NON-MATERNAL INVOLVEMENT IN FEEDING AND THE DEVELOPMENT OF OBESOGENIC DIETS AMONG INFANTS AND TODDLERS

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ABSTRACT

HEATHER M. WASSER: Non-maternal Involvement in Feeding and the Development of Obesogenic Diets among Infants and Toddlers
(Under the direction of Dr. Margaret E. Bentley)

The prevalence of overweight among infants and toddlers has increased by approximately 35% over the last 30 years. Concurrent to this rise, there was an increase in maternal employment and the use of non-maternal caregivers while the mother is working. Despite these important social changes, few studies have examined non-maternal involvement in *feeding* between birth and two years. Specific aims of the current research were: (1) to quantify longitudinal intakes of obesity-related foods and beverages during the period of complementary feeding; (2) to characterize the extent to which non-maternal caregivers share responsibility for feeding during the first two years of life; and, (3) to determine associations between non-maternal involvement in feeding and dietary intakes of infants and toddlers.

To achieve these aims, we used data were from the Infant Care, Feeding and Risk of Obesity Study, a cohort of 217 low-income, African-American mother-infant dyads, followed from 3-18 months postpartum. Our results showed that the proportion of infants and toddlers consuming any amount of selected foods and beverages increased over time. Total daily servings of low energy-dense foods (e.g. fruits and vegetables) remained constant over time while high energy-dense foods and beverages (e.g. desserts and

sweets, fried potatoes) increased by 125% to 800% between six and 18 months, with the greatest increases occurring between nine and 12 months of age. Non-maternal involvement in feeding was highly prevalent, with more than half of all households at each time point reporting the use of a non-maternal caregiver (NMC)—someone other than the mother responsible for feeding the infant ≥50% of his/her daily meals. Common NMCs were fathers, grandmothers, and licensed childcare providers. In longitudinal models, we found use of any NMC to be associated with decreased odds of breastfeeding and increased odds of infants and toddlers consuming fruit or juice. Thus, potentially obesogenic diets begin early, suggesting anticipatory guidance on healthy feeding practices is needed prenatally and/or in the first few months postpartum, and the inclusion of NMCs in future observational and experimental studies is warranted as they are highly involved in the feeding of infants and toddlers and impact dietary intake.

DEDICATION

To my family:

John, Parker, and Clementine Harrison

Jerry and Margie Wasser

Jodi, Jordin, and Brittany Bingham

Angie, Joe, Mia, and Julien DelaCruz

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LIST OF ABBREVIATIONS

24-hour DR	24-hour dietary recall
BMI	Body mass index
CACFP	Child and Adult Care Food Program
DGAs	Dietary Guidelines for Americans
DRI	Dietary Reference Intake
EST	Ecological Systems Theory
FITS	Feeding Infants and Toddlers Study
NDSR	Nutrition Data System for Research
NMC	Non-maternal caregiver
US	United States
WLZ	Weight-for-length z-score
WIC	Supplemental Nutrition Program for Women, Infants and Children

CHAPTER I

INTRODUCTION

The prevalence of overweight among infants and toddlers has increased by approximately 35% over the last 30 years (Ogden, Flegal, Carroll, & Johnson, 2002; Ogden, Carroll, Kit, & Flegal, 2012). Concurrent to this rise, there has been an increase in maternal employment and the use of non-maternal caregivers, such as relatives and licensed childcare providers, while the mother is working (Anderson & Butcher, 2006; Mulligan, Brimhall, West, & Chapman, 2005). Yet, despite these important social changes, we find few studies have examined the extent of non-maternal involvement in feeding infants and toddlers and the impact of this involvement on the intakes of obesity-related foods and beverages.

Knowing who shares responsibility for feeding during the early years is important in light of the increasing number of dietary interventions among children birth to two years aimed at the prevention of overweight(Ciampa et al., 2010). There are currently several randomized trials targeting the quality of foods and beverages provided during the period of complementary feeding—the time during which a child transitions from breast milk or formula to table foods, typically occurring between six and 24 months of age. An examination of all these interventions reveals that few have included components for multiple caregivers (Ciampa et al., 2010). Since it is well documented that fathers,

grandmothers, and licensed childcare providers are influential to mothers' decisions and abilities to initiate and continue breastfeeding(Britton, McCormick, Renfrew, Wade, & King, 2007; Gill, Reifsnider, & Lucke, 2007; Kim & Peterson, 2008; Lavender et al., 2005; Perez-Escamilla, Cobas, Balcazar, & Holland Benin, 1999; Pisacane, Continisio, Aldinucci, D'Amora, & Continisio, 2005; Rempel, 2004; Scott, Binns, Oddy, & Graham, 2006; Wolfberg et al., 2004), it seems imperative to also understand their influence on feeding decisions related to the quality of the complementary diet. This information would have important implications for determining whether to include non-maternal caregivers as additional targets in future interventions. To address this gap, the aims in the current proposal seek to establish the extent to which a variety of non-maternal caregivers are involved in feeding during the first two years of life and to determine the impact that their involvement has on the intake of complementary foods associated with the development of overweight.

To achieve these aims, we use data from the Infant Care, Feeding and Risk of Obesity Study (Infant Care), a prospective cohort of 217 African-American, first-time mothers aged 18 to 35 years recruited through the North Carolina Supplemental Nutrition Program for Women, Infants and Children (WIC)(M. Slining, Adair, Goldman, Borja, & Bentley, 2010; M. M. Slining, Adair, Goldman, Borja, & Bentley, 2009; A. L. Thompson et al., 2009; Wasser et al., 2011). Data were collected during in-home visits when the infant was approximately 3, 6, 9, 12, and 18 months old. Infant Care defined non-maternal caregivers (NMCs) as those persons responsible for feeding the index child 50% or more of his/her daily meals.

Specific aims are:

Aim1. To quantify dietary intakes during the period of complementary feeding of food groups associated, either positively or negatively, with obesity among older children and adults. Food groups and items include low energy-dense foods (whole fruits and whole vegetables) and high-energy dense foods (100% juice, fried potatoes, desserts and sweets, sweetened beverages, and salty snacks).

Aim 2. To describe the extent to which NMCs are involved in feeding during the first two years of life and to identify the types of NMCs used at each time point.

Aim 3. To test for associations between use of NMCs and intakes of obesity-related foods during the period of complementary feeding.

Hypotheses. The effect of non-maternal involvement in feeding will vary according to the type of NMC involved. Father/male partner involvement will be associated with a decrease in the intake of fruits and vegetables and an increase in the intake of energy-dense snack foods. An increase in grandparent involvement will be associated with an increase in the intake of fruits and vegetables and a decrease in the intake of energy-dense snack foods. There will be no differences in intake by involvement of licensed childcare providers.

CHAPTER II

LITERATURE REVIEW

Pediatric overweight has increased even among infants and toddlers

The prevalence of overweight among United States (US) infants and toddlers has increased by approximately 35% in the past 30 years (Ogden, Flegal, Carroll, & Johnson, 2002; Ogden et al., 2012a). This increasing prevalence and disparity in overweight is concerning in light of research suggesting obesity has an intractable nature, with both large infant size and rapid postnatal growth being associated with subsequent child and adult overweight, hypertension, stroke, cardiovascular disease, and Type 2 diabetes (N. Cameron, Pettifor, De Wet, & Norris, 2003; Garn, 1985; Ong, Emmett, Noble, Ness, Dunger, & ALSPAC Study Team, 2006; Ong et al., 2009; Serdula et al., 1993)

Dietary factors associated with overweight and obesity emerge in infancy

During the first two years of life, infants and toddlers transition from a single food diet (i.e., breast milk or formula) to an omnivorous diet. Over this period of time, there are dietary factors associated with overweight (or rapid weight gain) that can be classified as specific to the infant/toddler phase of development [i.e., exclusivity and duration of breastfeeding (Arenz, Ruckerl, Koletzko, & von Kries, 2004; Harder, Bergmann, Kallischnigg, & Plagemann, 2005; Hediger, Overpeck, Kuczmarski, & Ruan, 2001;

Owen et al., 2005; Singhal & Lanigan, 2007) and timing of the introduction of complementary foods (CF) (Baker, Michaelsen, Rasmussen, & Sorensen, 2004; Kramer et al., 1985; Ong, Emmett, Noble, Ness, Dunger, & Team, 2006)], as well as those applicable across life stages (Hill, 1998; Swinburn, Caterson, Seidell, & James, 2004). This latter category of factors includes recommendations to predominately consume foods and beverages low in energy density (i.e., those high in fiber and low in fat and sugar), such as whole fruit and vegetables; and, conversely, recommendations to limit those high in energy density, such as fruit juices, sweetened beverages, fried potatoes, desserts and sweets, and salty snacks (Swinburn, Caterson, Seidell, & James, 2004).

While many studies have examined determinants of breastfeeding and introduction of complementary foods before four to six months, little is known about factors associated with the quality of the diet during the period of complementary feeding— the period between six to 24 months in which nutritive foods and beverages other than breast milk or infant formula are gradually introduced. This is important in light of national studies that show obesogenic dietary patterns begin during the first two years of life. Several rounds of data from the Feeding Infants and Toddlers Study (FITS), a nationally representative sample of young children from birth to four years, have raised concerns about the quality of the diet during this time of transition (Fox, Pac, Devaney, & Jankowski, 2004; Siega-Riz et al., 2010; Skinner, Ziegler, & Ponza, 2004; Skinner, Ziegler, Pac, & Devaney, 2004). The latest estimates from FITS continue to show that approximately 25% of infants and toddlers fail to consume any amount of whole fruit and 30% consume no whole vegetables on a given day. In contrast, nearly 20% of infants, ages six to 8.9 months, consume a dessert or sweet in a day, with the proportion

increasing to 80.6% of toddlers consuming such foods at 21-23.9 months (Siega-Riz et al., 2010).

Why study non-maternal caregivers?

Concurrent to the increase in childhood overweight seen over the last thirty plus years, there have been dramatic shifts in both maternal employment and family structures(Bianchi & Casper, 2000). Between 1970 and 2000, the rate of mothers in the labor force, either employed or looking for work, increased from 38% to 68%. This rise was even more dramatic, from 24% to 57%, among mothers with children under the age of three (Bianchi & Casper, 2000; Ehrle, Adams, & Tout, 2001). In addition to changes in maternal employment, the latter quarter of the 20th century witnessed several trends regarding family structure, including a decline in married couple households with a concurrent increase in same-sex cohabitation and single-parent families (Bianchi & Casper, 2000). When examined by race, the patterns of change in family structure and parental employment are quite different. The most striking difference is the substantially higher proportion of single-mother households among African-Americans versus whites, particularly those in which the mother is employed (Casper & Bianchi, 2002).

These changes in family structure and maternal employment have had implications for childcare arrangements of young children while the mother is working. Use of non-parental care begins early, with one-half of all 9-month-olds in a regular non-parental care arrangement (26% relative care, 15% nonrelative care, 9% center-based care, and 1% in multiple arrangements) (Mulligan et al., 2005). Furthermore, infants and toddlers spend a significant amount of time in non-parental care—children less than three

years of employed mothers spend an average of 25 hours per week in non-parental care (Ehrle et al., 2001; Mulligan et al., 2005). Despite these trends, we know very little about the type of individuals responsible for ***feeding*** infants and toddlers while the mother is working and how the use of these types of persons might change during the child's first two years.

Importantly, the types of caregivers utilized while mothers are working vary by select maternal and household demographics (Ehrle et al., 2001; Mulligan et al., 2005), namely maternal employment, maternal education, and single-parent headed households. Several of these are the same characteristics associated with dietary intakes among the FITS sample. In FITS, higher maternal age, higher levels of maternal education, being married, not being enrolled in WIC, and having ever breastfed were generally associated with a higher prevalence of children consuming fruits and vegetables, but a lower prevalence of children consuming salty snacks, sweetened beverages, or desserts and candy (Hendricks, Briefel, Novak, & Ziegler, 2006). These characteristics are therefore important confounding factors to consider in analyses examining the effect of non-maternal involvement in feeding on infant diet.

Bronfenbrenner's ecological systems theory: Theoretical rationale for studying non-maternal caregivers

In addition to the aforementioned sociological trends, Urie Bronfenbrenner's *ecological systems theory* (EST) provides a strong rationale for including non-maternal caregivers in any analysis related to child development, including the development of dietary patterns or eating habits (Bronfenbrenner, 1979). Bronfenbrenner's work forms the basis of ecological models now popular in many disciplines, including child

development (Berk, 2006)(Figure 2) and public health ((Sallis, Owen, & Fisher, 2008)). According to EST, a child's development is influenced by a system of relationships that form his or her environment. The environment in EST consists of four principle layers of nested systems, including the *microsystem*, the layer closest to the child and which contains the structures with which the child has direct contact (e.g. parental and non-parental caregivers); the *mesosystem,* a layer comprising connections between the structures in the child's microsystem (e.g., communication between parental and non-parental caregivers); the *exosystem,* the layer encompassing influences from the larger social system in which the child does not function directly, but that impact the child's development through some structure in his or her microsystem (e.g., flexible workplace policies); and the *macrosystem,* the outermost layer comprised of cultural values, customs, and laws (e.g. family medical leave laws).

Davison and Birch (2001) previously applied EST to the study of childhood obesity, using EST as the basis for a conceptual framework describing predictors of early obesity and opportunities for prevention (Davison & Birch, 2001). Despite this study's publication ten years ago, we still know very little about the predictors of obesogenic diets among infants and toddlers. The few studies in this area that do exist have concentrated largely on infant and maternal characteristics (e.g. infant gender, maternal age) or basic household demographics (e.g. income, marital status) (Hendricks, Briefel, Novak, & Ziegler, 2006; Robinson et al., 2007). The work suggested in this dissertation moves the field forward by identifying other caregivers in the child's microsystem that may be responsible for feeding.

What impact do we expect non-maternal caregivers to have on infant and toddler dietary intakes?

Hypotheses about the influence caregivers may have on the quality of the infant/toddler diet are difficult to make due to the lack of data. For fathers or male partners, there is evidence to suggest their influence will be negative. Among preschool-aged children, Hendy and colleagues (2009) found that fathers were less likely than mothers to place daily limits on snacks, to insure fruit and vegetable availability, or to use reduced fat cooking methods (Hendy, Williams, Camise, Eckman, & Hedemann, 2009). Fathers were also more likely to insist children eat food, and less likely to use positive persuasion during feeding. In a series of focus groups conducted among fathers identified as being significant caregivers of their preschool-aged children, a common theme was that fathers were not accustomed to thinking about nutrition and food, with a common sentiment being, "I just eat" (Gemlo et al., 1998; Gemlo, Keenan, Ruffing, & Sweet D., 1998). Indeed, this is reflected in national data showing men are less likely than women to consider nutrition as very important when shopping for food (69.8% vs. 55.2%: OR=0.54, 95% CI: 0.46-0.64) (Bowman, 2005). Men are also less likely than women to consume at least two servings of fruit per day (28.7% vs. 36.1%) or three or more servings of vegetables (21.4% vs. 30.9%) (Centers for Disease Control, 2010).

