DISSERTATION

HEALTHY HOMES: EXPLORING THE QUALITY OF THE HOME FOOD ENVIRONMENT AND MATERNAL HEALTH FACTORS

Submitted by

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ABSTRACT

HEALTHY HOMES: EXPLORING THE QUALITY OF THE HOME FOOD ENVIRONMENT AND MATERNAL HEALTH FACTORS

Background: Child overweight and obesity is a public health concern as it leads to health risks in childhood and later in life, such as increased risk factors for developing cardiovascular disease and Type 2 Diabetes. In the past several years, research has focused on child weight status in relation to the physical home environment (home food availability, presence of physical activity equipment/electronic devices) and the social home environment (parent feeding behaviors/styles, expectations, role modeling of dietary intake). Parents substantially contribute to the physical and social aspects of the home that may impact both adult and child obesity. When considering the physical environment in terms of home food availability, several studies have found significant outcomes that relate home food availability to intake – i.e., if it is in the home, the diet shows that food is often included in intake. This has been shown for individual foods, however, no tool currently exists that describes the overall *quality* of the home food environment. Relationships have also been reported for parent-child dietary intake, and select parent-child health factors, such as body mass index, blood pressure, and clustering of cardiovascular risk factors. What is currently unknown is how measures of overall quality for the home food environment, parental dietary quality, parent overall health associate with each other in the home environment, and how they associate with child weight status.

Purpose: The purpose of this research is two-fold, 1) to create a metric for describing the overall quality or patterning of the home food environment, the Home-IDEA Quality Score, and

2) to assess relationships among the quality of the home food environment, maternal dietary quality, maternal health indicators and child weight status in a multi-ethnic sample of mothers with young children (the Family Health Study).

Methods: The Home-IDEA Quality Score was developed using the Healthy Eating Index 2010 algorithms (https://epi.grants.cancer.gov/hei/) and evaluated against the National Food Acquisition and Purchase Survey food-at-home data set (https://www.ers.usda.gov/data-products/foodaps-national-household-food-acquisition-and-purchase-survey.aspx). Development and evaluation included assessments for content and criterion validity, and reliability. The Family Health Study included the following assessments for mothers: mailed surveys (Health History and Demographics Form, International Physical Activity Questionnaire – Short Form, and the Home Inventory for Describing Eating and Activity), in-person assessments of maternal cardiovascular risk factors (lipids, blood glucose, blood pressure, height, weight, waist circumference) and a facilitated 24-hr dietary recall using the National Cancer Institute's Automated Self-Administered 24-hr recall system (https://epi.grants.cancer.gov/asa24/). Child height and weight were measured in-person. Data were collapsed into quality variables – the Home-IDEA Quality Score, Maternal Dietary Quality, and Maternal cardiovascular risk (as a sum score of five cardiovascular risk factors). Differences by income for participant characteristics, the Home-IDEA Quality Score, Maternal Dietary Quality, Maternal cardiovascular risk and individual maternal cardiovascular risk factors were assessed with Kolmogorov-Smirnov Z and Chi-Square tests. Pearson and Spearman correlations were used to assess relationships among the home food environment with maternal dietary intake, and maternal health factors with child weight status. Linear regression models were constructed to further visualize relationships of the quality of the home food environment with maternal dietary quality, and for the prediction of child weight status based on maternal cardiovascular risk.

Results: A metric for describing the overall quality of the home food environment (The Home-IDEA Quality Score) was successfully developed and evaluated. The exploratory Family Health Study demonstrated feasibility by collecting data that described the quality of the home food environment, maternal dietary quality, and overall maternal health with 85 mother-child dyads from 16 preschools in Colorado. Utilizing categories similar to the Healthy Eating Index, home food quality was characterized as 'needs improvement' with mean scores ranging from 72.41-76.20. Maternal Dietary Quality was characterized as 'poor' to 'needs improvement' with scores ranging from 45.75-52.74. The four most prevalent cardiovascular risk factors included increased waist circumference (69%), low high density lipoprotein cholesterol (HDL-C) (49%)), high triglycerides (48%), metabolic syndrome (39%). Mothers with low HDL-C (odds ratio 4.35, CI 1.59-11.92), high HbA1c (odds ratio 4.21, CI 1.13-15.71), overweight/obese (odds ratio 2.66, CI 1.02-6.93), and metabolic syndrome (odds ratio 3.05, CI 1.07-8.66), had greater odds of being low-income than non-low income. Linear regression models for Maternal Dietary Quality and Child Weight Status were significant; the Home-IDEA Quality Score explained 9.1% of the variance in Maternal Dietary Quality, and Maternal CVD Health explained 9.4% of the variance in Child Weight Status.

Discussion: The development and evaluation of the Home-IDEA Quality Score produced a novel tool for assessing the home food environment, which was successfully used in the analysis of the Family Health Study to characterize the overall quality of the home food environment. Future research on the Home-IDEA Quality Score should include refining the Home-IDEA Checklist to include items that are missing, but that regularly appear in homes, such as canned soup and ready-to-eat baked goods, and separating composite items, such as lettuce, into separate items (regular lettuces – head lettuce, butter lettuce, leaf lettuce; dark green lettuces – kale, spinach, chard) that better profile the wide differences in nutrition across specific types of similar items. Additionally, it is recommended that the food amounts for shelf-stable foods be examined, such as for peanut butter, which could be contributing to ceiling effects for Seafood & Plant Proteins.

