGAs; Aim 2 examines the association between maternal and infant intake of key food groups across the ages of 6 to 18 months in a sample of NHB first-time mothers; Aim 2 further examines factors that moderate that relationship; and Aim 3 uses qualitative research methods to investigate barriers and facilitators to eating healthy during the first two years postpartum.

Quantitative analysis of maternal and infant diet using Infant Care data; Aims 1 and 2

Description of study population

Data for study aims 1 and 2 come from the Infant Care, Feeding and Risk of Obesity Project (Infant Care), a longitudinal, observational cohort study on NHB mother-infant dyads, which measured infant feeding styles and maternal and infant diets (Laraia, Borja, & Bentley, 2009; Sacco, Bentley, Carby-Shields, Borja, & Goldman, 2007; A. L. Thompson, Adair, & Bentley, 2013a, 2013b; A. L. Thompson & Bentley, 2013; H. Wasser et al., 2011; H. M. Wasser et al., 2013). First-time, NHB mothers aged 18-35 years were recruited through the North

Carolina Supplemental Nutrition Program for Women Infants and Children (WIC) and assessed during in-home visits when infants were 3, 6, 9, 12 and 18 months old. Infants were excluded if they were not full term; were <2500 or above 4500 grams in birth weight; had chronic or congenital illness; were receiving medical treatment that interfered with dietary intake, growth, or development (e.g., Down's syndrome, cerebral palsy, epilepsy, diagnosed mental retardation, cleft lip or palate); or presented with failure-to-thrive. Data collection began in November 2003 and was completed in October 2007. At each home visit, a wide array of maternal, infant and household characteristics were assessed through questionnaires.

The Infant Care dataset contains data on 217 mother-infant pairs at 3-months, 161 pairs at 6 months (74% of baseline), 165 pairs at 9 months (76% of baseline), 151 pairs at 12 months (70% of baseline), and 129 pairs at 18 months (59% of baseline). Fifty-nine participants were lost to follow-up, 15 refused to participate at some period after three months, one was dropped due to unreliable data, one was dropped due to incomplete data, and two were dropped due to problems encountered with the respondent, rendering the data questionable.

Dietary Intake Data

To assess infant dietary intake at several intervals throughout the first two years of life, a computerized 24 hour dietary recall (24HDR) method was used, Nutrient Data System for Research (NDS-R^{TM}) (version 2005; Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN). The NDS-R^{TM} is comprehensive nutrient calculation software that includes more than 18,000 foods and over 8,000 brand-name foods (including infant foods). It contains values for 120 nutrients and nutrient ratios derived from the U.S. Department of Agriculture (USDA), food industry manufacturers, food composition tables, and the scientific literature.

During each home visit, mothers were asked to complete a single 24HDR for themselves and their infant. To ensure accuracy of collecting the dietary information, all study personnel administering the 24HDR were trained to use the software by an NDS-R^{TM} certified staff member of the Nutrition Obesity Research Center (NORC) at the University of North Carolina at Chapel Hill. Food models and pictures were used to aid in the estimation of portion sizes; pictures included infant foods such as jarred baby foods, cereal foods and cereal in the bottle. This methodology is similar to that used in FITS (Ziegler, Briefel, Clusen, & Devaney, 2006) including the use of picture aids to help mothers estimate portion sizes, and has been shown among infants to produce similar patterns of intakes of food groups compared with 3-day weighed food records (Lanigan, Wells, Lawson, & Lucas, 2001). While the FITS methodology has been shown to overestimate energy intake among infants, it produces similar patterns of intakes of food groups, and the overestimation does not differ by maternal body mass index (BMI), education, or ethnicity; family income; social desirability; or child care participation (Fisher et al., 2008). To improve estimates of usual food intakes among infants, a subsequent telephone 24HDR was collected on a random, nonconsecutive day within two weeks after the home visit to generate a more representative estimate of the infant's average intake (F. E. Thompson & Subar, 2013). An effort was made to have an equal representation of weekend and weekdays.

The 24-hour recall method is considered the best technique to estimate absolute intake since it is easy to administer, has low respondent burden, is cost effective and can accommodate any food or food combination reported by the subject due to its open-ended format, which is important when capturing intake of infants and toddlers (Biro, Hulshof, Ovesen, Amorim Cruz, & Group, 2002; R. R. Briefel et al., 1992). However, similar difficulties in collecting dietary data

from adults are also experienced when using a proxy to collect information on children, including poor recall, difficulty assessing portion size, response bias and intra-individual variation (Ferguson, Gibson, & Opare-Obisaw, 1994; Lytle et al., 1993). Though accuracy of reporting has been shown to increase through practice and the use of food models and pictures (Lytle et al., 1993).

Maternal dietary intake was assessed using similar methodology. During each home visit a single 24HDR was administered using the NDS-R ™. Although not ideal, one-day estimates from 24HDR have been successfully used in other studies such as FITS and the National Health and Human Examination Survey (NHANES) (R. Briefel, Ziegler, Novak, & Ponza, 2006; The National Cancer, National Center for Health, & Agriculture, 2013).

Measures and variable creation

Dietary intake

Aims 1 and 2 focus on specific components of maternal and infant diet. For Aim 1, outcomes included maternal consumption of foods included in the DGAs: fruits, vegetables, grains, whole grains, protein foods, dairy and SSBs. The outcomes for Aim 2 include maternal and infant consumption of foods potentially associated with an obesogenic diet (Johnson, Mander, Jones, Emmett, & Jebb, 2008; Patro & Szajewska, 2010; Sanigorski, Bell, & Swinburn, 2007). These include SSBs, desserts and sweets, salty snacks, fried vegetables, whole grains, fruits (with and without 100% fruit juice), vegetables (without fried) and lean protein foods. Data for these outcomes come from the 24HDRs that were administered at each home visit, as described above. For Aim 2, analysis of diet data begins at 6 months given feeding any solids or beverages other than breast milk or formula prior to is considered inappropriate (American

Academy of Pediatrics, 2012). Each 24HDR was administered and analyzed via NDS-R. For infants, intake of key food groups at each time point was averaged from the two recalls to produce an estimate of usual intake. Given expected variability in daily infant intake an average from two 24HDR is preferable over using just one 24HDR. "Infant" foods (i.e. jarred baby foods) and "adult" foods were differentiated.

Servings from each of the specific food groups were obtained by using the NDS-R Food Group Serving Count System (FGSCS). The NDS-R FGSCS consists of 9 major food groups and 166 subgroups. For example, for the fruit group, there are seven subgroups: citrus juice, fruit juice excluding citrus juice, citrus fruit, fruit excluding citrus fruit, avocado and similar, fried fruits, and fruit-based savory snacks. Serving sizes are based on recommended adult servings defined per the 2005 DGAs, which were current at the time of data collection or, for foods not recommended in the DGA, the food-label serving sizes from the Food and Drug Administration (FDA). Prior analyses of infant diet show positively skewed distributions for the daily serving size variables, with clustering at zero (i.e., many non-consumers of particular foods or beverages). Therefore, median servings sizes were presented.

Covariates

Confounding variables and risk factors were drawn from the literature and include factors associated with maternal and infant diet including: maternal education, age, and BMI; marital status; depression; infant gender and weight; non-maternal caregivers; and receiving Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) assistance (Hendricks, Briefel, Novak, & Ziegler, 2006; Smithers et al., 2012). Given the effects breastfeeding can have on maternal intake and diet quality, (G.C. George et al., 2005; Wiltheiss et al., 2013) the

influence of breastfeeding on maternal and infant intake is also included as a confounder. Current breastfeeding status was assessed at each home visit (are you still breastfeeding "yes/no"); prior analyses show breastfeeding rates are low (14.4% at 6 months, 11.5% at 9 months, 5.2% at 12 months and 2.2% at 18 months) (H. M. Wasser et al., 2013). All variables other than maternal education and infant gender were time varying. Maternal depression is a dichotomous (yes/no) variable measured using the Center for Epidemiological Studies Depression Scale, with a score of 16 or greater indicating the presence of maternal depressive symptoms (Radloff, 1977). Marital and BMI status are also dichotomous variables (yes/no) (married/otherwise and normal/overweight or obese, respectively).

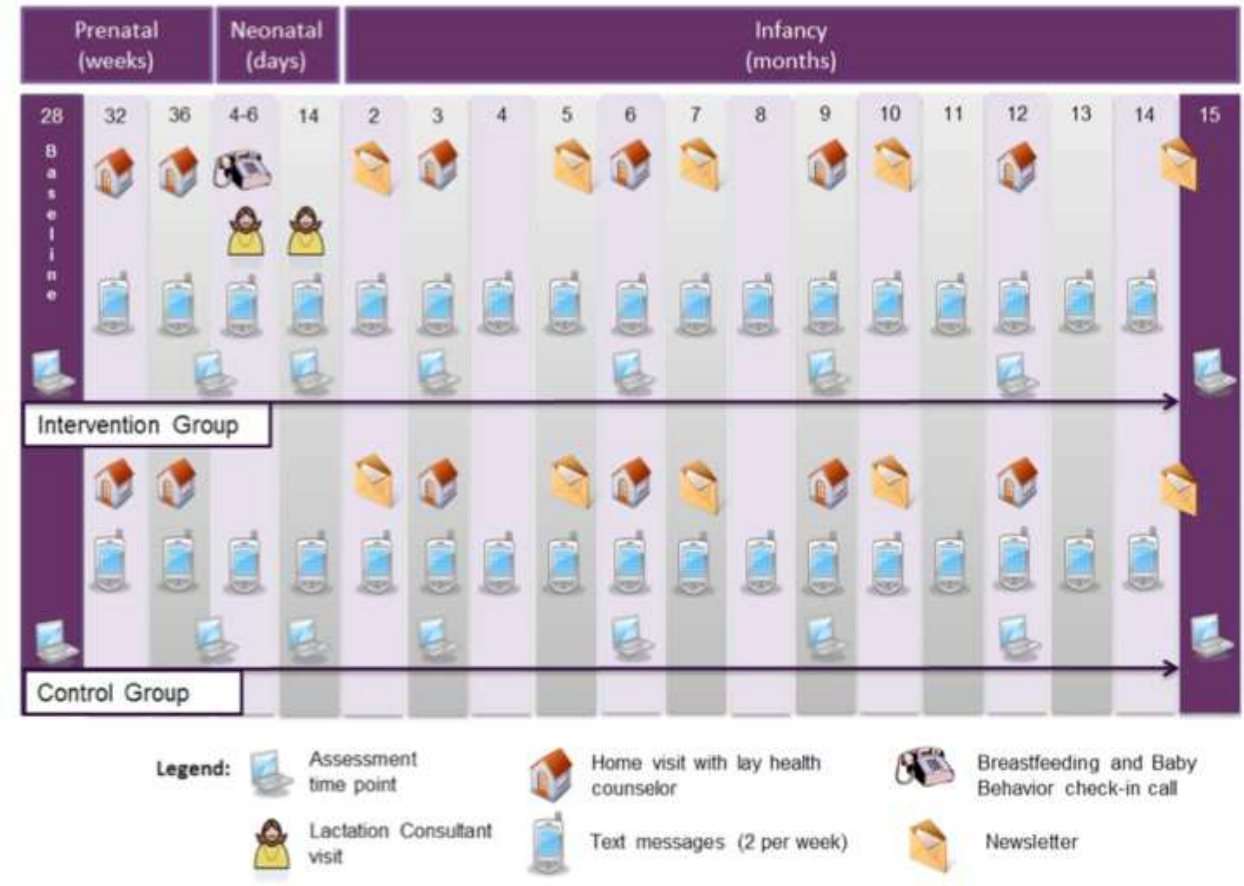
Qualitative analysis of barriers and facilitators to healthy eating among non-Hispanic black mothers*; Aim 3.*

Mothers and Others: Family-based Obesity Prevention for Infants and Toddlers.

Data for Aim 3 come from an ongoing randomized control trial. *Mothers and Others: Family-based Obesity Prevention for Infants and Toddlers,* is a two group randomized control trial in which 468 pregnant NHB women are being randomized to receive either the intervention or a Child Safety attention control. *Mothers and Others* is a comprehensive intervention focusing on infant care, growth and feeding among families at risk for pediatric obesity with the ultimate goal of influencing healthy weight gain patterns in infants. Mothers and study partners in the intervention group receive anticipatory guidance on breastfeeding, responsive feeding, use of non-food soothing techniques for infant crying, healthy complementary feeding, age-appropriate infant sleep, and minimization of TV/media. The primary delivery channel is 6 home visits by a peer educator, 4 interim newsletters and twice-weekly text messaging. Intervention families also

receive 2 home visits from an International Board Certified Lactation Consultant. Assessments occur at 28 and 37 weeks gestation and when infants are 1, 3, 6, 9, 12 and 15 months of age (see Figure 2).

Figure 2. Schematic of Mothers and Others intervention and assessment time points.



Sample description and recruitment

Mothers and Others recruited NHB pregnant mothers with a singleton pregnancy from antenatal clinics at UNC-Chapel Hill and WakeMed hospitals in North Carolina. Women were recruited through the UNC Maternal Fetal Medicine Unit (MFMU) upon entry into prenatal care and screened for eligibility criteria. Recruitment staff determined that women were <28 weeks pregnant, English speaking, lived within 35 miles of the study center and planned to stay within

the study area for the subsequent 2 years. Women were considered ineligible if they did not self-identify as black or African American, were not between the ages of 18 and 35 and not expecting a singleton birth. After birth, women were considered ineligible if they delivered prematurely (<37 weeks gestation), delivered multiples, or had a stay in the newborn nursery or NICU or a maternity stay >7 days. In addition, a child born with a congenital anomaly or other condition that affects feeding was considered ineligible after birth (e.g. Down's syndrome or cleft palate). Women who became ineligible after birth had access to study materials and received compensation for any assessments completed prior to exclusion and were linked to community resources specific to their circumstances for exclusion. Using a conservative estimate of eligible women as well as a 20% attrition rate and a rate of 15% for women who may become ineligible after enrollment, recruitment was set at 20 women per month (10 intervention and 10 control) over a period of 24 months to reach the desired sample size of 468 women (234 intervention and 234 control).

Initial consent, assessment and randomization scheme

Upon enrollment, the first home visit was scheduled where trained intervention staff went to the participant's home to obtain informed consent and conduct the initial baseline visit. Following completion of the baseline visit, participants were randomized via computer-generated software into the intervention or control condition. Randomization occurred within strata in that each clinic was considered a separate stratum with 234 participants per strata for a total of 468 participants. Permutated block randomization was used with block sizes kept confidential.

Retention

For retention purposes both physical and verbal contact was maintained throughout the study period. Reminder calls regarding survey completion and scheduled study visits were conducted weekly as appropriate and monumental events such as birthdays, baby milestones and other personal happenings were acknowledged via cards, phone calls and emails. At the first home visit mothers received a small baby gift. All participants received monetary compensation for surveys completed ($40 at baseline, $25 at months 3-12 and $50 at final assessment at 15 months).

Intervention components

The intervention components that focus specifically on maternal diet were delivered through a home visit at month 3 with subsequent follow up at months 6, 9 and 12, and are described in detail below.

Home visits.

As previously mentioned, a trained interventionist entered the participant's home approximately every 3 months for a tailored nutrition education and/or infant feeding or behavior session. Intervention staff are required to have an advanced degree in counseling or a health related field or a BS/BA plus at least 2 years related work experience. Sessions lasted approximately 1 hour and each subsequent home visit built upon prior visits to provide targeted education and tailored feedback based on answers to assessment measures and goal setting achievements. Visits coincided with the building of a *Best Practices* toolkit where at each home visit participants received a component of the toolkit to place in a personalized binder distributed

at study commencement. The binder served as a source of reliable information and as a place to organize intervention materials received over the course of their participation. Each session concluded with setting goals and determining strategies for overcoming barriers, either anticipatory or existing. The topics for the intervention materials and accompanying toolkit materials that focused on maternal diet are listed in Table 1. These materials were the focus of the 3-month home visit, but opportunities to check in and set new nutritional goals occurred at subsequent visits.

Table 1. Mothers and Others intervention goals, topics and toolkit components for influencing maternal diet.

Intervention goal	Topics and themes	Toolkit components
• Develop goal-setting skills • Incorporate more F&V and less SSBs and desserts/sweets • Define healthy eating • Make F&V available and accessible in the home	• Benefits of increasing F&V and decreasing SSB and desserts/sweets • Eating more together as a family • Tailored education and goal setting based on results of the Home Food Inventory • Healthy family behaviors (check-in on diet, physical activity, limiting screen time)	• Guide to Fresh Produce and Farmer's Markets • *Aisle By Aisle: Choosing Foods Wisely* (CD) • *Eat Smart North Carolina: Snacks and Drinks* • Go, Slow, Whoa Guide to Beverages • Right Size Your Portion • Mealtime Games & Conversation Starters

Goal setting and tracking calendar sheets.

Colorful goal setting and monthly tracking sheets were distributed to participants at the first home visit after the delivery of their baby to serve as a self-monitoring tool (Appendix I). Participants were asked to set monthly goals at the end of each home visit and track their progress weekly by marking the days/weeks in which goals were achieved. As reinforcement, the interventionist reviewed the calendar at each visit. All feedback was framed in a positive manner regardless of progress made to improve confidence and provide encouragement to pursue unmet

achievements and to celebrate successes. The calendar was also used as an active learning tool for the interventionist to discuss targeted healthy behaviors; participants marked major developmental milestones for their child such as targeted ages for exclusive and continued breastfeeding and when to introduce complementary foods and of which texture.

Control group.