There is even less evidence for the role of grandparents or other older adults. While several qualitative studies have reported a negative influence of grandmothers on the timing of the introduction of CF (M. Bentley, Gavin, Black, & Teti, 1999; M. E. Bentley, Caulfield, Gross, Bronner, Jensen, Kessler, & Paige, 1999; Corbett, 2000; Corbett, 2000), their impact on the quality of the complementary diet is likely positive. Among adults, fruit and vegetable consumption increases with age and is greatest among

those 65 years of age and older: 41.3% vs. 30.8% and 29.0% vs. 20.1% of adults ≥65 years vs. 18-24 consume two or more servings of fruit or three or more servings of vegetables per day (Centers for Disease Control, 2010). Older adults are also more likely than younger adults to rate nutrition as very important when shopping for food: compared to adults 20-39 years of age, odds ratios for those 40-54 years and ≥55 years are 1.33 (95% CI: 1.12-1.57) and 1.97 (95% CI: 1.70-2.28), respectively (Bowman, 2005).

For childcare providers, the body of research specific to infant and toddler feeding is also very small, but the evidence suggests their role will be neutral (i.e. not significantly better or worse than mothers). While non-parental childcare has been associated with decreased rates of breastfeeding at 3, 6, and 12 months, as well as a greater likelihood of solid feeding before 4 months (Hendricks, Briefel, Novak, & Ziegler, 2006; Kim & Peterson, 2008)data from FITS documented a positive influence of childcare on toddlers' nutrient intakes—lunches eaten at childcare versus at home or other away locations were significantly higher in vitamins and minerals, but no there were no significant differences in macronutrient or fiber intakes (Ziegler, Briefel, Ponza, Novak, & Hendricks, 2006). At the same time, there have been several studies among preschool-aged children documenting suboptimal intakes of food groups while attending childcare, particularly low intakes of vegetables and whole fruit, but high intakes of high-fat/fried meats (Ball, Benjamin, & Ward, 2008; Padget & Briley, 2005). Although these findings seem contradictory, it may be the case that childcare providers, who almost certainly could stand to improve the quality of foods and beverages provided to children, are simply no better or worse of an influence on young children's dietary patterns than are mothers, fathers or other caregivers. In fact, one positive aspect of childcare in North

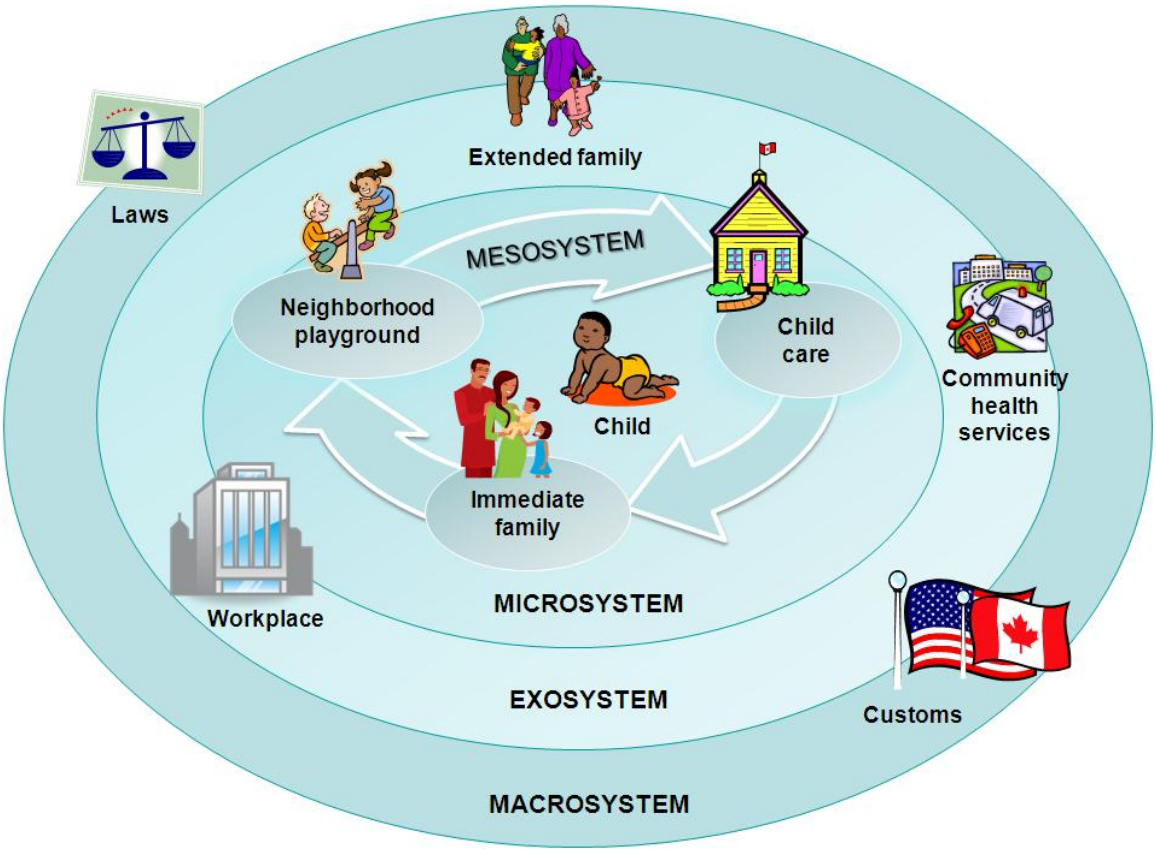
Carolina is the requirement that *all* licensed facilities follow the meal pattern guidelines of the Child and Adult Care Food Program (CACFP) and that sweetened beverages and other foods of low nutritional value are limited (North Carolina Division of Child Development, 2010).

Summary and significance

Despite dramatic changes in maternal employment over the last several decades, there is a major gap in our understanding of the types of caregivers, other than the mother, that have responsibility for feeding young children between the period of birth to two years. There are also relatively few studies that have examined the quality of the diet as related to obesity prevention during the period of complementary feeding. The work undertaken in the current dissertation aimed to fill these gaps by: (1) quantifying the intakes of obesity-related foods and beverages between six and 18 months of age; (2) examining the extent of non-maternal involvement in feeding during the first two years of life and identifying the types of NMCs used at various ages; and, (3) determining in longitudinal models the association between NMC use and dietary intakes. This research will have important implications for measures to include in future observational studies on infant and toddler feeding, as well as in the design of behavioral interventions aimed at promoting optimal complementary feeding practices for the prevention of overweight.

Tables and figures

Figure 1. Illustration of Urie Bronfenbrenner's Ecological Systems Theory. Adapted from Berk (2006).



CHAPTER III

METHODS

Dataset and study design

Data for all study aims are from the Infant Care, Feeding and Risk of Obesity Study (Infant Care), an observational cohort of mother-infant pairs from 3-18 months postpartum(M. Slining et al., 2010; M. M. Slining et al., 2009; A. L. Thompson et al., 2009; Wasser et al., 2011). First-time, African-American 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 at infant ages 3, 6, 9, 12 and 18 months. Infants were excluded if they were not full term; were <2500 or above 4500 grams in birthweight; 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 FTT (failure-to-thrive). Data collection began in November 2003 and was completed in October 2007. Sample attrition was as follows: 217 mother-infant pairs at 3-months, 168 pairs at 6 months (77% of baseline), 170 pairs at 9 months (78% of baseline), 154 pairs at 12 months (71% of baseline), and 139 pairs at 18 months (64% 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.

Setting description

Infant Care participants were recruited through WIC clinics in central North Carolina. The population from which the sample was drawn was therefore quite different than the US population at large. Selected demographic and health characteristics are provided in Table 1, broken down by race where available. Key differences between the general US population and the population from which the Infant Care sample was drawn include a much higher prevalence of households below poverty, a higher proportion of overweight women prior to pregnancy, a higher prevalence of infant and toddler overweight, and a lower prevalence of ever breastfeeding. There are additional differences by race/ethnicity even within the North Carolina WIC population: African-American women have a higher prevalence of overweight prior to pregnancy and the lowest prevalence of any breastfeeding.

Description of the Infant Care assessments

The Infant Care assessments collected data on infant, caregiver, household, and community characteristics potentially associated with the risk of obesity. Interviews and assessments were administered in the respondent's home by trained project staff. During the home visit, interviewers administered a questionnaire; obtained anthropometric measurements on the infant, mother and biological father; administered an infant motor

scale development assessment; and videotaped a feeding and play session. Table 2 contains a list of the assessments, by study visit/infant age.

Data collection procedures for key study variables

We describe here in detail the data collection procedures for the key study variables in this dissertation: infant dietary intake and use of non-maternal caregivers.

Infant dietary intake

The Nutrient Data System for Research (NDSR) (Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN), the most accurate and comprehensive nutrient calculation software available for research purposes, was used to capture infant and toddler dietary intakes. A total of three 24-hour dietary recalls (24-h DRs) were collected during each observation interval to generate a valid estimate of infants' and toddlers' usual intakes of food groups and nutrients. The first recall was administered during the home visit, with two random, nonconsecutive, telephone recalls occurring within a two-week interval after the home visit. Study personnel were trained by an NDSR–certified staff member of the University of North Carolina at Chapel Hill Nutrition Epidemiology Core (National Institutes of Health grant DK56350).

Variables of interest were those food groups associated, either positively or negatively, with obesity among older children and adults (Swinburn, Caterson, Seidell, & James, 2004), namely low energy-dense foods (ie, whole fruits and whole vegetables) and high-energy dense foods and beverages (ie, 100% juice, fried potatoes, desserts and sweets, sweetened beverages, and salty snacks). Variables were patterned after the major

and minor food groups utilized in FITS (Fox, Pac, Devaney, & Jankowski, 2004; Siega-Riz et al., 2010) (Appendix).

Non-maternal caregivers

Non-maternal caregivers (NMCs) were defined in Infant Care as those persons involved in feeding an infant or toddler 50% or more of his/her total feedings in a day. At each study visit, NMCs were identified through a series of four questions. First, the mother was asked how many times the index child was usually fed in a day. Fifty percent of this number was then calculated and mothers were asked if there was anyone, other than herself, responsible for feeding the index child that number of times (or more) in a day. If the mother affirmed use of a NMC, she was asked how the person was related to the index child.

Sample characteristics and potential confounding variables

Variables used to describe the study sample included infant birthweight, weight-for-length z score (WLZ), gestational age, and gender; maternal age, education, body mass index (BMI), breastfeeding, depression, and employment; and household size. These variables were also used in tests of sample attrition, with a subset included as confounding variables in analyses testing associations between non-maternal caregiving and infant and toddler intake of obesity-related foods and beverages. Data collection for sample characteristics and confounders is discussed in more detail, as needed, in the following chapters.

Tables and figures

Table 1. Comparison of selected demographic and health characteristics between general national population, national WIC population, and North Carolina WIC population.

	Nation	Nation WIC	North Carolina WIC	North Carolina WIC		
				White	African-American	Hispanic
Below poverty, %	15.3[a]	64.8[b]	61.1[c]	NA	NA	NA
Pre-pregnancy overweight	36.3[d]	52.9[b]	56.4[c]	52.0[c]	61.2[c]	59.7[c]
Pregnancy weight gain[e]						
<Ideal	22.7[f]	21.3[g]	25.8[h]	22.2 [h]	27.5 [h]	30.9 [h]
>Ideal	47.0[f]	48.8[g]	43.4 [h]	45.8 [h]	40.2 [h]	31.1 [h]
Infant and toddler obesity	9.7[i]	12.4[b]	13.6[j]	11.8[k]	12.6[k]	17.2[k]
Ever breastfed	76.9[l]	66.7[m]	62.5 [m]	61.7 [m]	50.8 [m]	83.0 [m]

[a]U.S. Census Bureau, 2006-2010 American Community Survey (U.S. Census Bureau,)

[b]Centers for Disease Control and Prevention, 2010 Pregnancy Nutrition Surveillance, Nation (Centers for Disease Control and Prevention, 2012)

[c]Centers for Disease Control and Prevention, 2010 Pregnancy Nutrition Surveillance, North Carolina(Centers for Disease Control and Prevention, 2012)

[d]Ogden CL, Carroll MD, BK Kit, and Flegal KM. Prevalence of Obesity and Trends in the Distribution of Body Mass Index Among US Adults, 1999-2010. *JAMA. 2012;307(5):491-497* (Ogden et al., 2012b)

[e] Based on 2009 IOM report, "Weight Gain During Pregnancy"

[f]Centers for Disease Control and Prevention, 2005-2007 Infant Feeding Practices Study II (Centers for Disease Control and Prevention, 2012)

[g]Centers for Disease Control and Prevention, 2006 Pregnancy Nutrition Surveillance, Nation (Centers for Disease Control and Prevention, 2012)

[h]Centers for Disease Control and Prevention, 2006 Pregnancy Nutrition Surveillance, North Carolina (Centers for Disease Control and Prevention, 2012)

[i]Ogden CL, Carroll MD, BK Kit, and Flegal KM. Prevalence of Obesity and Trends in Body Mass Index Among US Children and Adolescents, 1999-2010. *JAMA. 2012;307(5):483-490* (Ogden et al., 2012a)

[j]Centers for Disease Control and Prevention, 2010 Pediatric Nutrition Surveillance, Nation (Centers for Disease Control and Prevention, 2012)

[k]Centers for Disease Control and Prevention, 2010 Pediatric Nutrition Surveillance, North Carolina (Centers for Disease Control and Prevention, 2012)

[l]Centers for Disease Control and Prevention, 2012 Breastfeeding Report Card. Data is for 2009 births (Centers for Disease Control and Prevention, 2012)

[m]Centers for Disease Control and Prevention, 2009 Pregnancy Nutrition Surveillance, North Carolina(Centers for Disease Control and Prevention, 2012)

Table 2. Description of data collected in the Infant Care, Feeding, and Risk of Obesity Study (Infant Care)

	Infant Age (months)				
	3	**6**	**9**	**12**	**18**
Sections in Infant Care questionnaire					
Identification	X	X	X	X	X
Household Roster (including demographics of each member)	X	X	X	X	X
Breastfeeding, Infant Diet History, and Pacifier Use	X	X	X	X	X
Infant Health and Sleep Patterns	X	X	X	X	X
Infant Feeding Styles Questionnaire (Beliefs)	X	X	X	X	X
Infant Feeding Styles Questionnaire (Behaviors)	X	X	X	X	X
Body Satisfaction Questionnaire	X	X	X	X	X
Obesogenic Environment Checklist and Media Use	X	X	X	X	X
Alternate Caregivers	X	X	X	X	X
Infant Activity and Crying Patterns	X	X	X	X	X
Intervention Exposure and Sources of Infant Care Information	X	X	X	X	X
Parent Satisfaction Scale	X	X	X	X	X
Maternal and Household Characteristics	X	X	X	X	X
Maternal Physical Activity	X	X	X	X	X
Child Care Use	X	X	X	X	X
Food Security	X				X
Food Shopping and Eating Patterns	X	X	X	X	X
Neighborhood Environment and Facilities	X				
Smoking and Drug Use	X	X	X	X	X
Maternal Depression	X	X	X	X	X
Rosenberg Self-esteem Scale	X	X	X	X	X
Marlowe-Crowne Social Desirability Scale	X	X	X	X	X
Infant/Child Temperament	X	X	X	X	X
Parental spanking attitudes				X	X
Anthropometry	X	X	X	X	X
Video recording of feeding and play interaction	X	X	X	X	X
Motor development (Bayley Scales 2nd ed.)	X	X	X	X	X
24-hour dietary recalls	X	X	X	X	X

CHAPTER IV

OBESOGENIC DIETS BEGIN EARLY IN A COHORT OF INFANTS AND TODDLERS BORN TO LOW-INCOME, FIRST-TIME, AFRICAN-AMERICAN MOTHERS: THE INFANT CARE, FEEDING, AND RISK OF OBESITY STUDY

Introduction

Childhood obesity has reached even our youngest children. There has been an approximate 35% increase in the prevalence of overweight (ie, weight-for-length ≥95th percentile) among infants and toddlers over the past few decades (Ogden, Flegal, Carroll, & Johnson, 2002; Ogden et al., 2012a). Both large infant size and rapid postnatal growth are concerning due to their association with subsequent child and adult overweight (Botton et al., 2008; Chomtho et al., 2008; Mei, Grummer-Strawn, & Scanlon, 2003; Nader et al., 2006; Stettler, Zemel, Kumanyika, & Stallings, 2002; Stettler, Kumanyika, Katz, Zemel, & Stallings, 2003) and future comorbidities, such as cardiovascular disease (Law et al., 2002; Singhal, Cole, Fewtrell, Deanfield, & Lucas, 2004) and Type 2 diabetes (Bhargava et al., 2004; Forsen et al., 2000).