In terms of the findings from the Family Health Study, the linear regression model indicated that the Home-IDEA Quality Score was a significant contributor to the full model for predicting variance in Maternal Dietary Quality, a novel finding that adds to the literature. Additionally, Maternal CVD health was also a significant contributor to the linear regression model for examining predictors of variance in Child Weight Status. This extends the research literature in that few studies have examined multiple cardiovascular risk factors in mothers with young children for relationships with child weight status. From a public health perspective, it is troubling that the percentages of mothers with multiple cardiovascular risk factors was unexpectedly high – and as in the case of low HDL-C, substantially greater than available national averages. Colorado has long been considered a healthier state from an obesity perspective; however, the data from the Family Health Study indicate that this is simply not the case in this sample of rural, predominately low-income, multi-ethnic mothers of young children. Future research studies and public health programming should consider interventions in mothers of young children to improve health profiles.

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CHAPTER 1: INTRODUCTION

Overview

An ecological approach to obesity and chronic disease prevention indicates that the behaviors related to dietary intake and physical activity (or lack of) must be addressed in multiple environments: home, work, and community[1]. In the past several years, research has focused on child weight status in relation to the physical home environment (home food availability[2,3], presence of physical activity equipment/electronic devices) and the social home environment (parent feeding behaviors/styles, expectations, role modeling of dietary intake[4,5]). Several reviews have been published synthesizing these areas; in most cases, there is a general consensus that for children, there are consistent relationships for the above factors. For instance, home food availability of select foods (most studied are fruits, vegetables, dairy, and sugar-sweetened beverages) often positively correlates with intake of the respective food[5,6], authoritative parenting style is often associated with healthier dietary intake and lower child BMI [5,7], and parental dietary intake positively associates with child intake of same foods[5,6]. It is these relationships that provide the context for this dissertation, which will begin with a brief conceptualization of the following areas: the current status of child overweight and obesity, parental influences on child weight status, and the home food environment.

Child Overweight and Obesity

In 2012 in the United States, approximately 37.5% of children ages 2-5 years were characterized as overweight or obese (23.8% overweight, 13.7% obese)[8]. Contrasting this to the rate in Colorado in 2012, when approximately 22% of children ages 2-4 years were characterized as overweight or obese (13% overweight, 9% obese), indicates that Colorado was substantially below the national average for rates of child overweight and obesity[9]. Although still considered a relatively 'lean' state, the child overweight and obesity rates are high enough that the Colorado Department of Public Health & Environment has included obesity as one of its "10 Winnable Battles"[10].

Child overweight and obesity is a public health concern as it leads to health risks in childhood and later in life, such as increased risk factors for developing cardiovascular dysfunction[11], Type 2 Diabetes Mellitus (T2DM)[12], sleep apnea[13], joint problems and musculoskeletal discomfort[14], and non-alcoholic fatty liver disease[15]. These are in addition to the psychological and social issues, such as anxiety and depression[16], lower self-esteem, bullying and stigmatization[17]. Finally, overweight and obese children are more likely to become overweight or obese adults[18,19]; obesity in adulthood is an independent risk factor for developing lifelong chronic diseases, such as cardiovascular disease[20,21], cancer[20], and T2DM[20].

Potential Parental Influences on Child Weight Status

Parents are widely considered the gatekeepers of the home environment[22], and as such, substantially contribute to the physical and social aspects of the home that may impact both adult and child obesity. In terms of the home food environment in families with young children, parents affect the social and physical eating environment through their parenting styles & practices[23], their feeding styles and feeding practices[24], expectations for diet[25,26], and serve as role models for dietary intake[26]. Additionally, research has shown consistent positive correlations between parents and children for body mass index (BMI)[27,28], as well as individual correlates for specific health markers, such as blood pressure[29], or with clusters of cardiovascular risk factors[30-32]. However, there is limited research that measures multiple aspects of parent behavior and health factors concurrently with child weight status.

Potential Home Food Environment Influence on Child Weight Status

In recent years, with the increasing focus on addressing adult obesity and preventing childhood obesity, the home food environment (HFE) has come into focus as a modifiable factor in dietary intake[33,34]. While this is a relatively new area of research, several researchers have found significant outcomes that relate home food availability to intake – i.e., if it is in the home, the diet shows that food is often included in intake[33,35-42]. This makes it reasonable to hypothesize that if you make changes to what types of foods are found in the home, the diet may change respectively. In examining the HFE literature, there is limited research that concurrently examines parent behaviors, such as dietary intake, multiple parent health factors, comprehensive measures of the home food environment, and child weight status.

Specific Aims of this Research

This dissertation covers two topic areas that are related, but presented separately. The topic areas both center on factors that exist within the home environment that may influence child weight status, focusing on home environments of families with young children. The specific aims of this research project are two-fold:

1) To create a metric for describing the overall quality or patterning of the home food environment, the Home-IDEA Quality Score, and

2) To assess relationships among the quality of the home food environment, maternal dietary quality, maternal health indicators and child weight status in a sample of mothers with young children.

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CHAPTER 2: LITERATURE REVIEW

Overview

The prevalence of overweight and obesity among young children continues to be a public health concern[1,2]. As children interact with their environment at multiple different levels, such as at home, school, and within their neighborhoods, it is important to identify the key areas within each environment that promote overweight and obesity[3]. The home is one such environment that has come into focus as a potential modifiable target to improve healthy eating and physical activity behaviors[4]. In families with young children, parents have been identified as the dominant shapers' of their children's lifestyle behaviors[5-8], and as such, serve as role models for dietary intake and physical activity[9-15], in addition to controlling the home food environment (HFE).

