Evaluating Eating Patterns of Toddlers from Low-income Households: A Multi-method Approach to Understanding Eating Behaviors of Young Children

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ABSTRACT

Toddlerhood represents a period of change. As children develop physically and mentally, children learn and develop habits that will continue for years. This is also a time where children are adapting to the family diet, and developing dietary preferences and habits. While studies have been conducted to evaluate these changes during toddlerhood, much is still unknown about the dietary pattern development and changes that occur over toddlerhood in low-income populations at risk for obesity. Knowledge about dietary patterns at this age is important in shaping the development of recommendations for dietary intake and promoting dietary quality in children.

This body of work is an evaluation of early child diet patterns and a comparison of 4 different assessment methods. The purpose is to characterize the diets of young children in low-income families, while demonstrating the strengths and limitations of these methods. The goal is to present a comprehensive assessment of how children in this population are fed, and what improvements could be stressed in order to improve diet quality and promote long-term health. The data for this study was collected in the Toddler Overweight Prevention/ Tips on Parenting Study (TOPS) which was a 3-arm randomized trial of two interventions. This study was led by investigators at the University of Maryland, Baltimore, and data from the baseline assessments prior to the intervention are included in this work.

This evaluation includes 3 analyses. The first utilizes 2 different diet index summary methods, the Mean Adequacy Ratio, and the 2005 Healthy Eating Index to assess diet quality compared to the 2005 Dietary Guidelines for Americans and the Dietary Reference Intake values for 11 select vitamins and minerals. Factors associated with diet quality were also assessed. This analysis revealed that the maternal diet has a significant influence on the quality of the child diet, even when controlling for potential covariates, such as poverty/income. The second analysis identifies clusters of children with similar dietary intake patterns by cluster analysis, investigating the differences between the patterns. This analysis reveals 4 different patterns, and evaluatesthe relationship between the dietary patterns and diet quality. Lastly, the third analysis utilizes a mixed-methods approach to evaluating meal structure patterns. Less structured patterns were more common among children with the lowest dietary quality scores in the sample. The entire work reveals that dietary guidance should include information about increasing whole grain intake, beverage consumption (type and portion size), and structured meal environments in order to increase diet quality as related to the Dietary Guidelines for Americans among low-income children. In regard to nutrient intake, most children meet or exceed the Recommended Daily Allowances for the vitamins and minerals assessed. Dietary guidance should consider the balance between intake of nutrients and food groups to promote the healthiest outcomes.

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Chapter 1

INTRODUCTION

Obesity is a major risk to health in the United States. In 2011-2012, age-adjusted estimates showed that 68.5% (95% CI, 65.2-71.6) of adults were overweight or obese. Overweight and obesity in adults has been linked to many adverse health conditions including diabetes, heart disease, cancers, respiratory disorders, and kidney disease (Hubert, Feinleib, McNamara, Castelli, 1983; Wolk et al., 2001; Golay & Ybarra, 2005; Kahn, Hull, & Utzschneider, 2006; Yang et al., 2008). Reducing obesity rates is vital in reducing the incidence of many of these health conditions and promoting health in the United States.

The issues related to obesity are not limited to adults, and concerning overweight and obesity prevalence rates have been observed in even the youngest age groups. Obesity and overweight among US children ages 2-5 increased from 22.0% in 1999-2000 to 26.2% in 2003-2004 (Ogden et al., 2006) but appeared to plateau through 2012 (Ogden, Carroll, Kit, & Flegal, 2014), and even decrease in some states throughout the United States (Centers for Disease Control and Prevention, 2013). Even with a possible rate stabilization or decrease, obesity continues to be threat, one that is even greater among low-income and African-American populations as the prevalences in these populations tend to be greater than the averages in the general population (Ogden, Carroll, Kit, & Flegal, 2014). Anderson and Butcher (2006) illustrated increases in prevalence of overweight and obesity among U.S. children of all ages between 1971 and 2000, with greater increases observed among low-income and African-American children. Research shows that obesity in low-income 2 - 4 year-olds increased from 12.4 percent in 1998 to 14.5 percent in 2003 and reached 14.6 percent in 2008 (CDC, 2009). Even with the stabilization, one in 7 low-income preschool-aged children is obese (CDC, 2009). In addition, in Maryland, the prevalence of obesity among low-income 2 to 4 year olds is greater than the national averages, with increases from 12.0% in 1998 to 15.7% in 2008 (CDC, 2009). Obesity in childhood is a risk factor for obesity and many health concerns in adulthood (Inge et al., 2013), and the prevention of child and adolescent obesity is extremely important in the reversing these trends.

When considering how to address childhood obesity rates, a better understanding is needed around the development of dietary patterns, the combinations of foods and nutrients that are consumed, as food consumption plays an integral role in affecting energy balance, causing excess weight gain if dietary intake exceeds physiological energy needs. Dietary patterns of adults may be developed early (Mikkila et al., 2005), and have been linked to obesity and cardiovascular disease risks (Fung et al., 2001). In recent years, researchers have been directing more attention to dietary patterns as well as the contextual information about how and when foods are consumed, or meal occasion structure, in order to understand the relationship between dietary patterns and health. A better understanding of dietary and meal patterns especially among young children will help researchers and policy makers understand how children develop eating habits that are in line with national health goals. With this context in mind, better, tailored recommendations can be made to specific populations in order to improve dietary intake as one strategy to address the concerning obesity prevalence in the population.

This study is a multi-method evaluation of eating patterns of young children between the ages of 12 and 31 months of age in a low-income, predominately black/African-American population in Maryland who participated in the Toddler Overweight Prevention Study (TOPS) funded by the National Institutes of Health and the United States Department of Agriculture (USDA). This age range represents an important period in child development, and regarding eating patterns, children at this age are transitioning from an infant diet to the family diet. By evaluating diet quality, dietary intake patterns, and meal occasion patterns in toddlerhood, this study provides a deeper understanding of the interrelatedness of these constructs and provides information that could be used to improve current dietary recommendations and to plan targeted programs to address dietary concerns of young children.

Following this introductory chapter, chapter 2 presents the background and rationale for the current study of dietary patterns, including the methods that will be utilized and the maternal and child factors that will be evaluated in relation to the child dietary patterns. The theoretical and conceptual frameworks are also presented, followed by the study objectives and a description of the data source and measures. Chapters 3, 4 and 5 present 3 individual papers that evaluate dietary patterns in different ways. Chapter 3 utilizes two score-based methods, the Mean Adequacy Ratio and the 2005 Healthy Eating Index. Factors associated with dietary quality are also evaluated and presented in this chapter. Chapter 4 presents an analysis of dietary patterns using cluster analysis, a statistically driven method of evaluating dietary patterns. In chapter 5, a mixed-method approach using the dietary intake assessment as a text document is used to evaluate meal patterns and structure. An overall summary and discussion of these analyses and future directions for research and policy are presented in chapter 6.

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Chapter 2
BACKGROUND

This chapter describes the rationale, aims, hypotheses, and data source for this dissertation. It begins with a review of the concept of diet quality and nutritional guidance, followed by a presentation of the two methods selected to assess diet quality in this study. Next, background information about the assessment of dietary patterns by cluster analysis and meal intake patterns of toddlers as well as important points to consider in these types of analyses is described. Additionally, this chapter illustrates the maternal and child factors that will be evaluated in relation to dietary patterns. Lastly, the study objectives, conceptual framework, data source, measures included in this study, and a brief description of the sample are described.

2.1 Rationale

This study focuses on the eating patterns of children between 12 and 31 months of age. "Eating patterns" is a general term that refers to the consumption of foods to meet nutrient and energy needs, the types and combinations of foods, and context of consumption (Booth, Okely, Denney-Wilson, Hardy, Yang, & Dobbins 2006). Eating patterns are poorly understood between the ages of 1 and 2 as food consumption behaviors are rapidly evolving during this period of time. There are a few national studies about dietary and meal intake patterns of young children, however, more information is needed to understand the variations that occur within different populations (rural, urban, regional variations, etc.) throughout the United States. This study is a contribution to the literature by providing an in-depth analysis of eating patterns of children from low-income families in the greater Baltimore Maryland area who participated in the Toddler Overweight Prevention Study. As children develop additional motor, communication, and behavioral skills, they acquire eating behaviors and habits that may continue for many years to come (Mikkila et al., 2005). This study evaluated eating patterns that emerge during toddlerhood, comparisons of patterns in younger and older children of this age range, and the sociodemographic determinants of these patterns, with a goal of understanding the development of healthy eating behaviors in young children.

The following sections describe the 3 strategies used to evaluate eating patterns in this study. The first is an assessment of dietary quality, and the concept of diet quality and the evaluation methods included in this study are presented. The second method described is cluster analysis, which is used to assess dietary patterns of groups within a population. Lastly, a description of a meal intake pattern analysis, which evaluates eating behaviors that describe the context of meal consumption using both qualitative and quantitative methods, is provided.

2.1.1 Diet Quality and Assessment Methods

A healthy diet is defined by adherence dietary guidelines and recommendations based on scientific evidence showing the need for specific food components and nutrients to support optimal function, growth, and reduction of risks for adverse health conditions associated with lower dietary quality. Dietary quality can be assessed by comparing the individual nutrient intake to the Dietary Reference Intakes (DRI) for micronutrients and macronutrients (Otten, Hellwig, & Meyers, 2006), and food intakes with the Dietary Guidelines for Americans (USDA, 2010). This study includes comparisons of intake to both the DRIs and the Dietary Guidelines. This section describes the recommendations for a high quality diet, and the methods for assessing adherence to these guidelines.

Diet Quality- Dietary Reference Intakes

Specific nutrient guidance in the United States was established in 1941 by the National Research Council and included Recommended Dietary Allowances (RDA) of nutrients for the purpose of preventing illnesses related to nutrient deficiencies in U.S. population (Otten, Hellwig, & Meyers, 2006). The RDA intake values are scientifically derived estimates to meet the needs of most healthy persons of the population at specific age ranges and life stages (NRC, 1989). Over the 1960s and 1970s, the nutrient recommendations expanded to include food labeling information and Recommended Daily Allowances per serving of food on food labels. In the 1990s, the Dietary Reference Intake (DRI) standing committee was created to expand nutrient guidance. Through these efforts, the DRIs were created including the Estimated Average Requirements (EAR), the nutrient intake values estimated to meet the needs of 50% of healthy persons of a specific age and life stage; Recommended Dietary Allowance (RDA), the nutrient intake values estimated to meet the needs of 97-98% of the healthy population, calculated as 2 standard deviations greater than the EAR; Adequate Intake (AI), the observed nutrient intake value that meets the needs of most healthy persons, used when no EAR is established; and Tolerable Upper Intake Levels (UL), the value of nutrient intake at which risks for toxicity increases at intakes greater than this level (Otten, Hellwig, & Meyers, 2006).

The UL is also described as the "maximum amount that likely can be tolerated by the body when consumed on a daily basis" (Lee & Nieman 2007). The DRIs also include Acceptable Macronutrient Distribution Ranges (AMDR), which are ranges for the contributions of fat, carbohydrates, and proteins as a percent of total energy intake, and recommendations for dietary fiber intake (Otten, Hellwig, & Meyers, 2006).

This study focuses on the nutrient intakes of 11 selected nutrients. The RDAs for children between 1 and 3 years of age of these 11 nutrients are listed in Table 2.1. These nutrients were selected based on their importance to development at this stage of growth (Otten, Hellwig, & Meyers, 2006). The exposure to a variety of foods would increase the chances of meeting the nutrient intake requirements through food consumption.

Table 2.1: Recommended Daily Allowances (RDAs) of 11 key nutrients for children 1-3 years of age.

Nutrient	RDA
Vitamin A	300 μg/d
Vitamin C	15 mg/d
Vitamin B6	0.5 mg/d
Vitamin B12	0.9 μg/d
Calcium	500 mg/d
Folate	150 μg/d
Iron	7 mg/d
Niacin	6 mg/d
Riboflavin	0.5 mg/d
Thiamin	0.5 mg/d
Zinc	3 mg/d

The AMDRs are 30-40% of total daily caloric intake for fat, 45-65% for carbohydrate, and 5-20% for protein (Otten, Hellwig, & Meyers, 2006). The total fat intake recommendation changes after the age of two, at which point, total fat intake should be limited to 30-35% of the daily calories after this point.

Assessment of Adherence to Nutrient Intake Recommendations

Indices of dietary quality are designed to determine how well an individual's diet meets dietary recommendations or other well-established knowledge of nutrient adequacy. Score-based methods are commonly used to compare an individual diet to dietary recommendations or standards in order to provide feedback for improving the dietary intake, and reducing disease risks. The first index method used in this study is the Mean Adequacy Ratio (MAR). This measure compares individual intake of key nutrients to the nutrient intake guidelines for each nutrient. This ratio of observed to expected intake is called the Nutrient Adequacy Ratio (NAR). Many NAR calculations include the RDA as the expected intake value, and additionally some have used the EAR in this calculation (Steyn et al., 2006). In this study, RDA values were used as a way to represent the risks for inadequate intake that increase as nutrient intake decreases below the RDA levels. To calculate the MAR, the NAR values for each desired nutrient are truncated at 100% and all truncated NAR values are summed to create a total MAR score. This provides a summary based on the selected nutrients, and also illustrates the probability of inadequate nutrient intake based on the nutrients selected for inclusion.

While NAR and MAR calculations provide useful information regarding nutrient adequacy, there are a few points to consider when interpreting the results from this type of analysis. This measure provides a summary of diet quality as it pertains to the intake of nutrients. There are other aspects of diet quality that are not represented by the use of the MAR, and for this reason, two types of measures are presented in analysis. Also, the MAR scores reflect the adequacy of intake of the specific nutrients that are chosen for inclusion. There is no standard for nutrient selection for the MAR, and for this study, nutrients were selected that are important to the developmental stages of children at this age. The selection of nutrients may limit how comparable the results are across studies utilizing this method to summarize diet quality. It must also be noted that in this study, this method does not include energy intake in the calculation. The MAR score values are likely to be correlated with energy intake, meaning that the more food that is consumed, the greater the likelihood of a higher MAR score.

Diet Quality- Dietary Guidelines for Americans

Briefly, the United States Department of Agriculture (USDA), in conjunction with the U.S. Department of Human and Health Services (HHS), first developed the Dietary Guidelines for Americans in 1980. These recommendations were based on scientific evidence regarding nutrient requirements (the DRI described above), food composition and exercise needs for the purpose of reducing disease risks for the general public (USDA, 2005). Established by a panel of experts, the purpose of the dietary guidelines was to provide guidance on how to consume foods in order to meet nutrient needs and for the promotion of long-term health by reducing the incidence of illnesses with a known connection to poor diet and lack of exercise (USDA, 2010; Freeland-Graves, Nitzke & Academy of Nutrition and Dietetics, 2013). The Dietary Guidelines for Americans provide recommendations for the US population ages 2 and older (USDA, 2005; USDA, 2010), and are reviewed every 5 years to consider the results of newer research studies in order to develop the best strategy for promoting public health in the U.S. The current recommendations promote the consumption of a mostly plant-based diet that includes low-fat dairy products, small portions of lean meat, fish, whole grains and low intakes of sodium, saturated fat and added sugars (USDA, 2010). With the Dietary Guidelines for Americans are additional tips (e.g. MyPyramid, MyPlate), that simplify food guidance information for consumer use as a suggested approach to meeting the nutrient recommendations (USDA, 2014). Not following these guidelines does not necessarily equate to not meeting the DRIs, as there may be many approaches that would provide daily nutrient intake requirements. Ideally, people would consume the amount and types of foods that provide both the energy and the nutrients the body needs, thus meeting the DRIs for nutrients, in order to function optimally without exceeding energy balance. Poorly regulated energy balance over time may lead to underweight, overweight, or obesity, which are associated with undesired health conditions (USDA, 2010; Biro & Wein, 2010).

Dietary guidance for younger children focuses on the promotion of exclusive breastfeeding until 6 months of age, delayed introduction of solid foods until at least 4-6 months of age, and the prevention of nutrient deficiencies (AAP, 2012). Between the ages of 1 to 2, when children's knowledge and opinions about foods is increasing at a fast rate, recommendations focus on the exposure to a variety of healthy foods so that children will acquire the nutrients they need, and have a taste for nutritious foods, particularly since children have a genetic predisposition toward sweet foods (Birch & Fisher, 1998), and are also quick to develop a preference for flavors associated with high dietary fat (Johnson et al., 1991).

The recommended daily energy intake for 1 year old children is approximately 900 kilocalories (Gidding et al., 2006), and 1000 kcal/day for children between 2 to 3 years old (USDA, 2005). Unlike for older children, adolescents, and adults, total daily energy recommendations for children 1 and 2 years of age do not vary by activity level or gender. Additionally, whole or 2% milk is recommended for children between 1 to 2 years old to support AMDR recommendations for fat intake, which is greater at age 1 than at age 2.

After age two, recommendations also include a diet rich in fiber, whole fruits, vegetables and whole grains. Specific recommendations for children 2 to 3 according to the Dietary Guidelines include at least 3 oz. of grains, with most coming from whole grain sources, 1 cup of vegetables, 1 cup of fruit, 2 cups of low fat dairy, and 2 ounces of meat or beans each day (USDA, 2005). Parents have an important role in helping their children to develop preferences for healthy foods by encouraging them to try new foods and repeatedly offering the foods to young children and the rest of the family.

Index measures- Healthy Eating Index-2005

The second index measure that is used in this study to assess dietary quality is the 2005 Healthy Eating Index (Guenther et al., 2007). The Healthy Eating Index (HEI-2005) is a measure of dietary quality assessing the adherence to the USDA's MyPyramid dietary recommendations (USDA, 2005), which translates the Dietary Guidelines for Americans into concrete recommendations that can be easily understood and implemented by the general public. The HEI-2005 reflects the emphasis in the 2005 Dietary guidelines on the intake of whole grains, dark green leafy and orange vegetables, whole fruit, and limitations on sodium, added sugars, and specific types of fat. Like older versions of the HEI, the HEI-2005 also includes components that represent the major food groups in the MyPyramid recommendations including: total fruit; total vegetables; total grains; milk, including soy beverages; meat and beans, including meat, poultry, fish, eggs, non-beverage soybean products, nuts, seeds and legumes – when they are not counted with vegetables; plus whole fruit, excluding juice; dark green and orange vegetables and legumes; whole grains; oils; Saturated fat; Sodium; and "SoFAAS," which are calories from Solid Fat, Alcohol, and Added Sugar. Each component is assigned a specific number of points, and all components are added to create a total score. There is a maximum of 100 points for a dietary intake that at least meets the minimum recommendations for all component groups (Guenther et al., 2007).

The HEI-2005 can be applied to a greater range of ages and life stages by assessing intake per 1000 calories (Guenther et al., 2007). However, this tool was not created for children younger than 2 years of age, and most dietary quality scales focus on children older than 2 years of age. In this study, we used the HEI-2005 as a measure of diet quality of one and two year old children, indicating how well the 1 year old children were transitioning to the recommendations for the family's diet. The HEI-2005 does not assess excess intake of oils, total fat, trans-fats, or cholesterol directly. In addition, it does not take into account energy recommendations for specific weight, age, gender, and life stage requirements.

Trends in dietary intake of US Children

In the 2008 Feeding Infants and Toddlers Study (FITS), there were low risks of inadequate intake of most micronutrients for national random sample of 3,273 U.S. children between the ages of 1 and 3 (such as vitamins A, C, Thiamin, Riboflavin, Niacin, B6, Folate, B12, Calcium, Magnesium, Phosphorus, Sodium, Iron and Zinc (Butte et al., 2010). In the same study, excess intakes of several nutrients (vitamin A, Folate, Sodium, and Zinc were also reported for a portion of children at the same age, and intakes well below the recommendations for fiber for at least 90% of children 1-3 years of age. The risks for long-term excess intake of vitamin A, Folate, and Zinc, and the resultant effects are not clear and should be evaluated.

Studies indicate that many people do not generally heed the recommendations of the Dietary Guidelines (Munos, et al., 1997, USDA, 2009b). Dietary intake data from the 2003-2004 National Health and Nutrition Examination Survey (NHANES) for U.S. children 2-17 years was evaluated to assess population adherence to dietary recommendations. While children 2-5 had greater intakes than children 4-11, and 12-17 for total fruits, whole fruits, milk, and extra calories from solid fats and added sugars (indicating a lower intake of these extra calories), the average diet quality scores for all children indicated that significant improvements were highly necessary (USDA, 2009b). Intake of whole grains, fruits and vegetables are consistently low among children (Munoz et al., 1997; USDA, 2009b) at a time during the lifespan in which low dietary quality has the potential to have a critical impact on cognitive and physical development (Black, 2003). For this reason, more studies are needed to broaden the general knowledge about how foods are consumed in order to improve adherence to dietary recommendations in support of optimal growth and development. This study will evaluate the adherence to dietary guidelines, stressing how these recommendations can be met in low-income populations.

Obesity and overweight among US children ages 2-5 increased from 22.0% in 1999-2000 to 26.2% in 2003-2004 (Ogden et al., 2006). National prevalences of obesity alone among children 2-5 increased from 10.3% to 13.9%. Obesity appears to be a greater threat to low-income and African-American populations. Anderson and Butcher (2006) illustrated increases in prevalence of overweight and obesity among U.S. children of all ages between 1971 and 2000, with greater increases among low-income and African-American children. Research shows that obesity in low-income 2 - 4 year-olds increased from 12.4 percent in 1998 to 14.5 percent in 2003 and reached 14.6 percent in 2008 (CDC, 2010). Even with the stabilization, one in 7 low-income preschool-aged children is obese (CDC, 2010). In Maryland, researchers estimate the prevalence of obesity among low-income 2 to 4 year olds to be greater than the national averages, with increases from 12.0% in 1998 to 15.7% in 2008 (CDC, 2009). These high prevalences of overweight and obesity force researchers to consider a variety of approaches for understanding and evaluating the relationship between diet and adverse health outcomes in order to improve recommendations and reverse these trends.

2.1.2 Dietary intake patterns

In addition to index measures, this study utilized a statistically driven method to identify dietary patterns. Cluster and factor analysis are common methods for identifying population consumption patterns (Reedy et al., 2009). This study utilizes cluster analysis in order to identify potentially non-overlapping groups of individuals with similar consumption patterns (Willett, 1998), whereas using factor analysis one identifies groups of food or nutrients based on correlations in dietary intake (Bailey et al., 2007). Once clusters are identified, they can be evaluated for nutrient sufficiency, dietary quality, and the relation between the clusters and health outcomes can be assessed.

There are two types of cluster analyses, hierarchical and non-hierarchical (Everitt, Landau, Leese & Stahl, 2011). In hierarchical cluster analysis, each individual starts as their own cluster. The clusters are combined based on one of several methods for evaluating the similarities and/or distances between the clusters, including complete linkage, group average linkage, centriod clustering, and Ward's method (Everitt, Landau, Leese & Stahl, 2011). Ward's method is common in the dietary pattern analysis literature, and involves the creation of clusters based on the sums-of-squares criterion, and is meant to minimize the variance within each individual cluster and maximize the variance between the clusters (Ward, 1963). These methods are exploratory, and used when the number of clusters present is unknown. Non-hierarchical or divisive cluster analysis begins with one large cluster that divides into a specified number of clusters. K-means cluster analysis is an example of this type of method that is often used in dietary pattern analyses (Devlin, McNulty, Nugent & Gibney, 2012). This method comes under scrutiny because it requires the investigators to select the number of clusters that will be described, using cross-validation methods to verify the number that is selected (Devlin et al., 2012).

There are several issues that arise when conducting dietary pattern analyses. Dietary patterns are only as good as the data that are used to create the patterns. As a result, it is imperative that dietary data are collected carefully, with procedures for reducing recall error (Slattery, 2010). Additionally, food groupings that form the basis of the cluster formation are created by the researchers, stressing the need for the grouping to reflect the established intake patterns in the population or age group (Slattery, 2010). When creating the food groupings, Reedy et al. (2009) recommends creating energy-adjusted variables rather than absolute dietary intake to adjust for differences in nutritional requirements based on body size, sex, or physical activity levels.

Currently, little is known about the dietary patterns of young children and the relationship between these patterns and an overall diet quality. This study assesses differences in dietary patterns of children between 12 and 31 months of age and characterizes their dietary intake by the items consumed during the day. A similar study was conducted evaluating dietary intake patterns using cluster analysis among a national sample of 2,748 U.S. children ages 2 to 3 years and 4 to 8 years who lived in households with incomes equal to or lower than 185% of the federal poverty level (Knol et al., 2005). The patterns were based on USDA MyPyramid Servings Database, and included 22 food subgroups which formed the 5 recommended food groups in the Pyramid, plus two additional groups created to reflect foods commonly consumed by young children. The study identified six major consumption patterns for the 2-3 year old children. These patterns ranged from “big eaters”, to “light eaters”, “bean eaters”, “substituters”, “low-cost eaters”, and “semi-vegetarians” (Knol et al., 2005).

2.1.3 Meal Patterns

An additional approach to identify eating patterns used in this analysis provides a contextual analysis of eating behaviors to identify patterns that collectively may be called “meal patterns”.” The term “meal pattern” describes a variety of behavioral eating patterns and contexts in which foods are consumed. Those of particular concern include when and where meals are consumed daily, the variety of what is consumed, portion sizes, fast food consumption, the location of meal, meal skipping, and the nature of snack or beverage consumption. Researchers are now trying to determine the relationship between these patterns and the development of obesity and other health issues (Ma et al., 2003; Slattery, 2008). As the general habits of a growing children change, it is important to identify those that have the potential for contributing to the development of desired or undesired outcomes. This section describes eating behaviors that are evaluated in this study.

Meal Frequency and Structure. In terms of meal patterns, late infancy through toddlerhood marks the transition period from many unscheduled feedings to fewer, larger meals consumed at regular points during the day. Researchers have shown in a nationally representative sample that from ages 4 months to 24 months, the median number of daily eating occasions consumed is 7, ranging from 3-15 (Skinner et al., 2004). In the same sample, the breakfast, lunch, dinner plus snacks pattern begins to emerge at 7-8 months of age and increases for more children as age increases. This shift may have several purposes as it prepares children for scheduled feeding regimens encountered upon entering the preschool environment as well as assisting in the development of critical behavioral controls acquired at this age (Satter, 1990, Satter, 1995).