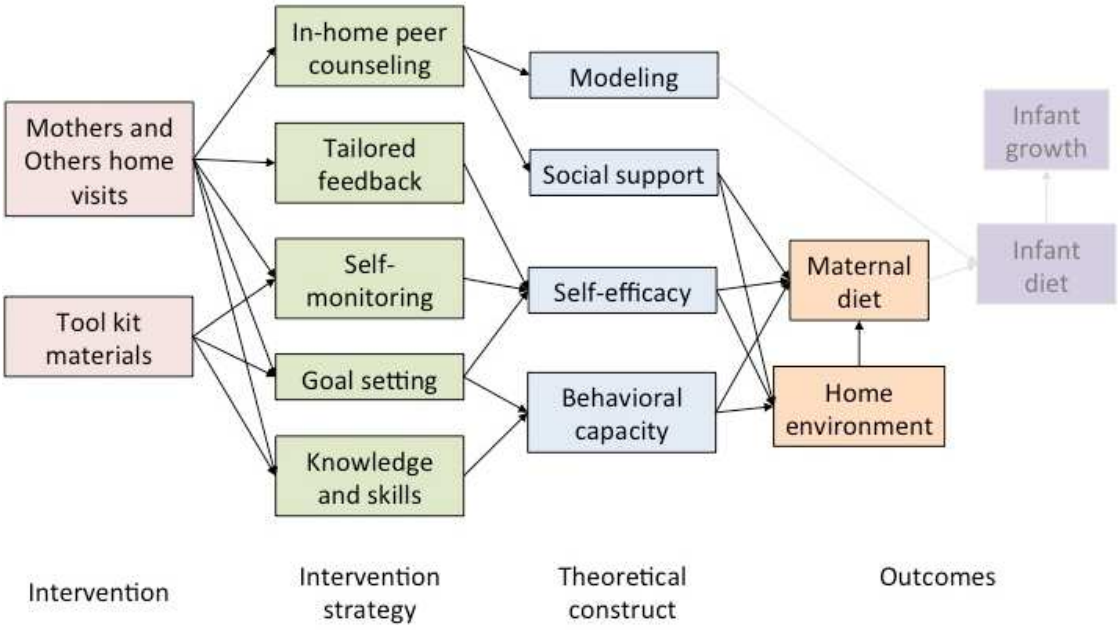
To minimize the effects of differential attrition, mothers randomized to the attention control group received the same number of home visits and newsletters as well as data collection procedures, but content delivered focused on child safety and injury prevention. Curriculum included topics such as sleep safety, car safety and minimizing risks around the home and was developed from recommended guidelines from the AAP and the Centers for Disease Control and Prevention (CDC). This is done not only to account for time and attention of the intervention group, but also to increase retention and maintain interest.

Theoretical guidance

Intervention materials focused on influencing maternal diet were created using constructs from Social Cognitive Theory (SCT) and the theory of Social Networks and Social Support. A conceptual model is provided in Figure 3. A core concept of SCT, developed by Bandura (Bandura, 1986), is reciprocal determinism in which individual and environmental changes occur through a series of activities, relationships and influences between individual level factors (e.g., thoughts, beliefs) and environmental factors (e.g., availability and accessibility to resources). Personal, environmental and behavioral factors dynamically interact with each other. In order to make positive changes in healthy eating and ultimately infant diet, *Mothers and Others* focused

on key determinants of behavior: self-efficacy, the belief regarding one's ability to successfully perform a specific behavior, and behavioral capacity, which is dependent on knowledge and skills needed to perform a behavior. *Mothers and Others* also emphasized social support (Hall & Wellman, 1985), an important predictor of behavior change (Britton, McCormick, Renfrew, Wade, & King, 2007; Gill, Reifsnider, & Lucke, 2007), by engaging secondary caregivers and using peers as trained interventionists to provide in-home counseling. *Mothers and Others* used cognitive-behavioral strategies such as goal setting and tailored feedback to increase behavioral capacity and self-efficacy and provide reinforcement for behavior change. Self-monitoring has also been shown to be an effective intervention strategy for eliciting behavior change (Michie, Abraham, Whittington, McAteer, & Gupta, 2009; Spahn et al., 2010). Lastly, an important construct of SCT in changing behavior is observational learning; *Mothers and Others* emphasized modeling to ultimately promote observational learning, a primary way in which children learn health behaviors.

Figure 3. Conceptual model for Mothers and Others intervention materials.



Data Gathering

Upon completion of the study, mothers were eligible to participate in a follow-up home visit for the purpose of exploring barriers and facilitators to healthy eating (Aim 3). Qualitative methods were used to gather information on participant insight specific to the healthy eating habits. The main objective is to explore barriers to healthy eating during the postpartum period to better understand challenges specific to the target population of NHB mothers. Information gathered will assist in future development of intervention materials aimed at changing dietary behaviors in mothers.

Sample

The interviews were conducted on a sample of mothers who were randomized to the intervention arm, had graduated out of the study, had received the healthy eating intervention at the 3 month visit, and agreed to be contacted for future research. Interviews were conducted until theme saturation was reached, which occurred after 22 interviews.

Recruitment of Participants

Recruitment took place via the phone. Eligible mothers were contacted to assess interest and schedule participation. Those who participated were compensated with $20 cash.

Data Collection

In-depth Interviews

Interviews are the preferred method of data collection given their ability to capture deep insight into individual-level attitudes and behaviors, as well as cultural and social norms surrounding selected beliefs and behaviors (Bentley et al., 2014). They are also preferred when discussing issues related to dietary behaviors, as this can be considered a sensitive topic that participants may be hesitant to discuss in a group setting. The interviews were conducted in-person and occurred at a place convenient to each participant. Interviews lasted between 20 and 45 minutes. An interview guide was developed to ensure consistency across interviews, but to allow for probing for more information, as deemed appropriate by the interviewer (Appendix II). The interview questions were designed to gather insight on the interviewee's perceptions of barriers and facilitators to healthy eating. All interviews were audio-recorded with a digital recorder and the interviewer let the participant know that their responses will be kept confidential.

Data Analysis

Audio recordings from all the interviews were transcribed. Analysis of transcript data was performed on an iterative basis with results used for ongoing refinement of the interview guide and transcript quality was audited (Bentley, Tolley, & Pequegnat, 2011). An additional coder reviewed a subset of transcripts. A deductive and inductive process was used to develop a consensus codebook from the initial set of topical codes included in the interview guide and supplemented with interpretive codes found through ongoing analysis of transcripts. The coders met to revise the codebooks, resolve disagreements on how to apply codes, and reach consensus

on coding. Once the data were coded, matrices were developed to explore the data and identify similarities and differences between respondents (Miles & Huberman, 1994). Relevant themes were identified and salient quotes used to illustrate each theme. Content analysis was performed to identify patterns, make subgroup comparisons, and identify relationships within and between major themes in the data. Dedoose qualitative software was used for all qualitative analysis and descriptive statistics (Dedoose Version 5.0.11, 2014, Los Angeles, CA: SocioCultural Research Consultants, LLC).

CHAPTER IV: CONSUMPTION OF KEY FOOD GROUPS DURING THE POSTPARTUM PERIOD IN LOW-INCOME, NON-HISPANIC BLACK MOTHERS.

Overview

This study examined consumption of key food groups during the first 2 years postpartum among low income, non-Hispanic black, first-time mothers. Data were from the Infant Care, Feeding and Risk of Obesity Study, a cohort of 217 mother–infant dyads, followed from 3 to 18 months postpartum. Data were collected from 2003-2007. At each study visit (3, 6, 9, 12, and 18 months) 24-hour dietary recalls were collected. Consumption levels were compared to recommended amounts from the 2015-2020 *Dietary Guidelines for Americans* (DGAs) for each of the following food groups: fruits, vegetables, grains, whole grains, protein foods and dairy, as well as an estimated upper limit for sugar-sweetened beverage (SSB) consumption. At each time point, mothers met recommended intake levels for grains and protein foods only. In longitudinal models no demographic or household characteristics were associated with a likelihood of consuming recommended levels for any of the food groups according to the DGAs. Given the low intake of fruits, vegetables, whole grains and lean protein foods and high intake of SSBs and refined grains, interventions targeting women's diet during the postpartum period are warranted.

Introduction

The postpartum period marks a significant life transition that can impact diet quality and subsequently place women at greater risk for overweight or obesity. The prevalence of overweight or obesity (BMI≥25) among women of childbearing age is 58.5% (51.4-65.2), but among non-Hispanic black (NHB) women of the same age the prevalence is 80.0% (72.6-85.8) (C. L. Ogden et al., 2014). Although some women adopt healthier eating patterns during pregnancy (Fowles & Gabrielson, 2005; Fowles, Hendricks, & Walker, 2005), many discontinue these habits postpartum (G.C. George et al., 2005; Walker et al., 2004; Wiltheiss et al., 2013); this may be due to stress from increased financial and time demands. Food choices based on convenience as well as limited affordability and access to healthy foods may result in suboptimal diet quality, particularly among low-income women (Eikenberry & Smith, 2004a; Reyes, Klotz, & Herring, 2013). NHB mothers in particular have been shown to have lower diet quality, higher risk of depression and greater amounts of weight retained during the postpartum period compared to non-Hispanic white (NHW) mothers (Everson, Maty, Lynch, & Kaplan, 2002; Gillman et al., 2001; S. L. Hoerr, Tsuei, Liu, Franklin, & Nicklas, 2008; Siega-Riz, Evenson, & Dole, 2004).

Additionally, maternal diet in the postpartum period is considered a key determinant of infant diet (Howard et al., 2012; Wen et al., 2013). Maternal diet in general influences foods available in the home and consequently those offered during weaning. Infants who consume nutrient-poor foods such as sugar-sweetened beverages (SSBs), desserts and sweets in place of nutrient-rich foods such as fruits and vegetables (F&V) are at greater risk for obesity later in life (Dattilo et al., 2012; Golley et al., 2013; Park et al., 2014). For lactating women, what they eat can influence their child's palate and acceptance of solid foods during the weaning process as

well as taste preferences later in life (Birch & Fisher, 1998; Savage et al., 2007). Thus, understanding maternal consumption of such food groups is important not only for adult obesity rates but also to prevent future risk of obesity in children.

Recommendations for optimal diet quality to help achieve and maintain a healthy weight, promote health, and prevent disease exist through the *Dietary Guidelines for Americans* (DGAs) (U.S. Department of Health and Human Services & U.S. Department of Agriculture, 2015). The DGAs encourage Americans to focus on foods and beverages that promote a healthy diet. This includes recommendations to increase the consumption of F&V and to decrease the consumption of foods high in added sugar, refined grains and saturated fat. Data have consistently shown that many Americans fail to meet recommended levels of intake of these food groups. Only 17.5% of adult females (age 18 and older) consume recommended amounts of fruit, 9.8% consume recommended amounts of vegetables, and less than 2% consume the recommended amount of whole grains (Moore et al., 2015; U.S. Department of Agriculture, 2013). The DGAs also include a discretionary calorie allowance, which provides caloric limits for excess energy from consumption of food groups beyond recommended amounts and from solid fats, alcoholic beverages, and added sugars. These "empty calories", or sources of energy with little to no nutritional value, contribute more than the recommended amount in adult diets. Over 85% of women aged 19-30 consume more than the recommended limit of empty calories per day (US Department of Agriculture, Beltsville Human Nutrition Research Center Food Surveys Research Group, US Department of Health Human Services, Centers for Disease Control Prevention, & National Center for Health Statistics). For example, women aged 20-39 consume an average of 275 kcals per day from added sugars; an amount in excess of the recommended maximum of 258 kcals per day from *all* added sugars and solid fats (Ervin & Ogden, 2013).

Little research has been done to examine consumption of key food groups among women during the postpartum period and whether adhering to recommended intake levels is associated with various predictors of diet such as education, employment, age, weight, depression and breastfeeding (Fowles & Walker, 2006; G. C. George et al., 2005; Olson, 2005). Gaining insight into intake levels of such foods among postpartum women may identify important factors that influence diet and can be used in intervention studies for the purpose of improving the diets of both mothers and children. The purpose of this study is to (1) describe consumption of key food groups in a prospective cohort of first-time, NHB mothers from 3 to 18 months postpartum and to assess intake levels based on comparison to recommended servings sizes from the 2015-2020 DGAs, and (2) identify predictors of intake so that results can be used to guide nutrition interventions aimed at influencing maternal diet.

Methods

Study design

Data come from the Infant Care, Feeding and Risk of Obesity Project (Infant Care), a longitudinal, observational cohort study of first-time, NHB mothers aged 18-35 years who were recruited through the North Carolina Supplemental Nutrition Program for Women Infants and Children (WIC) (n=217) (Laraia et al., 2009; Sacco et al., 2007; A. L. Thompson et al., 2013a, 2013b; A. L. Thompson & Bentley, 2013; H. Wasser et al., 2011; H. M. Wasser et al., 2013). Mothers and infants were followed with in-home visits when infants were 3, 6, 9, 12, and 18 months of age. At each home visit, a wide array of maternal, infant and household characteristics were assessed through questionnaires. Infants were excluded if they were not full term; were <2500 or ≥ 4500 grams in birth weight; had chronic or congenital illness; were receiving medical

treatment that interfered with dietary intake, growth, or development (e.g., Down's syndrome, cerebral palsy, epilepsy, diagnosed mental retardation, cleft lip or palate); or presented with failure-to-thrive. Data collection began in November 2003 and was completed in October 2007. The overall study is described in detail elsewhere (Laraia et al., 2009). The protocol was approved by the School of Public Health Institutional Review Board at the University of North Carolina at Chapel Hill.

Measures

Maternal dietary intake

Dietary intake was assessed at each home visit with one computerized 24-hour dietary recall (24HDR) administered using the Nutrient Data System for Research (NDS-R™) (version 2005; Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN). The NDS-R™ is comprehensive nutrient calculation software that includes more than 18,000 foods and over 8,000 brand-name foods. To ensure accuracy, all study personnel were trained to use the software by an NDS-R™ certified staff member of the Nutrition Obesity Research Center (NORC) at the University of North Carolina at Chapel Hill. Food models and pictures were used to aid in the estimation of portion sizes.

Food groups were defined according to the DGAs: fruits (including 100% fruit juice), vegetables (excluding fried vegetables), total grains, whole grains, dairy and protein foods (meat, poultry, seafood, eggs, soy products and nuts). Servings for commonly consumed and potentially obesogenic foods, such as SSBs and fried vegetables, which include French fries, hash browns and onion rings, were also obtained. Servings from each of the specific food groups at each time point between 3-18 months were obtained by using the NDS-R Food Group Serving Count

System. Serving sizes were based on the recommended adult servings that were current at the time the survey was delivered, which were defined per the 2005 DGAs or, for foods not recommended in the DGAs (e.g. cookies, SSBs), the food-label serving sizes from the Food and Drug Administration (FDA). The NDS-R serving sizes were then compared to the food group serving sizes recommended by MyPlate, a web-based program that personalizes recommendations based on the DGAs (https://www.choosemyplate.gov/MyPlate-Daily-Checklist) (U. S. Department of Agriculture, 2016). For this study, current recommendations were used, which at the time of analysis, were the 2015-2020 DGAs. Similar to Durham et al., a hypothetical referent mother was created based on the average characteristics of participants in Infant Care: 23 years old, 175lbs, 5'4", not breastfeeding and sedentary (Durham et al., 2011). Using MyPlate, recommended food group amounts were based on a 2000 calorie diet and include: 4 servings (2 cups) of fruit, 5 servings (2.5 cups) of vegetables, 6 servings (ounces) of grains, 3 servings (ounces) of whole grains, 5.5 servings (ounces) of protein and 3 servings (cups) of dairy. There is no specific guideline for SSB intake. For a 2000 calorie diet, the FDA recommends a daily limit of 50g from added sugars from all foods and beverages (Food and Drug Administration, 2015). The average SSB contains approximately 25-30g of sugar per 8oz serving. Therefore, an upper limit (UL) for SSBs is estimated at 1.5 SSBs per day.

Predictor variables

Predictors of intake were drawn from the literature and include factors previously associated with diet: education, age, BMI, marital status, employment, depression, living in a single-headed household, receiving WIC benefits and breastfeeding (G.C. George et al., 2005; Hendricks et al., 2006; Smithers et al., 2012; Wiltheiss et al., 2013). Data were collected by

trained researchers using a comprehensive, interviewer-administered questionnaire at each time point. Depression was measured using the Center for Epidemiological Studies Depression Scale (Radloff, 1977). For breastfeeding status, mothers were asked whether they were still breastfeeding. Weight and height were measured by a trained research assistant at a subset of visits (3, 6 and 18 months). Height was measured to the nearest 0.5cm and weight to the nearest 0.1kg using a digital scale. BMI was calculated for each individual (weight (kg)/height $(m)^2$). Weight status was categorized based on international classification guidelines: underweight/normal = BMI<25; overweight = BMI 25-29.9; and obese = BMI ≥30.0.

Statistical analysis

Sample characteristics at each time point (3, 6, 9, 12 and 18 months) were described as frequencies for categorical variables and means and standard deviations for percentages and continuous variables. Daily serving size variables for maternal intake were positively skewed, with heavy clustering at zero (i.e., many non-consumers). For these variables, we present the data as the median among consumers only. Data are also presented as the proportion of mothers consuming any amount of a food group at each time point.