When considering examining multiple factors of the home environment – such as the HFE, parental dietary intake, parental health, and child weight status, it would be ideal if composite measures existed that would allow for quality to quality comparisons. Dietary intake data can be analyzed as dietary pattern scores, such as the Mediterranean Diet pattern, DASH Diet pattern, or the Healthy Eating Index (HEI)[16,17]. The ability to measure multiple health factors in addition to weight status for adults also exists in the context of composite risk scores, such as CVD risk[18], or Metabolic Syndrome[19]. Currently, within these constructs, only the HFE does not have a current assessment tool that describes the overall patterning or quality of the HFE. It is the intent of these research projects to develop a tool that will assess the quality of the HFE, and then to apply that tool in an exploratory study that will examine multiple constructs of the home environment that may help determine child weight status.

This literature review is sectioned into two parts that address the two specific aims presented in the Introduction. Part 1, Current Assessment and Analysis Methods in Home Food Environment Research will present information relevant to the motivations and methods for developing the Home-IDEA Quality Score, an overall quality score for the home food environment (HFE). Part 2, Exploring the Home Food Environment and Parental Influences on Child Weight Status, will present information relevant to the motivations and methods for examining the home food environment, and parental dietary intake and health factors in relation to child weight status in the Family Health Study.

Part 1: Current Assessment and Analysis Methods in Home Food Environment Research

In the last few decades, the home food environment (HFE) has come into play as a major factor in dietary intake; such that home food availability has been found to be consistently related to dietary intake for both adults and children[4,13,14,20-26]. This makes it reasonable to hypothesize that if you make changes to what types of foods are found in the home, the diet may change respectively.

Two reviews of the literature have been performed in an attempt to summarize and provide direction for assessment in HFE research. Pinard, et al. (2011) examined assessment tools from the perspective of variables measured and psychometric testing[27]. Gebremariam, et al. (2017), examined assessment tools that measured availability and/or accessibility and reported at least one psychometric property[28]. Both reviews indicated that there is tremendous variety in the way tools assess the HFE. This variety leads to challenges in synthesizing the literature due to issues in consistency of the conceptualization of availability and accessibility, measuring a single or a few specific dietary constructs within the HFE (fat, fruits, vegetables, sugar-sweetened beverages), and limitations in psychometric testing[27,28].

In cases where researchers ask a limited number of questions regarding food in the home, e.g. are these fruits in the home, are these vegetables in the home, the results are often analyzed for associations with intake of the same fruit/vegetable, or intake by food group[29-32]. More comprehensive measures, such as barcode scanning[21,33] or researcher-completed checklists[34,35], are resource/labor intensive and not feasible in all instances, however they can be analyzed for multiple foods/food groups to dietary intake, potentially providing a more rounded evaluation of the overall environment to overall diet. A limited number of tools have been developed that attempt to be reasonably comprehensive without being burdensome to respondents, and have been validated as self-report tools, thus reducing both researcher and respondent burden[28].

There is very limited literature indicating ways in which investigators have created an overall quality score, or some other overall score of the home food environment, outside of categorizing foods as core (foods considered healthful/nutrient dense – such as fruits, vegetables, whole grains, lean proteins) vs non-core (foods considered less-healthful/energy dense, high-fat, sugar-sweetened)[26,36]. Since individuals eat foods in combination, rather than in single item intake or food group, a way to create a comprehensive pattern or overall quality score would be beneficial. It would allow us to mimic the research literature that examines dietary patterns [16,17,37-40], thus providing the opportunity to compare the quality of the HFE to the quality of dietary intake.

Creating a Home Food Quality Score Using the Healthy Eating Index as a Model

The Healthy Eating Index

The Healthy Eating Index (HEI) was developed by the US Department of Agriculture (USDA) Center for Nutrition Policy and Promotion (CNPP)[41-43]. It is an index-based guideline for measuring adherence of a given dietary intake to the Dietary Guidelines for Americans[44] (DGA). The HEI was developed in the mid-1990's in response to the request for a way to summarize the nutrient needs and dietary guidelines into a single measure for the US consumer[41]. It was revised to reflect the 2005[42] and 2010[43] DGAs; revisions are currently underway that will reflect the 2015 DGAs. The HEI-2010 version was selected for use in this research project as the timeframe for data collection occurred between the 2010 and 2015 DGA editions, therefore dietary intake data would be reflective of the 2010 DGAs.

The HEI-2010 is comprised of 12 Components and a Total Score (Table 1)[43]. The 12 Components reflect both nutrients that are discussed in terms of adequacy (or to increase intake of; higher intakes will result in higher Component scores), and nutrients to consume in moderation (decrease intake of; lower intakes of these Components result in higher Component scores). The adequacy Components include Total Vegetables, Greens & Beans/Peas, Total Fruit, Whole Fruit, Whole Grains, Total Dairy, Total Protein, Seafood & Plant Proteins, and Fatty Acid Ratio. The moderation Components include Sodium, Refined Grains, and SoFAAS (Solid Fats, Alcohol, and Added Sugars). The intake amounts selected for maximum scores were set using the least-restrictive recommendations among those for 1,200-2,400 calorie levels, regardless of age or sex, consistent with their development for the HEI-2005[42]. According to the developers, total scores may be interpreted as: >80 "good", 51-80 "needs improvement", and <51 "poor"[41].