Breakfast Skipping. The presence or absence of breakfast is also of interest to many researchers (Baldinger, Krebs, Muller & Aeberli, 2012; Coppinger, Jeanes, Hardwick & Reeves, 2012; Williams et al., 2008). Elementary school age children who consume breakfast early every day have better nutrient intake and lower BMI than children who regularly skipped breakfast (Baldinger, Krebs, Muller & Aeberli, 2012; Coppinger, Jeanes, Hardwick & Reeves, 2012; Williams et al., 2008). In addition, eating breakfast is associated with increased alertness, attentiveness, and cognition in school-aged children (Booth et al., 2006). In a national study of infants and toddlers, breakfast contributed to 19-20% of the total daily energy intake among children ages 12-24 months, contributing the highest nutrient density for calcium, iron, folate, and vitamin A compared to lunch and dinner (Skinner et. al., 2004). In the same study, toddler breakfast consisted of milk (mostly whole milk), ready-to-eat cereals, fruits, eggs, and breads. Cereals and other ready-to-eat breakfast choices can provide significant nutrients to the diet as they are fortified with micronutrients. Data from the 1999-2002 National Health and Nutrition Examination Survey indicated that 7.4% of children 1-5 years of age and 16.9% of children 6-12 reported skipping breakfast (Williams, O'Neil, Keast, Cho & Nicklas, 2008).

Snacking. Snacking, or eating occasions before or after breakfast, lunch, and dinner meals is a common feature in the overall food consumption pattern of young children. While snacking in some contexts (depending on the type of foods consumed and the frequency of consumption) may be considered unhealthy for adults if it leads to excess energy consumption, with the choice of healthy items, snacks can play a positive role in overall energy regulation and daily intake (Hartmann, Siegrist, & vanderHorst, 2013). The quality and quantity of snacks is an important considering in determining how snacking is related to healthy or unhealthy eating patterns. In regard to the quality of snacks, energy dense, nutrient deficient snacks, and large portion sizes of snacks may contribute to excess energy intake and energy imbalance over time. For infants, smaller, frequent feedings are necessary due to the energy requirements infants during this period of rapid growth, as well as the gastric capacity of children of this age. As children get older, the energy requirements and gastric capacity change, and children are able to consume more at one time (AAP, 2014). Snacking behavior has been described over infancy and toddlerhood in the US with snacks mainly consisting of formula/breast milk, water, crackers, juice, ready to eat cereal at 7-11 months of age (Skinner et al., 2004). During early toddlerhood, at 12-14 months, snacks consist of water, whole milk, crackers, cookies, and cereal. As children approached 2 years of age, more chips, fruit drinks, candy, ice cream, soda and less milk was consumed in the same study. By 19-24 months of age, 26% of the total daily energy was consumed through snacks, making this an important contribution to the overall diet.

Portion Sizes. The portion sizes of many foods, especially fast foods and those served in the home, have been increasing (Nielsen & Popkin, 2003; Piernas & Popkin, 2011). While infants and toddlers may be able to self-regulate energy intake, adjusting for increases and decreases in meal size (Fox et al., 2006), older individuals may not be as capable of resisting the urge to consume more if presented more during the meal. Researchers have established a direct connection between increased portion sizes and energy intake, showing that when adults are served greater portions of food, they are likely to consume more calories, potentially overriding internal cues to satiety (Ello-Martin, Ledikwe, & Rolls, 2005; Rolls et al., 2004a; Rolls et al, 2004b; Diliberti et al., 2004). This is a tendency that does not naturally occur in infancy or early toddlerhood, and is therefore learned at some point during childhood, perhaps not too long after toddlerhood. Research conducted by Rolls, Engell, and Birch (2000) showed that changes in portion size among 3 year old children did not affect their intake, but increases in portion size among 5 year old children did result in increased food consumption.

Location. The location of meals (inside of the house vs. outside of the house or at a day care facility) can also impact the dietary intake and possibly the meal patterns of toddlers. Significant differences in nutrient density of snacks and lunches consumed at home, day care, or another location outside of the home have been observed in a nationally representative sample of children ages 15-24 months of age (Ziegler et al., 2006). Lunches consumed at day care facilities had a significantly higher nutrient density than meals consumed elsewhere. Unfortunately, only roughly 11% of the population consumed these higher quality meals. Lunches and morning or afternoon snacks consumed at day care and at home were more likely to include milk than lunches at another location outside of the home, and lunches consumed outside of home included more sweetened beverages such as soda or fruit-flavored drinks than those at day care or at home (Ziegler et al., 2006).

2.1.4 Factors Associated with Child Eating Patterns

In the following section, factors that may influence child eating patterns are presented including maternal, child, and other lifestyle factors. This study will evaluate the relationship between these factors and the diet quality, dietary patterns as identified by cluster analysis, and meal patterns identified in each of the separate analyses.

Understanding the factors associated with eating patterns is important, and provides information that can be used in tailoring interventions, programs, or screening procedures to target specific populations at risk of inadequate intake or low diet quality.

Maternal influences

The family environment plays an important role in the development of child eating behaviors. While children are inclined to develop tastes for sweet and salty foods (Johnson, McPhee, & Birch 1991), many of which are high in calories, and low in nutrients by nature, children can also develop preferences for nutrient dense foods such as fruits and vegetables through experience. Exposure to healthy foods in early childhood is guided by parents or caretakers, as they are responsible for providing the foods that the child consumes and they can influence their child's diet through parenting actions and child feeding styles or the way that foods are encouraged or discouraged to children and the interactions that occur during feeding (Birch, 1998; Black & Hurley, 2007). As previously stated, in early childhood, all solid foods are new, and one way that children learn to accept new foods is by the way that foods are encouraged or discouraged by their parents (Hoerr et al., 2009, Fisher & Birch, 1999).

In addition to how foods are encouraged or discouraged, many recent studies show similarities between the diets of young children and their mothers (Lee, Hoerr & Schiffman, 2005; Robinson et al., 2007; Papas et al 2009; Ovaskainen et al., 2009; Cameron et al., 2011). In general, maternal diet quality has been positively associated with child diet quality, and mothers with higher quality diets were more likely to have children with higher diet quality and greater intake of fruits and vegetables. While foods are likely shared within the household, behavior modeling may also play an important role for the development of eating behaviors. It is important to note that while maternal and child diet quality are positive correlated, the strength of the correlation may vary based on other maternal or child factors. Additional research is needed to understand how other factors affect the relationship between maternal and child diet quality in various populations.

Demographic factors. Few studies have assessed the maternal sociodemographic factors associated with diet quality of children in low-income families. In general, there are inconsistent results concerning the influence of race and ethnicity on diet quality (Hoerr et al., 2006; Kranz, 2002; Kranz, 2008; Hiza et al., 2013). In one national study of diet quality by HEI-2005, Hispanic children ages 2-18 had significantly greater diet quality scores than non-Hispanic Black children of the same age (Hiza et al., 2013). Maternal employment may affect child diet patterns in a few significant ways. Maternal employment increases the chances that the child is in another person's care during the day, and depending on where and which whom this care is taking place, this may affect the types of foods offered to the children. Additionally employment may increase the household income. Similarly, greater educational attainment may lead to additional financial opportunities within families, and as a result, additional household income. In national studies, education has been associated with diet quality of adults assessed by HEI-2005 (Hiza et al., 2013; Silke et al., 2004) and weakly associated with diet quality in children (Ryden & Hagfors, 2011). Low maternal education has also been associated with lower child diet quality in a study conducted in Brazil (Molina et al., 2010). Income and socioeconomic has been positively associated with diet quality and healthy dietary patterns of adolescents and adults (Silke et al., 2004; Aggarwal et al., 2012; Cutler et al., 2011; Ryden & Hagfors, 2011). In young children, studies assessing the impact of household income on diet quality are limited, and the relationships should be evaluated further.

Child Factors

Child age. The age of the child is a main driving force in the development of meal and dietary patterns in early childhood. Physical, behavioral, and cognitive development, in the absence of developmental delays, occurs over time, and particularly during early childhood, there will be many changes in the diet that are largely influenced by the changes occurring within the child.

Child Gender. Parents do not parent all children within the same family the same way, and parenting decisions often vary by the gender of the child (McHale et al., 1995). Additionally, maternal parenting and child feeding attitudes and behaviors may affect boys and girl children in different ways. In research conducted by Fisher and Birch (1999), the perception of restrictive maternal child feeding practices was associated with more overindulging in restricted snack foods when these foods became available to girls. This, however, was not the case in boys, suggesting that maternal concern about the child diet and feeding practices might be interpreted and internalized differently between girls and boys.

2.2 Theoretical and Conceptual Frameworks

This research is guided by a combination of Developmental-Ecological Theories that describe the development of the child as a dynamic process involving the direct interactions between the caregivers and the child and the interaction between the surrounding environment, or the context in which development occurs (Bronfenbrenner 1979). Changes in dietary and meal patterns can be applied to this developmental framework for children at this age. As the child acquires the fine motor skills for self-feeding, the child's food choices are constantly being influenced by the caregivers in regard to what foods are offered to the child, as well as when and how specific foods are introduced. Additionally the child is influenced by behaviors of people the child observes who are in the immediate surrounding environment, adapting some of their behaviors. While child personality or temperament affects the interaction between the caregiver and child, greater vocalization of food preferences further affect eating behaviors and ultimately diet quality. As the child continues to gain autonomy over time, the child exerts an even greater influence on the surrounding environment. This analysis will consider the effect of several family environmental factors on child diet.

2.3 Study Objectives and Aims

The purpose of this study is to examine how overall diet quality is related to the development of dietary and meal patterns in toddlerhood among children participating in the Toddler Overweight Prevention Study (TOPS) conducted by the University of Maryland, School of Medicine. In the original study, mothers and children 12-31 months of age were recruited and then followed for 12 months as they participate in one of three intervention arms (improving maternal lifestyle, improving parenting skills, and child safety (control). The specific aims for the current project are:

AIM 1. To evaluate diet quality of children between 12 and 31 months of age and influences on diet quality.

Hypothesis 1a: More than 50% of the children will not meet dietary intake recommendations for children of this age.

Hypothesis 1b: Diet quality will be negatively associated with child age.

Hypothesis 1c: Diet quality will vary by race/ethnicity, maternal unemployment status, and will improve with increased maternal diet quality, increased levels of maternal education, increased family income, special nutritional assistance program participation, and food security.

AIM 2. To identify dietary patterns of children 12 to 31 months of age, and to evaluate the influences on dietary patterns.

Hypothesis 2a: There will be at least 2 child dietary patterns, a healthy pattern characterized by high intake of fruits, vegetables, and milk, and an unhealthy pattern characterized by the intake of items such as cookies, chips, crackers, and/or sugary beverages.

Hypothesis 2b: Dietary patterns will vary by race/ethnicity, family income, special nutritional assistance program participation, and day care attendance the day of the dietary recall.

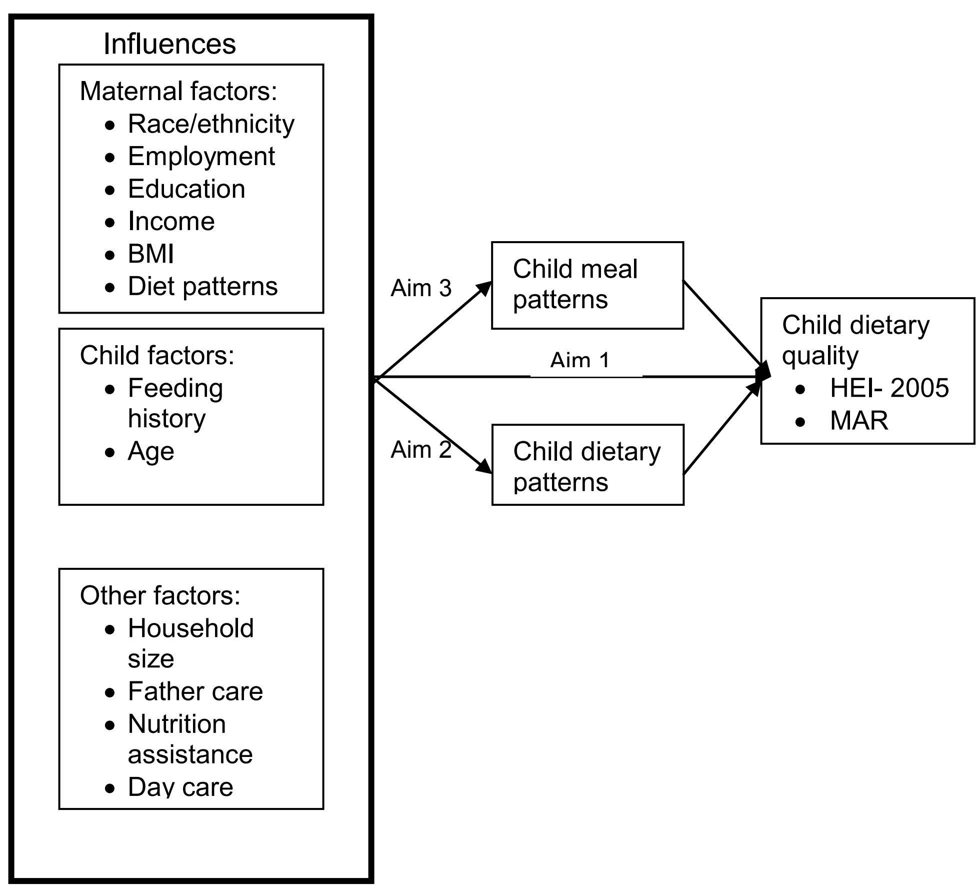
AIM 3. To identify meal patterns in children 12 to 31 months of age, and to assess influences on meal patterns.

Hypothesis 3a: A "structured" meal pattern, characterized by a morning breakfast, morning snack, mid-day lunch, afternoon snack, evening dinner, and possible evening snack, will emerge by 2 years of age.

Hypothesis 3b: Structured meal patterns will have a positive association with maternal age, maternal education, and day care participation when compared to children with less structured meal patterns.

The conceptual framework for this study is illustrated in figure 2.1. The framework models a relationship between maternal, child, and other factors to child diet quality, as well as the relationship between the dietary patterns and diet quality.

Figure 2.1. Conceptual framework for evaluating eating patterns of young children.



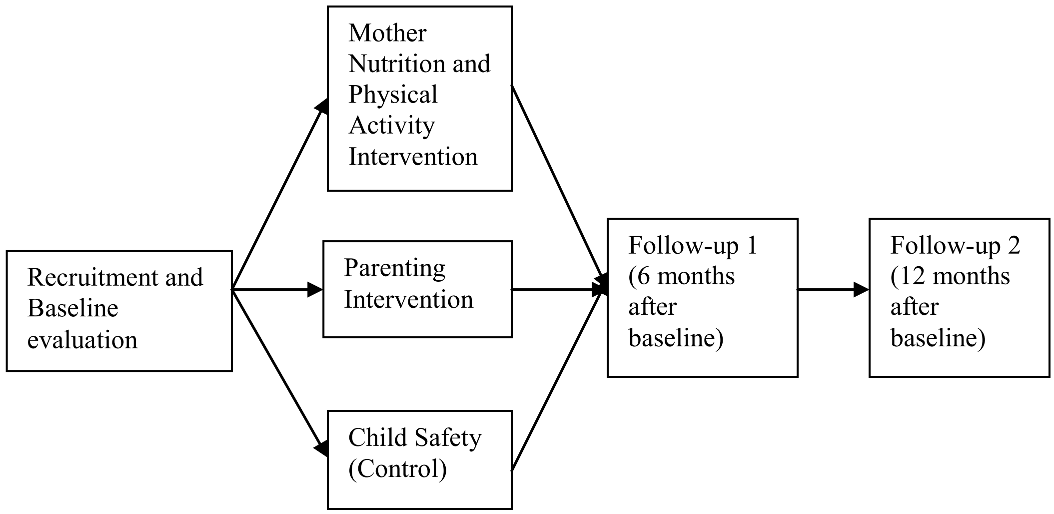
2.4 Data source

The data for this study was collected through the NIH and USDA-funded Toddler Overweight Prevention Study (TOPS), a behavioral intervention targeting mother and child pairs. The details of the TOPS study, sample, and study procedures are described below.

2.4.1. Study Design and Population

This study is a secondary analysis of data collected through the Toddler Overweight Prevention Study (TOPS), led by Principal Investigator Maureen Black, PhD at the University of Maryland, School of Medicine Department of Pediatrics. TOPS was a 3 cell randomized trial conducted in Anne Arundel County and Baltimore City County, Maryland to prevent overweight among toddlers. With rates of child obesity, defined as a weight-length (for children <2) or body mass index (BMI) (>2) greater than the 95% percentile for the child age and gender, increasing in the United States, researchers must develop and test strategies to reduce rapid weight gain earlier in life. Eligible mothers and toddlers are randomized to 1 of 3 study arms: a nutrition and physical activity intervention targeting the mothers of toddlers, a parenting skills intervention, and a child safety control group (Figure 2.2).

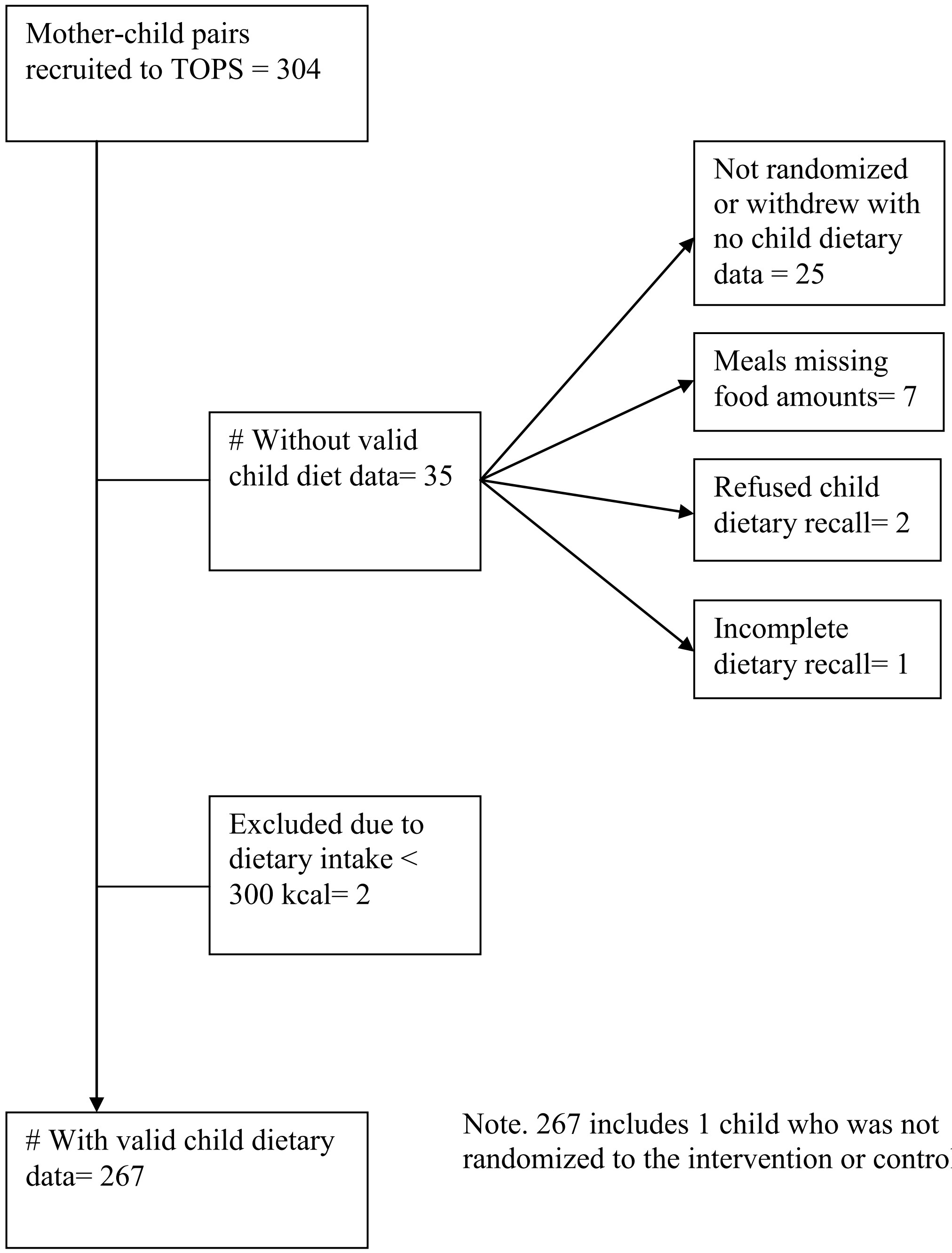
Figure 2.2. Study Design of the Toddler Overweight Prevention Study.



Eligible mothers were at least 18 years of age, not currently pregnant, and did not have any medical restrictions that prevent or limit physical activity. Eligible children were between the ages of 12-30 months old, not born premature (less than 38 weeks estimated gestational age at birth), weighed at least 5 pounds, 8 ounces at birth, and without any health restrictions or severe developmental delays.

The current study included data from all TOPS participants with complete baseline dietary data from the Anne Arundel County and the Baltimore City sites (n= 267, Figure 2.3).

Figure 2.3: Child diet data from the Toddler Overweight Prevention Study included in this study.



Note. 267 includes 1 child who was not randomized to the intervention or control

2.4.2. Recruitment procedures

Recruitment timing and procedures at each site were similar and are explained briefly. Mothers and toddler pairs were recruited August 2007 through June 2009 in Anne Arundel County by trained TOPS study staff at the Supplemental Nutrition for Women, Infants, and Children program office. Participants were also referred to TOPS by previous participants or through a contact at a child day care facility on the Fort Meade army base, also in Anne Arundel County, MD, and were screened for eligibility by the TOPS study staff. There were a total of 120 participant pairs from this area.

Recruitment was started in Baltimore City in August 2009 and was completed in October 2010. Participants were identified by three means. First, letters were sent to previous participants of other research activities led by the Dr. Maureen Black. Previous participants either contacted the study for additional information or were contacted via telephone and invited to participate. Interested participants were screened for eligibility by trained research staff, and scheduled for baseline evaluation appointments. Additionally, study participants in Baltimore City were recruited in person from the University of Maryland Pediatric Ambulatory Clinic. Interested participants were screened for eligibility in the same manner as the other participants, and those who were eligible were scheduled for a baseline evaluation. Lastly, participants were also referred by other participants in the TOPS study. A total of 184 baseline evaluations were initiated in Baltimore city between August 2009 and October 2010. Once participants were recruited for TOPS, informed consent procedures were completed, with information given the participants regarding study procedures, risks and benefits or participation, notification of voluntary participation, and confidentiality assurance.

2.4.3 Data collection procedures

Assessments were completed at three time points, baseline, at 6 months, and at 12 months, with two in-person contacts at each time point. At the first contact, the in-clinic assessment, mothers completed a computer-assisted interview through which maternal, child, and lifestyle characteristics were collected. Anthropometric measures including maternal height and weight, and child length and weight were also collected by trained data collectors. Additional measures were collected at the in-clinic assessment but not used in this analysis. The second contact was completed approximately 1 week after the first assessment at the home of the participant if possible. At this visit, the mother and child's dietary intakes were collected from the mother through one 24-hour recall collected by trained study staff using the Automated Multiple Pass Method (AMPM) of collecting dietary data developed by the USDA (USDA, 2009a). At the first contact, the mother was given a form to send with the child in case he or she was not with the mother on the day of the recall so that the foods and quantities for each meal can be recorded by the caregiver on that day to reduce errors in recall. The collection of dietary data at home allowed the caregiver to reference food packaging and serving containers to improve the accuracy of the information. The baseline evaluations occurred just after enrollment into the study, and prior to the start of the intervention. The intervention took place over 8 weeks, and was followed by the 6 and 12-month assessments, which occurred 6 and 12 months after the baseline evaluation, respectively. The current studies include data from the baseline evaluations only. All data collection instruments and procedures were approved by the Institutional Review Boards at the University of Maryland and the Maryland Department of Health and Human Hygiene.

Key Measures

Twenty-Four Hour Dietary Recall. When using this method, the caregiver (informant) lists and describes the foods consumed by the child from 12:00am the morning of the previous day until 12:00am of the morning of the recall. Automated Multiple Pass Method (AMPM) is a computer-assisted method for collecting these data and utilizes a 5-step multiple pass approach (USDA, 2009). The first step involves a quick list of items consumed during the previous 24 hours. The second step probes for foods forgotten from the quick list. Through the third step, the meal times and eating occasions for each food are collected. Next, detailed descriptions of the amounts are obtained using tools to aid in the accuracy of food quantity estimations. The last step includes a final probe for anything else that was consumed. This assessment was conducted at baseline, 6 months and 12 months and the data are entered directly into the AMPM software on laptop computers by trained study staff at the home visit. These data are later transferred from the laptop to a secure network and the Post Interview Processing System and Survey net coding system is used for reformatting data, assigning food codes, and calculating nutritional composition of consumed foods (Raper et al., 2004). These systems reduce the prevalence of coding inconsistencies, making the process more efficient. Automatic checks are built into the system to flag for potential errors in the portion size, eating occasion, day and time of foods for quality control (Raper et al., 2004).

Demographics/ Lifestyle Questionnaire. Maternal and child information including maternal age, education, household income, employment status, marital status, race, Hispanic ethnicity, number of total children, number of people in the home, toddler age, infant birth weight, infant birth length, breastfeeding duration, and usual caregivers, were assessed through an audio computer assisted self interview, completed by the mother at the baseline evaluation.

Data management. All ACASI files and 24-hour recall files were transferred from the local computers and merged to a main database that is managed by the TOPS data manager. To maintain participant confidentiality, data were maintained separately from participant contact information, and contact information was locked and accessible by the research coordinator. As data were collected, data quality checks were conducted to ensure that information had been entered accurately by the study staff. In addition, the study staff monitored the mother while she was completing the computer-assisted interviews to answer questions and assess general comprehension.