Pearson's correlation was used to test for collinearity among predictors. Marital status was highly correlated with education and single-headed households ($r > 0.68$) and was therefore dropped as a predictor. Receiving WIC benefits was also dropped due to the high percent of women receiving them at each time point. To examine longitudinal associations between meeting the DGAs for each food group and selected maternal and household characteristics, we used random-effects logistic regression models in which meeting the guidelines for a particular food group was the dependent binary variable and independent variables were maternal and

household characteristics plus a variable representing each study visit (time). Post analysis Wald tests were used to assess differences in maternal diet behavior over time. A Bonferonni correction was used to avoid Type 1 error due to multiple comparisons; statistical significance was set at $p \leq 0.001$. To account for missingness in the demographic and household predictor values we imputed using the last observation carried forward (LOCF) method. To address the potential for selection bias due to attrition, differences in baseline characteristics between those who were present and those who were absent at each visit were assessed. All analyses were conducted using Stata 14 (StataCorp, College Station, TX).

Results

Dietary recalls were collected from 197 mothers at month 3 (90.8%), 144 at month 6 (66.4%), 149 at month 9 (68.7%), 120 at month 12 (55.3%) and 122 at month 18 (56.2%) (see Table 2). Within this sample of young, first-time NHB mothers there was a high prevalence of obesity, single-headed households and mothers receiving WIC benefits. Fewer than a quarter of the mothers were breastfeeding at 3 months and rates significantly decreased over time; eight mothers were breastfeeding at 12 months (6.7%) and three at 18 months (2.5%). Differences among those who had complete dietary recalls versus those who did not at each time point revealed few significant differences (see Table 2). Mothers with dietary recalls at 12 months were more likely to be older, married, breastfeeding and have a college education. Those with dietary recalls at 18 months were more likely to be older and breastfeeding at baseline.

Table 2. Demographic characteristics of mothers participating in the Infant Care, Feeding, and Risk of Obesity study.

		Study visit (month)				
		3	6	9	12	18
Age, y (n)		22.6 ±3.8 (197)	23.0 ±3.9 (144)	23.4 ±3.9 (149)	24.2 ±4.2 (120) ***	24.5 ±4.1 (122) **
Education, % (n)	Less than high school	26.7 (52)	26.4 (38)	26.2 (39)	25.0 (30)	26.2 (32)
	High school	30.3 (59)	27.8 (40)	26.9 (40)	22.5 (27)	27.9 (34)
	Some college	32.3 (63)	34.7 (50)	34.9 (52)	39.2 (47)	33.6 (41)
	College or higher	10.8 (21)	11.1 (16)	12.1 (18)	13.3 (16) *	12.3 (15)
Married, % (n)		10.3 (20)	10.5 (15)	13.7 (19)	14.6 (16) *	17.0 (17)
Single-headed household, % (n)		20.3 (40)	23.9 (34)	24.5 (35)	24.6 (29)	30.9 (30)
Currently working, % (n)		54.4 (106)	61.7 (87)	63.0 (90)	58.6 (68)	61.0 (61)
Receiving WIC, % (n)		95.9 (185)	94.2 (130)	96.0 (119)	89.8 (88)	70.9 (56)
Depressive symptoms, % (n)[a]		27.7 (54)	29.5 (38)	25.2 (36)	15.7 (18)	37.3 (38)
Breastfeeding, % (n)		23.9 (47)	16.0 (23)	11.4 (17)	6.7 (8) *	2.5 (3) *
Weight status % (n)[b]	Underweight/ Normal	27.1 (54)	28.4 (40)	NA	NA	28.7 (25)
	Overweight	28.4 (56)	24.1 (34)	NA	NA	21.7 (18)
	Obese	44.2 (87)	47.5 (67)	NA	NA	48.2 (40)

Significantly different at baseline at * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
[a]Measured using the Center for Epidemiological Studies Depression Scale with a score of ≥16 indicating depressive symptoms.
[b]Weight status was not measured at the 9 and 12 month visits.

Across all study visits, fewer than half of the mothers consumed any fruit on a given day (Table 3) and the median serving size among consumers was half the recommended amount (Table 4). Many mothers consumed vegetables, though the median amount of servings per day was much lower than the recommended 5 servings per day across all study visits. Approximately one third of mothers consumed fried vegetables on a given day, with consumers having at least 1.5 servings. Few mothers consumed any whole grains; of those who did, the median serving size did not meet recommended levels. The median intake among consumers for protein foods was near or exceeded the recommended level of 5.5 ounces per day, but the median intake for

lean protein, the recommended source for most protein foods, was low at 3.1 ounces per day for month 3 and 2.0 ounces per day for months 6-18 (data not shown). Although many mothers consumed dairy foods, the median number of servings among consumers was approximately one-third the recommendation of 3 servings per day. Most mothers consumed SSBs on a given day and the median number of servings was between 2.3 and 2.8 per day. This is nearly double the estimated UL of 1.5 drinks/day. Nearly all mothers consumed grains and protein foods (i.e. meat, poultry, seafood, eggs, soy products, nuts and seeds); these food groups were the only food groups for which the recommendations were met. For all food groups, there were no significant differences in median servings consumed on a given day across study visits. Thus, among consumers on a given day mothers had on average 2.0 servings of fruit, 1.2 servings of vegetables, 1.7 servings of fried vegetables, 5.6 ounces of grains, 1.8 ounces of whole grains, 5.5 ounces of protein foods, 1.0 serving of dairy and 2.5 servings of SSBs (data not shown).

Table 3. Percent of mothers consuming key food groups 3-18 months postpartum participating in the Infant Care, Feeding, and Risk of Obesity study.

Food category	Percent Consuming				
	3 month (n=197)	6 month (n=144)	9 month (n=149)	12 month (n=120)	18 month (n=122)
Fruit[a]	44	47	43	43	41
Vegetables[b]	88	89	89	92	93
Fried vegetables[c]	31	34	29	30	25
Grains	99	99	97	98	99
Whole grains	39	31	32	38	34
Protein foods[d]	98	98	98	95	99
Dairy	84	87	85	87	87
Sugar-sweetened beverages	88	88	82	77	85

[a]All fruit, including whole fruit and juice
[b]All vegetables, including whole and juice, excluding fried vegetables
[c]Includes breaded and fried vegetables such as French fries, hash browns and onion rings
[d]All meat, poultry, seafood, eggs, soy products, nuts and seeds

Table 4. Median consumption of key food groups among mothers 3-18 months postpartum participating in the Infant Care, Feeding, and Risk of Obesity study.

Food category	Recommendation[a]	Median Servings per Day[b]				
		3 month (n=197)	6 month (n=144)	9 month (n=149)	12 month (n=120)	18 month (n=122)
Fruit[c]	4 servings (2 cups)	2.0	2.0	2.0	2.1	2.0
Vegetables[d]	5 servings (2.5 cups)	1.1	1.0	1.2	1.3	1.7
Fried vegetables[e]	NA	1.5	1.8	1.8	1.7	1.6
Grains	6 oz equivalents	5.9	5.6	4.8	5.3	5.6
Whole grains	3 oz equivalents	1.9	1.6	1.8	1.9	2.0
Protein foods[f]	5.5 oz equivalents	5.8	5.2	5.7	5.5	5.6
Dairy	3 servings	1.0	0.9	1.0	1.0	1.0
Sugar-sweetened beverages	$\leq$ 1.5 drink/day[g]	2.5	2.8	2.4	2.6	2.3

[a]Recommendations are based on MyPlate guidelines for a 2000 calorie diet for a woman aged 24, 175lbs, 5'4", not breastfeeding and sedentary
[b]Median among consumers only
[c]All fruit, including whole fruit and juice
[d]All vegetables, including whole and juice, excluding fried vegetables
[e]Includes breaded and fried vegetables such as French fries, hash browns and onion rings
[f]All meat, poultry, seafood, eggs, soy products, nuts and seeds
[g]Estimated upper limit, based on the FDA recommendation of 50g added sugar per day for a 2000 calorie diet; the average SSB has approximately 30g sugar per 8oz serving

Time interactions for the percentage of mothers meeting the 2015-2020 DGAs for the referent profile, which was based on a 2000 calorie diet, did not significantly differ for any of the food groups (see Figure 4). Although not significant, a slightly higher percentage of mothers met the guidelines for vegetables by 18 months and those consuming the estimated UL for SSB intake increased from 6 to 18 months post-partum. A higher percentage of mothers met the guidelines for protein foods and grains compared to other food groups across all study visits. On average, almost half of all participants met the DGAs for servings of grains (45%) and protein (49%) on a given day. However, on average, only 8.7% met the DGAs for fruit, 6.6% for vegetables, 8.0% for whole grains and 8.6% for dairy. For SSBs, on average, 38.1% of mothers consumed at or below the estimated UL of 1.5 drinks per day.

Figure 4. Percent meeting the 2015-2020 Dietary Guidelines for Americans and an estimated upper limit for sugar-sweetened beverage intake among mothers 3-18 months postpartum participating in the Infant Care, Feeding, and Risk of Obesity study.

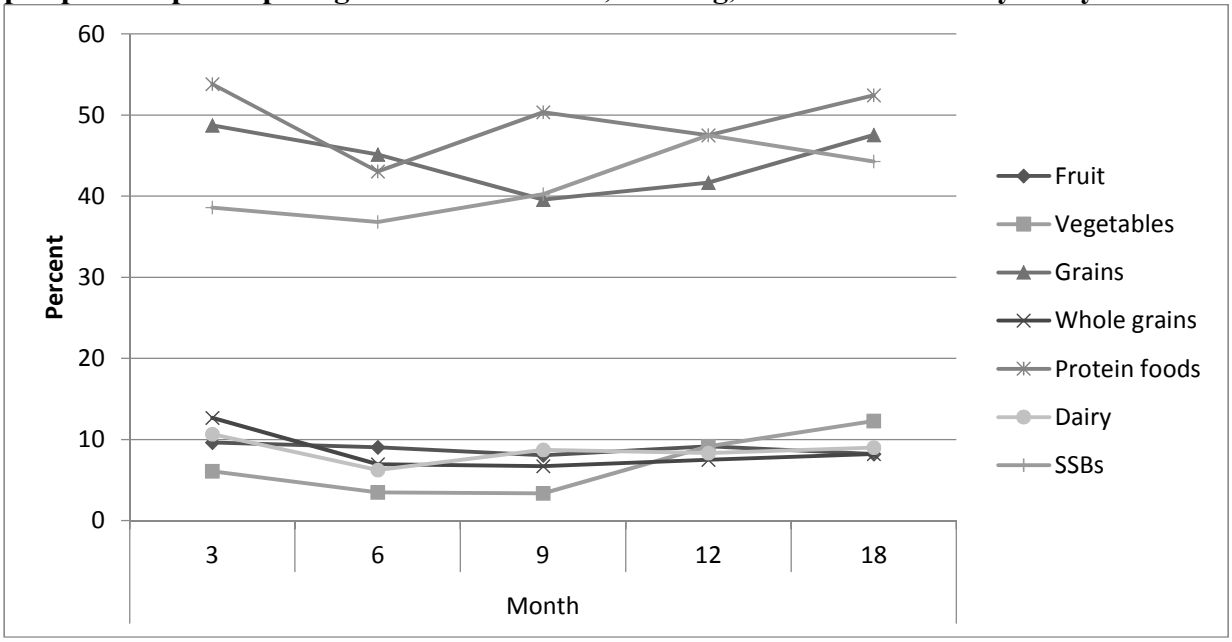


Table 5 shows the results of the random effects logistic regression, which assesses the odds of meeting the DGAs for each food group as well as the estimated UL for SSBs for each maternal demographic and household characteristic, while controlling for the others. No characteristics were predictive of meeting the 2015-2020 DGAs at the $p<0.001$ level, correcting for multiple comparisons. Although not significant, mothers were less likely to meet the DGA for dairy if they had a high school education compared to those with less than a high school education ($p<0.05$). Additionally, mothers who were still breastfeeding were more likely to meet the DGA for dairy compared to those who were not still breastfeeding; and mothers from single-headed households were more likely to meet the DGA for vegetables compared to mothers who were not from single-headed households ($p<0.05$).

Table 5. Predictors for meeting the 2015-2020 Dietary Guidelines for Americans and an estimated upper limit for sugar-sweetened beverage intake in mothers 3-18 months postpartum participating in the Infant Care, Feeding, and Risk of Obesity study.

	Odds ratio and 95% Confidence Interval (n=722 observations on 198 women)													
	Fruit		**Vegetables**		**Grains**		**Whole Grains**		**Protein**		**Dairy**		**SSB**	
Age	1.01	0.89,1.15	1.01	0.93,1.10	0.96	0.90,1.01	1.05	0.95,1.17	1.00	0.94,1.06	0.99	0.89,1.09	1.05	0.98,1.12
Education														
High School	0.34	0.09,1.28	0.93	0.39,2.26	0.64	0.39,1.04	0.55	0.21,1.40	0.71	0.42,1.20	0.32*	0.12,0.86	0.87	0.48,1.59
Some College	2.39	0.79,7.27	0.97	0.40,2.31	0.76	0.46,1.25	0.70	0.27,1.77	0.74	0.43,1.28	0.86	0.37,2.02	1.55	0.85,2.86
College or higher	0.85	0.14,5.10	1.83	0.57,5.85	0.77	0.36,1.65	0.50	0.11,2.28	0.82	0.36,1.87	1.21	0.34,4.29	1.34	0.53,3.38
Employed	0.79	0.38,1.61	0.64	0.34,1.19	1.03	0.72,1.46	0.61	0.32,1.16	0.78	0.54,1.12	1.02	0.55,1.90	0.90	0.61,1.34
Breastfeeding	1.69	0.62,4.62	1.85	0.76,4.54	1.13	0.66,1.94	1.95	0.82,4.67	0.96	0.55,1.67	2.46*	1.08,5.63	0.99	0.54,1.83
Depressive Symptoms	0.99	0.45,2.19	1.23	0.62,2.44	0.92	0.63,1.34	1.23	0.61,2.48	0.91	0.61,1.35	1.13	0.58,2.24	1.11	0.72,1.70
Single-headed Household	0.36	0.13,1.01	1.98*	1.04,3.76	0.78	0.51,1.18	0.61	0.26,1.42	0.83	0.54,1.29	1.00	0.48,2.08	0.70	0.43,1.13
Weight status														
Overweight	1.20	0.42,3.45	0.72	0.30,1.73	0.61	0.38,1.00	0.60	0.23,1.55	0.84	0.50,1.42	1.04	0.43,2.51	1.22	0.68,2.19
Obese	0.82	0.31,2.18	1.00	0.49,2.06	0.73	0.48,1.13	0.89	0.40,1.97	1.22	0.76,1.94	1.18	0.54,2.57	1.36	0.80,2.29

- $p < 0.05$, ** $p < 0.01$

Discussion

To our knowledge, this is the first longitudinal study to examine diet quality in relation to the 2015-2020 DGAs in a cohort of NHB mothers followed from 3-18 months postpartum. Overall, intake levels remained relatively constant with no significant changes in dietary behaviors or likelihood for meeting the 2015-2020 DGA or estimated UL for SSBs over the 15-month period. Most mothers did not meet the DGAs for any of the food groups. A large number did not consume any fruit on a given day and vegetable consumption was far below recommended levels. The median intake among consumers of grains neared recommended levels for most mothers, but whole grain intake was low, suggesting most grains are coming from refined, processed foods. When compared to a representative sample of U.S. women 20 and older, fruit, vegetable and dairy consumption in the Infant Care sample was lower at 2.0 vs. 2.2, 1.2 vs. 2.9, and 1.0 vs. 1.5 servings per day, respectively; grain consumption was comparable at 5.6 ounces per day and protein was greater at 5.5 vs.4.9 ounces per day (US Department of Agriculture et al.).

Our study demonstrates that early motherhood is accompanied by poor dietary choices. Cross-sectional studies among women at different time points in the postpartum period have found similar results, with mothers often not meeting recommended intake levels, particularly for F&V, while consuming excessive amounts of SSBs (Durham et al., 2011; Fowles & Walker, 2006; G. C. George et al., 2005; van der Pligt et al., 2016). Few studies have looked at changes in maternal diet longitudinally throughout the postpartum period. George et al. compared intake during pregnancy and 6 months postpartum and found that F&V consumption declined while intake of added sugars increased (G.C. George et al., 2005). Olson looked at food choice behavior during pre-pregnancy, pregnancy and postpartum and reported insufficient intake of

F&V, which, similar to our results, remained constant during the postpartum period (Olson, 2005). However, this study was conducted in a predominately white (96%), higher income sample.

Our study reports on a comprehensive set of dietary recommendations and highlights the need for intervention early during the transition to motherhood and throughout the postpartum period, particularly for low-income, NHB mothers. Cost and lack of time for food preparation may be contributing factors to the poor dietary behaviors seen in our study. More than half of participants were working at each time point and nearly all were receiving WIC benefits. Studies show that low-income mothers have lower intakes of F&V and low-fat dairy foods and intakes of F&V decline with decreasing income (Kendall, Olson, & Frongillo, 1996; Tarasuk, 2001). Despite shifting domestic roles, mothers remain principal family food providers. Time spent working could influence the number of meals cooked and consumed at home, thus placing a heavy emphasis on meals and snacks away from home or on prepackaged, ready-to-eat foods, which are often of lower nutritional quality (Robson, Crosby, & Stark, 2016).

Reaching mothers during the postpartum time period is important, especially for socioeconomically disadvantaged women who are often less health-conscious (Pampel, Krueger, & Denney, 2010), but are connected to health and nutrition services through WIC. During the postpartum period women are often receptive to nutrition education, which has been shown to influence vegetable intake and increase nutrition knowledge, particularly in mothers participating in WIC (Nuss, Freeland-Graves, Clarke, Klohe-Lehman, & Milani, 2007; van der Pligt et al., 2016). Intervening during the postpartum period has the potential to influence not only maternal diet, but also infant diet (Papas et al., 2009; Robinson et al., 2007; Wen et al., 2013). This is important, as eating patterns that emerge during infancy have been shown to track through

childhood and have lasting effects on food preferences and control of intake later in life (Golley et al., 2013; North & Emmett, 2000; Northstone & Emmett, 2005; Skinner et al., 2002). Since maternal diet quality in our sample was poor early in the postpartum period and did not improve over time, interventions may be best timed to begin during the prenatal period. Pregnancy is considered a "teachable moment" where mothers are motivated to adopt risk-reducing health behaviors that are within their means (Phelan, 2010). However, these interventions should continue through the postpartum period, a time that can be stressful, particularly for first time mothers, as they adjust to hormonal and sleep changes, the demands of caring for a newborn and adapting to their new role as parents (L. George, 2005).