Research into the causes of large infant size and/or rapid growth has been steadily increasing, with a growing interest in the role of the diet during the first two years of life, particularly during the period of complementary feeding. Complementary feeding typically refers to the period of six to 24 months of age, in which infants are introduced to nutritive foods and beverages other than breast milk and/or infant formula. The latest data from the Feeding Infants and Toddlers Study (FITS) (Briefel et al., 2010), a nationally

representative sample of children between birth and four years of age, raises concerns about the quality of the diet during this time of transition, particularly as it relates to the prevention of obesity (Siega-Riz et al., 2010). While the data is limited among infants and toddlers (Dattilo et al., 2012), foods low in energy density, namely fruits and vegetables, have been shown to be protective against obesity among older children and adults whereas foods and beverages high in energy density, such as fried potatoes, desserts and sweets, and sweetened beverages, have been shown to increase risk of obesity (Flynn et al., 2006; Swinburn, Caterson, Seidell, & James, 2004). In the FITS sample, it is therefore troubling that by one year of age a higher proportion of toddlers consumed French fries than they did dark-green vegetables (18.5% versus 10.9%, respectively) and that approximately two-thirds were consuming a dessert or sweetened beverage daily (Siega-Riz et al., 2010).

What remains unknown is the daily *quantity* of these foods and beverages that infants and toddlers are consuming and how this intake varies over time. Fox, Reidy, Karwe, and Ziegler (2006) reported average portions consumed by infants and toddlers at a given eating occasion, but not for the day (Fox, Devaney, Reidy, Razafindrakoto, & Ziegler, 2006). Most other studies have employed cross-sectional designs (Briefel, Reidy, Karwe, Jankowski, & Hendricks, 2004; Fox, Pac, Devaney, & Jankowski, 2004; Hoerr, Horodynski, Lee, & Henry, 2006; Siega-Riz et al., 2010)and/or reported the proportion of infants or toddlers consuming *any* amount of foods or beverages (Briefel et al., 2004; Fox, Pac, Devaney, & Jankowski, 2004; Kudlova & Rames, 2007; Siega-Riz et al., 2010). Therefore, the purpose of the current study is to describe longitudinal dietary intakes during the period of complementary feeding, with a focus on both the proportion

of infants and toddlers consuming *any amount* of obesity-related foods and beverages, as well as the *total daily amount* of consumption. Providing this level of description in a longitudinal cohort may be important for obesity prevention as it can identify the age intervals in which very young children are exposed to these potentially obesogenic foods and beverages.

Methods

Study design and participants

Data are from the Infant Care, Feeding and Risk of Obesity Study (Infant Care), an observational cohort of mother-infant dyads from 3 to 18 months after delivery (M. Slining et al., 2010; M. M. Slining et al., 2009; A. L. Thompson et al., 2009; Wasser et al., 2011). First time African-American mothers aged 18 to 35 years were recruited through the North Carolina Supplemental Nutrition Program for Women Infants and Children and assessed during in-home visits at infant ages 3, 6, 9, 12, and 18 months. The current study uses data from visits occurring when infants and toddlers were 6 to 18 months of age. Exclusion criteria for the Infant Care Study included delivery at <35 weeks gestation or presence of any of the following conditions: Down syndrome, epilepsy, cleft lip/palate, cerebral palsy, failure to thrive, mental retardation, severe food allergies, and any condition that might affect appetite, feeding, or growth. Data were collected from 2003 to 2007. The institutional review board of the University of North Carolina at Chapel Hill approved this study.

Data collection methods and outcome measures

During each home visit, mothers completed a 24-hour dietary recall (DR). To improve estimates of usual food intakes, the Infant Care Study collected two additional 24-hour DRs, which were taken by telephone on random, nonconsecutive days within two weeks of the home visit (F. E. Thompson & Subar, 2008). The 24-hour DR was administered and analyzed using the 2005 version of the Nutrition Data System for Research (NDSR) (Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN). Study personnel were trained by an NDSR–certified staff member of the University of North Carolina at Chapel Hill Nutrition Epidemiology Core.

To facilitate comparisons with national data from the Feeding Infants and Toddlers Study (FITS), we created variables similar to the major and minor food groups reported by Fox, Pac, Devaney and Jankowski (2004) (Fox, Pac, Devaney, & Jankowski, 2004)and Siega-Riz, Deming, Reidy and Fox (2010) (Siega-Riz et al., 2010). For each major and minor food group, two variables were created: (1) any intake (i.e. proportion consuming any amount of a food or beverage in the series of 24-hour DRs) and (2) average daily servings. We specifically chose servings rather than gram amounts, as servings are based on commonly used household metrics, such as cups, ounces, and tablespoons and may be easier for researchers and public health workers to translate to parents and caregivers. However, since the volume or weight of a serving size in NDSR is adult-sized—drawn from the Dietary Guidelines for Americans (DGAs) or, for foods that are not recommended in the DGAs, the food-label serving sizes from the Food and Drug Administration—it was necessary to adjust them to those appropriate for infants and toddlers. To this end, we created age-adjusted serving sizes based on the ratio of

infant to adult energy requirements (Institute of Medicine, 2005), thereby accounting for the natural increase in food intake occurring during infancy due to increasing body size. This method of age-adjusting serving sizes has been used in cross-sectional studies among older infants and toddlers (Cox, Skinner, Carruth, Moran, & Houck, 1997; Hoerr et al., 2006), with intakes of fruit, vegetables, and dairy each significantly correlated with mean adequacy ratio (MAR) scores, an index of the average percent of the recommended intakes of several key nutrients ($\rho = 0.24$, 0.22, and 0.44, respectively; $P<0.05$) (Hoerr et al., 2006). A detailed description of the coding rules used to convert NDSR serving sizes are provided in Table 2 and examples of age-adjusted serving sizes for selected food items are provided in Table 3.

Statistical methods

At each time point, dietary variables had positively skewed distributions with heavy clustering at zero (i.e., many non-consumers of particular foods or beverages). We therefore estimated proportions of infants and toddlers consuming any amount of selected foods and beverages and, among consumers only, the median number of daily servings. Differences in baseline characteristics between completers and non-completers were also assessed at each study visit to test the effects of attrition. T-tests were used for continuous variables and chi-square or Fisher's exact tests for categorical variables. Stata (release 12, 2012, StataCorp, College Station, TX) was used for all statistical procedures and significance was set at $P<0.05$ for all tests.

Results

Sample characteristics

Table 4 displays infant, maternal, and household characteristics by study visit. Generally, the Infant Care sample consisted of young, first-time, African-American mothers with a high prevalence of single-headed households and maternal obesity. In an examination of attrition over time, tests of baseline differences between completers and non-completers revealed few significant differences. There were slightly more mothers at 12 months with at least some college education or who were married. At 18 months, slightly more mothers were married and household size was lower.

Any intake

Table 5 contains cross-sectional data on the proportion of infants and toddlers consuming any amount of selected foods and beverages. At six months, a high percentage of infants were consuming fruit excluding juice (72%), vegetables excluding fried potatoes (70.2%), and juice (61.5%) and nearly one-third of infants were consuming a dessert or candy. Few six-month-olds were consuming fried potatoes (5.6%), sweetened beverages (4.3%) or salty snacks (2.5%). By 18 months, the proportion of infants consuming fruit had remained fairly stable (68.2%) whereas the percentages of infants consuming any amount increased substantially for all other major food groups: juice (90.7%), vegetables (98.4%), desserts and sweets (96.1%) and salty snacks (45.7%). At each time point, more infants were consuming fried potatoes than dark-green vegetables and popular sub-categories of desserts and sweets included cakes/pies/cookies/pastries, sugars/syrups/preserves, and sweetened beverages, particularly fruit-flavored drinks.

Total daily servings

Table 6 displays the median number of total daily servings among consumers, by infant/toddler age. At all time points, daily servings of juice were greater than servings of fruit. Servings of juice also doubled over time (2.3 servings/day at six months versus 5.3 servings/day at 18 months), while servings of fruit remained stable at approximately 1.8 servings/day. Similarly, daily servings of fried potatoes were greater than dark-green vegetables at all time points with servings of fried potatoes tripling between six and 18 months (0.3 and ~1 serving/day, respectively). One of the only food groups to decline over time was the vegetable subgroup, deep-yellow vegetables, which decreased from 1.3 servings/day at six months to 0.1 servings/day at 18 months. At six months, infants were consuming an average of 1.4 servings/day of desserts and sweets excluding beverages with this increasing to 2.2 servings/day by 18 months. As with 'any intake,' cakes/pies/cookies/pastries were consumed in the greatest amount. Servings of sweetened beverages increased seven-fold between six and 18 months, from 0.2 to 1.5 servings/day, respectively. Fruit drinks were consumed in the greatest amount at most time points. For salty snacks, there was more than a four-fold increase between six and 18 months, increasing from 0.2 to 0.9 servings/day, respectively.

Discussion

This study examined dietary intakes during the period of complementary feeding in a longitudinal cohort of infants born to low-income, first-time, African-American mothers. Due to the increase in the prevalence of overweight among infants and toddlers (Ogden, Flegal, Carroll, & Johnson, 2002; Ogden et al., 2012a), we specifically focused

on food groups that have been shown to be associated, either positively or negatively, with obesity among older children and adults (Dattilo et al., 2012; Flynn et al., 2006; Swinburn, Caterson, Seidell, & James, 2004). Our most important findings are (1) that large proportions of infants and toddlers in the Infant Care sample consumed foods and beverages that are high in energy density and potentially obesogenic; (2) that median intakes by infants and toddlers were greater for high energy-dense foods, such as juice and desserts and sweets, than for low energy-dense foods, namely fruits and vegetables; and (3) that increases in median intakes of several high energy-dense foods were greatest between the period of nine to 12 months.

As compared to the nationally representative sample in the FITS study (Siega-Riz et al., 2010), a smaller proportion of infants and toddlers in the Infant Care sample consumed any fruit in a day. Conversely, higher proportions of infants and toddlers in Infant Care versus FITS consumed high energy-dense foods, including juice, fried potatoes, desserts and sweets, and salty snacks. These findings suggest that infants and toddlers of low-income African-American mothers are a priority population for complementary feeding interventions. Given that several studies have shown food preferences may be set as early as two years of age (Cashdan, 1994; Skinner & Carruth, 2001), interventions that improve complementary feeding practices might decrease risk of later obesity if they decrease exposure to high energy-dense foods and beverages and increase preference for those low in energy density (Dattilo et al., 2012).

To our knowledge, few other studies have documented *the amount* of foods and beverages that infants and toddlers are consuming on a daily basis during the period of complementary feeding, particularly as it pertains to the prevention of overweight and

obesity. Most prior studies have reported the proportion of infants or toddlers consuming *any amount* of foods or beverages in a day(Briefel et al., 2004; Fox, Pac, Devaney, & Jankowski, 2004; Kudlova & Rames, 2007; Siega-Riz et al., 2010), average portion sizes of foods and beverages consumed at a *single* eating occasion (Fox, Reidy, Karwe, & Ziegler, 2006), or created dietary pattern scores via principal components analysis or an index (Cox et al., 1997; Kudlova & Rames, 2007; Robinson et al., 2007). Our analyses further substantiate the emergence of potentially obesogenic consumption patterns very early in life. At most time points, infants and toddlers in our sample consumed greater quantities of high energy-dense foods, such as desserts and sweets, sweetened beverages, juice, and salty snacks, than they did of less energy-dense foods, such as fruits and vegetables. Across time, consumption of fruits and vegetables remained fairly stable at approximately 1.8 and 2 servings/day, respectively. For a subgroup of vegetables, deep-yellow vegetables, there was a substantial decrease over time, which may be due to a diminishing reliance on jarred, pureed baby foods as infants grow teeth and improve fine motor skills (Carruth, Ziegler, Gordon, & Hendricks, 2004), development factors that allow them to more easily consume foods eaten by the rest of the family. These developmental factors may also explain the increase over time in the number of servings of high energy-dense foods, such as fried potatoes, cookies, and salty snacks, which are foods not typically available as commercially prepared infant foods. Importantly, we also found that several high energy-dense foods increased most substantially between nine and 12 months, highlighting the importance of intervening early, delivering nutrition education and other behavior change strategies during the first half of infancy.

Why servings versus absolute amounts? Compared to absolute amounts, such as grams or calories, serving sizes are based on commonly used household metrics, including cups, ounces, and tablespoons. For example, the 18-month-olds in our sample consumed an average daily amount of 5 tablespoons (Tbsp) of fruit, 7 Tbsp of vegetables excluding fried potatoes, 8 fluid ounces of juice, 4 French fries or tater tots, 2¼ chocolate chip cookies, 4½ fluid ounces of sweetened beverages, and nearly 10 grams of salty snacks, such as 11-12 cheese puffs. Contrast the interpretability of these findings to a study by Briefel, Reidy, Karwe, Jankowski, and Hendricks (2004) in which quartiles of total energy intake from table foods were calculated and then comparisons were made between the proportion of infants and toddlers consuming different types of foods and beverages, by low versus high quartile of total energy (Briefel et al., 2004). Their main findings that a higher proportion of infants and toddlers in the *lowest* energy quartile consumed deep yellow vegetables while higher proportions of infants and toddlers in the *highest* energy quartile consumed pizza, carbonated sodas, French fries, and sweets, are clearly important. Yet, they may be difficult messages for the media or public health workers to readily translate to parents and caregivers.