Processing of Dietary Data

Upon returning to the office after the home visit, the interview data files were imported into Survey Net, a program developed by USDA for managing and reviewing AMPM interviews, and identifying unknown foods and amounts (Blanton et al., 2006). The USDA's Food and Nutrient Database for Dietary Studies 3.0 was used for processing the intakes by providing detailed information about nutrients and portion sizes of foods for coding (Bowman et al., 2008). All coding was completed by trained research assistants and checks for reliability and validity were conducted periodically. Any comments made while collecting the data from participants or by coders were reviewed by a professor with extensive knowledge about dietary intake coding. Decisions were made to determine if intake was insufficient and unlikely, as well as to identify new foods or unspecified portions of foods when participants were not sure how much food the child may have consumed. The amounts entered in this instance were based on both the parent's suggestions of usual intake for the child and national estimates of specific food portions average for children of this age.

Sample size

As previously mentioned, this is a secondary data analysis of data collected in the TOPS study. Calculations for sample size of the broad TOPS study were conducted to determine the appropriate size need to determine a difference in outcome measures between the two intervention groups and the control group. As a result 288 participants were recruited for the study. Because there will be a set sample size for the study, the following calculations focus on the ability to detect significant differences in mean diet quality between groups, or a power analysis. Assuming a normal distribution for diet quality, the following results indicate the power to detect a difference in the means (presented as effect size), given the sample sizes of two groups from a total sample of 280:

Sample Size (Group 1/ Group 2)

	60/220	80/200	100/180	120/160	140/140
0.3	0.659	0.732	0.773	0.798	0.805
0.4	0.863	0.915	0.940	0.951	0.955
0.5	0.962	0.983	0.991	0.994	0.994
0.6	0.993	0.998	0.999	0.999	0.999

Effect size

As shown, power on the order of 0.80 or greater is found with effect sizes on the order of 0.3 for two equal groups and for effect sizes of 0.4 or greater across assumptions of group size. Thus, meaningful differences in diet quality should be detectable with the sample size available for the analysis.

Description of the sample

Differences in maternal and child characteristics of the sample included in this study and TOPS project overall are presented in Table 2.2. There were no significant differences between the sample included in this study and TOPS project total sample. Roughly 60% of the children participated in the TOPS in Baltimore city, and the majority were black or African American (70%) and from low-income households. Mothers of children included in this study were on average 27.5 years old (SD= 6.2) and had completed at least a high school education at the time of the assessment. The toddler involved in the study was the mother's first child for 120 (45.5%) of the sample.

Table 2.3 illustrates dietary intake of the children in the study by major food groups and age. At age 2, children were more likely to consume any nuts, omega-3 fish and shellfish than children year of age.

2.5 Summary

This chapter described the rationale for using multiple methods for assessing eating behaviors of young children. Through the 4 methods (3 types) described, this study provides a more complete assessment of young child dietary intake. Chapters 3 describes the two assessments of dietary quality, relating the intakes of the children from the Toddler Overweight Prevention Study to the Dietary Guidelines for Americans and the Dietary Reference Intakes of specific vitamins, minerals, and macronutrients. Chapter 4 identifies groups of children with similar intake patterns, describing the intake of each group and identifying similarities and differences between clusters. Chapter 5 is an assessment of meal patterns, paying specific attention the context in which foods were consumed during the 24-hour recall. Lastly, Chapter 6 is a discussion of these analyses, identifying key strengths and weaknesses, and the potential implications of this research on future research.

Table 2.2: Child background characteristics for the current study.

Maternal Characteristics [1]	Total =304	In analysis= 267
Mean age (SD), range 18-46	27.1 (6.2) n=303	27.5 (6.2)
Mean BMI (mother)	31.6 (9.5) n= 297	31.8 (9.4)
Education (%)	N=303	
< High school	57 (18.8)	47 (17.7)
High school or GED	108 (35.6)	92 (34.8)
>High school	138 (45.5)	125 (47.3)
Married (%)	80 (26.6) n=302	76 (28.8)
Toddler is her first child	141 (46.7) n=302	120 (45.5)
> 1 child	126 (41.6) n=303	107 (40.2)
Employed (%)	106 (34.9)	89 (33.7)
Household Income	n-297	
Under $10000	145 (48.8)	123 (46.6)
$10000-20000	50 (16.8)	45 (17.0)
$20000-30000	13.2 (13.5)	33 (11.4)
$30000-40000	32 (10.8)	30 (11.4)
$40000-50000	10 (3.4)	8 (3.0)
> $50000	20 (6.7)	19 (7.2)
Location		
Baltimore City	184 (60.5)	156 (59.1)
Anne Arundel County	120 (39.5)	108 (40.9)

Child Characteristics		
Age (Mean, SD)	20.3 (5.6) n=302	20.0 (5.5)
12-23 months old (%)	215 (70.7)	192 (72.7)
24-31 months old (%)	87 (28.6)	72 (27.3)
Race/Ethnicity	n=303	
White (%)	64 (21.1)	62 (23.5)
African- American (%)	212 (70.0)	180 (68.2)
Other race (%)	20 (6.6)	17 (6.4)
Hispanic ethnicity (%)	7 (2.3)	5 (1.9)
Male gender (%)	147 (52.9)	140 (52.6)
Feeding history		
Ever Breastfed (%)	147 (48.4) n=288	132 (50.0)

Notes:
[1] Data are based on a total sample of 304 participant pairs, and study analysis of 267 pairs unless noted otherwise.
[2] Valid percentages are reported.

Table 2.3: Difference in food group intake between 1 and 2 year old children in the Toddler Overweight Prevention Study 2007-2012 at baseline.

Variable	1 year (%) N=194	2 year (%) N= 73	p-value[1]
Any grains	100	100	NA
Any whole grains	68.6	76.7	0.191
Any vegetables (total)	95.4	95.9	1.00
Any orange vegetables	25.8	16.4	0.107
Any dark green vegetables	23.2	23.3	0.987
Any potato	53.1	60.3	0.293
Any starchy vegetables	32.5	21.9	0.092
Any tomato	52.1	60.3	0.230
Any “other” vegetables	71.1	75.3	0.493
Any fruit	95.4	97.3	0.732
Any whole fruit	79.4	76.7	0.635
Any citrus	71.6	75.3	0.546
Any fruit juice	85.6	86.3	0.878
Any dairy	98.5	98.6	1.000
Any milk	94.8	97.3	0.521
Any yogurt	11.3	12.3	0.822
Any cheese	74.7	76.7	0.739
Any meat, poultry, fish (total)	91.8	93.2	0.705

Any meat (beef, pork, veal, game)	50.5	53.4	0.672
Any organ meats	0.5	2.7	0.182
Any franks	31.4	35.6	0.517
Any poultry	55.7	56.2	0.942
Any omega 3 fish and shellfish	3.1	9.6	0.049
Any fish	12.9	11.0	0.670
Any eggs	54.1	53.4	0.919
Any soy	50.0	42.5	0.272
Any nuts	21.6	34.2	0.034
Any legumes	4.1	9.6	0.131

[1]p-values are determined by significance Pearson's Chi-square or Fisher's Exact Test

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Chapter 3.

Diet Quality of Children 12 to 31 Months of Age from Low-Income Households

Abstract

The purpose of this study was to evaluate the diet quality and factors associated with diet quality among 267 toddlers 12-23 and 24-31 months of age from low-income households in an Eastern United States metropolitan area. Diet quality was measured using two methods, the Mean Adequacy Ratio (MAR) to assess nutrient intake and the 2005 Healthy Eating Index (HEI-2005) to assess adherence to the Dietary Guidelines for Americans. Mothers provided a 24-hour dietary recall of the toddler diet, collected by trained research staff using the United States Department of Agriculture Automated Multiple Pass Method (AMPM). Toddlers of both ages had a low probability of inadequate nutrient intake (median MAR=98.0% and 99.0%), and excess intakes vitamin A (24.7% and 32.9%), niacin (64.4% and 74%), and zinc (36.6% and 53.4%) for children aged 12-23 and 24-31 months respectively. However average dietary quality by HEI-2005 was low at both ages [55.1 ±10.7 at 12-23 months; 55.1±12.3 at age 24-31 months], indicating that improvements were needed to better meet the Dietary Guidelines for intake of whole grains, total vegetables, total dairy, total meat/poultry/fish, sodium, and extra calories. Maternal and child determinants of diet quality by HEI-2005 were assessed using multivariate regression. Poverty measured by the Poverty Index Ratio (PIR, ß=2.57 p=0.004) and maternal diet quality (ß=0.30, p< 0.001) were positively related to average child HEI-2005 scores without controlling for potential covariates.

Controlling for other potential maternal and child covariates, maternal diet quality was the only factor significantly related to child diet quality (ß=0.43, p=<0.001). While poverty often influences diet quality, toddlers of low-income families may have more than sufficient nutrient intake likely due to the successes of nutrient fortification of the food supply and access to food assistance programs. For a balanced diet, focusing on the mother's dietary choices, and attention to vegetable, dairy, whole grain, added fat, and added sugar intake is warranted in order to promote the early development of life-long healthy eating patterns.

3.1 Introduction

Diet quality is critical to optimal child development and growth, and the prevention of adverse health conditions. Declines in estimated diet quality over childhood have been observed in many studies in the United States (CNPP, 2008, Affenito et al., 2007, Demory-Luce, 2004, Kranz, 2008), and the decline in diet quality may begin to occur as early as toddlerhood, when children are transitioning from specially prepared infant foods and liquids to the family diet. Despite specific dietary recommendations designed to promote healthy child growth and development, and the prevention of micronutrient deficiencies, obesity, diabetes, cardiovascular disease, and other undesired health outcomes, people do not fully heed these recommendations (Munos et al., 1997, USDA, 2009b). Dietary intake data from the 2003-2004 National Health and Nutrition Examination Survey (NHANES) for U.S. children 2-17 years of age were evaluated to assess population adherence to dietary recommendations. Although children 2-5 years of age had greater intakes of total fruits, whole fruits, and milk, and lower intakes of extra calories from solid fats and added sugars (termed SoFASS) than children between the ages of 4-11, and 12-17, the average scores for all age groups indicated that significant improvements in overall intake were necessary (USDA 2009b). National estimates of toddler dietary quality in 2008 showed adequate intakes of most micronutrients with the exception of vitamin E where 63% of toddlers age 12-23 months of age consumed less than the Estimated Average Requirement (EAR) (Butte, Fox, Briefel, Siega-Riz, Dwyer, Deming & Reidy, 2010). Additionally, there were intakes greater than the Upper Tolerable Intake Level (UL) for Folate (6%), Vitamin A (31%), Zinc (47%), and Sodium (45%), less than desired intake of fiber, and high intakes of saturated fat (Butte et al., 2010). With intake of healthy foods such as fruits, vegetables, and whole grains being lower than recommended for US children and adolescents (Munoz et al., 1997, USDA, 2009b) at a time during the lifespan in which low dietary quality has the potential to have a negative impact on cognitive and physical development (Black, 2003), more studies are needed to broaden general knowledge about how foods are consumed and how eating behaviors are developed in early childhood.

The purpose of this study was to evaluate diet quality of children between 12 and 31 months of age using two score-based diet quality assessment methods, the 2005 Healthy Eating Index (HEI-2005), and the Mean Adequacy Ratio (MAR) (Krebs-Smith and Clark, 1989). We also evaluated the relationship between maternal factors (age, employment, education, marital status, parity, Body Mass Index (BMI), maternal diet quality, participation in food assistance programs) and child factors (age, gender, race, BMI for age, and breastfeeding history) and diet quality.

3.2 Materials and Methods

The data for these analyses were collected through the Toddler Overweight Prevention Study (TOPS). TOPS was a 3 cell randomized trial conducted in Anne Arundel County and Baltimore City, Maryland to prevent rapid weight gain and overweight among toddlers. Mothers and toddlers were randomized to 1 of 3 study arms: an intervention targeting nutrition and physical activity behaviors of mothers of toddlers, a parenting skills intervention, and a child safety control group. The TOPS study was approved by the University of Maryland and Maryland Department of Health and Mental Hygiene Institutional Review Boards. The analyses presented here utilize data collected at baseline, prior to intervention.

Description of the sample.

Mothers were recruited by trained study staff at a suburban Women's Infants and Children (WIC) clinic, and an urban pediatric clinic serving primarily low-income families. Mothers were also referred to the study by friends who were study participants. Eligible mothers were at least 18 years of age, not pregnant, and did not have any medical restrictions or chronic conditions that would prevent or limit physical activity. Eligible toddlers were between the ages of 12-31 months at the time of recruitment, not born premature (defined as less than 37 weeks estimated gestational age at birth), weighed at least 5 pounds, 8 ounces at birth, and were without any health restrictions or developmental delays. There were 304 mother/toddler pairs who were initially consented for the study. Thirty-five families were removed from analysis; 25 did not complete the entire baseline assessment, eight toddler dietary records were incomplete because the mother was not with the child the day of intake and she did not have additional information about the toddler's dietary intake, and two mothers refused to provide the dietary recall assessment, leaving 269 complete toddler dietary intake records from the baseline assessment. Two additional records were excluded for having energy intakes below 300 kcal for the day and thus, 267 children (87.8%) were included in these analyses.

Data collection.

Toddler and maternal dietary intake was reported by the mother in person to trained research assistants using the USDA Automated Multiple Pass Method (AMPM) for 24-hr dietary recall (USDA, 2009). The AMPM was linked to a food composition database that provided detailed nutrient information for each food selected. Food model booklets were used to assist in estimating the quantity of foods consumed. Additionally, because the recall occurred at the participant's home, participants were able to show research assistants the foods and utensils used to aid with accuracy of data collection. Food intake data were imported into a computerized coding system and coded by trained research assistants. Coders were monitored for reliability and quality checks were conducted regularly to ensure accuracy. Dietary intake results reflect nutrient intakes from food and do not include supplement consumption. Estimates of breast milk consumption (n=12) were imputed based on the toddler's age and their intake of infant formula and/or cow's milk. We assumed a breast milk intake of 89 mL per feeding occasion between 12-17.9 months of age, and 59 mL per feeding occasion for toddlers over 18 months of age, based on estimates of breast milk intake for children of this age in the United States in other studies (Dewey, Finley, & Lonnerdal, 1984; Butte et al., 2010).

Maternal characteristics and family environment (age, education, employment status, marital status, number of total children, number of people in the home, location, household income, food insecurity, and participation in the Supplemental Nutrition Assistance Program (SNAP) and the Maryland Special Supplemental Program for Women Infants and Children (WIC) and child characteristics (age, gender, race, BMI for age, and breastfeeding history) were collected through an audio computer assisted self-interview, completed by the mother at the baseline evaluation. Household food security status was measured by a 6-item United States Food Security Scale, a valid and reliable household-level measure of food security that was scored and scaled in accordance with established procedures (Bickel, 2000). Households were classified as food insecure if they reported not being able to afford enough food for an active healthy life for all household members.

Mother's height and weight and child's length and weight were measured by trained research assistants. Maternal height and child length were measured to the nearest 0.1 cm (Shorr Productions, Olney, Maryland). Maternal weight was assessed to the nearest 0.1 kg with clothing but without shoes (TANITA 300GS; Tanita Corp, Arlington Heights, IL). Child weight was assessed while wearing only a clean diaper to the nearest 0.1 kg using a TANITA 1584 Baby Scale (Tanita Corp, Arlington Heights, IL). The measurements were taken 3 times, and the average of the three measurements was used in this analysis. Mother's BMI was calculated as weight in kilograms divided by the squared value of the height in meters. Overweight was defined as a BMI greater or equal to 25 and less than 30, and obese as BMI greater or equal to 30 (CDC, 2012).

Data analysis

All data analyses were completed using STATA 10.1 (College Station, TX). Descriptive statistics including means, medians, and standard deviations where appropriate were conducted for the maternal and child characteristic variables. Differences between in characteristics between ages 1 and 2 were assessed using t-tests and chi-square analyses. Diet quality summary scores were calculated using two methods, the Mean Adequacy Ratio (MAR) and the 2005 Healthy Eating Index (HEI-2005), and descriptive analyses of the total scores and individual component scores were conducted.

The MAR is an average of multiple nutrient adequacy ratios (NAR), ratios of nutrient intakes to Recommended Daily Allowances (RDA), multiplied by 100 to represent the percentage of the RDA consumed. NARs were calculated for the following 11 micronutrients: vitamins A, C, B6, and B12, thiamin, riboflavin, niacin, folate, calcium, iron, and zinc. An individual NAR may exceed 100%, however, to calculate the MAR, each NAR is truncated at 100% so that no individual nutrient carries more weight than another in the MAR calculation. The maximum value of the MAR is 100% which indicates nutrient intake at least equivalent to the RDA for each nutrient. For both NAR and MAR, a value of 100% is ideal because there is a low probability of inadequate intake associated with this value (Steyn et al., 2005). There is no consensus regarding the MAR score that indicates low diet quality. For the purpose of this study, we chose a score of 85%, as indicated in a study of a similar population (Hoerr et al., 2006).

The HEI-2005 is a measure of dietary quality assessing adherence to the USDA's MyPyramid 2005 Dietary Guidelines for Americans age 2 and older (Guenther et al., 2007). The HEI-2005 measure grain reflects the emphasis on the intake of whole grains, dark green leafy and orange vegetables, whole fruit (excludes 100% fruit juice), and limitations on SoFASS. The HEI-2005 also includes components that represent the major food groups in the MyPyramid recommendations including: total fruit; total vegetables; total grains; total milk, including soy beverages; meat and beans, including meat, poultry, fish, eggs, non-beverage soybean products and nuts; whole fruit excluding juice; dark green and orange vegetables and legumes; whole grains; oils; saturated fat; sodium; and SoFAAS. Seeds and legumes are counted as meat and beans when intakes of meat are less than 3oz per 1000 kcal total energy intake. Over this meat and beans intake, seeds and legumes are counted as vegetables. Each component is assigned a specific number of points (see Table 3.3), and all components are added to create a total score. The maximum score for each component is given if the standard is reached or exceeded. There is a maximum of 100 points for a dietary intake that meets the minimum recommendations for all component groups and a higher score reflects a greater adherence to the dietary guidelines (Guenther et al., 2007).

Although the HEI-2005 was not developed for children under 2 years of age (Guenther et al., 2007), we used it to evaluate how the child's diet compares to the recommendations that will apply at the age of 2, after the transition to the family diet.

The percentages of children with nutrient intakes above the Tolerable Upper Intake Level (TUL) as defined by the National Academy of Sciences Dietary Reference Intakes (2005) were also calculated.

A poverty income ratio (PIR) was created using specifications defined by the US government for indicating poverty and is based on the money income, estimate of need, and the number of adults and children in the household (www.census.gov). This variable was examined as a continuous variable and as a categorical variable (less than 100%, or greater or equal to 100%; less than or equal to 185%, or greater than 185%; and less than or equal to 130%, or greater than 130%). WIC eligibility was assigned to those with a reported PIR equal or less than 185%, plus any participants who indicated that they participated in WIC but were not eligible by our calculation of the PIR. Eligibility for the Supplemental Nutrition Assistance Program (SNAP) was assigned to PIR values equal to or less than 130%, plus any additional participants who indicated that they received food stamps but were not eligible by our estimation of the PIR.

Social determinants of diet quality were assessed by first investigating the bivariate associations between the selected social demographic characteristics and child HEI-2005 scores using simple linear regression analyses. Variables selected include child age, gender, race/ethnicity (white vs. other), breastfeeding duration, urban/suburban location, (SNAP) participation, WIC participation, mother's BMI, food insecurity, mother's diet quality as measured by the HEI-2005, marital status, employment, educational attainment, and PIR. A multiple linear regression model was created using variables with bivariate associations with p-values less than 0.1. We intended to evaluate the association between social determinants and MAR scores. However, the distribution of toddler MAR score was highly skewed, only 6% of the toddlers had MAR values less than 85%. Therefore, we investigated nutrient intake greater than the TUL and food group intake, as additional indicators of risk of poor diet quality. Analyses were conducted using SPSS version 20.0 (IBM SPSS) and STATA version 10.1 (STATA Corp, College Station, TX).

3.3 Results

Sociodemographic characteristics

Of the 267 mother-toddler pairs included in this analysis, about 60% from Baltimore City and the remaining 40% from Anne Arundel County (Table 3.1). The average child age was 20 months (range 12-31 months, 194 children age 12 to 23 months, 73 children age 24-32 months), 52.1% were male, and 60% were first-born with no siblings. Mothers ranged in age from 18 to 46 years (mean 27.5, SD= 6.2). Most mothers were not married (71.2%), 40.5% were employed full or part-time, and more than 80% had a high school education or more. Most of the families were of low income (mean PIR= 79.6%, ranging from 11% to 319%).

Energy Intake, Nutrient Adequacy, and MAR

Average energy intake among 1 year old children was 1240 kcal (SD= 450) ranging from 330 to 3050 kcal/day. Average energy intake was significantly greater among 2 year old children compared to 1 year old children (mean = 1380, SD= 475), and ranged from 530 to 2780 kcal/day (data not shown). Median NAR results prior to being truncated at 100% illustrated intakes 1-7 times the RDA for all of the nutrients, with highest NAR% for vitamin B6 (213% and 261%), riboflavin (301% and 308%), vitamin B12 (353% and 407%), vitamin C (436% and 456%) for ages 1 and 2 years respectively (Table 3.2). The median MAR for children 12-23 months and 24-31 months was 98.1 and 98.9%, respectively, meaning that more than 50% of toddlers in this sample had consumed nearly the RDA or greater for each of the 11 nutrients included in the analysis.

Seventy-five percent of children age 12 and 24 months had MAR values greater than 95%. Only 16 toddlers had MAR values that fell below the cut-point for low dietary quality (MAR $\leq$ 85).

Many children had nutrient intakes greater than the TUL, including 24.7% and 32.9% of children ages 12-23 months and 24-31 months, respectively for vitamin A; 64% and 74% of children ages 12-23 months and 24-31 months respectively for niacin; 36.6% and 53.4% of children 12-23 months and 24-31 months respectively for zinc (Table 3.3). These results illustrate the potential for excess usual nutrient intake among a significant portion of this sample.

HEI-2005 and Food Group Intake

Mean (±SD) HEI-2005 scores (Table 3.4) were nearly identical for children ages 12-23 months (55.1 ± 10.7) and ages 24-31 months (55.1 ± 12.3). No component average scores were equal to the optimal score for either age group. Total fruits and total grains were the closest to their recommended scores with averages of 4.0/5 (1.58) and 3.8/5 (1.7) scored for total fruits; 3.9/5 (1.2) and 3.9/5 (1.2) for total grains; 7.7/10 (3.4) and 7.4/10 (3.2) for milk; and 6.6/10 (3.1) and 7/3/10 (2.8) for ages 1 and 2 respectively. While overall HEI-2005 scores were the same, a closer look at the individual HEI-2005 component scores by age shows that the intakes differ significantly for oil [mean at age 1= (4.0 ± 3.5), mean at age 2= (5.1 ± 3.6), t= 2.27, p=0.02, sodium [mean at age 1= (6.0 ± 3.0), mean at age 2= (5.0 ± 2.9), t= 2.56, p=0.01], and SoFASS intakes [mean at age 1= (12.0 ± 5.0), mean at age 2= (10.6 ± 5.6), t=1.97, p=0.05]. This finding may indicate negative changes in dietary patterns between ages 1 and 2 years with greater intakes of sodium, solid fat, and added sugar occurring at age 2.

When comparing intakes of food groups to the Dietary Guidelines, 53% and 11% and 58% and 21% of children ages 1 and 2 met the recommendations for total grains and whole grain intake respectively. Similarly, 57.5% and 45%, and 63% and 56% of children ages 1 and 2 met the recommendations for total and whole fruit intake, respectively (data not shown). For all other food groups, less than 50% of children ages 1 or 2 met the recommended intake levels. Milk intake recommendations of 2 cups were met by 47.2 and 41% of children ages 1 and 2. An evaluation of milk intake types by age showed no significant differences in whole milk ($t= 1.094$ (265), $p= 0.2748$) and nearly significant differences in low-fat milk mean intake ($t=-1.555$ (265), $p=0.061$) by age (data not shown). A greater percentage of children age 1 met the sodium recommendation for 2 year old children than the 2 year old children in the sample (44.8% vs. 24.7%). Very few children of either age met the recommendation for less than 165 extra calories from solid fat, added sugar per 1000 kcal of energy intake (4.6% age 12-23 months, 1.4% age 24-31 months).

Sociodemographic Factors Associated with Diet Quality

The relationship between maternal factors (age, employment, education, marital status, parity, Body Mass Index (BMI), maternal diet quality, participation in food assistance programs) and child factors such as age, gender, race, weight for age, BMI for age and breastfeeding history and diet quality were also assessed. Bivariate analyses revealed significant relationships between child diet quality and PIR, mother's diet quality, marital status, and child race. Results of a multivariate model including PIR, maternal diet quality, marital status, child race, and child age resulted in the single significant factor of maternal diet quality (ß=0.43, p=<0.001), illustrating positive relationship between toddler diet and the mother's diet (data not shown). Additional multivariate analyses controlling for other factors revealed a marginally significant interaction between maternal diet quality and PIR (ß = -0.20, p= 0.072), showing the possibility of an attenuated effect of maternal diet quality on child diet quality at PIR values greater than 130 (Figure 3.1).

3.4 Discussion

This study illustrated two methods for assessing the quality of a child's diet. The two methods were complementary in many respects. Alone, neither of these provided a complete picture of toddler diet, but together, these methods provided a composite view of the dietary habits of children at this age and an illustration of how food and nutrients are consumed. From purely a nutrient intake perspective, the probability of inadequate intake of the 11 nutrients included in this analysis is low for this population as most children had MAR scores over 95%. Although 67% of the families of children in this sample were of low-income with 27.9% reporting food insecurity, the nutrient intake RDAs were achieved, suggesting that children were receiving most of the vitamins and minerals that they needed. In many cases, children received even more than recommended; for example, 24-31 year olds consumed more than the TUL for vitamin A (32.9%), zinc (53%), and niacin (74%). These intakes may be attributed to the intakes of breads, cereals, milk, and other nutrient fortified foods that were frequently consumed among children in this sample and are commonly consumed by children at this age. While having low risks of inadequate intake is important, consistent intakes of vitamin A, niacin, or zinc above the TUL is associated with liver toxicity, skin an eye abnormalities (vitamin A and Niacin), and immune system impairment (zinc) (Meltzer et al., 2003). Excess intakes of zinc, folate, and vitamin A were also observed in a substantial portion of toddlers in a national study, and was attributed to food and supplement intake (Butte et al., 2010; Berner et al., 2014). Here our results only considered nutrient intakes from diet; however, they confirm results from other studies of toddler diet quality in national and regional populations demonstrating that many children meet their nutrient needs without meeting the food group intake recommendations, particularly for vegetables and whole fruit (Hoerr et al., 2006).