Table 1: **Healthy** Eating Index-2010 Component and Total Scores[a]

HEI-2010 Components	Range of Scores	Relationship to 2010 Dietary Guidelines for Americans	
		Maximum score[b]	Minimum score[b]
		Per 1000 calories	
Total Vegetables[c]	0-5	≥1.1 cup equiv.	No Vegetables
Greens and Beans[c]	0-5	≥0.2 cup equiv.	No Dark Green Vegetables or Beans/Peas
Total Fruit[d]	0-5	≥0.8 cup equiv.	No Fruit
Whole Fruit[e]	0-5	≥0.4 cup equiv.	No Whole Fruit
Whole Grains	0-10	≥1.5 oz equiv.	No Whole Grains
Dairy[f]	0-10	≥1.3 cup equiv.	No Dairy
Total Protein Foods[g]	0-5	≥2.5 oz equiv.	No Protein Foods
Seafood and Plant Proteins[g,h]	0-5	≥0.8 oz equiv.	No Seafood or Plant Proteins
Fatty Acid Ratio[i]	0-10	≥2.5	≤1.2
Sodium	0-10	≤1.1 gram	≥2.0 grams
Refined Grains	0-10	≤1.8 oz equiv.	≥4.3 oz equiv.
SoFAAS Calories[j]	0-20	≤19% of energy	≥50% of energy
Total Score	0-100		

HEI: Healthy Eating Index; equiv.: equivalent; oz: ounce; SoFAAS: Solid Fats, Alcohol, Added Sugars

[a]Adapted from https://epi.grants.cancer.gov/hei/developing.html

[b]Intakes between the minimum and maximum standards are scored proportionately. Nine components are scored for intakes in terms of nutritional adequacy; three components (Sodium, Refined Grains, SoFAAS calories) are scored for moderation of nutritional intake, that is, reverse scored so higher intakes result in lower component scores. Development of the scoring rubric has been previously described in detail.[42]

[c]Includes any beans and peas not counted as Total Protein Foods.

[d]Includes 100% fruit juice.

[e]Includes all forms except juice.

[f]Includes all milk products, such as fluid milk, yogurt, and cheese, and fortified soy beverages. Dairy products are fractionated to reflect only the low-fat portion of diary. The fatty portions of diary are segregated to the Fatty Acid Ratio Component, where they are reflected as saturated fat.

[g]Beans and peas are included here (and not with vegetables) when the Total Protein Foods standard is otherwise not met. Meat products are fractionated to reflect only the low-fat portion of meat. The fatty portions of meat are segregated to the Fatty Acid Ratio Component, where they are reflected as saturated fat.

[h]Includes seafood, nuts, seeds, soy products (other than beverages) as well as beans and peas counted as Total Protein Foods.

[i]Ratio PUFAs and MUFAs to SFAs. (PUFAs + MUFAs)/ SFAs

[j]Calories from solid fats, alcohol, and added sugars; threshold for counting alcohol is >13 grams/1000 kcal.

The HEI-2010 is density-based, or a relative measure, meaning that the intake of a given Component is scored based on the intake per 1,000 calories, thus dissociating the pattern from absolute caloric content. Because the HEI is not a measure of energy balance, and therefore may not be reflective of over- or under-consumption of energy, it is typically not analyzed for associations with body mass index (BMI), which is often interpreted as a proxy for energy intake. Rather, as a measure of nutrient density, it may be sensitive to health measures that are, in part, reflective of the nutrient composition of diets, such as biomarkers of fruit and vegetable intake[45], inflammation[46], or health outcomes such as Metabolic Syndrome[47], cardiovascular disease, cancer, or mortality[38,48-50]. The intersection of the HEI-2010 and health outcomes will be discussed in more detail in Part 2 of this literature review, when maternal health factors are presented as a component of interest for the Family Health Study.

Examining Validity and Reliability of the Healthy Eating Index

Considerable effort was taken by the CNPP to measure and report the methods used to assess validity and reliability during development and evaluation of the HEI, throughout all versions. In the 2005 and 2010 updates, several measures were described in detail (Table 2)[42,43,51], allowing researchers to understand how the HEI works and provide more clarity for interpretation of HEI Components and Total Score. The detail provided by CNPP is also helpful in that it creates a 'roadmap' for others to follow in evaluating their own data when developing complementary tools or using the HEI at different levels of the food stream.

Table 2: Psychometric Properties Examined for the Healthy Eating Index 2005 and 2010 Updates

Property	Evaluation Question	Analysis Strategy
Validity		
Content validity	Does the index capture the various key aspects of diet quality specified in the *Dietary Guidelines for Americans?*	Checked HEI components against the respective version of *Dietary Guidelines for Americans*
	Does the index measure what it is supposed to be measuring as judged by nutrition experts, i.e., does it have face validity?	Reviewed scores of selected NHANES 24-hr recall reports
Construct validity	Does the index give maximum scores to menus developed by nutrition experts to illustrate high diet quality?	Computed scores for menus from USDA's MyPyramid, NHLBI's DASH Eating Plan, Harvard's Healthy Eating Pyramid, and the American Heart Association's No-Fad Diet
	Does the index distinguish between groups with known differences in diet quality, i.e., does it have concurrent criterion validity?	Compared scores of smokers and nonsmokers Compared scores of men and women, younger and older adults
	Does the index measure diet quality independent of diet quantity?	Estimated Pearson's correlations between component scores and energy intake
	What is the underlying structure of the index components, i.e., does it have more than one dimension?	Examined structure by using a principal components analysis
	Are the total and component scores sufficiently sensitive to detect meaningful differences?	Examined population distributions of total and component scores
Reliability		
Internal consistency	How reliable is the total index score if diet quality is found to have one dimension?	Determined Cronbach's coefficient alpha
	What are the relationships among the index components?	Estimated Pearson's correlations among component scores
	Which components have the most influence on the total score?	Estimated correlations between each component and the sum of all others