Knowing whom to target for nutrition interventions is an area needing more research. The lack of significant findings for the various demographic and household characteristics in predicting the likelihood of mothers meeting recommended intake levels for each of the food groups is likely due to the homogenous nature of our sample in that most mothers were not consuming recommended levels and therefore not meeting the DGAs. In addition, the women sampled were all NHB low-income first-time mothers, recruited through WIC clinics; it is possible that income levels are driving the suboptimal dietary behaviors we uncovered rather than the demographic predictors. Future studies should include a larger, more heterogeneous sample to identify demographic and household predictors of maternal diet quality. Given the large percentage of overweight or obese women in our sample, underreporting of intake is a concern (Braam, Ocke, Bueno-de-Mesquita, & Seidell, 1998; G. Johansson, Wikman, Ahren, Hallmans, & Johansson, 2001; L. Johansson, Solvoll, Bjorneboe, & Drevon, 1998). However, considering the reported intakes as conservative estimates only strengthens the need to intervene, for intake of important food groups like whole grains were low, whereas that of fried vegetables

and SSBs was high. Using the LOCF method for predictors that are expected to change, such as employment and depression could impact our findings by inducing bias as well as understating variability. However, sensitivity analyses using complete case data revealed no significant changes in our conclusions. Lastly, as with any cohort study with loss to follow up, it is important to note potential selection bias due to attrition. Mothers who dropped out of the study were less likely to be older, married, breastfeeding and have a college education, characteristics often associated with poor diets. However, despite the loss of mothers more at risk for poor diet quality, our conclusions still demonstrate the need to intervene.

The strengths of the current study outweigh the limitations. This study is innovative, as it is one of the first to examine post-partum maternal diet quality over time in a population at high-risk for obesity. Few studies have looked at NHB women specifically, a priority population given their different behavioral patterns and infant feeding practices compared to other races/ethnicities, such as greater likelihood for early introduction of inappropriate foods (A. L. Thompson & Bentley, 2013). The longitudinal nature of the data allowed us to simultaneously model and determine the relationship between the longitudinal development of diet quality and the longitudinal changes in maternal diet and household characteristics. Although we had one 24HDR at each time point our results demonstrated a lack of change in consumption patterns over time, thus providing multiple 24HDR to characterize the postpartum period, which provides a unique dataset for others explore. Additionally, using a comparable classification of intake such as the DGAs allows for the comparison of diet in various other populations.

Conclusion

Diet quality for women is suboptimal during the postpartum period and prospective and comprehensive examination of food choices beyond 12 months postpartum is limited, especially in vulnerable populations such as NHB families. This study attempts to close the gap in the literature by describing maternal intake during a time when it can heavily influence the diets of their children. The impact these maternal dietary behaviors can have on infants should not be ignored given the implications role modeling and breastfeeding can have on a child's dietary habits and food preferences. Therefore, future research should focus on the relationship between maternal and infant intake with the goal of uncovering effective intervention targets to prevent early obesogenic patterns from being adopted.

CHAPTER V: CONSUMPTION OF OBESOGENIC FOODS IN NON-HISPANIC BLACK MOTHER-INFANT DYADS.

Overview

This study examined the association between maternal and infant consumption of key food groups from 6 to 18 months using data from the Infant Care, Feeding and Risk of Obesity Study, a prospective cohort of 217 non-Hispanic black, WIC eligible, first-time mothers. Using data from 24-hour dietary recalls collected during in-home visits at 6-, 9-, 12- and 18-months, we assessed intake of both energy-dense, nutrient-poor (obesogenic) food groups and fiber-, nutrient-rich food groups for mothers and their infants. Both mothers and their infants had high intake of sugar-sweetened beverages, desserts and sweets and low intake of vegetables and whole grains. Infant consumption of key food groups was strongly associated with maternal consumption, suggesting the need for focused interventions to target maternal diet as a pathway to decreasing risk for the establishment of poor dietary patterns early in life.

Introduction

Childhood obesity continues to be a major public health concern, affecting even the youngest age group of infants and toddlers (C. L. Ogden et al., 2014). Currently, 8.1% of children under 2 are considered at risk for obesity (weights-for-length $\geq 95^{th}$ percentile) with rates higher among non-Hispanic black (NHB) children compared to non-Hispanic white children (NHW) (Dalenius et al., 2012; Freedman, 2011). Being overweight in the first 2 years of

life is associated with obesity and higher risk for chronic diseases in adolescence and adulthood (Baird et al., 2005; Nader et al., 2006; Reilly et al., 2005; Skilton et al., 2013; Stocks et al., 2011; Taveras et al., 2011). Obesogenic diets, or diets high in energy-dense, nutrient-poor foods, are provided early with infants being fed sugar-sweetened beverages (SSBs), desserts and sweets as early as 6 months, while a substantial proportion of infants > 6 months consume no fruits or vegetables in a given day (Saavedra et al., 2013; Siega-Riz et al., 2010; A. L. Thompson & Bentley, 2013). Eating patterns that emerge during infancy track through childhood and have lasting effects on the development of food preferences and control of intake later in life (Golley et al., 2013; North & Emmett, 2000; Northstone & Emmett, 2005; Skinner et al., 2002). For example, children who consume SSBs during infancy are more likely to consume them at age 6 years whereas not consuming fruits and vegetables (F&V) makes children less likely to consume them later on (Park et al., 2014). High intake of obesogenic foods combined with low intake of foods rich in fiber and nutrients, such as F&V, sets up a predisposition for unhealthy diets, increasing risk for obesity (Dattilo et al., 2012). One possible, yet understudied, determinant of infant diet is maternal diet (Howard et al., 2012; Wen et al., 2013). Mothers are typically responsible for purchasing food, preparing meals and feeding their children. A mother's preference for and consumption of certain foods could impact whether or not they are offered to her children, which for older children, has been shown to influence not only their dietary preferences, but also their weight (Fisher & Birch, 1995; Howard et al., 2012; Papas et al., 2009; Robinson et al., 2007; Saavedra et al., 2013).

The *2015-2020 Dietary Guidelines for Americans* (DGAs) recommend increased consumption of F&V, whole grains and lean protein foods, particularly in place of foods high in added sugar, refined grains and saturated fat, for they reduce the risk of disease and help manage

weight (U.S. Department of Health and Human Services & U.S. Department of Agriculture, 2015). Infants of mothers who meet dietary recommendations for fruits, vegetables and whole grains are more likely to have diets that include these items whereas infants of mothers who eat energy dense/nutrient poor foods are more likely to also consume those foods (Robinson et al., 2007). For many women, diet quality is suboptimal, particularly in the postpartum period (Durham et al., 2011; Fowles & Walker, 2006; G.C. George et al., 2005; Wiltheiss et al., 2013). For example, 92.7% of adult females aged 19-30 do not meet the minimum recommendation for fruit, 94.1% for vegetables and 99.8% for whole grains (Krebs-Smith, Guenther, Subar, Kirkpatrick, & Dodd, 2010). The DGAs also include a discretionary calorie allowance, which provides caloric limits for excess energy from solid fats and added sugars. These "empty calories", or sources of energy with little to no nutritional value, contribute more than the recommended amount in American diets. Nearly all children aged 2-3 years (99.4%) and 94.4% of adult females aged 19-30 years exceed recommendations for solid fats and 98.3% and 85.0% exceed recommendations for added sugars, respectively (Krebs-Smith et al., 2010). Increasing evidence suggests that consuming obesogenic foods like desserts, sweets and SSBs in place of nutrient- and fiber-rich foods such as F&V contributes to unhealthy eating patterns and weight gain (Houchins et al., 2012; Leahy et al., 2008; Rolls et al., 2004).

Understanding the influence that maternal diet has on infant diet may be particularly important among NHB families, owing to their different feeding practices compared to other races/ethnicities, such as greater likelihood for early introduction of inappropriate foods (A. L. Thompson & Bentley, 2013) and breastfeeding rates that lag far behind that of white and Hispanic women (Centers for Disease & Prevention, 2010). Yet few studies have been conducted among dyads from this important racial/ethnic group. Given the importance of early learning on

the development of food preferences and the prevalence of obesogenic diets, a need for longitudinal studies focused on infant consumption in NHB families exists. The purpose of this study is to 1) explore maternal and infant consumption of key food groups from 6-18 months postpartum in a low-income, NHB population, 2) identify predictors of maternal and infant intake, and 3) determine associations between maternal and infant consumption of key food groups so that results can be used to guide interventions aimed at influencing intake during the first two years of life.

Participants

Data come from the Infant Care, Feeding and Risk of Obesity Project (Infant Care), a longitudinal, observational cohort study of first-time, NHB mothers aged 18-35 years who were recruited through the North Carolina Supplemental Nutrition Program for Women Infants and Children (WIC) (Laraia et al., 2009; Sacco et al., 2007; A. L. Thompson et al., 2013b; A. L. Thompson & Bentley, 2013; H. Wasser et al., 2011; H. M. Wasser et al., 2013). Data collection began in November 2003 and was completed in October 2007. A total of 217 dyads were recruited. Mother-infants dyads were followed with in-home visits when infants were 3, 6, 9, 12, and 18 months of age. At each home visit, various maternal, infant and household characteristics were assessed through interviewer-administered questionnaires. Infants who were $\leq$35 weeks gestation, <2500 or $\geq$ 4500 grams in birth weight, had chronic or congenital illness, were receiving medical treatment that interfered with dietary intake, growth, or development (e.g., Down's syndrome, cerebral palsy, epilepsy, diagnosed mental retardation, cleft lip or palate), or presented with failure-to-thrive were excluded from the study.

The analytic sample includes 179 mother-infant dyads with dietary intake data at months 6,

9, 12 and 18. The protocol was approved by the Institutional Review Board at the University of North Carolina at Chapel Hill.

Methods

Dietary intake

During each home visit, maternal and infant dietary intakes were assessed with computerized 24-hour dietary recalls (24HDR) administered by trained study personnel using the Nutrient Data System for Research (NDS-R^{TM}) (version 2005; Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN). For infants, to improve estimates of usual food intakes an additional 24HDR was collected via telephone on a random, nonconsecutive day within 2 weeks of the home visit (F. E. Thompson & Subar, 2013). Mothers were instructed in advance to obtain information about any foods and beverages consumed by the infant while not in her care. Food models and pictures were used to aid in the estimation of portion sizes. One 24HDR was used for mothers and an average of two 24HDR were used for infants from each visit.

Food groups were defined according to the DGAs: fruits (including 100% fruit juice), vegetables (excluding fried vegetables), whole grains and lean protein foods (meat, poultry, seafood, eggs, soy products and nuts). In addition, obesogenic food groups were also included which consisted of SSBs, salty snacks, desserts and sweets, and fried vegetables, which includes French fries, hash browns and onion rings. Servings from each of the specific food groups at each time point were obtained by using the NDS-R Food Group Serving Count System. Serving sizes were based on the recommended adult servings that were current at the time the survey was administered, which were defined per the 2005 DGAs or, for foods not recommended in the

DGAs (e.g. cookies, SSBs), the food-label serving sizes from the Food and Drug Administration. Mothers and infants were defined as "consumers" of a food group if it occurred at least once in the food record.

Predictor variables

Predictors of intake were drawn from the literature and include factors previously associated with maternal and infant diet: maternal education, age, BMI, marital status, employment, depression, living in a single-headed household, breastfeeding and infant weight-for-height and sex (G.C. George et al., 2005; Hendricks et al., 2006; Smithers et al., 2012; Wiltheiss et al., 2013). Depression was measured using the Center for Epidemiological Studies Depression Scale (Radloff, 1977). For breastfeeding status, mothers were asked at each visit whether they were still breastfeeding. Maternal weight and height were measured by a trained research assistant at a subset of visits (3, 6 and 18 months) and BMI was calculated for each individual (weight(kg)/height(m)^2). Weight status was categorized based on international classification guidelines: underweight/normal = BMI<25; overweight = BMI 25-29.9; and obese = BMI ≥30.0. Infant anthropometrics were measured at each home visit. Weight-for-length z-scores (WLZ) were calculated using the CDC/NCHS 2000 growth reference (C. L. Ogden et al., 2002). Lastly, to account for infants and toddlers who were fed the majority of their foods from someone other than their mother, we included a measure for the presence of a non-maternal caregiver (NMC), similar to Wasser et al., which was defined as a person involved in feeding an infant or toddler 50% or more of his/her total feedings in a day (H. M. Wasser et al., 2013).

Statistical analysis

Sample characteristics at each time point (6, 9, 12 and 18 months) are described as frequencies for categorical variables and means for continuous variables. Data are presented as the proportion consuming any amount of a food group at each time point. Pearson's correlation was used to test for collinearity among predictors. Marital status was highly correlated with education and single-headed households ($r \geq 0.7$) and was therefore dropped as a predictor. We assessed the bivariate relationship of demographic and household characteristics with infant and maternal intake separately for each food group.

We used random-effects logistic regression models to assess how infant consumption of foods from each food group related to maternal consumption of that same food group, adjusting for demographic and household characteristics shown to be significant predictors in the bivariate analyses, plus a variable representing study visit (time). All tests were two-sided, and *p* values <0.05 were regarded as statistically significant. Due to correlations between outcome variables, correction for multiple testing using the Bonferroni method (which assumes totally independent tests and variables) was not applied. To account for missingness in the demographic and household predictor values we imputed using the last observation carried forward (LOCF) method. To address the potential for selection bias, differences in baseline characteristics between those who were present and those who were absent at each visit were assessed. All analyses were conducted using Stata 14 (StataCorp, College Station, TX).

Results

Dietary recalls were collected from 143 mothers-infant dyads at month 6 (65.9%), 147 at month 9 (67.7%), 120 at month 12 (55.3%) and 122 at month 18 (56.2%) (see Table 6). There

was a high prevalence of obesity within this sample of young, first-time NHB mothers. Most mothers were receiving WIC benefits and many were employed. Few mothers were still breastfeeding at 6 months and rates significantly decreased over time. Approximately half of infants and toddlers were fed by a NMC at each time point. Differences among those who had complete dietary recalls versus those who did not at each time point revealed few significant differences (see Table 6). Mothers with dietary recalls at 12 months were more likely to be older, married, breastfeeding and have a college education and less likely to have an overweight infant at baseline. Those with dietary recalls at 18 months were more likely to be older and breastfeeding at baseline.

Table 6. Demographic characteristics of mothers and infants participating in the Infant Care, Feeding, and Risk of Obesity study.

		Study visit (month)			
		6 (n=143)	9 (n=147)	12 (n=120)	18 (n=122)
Maternal characteristics					
Age, y (sd)		23.0 (3.9)	23.3 (3.9)	24.2 (4.2) ***	24.5 (4.1) **
Education, % (n)	<High school	26.6 (38)	26.5 (39)	25.0 (30)	26.2 (32)
	High school graduate	28.0 (40)	27.2 (40)	22.5 (27)	27.9 (34)
	≥Some college	34.3 (49)	34.0 (50)	39.2 (47)	33.6 (41)
	≤College graduate	11.2 (16)	12.3 (18)	13.3 (16) *	12.3 (15)
Married, % (n)		10.6 (15)	13.9 (19)	14.6 (16) *	17.0 (16)
Single headed household, % (n)		24.1 (34)	23.4 (33)	24.6 (29)	30.9 (30)
Currently working, % (n)		61.9 (86)	63.1 (89)	58.6 (68)	61.0 (61)
Receiving WIC, % (n)		92.9 (131)	90.2 (129)	85.7 (96)	74.3 (84)
Depressed[a], % (n)		29.7 (38)	24.8 (35)	15.7 (18)	37.3 (38)
Still breastfeeding, % (n)		16.2 (23)	11.0 (16)	6.7 (8) *	2.5 (3) *
Weight status[b], % (n)	Underweight/normal	28.6 (40)	NA	NA	30.1 (25)
	Overweight	23.6 (33)	NA	NA	21.7 (18)
	Obese	47.9 (67)	NA	NA	48.2 (40)
Non-maternal caregiver[c]		55.9 (80)	56.0 (79)	58.5 (69)	57.4 (58)
Infant characteristics					
Sex (male), %, (n)		44.1 (63)	46.9 (69)	45.0 (54)	48.4 (59)
Overweight (>95th percentile), % (n)		15.5 (22)	15.2 (22)	12.1 (14) **	11.5 (14)

Significantly different at baseline at * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

[a]Measured using the Center for Epidemiological Studies Depression Scale with a score of ≥16 indicating depressive symptoms.

[b]Weight status was not measured at the 9 and 12 month visits.

[c]Use of a non-maternal caregiver for majority of infant or toddler total feedings in a day.

Across study visits, most mothers reported consuming vegetables and lean protein foods, while less than half consumed fruit, juice and whole grains on a given day (see Figure 5). Most mothers reported consuming SSBs and at least a quarter of the mothers consumed desserts and sweets, fried vegetables and salty snacks on a given day. Over time, the percentage of children consuming each of the food groups increased with nearly all children consuming fruit, vegetables, lean protein foods and juice at the 18-month visit. At the 12-month visit at least half the children consumed SSBs, desserts and sweets and salty snacks. At the 18-month visit more than half the children consumed fried vegetables, SSBs and salty snacks, and over 80% consumed desserts and sweets. A smaller proportion of fruit, vegetables and juice came from baby foods across study visits. Compared to mothers, a higher percentage of infants consumed fruit, whole grains, juice and desserts and sweets.