The HEI-2005 is a useful measure for comparing the child's intake to dietary recommendations for food group intake. By assessing intake per 1000 calories, researchers are able to use the tool to summarize food intake at a variety of life stages (Guenther et al., 2007). However, this scale was created to measure dietary quality as defined by the 2005 Dietary Guidelines for Americans, which was intended for children age 2 and older. Our application of the HEI-2005 as a measure of dietary quality is to assess how children age 12-23 months are performing as they transition to the recommendations of children age two and above. Overall diet quality was the same at ages 1 and 2 but significant differences were present within a few of the dietary components including increased consumption of oils, sodium, and solid fat/added sugar at age 2 compared to age 1. An important difference in dietary recommendations at 1 and 2 years of age is regarding the total dietary intake of calories from fat. At age 1, fat consumption of between 30-40% of total energy (kcal) is recommended compared to 30-35% at age 2 (Gidding et al., 2006). While the difference in fat consumption in theory could be attributed to meats or foods like cookies, cakes and other treats, differences in milk consumptions recommendations at age 1 compared to age 2 could also affect discretionary calorie intakes. When whole milk is consumed instead of 2% fat milk, 48 kcal per two cups of milk are added to the diet that would be considered "discretionary calories" when compared to the consumption of the equivalent amount of 2% milk (Gidding, 2006). Milk type recommendations change at 2 years of age as a way to lower the fat content of the diet (USDA, 2005). However, national estimates of low-fat milk intake are 13% at age 2-5, illustrating that this recommendation is not generally heeded at this age (Kit, Carroll & Ogden, 2011). In this sample, we observed that average intakes of whole milk were not greater at age 1 than at age 2. Additionally, it is important to note that those who consumed low-fat milk in the sample were marginally more likely to be 2 years of age (p=0.06). These differences in low-fat milk intake were not great enough to produce lower average HEI-2005 scores compared to 1 year old children. An assumption could be that the dietary quality of children age 1 might be better than those of age 2 if the measure of diet quality accounted for a greater allowance of solid fat contributed by whole milk intake at 1 year of age. It is not clear how significant of an impact this adjustment would have on the diet quality scores, and should be further evaluated.

In general, overall diet quality averages for both ages were substantially lower than the recommendations, as evidenced by the average sores of 55 for each age. Slightly higher results have been observed through measuring diet quality by HEI-2005 among a national sample of children ages 2-5 years of age, mean=60, 95% CI (56, 63) (Hiza et. al., 2013). However, children in the national study were also likely to have low component scores for whole grains, dark green and orange vegetables, oil, saturated fat, sodium and SoFAAS (Hiza et al., 2013).

When focusing on the HEI-2005 component scores between the ages 1 and 2, scores were similar for whole fruit, total fruit, total vegetables, dark green leafy vegetables, milk, meat, whole and total grains. Significantly different component scores were present for, sodium, oils and SoFASS when comparing children 12-23 months of age and children age 24+ months, suggesting that children in this population may have greater intakes of these dietary components as age increases. Increased intake of oils might be attributed to increased intake of nuts and nut butter products. Increased intake of SoFASS could be attributed to a variety of sources, including fruit juices, as well as sweet and salty treats. It is important to note that only 10 children in the sample met the recommendation for SoFAAS, nine at age 1 and one at age 2. Considerable improvements in dietary intake could be made by focusing on efforts to provide specific guidance and incentives for reducing intakes of sodium, added sugars and solid fats as well as increasing fruit and vegetable intake, and making substitutions such as whole wheat bread for white bread and low-fat milk for whole milk to increase diet quality scores in this age group. In addition, continued participation in SNAP and WIC programs for families who are eligible for these benefits may be helpful as these programs have shown to have positive effects on fat intake, added sugar consumption, and fruit intake and can be an effective way to promote these foods in low-income populations (Siega-Riz et al., 2004).

Studies have found relationships between adult diet quality and many factors including educational attainment, marital status, food poverty, and underweight status (Boynton et al., 2008; Harrington et al., 2011; Hiza et. al, 2013). Few studies have assessed the maternal sociodemographic factors associated with child diet quality with low family income and poor maternal diet quality typically related to lower diet quality and with inconsistent results concerning the influence of race and ethnicity (Hoerr, 2006; Kranz, 2002; Kranz, 2008). In this analysis, as mother's diet quality increased, child diet quality increased, supporting previous research indicating that improvements in the maternal diet indirectly improve the child's diet (Lee, Hoerr & Schiffman, 2005; Papas et al., 2010). However at higher PIR, the effect of mother's diet on child diet was attenuated. More research is needed to further explain this observation as this attenuation could be related several factors including time spent in child care, maternal employment, or number of employed persons in the household.

Dietary summary measurements provide useful information regarding intake however, there are important strengths and limitations that must be noted. First, MAR scores are a function of the nutrients that the investigators choose to include in the analysis. There is no standard list of nutrients that must be included to create the summary score at a given age or life stage. Depending on the relationships of interest to the investigators, nutrients that may improve the overall summary score may be excluded from the summary calculation. Second, the more food that a child consumes, the greater the MAR scores even if the foods are high in added sugars and solid fats. This may result in a high nutrient adequacy score for the nutrients included in the score calculation.

However, the high score does not reflect the potentially high fat and added sugar intake that may be present.

The dietary guidelines are recommendations for people to achieve long-term health benefits based on scientific consensus (USDA, 2010b). These recommendations are for energy and nutrient intake to prevent nutrient deficiencies, as well as a dietary pattern shown/suggested to help prevent the development of chronic disease. The results of this study show that although children are not consuming the food group recommendations (which are meant to lead to recommended nutrient intakes), the nutrient intake recommendations were nonetheless met or exceeded. Ideally food group recommendations should complement nutrient intake recommendations by providing tangible food consumption guidance for the public to receive both adequate nutrient intake as well as promoting long-term health. However, a better balance between food intake and nutrient intake should be met to prevent toxicity associated with excess intake of some nutrients. Considerations for the amounts and types of foods, such as fortified cereals and other nutrient fortified foods frequently consumed by children, is important to factor into the development of dietary recommendations that account for the risks for nutrient intakes greater than the upper tolerable intake levels that are observed. More research is needed to find the optimum balance between food intake guidance and nutrient intake recommendations, paying specific attention to the foods that are typically consumed in various populations and tailoring the food consumption advice to create a better balance with nutrient requirements.

Table 3.1: Selected characteristics[1] of mothers and children at baseline in the TOPS study

Characteristics	All children (N=267)	Age 12-23 mo (N=194)	Age 24-31mo (N=73)
Maternal:			
Age (y)	27.5 (6.2)	27.6 (6.6)	27.4 (5.1)
BMI (kg/m^2)[2]	31.8 (9.4)	32.0 (9.5)	31.1 (9.1)
Education (%)			
< High school	17.7	19.1	13.7
High school or GED	34.8	35.1	34.2
>High school	47.3	45.9	52.1
Married (%)	28.8	29.4	27.4
> 1 child (%)	41.1	43.8	34.2
Employed (%)	40.5	44.3	30.1
Poverty- Income Ratio ≤ 100% (%)	67.4	67.0	68.5
Supplemental Nutrition Assistance Program Participation (SNAP) (%)	51.5	47.2	63.0
WIC program participation (%)	87.6	90.8	79.1
Food Insecure (%)	27.9	30.1	22.2
Location (%)			
Baltimore City	59.2	55.7	68.5
Anne Arundel County	40.8	44.3	31.5
Child			
Age (mo)	20.0 (5.5)	17.3 (3.6)	27.2 (2.1)
Race/Ethnicity (%)			
White	23.2	23.2	23.3
African- American	68.5	67.5	71.2

Other race, Hispanic ethnicity	8.2	9.3	4.3
Male (%)	52.1	49.5	61.1

[1]Presented are mean (SD) or % as appropriate.
[2] Mother's BMI based included for 192 and 72 mothers of children ages 1 and 2 respectively
[3] Child weight included for 192 and 72 children ages 1 and 2 respectively.
[4] Child length included for 193 and 72 children ages 1 and 2 respectively.

Table 3.2: Mean Adequacy Ratio and Nutrient Adequacy Ratios for 11 key nutrients among children 1 and 2 years of age.

Nutrient/ Indicator	**RDA**	**UL**	**Child Age**			
			12-23 months		24-31 months	
			Median	25%, 75%	Median	25%, 75%
Energy (kcal)			1166.0	944.6, 1455.7	1224.9	1037.7, 1683.5
MAR			98.1	95.0, 100	98.9	96.1, 100
NAR						
vitamin A	300µg/d	600µg	152	95, 199	150	101, 223
Thiamin	0.5mg/d	ND	188	135, 245	204	154, 273
Riboflavin	0.5mg/d	ND	301	225, 414	308	239, 451
Niacin	6mg/d	10mg	190	140, 258	234	159, 328
vitamin B6	0.5mg/d	30mg	213	154, 281	261	202, 366
Folate	150µg/d	300µg	170	112, 262	200	137, 316
vitamin B12	0.9µg/d	ND	353	238, 535	407	300, 534
vitamin C	15mg/d	400mg	436	256, 719	456	258, 821
calcium	500mg/d	2.5g	142	98, 206	128	91, 229
Iron	7mg/d	40mg	115	83, 173	132	91, 199
Zinc	3mg/d	7mg	196	153, 271	241	174, 356

Note: Mean Adequacy Ratio and Nutrient Adequacy Ratios are reported as percentages based on the Recommended Daily Allowances (RDA) for each included nutrient. The RDA is the amount estimated to satisfy the nutrient needs of 97.5% of a given, healthy population, and is calculated as the Estimated Average Requirement (EAR) + 2*Standard Deviations of the EAR. A median NAR of 152 for vitamin A means that the median intake value for the sample 152% of the RDA or 1.5 times the value of the RDA for vitamin A.

Table 3.3: Percent of children with nutrient intakes greater than the Tolerable Upper Intake Level (UL)

Nutrient	UL	% Greater than UL	
		12 – 23 months	24 - 31 months
vitamin A	600µg	24.7	32.9
Thiamin	ND	ND	ND
Riboflavin	ND	ND	ND
Niacin	10mg	64.4	74.0
vitamin B6	30mg	0	0
Folate	300µg	0	0
vitamin B12	ND	ND	ND
vitamin C	400mg	0	1.4
Calcium	2.5g	0	2.7
Iron	40mg	0	0
Zinc	7mg	36.6	53.4

UL: Tolerable Upper Intake Level, the maximum amount of daily intake likely to pose no risk of adverse effects to most individuals.

ND: No established UL due to lack of data on adverse effects in this age group and low levels of concern regarding ability to handle excess amounts.

Table 3.4: Toddler HEI-2005 Scores

HEI-2005 Component	**HEI-2005 Scoring Criteria**		**Score**[1]		**Difference by age**[2]
	Maximum Points	***Standard for maximum score***[3]	***Age 12-23 m n=194***	***Age 24-31 m n=73***	
Total Fruit	5	≥ 0.8 cup equiv.[4]	4.0 (1.6)	3.8 (1.7)	0.75 (0.45)
Whole Fruit	5	≥ 0.4 cup equiv.[4]	3.1 (2.2)	3.2 (2.2)	-0.21 (0.84)
Total Grains	5	≥ 3.0 oz. equiv.[4]	3.9 (1.2)	3.9 (1.2)	0.11 (0.92)
Whole grains	5	≥ 1.5 oz. equiv.[4]	1.3 (1.6)	1.6 (1.8)	-1.35 (0.18)
Milk	10	≥ 1.3 cup equiv.[4]	7.7 (3.4)	7.4 (3.2)	0.70 (0.48)
Meat & Beans	10	≥ 2.5 oz. equiv.[4]	6.6 (3.1)	7.3 (2.8)	-1.57 (0.12)
Total Vegetables	5	≥ 1.1 cup equiv.[4]	1.8 (1.4)	2.1 (1.5)	-1.28 (0.20)
Dark Green & Orange Vegetables*	5	≥ 0.4 cup equiv.[4]	0.72 (1.4)	0.47 (1.0)	1.61 (0.11)
Oils	10	≥ 12 g[4]	4.0 (3.5)	5.1 (3.6)	-2.27 (0.02)
Saturated Fat	10	≤ 7% of energy	4.0 (3.7)	4.8 (3.8)	-1.59 (0.11)
Sodium	10	≤ 0.7 g[4]	6.0 (3.0)	5.0 (2.9)	2.56 (0.01)
Solid Fat, Added Sugar	20	≤ 20% of energy	12.0 (5.0)	10.6 (5.6)	1.97 (0.05)
Total HEI-2005 Score	100		55.1 (10.7)	55.1 (12.3)	0.01 (0.99)

Notes:
* Unequal variances (Levene's test result: f=7.442, p= 0.007)
[1]Presented are mean (SD).
[2]T-test (p-value) for differences in mean HEI-2005 component scores between children ages12-23 and 24+ months.

[3]For total grains, whole grains, total fruit, whole fruit, total vegetables, green/orange vegetables, milk, meat and beans, and oils, any value equal to or greater than standard receives the maximum score. For saturated fat, sodium, solid fat and added sugar, intake values LESS than or equal the standard receives the maximum score. Any intake value greater than the standard receives a score that is LOWER than the maximum score.
[4]per 1000 kcal

Figure 3.1. Child diet quality by maternal diet quality among families with Poverty Income Ratios greater than or equal to 130% poverty.

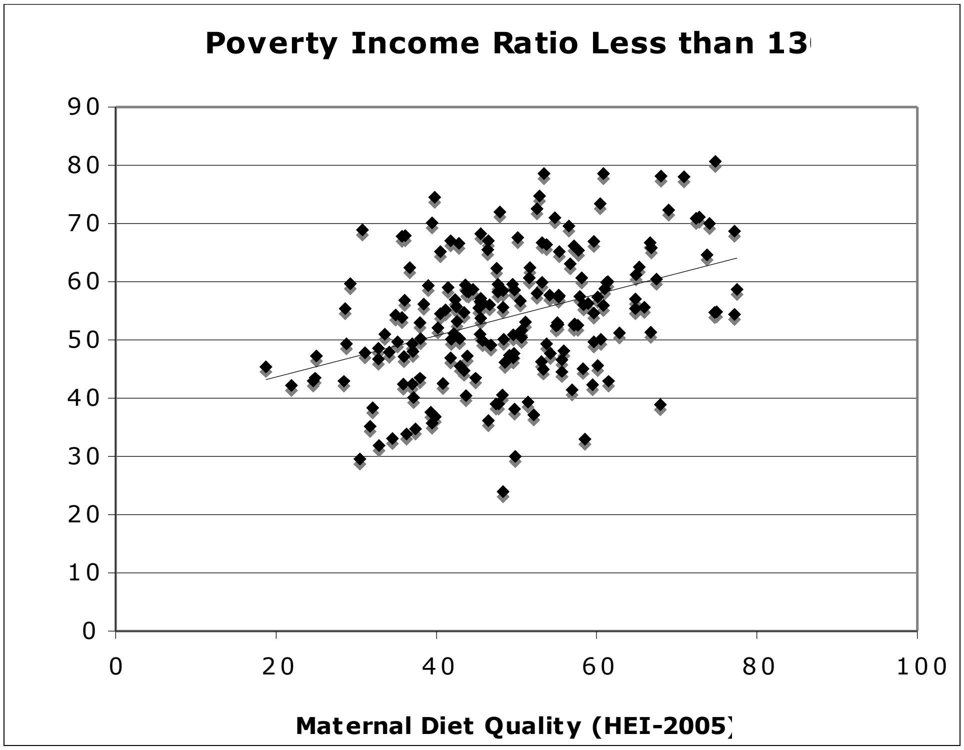
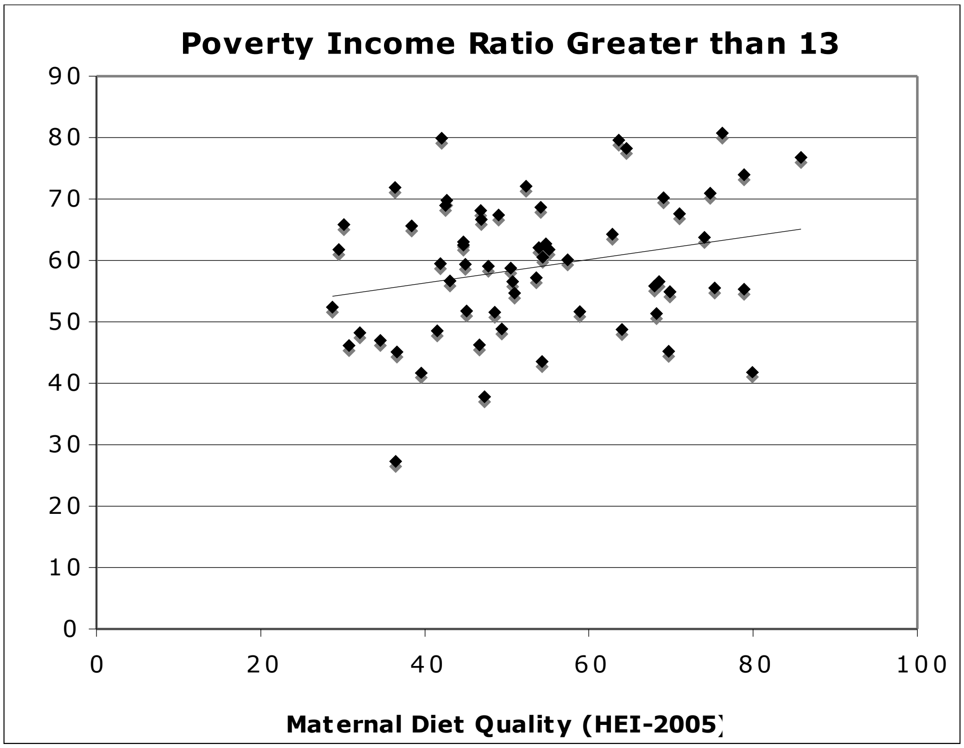


Figure 3.2. Child diet quality by maternal diet quality among families with Poverty Income Ratios less than 130% poverty.



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Chapter 4: Identification of Dietary Patterns of Young Children by Cluster Analysis

Abstract

Objective: This study evaluated dietary patterns of 267 children 1 and 2 years of age of low-income families in an U.S. urban and suburban area.

Methods: Dietary data was collected though 24-hour dietary recall using the Automated Multiple Pass Method. Dietary patterns were evaluated by cluster analysis using Ward's criteria. Frequencies of dietary intake components were examined for differences between the groups. Additionally, dietary quality and characteristics associated with the clusters were assessed.

Results: There were four dominant clusters: Light Eaters (n=104), Processed Meats, Potatoes and Fruit (n=102), Meat, Tomato, and Non-whole grains (n=43), and Whole Grains, Vegetables, Nuts, Fruit Juices (n=18). While maternal sociodemographic characteristics did not differ greatly between the clusters, there were clear consumption pattern differences in a seemingly homogeneous population.

Conclusions: Intake pattern clustering can be identified by groups of people with similar intake even as young as 1 years of age. Healthy choices should continue to be promoted to increase intakes of whole grains, fruits, vegetables, and lean meats to improve overall diet quality of young children.

4.1 Introduction

The development of healthy eating patterns is of great importance in public health. Studies show that food preferences are derived early in life, and may be related to genetic predispositions as well as early dietary exposures (Birch, 1999). Early food consumption patterns appear in infancy and toddlerhood as children are transitioning from the infant diet to the family diet and are exposed to more and more foods. Additional research has shown that early patterns of eating can continue throughout childhood, even through adolescence, supporting the importance of supporting the development of early healthy patterns (Mikkila et al., 2005).

Dietary intake pattern analyses differ from traditional nutrient intake analyses as these methods focus on the combinations of foods that are consumed rather than the relationship between individual specific nutrients. Because nutrients are not consumed in isolation, population dietary recommendations translate requirements for adequate nutrient intake into concrete food consumption recommendations for building healthy dietary habits and preventing chronic diseases (USDA, 2010). Cluster and factor analysis are common methods for identifying population consumption patterns (Reedy et al., 2009). The purpose of cluster analysis is to identify potentially non-overlapping groups of individuals with similar consumption patterns (Willett, 1998), whereas using factor analysis one identifies groups of food or nutrients based on correlations in dietary intake (Bailey et al., 2007). Once clusters are identified, they can be evaluated for nutrient sufficiency, dietary quality, and the relation between the clusters and health outcomes can be assessed.

There are two types of cluster analyses, hierarchical and non-hierarchical (Everitt, Landau, Leese & Stahl, 2011). In hierarchical cluster analysis, each individual starts as their own cluster. The clusters are combined based on one of several methods for evaluating the similarities and/or distances between the clusters, including complete linkage, group average linkage, centroid clustering, and Ward's method (Everitt, Landau, Leese & Stahl, 2011). Ward's method is common in the dietary pattern analysis literature, and involves the creation of clusters based on the sums-of-squares criterion, and is meant to minimize the variance within each individual cluster and maximize the variance between the clusters (Ward, 1963). These methods are exploratory, and used when the number of clusters present is unknown. Non-hierarchical or divisive cluster analysis begins with one large cluster that divides into a specified number of clusters. K-means cluster analysis is an example of this type of method that is also often used in dietary pattern analyses (Devlin, McNulty, Nugent & Gibney, 2012). This method comes under scrutiny because it requires the investigators to select the number of clusters that will be described, using cross-validation methods to verify the number that is selected (Devlin et al., 2012).

There are several issues that arise when conducting dietary pattern analyses. Dietary patterns are only as good as the data that are used to create the patterns. As a result, it is imperative that dietary data are collected carefully, with procedures for reducing recall error (Slattery, 2010). Additionally, food groupings that form the basis of the cluster formation are created by the researchers, stressing the need for the grouping to reflect the established intake patterns in the population or age group (Slattery, 2010).

Relationships have been found between unhealthy clustered eating patterns in adults and increased obesity risks, cardiovascular disease, diabetes and cancer (Devlin 2012). This supports the need to identify patterns of eating early in life in order to improve them and alter the risks for diet pattern-associated diseases. Factors associated with clustered patterns have also been evaluated, illustrating a variety of influences including parental social status, receipt of benefits, and housing accommodations (Pryer, et al., 2009).

The purpose of this study was to identify dietary clusters among toddlers 12-31 months of age and to evaluate the quality of these clusters based on the Healthy Eating Index-2005. Additionally, sociodemographic factors associated with membership in each cluster were evaluated. Currently, little is known about the dietary patterns of young children and the relationship between these patterns with overall diet quality. This study adds to the existing literature, while providing a suggested means for conducting cluster analysis studies that can be comparable to US dietary recommendations and to other cluster analysis studies.

4.2 Materials and Methods

The data for these analyses were collected through the Toddler Overweight Prevention Study (TOPS). TOPS was a 3 cell randomized trial conducted in Anne Arundel County and Baltimore City County, Maryland to prevent overweight among toddlers. Mothers and toddlers were randomized to 1 of 3 study arms: a nutrition and physical activity intervention targeting the mothers of toddlers, a parenting skills intervention, and a child safety control group. The TOPS study was approved by the

University of Maryland and Maryland Department of Health and Mental Hygiene Institutional Review Boards. The analyses presented here utilize data collected at baseline, prior to intervention.

Description of the sample

Mothers were recruited by trained study staff at a suburban Women's Infants and Children (WIC) clinic, and an urban pediatric clinic serving primarily low-income families. Mothers were also referred to the study by friends who had been already approached for study participation. Eligible mothers were at least 18 years of age, not pregnant, and did not have any medical restrictions that would prevent or limit physical activity. Eligible toddlers were between the ages of 12-31 months at the time of recruitment, not born premature (defined as less than 38 weeks estimated gestational age at birth), weighed at least 5 pounds, 8 ounces at birth, and were without any health restrictions or severe developmental delays. There were 304 mother/toddler pairs who were initially consented for the study. From this, 25 pairs withdrew before completing the entire baseline assessment. Eight toddler dietary records were incomplete because the mother was not with the child the day of intake and she did not have additional information about the toddler's dietary intake. Two mothers refused to provide the dietary recall assessment. As a result, there were 269 complete toddler dietary intake records from the baseline assessment. Additionally, two were excluded for having energy intakes below 300 kcal for the day and thus, a total of 267 children (87.8%) were included in these analyses.

Data collection

Toddler and maternal dietary intakes were reported by the mother in person to trained research assistants using the USDA Automated Multiple Pass Method (AMPM) for 24-hr dietary recall (Blanton et al, 2006). The AMPM is linked to a food a nutrient database that provides detailed nutrient composition information for each food selected. Food model booklets were used to assist in estimating the quantity of foods consumed. Additionally, because the recall occurred at the participant's home, participants were able to show research assistants the foods and utensils used to aid with accuracy of data collection. Food intake data were imported into a computerized coding system and coded by trained research assistants. Regular quality checks were made to ensure reliability and validity of coding. Dietary intake results reflect nutrient intakes from food and do not include supplement consumption. Estimates of breast milk consumption (n=12) was based on the toddler's age and intake of infant formula and/or cow's milk. To estimate breast milk intake, we assumed a breast milk intake of 89 ml per feeding occasion between 12-17.9 months of age, and 59mL per feeding occasion for toddlers over 18 months of age based estimates of breast milk intake for children of this age in the United States in other studies (Dewey, Finley, & Lonnerdal, 1984; Butte et al., 2010).