HEI: Healthy Eating Index; NHANES: National Health and Nutrition Examination Survey; USDA: United States Department of Agriculture; NHLBI: National Heart Lung and Blood Institute; DASH: Dietary Approaches to Stop Hypertension

In the last decade, in addition to analysis of dietary intake[16,17,40,51,52], researchers have applied the HEI algorithms to the national food supply[53], and to aspects of the community food environment, such as fast food restaurant menus[54], child care centers[55], food pantries[56], supermarket circulars[57], grocery carts[58], and corner stores[59]. This is possible because it is a density measure, and so may be used to assess any combination of foods as long as they can be linked to specific nutrition content that is scaled for the measured food amount. The HEI-2010 was selected as the foundation for developing a home food quality score due to its successful application at various types of community food environments, and because the CNPP outlines a 3-step process for applying the algorithm at any level of the food stream (Figure 1).

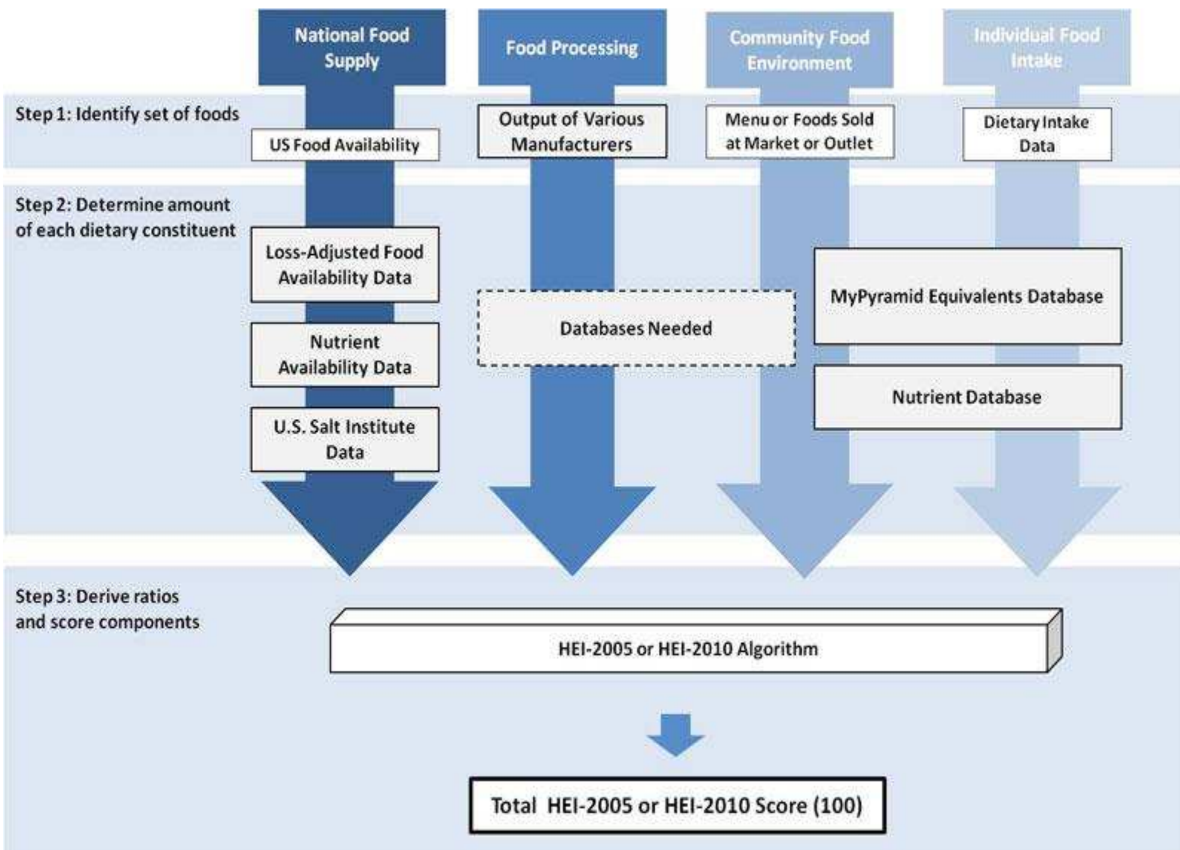

Figure 1: Steps required for deriving HEI scores across each of the four levels of the food stream.

From https://epi.grants.cancer.gov/hei/tools.html.

The 3-step process involves identifying a set of foods (Step 1), determining the amount of each dietary constituent (Step 2), and then applying the provided algorithms to generate the Components and Total Score (Step 3). As depicted in Figure 1, at the individual food intake level, Step 1 is completed by capturing dietary intake data. This could be done by completing a 24-hr recall or a Food Frequency Questionnaire (FFQ). When analyzing a 24-hr recall or a FFQ, the data are entered into a software program that assigns a food code to a given item based on the description of the food. These food codes are the same as the food codes in the Food and Nutrient Database for Dietary Studies (FNDDS), or the Food Patterns Equivalents Database (FPED, formerly the MyPyramid Equivalents Database), which are used in the HEI algorithm when calculating the Components and Total Score. Additionally, a 24-hr recall and FFQ also contain amounts of foods consumed, so in the analysis, food amounts are already present (Step 2). Therefore, application of the HEI algorithms (Step 3), is quite straight forward, as the original data collection methods include the content needed for Steps 1 and 2.