The bivariate analyses revealed various significant predictors of intake for both mothers and their infants (see Tables 7 and 8). Older mothers were more likely to consume fruit and whole grains, and less likely to consume fried vegetables and SSBs. Mothers with at least some college education were more likely to consume fruit, whole grains, desserts and sweets and less likely to consume fried vegetables compared to mothers with less than a high school education. Breastfeeding mothers were more likely to consume fruits and less likely to consume fried vegetables. Mothers were less likely to consume whole grains if they exhibited depressive symptoms.

Infants of older mothers were more likely to consume whole grains, desserts and sweets. Infants were less likely to consume lean protein foods, fried vegetables, SSBs and salty snacks as their mother's education level increased. If their mother was still breastfeeding, infants were less likely to consume lean protein foods, fried vegetables and SSBs. Infants were more likely to

consume lean protein foods and fried vegetables if their mother had depressive symptoms. Infants were more likely to consume fruit if their mother was obese. Boys were less likely to consume fruit compared to girls.

The results from the adjusted logistic regression random effect models revealed that if mothers consume obesogenic foods, their infants are more likely to do so. Infants were at least 2 times as likely to consume SSBs, desserts, sweets and salty snacks if their mother consumed them (see Table 9) and more than 3 times as likely to consume fried vegetables. Infants were more likely to consume fruit if their mother consumed it, though the association was attenuated when juice was excluded (data not shown). There were no significant associations of maternal intake of vegetables, whole grains or lean protein foods with infant intake of these foods. Infants were more likely to consume whole grains if their mother was older. Infants were more likely to consume lean protein foods and fried vegetables if their mother exhibited depressive symptoms. Infants were less likely to consume lean protein foods, SSBs and salty snacks if their mother had a higher education level. There were no significant associations among infants of mothers breastfeeding or from single-headed households for any of the food groups.

Discussion

This study explores maternal and infant intake of key food groups from 6 to 18 months postpartum and examines associations between maternal consumption of such foods and infant consumption. Understanding the link between diets of mothers and their young children is important as it broadens our understanding of potential pathways for influencing early life nutrition that can help to refine nutrition-focused interventions and improve dietary intakes of these young children. This study demonstrates that NHB infants are consuming obesogenic foods

such as SSBs as early as 6 months and continuing to do so through infancy. Our results were similar to those in a study of a nationally representative sample of infants aged 0 to 48 months in which 43% of 9–11 months olds consumed some type of dessert, sweet or SSB at least once in a day and this percentage increased to 72% at 12-23 months (Saavedra et al., 2013; Siega-Riz et al., 2010).

Despite early consumption of obesogenic foods, overall infant diets were better than those of their mothers, a finding supported elsewhere (S. Hoerr, Dersch, Vandenbilt, Luster, & VonEye, 1998; Lee et al., 2005). For example, in our sample, less than half of mothers consumed fruit and whole grains on a given day and although many consumed vegetables, the average median serving was 1.25, which is a quarter of the recommended daily amount. Furthermore, most women consumed SSBs and many consumed desserts and sweets. These results aren't surprising; other research shows that for many women diet quality is suboptimal, particularly in the postpartum period (Durham et al., 2011; Fowles & Walker, 2006; G.C. George et al., 2005; Wiltheiss et al., 2013).

In assessing predictors of infant and maternal intake, it is evident that certain demographic and household characteristics can have an impact on what children and their mothers eat, particularly maternal age, education and breastfeeding. Higher maternal education levels and age are generally associated with a more favorable eating pattern in infants (Brekke, van Odijk, & Ludvigsson, 2007; Northstone & Emmett, 2005; Robinson et al., 2007; Smithers et al., 2012; Svensson et al., 2016). In our study a higher education level was associated with infants being less likely to consume obesogenic foods. Mothers with higher education appear to know or follow recommendations for feeding healthier foods to their infants, however they do not appear to apply this information to their own diet.

Our study demonstrates that infant consumption is strongly associated with that of their mother. Infants were significantly more likely to consume key food groups if their mother consumed them, particularly obesogenic foods. Interestingly, infants of mothers exhibiting depressive symptoms were more likely to consume lean protein foods and fried vegetables. Although most lean protein foods are considered healthy choices, the most commonly consumed lean protein food among mothers in this study were chicken drumsticks with the skin eaten (data not shown), which have higher calories, fat and saturated fat compared to other forms of chicken. In addition, the most commonly consumed fried vegetables were fast food French fries. Evidence is sparse, but some studies have linked maternal mental health to dietary patterns in older children (Ystrom, Niegel, & Vollrath, 2009). During times of stress, mothers may be more likely to feed their children, and themselves, unhealthy foods, perhaps for ease in caregiving, leading to convenient, and often unhealthy, food choices (Hurley, Black, Merry, & Caulfield, 2015; Ystrom et al., 2009).

The home environment is key to understanding the development of children's diet and food preferences, for young children ages 2-6 years consume 71% of their daily energy intake at home (Poti & Popkin, 2011). As infants make the significant dietary transition from a milk-based diet to foods indicative of their caregiver's diet, they learn what, when and how much to eat from those around them. Although few studies exist among infants, studies among mothers of preschool-age children suggest that maternal influence on children's food intake occurs primarily through role modeling and food availability in the home (Anzman, Rollins, & Birch, 2010; Hart et al., 2010; Wang, Beydoun, Li, Liu, & Moreno, 2011). Role modeling healthy food choices (e.g., F&V and foods low in added sugar and fat) is an important component to shaping healthy diets in children. Maternal preference for obesogenic foods can send conflicting messages, such

as when asking a child to eat F&V that she herself is not consuming. However, few interventions aim to change maternal diet directly (Havas et al., 1998; Lioret et al., 2012; Ostbye et al., 2012). What our study shows is that an important and often overlooked path for intervening on infant diet is through maternal diet as it can influence the types of complementary foods available in the home and subsequently offered.

A major strength of this study is that it consisted of longitudinal data on matched mother-infant dyads. To our knowledge, it is the first study to focus on the consumption of key food groups in infants and toddlers among a sample of NHB, low-income mothers, a population often not well represented in national surveys. Although our focus is on a unique and understudied population, these findings should be considered with caution in light of some limitations. First, given the focus on a particular population, generalizability of findings may be limited. The women sampled were all NHB first-time mothers, recruited through WIC; future studies should include a larger, more heterogeneous sample. However, data were collected prior to the reauthorization of WIC food packages, which now include vouchers for fresh F&V; an important policy change that could influence F&V intake, warranting future research in this population. The use of a single 24HDR for assessing maternal intake could bias our estimates of episodically consumed foods due to the inability to classify an individual as a true non-consumer. However, aggregating foods into key food groups can minimize this risk; furthermore, one-day estimates from 24HDR have been used in other studies such as the Feeding Infants and Toddlers Study (FITS), a dietary intake survey of parents and caregivers of young children (R. Briefel et al., 2006). Although we use only one 24HDR at each time point, sensitivity analyses demonstrated a lack of change in consumption patterns over time (data not shown); therefore we chose to use one recall from each time point in order to match on infant recalls. In measuring the association

between infant and maternal intake, it is important to note that we are not measuring concordance of intake, for at least one of the two 24HDR for infants was collected on a different day than the mother's. Given that approximately 60% of mothers were employed at each time point, infants are not likely to be eating every meal with their mother. The significant associations found among infant and maternal intake are likely due to both the food environment, which is largely shaped by the mother, and role modeling. Lastly, as with many cohort studies, our results are subject to selection bias due to loss to follow up, especially given mothers who did not complete the study exhibited characteristics often associated with poor diets. However, sensitivity analyses using complete case data revealed no significant differences in results.

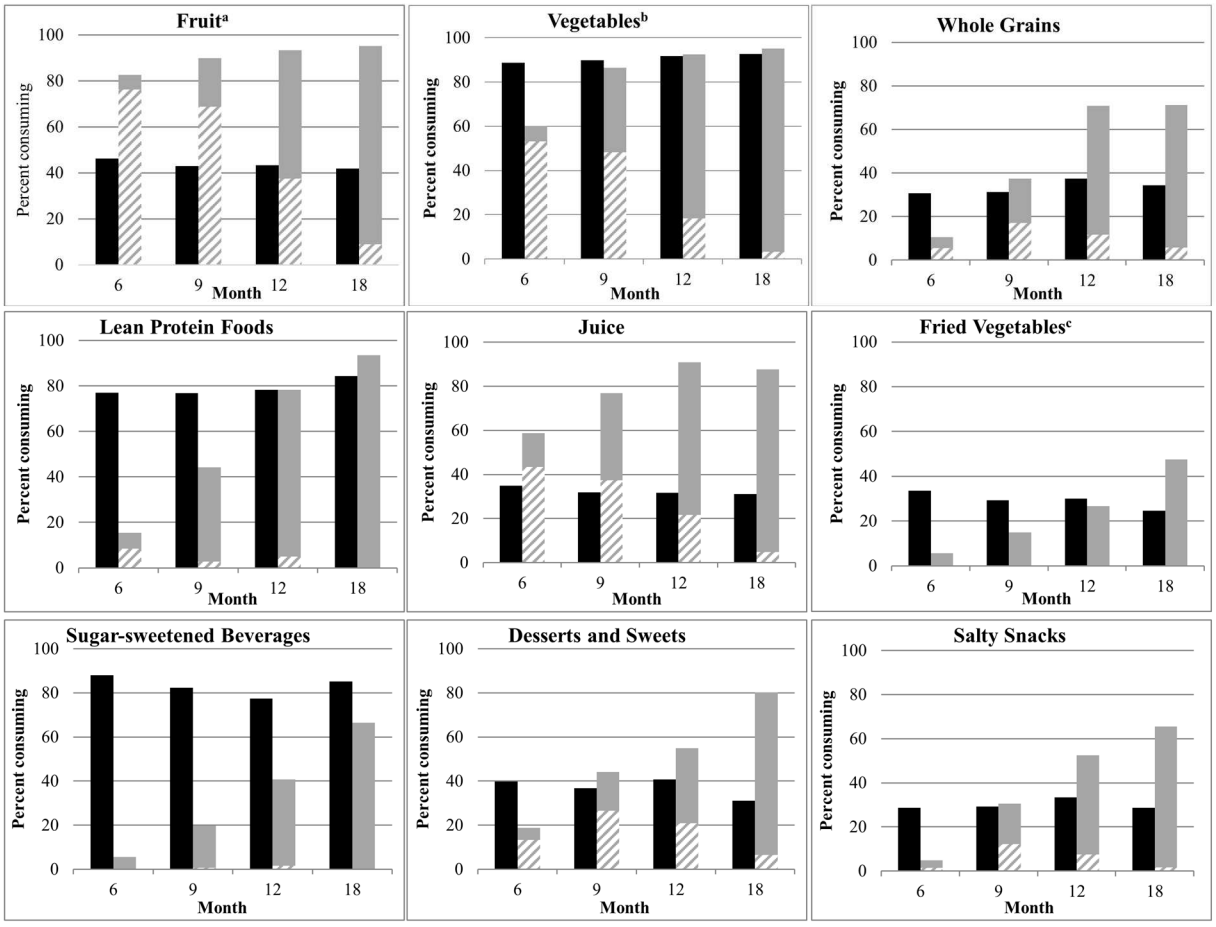
Future research should focus on developing effective interventions that support mothers in adopting healthy eating behaviors for themselves and their children throughout the postpartum period. Our research shows that mothers may have adequate knowledge of what constitutes a healthy diet, and thus feed their children in that way, but adequate nutrition knowledge may not be a sufficient factor in influencing their own intake (Worsley, 2002). Given the link between maternal and infant consumption, particularly for obesogenic foods, and the importance of role modeling healthy food choices as children age and their acceptance of solid foods broadens, targeting maternal diet could be an effective strategy for preventing early life obesity.

Conclusion

This study is both timely and important, for it provides evidence that dietary guidelines are needed for infants and toddlers. Currently the DGAs begin at age 2, with no specific guidelines for children from birth to 2 years or pregnant and breastfeeding mothers other than to increase folic acid intake. An initiative is under way to include these populations in future

DGAs, which, as our study demonstrates, is necessary for these populations are likely falling short in consuming recommended foods. Children are consuming foods associated with obesity early in life, yet few studies focus on the impressionable time period of 0-2 years. Given the early emergence of diet-related diseases such as obesity, infancy is an opportune time to intervene, for that is when food preferences and lifelong diet habits begin to form. In addition, the effects maternal dietary behaviors can have on infant consumption patterns is not well understood. The impact maternal dietary behaviors can have on infants should not be ignored given the implications role modeling can have on a child's dietary habits and food preferences. Programs that target adoption of healthy eating behaviors in mothers may prove beneficial for young children's eating behaviors and subsequent obesity risk.

Figure 5. Percent consuming key food groups among mothers and infants aged 6 to 18 months participating in the Infant Care, Feeding, and Risk of Obesity study.



Legend: ■ Mom, ■ Infant, ▨ Proportion of foods consumed by infants that were baby foods

[a]All fruit, including whole fruit and juice

[b]All vegetables, including whole and juice, excluding fried vegetables

[c]Includes breaded and fried vegetables such as French fries, hash browns and onion rings

Table 7. Bivariate analysis (Odds Ratio, 95% Confidence Intervals) of maternal consumption of key food groups and household and demographic predictors in mothers 6 to 18 months postpartum participating in the Infant Care, Feeding, and Risk of Obesity study

		Fruit[a]		Vegetables[b]		Whole grains		Lean Protein foods[c]		Fried Vegetables[d]		SSB[e]		Desserts and sweets		Salty Snacks	
Maternal characteristics																	
Age		1.12***	1.05, 1.20	1.01	0.93, 1.09	1.06*	1.01, 1.13	1.02	0.96, 1.09	0.91**	0.86, 0.97	0.88**	0.81, 0.96	1.02	0.97, 1.08	1.01	0.95, 1.06
Edu-cation[f]	High school	0.66	0.32, 1.35	1.42	0.56, 3.61	1.38	0.73, 2.60	0.51	0.25, 1.02	0.68	0.39, 1.17	1.01	0.37, 2.80	0.97	0.51, 1.84	0.74	0.39, 1.39
	≥ Some College	2.89***	1.55, 5.38	0.94	0.43, 2.02	1.99*	1.13, 3.48	0.77	0.41, 1.47	0.44**	0.27, 0.73	0.48	0.20, 1.15	1.93*	1.10, 3.39	0.88	0.51, 1.53
Employment		1.48	0.91, 2.40	0.72	0.37, 1.38	0.90	0.58, 1.39	0.95	0.59, 1.55	0.99	0.65, 1.51	0.98	0.53, 1.83	1.53	0.97, 2.39	0.78	0.50, 1.21
Breastfeeding		3.04*	1.38, 6.73	1.88	0.53, 6.65	1.72	0.87, 3.39	1.02	0.46, 2.29	0.44*	0.20, 0.96	1.18	0.44, 3.19	1.72	0.86, 3.41	1.48	0.74, 2.95
Depressive symptoms		1.25	0.73, 2.12	1.56	0.72, 3.38	0.49**	0.30, 0.81	0.96	0.56, 1.64	1.14	0.72, 1.80	1.10	0.56, 2.17	0.75	0.46, 1.22	0.86	0.53, 1.41
Single-headed household		1.06	0.60, 1.90	0.62	0.31, 1.23	0.75	0.45, 1.26	0.64	0.38, 1.10	0.78	0.48, 1.28	0.93	0.43, 1.97	0.87	0.52, 1.45	0.58*	0.34, 0.99
Weight	Over-weight	1.18	0.56, 2.48	0.53	0.21, 1.31	1.37	0.73, 2.56	0.77	0.39, 1.49	1.00	0.56, 1.79	0.58	0.22, 1.58	0.87	0.46, 1.65	0.82	0.44, 1.54
	Obese	0.90	0.47, 1.74	0.70	0.30, 1.61	1.34	0.77, 2.32	1.30	0.71, 2.38	0.63	0.38, 1.07	0.48	0.20, 1.13	0.82	0.47, 1.43	0.84	0.49, 1.44
Infant characteristics																	
Sex		0.91	0.52, 1.59	1.11	0.58, 2.12	0.94	0.59, 1.49	0.75	0.45, 1.25	0.91	0.59, 1.40	0.79	0.39, 1.60	1.07	0.67, 1.72	0.90	0.57, 1.43
Overweight		0.91	0.45, 1.86	0.58	0.26, 1.31	1.21	0.65, 2.27	1.68	0.77, 3.68	1.53	0.85, 2.74	1.52	0.55, 4.20	1.07	0.56, 2.02	0.87	0.46, 1.67
Non-maternal caregiver[g]		0.91	0.58, 1.44	1.11	0.60, 2.07	0.77	0.51, 1.17	1.10	0.69, 1.75	0.84	0.56, 1.27	0.82	0.45, 1.50	1.32	0.87, 2.02	0.66	0.43, 1.02

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[a]All fruit, including whole fruit and juice

[b]All vegetables, including whole and juice, excluding fried vegetables

[c]Includes lean meat, poultry and seafood, eggs, soy products, nuts and seeds

[d]Includes breaded and fried vegetables such as French fries, hash browns and onion rings

[e]Sugar-sweetened beverages

[f]Referent category is less than a high school education

[g] Use of a non-maternal caregiver for majority of infant or toddler total feedings in a day

Table 8. Bivariate analysis (Odds Ratio, 95% Confidence Intervals) of infant consumption of key food groups and household and demographic predictors in 6 to 18 months olds participating in the Infant Care, Feeding, and Risk of Obesity study.