Maternal and family environment characteristics (age, education, employment status, marital status, number of total children, number of people in the home, location, household income, food insecurity, and participation in the Supplemental Nutrition Assistance Program (SNAP) and the Maryland Supplemental Program for Women Infants and Children (WIC)), and child characteristics (age, gender, race, breastfeeding history) were collected through an audio computer assisted self-interview, completed by the mother at the baseline evaluation. Household food security status was measured by the 6-item United States Food Security Scale developed in 2000. It is a valid and reliable household-level measure of food security that was scored and scaled in accordance with established procedures (Bickel, 2000). Households were classified as food insecure if they reported not being able to afford enough food for an active healthy life for all household members.

Mother's height and weight and child's length and weight were measured by trained research assistants. Maternal height and child length were measured to the nearest 0.1 cm (Shorr Productions, Olney, Maryland). Maternal weight was assessed to the nearest 0.1 kg (TANITA 300GS; Tanita Corp, Arlington Heights, IL), and child weight was assessed to the nearest 0.1 kg using a TANITA 1584 Baby Scale (Tanita Corp, Arlington Heights, IL). The measurements were taken 3 times, and the average of the three measurements was used in this analysis. Body Mass Index, BMI, was calculated for mothers and children as weight (kg) divided by the squared value of height in meters. Maternal overweight was defined as a BMI greater or equal to 25 and less than 30 kg/m^2, and obese as BMI greater or equal to 30 kg/m^2 (CDC, 2012). Child BMI was plotted on CDC BMI-for-age growth charts for boys or girls to determine the percentile ranking for children of that age and gender. Less than the 5^{th} percentile is considered underweight, above the 85^{th} and less than the 95^{th} percentile is overweight. Equal to and above the 95^{th} percentile is obese (CDC, 2011).

Data analysis

We used cluster analysis to evaluate the dietary patterns of the sample. Food group clustering variables were defined by the US Department of Agriculture 2005 MyPyramid food groupings, which are based on the 2005 US Dietary Guidelines for Americans (USDA, 2005). These variables are established by the USDA and include 26 food groups: Non-whole grains, whole grains, dark green leafy vegetables, orange/red vegetables, starchy vegetables, tomatoes, potatoes, other vegetables, citrus fruit, non-citrus fruit, whole fruit, fruit juice, milk (including soy milk, infant formula, and breast milk), yogurt, cheese, beef/pork/wild game meats, poultry, low and high omega-3 fish, sausages/frankfurters or lunch meats, eggs, nuts, oils, saturated fats, added calories from solid fat/added sugar (USDA, 2005). Detailed descriptions of these variables are located in the appendix. To create these variables, food intake assessed through the 24-hour dietary recalls described above was converted using the MyPyramid Equivalents Database 3.0 (Bowman et al., 2008). This database provides ounce and cup equivalents that relate to recommendations from the USDA (USDA, 2005). This was chosen to allow for comparisons with other studies on dietary patterns of US children (Knol et al., 2005) and adherence to the 2005 Dietary Guidelines, the recommendations at the time of data collection. Dietary intake variables were standardized prior to being using in the analysis to minimize the influence of variables based on differences in units (Knol et al., 2005). Ward's hierarchical cluster analysis method was used to identify the food patterns (Ward, 1963). The analysis was not conducted separately for male and female children due to similarities in dietary requirements and recommendations at this age. In Ward's cluster analysis, each person initially represents an individual cluster. Clusters are then combined based on the sum of squares between two clusters summed over all dietary intake variables (Everett et al., 2011). In order to identify the final number of clusters, a dendrogram was produced, which gave a visual representation of the clusters in order to identify the total number present (Appendix B). We evaluated the possibility of 3 and 4 cluster solutions based on the dendrograph. The 3 cluster solution combined clusters 2 and 3 from the 4 cluster solution. Because clusters 2 and 3 appeared to have important differences when comparing the individual food group frequencies by cluster, 4 clusters were selected and are described in the results of this analysis.

Once clusters were identified, the means and standard deviations of variables were calculated by cluster to illustrate the differences between the clusters. ANOVA and Chi-square analyses were used to identify maternal, child, or family factors that were related to the identified clusters and a multivariate model was produced. Where statistically significant ANOVA tests were reported ($p<0.05$), additional post hoc tests including Bonferoni and Tukey's tests were calculated to determine where the difference significance were among the groups.

Average diet quality was also presented for each cluster, and differences were assessed by ANOVA and Tukey's tests to determine differences in diet quality between clusters. Briefly, diet quality summary scores were calculated using two methods, the 2005 Mean Adequacy Ratio (MAR) and the Healthy Eating Index (HEI-2005). The MAR is an average of multiple nutrient adequacy ratios (NAR), which are the ratios of nutrient intakes to Recommended Daily Allowances (RDA) multiplied by 100 to represent the percentage of the RDA consumed. A NAR was calculated for the following 11 micronutrients: vitamins A, C, B6, and B12, thiamin, riboflavin, niacin, folate, calcium, iron, and zinc. An individual NAR may exceed 100%, however, to calculate the

MAR, each NAR is truncated at 100% so that no individual nutrient intake carries more weight in the MAR calculation. The maximum value of the MAR is 100% which indicates nutrient intake at least equivalent to the RDA for each nutrient. For both NAR and MAR a value of 100% is the ideal because this level of usual nutrient intake has a low probability of inadequacy (Steyn et al., 2006). There is no consensus regarding the MAR score that indicates low diet quality. For the purpose of this study, we chose a score of 85%, as indicated in a study of a similar population (Hoerr et al., 2006).

The HEI-2005 is a measure of dietary quality assessing adherence to the USDA's MyPyramid 2005 Dietary Guidelines for Americans age 2 and older (Guenther et al., 2007). The HEI-2005 measure grain reflects the emphasis on the intake of whole grains, dark green leafy and orange vegetables, whole fruit (excludes 100% fruit juice), and limitations on SoFASS. The HEI-2005 also includes components that represent the major food groups in the MyPyramid recommendations including: total fruit; total vegetables; total grains; total milk, including soy beverages; meat and beans, including meat, poultry, fish, eggs, non-beverage soybean products and nuts; whole fruit excluding juice; dark green and orange vegetables and legumes; whole grains; oils; saturated fat; sodium; and SoFAAS. Seeds and legumes are counted as meat and beans when intakes of meat are less than three oz per 1000 kcal total energy intake. Over this meat and beans intake, seeds and legumes are counted as vegetables. Each component is assigned a specific number of points, and all components are added to create a total score. The maximum score for each component is given if the standard is reached or exceeded. There is a maximum of 100 points for a dietary intake that meets the minimum recommendations for all component groups (Guenther et al., 2007).

Although the HEI-2005 was not developed for children under two years of age (Guenther et al., 2007), we used it to evaluate how the child's diet compares to the recommendations that will apply at the age of two years, after the transition to the family diet. All analyses were conducted using SPSS version 10.1 (College Station, TX).

4.3 Results

Cluster analysis results

There were 4 groups identified by cluster analysis. The largest two, Light Eaters (n=104) and Processed Meat, Potatoes and Fruit (Cluster 2, n=102) included 77% of the sample (N=267). Two smaller yet unique clusters were also identified (Meat, Tomato and Non-whole Grains, n=43; Whole Grains, Nuts and Fruit Juice, n=18).

Cluster 1- Light Eaters. Cluster 1 includes 104 (39%) children, with the lowest average age in comparison to the other groups [*M*, 18.9 months (SD= 5.4), (p=0.05)]. Forty- four percent of the group was male, 71% were black race, and the average BMI for age percentile was 62.3 (*SD*= 29.6). Compared with the other groups, Cluster 1 was characterized by a lower average energy intake [*M,* 988 kcal (*SD*= 254), P<0.001], as well as lower intakes of protein [M, 36.4g (SD= 12.7), p<0.001], carbohydrate [M, 131.1g (SD= 40.1), P<0.001], and fiber [M, 5.9g (SD= 2.4), p<0.001]. The average fat intake for cluster 1 (36.4g, SD=11.7) was significantly lower than clusters 2 and 3, but not for cluster 4. The average intakes of most of the included food groups were lowest among the four clusters, with few food groups standing out as high intake categories with the exception of the milk group (average intake= 1.8 ± 1.3 cup equivalents). Average diet quality by HEI-2005 was 53.2 (SD 10.1) and 96.7 (SD 7.9) by MAR. These scores were only significantly lower than cluster 4 (Table 2).

Cluster 2- Processed Meat, Potatoes, and Fruit. Cluster 2 includes 102 (38%) children, 60% male, and 64% black race. The average child age is 20.6 months (SD= 5.5). This cluster was characterized by higher intake of servings of orange vegetables (M, 0.054 cup equivalents (*SD*=0.12) potatoes (M, 0.29 cup equivalents (*SD*=0.35), other vegetables (M, 0.16 cup equivalents (*SD*=0.25), citrus fruit (M, 0.38 cup equivalents, *SD*=0.60), whole fruit (M, 0.95 cup equivalents, *SD*= 0.80) cheese (M, 0.38 ounce equivalents (*SD*=0.49), frankfurters/sausages (M, 0.80 ounce equivalents, *SD*= 1.19), and egg (M, 0.36, *SD*=0.68) compared to the other 3 clusters (Table 4.2). The mean energy intake for the group was 1362 kcal (*SD*= 412), and the average diet quality measured by HEI-2005 was 56.9 (*SD*= 11.6).

Cluster 3- Meat, Tomato, and Non-whole Grains. Cluster 3 includes 43 (16%) children with a mean age of 20.3 months (SD=5.3). Nearly 56% of the children are male, 79% are of black race, and most participated in Baltimore City (72%). In regard to food group intake, this group is characterized by the highest average intake of servings of non-whole grains [4.26 (SD= 1.98)], tomato [0.28 (SD= 0.33)], milk [2.57 (SD=2.27], poultry [1.53 (SD=1.59)], pork, beef or veal [1.25 (SD=1.65)], and lowest intakes of whole grains, starchy vegetables, nuts, legumes, fruit juice and whole fruits. The mean HEI-2005 score was also the lowest between the groups at 52.6 (SD=31.1).

Clusters 2 and 3 separate when going from a 3 cluster solution to a 4 cluster solution as selected in this analysis. Both of these groups have high meat intakes in comparison with clusters 1 and 4. However differences in types of meats are observed, with highest intakes of franks, sausages and cold cuts in cluster two, and the highest intakes of poultry, beef, and pork clustering in the 3rd group. The highest average fruit intakes were in cluster 2, specifically for bananas, berries, melons, citrus. In regard to milk intake, cluster two had the highest average infant formula intake, and the lowest average whole milk intake. Cluster 3 was also in high “meat mixtures,” or foods like spaghetti and meatballs, lasagna with meat, casseroles with meat combined with other food group categories (e.g. grains, vegetables), pasta, tomato, sweetened beverages, French fries, potato chips, whole milk, and sweetened beverages.

Cluster 4- Whole Grains, Vegetables, Nuts and Fruit Juice. Cluster 4 includes 18 (7%) children with the highest mean age of 21.9 months (*SD*= 5.3) among the 4 clusters. Fewer children were identified as black race compared to the other clusters (55% compared to 64-79% in the former clusters). Of the 18 children in this group, 44.4% have food insecurity in their home, and low PIR values although the average PIR is the highest among the 4 groups at 1.1 (*SD*=0.9). Half of the mothers were single and less than 40% had completed high school. Their intake is characterized by the highest average servings of whole grains (1.39 ±1.31), dark green vegetables (0.13 ±0.29), starchy vegetables (0.33 ±0.47), yogurt (0.19± 0.33), other fruit (1.94 ±1.82), low omega 3 fish (0.47 ±2.0), soy (0.13±0.26), nuts (1.14 ± 2.23), legumes (0.17 ± 0.33), added sugar (14.1 ±2.23), and fruit juice (1.40 ±1.60). This group also had the lowest average servings of cheese, franks and sausages, poultry, and eggs.

Factors associated with Dietary Clusters

Univariate associations revealed significant differences in child age and cluster groupings. Children in cluster 1 were likely to be younger than children in the other clusters. Additionally, marginally significant differences in WIC participation and cluster groupings. However, multivariate models did not result in any significant factors associate with dietary cluster groupings.

4.4 Discussion

This paper provides information about dietary patterns of young children by illustrating the clustering patterns of food intake within a population. More information about clustering patterns of toddlers can aid in the tailoring of messages the behavior patterns of specific groups for the purpose of improving adherence to dietary recommendations.

There were 4 clusters identified in this analysis that differed greatly from each other. Children in cluster 1 were light eaters, having the lowest overall averages of most of the food groups, as well as fat, carbohydrates, and protein. These were also the youngest children overall in the sample, and smaller intakes of solid foods would be appropriate for younger children at this developmental stage. However, it is unclear from this analysis if the food proportions consumed were lower than what was needed for their age. Average diet quality scores by HEI-2005 were low in this group, illustrating low adherence to the Dietary Guidelines for Americans. Average dietary quality measured by MAR, which accounted for differences in nutrient requirements by age was adequate overall (96%) yet lower than the other clusters, with the lowest scoring children in the sample clustering in this group. This indicates that many children may be reaching their nutrient requirements within this pattern, but improvements could still be made to improve overall dietary quality.

While many diets did not meet the recommended intake described in the Dietary Guidelines for Americans, it is clear that choices were made to try to provide healthy, nutritious foods to children. In Cluster 4, there is a high sugar intake, notably from juice, which is considered a healthy choice. While there is high reported food insecurity in this group, mothers clearly made other health-conscious choices including, soy products, nuts, whole grains, vegetables, and fruit. In cluster 2, despite the high average intakes of hot dogs, sausages, and cold cuts, parents provided healthy choices for the children including fruits and vegetables. Additionally, this cluster has the lowest average whole milk intake in the sample, trending toward the recommendations for milk intake above age 2. Improvements can be made by increasing whole grains, and leaner meat selections to reduce saturated fat intake.

Cluster 3 has elements of a Fast-Food or Convenience dietary pattern as described in previous studies (Pryer, et al., 2009; Ovaskainen et al., 2009). We observed a high meat intake, grains from non-whole grain breakfast foods, hamburgers, and meat/grain mixtures such as spaghetti and meatballs or lasagna. There are also high calorie snack foods such as potato chips. Improvements can be made by encouraging leaner meat intake, lower fat milk at the age of 2, increases in whole fruit and vegetable intake by encouraging fruit or vegetables as snacks instead of energy dense and/or nutrient deficient options.

Cluster analysis studies are often difficult to compare with each other due to differences in dietary intake variables selected by investigators. This study uses food variables as described by the USDA, mapping onto overall dietary recommendations for Americans. This provides a means of comparison to standards as well as between studies if these variables are used in other cluster analysis dietary studies. This study assesses dietary patterns of children between 12 and 30 months of age from low-income households in the eastern United States. A similar study was conducted evaluating dietary intake patterns among low-income U.S. children ages 2-3 years and 4-8 years (Knol et al., 2005). The patterns were based on USDA Pyramid Servings Database, and included 22 food subgroups which formed the 5 recommended food groups in the Pyramid, plus two additional groups created to reflect foods commonly consumed by young children. The study identified six major consumption patterns for the 2-3 year old age group. These patterns ranged from The Big Eaters, to Light Eaters, Bean Eaters, Substituters, Low-Cost Eaters, and Semi-Vegetarians (Knol et al., 2005).

Another study examining dietary patterns among a national sample boys and girls age 1 ½ to 4 ½ in Great Britain found Traditional, Healthy, and Convenience dietary clusters for both the boys and girls in the sample. The predominant cluster, Healthy (52% of the boys and 59% of the girls) was slightly different in both samples, but was generally characterized by whole grain cereals, low-fat dairy products, eggs, poultry, vegetables, fruits (and fruit juices) and nuts (Pryer, et al., 2009). The convenience diet, shared by 38% and 37% of boys and girls respectively, also differed slightly by gender, but was generally high in white refined cereals, cakes/puddings, high-fat dairy products, bacon/ham, beef/veal/lamb/pork, sugar/confectionery, prepared meat products, chips/potatoes, and soft drinks. This study also evaluated the relationship between social and behavioral factors and the identified clusters, finding household head social class, receiving benefits, type of home accommodations, and child wellness at the time of the survey to be significant predictors among the boys, and receiving benefits, and child wellness at the time of the interview as significant predictors for the girls (Pryer et al., 2009).

A cluster analysis study evaluating dietary patterns of children 1, 3 and 6 years of age in Finland found 3 dietary patterns at each age; Healthy, Traditional and Ready-to-eat baby food at age 1; Health, Traditional, and Fast Food, Sweets at ages 3 and 6 (Ovaskainen et al., 2009). Healthy patterns were high in low-fat milk, fruits (whole and juice), vegetables, and whole cereal bread while Fast Food/Sweets patterns were high in meat dishes (age 6), potatoes, berry-based drinks, sweetened beverages, and baked goods or sweets.

There are several limitations that must be noted. These dietary data are based on reports from the mothers about the toddler diet. Although the 24-hour AMPM recall method has many characteristics built in to minimize error based on self-report of diet, mothers who were not with their child the entire day of the recall were instructed to send a form with the child caretaker to record foods and amounts that were consumed. Additionally, children may not eat the full amount served to them. While mothers were instructed to provide the amount consumed, there is a possibility for a disconnect, based on individual interpretation of this question. As a result, there is a chance for recall bias that could affect the accuracy of the estimates. Dietary intake fluctuates between ages 1-2 such that more than one dietary intake record would be needed to estimate usual intake patterns. The cluster analysis method provides averages among the overall population, and are often conducted with one dietary intake assessment. However, additional days of intake would provide better estimates of intake.

Table 4.1: Selected characteristics[1] of mothers and children at baseline in the TOPS study

Characteristics	**All children N=267**	**Cluster 1 n=104**	**Cluster 2 n=102**	**Cluster 3 N=43**	**Cluster 4 n=18**
Maternal:					
Age (y)	27.5 (6.2)	27.3 (6.5)	27.6 (6.0)	27.2 (6.2)	28.3 (6.3)
BMI kg/m^2 *M (SD)*	31.8 (9.4)	32.0 (9.0)	31.3 (9.4)	33.6 (10.4)	28.6 (7.7)
> High school Education (%)	47.6	49.0	49.0	44.3	38.9
Single (%)	71.1	71.2	70.1	81.4	50.0
Unemployed (%)	59.3	54.8	60.8	60.5	66.7
Poverty- Income Ratio *M (SD) n=260*	0.80 (0.76)	0.71 (0.68)	0.88 (0.82)	0.69 (0.71)	1.07 (0.92)
SNAP (%)	51.5	54.8	45.1	61.9	44.4
WIC participation(%)[5]	87.6	89.4	75.5	83.7	77.8
Food Insecure (%)	27.9	28.8	21.6	32.6	44.4
Baltimore City (%)	59.2	56.7	55.9	72.1	61.1

Child					
Age, mo. *M(SD)*[6]	20.0 (5.5)	18.9 (5.4)	20.6 (5.5)	20.3 (5.3)	21.9 (5.3)
Race/Ethnicity (%)					
White	23.2	19.2	26.5	18.6	44.4
African- American	68.5	71.2	63.7	79.1	55.6
Other race, Hispanic ethnicity	8.2	9.6	9.8	2.3	0
Male (%)	52.1	44.2	59.8	55.8	55.6
BMI/Age %tile[4]	63.7 (28.6)	62.3 (29.6)	64.0 (28.2)	65.1 (28.1)	66.5 (28.7)

[1]Presented are mean (SD) or % as appropriate.
[2] Mother's BMI based
[3]PIR based on n=260, 101, 100, 41, and 18 for the total sample and clusters 1-4 respectively.
[4]Child BMI percentile based on n=260, 103, 102, 43, 16 for the total sample and clusters 1-4 respectively.
[5]Marginally significant differences in clusters, p=0.065
[6]Significant differences observed at p=0.05

Table 4.2: Average (SD) food group servings of 4 clusters identified in the TOPS study.

Food groups	**Cluster 1 (n=104)**	**Cluster 2 (n=102)**	**Cluster 3 (n=43)**	**Cluster 4 (n=18)**
Whole grains (ounce equivalents)	0.58 (0.99)^{w}	0.62 (0.82)^{w}	0.46 (0.56)^{w}	1.39 (1.31)^{z}
Non-whole grains (ounce eq.)	2.26 (1.41)^{w}	2.72 (1.60)^{w}	4.26 (1.98)^{z}	2.88 (1.82)^{w}
Dark green vegetables (cup eq.)	0.02 (0.07)^{w}	0.04 (0.13)^{w}	0.03 (0.07)^{w}	0.13 (0.29)^{z}
Orange vegetables (cup eq.)	0.02 (0.05)^{w}	0.05 (0.12)^{x}	0.02 (0.04)^{wx}	0.02 (0.06)^{wx}
Potato (cup eq.)	0.10 (0.14)^{w}	0.29 (0.35)^{x}	0.15 (0.19)^{w}	0.15 (0.23)^{wx}
Starchy vegetables (cup eq.)	0.04 (0.10)^{w}	0.06 (0.14)^{w}	0.03 (0.08)^{w}	0.33 (0.47)^{z}
Tomato (cup eq.)	0.06 (0.10)^{w}	0.08 (0.14)^{w}	0.28 (0.33)^{y}	0.16 (0.24)^{wy}
Other vegetables (cup eq.)	0.08 (0.10)^{w}	0.16 (0.25)^{x}	0.11 (0.16)^{wx}	0.06 (0.08)^{wx}
Citrus fruit (cup eq.)	0.17 (0.24)^{w}	0.38 (0.60)^{x}	0.23 (0.30)^{wx}	0.31 (0.38)^{wx}
Other fruit (cup eq.)	0.87 (0.63)^{w}	1.58 (1.18)^{x}	0.68 (0.75)^{w}	1.94 (1.82)^{xz}
Milk (cup eq.)	1.81 (1.33)^{w}	1.36 (1.32)^{w}	2.57 (2.27)^{y}	1.57 (1.09)^{wy}
Yogurt (cup eq.)	0.01 (0.04)^{w}	0.09 (0.20)^{x}	0.05 (0.17)^{w}	0.19 (0.33)^{x}
Cheese (cup eq.)	0.21 (0.26)^{w}	0.38 (0.49)^{x}	0.23 (0.36)^{wx}	0.20 (0.32)^{wx}
Pork, beef, veal (ounce eq.)	0.39 (0.62)^{w}	0.44 (0.76)^{w}	1.25 (1.65)^{y}	0.40 (0.74)^{w}
Franks (ounce eq.)	0.28 (0.54)^{w}	0.80 (1.19)^{x}	0.21 (0.52)^{w}	0.00^{w}
Poultry (ounce eq.)	0.53 (0.70)^{w}	1.04 (1.60)^{xy}	1.53 (1.59)^{y}	0.51 (0.73)^{wx}
Fish- low omega	0.11 (0.29)^{w}	0.14 (0.50)^{w}	0.10(0.42)^{w}	0.47 (2.00)^{w}
Egg (ounce eq.)	0.15 (0.29)^{w}	0.36 (0.68)^{x}	0.28 (0.41)^{wx}	0.14 (0.31)^{wx}
Soy (ounce eq.)	0.01 (0.02)^{w}	0.01 (0.04)^{w}	0.03 (0.05)^{w}	0.13 (0.26)^{z}
Nuts (ounce eq.)	0.09 (0.24)^{w}	0.12 (0.36)^{w}	0.14 (0.36)^{w}	1.14 (2.23)^{z}
Legumes (cup eq.)	0.01 (0.03)^{w}	0.01 (0.03)^{w}	0.02 (0.08)^{w}	0.17 (0.33)^{z}
Discretionary oil (tsp.)	4.64 (4.39)^{w}	7.78 (7.76)^{x}	12.30 (10.32)^{y}	9.00 (12.00)^{wxy}
Discretionary solid (g.)	26.16 (10.77)^{w}	32.80 (16.99)^{x}	44.44 (20.39)^{y}	30.07 (15.14)^{wxz}
Added sugar (tsp.)	5.81 (4.83)^{w}	8.81 (6.44)^{x}	12.48 (10.47)^{y}	14.06 (10.24)^{y}
Fruit juice (cups)	0.62 (0.52)^{w}	1.02 (0.92)^{x}	0.55 (0.62)^{w}	1.40 (1.60)^{x}
Whole fruit (cups)	0.42 (0.45)^{w}	0.95 (0.80)^{x}	0.36 (0.39)^{w}	0.85 (0.87)^{x}
Discretionary calories (kcal)	330 (120)^{w}	440 (210)^{x}	610 (280)^{y}	510 (260)^{xy}

Means with different subscripts are significantly different from each other at $p<0.05$.

Table 4.3: Average amounts of Foods Consumed by Cluster (grams).