Perhaps most importantly, our findings call for greater attention to the period of complementary feeding. Currently, there are no Healthy People 2020 goals for complementary feeding of infants and toddlers (U.S. Department of Health and Human Services, Office of Disease Prevention and Health Promotion.,) and this age group has historically been excluded from the Dietary Guidelines for Americans (U.S. Department of Agriculture & U.S. Department of Health and Human Services, 2010). The promotion of optimal complementary feeding practices has traditionally been recognized as a core

intervention for prevention of undernutrition in low- and middle-income country settings (Bhutta et al., 2008). Growing evidence suggests that complementary feeding practices should also play a role in the obesity prevention discourse (Dattilo et al., 2012), as foods and beverages associated with obesity among older children and adults appear to emerge in the diet during this time of transition.

There are limitations to the current study. The sample consisted of low-income, first-time, African-American mothers, and the results should only be applied to this subset of the population. While a major strength of the current study is the longitudinal design, loss to follow-up is always a concern with such studies. However, an examination of participant attrition in our sample revealed significant differences on only a few variables, including slightly more mothers at 12 months with at least some college and more married mothers at both 12 and 18 months. Given the literature, we would expect these differences to attenuate our findings, since having a college education and being married are two factors associated with positive infant and toddler feeding practices, such as feeding fruit and avoiding sweetened beverages (Hendricks, Briefel, Novak, & Ziegler, 2006).

Conclusions

Data from the Infant Care study provides evidence that infants and toddlers of low-income, first-time African-American mothers are at risk for developing preferences for foods and beverages shown to be associated with obesity among older children and adults. Additional research is needed to determine whether these dietary intakes are associated with energy intakes and weight status and to identify predictors of these early

feeding patterns. Since high energy-dense foods are prevalent even at six months in this subpopulation, caregivers would benefit from anticipatory guidance on healthy complementary feeding during the prenatal period and/or early in the first six months of life. This study adds to the growing evidence that complementary feeding practices should be an important component of policies and programs aimed at establishing healthy diets.

Tables and figures

Table 3. Coding rules for converting adult-based NDSR[a] serving sizes to those appropriate for infants and toddlers.

Child age (mo) at time of dietary recall	Boys		Girls		
	Energy requirement[b]	Fraction of adult male requirement[c]	Energy requirement[d]	Fraction of adult female requirement[e]	Coding rule
6	645	0.25	593	0.26	NDSR*0.255
9	746	0.29	678	0.29	NDSR*0.290
12	844	0.32	768	0.33	NDSR*0.325
18	961	0.37	899	0.39	NDSR*0.380

[a]Nutrition Data System for Research (NDSR) (Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN)

[b]Dietary reference intake (DRI) for energy for boy of corresponding age and at median weight-for-age

[c]Value is 2600 calories per day, the DRI for energy for a 30-year-old male with a healthy body-mass-index (BMI) (18.5-24.9) and low active to active lifestyle

[d]DRI for energy for girl of corresponding age and at median weight-for-age

[e]Value is 2300 calories per day, the DRI for energy for a 30-year-old female with a healthy BMI (18.5-24.9) and low active to active lifestyle

Table 4. Examples of age-adjusted serving sizes for selected food items.

		Age-adjusted Serving Size	
		Age (mo)	
Food item	**NDSR Adult Serving Size**	**6 and 9**	**12 and 18**
Fruit juice	4 fl oz	1 fl oz	1½ fl oz
Fruit, fresh, frozen, or canned (chopped)	½ cup (8 Tbsp)	2 Tbsp	3 Tbsp
Vegetables, raw, cooked, or canned (chopped)	½ cup (8 Tbsp)	2 Tbsp	3 Tbsp
Fried potatoes	½ cup (10-14 fries)	2 Tbsp (3-4 fries)	3 Tbsp (4-5 fries)
Cookies, chocolate chip, commercially prepared	30 g (2½ cookies)	8 g (2/3 cookie)	11 g (1 cookie)
Sweetened beverages	8 fl oz	2 fl oz	3 fl oz
Ice cream	½ cup (8 Tbsp)	2 Tbsp	3 Tbsp
Cheese puffs	28 g (32 pieces)	0.3 ounces (8-9 pieces)	10 g (11-12 pieces)

Table 5. Characteristics of mothers and infants participating in the Infant Care, Feeding, and Risk of Obesity study.

	Study Visit				
	3-month	**6-month**	**9-month**	**12-month**	**18-month**
	← *mean±SD/n(%)* →				
Total (n)	217	161	165	151	129
Infant characteristics					
Gestational age (weeks)	39.5±1.5	39.6±1.4	39.5±1.4	39.6±1.4	39.5±1.4
Birthweight (kg)	3.2±0.5	3.3±0.5	3.2±0.5	3.2±0.5	3.2±0.5
Age (months)	3.2±0.3	6.4±0.5	9.4±0.5	12.6±0.7	19.1±2
Female	116 (53.5)	85 (53.5)	85 (51.8)	80 (54.8)	68 (52.7)
Weight-for-height Z score	0.6±1	0.5±1.1	0.5±1.1	0.4±1.1	0.3±1.1
Infant overweight[a]	63 (29)	41 (25.8)	40 (24.4)	32 (21.9)	25 (19.4)
Maternal and household characteristics					
Age (years)	22.7±3.8	22.9±3.8	23.3±4	23.7±3.9	24.3±
Maternal education					
Less than highschool	58 (27.1)	43 (26.7)	45 (27.6)	41 (27.3)	35 (27.1)
Highschool graduate	65 (30.4)	45 (28)	46 (28.2)	37 (24.7)**	34 (26.4)
Any college	91 (42.5)	73 (45.3)	72 (44.2)	72 (48)**	60 (46.5)
Married	21 (9.8)	17 (10.6)	19 (12.3)	16 (11.8)*	16 (15.8)**
Any maternal employment	115 (53.7)	97 (61.8)	101 (63.5)	83 (58.5)	61 (60.4)

Maternal obesity (BMI≥30)	96 (44.2)	71 (44.1)	73 (44.8)	63 (42)	55 (42.6)
Maternal depression[b]	62 (29.1)	40 (27.6)	37 (23.6)	24 (17.1)	35 (34)
Household size	3.9±1.7	4.1±1.7	3.6±1.5	3.5±1.5	3.3±1.3**
Ever breastfed	151 (69.6)	119 (73.9)	119 (72.2)	108 (72)	94 (72.9)

[a]>90th percentile 2000 CDC NCHS growth charts

[b]Score ≥16 on the Center for Epidemiological Studies Depression Scale

*P<0.05

**P<0.001

Table 6. Proportion of infants and toddlers consuming any amount of selected foods and beverages in a day.

	Proportion Consuming at Least Once in a Day			
	Age (mo)			
Food group	**6**	**9**	**12**	**18**
	← *mean±standard error* →			
Total (n)	161	165	151	129
All fruit, excluding juice[a]	72±3.5	67.3±3.7	64.9±3.9	68.2±4.1
100% fruit juice	61.5±3.8	78.8±3.2	90.1±2.4	90.7±2.6
All vegetables	72±3.5	89.7±2.4	94±1.9	98.4±1.1
Dark-green vegetables	4.3±1.6	10.3±2.3	22.5±3.4	31±4.1
Deep yellow vegetables	42.9±3.9	45.5±3.9	51.7±4.1	45.7±4.4
White potatoes	12.4±2.6	34.5±3.7	48.3±4.1	45±4.4
Fried potatoes	5.6±1.8	20±3.1	38.4±4	55±4.4
Other starchy vegetables[b]	27.3±3.5	35.8±3.7	45±4.1	65.9±4.2
Other vegetables[c]	30.4±3.6	56.4±3.9	76.8±3.4	86.8±3
All desserts and sweets	30.4±3.6	68.5±3.6	86.1±2.8	96.1±1.7
Desserts and candy	25.5±3.4	56.4±3.9	62.9±3.9	81.4±3.4
Baby food desserts	10.6±2.4	15.8±2.8	6.6±2	0.8±0.8[d]
Cakes, pies, cookies, and pastries	14.9±2.8	43.6±3.9	53±4.1	61.2±4.3

Ice cream, frozen yogurt, pudding	5±1.7	7.3±2	13.2±2.8	30.2±4.1
Other desserts[e]	0	0	2.6±	6.2±2.1
Candy	0	4.8±1.7	11.3±2.6	26.4±3.9
Other sweets	7.5±2.1	23.6±3.3	44.4±4.1	70.5±4
Milk flavorings	0	0.6±0.6[d]	0	3.1±1.5
Sugars, syrups, preserves	7.4±2.1	23±3.3	44.4±4.1	70.5±4
Sweetened beverages	4.3±1.6	20±3.1	45.7±4.1	69±4.1
Carbonated sodas	1.9±1.1[d]	3.6±1.5	9.3±2.3	17.1±3.3
Fruit-flavored drinks	1.2±0.9[d]	16.4±2.9	39.7±4	65.9±4.2
Other[f]	1.9±1.1[d]	4.2±1.6	6±1.9	10.9±2.7
Salty snacks[g]	2.5±1.2	7.3±2	23.8±3.5	45.7±4.4

[a]Excludes fried fruits or fruit-based savory snacks

[b]Includes starchy vegetables in mixed dishes (eg, corn, lima beans, lentils, peas)

[c]Includes tomato, tomato products (eg, sauce, puree, paste) and vegetables in mixed dishes (eg, beets, cabbage, summer squash)

[d]Point estimates is imprecise due to uncommon event

[e]Includes gelatin desserts and pie fillings

[f]Includes sweetened tea, coffee and water

[g]Includes onion rings, corn chips, cheese puffs, and popcorn

Table 7. Number of total daily servings of selected foods and beverages, among consumers only.

	Total Daily Servings			
	Age (mo)			
Food group	**6**	**9**	**12**	**18**
	← *median±standard error* →			
Total (n)[a]	161	165	151	129
All fruit, excluding juice[b]	1.8±0.3	1.9±0.2	2.1±0.4	1.7±0.2
100% fruit juice	2.3±0.3	2.9±0.4	4.9± 0.4	5.3±0.5
All vegetables, excluding fried potatoes	1.8±0.2	1.7±0.1	2±0.2	2.3±0.2
Dark-green vegetables	0.1±0.3[c]	0.4±0.2	0.4±0.1	0.3±0.1
Deep yellow vegetables	1.3±0.1	0.9±0.2	0.2±0.1	0.1±0.0
White potatoes	0.6±0.2	0.7±0.2	0.6±0.2	0.9±0.1
Other starchy vegetables[d]	0.8±0.1	0.3±0.2[c]	0.1±0.1	0.4±0.1
Other vegetables[e]	0.7±0.1	0.8±0.1	0.9±0.1	0.9±0.1
Fried potatoes	0.3±0.1	0.6±0.2	1.1±0.2	0.9±0.1
All desserts and sweets, excluding beverages	1.4±0.4	1.4±0.2	1.6±0.3	2.2±0.2
Desserts and candy	1.4±0.4	1.2±0.2	1.5±0.2	1.5±0.2
Baby food desserts	1±0.2	1.1±0.2	2±0.5	1.2±0[c]
Cakes, pies, cookies, and pastries	2.1±0.6	1.1±0.2	1.2±0.2	1.2±0.1
Ice cream, frozen yogurt, pudding	0.2±0.2[c]	0.6±0.2	0.4±0.1	0.9±0.2

Other desserts[f]	0	1.1±0[c]	0.5±0.1	0.7±0.5[c]
Candy	0	0.3±0.3[c]	0.5±0.4[c]	0.6±0.2
Other sweets	0.1±0.1[c]	0.3±0.1	0.3±0.1	0.5±0.1
Milk flavorings	0	2.2±0[c]	0	0.6±0.3
Sugar, syrup, preserves	0.1±0.1[c]	0.3±0.1	0.3±0.1	0.5±0.1
Sweetened beverages	0.2±0.2[c]	0.7±0.2	1.2±0.2	1.5±0.2
Carbonated sodas	0.2±0.2[c]	0.5±0.1	0.5±0.1	0.7±0.2
Fruit-flavored drinks	0.3±0.1	0.7±0.2	1.1±0.2	1.1±0.2
Other[g]	0.3±0.3[c]	0.3±0.2[c]	0.8±0.4[c]	0.5±0.3[c]
Salty snacks[h]	0.2±0.1	0.1±0	0.6±0.1	0.9±0

[a]Size of total sample at study visit.

[b]Excludes fried fruits or fruit-based savory snacks

[c]Point estimate is imprecise due to uncommon event

[d]Includes starchy vegetables in mixed dishes (eg, corn, lima beans, lentils, peas)

[e]Includes tomato, tomato products (eg, sauce, puree, paste) and vegetables in mixed dishes (eg, beets, cabbage, summer squash)

[f]Includes gelatin desserts and pie fillings

[g]Includes sweetened tea, coffee and water

[h]Includes potato chips, onion rings, corn chips, cheese puffs, and popcorn

CHAPTER V

WHO'S FEEDING BABY? NON-MATERNAL INVOLVEMENT IN FEEDING AND ITS ASSOCIATION WITH INTAKES OF OBESITY-RELATED FOODS AMONG INFANTS AND TODDLERS

Introduction

It is well documented that the prevalence of obesity among children and adolescents ages two to 19 years has more than tripled since 1980 (Ogden & Carroll, 2010). Among infants and toddlers, the increase has been smaller, yet still substantial—in 2010 compared to 1976-1980, 35% more children less than two years had a high weight-for-length z-score (WLZ) (WLZ ≥95th percentile) (Ogden, Flegal, Carroll, & Johnson, 2002; Ogden et al., 2012a). In light of these trends, obesity prevention has begun earlier in life, with a growing number of interventions targeting risk factors during the first two years(Ciampa et al., 2010).

There are several dietary factors occurring during infancy which may have protective effects against later obesity. Several meta-analyses have reported similar findings that breastfeeding confers a small, protective effect against obesity or overweight in childhood or adolescence (OR=0.78, 95% CI: 0.72-0.84) (Arenz, Ruckerl, Koletzko, & von Kries, 2004; Horta, Bahl, Martines, & Victora, 2007). Duration of any breastfeeding may be particularly important in light of the findings by Harder, Bergmann, Kallischnigg, and Plagemann (2005) that each month of breastfeeding was associated

with a four percent decrease in the risk of overweight (95% CI: 0.94, 0.98) (Harder, Bergmann, Kallischnigg, & Plagemann, 2005).

Several factors during the period of complementary feeding may also play a role in obesity prevention. Complementary feeding is the transitional process between exclusive milk feeding in which nutritive foods and beverages other than breast milk or infant formula are gradually introduced. Both the American Academy of Pediatrics and the World Health Organization recommend that complementary feeding begin at six months, after a period of exclusive breastfeeding (American Academy of Pediatrics Committee on Nutrition, 2009; World Health Organization, 2003). However, many infants are fed complementary foods before this time (Grummer-Strawn, Scanlon, & Fein, 2008; Wasser et al., 2011), some as early as seven to 10 days postpartum (Bronner et al., 1999). In a recent systematic review, Moorcroft, Marshall and McCormick (2011) reported no clear association between the age of introduction of complementary foods and obesity (Moorcroft, Marshall, & McCormick, 2011). However, studies were highly heterogeneous in terms of the exposure (early introduction to complementary foods) and the outcome (infant and child obesity) preventing the conduct of a meta-analysis and the ability to make robust conclusions.