		Fruit[a]		Vegetables[b]		Whole grains		Lean Protein foods[c]		Fried Vegetables[d]		SSB[e]		Desserts and sweets		Salty Snacks	
Maternal characteristics																	
Age		1.03	0.95, 1.11	1.04	0.98, 1.11	1.09***	1.04, 1.15	1.02	0.98, 1.06	0.96	0.90, 1.01	0.99	0.95, 1.05	1.05*	1.00, 1.09	1.02	0.98, 1.07
Education[f]	High school	0.72	0.31, 1.66	1.07	0.58, 1.96	0.74	0.45, 1.22	0.58*	0.36, 0.94	0.85	0.48, 1.48	0.63	0.38, 1.05	0.84	0.53, 1.35	0.49**	0.29, 0.82
	≥ Some College	0.69	0.32, 1.46	1.18	0.69, 2.04	1.05	0.68, 1.61	0.56**	0.37, 0.86	0.42**	0.25, 0.72	0.45***	0.28, 0.71	0.97	0.64, 1.46	0.68	0.44, 1.05
Employment		1.66	0.92, 3.00	0.75	0.47, 1.20	0.97	0.68, 1.39	0.73	0.51, 1.03	0.69	0.44, 1.08	1.00	0.67, 1.48	0.96	0.68, 1.35	1.13	0.78, 1.64
Breastfeeding		0.62	0.27, 1.43	0.93	0.45, 1.93	0.71	0.37, 1.35	0.54*	0.31, 0.95	0.31*	0.11, 0.82	0.42*	0.20, 0.91	0.64	0.36, 1.13	0.64	0.33, 1.24
Depressive symptoms		1.32	0.66, 2.64	1.25	0.74, 2.13	0.91	0.61, 1.35	1.58*	1.06, 2.36	2.09**	1.29, 3.40	1.24	0.80, 1.90	1.01	0.68, 1.48	1.24	0.82, 1.86
Single-headed household		0.70	0.37, 1.33	1.02	0.61, 1.72	1.20	0.80, 1.80	0.97	0.65, 1.43	0.86	0.51, 1.45	0.96	0.61, 1.51	1.32	0.89, 1.96	0.93	0.61, 1.43
Weight	Over-weight	1.43	0.69, 2.99	1.02	0.57, 1.84	0.83	0.51, 1.37	0.95	0.59, 1.53	1.13	0.61, 2.06	1.13	0.64, 1.99	0.73	0.46, 1.17	0.92	0.55, 1.55
	Obese	2.08*	1.06, 4.05	1.45	0.85, 2.47	1.07	0.70, 1.65	0.86	0.57, 1.29	0.86	0.50, 1.47	1.44	0.88, 2.36	0.90	0.60, 1.35	1.15	0.74, 1.80
Infant characteristics																	
Sex		0.41**	0.22, 0.77	1.15	0.73, 1.80	1.04	0.73, 1.49	1.00	0.71, 1.40	1.16	0.73, 1.83	1.28	0.86, 1.90	1.13	0.80, 1.58	1.21	0.83, 1.75
Overweight		2.11	0.73, 6.10	1.17	0.59, 2.33	0.63	0.38, 1.07	1.00	0.60, 1.64	0.63	0.31, 1.29	0.96	0.55, 1.67	0.96	0.58, 1.57	1.13	0.66, 1.91
Non-maternal caregiver[g]		1.74	0.97, 3.12	1.23	0.78, 1.93	1.34	0.93, 1.93	1.19	0.84, 1.68	0.71	0.45, 1.11	1.23	0.83, 1.81	1.23	0.87, 1.73	1.31	0.91, 1.90

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[a]All fruit, including whole fruit and juice

[b]All vegetables, including whole and juice, excluding fried vegetables

[c]Includes lean meat, poultry and seafood, eggs, soy products, nuts and seeds

[d]Includes breaded and fried vegetables such as French fries, hash browns and onion rings

[e]Sugar-sweetened beverages

[f]Referent category is less than a high school education

[g]Use of a non-maternal caregiver for majority of infant or toddler total feedings in a day

Table 9. Results of logistic regression random effect models examining the odds of infants consuming key food groups if their mother consumed them in mother-infant dyads 6-18 months old participating in the Infant Care, Feeding, and Risk of Obesity study.

Odds ratio and 95% Confidence Interval (n=529 observations on 179 mother/infant dyads)										
			Fruit[a]		Vegetables[b]		Whole Grains		Lean protein foods[c]	
Odds Ratio[g]			2.63**	[1.35,5.13]	1.23	[0.56,2.70]	1.57	[0.97,2.54]	1.14	[0.60,2.17]
Maternal Characteristics	Age		1.02	[0.93,1.12]	0.99	[0.92,1.06]	1.09*	[1.01,1.16]	1.00	[0.92,1.09]
	Education[f]	High school	0.75	[0.32,1.76]	1.09	[0.56,2.13]	0.61	[0.31,1.19]	0.37*	[0.16,0.84]
		≥ Some college	0.58	[0.24,1.39]	1.12	[0.57,2.18]	0.65	[0.34,1.26]	0.27**	[0.11,0.62]
	Breastfeeding		0.80	[0.32,1.98]	1.61	[0.71,3.62]	1.20	[0.53,2.68]	1.85	[0.71,4.84]
	Depressive symptoms		1.34	[0.65,2.76]	1.44	[0.80,2.60]	1.20	[0.70,2.05]	2.79**	[1.42,5.48]
	Obese		1.86	[1.00,3.46]	1.65*	[1.00,2.74]	1.11	[0.68,1.80]	0.87	[0.48,1.58]
	Single-headed household		0.69	[0.36,1.34]	0.94	[0.53,1.67]	1.09	[0.63,1.87]	0.74	[0.38,1.44]
Obesogenic foods										
			Fried Vegetables[d]		SSB[e]		Desserts/Sweets		Salty snacks	
Odds Ratio[g]			3.67***	[2.04,6.57]	2.17*	[1.07,4.39]	2.26***	[1.49,3.43]	1.91*	[1.16,3.17]
Maternal Characteristics	Age		0.96	[0.88,1.05]	0.98	[0.90,1.05]	1.02	[0.97,1.08]	0.98	[0.92,1.05]
	Education[f]	High school	0.92	[0.43,1.94]	0.54	[0.26,1.12]	0.81	[0.47,1.40]	0.37**	[0.18,0.75]
		≥ Some college	0.45*	[0.21,1.00]	0.33**	[0.16,0.70]	0.77	[0.45,1.33]	0.59	[0.30,1.14]
	Breastfeeding		0.81	[0.24,2.79]	1.20	[0.44,3.25]	0.93	[0.47,1.85]	1.52	[0.65,3.55]
	Depressive symptoms		2.31**	[1.25,4.28]	1.19	[0.66,2.14]	0.98	[0.61,1.56]	1.50	[0.87,2.59]
	Obese		0.74	[0.41,1.32]	1.47	[0.84,2.56]	1.08	[0.72,1.61]	1.32	[0.80,2.16]
	Single-headed household		0.83	[0.43,1.59]	0.92	[0.50,1.69]	1.32	[0.83,2.09]	0.82	[0.47,1.44]

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[a]All fruit, including whole fruit and juice

[b]All vegetables, including whole and juice, excluding fried vegetables

[c]Includes lean meat, poultry and seafood, eggs, soy products, nuts and seeds

[d]Includes breaded and fried vegetables such as French fries, hash browns and onion rings

[e]Sugar-sweetened beverages

[f]Referent category is less than a high school education

[g]Adjusted for maternal age, education, breastfeeding status, depressive symptoms, obesity and single-headed household

CHAPTER VI: BARRIERS AND FACILITATORS TO HEALTHY EATING AMONG NON-HISPANIC BLACK MOTHERS.

Overview

Infant diet is heavily influenced by maternal diet, yet poor diet quality is common among women, placing themselves and their infants at risk for obesity. To better understand barriers and facilitators to healthy eating during the first two years postpartum, in-depth interviews were conducted with 22 non-Hispanic black mothers who participated in the *Mothers and Others: Family-based Obesity Prevention for Infants and Toddlers* intervention trial. Ten themes were identified around barriers and facilitators to healthy eating. Mothers believed that time and taste were significant barriers to eating healthy. Social influence and social support had both positive and negative influences on mothers' ability to adopt healthy eating behaviors. Despite their children often being a facilitator to healthy eating, many mothers struggled with finding the time, energy and desire to focus on themselves when it came to healthy eating. Future interventions should focus on behavior change strategies that incorporate goal-setting and self-monitoring while including skill-building activities emphasizing time-saving methods for planning and preparing healthy meals and snacks.

Introduction

Obesity continues to be a major public health concern, particularly among non-Hispanic black (NHB) populations. Rates are higher among NHB women compared to men and women of

any other race/ethnicity with 56.9% of NHB women obese (C.L. Ogden, Carroll, Fryar, & Flegal, 2015). Obesity affects even the youngest age group; 8.1% of infants and toddlers are currently considered obese (weights-for-length $\geq 95^{th}$ percentile) with rates higher among NHB children compared to non-Hispanic white children (NHW) (Dalenius et al., 2012; Freedman, 2011). Diet quality is an important, modifiable factor in the development of obesity (Guo, Warden, Paeratakul, & Bray, 2004; Wolongevicz et al., 2010; World Health Organization, 2013). Child diet and food preferences are shaped early in life; and infants are being fed sugar-sweetened beverages (SSBs) and energy dense foods such as desserts and sweets, while a substantial proportion do not consume any fruit or vegetable in a given day (Saavedra et al., 2013; Siega-Riz et al., 2010; A. L. Thompson & Bentley, 2013). Mothers play a pivotal role in the development of dietary habits in their children, for they have been shown to spend more time interacting with their children, particularly during meal times, and they are more likely to be the gatekeepers of food (Byrd-Bredbenner, Abbot, & Cussler, 2008; Hamrick & McClelland, July 2016). Numerous studies have demonstrated that a child's preferences and eating patterns are related to their mothers (Birch & Fisher, 1998; Fisher & Birch, 1995; Saavedra et al., 2013). Mothers influence the foods available and offered to children and also serve as role models, communicating through their behavior what is "good" to eat. (Howard et al., 2012; Papas et al., 2009; Robinson et al., 2007; Wen et al., 2013). Additionally, maternal diet shapes the home food environment, where the majority of daily energy intake is consumed (Poti & Popkin, 2011).

For many women, diet quality is suboptimal, particularly in the postpartum period (Durham et al., 2011; Fowles & Walker, 2006; G.C. George et al., 2005; Wiltheiss et al., 2013). There are limited data available that specifically describe the diets of mothers, but among women of childbearing age (19-30 years), most (92.7%) do not consume the recommended amounts for

fruit, vegetables (94.1%) or whole grains (99.8%) (Krebs-Smith et al., 2010). In addition, nearly all (94.4%) adult females aged 19-30 years exceed recommendations for solid fats and 85.0% exceed recommendations for added sugars (Krebs-Smith et al., 2010). Although some women adopt healthier eating patterns during pregnancy, many discontinue these habits postpartum and studies show that diet quality is suboptimal during the postpartum period (Durham et al., 2011; G.C. George et al., 2005; G. C. George et al., 2005). In addition, different behavioral patterns and feeding practices have been observed in NHB families compared to other races/ethnicities (Centers for Disease & Prevention, 2010; A. L. Thompson & Bentley, 2013).

An in-depth inquiry into the barriers and facilitators that influence mothers' adoption of healthy eating behaviors during the postpartum period is lacking, specifically for NHB mothers. Few studies have assessed factors that influence food choice among mothers of mixed race/ethnicities (Byrd-Bredbenner et al., 2008; Nuss, Clarke, Klohe-Lehman, & Freeland-Graves, 2006); while some have used qualitative methods to assess factors in pregnant women (Goodrich, Cregger, Wilcox, & Liu, 2013; Reyes et al., 2013). To our knowledge, only one qualitative study has been conducted among mothers of young children and included overweight and obese NHB and NHW low-income women (Chang, Nitzke, Guilford, Adair, & Hazard, 2008). Thus, combined with evidence regarding early learning of food preferences and obesogenic (energy-dense, nutrient-poor) patterns currently in existence, particularly in disparate populations, there exists a need for effective intervention strategies that use mothers as a target audience given their potential to influence the diets of children, while also having a direct effect on maternal diet. This study uses in-depth qualitative research methods to investigate the barriers and facilitators to healthy eating among a sample of NHB mothers participating in a family-based obesity prevention intervention; providing important formative research to guide future

interventions aimed at influencing maternal diet for the purpose of establishing healthy infant dietary habits to prevent obesity.

Methods

Study design and participants

Semi-structured individual interviews were conducted with participants from the intervention arm of a randomized control trial, *Mothers and Others: Family-based Obesity Prevention for Infants and Toddlers. Mothers and Others* is a multicomponent intervention that begins at 28 weeks gestation and continues through 15 months postpartum. The study uses a combination of home visits, newsletters and text messages to deliver anticipatory guidance on healthy eating and infant feeding practices, as well as sedentary time, TV/media, and sleep, to families at risk for pediatric obesity with the ultimate goal of influencing healthy weight gain patterns in infants. The primary mode of delivery is via home visits conducted every 3 months where a trained intervention specialist delivers face-to-face counseling sessions. Intervention components that aim to influence maternal diet were delivered at the 3-month home visit.

Mothers and Others recruited NHB pregnant mothers with a singleton pregnancy from antenatal clinics in central North Carolina. Enrollment was restricted to women who self-identified as NHB, were between the ages of 18 and 39 and expecting a singleton birth. After birth, women were considered ineligible if they delivered prematurely (<37 weeks gestation), delivered multiples, or had a stay in the newborn nursery or NICU or a maternity stay >7 days. In addition, a child born with a congenital anomaly or other condition that affects feeding was considered ineligible after birth (e.g. Down's syndrome or cleft palate).

Recruitment of Participants

Participants from *Mothers and Others* were eligible to participate in the qualitative study if they were randomized to the intervention arm, had graduated out of the study, had received the healthy eating intervention at the 3-month visit, and agreed to be contacted for future research. Eligible mothers were randomly chosen and contacted via phone by one of the study authors (MCK) to assess interest and schedule participation. An email and text message was sent to those who could not be reached via phone. Interviews were conducted until theme saturation was reached. A total of 22 mothers participated in and completed the study. Each participant provided written consent and was compensated for their time with $20 in cash. The University of North Carolina at Chapel Hill Institutional Review Board approved the study protocol.

Data Collection

A series of in-depth interviews were conducted at a time and place convenient to the participant. Most were conducted in the homes of participants or that of a family member; one was conducted in a public eating establishment. Twelve interviews were conducted by one of the study authors (MCK); 10 were conducted by the interventionist for the control arm of *Mothers and Others*, a trained interventionist with 5 years related experience. Interviews were the preferred method of data collection given their ability to capture deep insight into individual-level attitudes and behaviors, as well as cultural and social norms surrounding selected beliefs and behaviors (Bentley et al., 2014). An interview guide was developed to ensure consistency across interviews, but to allow for probing for more information, as deemed appropriate by the interviewer. The interview guide was developed by the authors and informed by prior research among a similar population of NHB mothers (A. L. Thompson & Bentley, 2013; H. M. Wasser

et al., 2013). All interviews began by asking participants what a healthy diet looks like to them, to both build rapport and assess their understanding of what healthy eating practices include. Questions were then divided into two broad categories: 1) barriers and facilitators to healthy eating after having a baby and 2) perceptions of social support for healthy eating. Sample questions included: "After having [BABY'S NAME] what were some of the things you were struggling with in terms of diet?"; "Was there somebody who was supporting you with diet? Who was it? How did they help you?"; "What do think would motivate new or expecting moms to eat healthier?" Specific probing questions, such as "Can you tell me more about that?" or "Can you tell me what you mean by that?" were used to clarify participant responses and narrow the discussion. At the time of their interview, participants were also asked to complete a questionnaire assessing current demographics and reported weight and height. Each interview lasted between 20 and 45 minutes.

Data Analysis

All interviews were audio-recorded and transcribed verbatim. Analysis of transcript data was performed on an iterative basis by one of the study authors (MCK) with results used for ongoing refinement of the interview guide and to audit transcript quality (Bentley et al., 2011). An additional coder (author HW) reviewed a subset of transcripts. A deductive and inductive process was used to develop a consensus codebook from the initial set of topical codes included in the interview guide and supplemented with interpretive codes found through analysis of transcripts. The coders met to revise the codebooks, resolve disagreements on how to apply codes and reach consensus on coding. Once the data were coded, matrices were developed to explore the data and identify similarities and differences between respondents (Miles &

Huberman, 1994). Relevant themes were identified and salient quotes used to illustrate each theme. Dedoose qualitative software was used for all qualitative analyses and descriptive statistics (Dedoose Version 5.0.11, 2014, Los Angeles, CA: SocioCultural Research Consultants, LLC).

Results

Participant characteristics

The sample consisted of 22 NHB mothers whose mean age was 28.7 (standard deviation=5.0) years. Less than a quarter of the women had a high school degree (n=5, 22.7%); over a third (n=8, 36.4%) had at least a bachelor's degree and 4 women had an advanced degree (18.2%). Over a third (n=8, 36.4%) of the women were married and 72.7% were employed full time (n=16). Nearly half (n=10, 45.5%) had incomes less than $25,000 per year and 40.9% were receiving benefits from the North Carolina Supplemental Nutrition Program for Women Infants and Children (WIC) at the time of the interview (n=9). Most of the women (n=20, 90.9%) were considered overweight (BMI>=25.0) and nearly half (n=10, 45.5%) were considered obese (BMI>=30.0).