	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Breast milk	27.8 (107.2)^{w}	19.0 (86.7)^{w}	22.9 (104.8)^{w}	0.0^{w}
Infant formula	13.9 (73.9)^{w}	42.8 (160.7)^{w}	38.3 (251.2)^{w}	13.6 (57.5)^{w}
Whole milk	273.5 (298.9)^{wx}	187.9 (287.9)^{w}	393.4 (494.0)^{x}	215.6 (237.8)^{wx}
Reduced fat milk	127.7 (295.1)^{w}	88.6 (219.6)^{w}	119.0 (314.3)^{w}	46.6 (118.2)^{w}
Soy milk	3.8 (39.0)^{w}	0^{w}	22.8 (149.4)^{w}	91.9 (252.3)^{y}
Infant cereal	2.3 (10.9)^{w}	0.78 (5.8)^{w}	0^{w}	0.2 (0.9)^{w}
Non-infant cereal	32.9 (61.6)^{w}	53.1 (85.5)^{w}	30.8 (56.7)^{w}	66.1 (107.9)^{w}
Breads & rolls	12.0 (16.8)^{w}	13.6 (19.4)^{w}	16.7 (27.9)^{w}	25.9 (36.0)^{w}
Crackers, pretzels	5.5 (10.9)^{w}	4.7 (10.8)^{w}	5.8 (13.0)^{w}	8.6 (13.8)^{w}
Rice	5.2 (22.4^{w})	4.5 (23.6)^{w}	4.7 (17.5)^{w}	6.7 (15.7)^{w}
Pasta	0.24 (2.2)^{w}	3.0 (13.8)^{w}	3.7 (24.4)^{w}	0^{w}
Quick breads, French toast	7.6 (17.4)^{w}	8.6 (22.3)^{w}	18.8 (28.0)^{x}	9.1 (22.6)^{wx}
Mixtures, mostly grain	67.1 (98.5)^{w}	77.0 (124.6)^{w}	167.0 (162.9)^{x}	140.3 (178.0)^{wx}
Cakes, cookies, pastries	10.7 (18.3)^{w}	17.1 (24.5)^{w}	21.4 (29.7)^{w}	20.9 (40.1)^{w}
Ice cream, frozen yogurt	8.9 (32.8)^{w}	16.5 (39.6)^{w}	22.1 (51.6)^{w}	30.3 (74.3)^{w}
Candy	4.4 (12.6)^{w}	6.0 (15.7)^{w}	9.2 (14.4)^{w}	12.8 (25.9)^{w}
Other sweets, syrups	11.9 (31.8)^{w}	13.6 (32.8)^{w}	12.7 (30.3)^{w}	9.4 (18.1)^{w}
Sweetened beverages	77.1 (176.0)^{w}	126.6 (201.1)^{w}	266.9 (394.7)^{x}	130.8 (239.7)^{wx}
Potato chips	2.3 (5.8)^{w}	5.9 (12.3)^{x}	0.9 (4.5)^{xy}	0^{wy}
Corn chips, popcorn	2.1 (6.3)^{w}	2.6 (7.4)^{wx}	6.3 (13.0)^{x}	1.7 (7.1)^{wx}
French fries, potato puffs	4.2 (10.5)^{w}	10.5 (24.3)^{wx}	17.1 (26.4)^{x}	5.1 (14.7)^{wx}

Means with different subscripts are significantly different from each other at $p<0.05$.

Table 4.4: Average (SD) nutrient intake among the 4 identified clusters of children in the TOPS study.

	Cluster 1	**Cluster 2**	**Cluster 3**	**Cluster 4**
Energy intake (kcal)	988 (254)^{w}	1362 (412)^{wx}	1649 (484)^{x}	1611 (560)^{x}
MAR	96.7 (7.9)^{w}	98.7 (2.4)^{w}	98.6 (3.3)^{w}	99.0 (2.4)^{w}
Toddler HEI-2005	53.2 (10.1)^{wx}	56.9 (11.6)^{xy}	52.7 (31.1)^{xy}	62.9 (9.5)^{yz}

Note: Means with different subscripts are significantly different from each other at $p<0.05$.

Appendix 1

Food Group Descriptions

Whole grains. Flour, bread, rolls, quick breads, corn muffins, tortillas, crackers, pasta, cereal, snack bars, and snack chips made with whole grain or some whole grain; and popcorn.

Grains. Flour, bread, rolls, quick breads, corn muffins, tortillas, crackers, pasta, cereal, snack bars, and snack chips made with refined grains.

Dark green vegetables. Raw and cooked dark green leafy vegetables such as romaine lettuce, greens, kale, spinach, and broccoli.

Orange vegetables. Includes yellow or orange vegetables such as sweet potatoes, carrots winter squash, and mixtures with deep yellow/orange vegetables as the main ingredient.

Tomatoes. Tomato raw or cooked, including vegetable juice containing tomato, chili sauce, salsa, catsup and other tomato based sauces.

Starchy vegetables. Includes vegetables such as peas, lima beans, corn, green beans. Excludes potato varieties and dry lima beans or peas.

Potato. Includes white potato varieties.

Other vegetables. Includes celery, cabbage, zucchini, cucumber, mushrooms, cauliflower, okra, green peppers, others).

Citrus fruit. Includes all lemon, lime, orange, grapefruit, other citrus fruit varieties, whole fruit and juice, fresh, canned, dried or frozen.

Other fruit. Includes berries, melon, apples, bananas, other non-citrus fruit varieties, whole fruit and juice fresh, canned, dried or frozen.

Whole fruit. Excludes juice for any fruit variety.

Milk. Includes whole, 2%, low-fat milk varieties, liquid and powder mixtures, human milk, flavored milks, infant formula, creamers, and milk desserts. Fat and sugar content that exceed identified amounts are disaggregated from the content

Yogurt. All yogurt varieties

Cheese. Includes natural, cottage, cream, imitation and processed cheeses, cheese mixtures and soups

Meats. Includes beef, pork, lamb, veal or game meats.

Organ meats. Organ meats and mixtures from beef, pork lamb, game, and poultry sources.

High Omega-3 Fish. Includes fish with high sources of omega-3 fatty acids, an essential polyunsaturated fatty acid. Examples include anchovies, wild salmon, whitefish, sardines, Atlantic herring, Bluefin tuna, and rainbow trout.

Low Omega-3 Fish. Includes several varieties of fish and seafood including clams, ocean perch, canned tuna,

Yellowfin tuna, cod, lobster, and crayfish.

Franks. Includes all lunch meats and cold cuts, hot dogs, sausages, and potted meat.

Poultry. Includes all chicken, turkey products.

Egg. Includes chicken and other poultry eggs, egg mixtures from dishes, soups, sandwiches, egg substitute from liquid, powder, or frozen mixture.

Soy. Soybean derived products, including milk, meat substitutes, and tofu.

Nuts. Includes nuts, seeds, and nut or seed butters

Legumes. Includes dried beans, peas, and lentils not including green beans or green peas.

Discretionary oil. Vegetables oils or fats that are liquid at room temperature including soybean, canola, cottonseed, olive, walnut, sunflower, sesame, and corn oils (among many others).

Discretionary solid fat. Fats that are solid at room temperature Includes butter, shortening, lard, animal fats. Often constituents of meat, milk, and cheese.

Added sugar. Includes sugar in sweets, cakes, cookies, pies, pastries, frozen dairy dessert, pudding, sweet sauces, candy (chocolate and non-chocolate), syrup, honey, jam, jelly, preserves, sugar, frosting and glazes.

Appendix 2. Average (SD) nutrient intake among the 4 identified clusters of children in the TOPS study.

	Cluster 1	**Cluster 2**	**Cluster 3**	**Cluster 4**
Protein (g)	36.4 (12.7)	47.5 (17.9)	61.8 (22.7)	53.7 (21.4)
Carbohydrates (g)	131.1 (40.1)	185.3 (62.7)	204.1 (64.5)	253.6 (103.7)
Fat (g)	36.4 (11.7)	50.2 (20.2)	66.7 (24.1)	47.0 (23.3)
Dietary fiber (g)	5.9 (2.4)	9.1 (3.9)	9.1 (4.3)	15.8 (5.6)
Vitamin E (mg)	2.7 (1.8)	4.3 (2.7)	4.6 (2.3)	**6.1 (5.1)**
Vitamin A (RAE) (ug)	351.2 (209.1)	541.8 (255.9)	497.3 (281.3)	**998.9 (1492.7)**
Thiamin (mg)	0.9 (0.4)	1.1 (0.5)	1.2 (0.4)	**1.6 (0.9)**
Riboflavin (mg)	1.6 (0.7)	1.7 (0.8)	2.1 (1.0)	**2.3 (1.4)**
Niacin (mg)	10.3 (5.1)	14.7 (7.0)	15.6 (5.3)	**20.7 (11.4)**
Vitamin B6 (mg)	1.0 (0.5)	1.4 (0.6)	1.3 (0.4)	**1.9 (1.1)**
Folate (ug)	256.6 (176.0)	356.3 (265.3)	368.0 (188.9)	**601.8 (392.4)**
Vitamin B12 (ug)	3.4 (1.9)	0.9 (1.2)	**5.5 (5.8)**	2.5 (3.0)
Vitamin C (mg)	58.1 (47.1)	103.3 (67.5)	82.3 (89.5)	**133.4 (94.9)**
Vitamin K (ug)	28.7 (34.5)	49.5 (54.2)	48.2 (41.0)	**65.8 (107.7)**
Calcium (mg)	729.6 (378.7)	769.0 (451.1)	**1004.0 (649.8)**	943.1 (486.1)
Phosphorus (mg)	757.6 (319.0)	905.4 (353.4)	**1170.0(538.1)**	1042.7 (432.1)
Magnesium (mg)	130.9 (46.5)	169.7 (56.3)	191.5 (73.6)	**279.1 (136.6)**
Iron (mg)	8.4 (6.6)	10.8 (5.4)	10.2 (4.7)	**16.5 (8.8)**
Zinc (mg)	5.7 (2.7)	7.6 (3.8)	8.8 (3.6)	**10.3 (6.9)**

Highest average intakes are bolded, lowest are underlined and are significantly different ($p<0.05$) with the exception of vitamin B12.

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Chapter 5

Assessment of Meal Patterns and Influences on Diet Quality in Toddlers aged 12-31 months: a Mixed-Methods Approach

Abstract

Healthy dietary patterns support adequate growth and development of young children. A mixed-methods analysis of dietary intake was conducted to determine meal intake patterns of children from low-income families of 1-2 years of age with lower (HEI-2005<41.3, LDQ, n=27) and higher (HEI-2005>70.0, HDQ, n=27) dietary quality scores. The foods consumed, timing of meals, number of occasions, skipped meals, and distribution of total energy intake was reviewed using a thematic analysis to identify patterns among the two groups of children. The analysis illustrated that most children consumed Breakfast, Lunch, and Dinner meals, with very few (3 children total, 2 in the LDQ and 1 in the HDQ group) skipping these main meals. Five main meal intake pattern structures were present including a Structured (10 in HDQ, 6 in LDQ group), Structured with High Frequency of Snacks/Beverages (5 in HDQ, 5 in LDQ group), Semi-Structured (8 in HDQ, 9 in LDQ group), Infant (3 in HDQ, 4 in LDQ group), and Unstructured pattern (1 in HDQ, 3 in LDQ group). A majority of all children consumed foods with added sugars and fats, and very few consumed soda. Even still, there were persistent differences in meal consumption patterns including three main themes among the LDQ sample: High beverage consumption; Low whole fruit and vegetable intake; and Early

morning milk/Beverage only meal. Three main themes emerged among the Higher Diet Quality group: Whole fruit and vegetable intake; Whole grain intake; and Balanced distribution of food during the day. Making small changes such as having whole fruit and whole grains, even in small portions can make a significant difference in diet quality of children of this age.

5.1 Introduction

Early childhood represents a period of rapid physical growth and behavioral development. Infants transition from a liquid diet to the family diet through the exposure of foods over time and the development of food preferences and new meal intake patterns. Caregivers are largely responsible for guiding this process through changes in meal patterns and other details of meal intake such as where foods are obtained, the types and portion sizes of foods that are offered to children through this stage. Meal patterns of particular interest when promoting the development of healthy patterns include the structure of meals, or when meals are offered, where meals are consumed, the variety of what is consumed, portion sizes, fast food consumption, differences in dietary quality based the location of meal, meal skipping, and increased overall energy intake due to excess consumption of high calorie snacks or beverages. It is important to identify and understand how these patterns affect child growth and development as early as possible in order to target patterns that may lead to unhealthy eating habits.

Late infancy through toddlerhood marks the transition period from many unscheduled feedings to fewer, larger meals consumed at regular points during the day. Infants require frequent, smaller feeding periods due to their high energy requirements relative to body size to support the fast rate of growth that occurs during infancy as well as their gastric capacity. As age increases, the amount of breast milk or infant formula consumed at a setting increases, as well as the introduction of increasingly more solid food, and as a result, the number of feeding occasions reduce (Skinner et al., 2004b; Butte et al., 2004). Frequent eating is developmentally appropriate for younger children, but as children progress through toddlerhood, the meal patterns changes. Researchers have shown in a nationally representative sample that from ages 4 months to 24 months, the median number of daily eating occasions consumed is 7, ranging from 3-15 (Skinner et al., 2004a). In the same sample, the breakfast, lunch, dinner plus snacks pattern begins to emerge at 7-8 months of age, appearing in more children as age increases. This shift may have several purposes as it prepares children for scheduled feeding regimens encountered upon entering the preschool environment as well as assisting in the development of critical behavioral controls acquired at this age (Satter, 1990, Satter, 1995).

Snacking, or eating occasions before or after breakfast, lunch, and dinner meals is common and contribute to overall daily energy consumption. With the choice of healthy items, snacks can play a positive role in overall energy regulation and daily intake (Hartmann, Siegrist, & vanderHorst, 2013). Snacking behavior has been described over infancy and toddlerhood in the US with snacks mainly consisting of formula/breast milk, water, crackers, juice, ready to eat cereal at 7-11 months of age (Skinner et al., 2004). During early toddlerhood, at 12-14 months, snacks consisted of water, whole milk, crackers, cookies, and cereal. In the same study, as children approached 2 years of age, more chips, fruit drinks, candy, ice cream, soda and less milk was consumed. By 19-24 months of age, 26% of the total daily energy was consumed through snacks, making this an important contribution to the overall diet.

The presence or absence of breakfast is also of interest when evaluating dietary intake patterns. Results from the 1999-2002 National Health and Nutrition Examination Survey indicate that 7.4% of children 1-5 years of age and 16.9% of children 6-12 report skipping breakfast (Williams, O'Neil, Keast, Cho & Nicklas, 2008). Preschool and elementary school age children who consume breakfast every day have better nutrient intake and lower BMI than children who regularly skipped breakfast (Dubois, Girard, Kent, Farmer & Tatone-Tokuda, 2009; Baldinger, Krebs, Muller & Aeberli, 2012; Coppinger, Jeanes, Hardwick & Reeves, 2012; Williams et al., 2008). Breakfast contributes significantly to the nutrient and energy intake, contributing 19-20% of the total daily energy intake among children ages 12-24 months, and the highest nutrient density for calcium, iron, folate, and vitamin A compared to lunch and dinner (Skinner et. al., 2004a). Studies show that a toddler breakfast may consist of nutrient dense foods such as milk, ready-to-eat cereals, fruits, eggs, and breads (Skinner, et al., 2004a).

The purpose of this study is to use a mixed-methods approach to evaluate meal patterns in a sample of children from low-income households with the lowest and highest diet quality as identified through the HEI-2005. We hypothesize that children with higher quality diets will have structured meal patterns that include breakfast, lunch, dinner meals, and 2-3 snacks meal occasions. Those with lower quality diets will have semi-structured meal plans with one or two larger meal occasions, with several smaller eating events during the day or an unstructured or "infant-like" pattern consisting of several small eating occasions throughout the day.

5.2 Materials and Methods

The data for these analyses were collected through the Toddler Overweight Prevention Study (TOPS). TOPS was a 3 cell randomized trial conducted in Anne Arundel County and Baltimore City County, Maryland to prevent overweight among toddlers. Mothers and toddlers were randomized to 1 of 3 study arms: a nutrition and physical activity intervention targeting the mothers of toddlers, a parenting skills intervention, and a child safety control group. The TOPS study was approved by the University of Maryland and Maryland Department of Health and Mental Hygiene Institutional Review Boards. The analyses presented here utilize data collected at baseline, prior to intervention.

Description of the sample

Recruitment and eligibility for the TOPS study has been described elsewhere (Krystal Lynch, Dissertation, Chapter 3). Mothers were recruited by trained study staff at a suburban Women's Infants and Children (WIC) clinic, and an urban pediatric clinic serving primarily low-income families or were referred to the study by friends who had been already approached for study participation. Eligible mothers were at least 18 years of age, not pregnant, and did not have any medical restrictions that would prevent or limit physical activity. Eligible toddlers were between the ages of 12-31 months at the time of recruitment, not born premature (defined as less than 38 weeks estimated gestational age at birth), weighed at least 5 pounds, 8 ounces at birth, and were without any health restrictions or severe developmental delays. There were 304 mother/toddler pairs who were initially consented for the study. From this, 25 pairs withdrew before completing the entire baseline assessment. Eight toddler dietary records were incomplete because the mother was not with the child the day of intake and she did not have additional information about the toddler's dietary intake. Two mothers refused to provide the dietary recall assessment. As a result, there were 269 complete toddler dietary intake records from the baseline assessment. Additionally, two were excluded for having energy intakes below 300 kcal for the day and thus, a total of 267 children (87.8%) were included in diet quality analysis. We used an exploratory sequential mixed methods research design (Creswell & Plano Clark, 2011) to further reduce the sample based on a quantitative analysis to evaluate diet quality by using the HEI-2005 diet quality index measure (Lynch Dissertation Chapter 3; Guenther et al., 2007). A detailed description of the HEI-2005 is provided previously in Chapter 3. Briefly, The HEI-2005 is a measure of adherence to the USDA's MyPyramid 2005 Dietary Guidelines for Americans age 2 and older (Guenther et al., 2007). The HEI-2005 also includes components that represent the major food groups in the MyPyramid recommendations including: total fruit; total vegetables; total grains; total milk, including soy beverages; meat and beans, including meat, poultry, fish, eggs, non-beverage soybean products and nuts; whole fruit excluding juice; dark green and orange vegetables and legumes; whole grains; oils; saturated fat; sodium; and SoFAAS. Each component is assigned a specific number of points, and all components are added to create a total score. The maximum score for each component is given if the standard is reached or exceeded, and a score of 0 points is given if no amount of the component is consumed. There is a maximum of 100 points for a dietary intake that meets the minimum recommendations for all component groups (Guenther et al., 2007).

In the previous study, the average HEI-2005 scores were 55.1 (standard deviation for children age 1 = 10.7 and 12.3 for children age 2) and ranged from 24.0 to 80.0. Children with the lowest 10% of diet quality scores in the sample (scores less than 41.3) and the highest 10% of diet quality scores (greater than 70.0) were selected for a follow-up qualitative analysis of dietary intake to better understand the context of lower and higher diet quality diets among young children. There were 27 children with diet quality scores less than 41.3 (Lowest Diet Quality, LDQ), and 27 children with diet quality scores greater than 70 (Highest Diet Quality, HDQ) included in this analysis.

Data collection

Toddler and maternal dietary intakes were reported by the mother in person to trained research assistants using the USDA Automated Multiple Pass Method (AMPM) for 24-hr dietary recall (USDA, 2009). The AMPM is linked to a nutrient database that provides detailed information on the nutrient content for each food selected (USDA, 2009). Food model booklets were used to assist in estimating the quantity of foods consumed. Additionally, because the recall occurred at the participant's home, participants were able to show research assistants the foods and utensils used in food preparation to improve the accuracy of data collection. Most participants' dietary data was collected Monday through Friday of the week (representing days Sunday through Thursday of intake). There was one record collected on a Saturday, representing the child's intake the previous day.

Food intake data were imported into a computerized coding system and coded by trained research assistants. Regular quality checks were made to ensure reliability and validity of coding. Dietary intake results reflect nutrient intakes from food and do not include supplement consumption. Estimates of breast milk consumption (n=12) were based on the toddler's age and intake of infant formula and/or cow's milk. To estimate breast milk intake, we assumed a breast milk intake of 89 ml per feeding occasion between 12-17.9 months of age, and 59mL per feeding occasion for toddlers over 18 months of age based on estimates of breast milk intake for children of this age in other U.S. based-studies (Dewey, Finley, & Lonnerdal, 1984; Butte et al., 2010). Meal occasions were indicated by the mother from the following options: breakfast, lunch, brunch, dinner, supper, snack, beverage, infant feeding, and extended consumption (defined as a food or beverage consumed over a period of time during the day). For this analysis, one child ate supper and this was recoded as dinner. Similarly, for one child, brunch was consumed in addition to breakfast and lunch and it was recoded as a snack. Infant feedings of milk, infant formula, or breast milk, and occasions of consumption of water or juice without solid foods were re-coded as beverage only for this analysis as conducted in previous studies of meal patterns (Skinner et al., 2004). Extended consumption beverages occurring at the same time as a meal were considered part of that meal. Else, they were recoded as beverage-only eating events. Additionally, one child consumed a meal replacement supplement for breakfast and for another occasion during the day that was indicated to be a snack. The second occasion was re-coded as a beverage-only occasion.

Maternal and child information including maternal age, education, employment status, smoking status, number of total children, toddler age, toddler race/ethnicity, breastfeeding history (initiation and duration), number of hours in the care of other adults (including day care facilities, relative or non-relative care), were assessed through an audio computer assisted self interview, completed by the mother.

Data analysis

Quantitative analyses

Descriptive summaries of meal occasions, energy intake at meals, maternal and child characteristics were conducted. Analyses were conducted using Stata version 10.1 (College Station, TX).

Qualitative assessment of dietary patterns

In addition to the sequential exploratory design, this study utilizes triangulation (Creswell & Plano Clark, 2007). Using triangulation, all data, qualitative and quantitative, are collected during the same phase of data collection and the data are merged together during the analysis or interpretation stages. In this study, the 24-hour dietary recall was analyzed qualitatively as a textual document. We utilized an ethnographic analysis approach for the qualitative component of this analysis (Creswell, 2007). The analysis was started by organizing the files for the data analysis by HEI-2005 score category (lowest vs. highest), followed by a review of the dietary intake text. A thematic analysis was conducted by reading and re-reading the intake data for all children in each category. While reviewing the intake text, notes and descriptive summaries were written about the types of foods consumed at each eating type of eating occasion, the portion size and comparison to recommended guidelines of portions for specific food items, identification of the meal location and the types of foods that are consumed at each location, timing and spacing between meals, frequency of milk, infant formula, or breastfeeding, and the structure of meal consumption during the day to form initial codes. The review phase was an iterative and reflexive process and as the files were repeatedly reviewed, patterns that may not have been apparent to focus upon initially were noted. This information was used to create a focused codebook (Appendix B). This information was used to create a story about the dietary intake and the presence or absence of a structured pattern of food consumption throughout the day. To evaluate the presence of a "structured meal pattern," the timing of meal consumption was evaluated based on the USDA recommendations for structured meal intake for children of preschool age for 3 main breakfast, lunch and dinner meals plus 1-2 snacks (USDA, 2014). For structured meal timing throughout the day, breakfast meals took place between the hours of 6:00 AM and 10:30 AM, lunch between the hours of 10:30 AM and 1:30 PM, and dinner between 3:00 PM and 8:30 PM. The time ranges were based on meal intake timing of pre-school age children transitioning to a child-age school schedule. All themes were discussed with an expert in nutrition and child psychology to ensure that themes were valid and applicable to this sample. The themes that were identified through this process are presented, as well as food intake records from 4 LDQ and 3 HDQ children to illustrate the patterns.

5.3 Results

In the original study (Chapter 3), diet quality by HEI-2005 was evaluated for 267 children 12-31 months of age. The LDQ group with HEI-2005 scores less than 41.3 (the lowest 10% of diet quality scores) included 27 children from 12.1 to 30.9 months of age with an average age of 20.0 (SD=6.1) months. The HDQ group with scores greater than 70 (the highest 10% of diet quality scores) included 27 children between ages 13.4 and

28.8 months, (average age =20.7 months, SD=4.9). The groups did not differ significantly by age or by any other maternal or child characteristic examined (Table 1).

Meal patterns

In the LDQ group, ten (of 27) children's food consumption began with a snack or beverage that was not considered "breakfast" by the caregivers and consisted of milk or fruit juice/ fruit-flavored drinks. These events occurred between the times of 12:00 AM and 9:00 AM. Breakfast meals took place between 7:00 AM and 11:00 AM. Lunch meals occurred between 10:30 AM and 5:30 PM, with 17 of 27 occurring between 11:00 AM and 2:00 PM. Dinner meals occurred between 5:00 PM and 10:56 PM, with 23 of 27 occurring between 5:00 PM and 8:00 PM. Children in the LDQ group consumed between 1 and 12 snacks and beverages (M = 3.5, SD=2.1 snacks) and between 4 and 15 total meals including beverage only events and snacks (M= 6.6, SD=2.4, meals).

Meal consumption was similar for the HDQ group. In the HDQ group, eight (of 27) children's food consumption started with snacks or beverages prior to the breakfast meal. These events occurred between 2:00 AM and 8:00 AM. Breakfasts were consumed between 6:15 AM and 11:00 AM. Lunch meals occurred 11:00 AM and 3:00 PM with 24 (89%) occurring between 11:00 AM and 2:00 PM. Dinner meals occurred between 3:00 PM and 9:30 PM, with 21 (78%) occurring between 5:00 PM and 8:00 PM. Children consumed 1-7 snacks or beverages (M= 3.3, SD=1.4) and between 4-10 total meals (M=6.3, SD=1.5).

The average energy intake (kcal) at each meal (breakfast, lunch, and dinner) did not differ significantly between the lower and higher diet quality groups (Table 2).

Additionally, there were no differences in energy consumed through snacks. However, the average energy consumed from beverages of the LDQ group (M=559, SD=329 kcal) was significantly higher than that of the HDQ group (M= 321, SD=175 kcal, p=0.001). In general, most meals were consumed at home. There were 6 children in the LDQ group and 9 in the HDQ group that consumed main Breakfast, Lunch, or Dinner meals outside of the home. The majority of the intakes for LDQ and HDQ groups occurred Monday through Thursday of the week (n=20 for LDQ and 22 for HDQ respectively). There were 7 recalls for Sundays in the LDQ group and 4 in the HDQ group. One recall in the HDQ group reflected intake on a Sunday. There were no observed relationships between the day of the week and the observed themes.

The timing of meal occasions across the entire day for LDQ and HDQ were reviewed to assess the meal structure. Five themes resulted from this review: Unstructured, Grazing or Infant-like, Semi-structured, Structured with High Frequency of Snacks or Beverages, and Structured (Table 3). Structured patterns included breakfast meals between the hours of 6:00 AM and 10:30 AM, lunch between 10:30 AM and 1:30 PM, dinner between 3:00 PM and 8:30 PM, and 0 to 3 snacks. Structured with High Frequency of Snacks patterns included a structured pattern with 4 or more snacks throughout the entire day. Semi-structured patterns included breakfast, lunch, and dinner meals outside of the time ranges listed for the structured meal pattern. Infant-like patterns included 3 or more snacks between or after breakfast, lunch, or dinner meals. Unstructured meal patterns had skipped breakfast or lunch meals and extended periods of time (e.g. 8 hours) between meals. There were 10 children with Structured patterns and 5 with Structured with High Frequency Snacks/Beverages in the HDQ group compared to 6 with the Structured pattern and 5 with Structured with High Frequency Snacks in the LDQ group. There were 8 children in the HDQ and 9 in the LDQ group with Semi-structured patterns. Grazing or Infant-like patterns were present in both groups, with 3 children from the HDQ and 4 from the LDQ with this pattern. Lastly there was 1 child with an Unstructured pattern in the HDQ group compared to 3 in the LDQ group. Appendix A includes examples of meal patterns in the HDQ and LDQ groups. Examples include a Structured, Structured with High Frequency of Snacks, and Infant-like patterns from both the HDQ and LDQ groups. While there are similarities in how the foods are consumed between these two groups, there are notable differences in types of foods (see thematic analysis below) and the quantity of foods.