A less studied but emerging area of interest is the quality of the diet during the span of complementary feeding. Several rounds of data from the Feeding Infants and Toddlers Study (FITS), a nationally representative sample of young children from birth to four years, have raised concern about the quality of the diet during this time of transition (Fox, Pac, Devaney, & Jankowski, 2004; Siega-Riz et al., 2010; Skinner, Ziegler, & Ponza, 2004; Skinner, Ziegler, Pac et al., 2004). The latest estimates from FITS continue

to show that approximately 25% of infants and toddlers fail to consume any amount of whole fruit and 30% consume no whole vegetables on a given day. In contrast, nearly 20% of infants, ages six to 8.9 months, consume a dessert or sweet in a day, with the proportion increasing to 80.6% of toddlers consuming such foods at 21-23.9 months (Siega-Riz et al., 2010). While the data is limited among infants and toddlers (Dattilo et al., 2012), these patterns are troubling since low intakes of whole fruits and vegetables and high intakes of energy-dense foods, such as desserts and sweets and sweetened beverages, have been associated with obesity among older children and adults (Flynn et al., 2006; Swinburn, Caterson, Seidell, & James, 2004).

An important social change paralleling the rise in childhood obesity is the increase in mothers participating in the labor force (Anderson & Butcher, 2006). Between 1970 and 2000, the rate of mothers in the labor force, either employed or looking for work, increased from 38% to 68%. The increase was even more dramatic among mothers with children under the age of three, with 24% of such mothers in the labor force in 1970 and 57% in 2000 (Ehrle et al., 2001). These changes in maternal employment have had implications for childcare arrangements of young children while the mother is working. The use of non-parental care begins early in life, with approximately half of all 9-month-olds in a regular non-parental care arrangement: 26% in relative care, 15% in non-relative care, 9% in center-based care, and 1% in multiple arrangements(Mulligan et al., 2005).

Despite these social changes, relatively little is known about the types of non-maternal caregivers involved in feeding infants and toddlers and the impact they may have on early dietary habits. To fill this gap, the current study sought to answer several research questions. *To what extent do non-maternal caregivers share responsibility for*

feeding during the first two years of life? What types of non-maternal caregivers are used most frequently? What impact does their involvement have on breastfeeding, timing of introduction of complementary foods, and the intake of foods and beverages associated with obesity?

Methods

Study design and participants

Data are from the Infant Care, Feeding and Risk of Obesity Study (Infant Care), an observational cohort of 217 low-income mother-infant dyads from 3 to 18 months after delivery (M. Slining et al., 2010; M. M. Slining et al., 2009; A. L. Thompson et al., 2009; Wasser et al., 2011). First-time African-American mothers aged 18 to 35 years were recruited through the North Carolina Supplemental Nutrition Program for Women Infants and Children (WIC) and assessed during in-home visits at infant ages 3, 6, 9, 12, and 18 months. Exclusion criteria for the Infant Care Study included delivery at <35 weeks gestation or presence of any of the following conditions: Down syndrome, epilepsy, cleft lip/palate, cerebral palsy, failure to thrive, mental retardation, severe food allergies, and any condition that might affect appetite, feeding, or growth. Data were collected from 2003 to 2007. The institutional review board of the University of North Carolina at Chapel Hill approved this study.

Measures

Non-maternal caregivers. Non-maternal caregivers (NMCs) were defined in Infant Care as those persons involved in feeding an infant or toddler 50% or more of his/her total

feedings in a day. At each study visit, NMCs were identified through a series of three questions. First, the mother was asked how many times the index child was usually fed in a day. Fifty percent of this number was then calculated and mothers were asked if there was anyone, other than herself, responsible for feeding the index child that number of times (or more) in a day. If the mother affirmed use of a NMC, she was asked how the person was related to the index child. A total of six variables were created, one representing any use of a NMC and five representing the type of NMC. Categories for type of NMC included father, grandmother, other relative (e.g. aunt, cousin), non-relative (e.g. babysitter, nanny), and licensed child care provider, which included child care centers and family day care homes.

Infant and toddler dietary intake. During each home visit, mothers completed a questionnaire assessing current breastfeeding status (still breastfeeding "yes/no") and a 24-hour dietary recall (DR). To improve estimates of usual food intakes, the Infant Care Study collected two additional 24-hour DRs, which were taken by telephone on random, nonconsecutive days within two weeks of the home visit (F. E. Thompson & Subar, 2008). Mothers were aware of the timing of home visits and telephone recalls and were instructed in advance to obtain information about any foods and beverages consumed by the infant while not in her care. The 24-hour DR was administered and analyzed using the 2005 version of the Nutrition Data System for Research (NDSR) (Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN). Study personnel were trained by an NDSR–certified staff member of the University of North Carolina at Chapel Hill Nutrition Epidemiology Core.

We used data from NDSR to create several variables of interest, including early introduction to complementary foods before four months of age and intake of a series of foods and beverages associated, either positively or negatively, with obesity among older children and adults (Flynn et al., 2006; Swinburn, Caterson, Seidell, & James, 2004), namely low energy-dense foods (whole fruits and whole vegetables) and foods and beverages high in energy-density (100% juice, fried potatoes, desserts and sweets, sweetened beverages, and salty snacks). This latter set of variables was patterned after the major and minor food groups utilized in FITS (Fox, Pac, Devaney, & Jankowski, 2004; Siega-Riz et al., 2010). For each of these major and minor food groups, two variables were created: the proportion of infants and toddlers consuming any amount, and total daily servings consumed. Serving sizes rather than gram amounts were chosen as serving sizes are based on commonly used household metrics, such as cups, ounces, and tablespoons, and may be easier for researchers and public health workers to translate to parents and caregivers. When reporting servings of the major and minor food groups of interest, we adjusted the NDSR *adult-based* serving sizes to those appropriate for infants and toddlers, as has been done in previous studies (Cox et al., 1997; Hoerr et al., 2006). This is a necessary step as the serving sizes in NDSR are adult-sized—drawn from the Dietary Guidelines for Americans (DGAs) or, for foods that are not recommended in the DGAs, the food-label serving sizes from the Food and Drug Administration. Age-adjusted serving sizes were based on the ratio of infant to adult energy requirements. For example, to calculate the age-adjustment factor for a 6-month-old boy, the dietary reference intake (DRI) for energy for a 6-month-old boy at the median weight-for-age was divided by the DRI for energy for a 30-year-old male with a healthy body-mass-

index (BMI) (18.5-24.9) and low-active to active lifestyle (Institute of Medicine, 2005). Calculations were done separately for boys and girls at each age (6, 9, 12, and 18 months). However, ratios did not differ by gender, resulting in the following single set of adjustment factors: 0.26 at 6 months, 0.29 at 9 months, 0.33 at 12 months, and 0.38 at 18 months. Examples of age-adjusted serving sizes for selected food items are provided in Table 7.

Confounding variables. Potential confounding variables were drawn from the literature and include factors associated with infant and toddler feeding practices (Hendricks, Briefel, Novak, & Ziegler, 2006) as well as non-maternal caregiving in general(Bianchi & Casper, 2000; Ehrle et al., 2001). These maternal and household characteristics encompass: any maternal employment, any maternal college education, maternal age, marital status, and maternal depression. Maternal depression was 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).

Statistical analyses

Descriptive statistics were used to examine study variables at each time point (3, 6, 9, 12, and 18 months) with the exception of daily servings of foods and beverages during the period of complementary feeding. We do examine 'any intake' of foods and beverages between three to 18 months, but examination of daily servings would require calculation of serving sizes for three-month-olds, which is inappropriate for infants younger than six months. This step revealed positively skewed distributions for the daily

serving size variables, with heavy clustering at zero (i.e., many non-consumers of particular foods or beverages). For these variables, we present the data in terms of the proportion of infants or toddlers consuming any amount of a food group or food item as well as the median among consumers only. We also examined cross-tabulations at each time point between any NMC usage or type of NMC usage and dichotomous variables expected to change over time (still breastfeeding and any intake of selected foods and beverages). This step revealed small cell sizes for some cross-tabulations, which had implications for the number of visits included in longitudinal models. For each model, we specify the number of visits included and the sample size.

To examine longitudinal associations between maternal and household characteristics and NMC variables, we used random-effects logistic regression models in which NMC use was the dependent variable and independent variables were selected maternal and household characteristics plus a series of dummy variables representing study visit. Next, we ran cross-sectional logistic regression models using data from the 3-month visit, one unadjusted and one adjusted for potential confounders, to test for associations between NMC usage and early introduction to complementary foods (<4 months). At the 3-month visit (n=217), 42 infants were between 2.7 and 2.9 months old, 162 were between 3.0 and 3.9 months old, and 1 was ≥4.0 months old. To determine longitudinal associations between NMC usage and the dichotomous dietary variables (still breastfeeding and any intake of selected foods and beverages), we ran a series of unadjusted and adjusted random-effects logistic regression models with the dietary variable of interest as the dependent variable and NMC usage as the main independent variable. Longitudinal random-effects tobit models with lower limit censoring set at zero

were used to examine associations between NMC usage and daily servings of the selected foods and beverages. Data presented are post-estimation marginal effects among consumers only [E(y|y>0)]. Coefficients should be interpreted as the effect of NMC use versus no NMC use on the intake, among consumers only, of daily servings of selected foods and beverages.

Finally, differences in baseline characteristics between completers and non-completers were assessed at each study visit to test the effects of attrition. T-tests were used for continuous variables and chi-square or Fisher's exact tests for categorical variables. Stata (release 12, 2012, StataCorp, College Station, TX) was used for all statistical procedures. Significance was set at $P<0.05$ for all tests.

Results

Sample characteristics

Among this sample of young, first-time, African-American mothers, there was generally a high prevalence of single-headed households and maternal obesity (Table 8). In an examination of attrition over time, tests of baseline differences between completers and non-completers revealed few significant differences. There were slightly more mothers at 12 months with at least some college education or who were married. At 18 months, slightly more mothers were married and household size was lower.

Infant and toddler dietary intakes

Across study visits, approximately 30% of infants and toddlers consumed no whole fruit in a day, and at the majority of visits, a higher proportion of infants and

toddlers consumed juice than whole fruit (Table 8). By 18-months, nearly all toddlers consumed at least some amount of whole vegetables. Few infants consumed fried potatoes, sweetened beverages, or salty snacks at six months; however, by 18-months, approximately half or more of all toddlers were consuming these foods or beverages. Nearly all 18-month-olds consumed at least some solid dessert or sweet in a given day. When examining amounts, daily servings of whole fruits and vegetables excluding fried potatoes remained fairly stable over time. At any given age, infants and toddlers consumed approximately 1.8 servings of whole fruit in a day and 1.5-2.0 servings of vegetables. Conversely, average daily servings of most high energy-dense foods and beverages more than doubled between six and 18 months. Translated into common household measures, total daily servings among 18-month-olds were as follows: 5 tablespoons (Tbsp) of whole fruit, 7 Tbsp of vegetables excluding fried potatoes, 8 fluid ounces of juice, 4 French fries or tater tots, 1¼ chocolate chip cookies, 5 fluid ounces of sweetened beverages, and nearly 10 grams of salty snacks, such as 11-12 cheese puffs.

Use of non-maternal caregivers (NMCs)

More than half of all households reported the use of a NMC at each time point (Figure 2). The most frequent types of NMCs were fathers, grandmothers, and licensed childcare providers. The use of licensed childcare providers was significantly greater among older infants and toddlers, with the odds of a licensed childcare provider as the NMC being approximately three and four times greater among 12- and 18-month-olds than 3-month-olds, respectively (Table 9). Conversely, fathers may be more likely to

share responsibility for feeding early in infancy as the odds for fathers, while non-significant, were lower at each time point compared to the 3-month-visit.

Any maternal employment was the strongest predictor of NMC use, except for in the model specifically testing predictors of father involvement in feeding (Table 9). For fathers, being married was the strongest and only significant predictor of their involvement in feeding. In contrast, grandmother involvement in feeding was significantly less likely in married households and maternal age was inversely associated with their use.

NMCs and probability of dietary intake

There was no association between NMC use and early introduction of complementary foods (Table 10). However, there were several significant findings in longitudinal logistic regression models (Tables 10 and 11). Use of any NMC was associated with a 95% decrease in the odds of breastfeeding. This model only included data from 3-9 months due to low proportions of mothers still breastfeeding after this time. Use of any NMC was also associated with an increase in the odds of infants and toddlers consuming whole fruit or juice. By type of NMC, the only significant finding was that the use of grandmothers increased the odds of an infant or toddler consuming juice by 97%. In the adjusted models, several maternal characteristics were significantly associated with any intake of foods and beverages (data not shown). For example, in the adjusted model with any NMC as the dependent variable, a one-year increase in maternal age (years) was associated with an increased likelihood of consuming fruit [Odds Ratio (OR) = 1.09, 95%

Confidence Interval (CI): 1.02, 1.16] and maternal depression with an increased likelihood of consuming fried potatoes (OR=2.14, 95% CI: 1.15, 3.99).

NMCs and amount of dietary intake

Results of longitudinal random-effects tobit models showed no significant associations between use of NMCs, neither by any NMC nor by type of NMC, on infant and toddler dietary intake (Tables 12 and 13). As with the 'any intake' models, several maternal characteristics were associated with daily servings of foods and beverages. In the adjusted model with any use of a NMC as the main independent variable, a one-unit increase in maternal age was associated with 0.05 more servings of whole fruit (95% CI: 0.01, 0.08); any maternal college with fewer servings of fried potatoes (β = -0.19, 95% CI: -0.02, -0.35), sweetened beverages (β = -0.22, 95% CI: -0.01, -0.43), and salty snacks (β = -0.2, 95% CI: -0.05, -0.35); and maternal depression with more servings of salty snacks (β = 0.2, 95% CI: 0.05, 0.35)

Discussion

Knowing who shares responsibility for feeding during the first two years of life is important in light of the increasing number of obesity-prevention interventions aimed at infants and toddlers (Ciampa et al., 2010). An examination of these interventions reveals that most target one primary caregiver, most often the mother. Data from the current study supports the need to consider inclusion of multiple caregivers, as we document, in a cohort of low-income African-American mother-infant dyads, a high prevalence of non-maternal involvement in feeding between three to 18 months of age.

At each time point, more than half of the mothers in the Infant Care sample were employed and the types of NMCs utilized in this study were similar to the primary care arrangements used by employed mothers in a national sample. According to data from the U.S. Census Bureau, employed mothers utilized the following types of care for their infants and toddlers while working: fathers (27% and 24.2%, respectively), grandmothers (34% and 30.5%, respectively) and licensed child care providers (27.5% and 37.2%, respectively) (Laughlin, 2010). This finding adds another layer of complexity to the study of infant and toddler dietary intakes—the first two years of life is a period of fairly rapid exposure to a variety of foods and beverages, all of which is likely to be influenced by multiple caregivers, including their level of nutrition knowledge and their beliefs and behaviors about infant and toddler feeding (Scaglioni, Arrizza, Vecchi, & Tedeschi, 2011).