Themes

Related themes that emerged from patterns within the data were consolidated and then separated into two categories: 1) facilitators to healthy eating and 2) barriers to healthy eating. Themes and their representative quotes are summarized below.

Facilitators

Social support and social influence

Most of the mothers talked about the ways in which individuals in their lives provided support for behaviors related to healthy eating, such as family members or coworkers reminding them to make healthy choices or engaging in the behaviors with them. Cooking, grocery shopping and providing healthy meals were specific ways in which husbands, mothers and friends provided social support for healthy eating. Many discussed the ways in which the study interventionist provided support by increasing their knowledge and awareness of ways to eat healthy and teaching skills to support such behaviors.

> *I don't know who anybody got, but [the interventionist] was the bomb…She was on point, and she kept me on point, because she would tell me. She was real with me, and she was honest, like "You don't get it together, then who's gonna be here for your children? Get it together for them, because monkey see, monkey do."*

Some mothers specifically benefitted from the encouragement the interventionist provided.

> *She just encouraged you like "Okay, you can eat in small portions or you can do this, and you need to drink this amount of water." She just reminded you all the things that we've been talking about. She reapplies it every time we visit.*

Despite knowing much of the information she presented, it was the reassurance and reinforcement that helped them feel like they could adopt healthy eating behaviors for themselves and their family. Many of the mothers mentioned ways their baby significantly influences them to make healthier choices.

> *When it starting to be time for her to eat foods, I started paying more attention to what I was eating. I can't fix her yogurt, fruit, and all this healthy stuff for breakfast and I turn around and make me a bacon and egg sandwich…So I guess cooking for her and fixing her food actually helped me eat a little bit healthier because otherwise I'd just go for the quick bacon and eggs and toast.*

For many, the baby's diet is what influences their purchases at the grocery store and the meals they prepare.

I try to buy my groceries the healthiest for her and then I just end up eating what she, because all my groceries are pretty much around what she eats.

To meet baby's needs: breastfeeding and role modeling

Many mothers were motivated to eat healthy based on the needs of their baby. For mothers that breastfed, being the sole source of nutrition for their child was a major facilitator in making healthy choices.

They told me everything that you put in your mouth when you breastfeeding you pretty much feeding it to them so I couldn't just sit here and keep eating all this junk and unhealthy stuff, especially if I want his brain to develop better and makes them grow smart or whatever. I had to really watch what I was putting in my body.

In fact, some saw the completion of their breastfeeding journey as an opportunity to eat junk food and binge on unhealthy foods. Others saw the importance of modeling healthy choices as an important factor in shaping their eating habits. Mothers felt that their children were likely to adopt similar eating habits and that it was their responsibility to demonstrate healthy eating so that they would be more inclined to choose foods like F&V over French fries and chips.

I know that if I'm eating unhealthy, then of course she is too because she eat what I eat.

Personal factors

Many mothers in this study noted personal factors as facilitators for healthy eating, such as increasing self-esteem, losing weight or adhering to medical advice and saw making healthy food choices as a way to meet these goals.

I really wanted to lose weight and she told me the fast way and the nicest way is to eat healthy. It kind of goes off a little faster, because you know if you eat fast food and stuff, you'll be stuck with it for a while. That also was a big part of me eating healthy, that I wanted to kind of get back to my regular size.

Mothers noted that the postpartum period is a time when the body goes through a lot of changes and that can affect ones self-perception.

> *For as a woman's self-esteem, I think early on too, that you need to go ahead and start eating right because you can pick up the weight, and sometimes that can be depressing after you have a baby. This is my first time having a baby. My breasts feels different, they hang different, my stomach hangs different.*

A desire to feel good about oneself, either by losing weight or boosting self-esteem, was a motivator for making healthy dietary choices.

> *I think a lot of women wanna drop weight after having a baby because your body's just different. It's shaped different. You got this extra stuff, I still got it. I didn't have this before…A lot of women are self-conscious about the way they look, so you wanna lose weight.*

A few women also mentioned medical reasons as motivating factors for healthy eating. Some women suffered from chronic medical conditions themselves or were influenced by a family history of chronic illness.

Behavioral factors

Engaging in specific behaviors such as planning, self-monitoring and goal setting were important facilitators for healthy eating among some women in the study. Planning was seen as an important behavior in making it easier to eat healthy for themselves and their families.

> *I think planning your meals ahead of time was helpful for us. Go to the grocery store for what you're going to have for breakfast, lunch, and dinner…if we leave the house maybe put some food in a little Ziploc bag to take with us, maybe some carrots or some grapes or something…I would do it at night. If you do it at night, you kind of prep yourself so in the morning all that you do is just grab it from the refrigerator instead of trying to wait until the morning when you're trying to get out of the house and you're going to forget something. It kind of worked for us.*

To a lesser extent, setting goals and self-monitoring through dietary tracking were also seen as helpful behaviors for eating healthy.

Barriers

Social influence/lack of support

Being influenced by family members, friends and coworkers who engage in unhealthy eating habits was seen as a major barrier to healthy eating for many of the mothers in the study.

> *You're influenced with the people around you, and we all eat not healthy, so I guess your peers and family can have a bad influence.*

Temptation from their environment and the foods that were provided by others made it difficult to avoid consuming obesogenic foods.

> *Temptation. Especially when you got family or friends and stuff, they want to sit in front of you and just stuff their face with stuff that just looks so good. You can't have it because it's not good for the baby, it's not good for you, but they make it look so good.*

Mothers discussed the preferences of family members, particularly their husbands and children, as a barrier to cooking healthy meals, for cooking a healthy meal for herself might mean cooking two different meals. For some, having a partner that was uninterested in eating healthy placed the burden on her to prepare and serve healthy foods, which many found too much to shoulder alone. Similarly, not having support for preparing and consuming healthy meals was seen as barrier for many women in the study.

> *You have to balance when you do you cook? You know? Your first child, they're spoiled, they don't wanna lay down, you don't wanna strap them to you while you cook, so you're just going for something quick. Pop a pizza in the oven, can someone stop and get me this from here? I gained a lot of weight after I had her by getting people to bring me food.*

Single mothers in particular noted that the process of preparing a healthy meal (shopping, cooking and cleaning) for her to then eat alone was too overwhelming.

> *It was hard for me because cooking for one person, it seems like it should be easy but it's hard because you're just cooking for yourself, so it's like "Oh, you can just hurry up and grab something to eat" instead of cooking a whole meal washing dishes and all that. You can just hurry up and grab something easy, or because I'm a single parent I might be tired. I've been at work all day, now I have to tend to him…so it just was out of*

convenience not to have to cook, because I didn't have to cook because I don't have a traditional family.

Time/eating on-the-go

Not having enough time to prepare healthy meals at home was seen as a significant barrier for many of the mothers.

> *They say, "do everything while the baby's sleep." Sleep while the baby's sleep, wash while the baby's sleep, clean up while the baby's sleep, cook while the baby's sleep. You don't have time to do all that…So you gotta figure out- get your child unspoiled where they can sit down long enough for you to cook…You even end up skipping some meals sometimes, or you're tired, you wanna go to sleep…You don't wanna cook. You don't wanna clean up.*

Either due to work obligations or time spent caring for their children, mothers mentioned that despite their interest in eating healthy, not having enough time to prepare proper foods prevented them. Specifically, mothers mentioned the challenges of making healthy choices for themselves and their families when on-the-go.

> *I guess it's different when you're on the go and you got to feed, because I got a family of five, so it's different on the go trying to get healthy… it's quicker just to get a burger and fries than versus get everything grilled something or come home and grill something...I guess we need a healthy fast food place…It's easier just to swing my McDonald's or Burger King and just grab everybody something because I know everybody can eat off of it.*

Many mentioned the ease in purchasing food from fast food establishments due to perceived notions that their children will more readily eat them and the reduction in time spent preparing the meals.

Work environment and schedule

For working mothers, eating on-the-go made it easier to consume obesogenic foods, mostly from fast food restaurants, rather than taking the time to prepare and bring a healthy meal

or snack. Being surrounded by unhealthy, tempting foods at work made it difficult for many mothers to choose healthy options.

> *My job, most of the people there are overweight…They bring a lot of chips, they share a lot, bring goodies, cakes- someone just gave me half a cake yesterday. We're always having potlucks and gatherings and stuff for somebody's birthday…It's challenging. My coworker's like, "we have banana pudding. Bananas are healthy right? I can eat bananas and banana pudding, right?"…Yeah, my job has definitely made it harder to eat healthy so I gained weight, a lot of weight working there.*

Whether it was the physical environment or the people surrounding them at work, the constant presence of unhealthy foods made it too difficult not to consume them.

> *I work in the Biscuitville area then across we got pizza. Students, they come in there, they eat a lot. They come, they just sit in your face and just smashing pizza or smashing a burger or just scarfing down ice cream stuff. Serving all this food, it is temptation. Because everything at Biscuitville is not healthy so it makes it real hard.*

Additionally, some mothers mentioned their work schedule as a barrier to making healthy choices due to early morning start times or inability to take breaks to consume a healthy snack or meal.

Personal factors

Numerous mothers discussed personal factors such as taste preferences, mindset, habits or mood as hindrances to making healthy choices. Despite knowledge of what constitutes healthy and unhealthy foods, taste and cravings for unhealthy foods, were an even more important driving force in shaping many mothers' food choices.

> *I'm a junker, I like to eat junk food…because, just the taste and wanting the craving of the sweet and sweetness and candy and stuff…versus eating something healthy that's kind of a very bland taste…I wanna taste the sweets instead of just tasteless, bland, healthy.*

Additionally, some mothers used the consumption of obesogenic foods as an emotional coping response.

> *My coworker, like some days when she sees me having a rough day, she'll come up with one of those brownies I told you about...Like, "Hey, I got you one of these." It's not a bad thing, but sometime you just need a naughty snack to make you feel better.*

Consequently, mothers consumed high-fat, high-calorie foods such as chocolate, cookies, cakes, SSBs or fried foods to cope with stress at home or work and negative emotions such as feeling depressed, overwhelmed or lacking in self-esteem.

> *Everybody doesn't get maternity leave and you might be a little depressed. Eating junk food, comfort foods, make you feel better. Some chocolate make you feel better real quick."*

Some mothers mentioned themselves and their mindset as the biggest barrier to making healthy choices.

> *I'm not pushing myself like I need to. So it's nothing that's stopping me, it's just myself. I need to make myself make it more the regular routine because I did it when I was pregnant, why can't I still do it now?*

Similarly, mothers mentioned current dietary preferences being shaped by family traditions and habits, often due to them not knowing any differently.

Focused on baby

Many mothers mentioned difficulties in thinking of themselves when it came to making healthy eating choices, but remained focused on their children.

> *It's hard to actually think about myself eating half of the time. I know it's bad, but I have four children. They're ranging from 11, 5, 2, and I got a one month old, so it's kind of hard to think about me eating. By the time it's time for me to eat, I'm like it's time to lay down. It's time to go to bed. I have to really force myself to eat, but when I do the majority of the time it's probably not anything healthy. It's just something I got in the pantry or something. It's not really healthy.*

Despite spending time, money and energy on preparing and serving healthy meals to their children, they did not consider consuming such foods themselves.

He has to have fresh fruit so I cut his food fresh every morning, and I think after I put up all the fruit and stuff, I'm like "Well, why didn't you cut yourself some fruit?" Then I'm not about to go back and do it. Like this morning, I cut him up grapes and peaches and some chicken and I boiled some broccoli and carrots, and he has some Chex rice mix because he can't eat no other kind of cereal so I give him rice cereal, and when I got done that's exactly what I thought. I said "Well darn, you fixed him this nice, extravagant little lunch, and you could have had that same lunch", but I don't think about myself. I just think about him, then I go buy me something that's in a box, easy to cook.

Cost

Several mothers perceived healthy foods to be more expensive, either at the grocery store or when eating out. This was a barrier for choosing fruits, vegetables and lean protein foods.

First off, a lot of choices that are the healthier choices are more expensive choices. Which I find conflicting because they say they don't want families to be obese, they don't want them to be overweight, they want it to be better for kids, but you can get a big, huge bag of chips for like, a dollar and some change, but a big bag of oranges is like, 6 dollars, 8 dollars. You're like, "Well, how am I supposed to accommodate this?

Discussion

Among this sample of mostly overweight, highly educated NHB mothers, healthy eating appeared to be something most of the mothers strived for, but remained a difficult task for many. Although few qualitative studies have been conducted among postpartum women (Chang et al., 2008), our findings are consistent with other qualitative studies assessing dietary habits in pregnant women (Goodrich et al., 2013; Reyes et al., 2013) as well as assessments conducted in women of young children (Byrd-Bredbenner et al., 2008; Nuss et al., 2006). The support of family members, friends and coworkers made choosing healthy foods easier for most of the mothers; specifically, engaging in healthy eating behaviors with a support person(s) seemed to be a significant facilitator in making healthy food choices. However, just as those closest to them could be supportive, they could also sabotage efforts at eating healthy by providing obesogenic

foods or tempting them with cakes, cookies and soda that they themselves were consuming. This is similar to findings from Reyes et al, where social influence was a prominent factor in shaping the eating habits of pregnant low-income, overweight, African-American mothers (Reyes et al., 2013). Purchasing unhealthy foods for the household and pressure to eat were barriers these women faced when trying to make healthy choices. Future interventions would benefit from enrolling a support person who could participate in the study with mothers, to learn and adopt new behaviors alongside her.

Many mothers discussed their child as being a motivating factor to eating healthy either through her breast milk and/or by role modeling healthy behaviors. However, being overly focused on her child and not on her own needs was a barrier for many, a finding common among low-income mothers (Chang et al., 2008; McIntyre et al., 2003). Chang et al found that despite having knowledge of the importance of healthy eating behaviors, mothers tended to focus on their children's needs first, while seemingly putting themselves last (Chang et al., 2008). Personal factors such as boosting self-esteem and wanting to lose weight were also motivating factors. However, not having enough time to engage in practices that would support healthy eating, such as cooking healthy meals and preparing healthy snacks for on the go proved to be a large barrier to eating healthy, a shared sentiment among similar studies (Byrd-Bredbenner et al., 2008; Chang et al., 2008; Eikenberry & Smith, 2004b). Time constraints, along with taste preferences are the most commonly cited impediments to consuming healthy foods among mothers of young children. Common among other studies, mothers preferred the taste of fried foods and sweets to healthier alternatives, making choosing a healthy option very difficult (Chang et al., 2008; Eikenberry & Smith, 2004b; Goodrich et al., 2013; Reyes et al., 2013). Byrd conducted a survey among mothers of young children and found that taste was the main factor

guiding food choices for themselves and their family (Byrd-Bredbenner et al., 2008). Lastly, the perceived cost of healthy foods was a barrier to eating healthy identified for mothers and their families, the most prominent factor identified by Reyes et al (Reyes et al., 2013). Teaching mothers skills for cooking flavorful, healthy recipes with limited time and money as well as conducting grocery store tours showing mothers how to shop for healthy foods may help overcomes such barriers or taste and cost.

Using qualitative methods to study healthy eating behaviors among NHB mothers provides a unique opportunity to gain in-depth insight and capture subtleties around the human experience of eating, which are often missed with quantitative data. The small, homogenous sample may limit the generalizability of our results. However, the goal of this study was to provide specific insight into the intimate thoughts of NHB mothers related to healthy eating in order to develop intervention materials and methods specific to this population, given the increased risk for overweight and obesity. It is important to note that all participants had recently participated in an intervention focused on family-based obesity prevention. Therefore, our results may not extent to other NHB mothers. However, the dominant themes that emerged are similar to those found in other populations of mothers, including mothers of mixed races/ethnicities.

Conclusion

Through in-depth qualitative analysis, we were able to identify potential intervention methods for overcoming barriers to healthy eating in NHB mothers of young children for the prevention of early life obesity. Rather than focusing on enhancing nutrition knowledge, effective behavior change strategies targeted at mothers' eating behaviors including goal setting, self-monitoring and hands-on skill building around cooking and grocery shopping may be

important in influencing positive changes in their child's diet. One such study among a diverse sample of mothers of young children showed promise in this approach (Klohe-Lehman et al., 2007). The study found that targeting mothers of 1-3 year olds for weight loss via changes in eating and physical activity behaviors led to beneficial changes in their child's diets as well. The information gleaned from this and the present study demonstrate that future research aimed at using behavior change techniques to effectively target mothers may be an effective way to influence intake and food preferences of young children.

This study fills an important gap in child obesity research by providing evidence on the factors that influence maternal diet, a modifiable factor of infant diet. Although recognized as having a distinct association with infant diet, maternal diet has yet to be the primary target of an intervention aimed at influencing infant diet in the home, a promising setting in which to improve young children's eating habits given the amount of time children spend in the home. Given rising rates of obesity among young children, paralleling that of adults, finding unique solutions for effectively intervening is necessary. Food preferences and diet patterns begin to form during infancy and children are heavily influenced by their mother's eating behaviors. Therefore, mothers should be the targets of future interventions in an effort to not only prevent and treat adult overweight and obesity, but to also prevent childhood obesity.