At other food stream levels, this process becomes more complicated. In instances where foods may be identified by barcodes, such as in a grocery store[60], corner store[59], or shelf items in a food pantry[56], those barcodes are directly linked to databases that contain the FNDDS codes. In analysis of restaurant menus, in many cases, vendors have already compiled nutrition information to describe menu items, and in cases where that information is unavailable, it is possible to enter the menu items into nutrition analysis software, similarly as done for 24-hr recalls[54]. In cases such as the national food supply, multiple databases must be accessed to compile food descriptions that may be linked to FNDDS codes[61]. At the level of the home food environment, current methods would require the use a barcode scanner, or comprehensive records of every food by type/brand and amount would have to be obtained for entry into a nutrition analysis software in order to complete Steps 1 and 2.

Developing a Valid and Reliable Home Food Quality Score

To develop a Home Food Quality Score by applying the HEI algorithms, it is necessary to identify a set of foods (Step 1), and to determine the amount of dietary constituents in each food – which requires linking to nutrient databases such as the FNDDS or the FPED (Step 2). In considering tools that could be used to identify a set of foods in the home food environment, several concepts need to be considered, including comprehensiveness (to examine a pattern, multiple food types that span all HEI Components must by captured), researcher and participant burden, and reported psychometric testing.

First, tools would need to be comprehensive enough to sample sufficient foods for representation within all 12 HEI Components. Therefore, tools that sample only a single type of food (sugar-sweetened beverages), or a limited number of food groups (fruits, vegetables) would not provide sufficient breadth of data to accurately represent a complete pattern. This leaves one comprehensive checklist (the Home Inventory for Describing Eating and Activity – Home-IDEA), and barcoding as possible instruments that could be used to develop a home food availability quality score.

The second consideration is burdensome, from both researcher and participant perspectives. From a research perspective, barcoding can be cost-prohibitive as well as burdensome on the participant as they have to scan all foods that are present, and additionally deal separately with foods that do not have barcodes, such as produce and foods from bulk bins. However, barcoding automatically captures the exact amount of food and links the food directly to databases that contain FNDDS codes. Comprehensive checklists, on the other hand, are typically generalized, in that they sample food generically, such that "apple" may represent any type of apple (Granny Smith, Macintosh, Red Delicious), in any form (fresh, frozen, or canned), in any amount (one or multiples). While cost and participant burden are substantially reduced with the use of comprehensive checklists, researcher burden is temporarily increased in that another step would be required for identifying FNDDS codes and food amounts for the foods on a given checklist.

When considering the quality of data that would potentially result from using barcoding versus a comprehensive checklist, the limitations of barcoding should be weighed against reported psychometric properties of various checklists. As mentioned previously, a significant concern for the use of barcode scanners is participant burden. The increased burden creates the potential for substantial reporting effects, specifically selective and under-reporting. The potential for participants to simply not scan all the foods in their home food inventory (which requires substantial effort to go through the entire kitchen and food storage areas, item by item) is high, in addition to not capturing foods that are present but do not have barcodes. Unless steps are taken to additionally sample the home environment in an effort to measure burn-out or under-reporting, it would be difficult to assess the overall quality of the data in a large sample. In comparison, the one published comprehensive checklist available, the Home-IDEA had been validated for self-report through inter-rater reliability[62], and was independently reported as having a strong rating based on psychometric properties by Gebremariam, et al.[28] The use of this tool would not only be less expensive, but theoretically have lower participant burden and thus, potentially less burn-out or under-reporting in comparison to sampling with barcode scanners.

The Home-IDEA Checklist

The Home-IDEA Checklist is a self-report checklist of a limited number of foods (108) that cover several food groups (vegetables, fruit, grains, protein, dairy) and captures selected processed, sweet, and snack foods; it additionally captures physical activity and electronic equipment in the home[62]. The Home-IDEA has been validated in in low-income, multi-ethnic households with young children[62,63]. Currently the Home-IDEA has been analyzed by creating summary scores of types of foods in the household, e.g. number of fruits, number of vegetables, number of whole grains, and correlated with dietary intake of the same food group[62,63].

One challenge in applying the HEI 3-step process to a food inventory checklist like the Home-IDEA Checklist, is that the process requires the foods surveyed to be linked to a nutrition database (Step 2, Figure 1), such as the Food Nutrition Database for Dietary Studies (FNDDS) or the Food Pattern Equivalents Database (FPED). The Home-IDEA Checklist does not capture a specific food in a manner that would facilitate linking to a food code present in the FNDDS or FPED databases. While it provides the identified set of foods as specified in Step 1 of the 3-step process, the foods are incomplete. Because it is missing both direct links to food codes and a measure of food amount, a database is needed to provide that information in a way that may be linked both to FNDDS/FPED food codes and back to the foods indicated as present in the home via the Checklist. This database would support the Checklist, providing the necessary content for application of the HEI algorithm (Step 3). Currently, only one large, nationally representative home food inventory database exists, which is part of the National Food Acquisition and Purchase Survey[64].