Despite the high prevalence of non-maternal involvement in infant and toddler feeding, we document only a few associations between their use and early dietary intake. Even in models adjusted for confounding variables, use of NMCs was shown to decrease the odds of any continued breastfeeding. We could not examine associations between types of NMCs and breastfeeding status due to the limited number of mothers continuing to breastfeed in our sample; however, it is well documented that fathers, grandmothers, and childcare providers can impact breastfeeding outcomes(Britton et al., 2007; Meedya, Fahy, & Kable, 2010). One pathway of influence is through psychosocial factors. Two of the strongest predictors of breastfeeding duration are a woman's intention to breastfeed and her breastfeeding self-efficacy, each of which is influenced by people in her social network (Meedya et al., 2010). For example, in a large longitudinal study among women

in the U.S., DiGirolamo et al.(2005) found a significant correlation between breastfeeding attitudes at home and the length of time a woman intended to breastfeed ($r = 0.23$, $p < 0.01$) (DiGirolamo, Thompson, Martorell, Fein, & Grummer-Strawn, 2005). Similarly, among a sample of low-income African-American women living in Baltimore, Bentley et al. (1999) found that mothers who had partners supportive of breastfeeding were three times as likely to initiate breastfeeding than mothers whose partners thought they should feed formula (OR=3.33, 95% CI: 2.04-5.45) (M. Bentley, Gavin, Black, & Teti, 1999; M. E. Bentley, Dee, & Jensen, 2003).

There is also growing evidence on the importance of formal childcare arrangements, such as center-based licensed care, which has been associated with a decreased likelihood of breastfeeding as well as an increased likelihood of feeding complementary foods before four months (Kim & Peterson, 2008; Pearce et al., 2012). The extent to which the policies and environments in these facilities are supportive of breastfeeding may influence a mother's ability to continue breastfeeding while working. Benjamin et al. (2009) analyzed childcare regulations related to infant feeding practices in all U.S. states and census regions and found that only 11 states (22%) had regulations specific to breastfeeding promotion or support and only 2 states (4%) had regulations specific to delaying complementary foods until six months (Benjamin et al., 2009). In a survey of breastfeeding policies and practices in 101 childcare centers in the central Piedmont region of North Carolina, only a small proportion of facilities encouraged mothers to come to the facility to breastfeed (21.7%), had a written policy that encourages breastfeeding (20.8%), provided staff training on breastfeeding promotion and support (13.9%), displayed breastfeeding images and posters (3%), or referred

families to community resources (1%) (B. Cameron, Javanparast, Labbok, Scheckter, & McIntyre, 2012).

Breastfeeding promotion interventions are particularly needed for African-American women. According to national data, the prevalence of breastfeeding is much lower among African-American women than it is for White or Hispanic women: any breastfeeding ever (59.7% versus 77.7% and 80.6%, respectively), any breastfeeding at six months (27.9% versus 45.1% and 46%, respectively), and any breastfeeding at 12 months (12.9% versus 23.6% and 24.7%, respectively) (Centers for Disease Control, 2007). Comparatively, the proportion of mothers still breastfeeding in our sample was even lower than these national rates for African-American women. This may be due to the presence in our sample of multiple factors that have each been independently shown to decrease breastfeeding duration, including low-income status, participation in WIC, and residence in the Southeast (Grummer-Strawn et al., 2008; Li, Darling, Maurice, Barker, & Grummer-Strawn, 2005).

In longitudinal models examining associations between NMC use and any intake of obesity-related foods and beverages, our findings were mixed. The use of any NMC increased the odds of an infant or toddler consuming any whole fruit, but also increased the odds of them consuming any juice. Among the types of NMCs, a significant finding was that grandmother involvement in feeding increased the odds of juice consumption by 97%. Although controversial (Nicklas, O'Neil, & Kleinman, 2008), a few studies have documented positive associations between juice consumption and childhood overweight (Dennison, Rockwell, & Baker, 1997; Dennison, Rockwell, Nichols, & Jenkins, 1999). Because excessive juice consumption can also be associated with undernutrition and

short stature, as well as diarrhea, flatulence, abdominal distention, and tooth decay, the American Academy of Pediatrics (AAP) recommends juice not be given to infants less than 6 months of age and that it be limited to 4-6 fluid ounces per day among older infants and toddlers (Committee on Nutrition, 2001). The average amount of fruit juice consumed by 18-month-olds in our sample (8 fluid ounces per day) was approximately twice this recommended level. Why grandmothers were associated with increased odds of infants and toddlers consuming juice is unclear. Several studies have found that grandmothers influence the timing of the introduction of complementary foods (M. E. Bentley, Caulfield, Gross, Bronner, Jensen, Kessler, & Paige, 1999; M. E. Bentley et al., 2003), but there is little research on their role in infant feeding thereafter. It is possible that grandmothers are unaware of the AAP recommendations as juice consumption was less of a concern during their time of childrearing, perhaps in part because so fewer forms were available (Dennison, 1996). However, given that use of a grandmother as the NMC was not associated with greater *amounts* of juice consumption—results discussed in more detail below—we cannot conclude that their impact on juice consumption is necessarily negative. Juice served in age-appropriate amounts can be a healthful beverage.

Why use of any NMC was associated with increased odds of whole fruit consumption among infants and toddlers is also unclear, particularly since there were no significant findings by type of NMC. A possibility is that the combined influence of grandmothers and licensed childcare providers is driving this finding, but that our sample size limited the ability to detect their separate effects. Among adults, fruit and vegetable consumption increases with age and is greatest among those 65 years of age and older—more adults ≥65 years consume two or more servings of fruit a day (41.3%) as compared

to those 18-24 years (30.8%) (Centers for Disease Control, 2010). It has also been shown that older adults (≥55 years) are more likely than younger adults (20-39 years) to rate nutrition as very important when shopping for food (OR=1.97, 95% CI: 1.70-2.28) (Bowman, 2005). The use of a licensed childcare provider might increase the likelihood of fruit consumption as all childcare facilities in North Carolina are mandated to follow the meal pattern guidelines of the Child and Adult Care Food Program (CACFP)(North Carolina Division of Child Development, 2010), a federally funded and state-administered nutrition assistance program. These meal patterns require fruit to be served at breakfast and lunch, beginning during late infancy.

In models examining amount of dietary intake, we found no significant associations with NMC involvement. It is important to note that the NDSR data collection method did not differentiate the types and amounts of foods and beverages fed by different types of caregivers. Therefore findings represent broad associations between non-maternal involvement in feeding and dietary intakes rather than direct comparisons of the types of foods and beverages fed by mothers versus NMCs. We believe this limitation has stronger implications for models examining amount of consumption versus any consumption, as there is likely to be more error in maternal second-hand reports of the former versus the latter. It is also possible that this set of analyses was limited by the sample size and less power to detect small differences in amounts of actual consumption versus probabilities of any consumption.

Thus, our data suggests that NMC involvement in feeding has limited impact on the intake of obesity-related foods and beverages during the period of complementary feeding, particularly for intake of high energy-dense foods such as fried potatoes, desserts

and sweets, and salty snacks. However, the inclusion of NMCs in nutrition education is still imperative as we have documented they are highly involved in the feeding of infants and toddlers. Indeed, our analyses only suggest that NMCs may be no worse than mothers in exposing very young children to potentially obesogenic foods and beverages, but that overall intake patterns in this sample is concerning. Similar to findings from FITS (Siega-Riz et al., 2010), exposure to obesity-related foods and beverages in the Infant Care sample began as early as six months and continued through 18 months. Given the substantial involvement of NMCs, interventions aimed at establishing healthy eating habits early in life are likely to be more effective when multiple caregivers are engaged rather than only the mother or other primary caregiver (American Dietetic Association, 2006; Birch & Ventura, 2009).

Additional important findings of this research are the associations between maternal and household characteristics and intakes of obesity-related foods and beverages. Higher maternal age and any maternal college were protective against intakes of obesity-related foods and beverages—the same factors associated with higher consumption of fruits and vegetables and lower consumption of sweetened beverages, desserts and candy, and salty snacks among the FITS sample (Hendricks, Briefel, Novak, & Ziegler, 2006). Our finding that maternal depressive symptoms are associated with higher intakes of potentially obesogenic foods before two years of age adds to the growing body of evidence showing maternal depression to be a risk factor for suboptimal infant and toddler feeding practices (Dennis & McQueen, 2007; Hurley, Black, Papas, & Caulfield, 2008; McLearn, Minkovitz, Strobino, Marks, & Hou, 2006; Paulson, Dauber, & Leiferman, 2006). The negative impact of postpartum depression on breastfeeding

outcomes has been well studied (Field, 2010) and our data shows that maternal depression negatively impacts the quality of the complementary diet as well. In light of depression's adverse impacts on general parenting and quality of early interactions, some have called for universal screening of maternal and paternal depression by pediatricians (Field, 2010).

The current study had several important strengths, including a longitudinal design and analysis of a wide variety of dietary variables, but it also had several limitations in addition to those already mentioned. The sample consisted of infants and toddlers of low-income, first-time African-American mothers, and the results should only be generalized to this subset of the population. Additionally, the measure of NMC involvement was dichotomous, defined as those responsible for feeding an infant or toddler 50% or more of the time. Future research might benefit from a more continuous measure of non-maternal involvement. Finally, loss to follow-up is always a concern with longitudinal studies. However, examination of participant attrition in our sample revealed few significant differences in infant, maternal, or household characteristics between the baseline (three-month) sample and the sample at each subsequent study visit.

Conclusions

The current study documents a high prevalence of non-maternal involvement in feeding among infants and toddlers of low-income, first-time African-American mothers. The types of NMCs sharing responsibility for feeding were most frequently fathers, grandmothers, and licensed child care providers. We also document that NMC involvement is associated with lower likelihood of continued breastfeeding and higher

likelihood of children consuming juice or whole fruit. Given the high prevalence of non-maternal involvement in feeding and the early emergence of obesity-related foods and beverages, interventions targeting multiple family members are warranted as they are likely to be more effective than those targeting the mother alone.

Table 8. Examples of age-adjusted serving sizes for selected food items.

		Age-adjusted Serving Size	
		Age (mo)	
Food item	**NDSR Adult Serving Size**	**6 and 9[a]**	**12 and 18[b]**
Fruit juice	4 fl oz	1 fl oz	1½ fl oz
Fruit, fresh, frozen, or canned	½ cup chopped (8 Tbsp)	2 Tbsp	3 Tbsp
Vegetables, raw, cooked, or canned	½ cup chopped	2 Tbsp	3 Tbsp
Fried potatoes	½ cup (10-14 fries)	2 Tbsp (3-4 fries)	3 Tbsp (4-5 fries)
Cookies, chocolate chip, commercially prepared	30 g (2½ cookies)	8 g (2/3 cookie)	11 g (1 cookie)
Sweetened beverages	8 fl oz	2 fl oz	3 fl oz
Ice cream	½ cup	1/8 cup (2 Tbsp)	3 Tbsp
Cheese puffs	28 g (32 pieces)	0.3 ounces (8-9 pieces)	10 g (11-12 pieces)

[a]Servings at both and six and nine months are approximately one-quarter that of an adult

[b]Servings at both and 12 and 18 months are approximately one-third that of an adult

Table 9. Characteristics of mothers and infants participating in the Infant Care, Feeding, and Risk of Obesity study.

	Study Visit				
	3-month	**6-month**	**9-month**	**12-month**	**18-month**
			mean±SD/n(%)		
Total (n)	217	161	165	151	129
Infant characteristics					
Age (months)	3.2±0.3	6.4±0.5	9.4±0.5	12.6±0.7	19.1±2
Gestational age (weeks)	39.5±1.5	39.6±1.4	39.5±1.4	39.6±1.4	39.5±1.4
Birthweight (kg)	3.2±0.5	3.3±0.5	3.2±0.5	3.2±0.5	3.2±0.5
Female	116 (53.5)	85 (53.5)	85 (51.8)	80 (54.8)	68 (52.7)
Weight-for-height Z score	0.6±1	0.5±1.1	0.5±1.1	0.4±1.1	0.3±1.1
Infant overweight[a]	63 (29)	41 (25.8)	40 (24.4)	32 (21.9)	25 (19.4)
Maternal and household characteristics					
Age (years)	22.7±3.8	22.9±3.8	23.3±4	23.7±3.9	24.3±
Maternal education					
Less than highschool	58 (27.1)	43 (26.7)	45 (27.6)	41 (27.3)	35 (27.1)
Highschool graduate	65 (30.4)	45 (28)	46 (28.2)	37 (24.7)**	34 (26.4)
Any college	91 (42.5)	73 (45.3)	72 (44.2)	72 (48)**	60 (46.5)
Married	21 (9.8)	17 (10.6)	19 (12.3)	16 (11.8)*	16 (15.8)**
Any maternal employment	115 (53.7)	97 (61.8)	101 (63.5)	83 (58.5)	61 (60.4)

Maternal obesity (BMI≥30)	96 (44.2)	71 (44.1)	73 (44.8)	63 (42)	55 (42.6)
Maternal depression[b]	62 (29.1)	40 (27.6)	37 (23.6)	24 (17.1)	35 (34)
Household size	3.9±1.7	4.1±1.7	3.6±1.5	3.5±1.5	3.3±1.3**
Infant diet					
Ever breastfed	151 (69.6)	119 (73.9)	119 (72.2)	108 (72)	94 (72.9)
Still breastfeeding	49 (22.6)	24 (14.4)	19 (11.5)	8 (5.2)	3 (2.2)
Any intake of food groups/items					
Fruit, excluding juice	55 (25.1)	116 (72.1)	111 (67.3)	98 (64.9)	88 (68.2)
Vegetables, excluding fried potatoes	50 (22.8)	113 (70.2)	144 (87.3)	136 (90.1)	124 (96.1)
Juice	53 (24.2)	99 (61.5)	130 (78.9)	136 (90.1)	117 (90.1)
Fried potatoes	0	9 (5.6)	33 (20)	58 (38.4)	71 (55)
Desserts and sweets, excluding beverages	0	45 (28)	105 (63.6)	120 (79.5)	121 (93.8)
Sweetened beverages	3 (1.4)	7 (4.4)	33 (20)	69 (45.7)	89 (69)
Salty snacks	1 (0.5)	4 (2.5)	12 (7.3)	36 (23.8)	59 (45.7)
Daily servings of food groups/items					
Fruit, excluding juice	--	1.8±0.3	1.9±0.2	2.1±0.4	1.7±0.2
Vegetables, excluding fried potatoes	--	1.8±0.3	1.7±0.1	2±0.2	2.3±0.2
Juice	--	2.3±0.3	2.9±0.4	4.9±0.4	5.3±0.5
Fried potatoes	--	0.3±0.1	0.6±0.2	1.1±0.2	0.9±0.1

Desserts and sweets, excluding beverages	--	1.4±0.4	1.4±0.2	1.6±0.3	2.2±0.2
Sweetened beverages	--	0.2±0.2	0.7±0.2	1.2±0.2	1.5±0.2
Salty snacks	--	0.2±0.1	0.1±0	0.6±0.1	0.9±0

[a]>90th percentile 2000 CDC NCHS growth charts

[b]Score ≥16 on the Center for Epidemiological Studies Depression Scale

*Significantly different from baseline at P<0.05.