CHAPTER VII: SYNTHESIS

The purpose of this research is to describe maternal and infant dietary intake and factors that predict consumption of key food groups. Key food groups were defined by the DGAs for Aim 1; Aim 2 included food groups associated with an obesogenic diet, such as SSBs, desserts and sweets. Given mothers act as role models for developing healthy eating habits, we also wanted to uncover barriers and facilitators to healthy eating for the purposes of designing targeted interventions to influence not only maternal diet, but also infant diet. Specific aims included: 1) compare maternal consumption of key food groups to recommended serving sizes from the 2015-2020 *Dietary Guidelines for Americans* and examine predictors of dietary intake; 2) determine the longitudinal association between maternal and infant consumption of key food groups and factors that predict consumption among first-time non-Hispanic black mothers and their children; and 3) explore barriers and facilitators to healthy eating during the postpartum period to uncover potential behavior change techniques for future interventions.

Overview of findings

For the first aim related to evaluating maternal diet within the first 18 months postpartum by comparing intake levels of food groups from the DGAs to servings sizes recommended by the current 2015-2020 DGAs, we found that maternal diet quality was lacking during this critical period of data collection. Aside from grains and protein foods, few mothers consumed recommended amounts for any of the food groups. Of the mothers who consumed grains and

protein foods, few were from whole grains or lean protein sources, which imply that mothers are meeting recommended levels by consuming foods high in refined grains and unhealthy fats. More concerning is that a large number of mothers did not consume any fruit in a given day and most consumed an inadequate amount of vegetables. Although concerning, our results are not surprising considering the diets of most Americans are suboptimal (Hiza, Casavale, Guenther, & Davis, 2013; US Department of Agriculture et al.). However, results from Aim 1 highlight that diets among low-income NHB women in particular are less than ideal, a finding supported by other studies (G. C. George et al., 2005; S. L. Hoerr et al., 2008; Kendall et al., 1996; Tarasuk, 2001). These women are at greater risk for poor diet quality and subsequently passing these habits on to their children. Our study further emphasizes the need for interventions during the postpartum period; not only were diets poor, they remained unchanged. Given this, interventions may be best timed to begin during the prenatal period, as this population is at greater risk for higher gestational weight gain and postpartum weight retention (Headen, Davis, Mujahid, & Abrams, 2012; Pawlak, Alvarez, Jones, & Lezotte, 2015; Walker et al., 2004).

Results from Aim 2 further support the need to develop interventions focused on the dietary habits of NHB mothers. The goal of aim 2 was to determine the relationship between maternal intake of key food groups and infant intake during the first 18 months of life among a population of low-income, first-time NHB mothers. We found that NHB infants are consuming obesogenic foods as early as 6 months with more than half consume them at 18 months and that intake of key food groups is associated with their mother's intake, specifically for obesogenic foods. However, overall infant diets were better than those of their mothers; many women consumed SSBs, fried vegetables and desserts and sweets. This is concerning given the influence mothers have on the home food environment as well as the impact role modeling food choices

can have on infant food preferences (Birch & Doub, 2014). In addition, we found that age, education, the presence of depressive symptoms and breastfeeding were significant predictors of maternal and infant intake of key food groups. Determining this association and factors that predict this relationship provides insight into how targeted interventions on maternal dietary intake could potentially influence infant intake to break the cycle of obesity in a population at high risk.

In Aim 3, our goal was to gain an in-depth understanding of the challenges among NHB mothers when it comes to making healthy eating choices for themselves and their families. We found that most mothers had an understanding of the need to adopt or maintain healthy eating behaviors for themselves and their families, but lack of time, social influence and lack of social support made it difficult. Role modeling healthy habits for their children motivated them to make healthy choices, but for many, this was only when their child could directly observe them, leaving them to make poor choices when away from the home. However, most of the women were receptive to nutrition intervention and truly valued the social support provided from a skilled and knowledgeable interventionist entering their home.

In Aim 3 we also found that having young children places a heavy burden on a mother's time, a problem exacerbated for single mothers and mothers who work. In the Infant Care study cohort, most of the mothers were not married and were employed and our results demonstrated that they can still heavily impact infant eating behaviors. A working mother is often limited in time spent at home, which could impact what she prepares and offers as meals and snacks to her family. This can result in heavy emphasis placed on convenience foods, often purchased from fast food restaurants, which are higher in calories, fat and sodium and often lacking in F&V (Robson et al., 2016). As we found in Aim 3, lack of time contributed to increased likelihood of

relying on fast foods for themselves and their families, particularly for single mothers. Studies show that diet quality differs among single vs. married mothers, marked by lower intakes of F&V and higher intake of energy dense foods (Elfhag & Rasmussen, 2008; Farbu, Haugen, Meltzer, & Brantsaeter, 2014). In addition, low income women are often less health-conscious (Pampel et al., 2010), further supporting the potential of this population to rely on cheap, quick, obesogenic foods. Given these factors, a need exists for interventions focused on NHB mothers for the purposes of influencing not only their own diet, but that of their children as well.

Future studies

When designing future interventions, our results show that targeting younger mothers with lower education and income levels may have the most impact. Consumption of key food groups among mothers and infants was significantly influenced by these demographic characteristics. In addition, breastfeeding status was associated with more favorable dietary outcomes as well as more motivation to comply with healthy eating recommendations. Interventions that include support for breastfeeding initiation and continuation could have a positive impact on both maternal and infant diet. Thus, interventions may be best timed to begin during the prenatal period, a time when many mothers are motivated to adopt healthy eating behaviors. However, these interventions should continue through the postpartum period, for as our results show, diet quality is poor early on and does not improve.

Mothers also mentioned cost and taste as barriers to making healthy choices, a resounding factor in the struggle against consumption of obesogenic foods (Glanz, Rimer, & Viswanath, 2008). There is no doubt about it, competing against good tasting, convenient, low-cost foods is an uphill battle. The issue of whether healthy food costs more is debated

(Drewnowski & Darmon, 2005), but regardless, the perception among most, especially low-income individuals, is that it does (Dibsdall, Lambert, Bobbin, & Frewer, 2003). Therefore, interventions must include strategies for shopping on a budget and increasing self-efficacy for shopping for, preparing and serving healthy meals that taste good.

In short, increasing knowledge and awareness of what is healthy is only part of the battle (Lawrence & Barker, 2009); most of the work should focus on increasing skills for adopting healthy eating behaviors with the goal of increasing self-efficacy around cooking and consuming good tasting, healthy meals while emphasizing a reliance on positive sources of social support. Interventions should also include timesaving steps for preparing and consuming healthy meals and snacks both at home and on the go.

Strengths and Limitations

As with any study, there are limitations to our findings. First there is the issue of generalizability given the homogenous nature of our sample. For our results from the Infant Care study, the women sampled were all NHB low-income first-time mothers, recruited through WIC clinics and most were unmarried, not breastfeeding and overweight or obese. Similarly, our sample from the Mothers and Others randomized trial included NHB mothers who were mostly overweight with low incomes. Results applied beyond these populations should be done so with caution. However, the goal of this study was to provide insight into a population at high risk of overweight and obesity. Secondly, as with any longitudinal study, results from the Infant Care study are subject to bias from loss to follow up. However, examination of participant attrition revealed few significant differences in infant, maternal, or household characteristics between the baseline sample and those who completed the study. Those who were present for the 18 month

study visit were more likely to be older and breastfeeding at baseline. However, we did see significant differences in baseline characteristics among those who had dietary recalls at the 12 month visit versus those who did not. Participants were more likely to be older, educated, married and breastfeeding and have an overweight infant at baseline. This could bias our findings, for those lost to follow up could be considered more at risk for poor dietary behaviors. However, this is not likely to change our conclusions, for our results show maternal and infant diets are in need of improvement regardless. Additionally, using the LOCF method for predictors could impact our findings by introducing bias as well as understating variability. However, sensitivity analyses conducted using complete case data revealed no significant changes in outcomes. Lastly, the use of a single 24HDR for assessing maternal intake could bias our estimates of episodically consumed foods due to the inability to classify an individual as a true non-consumer. However, aggregating foods into key food groups can minimize this risk; furthermore, one-day estimates from 24HDR have been successfully used in other studies such as FITS and NHANES (R. Briefel et al., 2006).

The strengths of the current study outweigh the limitations including a longitudinal design and high-quality diet data. The longitudinal nature of the data allowed us to simultaneously model and determine the relationship between the development of diet quality and the changes in maternal and infant diet and household characteristics over time. Another strength was the quality of the dietary data collected on matched mother-infant dyads, which included multiple 24HDRs, administered and analyzed using the 2005 version of the Nutrition Data System for Research (NDSR) (Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN), a methodology similar to that used in FITS. Additionally, using qualitative

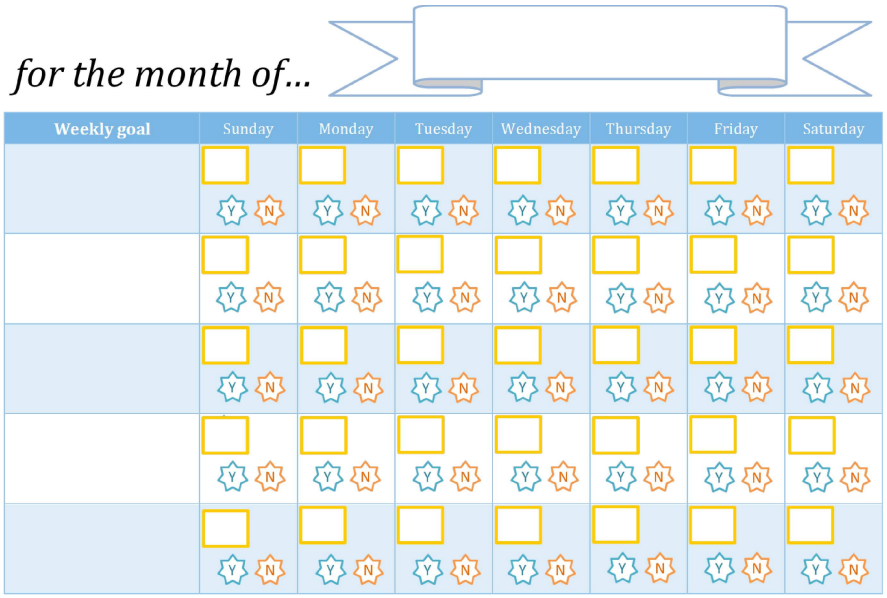
methods provided a unique opportunity to gain in-depth insight and capture subtleties around the human experience of eating – that are often missed with quantitative data.

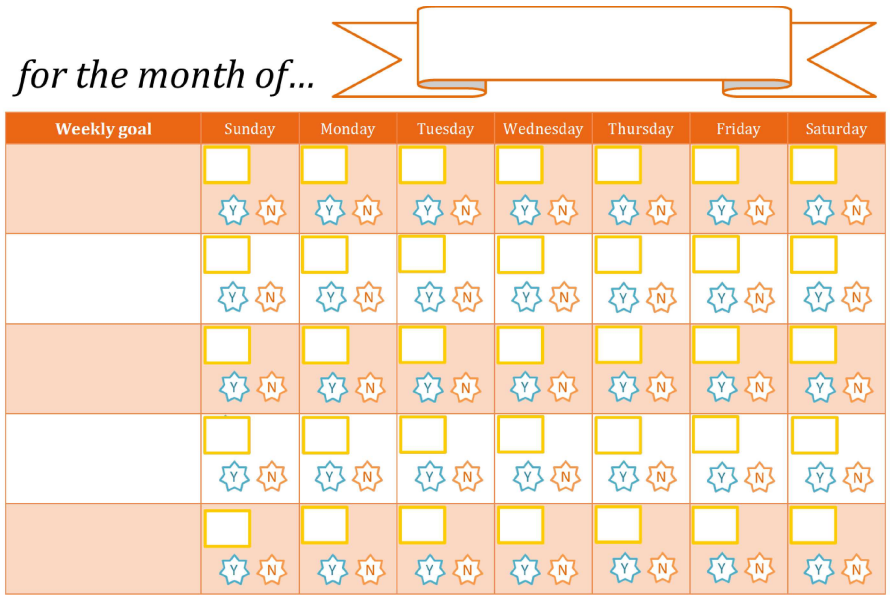
Public Health Significance

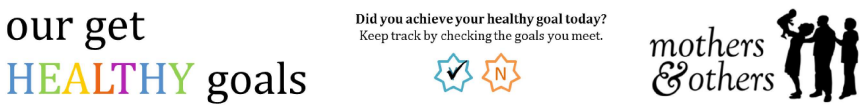
This study fills an important gap in child obesity research by focusing on the development of the diet during the first two years of life and uniquely targeting maternal diet as a modifiable factor. It is one of the few to examine the extent to which maternal intake of key food groups is associated with infant intake, particularly in a minority population at high risk for overweight and obesity. As our results show, infants are consuming SSBs and desserts and sweets beginning at an early age and continuing to do so throughout infancy. Infant diets need improvement and intervening during infancy is warranted; unfortunately evidence for the best methods is lacking. Through our in-depth qualitative analysis, we are able to provide evidence on the factors that influence maternal diet, a modifiable factor of infant diet. Examples of such evidence include relying on a positive system of social support and gaining skills around time management for food preparation and consumption. Here, we highlight effective intervention behavioral targets to influence maternal dietary intake of key food groups including goal setting and self-monitoring, with the ultimate goal of influencing infant intake. The information gleaned from this research can be used to guide future interventions and to develop resources that will have the most success at instituting change. Although recognized as having a distinct association with infant diet, maternal diet has yet to be the primary target of an intervention aimed at influencing infant diet in the home, a promising setting in which to improve young children's eating habits given the amount of time children spend in the home. Lastly, our results have high public health relevance for future obesity-prevention efforts aimed at children less than two

years, specifically national policies aimed at shaping the diets of mothers and children. Currently the DGAs begin at age 2; our results demonstrate a need to provide guidelines for mothers and young children that can be used to shape intervention research studies at the federal, state and community level.

APPENDIX I: *MOTHERS AND OTHERS* GOAL SETTING AND TRACKING CALENDAR SHEETS







APPENDIX II: INTERVIEW GUIDE

Mothers and Others: Family-based Obesity Prevention for Infants and Toddlers
Family Diet

Introduction and Consent
Thank you for agreeing to meet with me today to talk about your family's diet while participating in the Mothers and Others study. Our discussion should last about 45 minutes. Everything you say is important, and I want to make sure I don't miss any comments, so I would like to record this interview. Later, I'll go through all of your comments and use them to prepare a report on our discussion. I want to assure you, however, that all of your comments are confidential and will be used only for research purposes. Nothing you say will be connected with your name. To insure this, after we complete this interview, the audio recording will be locked in a file cabinet at our project office. Soon after, a study staff member will listen to the recording and type up a transcript of the tape. We will use a code to identify your name on the transcript. The code sheet and transcript will be stored in a locked file cabinet in the study office. Do you mind if we record this for our records? **[Do not record if any participant objects.]**

I also want to remind you that you can refuse to answer any question and that you may stop the interview at any time. Participants that complete the full interview will receive $20 compensation for their time.

Do you have any questions?

Okay. Let's get started.

You received a lot of information over the course of the Mothers and Others study. Today we're going to focus on the information about healthy eating for the family. Don't hold back—we really want to hear what you have to say about this part of the study and what you might change to make it better for other mothers and families in the future.

As a reminder, the first time you and Kenitra talked about family diet was when [BABY'S NAME] was about 3 months old. This was the first time you saw Kenitra since he/she was born.
[PULL UP PPT SLIDE]
Tell me about what you see here.
Probe: What does this mean to you?
Probe: Anything else?
Probe: Why do you think we put the baby in the middle there?

Probe: Well actually in our intervention we really tried to make a connection between mom's diet and baby's diet. Our intention was that by focusing on your diet that would actually make a difference in how you feed your baby.
[Pause]

Now you may or may not remember, but you and Kenitra talked about healthy eating at home and on the go as part of our intervention at 3 months.
[PULL UP NEXT PPT SLIDE]
Tell me about what you see here. What does this mean to you?
Probe: What do these images mean to you?
[CLICK TO ADD TEXT]
You might remember when you and Kenitra talked about this these were some of the recommendations. What do you think about these recommendations?
Did you try to make any changes based on this information? Why or why not? What were those changes? What happened with that?
Probe: Tell me about portion sizes.
Probe: What about fruits? Vegetables? Beverages?
Probe: Do you "snack smart"? What does that mean to you?

After having [BABY'S NAME] what were some of the things you were struggling with in terms of diet? What were some things that made that easy or hard?
Was there somebody who was supporting you with diet? Who was it? How did they help you?

[If they do not mention their study partner say:] Now think about your study partner, who was [NAME] at that time. Can you think of some ways that he/she made it harder or easier for you?
Probe: In what ways does he/she make it easier for you and your family to eat healthy?
Probe: In what ways does he/she make it more difficult?
What would you like him/her to do to help you eat healthier?
Let's talk about the timing. Were you surprised we were talking about the family's diet when your baby was 3 months old? Why or why not?

- Would you have preferred this information at another time? Why or why not?
- Would this information have been helpful while you were pregnant?
- Would you have liked us to talk about this more at each of the visits?

If you were in charge of designing a program to help expecting or new moms eat healthier, what would it look like?

- When would you start (pregnancy or later)?
- How would you provide it (home visits, in-person social groups, online [website, Facebook, other social media])?
- What would be most convenient? Fun?
- What do think would motivate new or expecting moms to eat healthier/participate?
- Would you include study partners or other support people? Who would you include? Why and how might you include them?

Closing
That is all the questions I have for you today. Are there any additional comments you have for me? Any questions?

[Fill out demographic survey]

I want to thank you again for participating in this interview. The information you shared is very important and will help us better the design of our materials – materials for a study that has important benefits to mothers and their families. Here is your gift card. [Be sure to have participant sign receipt and record in log]. Again, thank you so much for your time and participation.

Finally, if you could fill out this short survey to provide a little more information about yourself our time will be complete.

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