The National Food Acquisition and Purchase Survey

The National Food Acquisition and Purchase Survey (FoodAPS) was a joint survey performed by the USDA Economic Research Service (ERS) and the Food and Nutrition Service (FNS) from April 2012 through January 2013[64]. It is the first, and currently only, survey where detailed information regarding food acquisitions and purchases was collected across a national sample of 4,826 households. The survey collected detailed data about all types of foods purchased from any outlet (e.g. grocery stores, corner stores, food assistance programs, vending machines, restaurants, fast-foods) that were intended to be consumed at home or away from home during a 1-week timeframe. The data were collected as self-report, through barcode scanners and purchase receipts; a booklet was provided that had additional barcodes for produce and foods obtained from bulk bins. A multi-level complex sampling method was used that sampled from four subgroups based on income: 1) households participating in the Supplemental Nutrition Assistance Program (SNAP), 2) households below the 100% poverty guideline, but not participating in SNAP, 3) households between the 100%-185% poverty guideline, but not participating in SNAP, and 4) households with greater than 185% of the poverty guideline and not participating in SNAP. The FoodAPS database houses several data sets, such as household food inventories, food away from home consumption, individual meal/snack consumption data, geographical locations of where food was consumed or purchased, household level characteristics, and individual-level characteristics. The household food inventory dataset includes foods and food amounts that are linked to FNDDS codes.

The use of the FoodAPS food at home data set could address a critical underlying validity assumption as it provides a way to operationalize a generic food into a specific food with a corresponding food code and food amount. Because the FoodAPS food at home data set includes FNDDS food codes, food descriptions, and measured food amounts as found in homes, it provides a viable database for use at Step 2 (identifying dietary constituents) of developing a home food quality score.

The FoodAPS has reported its own set of limitations in study design and data collection on its website under Data Quality and Accuracy (https://www.ers.usda.gov/data-products/foodaps-national-household-food-acquisition-and-purchase-survey/data-quality-and-accuracy/#evaluation), in addition to several publications[65-67]. Several studies have examined the FoodAPS data sets, including, but not limited to, comparisons of data to other national survey data (includes demographic and household descriptors)[68], food store choices[69], household characteristics in context of child weight status[70], and in context of family food decisions[71]. Only one study was found that used the FoodAPS data in a manner similar to that proposed in this research project, as a dataset for development and validation of a tool, in this case developing a method to measure the quality of grocery purchases[58]. The main limitations that could potentially affect the outcomes of this research project include, but are not limited to, those that underlie the food at home data, such as self-selection bias of the participants, under- or selective-reporting of foods in the home, incomplete reporting, and technology or burden issues with reporting (record book and bar-code scanning).

Validity and Reliability Tests for Tool Development

Whenever one attempts to develop a tool, it is strongly advised that validity and reliability be assessed to ensure integrity of the tool and that its results can be confidently interpreted. There are several types of validity and reliability, which are selectively applied depending on the use of the tool. As the Home-IDEA Quality Score will be developed using HEI algorithms, validity and reliability will be discussed as they relate to the HEI[42,43,51].

There are three main types of validity that are relevant to the HEI and, thus the development of a home food quality score: Content, Construct, and Criterion. Content validity includes both face and domain[72], both of which were examined during the development of the HEI-2005[42] and HEI-2010[43,51]. Content validity if often assessed using experts in the field for face and domain validity. Face validity is a measure of whether or not the items look like they measure what they should measure, for example, does the index measure diet quality as assessed by nutrition experts. Domain validity is a measure of whether or not the tool items match content domain or a theoretical construct, for example, do the Components represent the Dietary Guidelines for Americans[44].

Construct validity[72] can be both convergent or discriminant, i.e., associated or not associated with the items it should or should not be associated with, respectively. Criterion validity[72] occurs when the correlation between a test variable and a criterion variable is representative of a construct/theory. In the case of the HEI development and evaluation, criterion validity was lumped in with construct validity (Table 2), and evaluated several ways, to include ability to measure high-quality diets, distinguish between groups with known dietary differences, diet quality independent of diet quantity, multiple underlying dimensions, and sensitive enough to detect meaningful differences across a wide range of scores[51].

Reliability[72] in tool development is often assessed via test-retest or inter-rater reliability. Since the data underlying the application of the algorithm would not change when testing the algorithm, and there is no variation in application of the algorithm, these tests were not applicable in the development and evaluation of the HEI[51]. Additionally, in a home-food environment it would be expected that the home food inventory would change every day, therefore test-retest procedures would automatically report that variation, which would not adequately meet the statistical assumptions of the test – that all variation would be due to the test taker, not do to fluctuations in the content of what is being measured. Internal consistency reliability of the HEI-2005/2010 Components and Total Score were assessed through Cronbach's alpha, and Pearson's correlations were conducted to examine and visualize theoretical constructs regarding relationships among the Components and Total Score (Table 2)[51]. Cronbach's alpha is a measure of how well the Component and Total Scores associate with each other. Pearson's correlations among the Components and Total Score provided reliability information in the context of theoretical constructs about how the Components interacted with each other and the Total Score. It was theorized that the SoFAAS Component would have a higher correlation with the Total score as it contributes up to 20 points to the Total Score, whereas all other Components contribute 5 or 10 points.

Part 2: Exploring the Home Food Environment and Parental Influences in Relation to Child Weight Status

Potential Influence of the Home Food Environment on Child Weight Status

Many cross-sectional studies that measure the home food environment have shown positive relationships between the presence of certain food items, e.g. fruits, vegetables, sugar-sweetened beverages, non-core foods, in the home and child intake of the respective food[4,13,20,23,25,26,32,36,73]. There is much less literature for longitudinal and intervention-based work that measures the home food environment as an outcome variable of interest. Three studies were noted that reported changes in the home food environment at post-intervention[23,74,75], with minimal, if any, changes in the home food environment remaining significant at later follow-up time-points[74,75]. Interventions more often report dietary intake as the outcome of interest, and while the intervention components may focus on increasing availability or offerings of a particular food, aspects of the home food environment are described rather than analyzed as an outcome of interest[11,76,77].