Results of a thematic analysis evaluating patterns common to all children, those with low diet quality and higher diet quality are presented in table 4. In general, most children consumed Breakfast, Lunch and Dinner meals with the addition of snacks or beverage only events (n=51). Main meal skipping (breakfast, lunch, or dinner meals) was not common in either group. There were two children with skipped meals (one with breakfast and lunch, one with lunch only) in the LDQ group and one child (skipped lunch) in the HDQ group. Additionally, additions of sugar, syrup, butter, or similar condiments were common in both groups, but to a lesser extent in the HDQ group. No children with the lowest or highest intake consumed soda.

A prominent theme of the HDQ group was a balanced distribution of caloric intake throughout the day (theme present among 18 children). This pattern was characterized by several meals of similar caloric value throughout the day or "balanced" energy consumption throughout the day.

In contrast to a balanced distribution pattern, a prominent theme of the LDQ group was high beverage consumption, characterized by a high proportion of total energy intake from liquids including juice and milk. There were 15 of 27 children with greater than 40% of the total daily energy consumption from beverages compared to 5/27 children in the HDQ group, and the average percentage of energy from beverages was 43.5% in the LDQ group compared to 27.5% in the HDQ group (p=0.006). It is important to note that while high beverage was an important distinction between the HDQ and LDQ groups, there were children in the HDQ group with similar energy intake percentages from beverages that still had high diet quality scores.

An additional LDQ theme included no whole fruits or vegetables (excluding French fries). These children (n=14) consumed very low amounts of fruits and vegetables during the day. In contrast, 25 of 27 children in the HDQ group that consumed whole fruits or vegetables.

Notes taken during the reviews also suggested that the HDQ group consumed more foods containing whole grains compared to the LDQ group. Ingredients of foods, namely cereals, were reviewed for whole grain content to verify this suggestion. Indeed, most of the HDQ group (17 of 27 children) consumed foods with whole grain content including whole wheat bread, oatmeal, cereals, and popcorn with whole grain listed as the first ingredient. In contrast, 5 of 27 children consumed whole grain foods in the LDQ group.

5.4 Discussion

This study involved the use of quantitative and qualitative methods to identify patterns relating to meal structure and consumption among children with the lowest and highest diet quality scores in a sample of children from primarily low-income households in the Baltimore Metropolitan area. The development of structure in meal consumption and food intake is important for children of this age (Satter, 2007; Butte et al., 2004). At this period of child development, children are yet transitioning from dietary intake characterized by many daily milk and food consumption occasions to fewer and more structured meals as they enter the preschool age, where many children attend daily child care or preschool and do not have the flexibility of having many small meals on demand throughout the day. Structure involves the intentional provision of food at primary meal times such as breakfast, lunch, and dinner, and the planning that is part of this provision increases the likelihood that these key meals will be of higher quality (Satter, 2007). Additionally, toddlers with structured meals are more likely to focus on consuming more during those larger meals (Satter, 2007).

In this study, the intake structures between the two groups were not highly differentiated as hypothesized. It is clear that children with both low and high diet quality scores may have consumed food through smaller, frequent meal occasions including snacks and beverages. Contrastingly, children of both groups may have consumed food through 3 “large” breakfast, lunch, and dinner meals, with the addition of a snack or two. While skipping breakfast, lunch, or dinner meals has been associated with lower diet quality compared to those who do not skip these meals (Dubois et al., 2007; Dubois et al., 2009; Baldinger et al., 2012; Coppinger et al., 2012; Williams et al., 2008), in the present study, very few children (1 in LDQ and 2 in HDQ) skipped meals. The HDQ group had a high frequency of breakfast intake (100%), suggesting a positive pattern. Likewise, most children in the LDQ group also consumed breakfast. Many children at this age consume hot or ready-to-eat cereals, which has been linked to greater intakes of whole grains, and healthier overall dietary intake among children age 4-12 (Alberson et al., 2013).

While main meals (breakfast, lunch, and dinner) occurred within specific time ranges, there was no difference in this observation by age. However, the results suggest that higher diet quality is associated with greater structure in general. Timing of meals and snacks is important to child dietary intake as the presence of snacks close to mealtime may affect the amount of food consumed during the meals. In addition, children are more likely to eat healthy and/or new foods if they are hungry at the time of the meal opposed to having a snack close to mealtime (USDA, 2014).

It appeared that starting the day with a beverage (milk, juice, or water) or the extended consumption of large amount of total beverage during the day might replace food that may have been consumed, resulting in a lower diet quality as assessed using the HEI-2005. However, some children with higher diet qualities also started the daily consumption with milk or juice and starting the day with a beverage is not the sole factor driving the relationship between beverage intake and low diet quality. What appears to be more relevant is the importance of the types of beverages and the portions consumed in relationship to other foods consumed during the day. This study showed that even healthy beverages such as milk and juice can contribute significantly to low dietary quality if the quantities are displacing other nutrient-rich foods such as whole fruits, vegetables, and whole wheat grains which are typically low in the U.S. diet (Guenther et al., 2006). At this age, a large beverage might replace a solid food meal (e.g. if child has a milk feeding in the morning instead of a solid meal), affecting the intake of macro and micronutrients in food. In addition, prolonged bottle feeding (greater than 12 months of age) has been associated with excess energy intake and increased risk of overweight or obesity (Bonuck et al., 2013; Bonuck et al., 2014). High beverage intake could be a risk for unhealthy pattern development as it has been correlated to high energy intakes, and has been associated with greater BMI in children in cross-sectional and longitudinal assessments of diet patterns (Deboer et al., 2013; Malik, Willett, & Hu, 2013).

Where foods are consumed, such as child care (especially day care facilities) may have an impact on meal patterns of young children as child care facilities tend to provide healthier meals, as they are required to meet specific dietary requirements. In addition, participation in child care may also encourage and reinforce structure due to the nature of child care environments which tend to be highly structured. We did not have sufficient information to conclude that there was a relationship between child care and the diet quality score. However, this is an important point to remember when providing recommendations to parents about improving child diet.

There are notable limitations in this study. Data collection includes one 24-hour dietary recall per person. More dietary recalls per person would aid in the identification of patterns as one day may not be a sufficient amount of time to understand usual patterns. Key information about the details of food or beverage consumption relevant to children of this age was not asked such as if milk or juice was consumed through a cup or a bottle. Mothers were asked to identify the food consumption occasion; however, information about the occasion such as if the child was consuming food alone or with others, or if the occasion was a seated meal (e.g. at a table, with a special high chair) was not assessed. Having additional contextual information about the food consumption occasions could have aided in the assessment of a presence or absence of structure in the meal patterns. Additionally, mothers were able to consider "extended consumption" of beverages that were consumed over the course of the day. For example, mothers could state that 24 ounces of milk were consumed starting at 6:00 AM. No additional information was known in regard to exactly when that consumption took place (e.g. how much at meal times, and between mealtimes). This reduces the amount of information known about the daily consumption pattern. This imposes a bias to the results and should be kept in mind when interpreting the results presented in this analysis. Additional research should consider specifying when all beverages or foods were consumed so that this type of analysis could accurately illustrate consumption patterns.

A strength of this study is the utilization of a mixed method approach to evaluating the dietary intake for meal patterns. Reading the intakes as text documents provides a visual illustration of dietary intake that allows structure patterns to emerge that would not have through traditional nutrient intake analyses. There are not many studies that evaluate the meal pattern structures qualitatively. A study evaluating structure patterns of adults found with low scores on an index related to dietary intake and cancer prevention identified themes such as chaos or irregular intake across three days of dietary intake, and "kitchen never closes" which consisted frequent beverage consumption occasions and late night snacks (Klassen et al., 2009). Similarly, in this study the qualitative analysis easily illustrated how high intake of beverages and unstructured dietary patterns may contribute to LDQ intakes. Nutrient intake analyses may have revealed high carbohydrate quantities, but additional assessments would be needed to identify the sources of those carbohydrates (in the case of high intakes of juice or fruit drinks).

This meal pattern analysis illustrated the importance of meal timing and structure to diet quality. Structured meal patterns can be very important in regulating intake and encouraging dietary variety. However, the structured meal plan must be supported with healthy options and nutritious foods, and a balance must be reached between the transitional period from frequent, small meals, to larger discrete meals and the parental-child feeding relationship. Unstructured or "Infant" patterns among children at age 2 may be indicative of a feeding problem. It has been estimated that a quarter of children show feeding problems during this age, some which may include failure to progress to table foods appropriately and these feeding problems may relate to parent-child relationships or child feeding behaviors (Satter, 1995). In this study, it is not clear if the unstructured patterns were related to child feeding problems driven by the parental feeding behaviors or child preferences and assessments over time of child diet structure development may be better able to illustrate if issues are present that need to be addressed. Information about developmentally appropriate meal patterns should be given to caretakers of children in order to be able to identify problems that arise before they affect diet quality and child development. Caretakers of young children should be informed of the benefits of structured meal patterns, how snacks and beverages factor into a healthy diet, and how small changes can make notable improvements in dietary intake.

Table 5.1: Maternal and Child Characteristics of the Sub-sample.

	HEI-2005 < 40 (LDQ)	HEI-2005 > 70 (HDQ)	Statistical significance
Number of children	27	27	
Average age (months), SD	20.4 (6.1)	20.5 (4.9)	NS
Ever breastfed (yes)	15 (55.6%)	15 (55.6%)	NS
Currently breastfeeding	0 (0%)	2 (7.4%)	
Child race			NS
Black	21 (77.8%)	15 (55.6%)	
White	4 (14.8%)	10 (37.0%)	
Other	2 (7.4%)	2 (7.4%)	
Average hours in other's care	13.9	20.4	NS
Gender (Female)	14 (51.9%)	11 (40.7)	NS
Maternal age (years)	25.3 (6.5)	28.9 (6.5)	NS
Current smoker*	8 (29.6%)	3 (11.1%)	0.09
Maternal education (HS+)	23 (85.2%)	22 (81.5%)	NS
Currently employed	12 (44.4%)	11 (40.7%)	NS
Average number of children at home	2.4 (1.1)	2.1 (1.1)	NS
Marital status (non-married)*	24 (92.6)	14 (52.9)	0.006
Location			NS
City	19 (70.4%)	11 (40.7%)	
County	8 (29.6%)	16 (59.3%)	
Currently receive WIC	23 (85.2%)	19 (70.4%)	NS
Food Insecure	8 (29.6%)	6 (22.2%)	NS
Median PIR (IQR)	0.29 (0.19, 0.83)	0.67 (0.19, 2.03)	

Note: Other's care included relatives, non-relatives, or child day care
Significance was assessed by t-test or chi-square or fisher's exact tests.
*Fisher's exact test

Table 5.2: Average energy intake for Breakfast, Lunch, Dinner, Snacks (total) and Beverages (total).

Average Energy Intake	HEI-2005 <40	HEI-2005>70
Breakfast (kcal)	215 (167)	259 (143)
Lunch (kcal)	272 (212)	294 (181)
Dinner (kcal)	287 (235)	271 (200)
Snacks (kcal)	305 (315)	287 (234)
Beverages (kcal)*	559 (329)	321 (175)
Total (kcal)	1408 (601)	1168 (393)
Average number of snacks or beverage only events	3.6 (2.1)	3.3 (1.4)
Average number of meal occasions**	6.6 (2.4)	6.3 (1.5)

*Averages were significantly different by t-test, p-value= 0.003.
**Meal occasions include breakfast, lunch, dinner, snack, milk feedings, and drink only consumption events.

Table 5.3: Meal Structure Themes

Theme	Definition	HDQ group (n)	LDQ group (n)
Unstructured	Breakfast, lunch, or dinner meals are skipped; may include long time periods between meals	1	3
Grazing	Consumption includes 3 or more snacks between breakfast, lunch, or dinner meals	3	4
Semi-structured	Consumption includes breakfast, lunch, and dinner meals; However, timing does not occur within the timing guidelines of the structured intake pattern	8	9
Structure-high frequency of snacks/ beverages	Consumption includes breakfast between 6:00 AM and 10:30 AM; lunch between 10:30 AM and 1:30 PM; dinner between 3:00 PM and 8:30 PM; 4 or more snacks	5	5
Structured	Consumption includes breakfast between 6:00 AM and 10:30 AM; lunch between 10:30 AM and 1:30 PM; dinner between 3:00 PM and 8:30 PM; 0-3 snacks	10	6

Table 5.4: Intake themes for all children, Low Diet Quality (LDQ), and High Diet Quality (HDQ) groups.

Group	Theme Name	Number of children	Description
All children	Breakfast, Lunch Dinner	51	Characterized by intake of each breakfast, lunch, and dinner meals. May also include additional eating occasions (snacks, beverage only events).
	No soda	54	No consumption of soda.
LDQ	High beverage consumption	15	High proportion (>40% total energy) of total daily intake from liquids. Includes juice, milk as stand-alone feedings, or milk with cereal.
	No whole fruits or vegetables	11	No whole fruits, vegetables, legumes or a very small amount consumed (e.g. 1-2 Tbsp total). May have consumed mixed pasta and tomato sauce entrées (n=2).
	Early morning milk feeding/First meal beverage only	9	Consumption starts with a liquid feeding of 8 ounces or more. Most often milk consumed, may include other beverages such as meal replacement beverage, fruit juice drinks
	Added sugar or fat	14	Characterized by the addition of sugar (granulated sugar, syrup, honey, jelly) or fat (butter, margarine, mayonnaise) to the meal. Does not include two additional children with added low sugar or diet syrup at breakfast.
HDQ	Balanced Distribution	18	Characterized by several meals of similar caloric value throughout the day or "balanced" energy consumption throughout the day.
	Whole fruits and vegetables	25	Characterized by the consumption of several whole fruits and vegetables during the day
	Whole grain	17	Characterized by the consumption of

	intake		whole grain items (e.g. wheat bread, breakfast cereals with whole grain listed as the first ingredient, oatmeal, whole wheat pasta)
	Added sugar or fat	7	Characterized by the addition of sugar (granulated sugar, syrup, honey, jelly) or fat (butter, margarine, mayonnaise) to the meal.

Appendix 1. Meal Structure Examples

Example 1: High Diet Quality Group: Age 26 Months, Structured Meal Pattern

Time	Meal	Foods	Amount	Grams	Kcal
6:30 a.m.	Early morning snack	Cracker, snack	1	3	15.1
		Apple juice	10.5 ounces	325.5	153.0
8:00 a.m.	Breakfast	Apple, raw	2 pieces	34	17.7
		Pancakes, plain	2	26	58.5
		Pancake syrup, maple or corn	0.125 cup	39.38	104.3
		Milk, cow's, whole	5 ounces	152.5	91.5
11:00 a.m.	Lunch	Tuna salad	0.5 cup	104	191.4
		Bread, white	2	52	138.3
		Mixed vegetables (corn, lima, peas)	0.25 cup	45.5	22.2
		Pineapple, cooked or canned	2	13.6	8.2
		Milk, cow's whole	5 ounces	152.5	91.5
3:00 p.m.	Afternoon snack	Apple juice	3.5 ounces	108.5	51.0
		Rice cake, cracker-type	0.5 unit	7.5	29.4
5:00 p.m.	Evening snack	Oranges, Mandarin, canned	0.5 cup	126	76.9
5:30 p.m.	Dinner	Ham, smoked or cured, cooked	0.25 cup	33.5	46.7
		Corn, yellow, cooked from can	0.5 cup	82	66.4
		Oranges, Mandarin, canned	0.25 cup	63	38.4
		Apple juice	5 ounces	155	72.9
Total Energy (kcal)					1273.4

Example 2. High Diet Quality Group: Age 20 months, Structured with High Frequency of Snacks/Beverages

Time	Meal occasion	Foods	Amount	Grams	Kcal
8:45 a.m.	Breakfast	Cheerios	0.5 cup	15	55.1
		Egg whites, cooked	1 egg	33	15.8
		Milk, cow's, whole	0.1875 cup	45.75	27.5
		Bread, wheat or cracked wheat	0.5 slice	12	37.6
		Water, bottled, unsweetened	5 cups	1185	0
11:15 a.m.	Morning snack	Cracker, snack	2 crackers	8	40.2
		Cheese, processed, American	0.5 piece	10.5	35.3
12:30 p.m.	Lunch	Chicken nuggets	4 nuggets	64	190.1
		Carrots, raw	2 carrots	20	8.2
		Apple juice	1 cup	248	116.6
3:00 p.m.	Afternoon snack	Bread, wheat, or cracked wheat	1 piece	26	69.2
		Jelly	0.25 tsp	1.56	4.2
4:30 p.m.	Early evening snack	Cookie, baby	3 cookies	19.5	84.4
6:30 p.m.	Dinner	Chicken, wing, roasted or broiled	1 wing	30	86.3
		White potato, fresh, mashed	1 cup	210	211.4
		Corn, yellow, canned, low sodium	1 tbsp	10.25	11.1
		Kale, cooked, from fresh	0.125 cup	16.25	4.5
		Roll, white, soft	0.5 roll	14	39.1
8:30 p.m.	Late evening snack	Cracker, animal	3 crackers	7.5	33.5
		Milk, cow's, fluid, whole	0.1875 cup	45.75	27.5
Total Energy (kcal)					1097.6

Example 3: High Diet Quality Group: Age 13 months, Grazing Pattern

Time	Meal	Foods	Amount	Grams	Kcal
8:00 a.m.	Pre-breakfast beverage	Milk, cow's, fluid, whole	1 cup	244.0	146.4
8:10 a.m.	Snack	Cheerios	1 tbsp	1.9	6.9
8:15 a.m.	Snack	White potato chips	2 pieces	3.6	19.7
9:00 a.m.	Breakfast	Ham, baby food, strained	1 unit	35.0	34.0
		Eggs, whole, cooked	0.5 egg	25.0	41.7
		Oatmeal baby food cereal	**5**	19.0	75.8
		Orange-apple-banana juice, baby	1 cup	249.6	117.3
10:00 a.m.	Snack	Bananas, baby food, strained	1 unit	113.0	102.8
12:00 p.m.	Lunch	Macaroni with beef and tomato sauce	1	170.0	137.7
		Water, bottled, unsweetened	0.75 cup	177.8	0
3:00 p.m.	Snack	Pudding, not chocolate	99 grams	99.0	128.7
6:30 p.m.	Dinner	Ham, baby food, strained	0.5 unit	35.5	34.4
		Pineapple, canned	3	28.2	16.9
7:30 p.m.	Snack	Cake (type unspecified)	1 (RG)	4.4	15.6
		Orange-apple-banana juice, baby	0.5 cup	124.8	58.7
7:45 p.m.	Beverage only	Fruit juice drink	1 tbsp	15.5	7.1
8:30 p.m.	Beverage only	Milk, cow's, fluid, whole	0.75 cup	183.0	109.8
Total Energy (kcal)					1053.5

Example 1: Low Quality Group: Age 26 months, Structured with High Frequency Snacks/Beverages

Time	Meal	Foods	Amount	Grams	Kcal
7:00 a.m.	Pre-breakfast beverage, extended consumption	Milk, cow's, whole	9 cups	2196.0	1317.6
9:30 a.m.	Breakfast	French toast sticks, plain	1.5	31.5	107.1
		Syrup, dietetic	0.25 tsp	1.3	0.5
		Egg omelet or scrambled egg	0.5	30.0	38.1
		Bacon, NS as to type of meat	1	5.0	27.1
10:30 a.m.	Snack	Cookie, chocolate, sandwich	1	11.0	51.3
12:30 p.m.	Lunch	Frankfurter, or hot dog	1	57.0	168.0
		Pork & beans	3 oz.	94.9	89.2
2:00 p.m.	Snack	Apple, raw	0.5	53.0	27.6
		Water, bottled, unsweetened	0.5 cup	118.5	0
8:30 p.m.	Dinner	Kale, cooked from fresh, no fat added,	1 tbsp	8.1	2.3
		Rice, white, cooked,	1 tbsp	10.9	13.3
		Chicken wing, roasted/broiled	1.5	28.5	82.0
9:00 p.m.	Snack	Salty snack, mostly corn	0.25	10.0	49.9
Total Energy (kcal)					1974.0

Example 2: Low Diet Quality Group: Age- 19 months, Structured Pattern

Time	Meal	Foods	Amount	Grams	Kcal
9:30 a.m.	Breakfast	Pork bacon	2 pieces	10.0	54.1
		Egg omelet or scrambled eggs	0.25 cup	53.5	79.3
		Cheese, Processed, American	1	21.0	70.7
		Waffle, plain	1	39.0	121.1
		Pancake syrup, reduced calorie	1 tsp	5.0	8.4
		Cream of wheat	0.5 cup	119.5	52.4
		Granulated white sugar	1 tbsp	4.2	16.1
		Margarine-like spread	1 tsp	4.8	25.6
		Orange juice	0.5 cup	124.5	52.3
12:00 p.m.	Lunch	Soup, mostly noodles	0.5 unit	247.0	170.2
		Grilled cheese sandwich	1 sandwich	83.0	291.2
		Bottled water, unsweetened	0.5 pint	237.0	0
2:30 p.m.	Snack	Processed cheese food	1 unit	16.0	52.8
		Snack cracker	4 crackers	16.0	80.3
6:30 p.m.	Dinner	Pot roast, beef	1 slice	25.5	60.0
		White potato, boiled, without peel	0.25 cup	40.3	40.4
		Carrots, cooked from fresh	0.5 cups	40.3	20.0
		String beans, cooked from frozen	1 tbsp	8.8	3.9
Total Energy (kcal)					1198.8

Example 3: Low Diet Quality Group: Age 12 months, Semi-structured Pattern

Time	Meal	Foods	Amount	Grams	Kcal
3:00 a.m.	Early extended consumption beverage	Infant formula- Similac Lactose Free Advance	6.75 cups (54 oz)	1647	1052.3
10:30 a.m.	Breakfast	Cap'n crunch cereal	0.25 cup	11.3	45.2
		Milk, cow's, fluid, whole	0.53 cup	129.6	77.8
12:00 p.m.	Lunch	Soup, mostly noodles	3 tbsp	43.7	30.1
		Beef & noodles, no sauce	1 tbsp	9.8	18.4
4:00 p.m.	Snack	Ham, sliced, packaged or deli	0.25 piece	7.0	9.9
		Chicken/turkey loaf, prepackaged	0.25 piece	7.0	8.3
		Cheese, cheddar or American	0.25 piece	6.0	21.5
		Bread, white	0.5 piece	13.0	34.6
		Mayonnaise, regular	1 tsp	4.6	32.9
		Mustard	0.25 tsp	1.3	0.9
7:00 p.m.	Dinner	Spaghetti, tomato sauce, & beef	0.333	56.6	38.5
		Beef, steak sandwich	1 unit	41.0	128.0
		Cheese, processed, American	0.5 piece	10.5	35.3
		Roll, white, soft	0.5 piece	21.5	60.0
Total Energy (kcal)					1593.7

Example 4. LDQ Age 18 Months, Grazing Pattern

Time	Meal	Foods	Amount	Grams	Kcal
8:00 a.m.	Breakfast	Kix cereal	3.5 ounces	9.63	35.324
		Milk, cow's, fluid, whole	0.5 cup	122	73.2
9:15 a.m.	Beverage only	Milk, cow's, fluid, whole	5 ounces	152.5	91.5
12:00 p.m.	Beverage only	Milk, cow's, fluid, whole	5 ounces	152.5	91.5
12:30 p.m.	Snack	Pudding, canned, not chocolate	1 unit	113	114.13
1:00 p.m.	Snack	Animal crackers	1.32 unit	73.92	329.683
1:40 p.m.	Lunch	Ravioli, meat-filled, with tomato sauce	0.5 cup	125.5	124.578
2:00 p.m.	Beverage only	Milk, cow's, fluid, whole	5 ounces	152.5	91.5
3:25 p.m.	Beverage only	Water, tap	5 ounces	148.13	0
4:00 p.m.	Snack	Pudding, canned, not chocolate	1 unit	113	114.13
		Milk, cow's, fluid, whole	5 ounces	152.5	91.5
5:00 p.m.	Snack	Milk, cow's, fluid, whole	5 ounces	152.5	91.5
		Animal crackers	0.5 unit	32	142.72
5:30 p.m.	Beverage only	Water, tap	2.5 ounces	74.06	0
5:50 p.m.	Beverage only	Fruit flavored drink	2.5 ounces	78.13	27.442
6:00 p.m.	Dinner	Pork chop, broiled or baked	0.25 cup	33.5	80.395
		White potato, mashed	0.25 cup	52.5	44.829
		Kale, cooked from canned	2.5 TB	25.47	7.079
		Fruit flavored drink	5 ounces	156.25	54.884
6:15 p.m.	Snack	Cookie, butter or sugar	1 cookie	16	76.04
7:00 p.m.	Beverage only	Fruit flavored drink	2.5 ounces	78.13	27.442
10:00 p.m.	Beverage only	Milk, cow's, fluid, whole	5 ounces	152.5	91.5
Total Energy (Kcal)					1800.876

Appendix 2: Codebook

Meal	Description of characteristic
Breakfast	Early- Before 6:30am
Breakfast	Late- After 11:00am
Breakfast	Skipped breakfast
Breakfast	Number of breakfast meals
Drinks	Number of juice events
Drinks	Amount of juice consumed during the day
Last meal	Time of last meal
Last meal	Description of last meal, Eg. Sweet treat/ dessert, snack, milk consumption
Snacks	Number of sweet treats during the day
Snacks	Number of salty treats during the day
Snacks	Number of fruit/vegetable snacks during the day
Snacks	Other types of snacks
Lunch	Meal skipped
Breakfast	Sugary cereal type
Lunch	Late- after 2:00pm
Other	Cereal meals-general
Drink	Number of milk events
Drink	Amount of milk consumed
Highlighted items- combination meals of interest	Peanut butter and jelly sandwiches
Highlighted combination meals of interest	Hamburger/cheeseburger
Highlighted combination meals of interest	Macaroni and cheese
Highlighted combination meals of interest	Pizza
Snacks	Candy, note when consumed
Other	No meat consumed during the day
Light meal	Eg. Only one fruit for breakfast
Other	Cereal meals- sugary type
Other	Number of meals *consider milk a meal if listed by itself, Eg. 8 fluid oz. milk in evening before bed
Other	Time between meals
Other	Location of meals- % at home
Breakfast	Type of breakfast- Hot breakfast- Bacon, eggs, sausage, pancakes, waffles, biscuits (in combination)
Breakfast	Hot grains- oatmeal, grits, cream of wheat

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Chapter 6

Discussion

In this collective study of child eating patterns, 4 different methods of characterizing child diet are presented. This overall body of work serves to illustrate four methods of assessing the eating patterns of young children. This study contributes to the literature by evaluating eating patterns in a population of low-income children in Maryland. This chapter summarizes the work that has been presented in this study, the strengths and limitations of the research, and implications of these findings for future studies and program development.