**Significantly different from baseline at P<0.001.

Figure 2. Use of non-maternal caregivers (NMCs), by infant ag

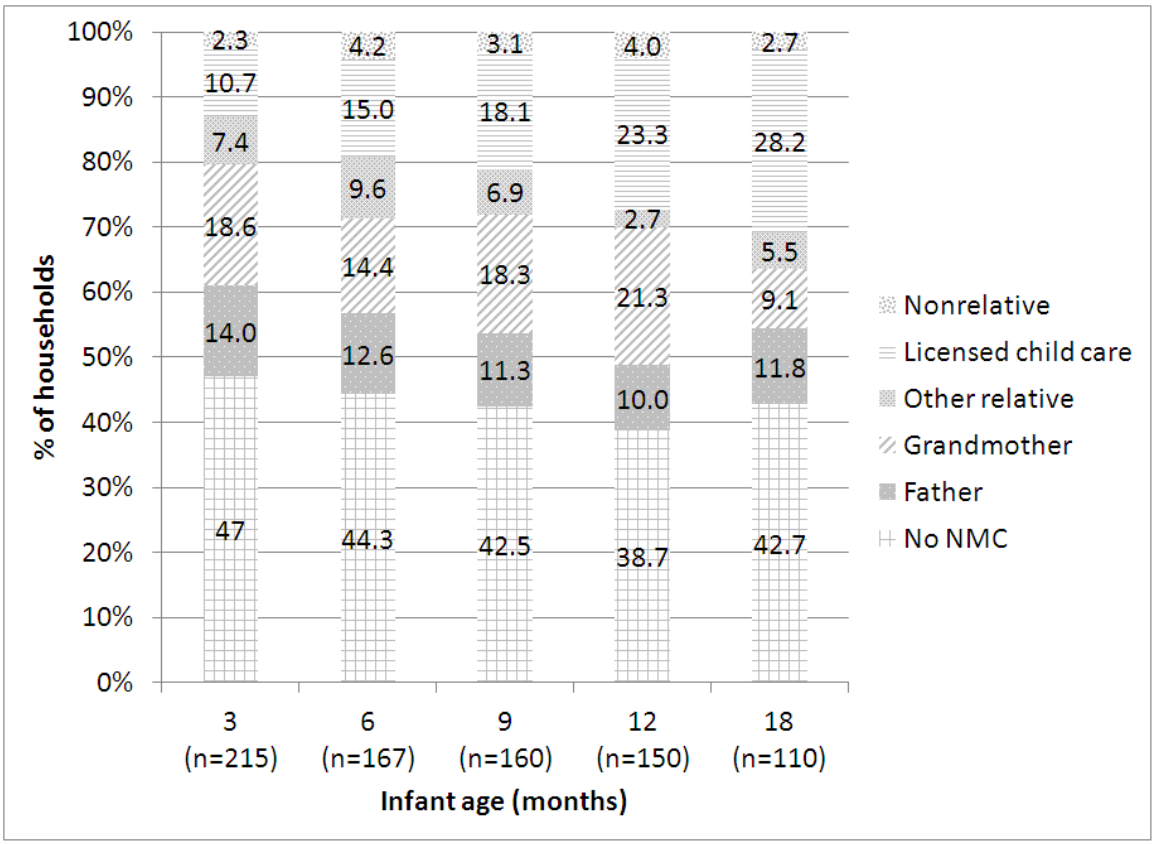


Table 10. Longitudinal associations between maternal and household characteristics and use of non-maternal caregivers (NMCs), by any NMC and type of NMC.

	Any NMC		Father		Grandmother		Licensed Provider	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Any maternal employment	6.19***	3.94, 9.75	1.81	0.95, 3.45	8.22***	3.65, 18.48	2.86**	1.43, 5.72
Married	1.01	0.45, 2.25	7.38**	2.37, 23.00	0.09*	0.01, 0.94	1.18	0.30, 4.70
Maternal depression	1.10	0.70, 1.74	0.89	0.44, 1.81	0.68	0.32, 1.43	0.95	0.46, 1.97
Any maternal college	0.76	0.44, 1.36	0.81	0.34, 1.94	0.50	0.18, 1.39	1.99	0.72, 5.49
Maternal age	0.96	0.89, 1.03	0.89	0.78, 1.00	0.83*	0.70, 0.97	1.03	0.90, 1.17
Infant age								
3 months (ref)	--	--	--	--	--	--	--	--
6 months	1.06	0.62, 1.81	0.81	0.37, 1.76	0.56	0.25, 1.28	1.80	0.76, 4.26
9 months	1.14	0.65, 2.00	0.51	0.22, 1.20	1.32	0.59, 2.95	2.06	0.85, 4.97
12 months	1.19	0.62, 2.29	0.40	0.14, 1.13	2.46	0.93, 6.53	2.79*	1.01, 7.74
18 months	1.04	0.52, 2.10	0.55	0.19, 1.59	0.64	0.20, 2.04	4.05*	1.40, 11.68

*P<0.05, ** P <0.01, *** P <0.001

Table 11. Results of logistic regression models examining associations between use of non-maternal caregivers (NMCs) and infant and young child feeding practices.

	Early Complementary Feeding[a,b]	**Any Breastfeeding**[a,c]	**Any Whole Fruit**[a,d]	**Any Vegetables**[a,d]	**Any Juice**[a,d]
	(n=209)	**(n=210)**	**(n=210)**	**(n=210)**	**(n=210)**
			Odds Ratio (95% Confidence Interval)		
Any NMC	1.71 (0.83, 3.53)	0.05 (0.00, 0.50)	1.51 (1.03, 2.23)	1.25 (0.79, 1.99)	1.64 (1.01, 2.67)
Type of NMC					
Father	1.32 (0.52, 3.35)	--	1.12 (0.64, 1.97)	0.93 (0.48, 1.8)	0.83 (0.42, 1.64)
Grandmother	1.16 (0.51, 2.65)	--	0.92 (0.57, 1.5)	0.89 (0.5, 1.59)	1.97 (1.02, 3.81)
Licensed Provider	1.69 (0.65, 4.42)	--	1.55 (0.93, 2.59)	0.96 (0.52, 1.79)	1.2 (0.61, 2.34)

[a]All models were adjusted for maternal employment, marital status, maternal depression, any maternal college, and maternal age

[b]Cross-sectional model using only data from the 3-month visit.

[c]Includes data from visits occurring between 3-9 months.

[c]Includes data from visits occurring between 6-18 months.

Table 12. Results of logistic regression models examining associations between use of non-maternal caregivers (NMCs) and infant and young child feeding practices.

	Any Fried Potatoes[a,b] **(n=173)**	**Any Desserts and Sweets**[a,b] **(n=173)**	**Any Sweetened Beverages**[a,b] **(n=173)**	**Any Salty Snacks**[a,b] **(n=173)**
	Odds Ratio (95% Confidence Interval)			
Any NMC	0.82 (0.46, 1.43)	1.20 (0.77, 1.86)	1.17 (0.65, 2.12)	1.45 (0.67, 3.12)
Type of NMC				
Father	1.13 (0.48, 2.69)	0.85 (0.44, 1.67)	1.71 (0.71, 4.11)	2.06 (0.66, 6.39)
Grandmother	0.97 (0.48, 1.96)	0.74 (0.42, 1.28)	0.97 (0.46, 2.05)	1.03 (0.40, 2.69)
Licensed Provider	0.75 (0.38, 1.48)	1.30 (0.75, 2.26)	1.28 (0.63, 2.62)	0.71 (0.28, 1.79)

[a]All models were adjusted for maternal employment, marital status, maternal depression, any maternal college, and maternal age

[b]Includes data from visits occurring between 6-18 months.

Table 13. Results of longitudinal tobit models examining associations between use of non-maternal caregivers (NMCs) and infant and toddler dietary intakes (n=173).

	Fruit (excluding juice)[a,b]	**Vegetables (excluding fried potatoes)**[a,b]	**Fruit Juice**[a,b]
		β (95% Confidence Interval)[c]	
Any NMC	0.04 (-0.18, 0.26)	-0.01 (-0.25, 0.24)	0.27 (-0.2, 0.74)
Type of NMC			
Father	-0.06 (-0.39, 0.26)	-0.23 (-0.57, 0.11)	-0.43 (-1.11, 0.24)
Grandmother	-0.13 (-0.41, 0.14)	0.1 (-0.23, 0.42)	0.49 (-0.18, 1.15)
Licensed Provider	0.25 (-0.04, 0.53)	0.05 (-0.25, 0.35)	0.56 (-0.07, 1.2)

[a]All models were adjusted for maternal employment, marital status, maternal depression, any maternal college, and maternal age.

[b]Models include data from visits occurring between 6-18 months.

[c]Point estimates and confidence intervals are marginal effects among consumers [E(y|y>0)].

Table 14. Results of longitudinal tobit models examining associations between use of non-maternal caregivers (NMCs) and infant and toddler dietary intakes (n=173).

	Fried Potatoes[a,b]	**Desserts and Sweets**[a,b]	**Sweetened Beverages**[a,b]	**Salty Snacks**[a,b]
	β (95% Confidence Interval)[c]			
Any NMC	0.02 (-0.12, 0.16)	0.1 (-0.12, 0.33)	0.06 (-0.13, 0.25)	0.08 (-0.04, 0.21)
Type of NMC				
Father	-0.02 (-0.24, 0.20)	-0.06 (-0.40, 0.28)	0.27 (-0.04, 0.58)	0.07 (-0.13, 0.27)
Grandmother	0.08 (-0.11, 0.27)	-0.07 (-0.36, 0.22)	-0.03 (-0.27, 0.21)	0.02 (-0.14, 0.19)
Licensed Provider	0.07 (-0.12, 0.25)	0.16 (-0.12, 0.44)	0.09 (-0.15, 0.32)	0.04 (-0.12, -0.19)

[a]All models were adjusted for maternal employment, marital status, maternal depression, any maternal college, and maternal age.

[b]Models include data from visits occurring between 6-18 months.

[c]Point estimates and confidence intervals are marginal effects among consumers [E(y|y>0)].

CHAPTER VI

SYNTHESIS

The purpose of this research was to describe non-maternal involvement in infant and toddler feeding and to determine associations between the use of non-maternal caregivers and the quality of the diet during the period of complementary feeding. Our specific aims were (1) to describe the amount of daily intake between six and 18 months of selected foods and beverages associated with obesity among older children and adults, (2) to identify the age periods having the greatest slopes in daily intake of obesity-related foods and beverages, (3) to determine the prevalence of the use of non-maternal caregivers in infant and toddler feeding, and (4) to test in longitudinal models associations between non-maternal involvement in feeding and daily intakes of obesity-related foods and beverages among infants and toddlers. Food groups and items of interest included those high in energy density, and therefore positively associated with obesity, namely juice, fried potatoes, desserts and sweets, sweetened beverages, and salty snacks, and conversely, foods low in energy density, including whole fruit and whole vegetables (excluding fried potatoes). To achieve these research aims, we used data from the Infant Care, Feeding, and Risk of Obesity Study (Infant Care), a prospective cohort of low-income African American mother-infant dyads followed from three to 18 months postpartum.

In this chapter, we first present an overview of the findings and the public health implications of each analysis. This is followed by an outline of the limitations and strengths of our research findings. We then close this chapter with a discussion of the directions for future research.

Overview of findings

In our first set of analyses, we aimed to quantify intakes of obesity-related foods and beverages during the period of complementary feeding. Using longitudinal data from the Infant Care study and a set of age-adjustment factors based on the ratio of infant to adult energy requirements, we believe this is one of the first studies to document the total daily amount of obesity-related foods and beverages that infants and toddlers are consuming. Food groups and items of interest were those associated, either positively or negatively, with obesity among older children and adults (Flynn et al., 2006; Swinburn, Caterson, Seidell, & James, 2004), namely low energy-dense foods (fruits excluding juice and vegetables excluding fried potatoes) and high-energy dense foods (100% juice, fried potatoes, desserts and sweets, sweetened beverages, and salty snacks).

Our results further substantiate the emergence of potentially obesogenic diets very early in life. Our main findings are (1) that large proportions of infants and toddlers in the Infant Care sample consumed foods and beverages that are high in energy density and potentially obesogenic; (2) that median intakes by infants and toddlers were greater for high energy-dense foods, such as juice and desserts and sweets, than for low energy-dense foods, namely fruits and vegetables; and (3) that increases in median intakes of several high energy-dense foods were greatest between the period of nine to 12 months.

Quantification of daily dietary intakes during the period of complementary feeding is a major advance as most prior studies have reported the proportion of infants or toddlers consuming *any amount* of foods or beverages in a day (Briefel et al., 2004; Fox, Pac, Devaney, & Jankowski, 2004; Kudlova & Rames, 2007; Siega-Riz et al., 2010), average portion sizes of foods and beverages consumed at a *single* eating occasion (Fox, Reidy, Karwe, & Ziegler, 2006), or created dietary pattern scores via principal components analysis or an index (Cox et al., 1997; Kudlova & Rames, 2007; Robinson et al., 2007). Translated into common household units, average daily consumption by 6-month-olds versus 18-month-olds in the Infant Care sample was as follows: fruit excluding juice (4 vs. 5 Tbsp., respectively); vegetables excluding fried potatoes (4 vs. 7 Tbsp., respectively); fruit juice (2 vs. 8 fl. oz., respectively); fried potatoes (1 vs. 4 French fries or tater tots, respectively); desserts and sweets excluding beverages (1 vs. 2¼ chocolate chip cookies, respectively); sweetened beverages (½ to 4½ fl. oz., respectively); and, salty snacks (2 vs. 10 cheese puffs, respectively). Thus, for high energy-dense foods and beverages, the average daily amount of consumption between six to 18 months increased by 125% to 800%.

In our second set of analyses, we aimed to describe the extent to which non-maternal caregivers share responsibility for feeding during the first two years of life and to identify the types of caregivers utilized. We also aimed to determine the impact that non-maternal involvement in feeding has on dietary factors associated with obesity among older children and adults, namely duration of breastfeeding, early introduction of complementary foods (<4 months), and intakes of obesity-related foods and beverages. We used the same set of data from the Infant Care study, including dietary intakes from

3-18 months and use of non-maternal caregivers (NMCs) between 3-18 months. NMCs were defined in Infant Care as those persons other than the mother responsible for feeding the index child 50% or more of his/her daily meals.

The results of our analyses document a high prevalence of non-maternal involvement in feeding, with more than half of all households at each time point reporting the use of a NMC. Across all visits, the most common types of NMCs were fathers, grandmothers, and licensed childcare providers. In longitudinal logistic regression models examining associations between NMC use and *any* breastfeeding, early introduction of complementary foods, or *any* intake of obesity-related foods and beverages, findings were mixed. NMC use was associated with a decreased likelihood of continued breastfeeding and an increased likelihood of infants and toddlers consuming any juice, but NMC use was also associated with an increased likelihood of infants and toddlers consuming any fruit. Specific to our hypotheses, we found few associations by type of NMC. The only significant finding by type of NMC was that use of a grandmother as a NMC was associated with a higher likelihood of infants and toddlers consuming juice—a finding which seems contrary to our hypothesis that grandmother involvement in feeding would be associated with lesser intakes of high energy-dense foods, including juice. However, despite our expectations, we found no associations between NMC usage and the *amount* of daily intakes of obesity-related foods and beverages among infants and toddlers. Since juice is a healthy beverage when consumed in age-appropriate amounts, the positive association between any NMC or grandmother as the NMC and any intake of juice is not necessarily a negative finding. Therefore, our overall conclusions are that NMC involvement in feeding has a negative impact on

breastfeeding duration and a small, positive impact on intake of obesity-related foods and beverages.

Limitations and strengths

There are several limitations to our research findings. The first is limited generalizability, as the sample consisted of low-income, first-time, African-American mothers living in central North Carolina. Results should not be applied beyond this subset of the population. A second limitation, which is inherent to longitudinal studies, is loss to follow-up. However, examination of participant attrition in our sample revealed few significant differences in infant, maternal, or household characteristics between the baseline (three-month) sample and the sample at each subsequent study visit. While a larger proportion of mothers at 12 and 18 months versus baseline had at least some college or were married, we would expect these differences to attenuate our findings, since having a college education and being married are two factors associated with positive infant and toddler feeding practices, such as feeding fruit and avoiding sweetened beverages. Additional limitations are related to study measures. One is that the NDSR data collection method did not differentiate the types of foods and beverages fed by different caregivers. Therefore findings represent broad associations between non-maternal involvement in feeding and dietary intakes rather than direct comparisons of the types of foods fed by mothers versus NMCs. Another limitation is that the measure of NMC involvement was dichotomous rather than continuous, and defined as those responsible for feeding an infant or toddler 50% or more of the time. Finally, the sample size for models testing associations between sub-types of NMCs and intakes of obesity-

related foods was small and may have limited the power to detect effects, particularly in the long-term exposure models using only the 18-month data.

Importantly, this work also contains several strengths, including a longitudinal design and high-quality dietary data. Longitudinal studies contain repeated measures on the same individuals and provide opportunities for more robust analyses. In our first set of analyses, the longitudinal design allowed us to determine differences in dietary intake over time and therefore to identify critical periods of risk and opportunities for intervention. In our second set of analyses, the longitudinal design allowed us to document the instability in NMC use—few households utilized the same type of NMC across infant age. It also allowed us to examine associations between NMC use and infant and toddler dietary intake in multiple ways, by running concurrent change models as well as long-term exposure models, with the latter set of models yielding the only significant findings. Another strength was the quality of the dietary data collected during Infant Care, which included multiple 24-hour DRs, 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. Important to the current analyses, a major advantage of 24-hour dietary recalls is that they are quantifiably precise, allowing us to accurately report the average *amounts* of obesity-related foods and beverages consumed over time by the infants in our sample.

Public health significance

Results from our first set of analyses show that infants and toddlers of low-income, first-time African-American mothers are a priority population for public health

nutrition programs. In the U.S., African-American women have lower rates for all Healthy People 2020 breastfeeding outcomes, including ever breastfeeding (59.7% among African-American women versus 77.7% and 80.6% among White and Hispanic women, respectively) (Centers for Disease Control and Prevention, 2012). The prevalence of ever breastfeeding at 3-months in the Infant Care sample (69.6%) was slightly higher than the national rate for African-American women in general, but still substantially lower than that of White and Hispanic women. In addition, as compared to the FITS sample (Siega-Riz et al., 2010), even higher proportions of children in Infant Care were consuming juice, desserts and sweets, sweetened beverages, fried potatoes, and salty snacks in given day, while lower proportions were consuming fruit excluding juice.

Presumably because of their unique dietary needs, children birth to two years have been excluded from the Dietary Guidelines for Americans—an important document that serves as the basis for educating the general public on the types and amounts of foods and beverages to consume for good health (i.e., MyPlate) (U.S. Department of Agriculture & U.S. Department of Health and Human Services, 2010). Unfortunately, there is no analogous food guidance system for children under two years. Two federal nutrition assistance programs, the Supplemental Nutrition Program for Women, Infants, and Children (WIC) and the Child and Adult Care Food Program (CACFP), have each published meal patterns for infants and toddlers. However, compared to MyPlate, these meal patterns are not as readily accessible to the general public. A visually appealing, consumer-tested food guidance system for children under two years is much needed.

It is also concerning that there are no Healthy People 2020 objectives devoted to complementary feeding practices (U.S. Department of Health and Human Services, Office of Disease Prevention and Health Promotion). This is surprising given the obesity epidemic among young children (Ogden & Carroll, 2010), the increase in the proportion of infants and toddlers with high WLZ (Ogden, Flegal, Carroll, & Johnson, 2002; Ogden et al., 2012a), and data from both FITS and Infant Care showing a high prevalence of infants and toddlers consuming 'junk-type' foods associated with obesity (Siega-Riz et al., 2010). Optimal complementary feeding practices include gradual introduction of nutrient-dense foods with continued breastfeeding until at least one year, and then for as long as the mother and child desire (American Academy of Pediatrics Committee on Nutrition, 2009). Complementary feeding should begin around six months, when the infant is developmentally ready and likely to have depleted their endogenous iron stores. The first complementary food should therefore be one rich in iron, such as pureed meat or iron-fortified infant cereal. The order of introducing foods thereafter hasn't been shown to be important, as long as nutrient-dense foods, such as whole fruits and vegetables, are offered—due to rapid growth and micronutrient utilization, infants and toddlers have little room for discretionary calories. Healthy complementary feeding practices are therefore important not only for obesity prevention, but also for prevention of micronutrient deficiencies and the promotion of optimal brain growth.

Findings from our second set of analyses have important implications for *how* we achieve optimal infant and toddler feeding practices. Our findings document a high prevalence of non-maternal involvement in feeding—more than half of all households at each time point affirmed that a caregiver other than the mother was responsible for

feeding the infant or toddler half or more of his/her daily meals. In the area of breastfeeding promotion, federal and state WIC offices have realized the importance of reaching out to non-maternal caregivers to improve breastfeeding outcomes, particularly among African-Americans. There is now a wide variety of materials and campaigns on breastfeeding that are available to local WIC staff for the purpose of engaging and educating non-maternal caregivers, including fathers, grandmothers, and childcare providers. However, the development of similar materials or campaigns has not been undertaken for healthy complementary feeding. This is important as the WIC program alone reaches approximately half of all U.S. infants, birth to 12 months, and one-quarter of all children less than five years.

Directions for future research

The work undertaken in this dissertation has many implications for future research. Few other studies have captured the *amount* of non-milk foods and beverages consumed by infants and toddlers during the period of complementary feeding. A natural next step of this research is to test whether daily servings of obesity-related foods and beverages predict energy intakes and weight status. We hypothesize that greater daily servings of energy-dense foods and beverages, such as desserts and sweets, sweetened beverages, and fried potatoes, would be associated with higher total energy intakes and higher WLZ scores. Another next step in this line of research is to explore the impact of dietary patterns, moving beyond discrete analyses of individual food groups to testing the effects of total diet. *Are the same infants that are consuming desserts and sweets also consuming fried potatoes and juice? Are they consuming fewer fruits and vegetables?*

Currently, we know very little about this as few studies have tested associations between food groups or food items. This could begin with simple correlation analyses (e.g. Spearman's rank) and advance to the development of dietary patterns using either an *a priori* index or a data driven method, such as factor analysis or principal components analysis.

Our second set of analyses on non-maternal involvement in infant and toddler feeding has additional implications for future research. The high prevalence of households reporting an NMC at each time point provides a strong rationale for including NMCs in observational and experimental/intervention research. Returning to the conceptual framework by Davison and Birch (2001), which is based on the theoretical model underpinning this dissertation, Bronfenbrenner's ecological systems theory (EST), the current work suggests a stronger emphasis on non-maternal influences is warranted. In light of the changes in maternal employment and family structures that we described in chapter two and the results of our second set of analyses, it is evident that the microsystem of infants and toddlers has extended beyond the home environment and parental influences. Perhaps a more fitting title for the second outermost ring in Figure 4 would be "Caregiver styles and characteristics." Indeed, we hypothesize that future observational studies on the determinants of infant and toddler overweight will have more predictive models when including some of the factors highlighted in Figure 4 for multiple caregivers principally involved in the feeding and caring of young children. Data from Infant Care will allow us to test these hypotheses, as a subset of assessments was also administered to NMCs (Table 15). One of our next analyses is to determine the separate and combined effects of maternal and non-maternal feeding styles on longitudinal intakes

of obesity-related foods and beverages. Feeding styles are latent constructs that characterize caregivers based on their beliefs and behaviors around feeding children (Birch & Fisher, 1995). A major output of the Infant Care project was the development and validation of the Infant Feeding Styles Questionnaire (Thompson et al., 2009) and this next set of analyses will be one of the first to examine the feeding styles of multiple caregivers.

Finally, we believe the inclusion of NMCs is important to experimental research as well, since obesity-prevention interventions targeting the diets and activity patterns of infants and toddlers are likely to be more effective if they target multiple caregivers substantially involved in the feeding and care of young children than if they target the mother alone. To this end, we submitted and received funding for a five-year efficacy trial entitled "Mothers and Others: Family-based Obesity Prevention for Infants and Toddlers" (NICHD R01 HD073237). "Mothers and Others" is an efficacy trial of a multi-component, tailored intervention focused on infants of African-American mothers and families, and contains several innovations, including beginning during a 'teachable' moment, pregnancy; use of color-coded growth charts to enhance caregiver recognition of child growth and size; active engagement of multiple caregivers ('mothers and others'); and the use of tailoring and novel media technologies. If successful in promoting healthy infant growth and enhancing caregiver health behaviors, Mothers and Others will have high public health relevance for future obesity-prevention efforts aimed at children less than two years, including intervention research studies and federal, state and community health programs.

Tables and figures

Figure 3. "Ecological model of predictors of childhood overweight" from Davison and Birch (2001).

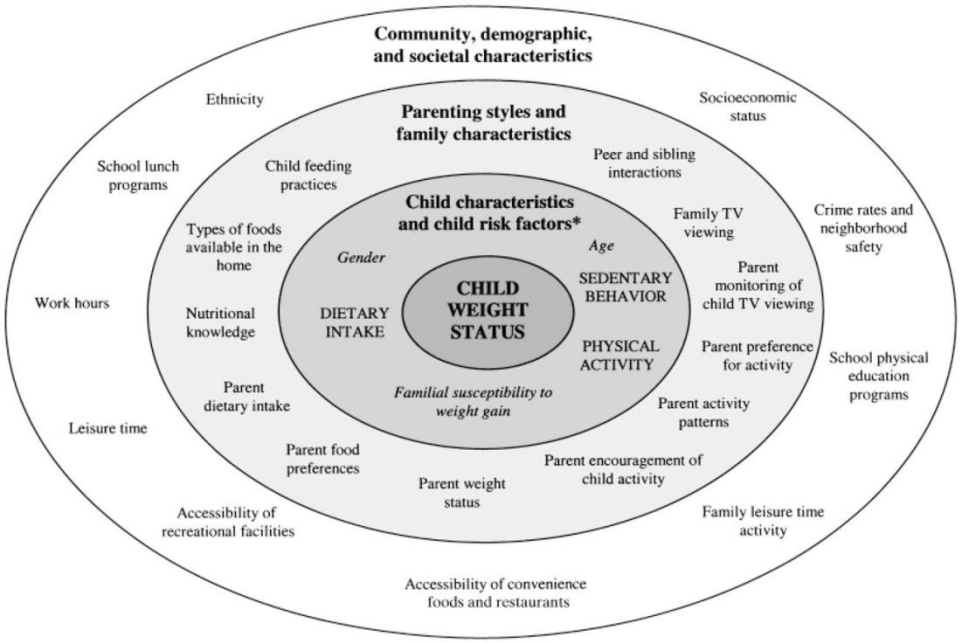


Table 15. Sections of the Infant Care questionnaire, by versions administered to mothers versus non-maternal caregivers (NMCs)

Sections in Mother's Questionnaire	Mothers	NMCs
Identification	X	X
Household Roster	X	X (demographics)
Breastfeeding, Infant Diet History, and Pacifier Use	X	X (pacifier use only)
Infant Health and Sleep Patterns	X	X (sleep only)
Infant Feeding Styles Questionnaire (Beliefs)	X	X
Infant Feeding Styles Questionnaire (Behaviors)	X	X
Body Satisfaction Questionnaire	X	
Obesogenic Environment Checklist and Media Use	X	X
Non-maternal Caregivers	X	
Infant Activity and Crying Patterns	X	X
Intervention Exposure and Sources of Infant Care Information	X	
Parent Satisfaction Scale	X	
Maternal and Household Characteristics	X	
Maternal Physical Activity	X	
Child Care Use	X	
Food Security	X	
Food Shopping and Eating Patterns	X	
Neighborhood Environment and Facilities	X	
Smoking and Drug Use	X	
Maternal Depression	X	
Rosenberg Self-esteem Scale	X	
Marlowe-Crowne Social Desirability Scale	X	X
Infant/Child Temperament	X	

APPENDIX

Food group classification scheme used by Fox et al. (2006) in the Feeding Infants and Toddlers Study and adapted from the one developed by Subar and colleagues(Fox et al., 2006)(Subar, Krebs-Smith, Cook, & Kahle, 1998a; Subar, Krebs-Smith, Cook, & Kahle, 1998b)**.**

Fruit	**Vegetables**	**Desserts and sweets**	**Salty snacks**
Apples/applesauce	Broccoli	Baby food desserts	Potato chips, popcorn, cheese curls/puffs, tortilla chips, corn chips, and other types of high-fat chips and salty snacks.
Apricots	Carrots	Cakes, pies, pastries, doughnuts, muffins, quickbreads	
Bananas	Corn	Cookies	
Berries	Green beans	Ice cream, frozen yogurt, sherbert, pudding	
Citrus fruits	Mixed/garden vegetables	Other desserts	
Fruit cocktail, mixed fruit	Peas	Sugar, syrups, jams, jellies, other sweeteners	
Peaches, nectarines, plums	Potatoes[c]	Sweetened beverages[b]	
Pears	Spinach/greens	Candy	
Grapes	Sweet potatoes, yams		
Melons	Tomatoes/tomato sauce		
Dried fruit (except apricots)	Winter squash		
Other fruit[a]	Other vegetables[d]		
100% juice[b]			

[a]Includes avocado/pineapple/cherries/kiwi/mango/papaya/prunes

[b]Analyzed as a separate food group/category.

[c]Fried potato products will not be included in the vegetable category, and will comprise their own food group/category

[d]Includes onions, cabbage, artichoke, asparagus, beets, cauliflower, celery, eggplant, peppers, mushrooms, okra, pea pods, zucchini, summer squash, water chestnuts, lettuce (other than Romaine), cucumbers, kohlrabi, leeks, parsnips, seaweed/kelp

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