6.1 Summary of major findings

Little is known about the development of eating patterns in toddlerhood, a critical period of eating pattern development, and the relationships between these patterns and overall dietary quality. This transition period infant diet to the family diet during toddlerhood can be challenging for some families given behavioral characteristics of toddlers and the complex interplay between the family and the child, and surrounding environments. As people may develop poor eating habits early, people could also develop healthy eating habits early with consistent exposure to healthy foods (Cook, 2007). It is imperative to influence the development of healthy eating behaviors as early as possible as research shows that poor eating habits are difficult to change once established (Shepherd, 2002).

In this project, eating patterns of young children were assessed in four different ways, each of them providing different information about the diets of young children of limited-income families. Chapter 3 utilized two index analyses, the Mean Adequacy Ratio (MAR) and the 2005 Healthy Eating Index (HEI-2005), both designed to compare intake values to standards of diet quality. The MAR was an average of Nutrient Adequacy Ratios, which were calculations of observed nutrient intake divided by gender and age-specific recommended intakes for vitamins A, C, Thiamin, Riboflavin, Niacin, B6, B12, Folate, and Iron, Zinc, and Calcium minerals. Researchers have used either the EAR values or estimated adequate requirements for 50% of healthy persons (Steyn et al., 2006), or RDA values or recommended dietary allowance or the intake values known to meet the needs of 99.5% of healthy persons (Hoerr et al., 2006) in their calculations of MAR in young children. In this analysis, MAR values calculated using the RDA values for each NAR were presented in the results to illustrate the low risks of inadequate intake among the study population such that there were risks for excess consumption of many nutrients. The NAR scores (Table 3.2) for children age 1 and 2 illustrated that for each of the selected vitamins and minerals, a majority of the children had results greater than 100% for each nutrient, and the 100% value meets the needs of 99.5% of the population of healthy children of that age. This analysis illustrated that most young children in the study have low risks of inadequate nutrient intake in spite of having low family incomes which has been associated with increased risks of food insecurity and as a result, declines in diet quality (Morrisey et al., 2014).

While the low risk of inadequate intake is preferential, the risks of excess intake were concerning, and for this reason additional analyses of Tolerable Upper Intake Level

(UL) of select nutrients were presented. These results show that over 64% of the 1 year old children consumed greater than the UL for Niacin, 24.7% for vitamin A, and 36.6% for zinc. The results were as similar for 2 year old children with 74% consuming greater than the UL for Niacin, 33% for vitamin A and 53% for zinc (Table 3.3). While these results were for one day of intake, this is an important finding that could affect recommendations for dietary intake for children of this age. A national study of nutrient intake and the nutrient contributions through intrinsic only, intrinsic plus added nutrients through fortification, and all food plus supplements illustrated the impact of food fortification on risks of intake lower than the EAR for specific nutrients and minerals and intake greater than the UL. There were 52.7% of children 2-8 years of age with zinc intakes greater than the UL from all foods (including fortified foods) and supplements, compared to 24.3% with zinc from intrinsic sources only. For niacin consumption, 28.4% of children 2-8 years of age had intakes greater than the UL with food plus supplements, compared to 0 from intrinsic sources. While risks of over consumption increase with food fortification and supplement use, the greatest increases in risks of consumption greater than the UL were observed among those with supplement use in addition to consumption of fortified foods (Berner et al., 2014). This study did not assess supplement intake, however, excess intake of several nutrients was reported. Actual nutrient intake values could be even greater if supplements were also taken.

In contrast, the HEI-2005 assessment measured adherence to the 2005 Dietary Guidelines for Americans, which emphasized the intakes of whole fruits, green leafy and orange vegetables, low-fat dairy products, and whole grains. This section of the analysis revealed key areas for dietary improvement that could be made in the interest of promoting long-term health and the prevention of chronic diseases such as increasing whole fruit, vegetable, and whole grain intake and decreasing added sugar and solid fat intake. As mentioned in chapter 3, with the updated Dietary Guidelines for Americans released in 2010 were changes in the recommendations in comparison to the 2005 Dietary Guidelines. The 2005 Dietary Guidelines were selected as the standard of comparison because the data were collected during the time that these recommendations were emphasized. There were notable differences in the guidelines from 2005 to 2010, and this may have resulted in different dietary quality scores due to recommendations the children were not given a the time of the data collection. The updated 2010 Dietary Guidelines emphasizes the intake of high-fiber foods such as whole grains, vegetables, and whole fruits, fat-free or low-fat dairy, using oils instead of solid fat, increasing the variety of protein foods, especially seafood and plant proteins, and limiting the consumption of refined grains, sodium, and empty calories (USDA, 2010). As it is, the dietary quality scores by HEI-2005 were low for most children. The use of the HEI-2010 for this analysis was considered, but was not selected due to the fact that the population would not have been aware of the 2010 Dietary Guidelines' increased emphasis on protein foods, and limitations on consumption of refined grains, which were not stressed in the previous guidelines.

Comparing the diet quality scores from the MAR and HEI-2005 analyses appear to result in two different stories about child diet quality. However, these results show different viewpoints of diet quality and the need to balance food intake with nutrient requirements. The food intake guidance must take into account the types of foods that are consumed to meet energy and nutrient requirements. This study illustrates that nutrient requirements for cellular function, physical processes, and the prevention of many health issues associated with inadequate nutrient intake can be met with diets that do not adhere to the Dietary Guidelines for Americans. However, these diets were low in whole grains and vegetables, and the consumption of high fiber foods is important. The consumption of more fiber may also balance the observed high intakes in added sugar and "empty/discretionary" calories consumed by many children in this study. Continued excess intake in this area could be of concern as these patterns may lead to energy imbalance and ultimately overweight or obesity.

The maternal caretaker of most children in this study participated in supplemental nutrition assistance program or the Women, Infants, and Children program (87.6%) and although it was not demonstrated in this study, these benefits might reduce the risks of undernutrition in this population. Because most children had adequate MAR scores, factors associated with high MAR scores was not assessed. However, factors associated with HEI-2005 scores were assessed, and it was demonstrated that the maternal diet was highly correlated with the child diet, such that mothers with higher diet quality were more likely to have children with higher diet quality, as demonstrated in previous studies (Hoerr et al., 2006; Lee et al., 2005). The unadjusted bivariate associations in chapter 3 illustrated that income was significantly associated with child diet quality by HEI-2005 before adjusting for other covariates. Although 28% of the children have food insecurity in their home, there was no relationship between food insecurity and diet quality scores. Like in this study, other studies have found no relationship between food insecurity and diet quality in young children suggesting that parents shield their children from the potential effects of food insecurity (Hanson & Connor, 2014).

Chapter 4 presented an evaluation of dietary patterns of young children by Ward's cluster analysis method. This resulted in 4 distinct clusters: Cluster 1- Light Eaters (n=104), Cluster 2- Processed Meat, Potatoes and Fruit (n=102), Cluster 3- Meat, Tomato, and Non-whole Grains (n=43), and Cluster 4- Whole Grains, Vegetables, Nuts and Fruit Juice (n=18). Cluster 1 was characterized by average consumption of small amounts of most food groups in comparison to the average food consumption by children in the other clusters. These children tended to be younger (average age= 18.9, SD= 5.4) than other groups, which could possibly explain the observed differences in average consumption amounts. They were also likely to be in families receiving WIC benefits (p=0.065). However, no other maternal or child characteristic was significantly different between the clusters. Cluster 2 was characterized by consumption of franks, sausages, or cold cuts, whole fruits, and vegetables including green beans, and potatoes. This cluster also had the lowest average whole milk consumption with comparing the average whole milk consumed between the clusters. Cluster 3 was characterized by meat, tomato, and non-whole grains. Foods like chicken, hamburgers, and spaghetti with meat sauce were consumed by several children, and "fast-food" was consumed by many in this cluster. This cluster also consumed the highest average whole milk compared to the other clusters. One might assume this dietary pattern would describe more than 43 children in the low-income sample due to the low intakes of most fruits and vegetables and high intakes of non-whole grains. However this cluster pattern was representative of less than 1/4 of the sample. Cluster 4 was an overall healthier cluster and this was supported by the higher HEI-2005 average diet quality scores than those of the other 3 clusters. However, high amounts of added sugar and juice were consumed by children in this group. As described in chapter 4, average diet quality assessed by HEI-2005 for each cluster was low. However, it appeared that mothers attempted to provide healthy choices to children by offering whole fruits and vegetables especially in clusters 2 and 4.

The purpose of the mixed-methods analysis in Chapter 5 was to evaluate the structure of daily meal consumption as related to low and high dietary quality as identified in chapter 3. Children with the lowest 10% (less than 41.3, n=27) and highest 10% of diet quality scores (greater than 70, n=27) by the HEI-2005 were included in the sample. The hypothesis was that meal structure would be related to dietary quality and those with low HEI-2005 scores would have less structured dietary patterns compared to children with higher scores. Additionally, the mixed-method analysis method left open the potential for identifying new patterns that were not considered and the identification of these patterns was an important part of the plans for the analysis. This analysis suggested differences in structure as related to energy distribution across meals, types of foods consumed, particularly portion sizes of beverages. However, the results were inconclusive in regard to differences in meal frequency between the two groups. Follow-up studies should include similar assessments of structure among the entire sample of children to determine if there are additional patterns that emerge for those with average diet quality scores for the sample, under the 25^{th} or greater than the 25^{th} percentile or other groups.

These analyses together provide key information about the diets of young children from low-income families. While the results are not completely generalizable, it can be concluded that one does not have to have a lot of money to have a nutritionally adequate diet in regards to nutrient intake. The majority of the children in this study had high nutrient intakes, many even excessive for select nutrients such as Vitamin A, Niacin, and Zinc. It is possible that food fortification played a strong role in the high intake of these nutrients (Berner et al., 2014). However it is important to note that food fortification in general strongly decreases the risks of having nutrient intakes lower than the EAR for vitamins A, D, Folate, and Iron in young children (Berner et al., 2014). In a time where people are very concerned about being able to provide healthy diets on limited incomes, this study shows that adequate nutrient intake is feasible even with low-cost foods. While no information was collected about money spent for food or specific purchasing habits, foods like franks and noodles, which were common, can be considered low-cost foods and fresh vegetables higher cost foods (McDernott & Stephens, 2010). Achieving a higher diet quality as measured by the HEI-2005 is possible with small changes for children of this age.

6.2 Strengths and Limitations of the Study

The strengths of this study are important to note. This study illustrates four methods of assessing eating patterns in young children. The use of these methods together is a strength of this study as each provides different information that can be factored into the understanding of young child eating patterns. There is no one method that is without limitations for children of this very young age, and it is important to compare the various methods and to find the best way to assess eating patterns at this age. This study also illustrates the patterns that are present as children are transitioning to the dietary recommendations of the Dietary Guidelines for Americans. Considering that dietary quality assessments did not vary greatly by age, this shows that there are significant improvements that need to be stressed in order to guide children toward these intake recommendations. These improvements may likely begin with the entire family and identifying ways to improve overall intakes for the general family, especially the mothers, since the diet quality scores were strongly correlated to the maternal diet quality scores more than any other potential predictor available for the assessment.

The use of a mixed-method approach in Chapter 5 was a strength of this study as it provides an illustration of contextual information that provides details that are not as easily noted by traditional nutrient analyses. This approach would be strengthened by an addition of qualitative assessment tools (an in-depth interview, meal setting observations) to provide additional information about the feeding occasion, people involved in feeding the child, location of meals, types of foods consumed, meals consumed during day care, or other meal context details.

The 24-hour recall collected through the Automated Multiple Pass Method is a strength of this study. The prompts and visuals built into the dietary assessment process aid in the recall of details of foods consumed during the day of the recall. However, this study included a single 24-hour recall from each person. Due to variations in daily intake of children, at least three 24-hour recalls per child are needed to improve accuracy of estimating energy intake of children ages 4-7 (Johnson et al 1996), especially in the cluster analysis conducted in chapter 4. Additionally, although the AMPM method improves the accuracy of dietary recall through prompts and the use of food model booklets, there are still risks for over-estimation of child intake by 24-hour recall (Fisher et al., 2008; Klesges et al., 1987). Recall and portion estimation by parents has been shown to be more accurate when the food is prepared and consumed at home compared to food consumed outside of the home (Klesges et al., 1987). Additionally it may not be clear if parents of young children are reporting the amounts of food fed to the child, or the amounts actually consumed. In addition, children in day care or other care during the day of recall may have inconsistent estimates. In this study, this threat was addressed by requesting that the mother sent a food record form with the child while with other caretakers. However, the accuracy of this information can not be guaranteed, especially without the use of measuring utensils or food model booklets to assist in the accuracy of portion estimation. Infant and toddler-specific methods such as the Toddler-Specific Estimated Food Record developed Hilbig and colleagues (2014) might increase accuracy of child dietary intake assessments.

6.3 Implications for Future Research

The development of healthy eating patterns is of great importance in public health. The entire work reveals that dietary guidance should include information about increasing whole grain intake, beverage consumption (type and portion size), and structured meal environments in order to increase diet quality as related to the Dietary Guidelines for Americans among low-income children. In regard to nutrient intake, many children meet or exceed the Recommended Daily Allowances for some vitamins and minerals. Dietary guidance should consider the balance between intake of nutrients and food groups to promote the healthiest outcomes. More research is needed to determine what that balance is considering the consumption patterns and food preferences of young children.

Additionally, the possibility of brief screening for mealtime structure should be assessed during well care visits to determine risks for low diet quality. By providing guidance about having structured meals, it is possible that additional food consumption related problems could be prevented. More research is needed to determine how feasible this is in the clinic setting, and how effective it would be in preventing eating behavior concerns.

Future studies should consider the use of mixed-methods including interviews and observations to fully assess meal patterns at this age. The use of mixed-methods may provide important information about eating behaviors, better informing programs and interventions targeting the improvement if diet quality.

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CURRICULUM VITAE

KRYSTAL L. LYNCH

PERSONAL DATA

Home Address: 9 Barkley Lane Apt. 452
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EDUCATION AND TRAINING

2007- PhD Candidate, Human Nutrition, Department of International Health, Johns Hopkins University, Bloomberg School of Public Health, Baltimore, MD
Dissertation: Evaluating Eating Patterns of Toddlers from Low-income Households: A Multi-method Approach to Understanding Eating Behaviors of Young Children

2005 MPH, Health Education, Department of Behavioral Science and Health Education, Emory University, Atlanta, GA
Thesis: Women's Knowledge of Mother-to-Child Human Immunodeficiency Virus Transmission (HIV) and Prevention in the Mother-Infant Rapid Intervention at Delivery (MIRIAD) Study

2000 BS, Biology, Spanish, The University of Michigan, Ann Arbor, MI

CERTIFICATIONS

2005-2010 Certified Health Education Specialist, CHES, National Commission for Health Education Credentialing, Inc.

PROFESSIONAL EXPERIENCE

2013- Public Health Data Analyst, BLH Technologies, Inc., Rockville, Maryland
Principal responsibilities: Analyze qualitative and quantitative data supporting research in the Tobacco Control Research Branch, Division of Cancer Control and Prevention Sciences, National Cancer Institute.

Manage the development of a tobacco control monograph. Conduct data analyses, support research activities as needed.

2011-2013 Intervention Coordinator, University of Maryland Baltimore, School of Medicine, Department of Pediatrics, Growth and Nutrition Division
Principal responsibilities: Oversee staff and the progress of a school-wide environmental physical activity and nutrition promotion intervention in the Challenge in Schools! Adolescent Obesity Prevention Study (Principal Investigator- Maureen Black, PhD). Foster relationships with school administration and staff. Monitor budget for school wide events. Mentor and train new employees on study procedures, teaching them nutrition topics related to the study. Assist with the collection of anthropometric and fitness measurements.

2010-2011 Health and Activity Committee Leader, University of Maryland Baltimore, School of Medicine, Department of Pediatrics, Growth and Nutrition Division
Principal responsibilities: Planned health promotion events for students and teachers; led a group of staff, students, and community members in a school-wide nutrition and physical activity promotion intervention in the Challenge in Schools! Adolescent Obesity Prevention Study (Principal Investigator- Maureen Black, PhD). Taught 8th grade students to lead intervention activities at their school. Networked with school staff, teachers, and administrators to secure assistance, buy-in/support, and enthusiasm for each activity.

2008- 2010 Health Educator, University of Maryland Baltimore, School of Medicine, Department of Pediatrics, Growth and Nutrition Division
Principal responsibilities: Taught intervention sessions on nutrition, parenting, or child safety with mothers of young children for the Toddler Obesity Prevention Study / Tips on Parenting Study (Principal Investigator- Maureen Black, PhD). Collected data including anthropometric measurements. Trained new employees.

2007- 2009 Research Assistant, Johns Hopkins University
Principal responsibilities: Recruitment and study implementation for the Young Women's Health Study, a behavioral study of pelvic inflammatory disease treatment in adolescents (Principal Investigator- Maria Trent, MD, MPH)

2005-2007 Oak Ridge Institute for Science Education Fellow, Centers for Disease Control and Prevention, National Center for HIV, Viral Hepatitis, STD, TB Prevention, Division of HIV/AIDS Prevention, Epidemiology Branch, Atlanta, GA.
Principal Responsibilities: Project coordinator for the Adolescent Impact behavioral intervention, the Phase II Open Trial of Maternal

Zidovudine/Lamivudine and Nevirapine for maximal reduction of Mother-to-child HIV transmission in Resource Limited Settings among Breastfeeding Populations (KiBS) Study, the Extended Infant Post-Exposure Prophylaxis with Antiretrovirals to Reduce Postnatal HIV Transmission (PEPI Malawi) study, and Kesho-Bora Mother-to-child HIV; Organized and maintained a tracking system for Severe Adverse Events in each study. Updated and submitted IRB renewal documents, assisted with other administrative tasks related to the studies.

2006- 2008 Research Assistant and Investigator, Centers for Disease Control and Prevention, NCHHSTP-DHAP-EB. Towards maximal Reduction of Perinatal HIV: A Hospital-Based Case-Control study of 'Sentinel Cases' (Pacts-Max)
Principal Responsibilities: Data entry, cleaning, and analysis using Microsoft Access and SAS 9.1

2004-2007 Research Assistant for the Pregnancy among Perinatally Infected Adolescent Study in the Centers for Disease Control and Prevention, NCHSTP/DHAP-SE/EB/MCT-PASS
Principal Responsibilities: Data entry, cleaning, management, and analysis in Microsoft
Access, SPSS, and SAS 9.1

2003-2005 Assistant Project Coordinator, Centers for Disease Control and Prevention, Atlanta,
GA
Principal Responsibilities: Assisting the Project Coordinator, Data Manager, and Medical Officers in various aspects of the Mother-Infant Rapid Intervention at Delivery (MIRIAD) study in the NCHSTP/DHAP-SE/EB/MCT-PASS. Responsibilities included tracking data, quality control measures of data collection, corresponding with data collection sites in 6 US cities, creating and maintaining study procedures manuals.

2005 Community Needs Assessment, Emory University Behavioral Science Health Education Department, Atlanta GA
Principal Responsibilities: Conducted a Community Needs Assessment research project of African-American infant care practices in Dekalb and Fulton, Counties, GA, for the Georgia SIDS Foundation; Developing qualitative and quantitative data collection forms administered to 60 caretakers enrolled in the Supplemental Nutrition Program for Women, Infants, and Children (WIC); Analyzing qualitative and quantitative data, and presented results orally and via written report to the stakeholders

2004-2005 Community Needs Assessment Investigator (Advisor, Dr. Michelle Kegler), Emory
University, Atlanta, GA

Principal Responsibilities: Designed and conducted a Community Needs Assessment project to assess breastfeeding support needs for Hispanic women utilizing Women, Infant, and Children Nutrition services in the East Metro Health District, State of Georgia Division of Health

2004 Graduate Teaching Assistant (Instructor, Dr. Kimberly Jacob Arriola), Emory University, Atlanta, GA
Principal Responsibilities: Instructing weekly lab sessions of 16-20 graduate students enrolled in BSHE 540, Behavioral Research Methods; Creating and implementing lesson plans for lab activities to supplement lectures; Grading assignments and providing students with feedback and guidance

2004 Program Evaluator, Department of Behavioral Science and Health Education, Emory University, Atlanta, GA
Principal Responsibilities: Evaluating the In School Follow-up component of the Atlanta Power over Prejudice (POP) Summit, a yearly anti-prejudice program for 500+ middle school students from the Metro Atlanta area; Developing two qualitative data collection instruments to evaluate long term outcomes of the POP Summit within participant's schools; Facilitating 5 focus groups and 6 qualitative interviews; Analyzing data for themes and presented results and recommendations to key program stakeholders

2000 Research Assistant, Advanced Research in Biology (Dr. D. Andrew Merriwether, primary investigator) University of Michigan, Ann Arbor, MI
Primary Responsibilities: Conducting DNA PCR and Gel Electrophoresis tests on specimens a South American Indigenous tribe

1999 Volunteer, Alternative Spring Break, Philadelphia, PA
Primary Responsibilities: Instructing High school health classes in Camden, NJ on HIV/AIDS prevention; Preparing and distributing 300+ kits for a needle exchange program

1995 Summer Science Academy, University of Michigan, Ann Arbor
Primary Responsibilities: Experienced an in depth and interactive program in premedical sciences; Obtained hands on experience in anatomy and physiology during interactive workshops

1994 Summer Research Program in Veterinary Medicine, (Mentor: Dr. E. Van Tassel) Michigan State University, East Lansing, MI
Principal Responsibilities: Constructing an experimental research design, including research questions and protocol, literature review, data collection, analysis, and oral presentation about food choices of beetles in relation to their natural color

PROFESSIONAL ACTIVITIES

Membership: American Society for Nutrition, 2008-2009
American Public Health Association, May 2006- 2007
Society for Public Health Education, October 2005- 2007
American Evaluation Association, September 2005- September 2006

HONORS AND AWARDS

2007-2009 Johns Hopkins Bloomberg School of Public Health Diversity and Health Disparities Predoctoral Fellowship

1996-2000 Full Tuition Scholarship, University of Michigan

PUBLICATIONS

Schindler-Ruwisch, J., Augustson, E., **Lynch, K**., & Patrick, H. (submitted). BMI and Smoking Status: Interrelated Factors among Cessation Website Users.

Augustson, E., M., Engelgau, M. M., Shu, Z., Ying, C., Cher, W., Li, R., Yuan, J., **Lynch, K.**, & Bromberg, J. E. (submitted). Text to Quit China: A mHealth Smoking Cessation Trial.

Koenig L, Pals S, Chandwani S, **Hodge K**, Abramowitz S, Barnes W, D'Angelo L. 2010. Sexual Transmission Risk Behavior of Adolescents With HIV Acquired Perinatally or Through Risky Behaviors, *JAIDS* 55, 3, 380-390.

Koenig L, Espinoza L, **Hodge K**, Ruffo N. 2007. Young, seropositive and pregnant: Epidemiologic and psychosocial perspectives on pregnant adolescents with human immunodeficiency virus infection. *American Journal of Obstetrics and Gynecology*, 197, 3Suppl, S123-31.

Dvordjevic, M., **Lynch, K**., Bromberg J. E. (2014). NIH Funding of Waterpipe Research. To be presented at the (The 2nd International Conference on Waterpipe Smoking, Qatar, October 2014).

Bromberg, J. E., **Lynch, K**., Augustson, E. (2014) Text to Quit China: A mHealth Smoking Cessation Trial. Presentation to be given at the Global mHealth Forum at the mHealth Summit – Shared Concurrent Session, Washington, DC. December 2014.

Dvordjevic, M., **Lynch, K**., Bromberg J. E. (2015). Global Waterpipe Research Funding. To be presented at the World Conference on Tobacco or Health, Abu Dhabi, United Arab Emirates, March 2015.

Koenig LJ, **Hodge K**, Chandwani S, Abramowitz S, LaGrange R, D'Angelo L. (December, 2007) Paper presented at the annual meeting of the HIV Prevention Conference, Atlanta, GA.

Koenig LJ, **Hodge K**, Chandwani S, Abramowitz S, LaGrange R, D'Angelo L. (August, 2008) Transmission risk and prevention needs of sexually active HIV-positive youth. Paper presented at the annual meeting of the American Psychological Association, Boston MA.

ADDITIONAL INFORMATION

Skills: Quantitative and qualitative data collection and analysis, survey development, anthropometry and fitness measurements, motivational interviewing, intermediate Spanish language- speaking, reading, and writing.

Personal statement of research interests

My research interests include health promotion, maternal and child nutrition, early child feeding behavior, adolescent health, and obesity prevention interventions.

Keywords
Child Nutrition; Health Education; Behavioral Science; Tobacco Control; Community Needs Assessment; HIV Epidemiology; Adolescent Risk Behavior.