Dietary intake, in terms of caloric density[78] and consumption of select food groups (core/non-core food[78], fruits/vegetables[10], fruit juice[79]) has been associated with weight status in children. Additionally, as described above, the availability of food in the home has been positively associated with intake of the respective food. Therefore, it is reasonable to hypothesize that foods in the home food environment may be reflective of weight status for individuals that consume the majority of their food intake from their home food inventory. The potential impact of the home food environment on dietary intake may be stronger for younger children than for adolescents or young adults, given that younger children are still highly dependent on their parent(s) for the provision of food[12,25,80,81].

Potential Parental Influences on Child Weight Status

Many parental behaviors have been identified as potential influences on child weight status; these include general parenting styles & practices[82], parenting feeding styles and feeding practices[80], and parent role modeling and expectations around diet[14,83] and physical activity[15,84]. Additionally, research has shown consistent positive correlations between parents and children for body mass index (BMI)[85,86], as well as individual correlates for specific health markers, such as blood pressure[87], or with clusters of cardiovascular risk factors[88-90]. The literature is more substantive for maternal relationships than for paternal relationships, indicating that mothers are the most often studied parent. Therefore, the focus of the next two sections will be limited to discussion of maternal dietary intake and maternal health factors.

Maternal Dietary Intake

Within the context of parent role modeling diet behaviors, maternal dietary intake has been reported as an important predictor of child intake, across several dietary components (non-core snacks, non-core drinks, fruits/vegetables)[36,91]. In most cases dietary intake is reported in cross-sectional studies, with associations noted between mother and child. Relationships among mother and child dietary intake have been studied in infants[21], young children[12,92], and adolescents[12,76,77]. In a systematic review of reviews, De Vet, et al. (2011) examined the state of the literature with regard to environmental influences on physical activity and dietary behaviors in children and adolescents[93]. The authors included 232 unique studies describing environmental correlates of dietary behavior; of which dietary modeling, most often described through dietary intake, was one of the few correlates consistently and positively associated with dietary intake for both children and adolescents.

In terms of overall diet quality, such as diet adherence to a Mediterranean diet pattern, DASH dietary pattern, or the Healthy Eating Index (HEI), the literature is sparse for studies of maternal dietary quality or family dietary quality. What is known is that, at the national level, for individuals aged 20-29 and 30-44 years, using NHANES 2007-2010 data, the mean Healthy Eating Index-2010 Total Scores are low, at 48.8 (CI: 47.2-50.5) and 53.8 (CI: 51.6-56.0) respectively, with a population mean for individuals ≥20 years of 55.9 (CI: 54.4-57.3)[94]. The 20-29 age group's HEI Total Score is considered 'poor' (scores below 50), whereas the individuals ages 30-44 years was marginally better, with a score that falls at the bottom of the 'needs improvement' range (scores of 51-80)[41].

Three studies were identified that looked specifically at family diet patterns, or maternal diet patterns. The first, a study performed by Fisk and colleagues (2011), examined a 'prudent' diet pattern that was characterized by high consumption of fruit, vegetables, whole grain bread. Greater adherence to the 'prudent' diet pattern was reported to explain 24.0-30.5% of the variance in the overall quality of child diet.[95] The second study reported that adherence to the Mediterranean diet pattern or the HEI pattern was associated with increased blood-cord insulin and markers of insulin resistance during pregnancy[96]. The third, by Blake and colleagues (2011), examining family clustering, reported that families that clustered into the home-cooking category also had higher HEI-2005 scores than families that clustered into the individualized eating and the missing meals clusters [97].

In the context of child weight status, the literature does not provide much clarity of whether maternal dietary intake is related to child weight status. There is context that select eating behaviors, such as disinhibited[98] or restrictive eating behaviors[99] may be correlated or indirectly predictive of child eating behavior and, thus weight status. However, these types of studies are often designed to investigate the context of disordered eating patterns, and so generalizations are not appropriate. It is therefore, unknown if maternal dietary intake will directly correlate with child weight status in the target population of low-income, multi-ethnic families.

Maternal Health Factors

The interest in health characteristics as a potential influence on the home food environment stems from the current obesity crisis, in that 78% of the adult population and 30% of the child population is considered overweight or obese[1]. It has been well-established that parental weight status is often strongly associated with child weight status[100-102], that parental obesity is a significant risk factor for child obesity[103], and that obese children are more likely to become obese adults[100,104]. In adults, obesity is an independent risk factor for cardiovascular disease (CVD) [105], cancer[106], Type 2 Diabetes (T2DM)[106,107], which were the first, second, and seventh causes of death in the U.S. in 2015, respectively[108]. As of 2015, physical inactivity was the most prevalent CVD risk factor (50.2%), followed by obesity (37.7%), hypertension (29.0%), use of combustible tobacco products (24.0%), hypercholesterolemia (11.0%), and diabetes (8.7%)[109].

This increased prevalence of a preventable risk factor in what was normally considered a healthy population has incited tremendous concern in the U.S. and increased the focus on preventative services and policies to reduce the impact of obesity in our nation. Even with the increase in preventative focus, adult females, ages 18-40 years, are perceived to be one of the "healthier" groups, and as such receive less attention[110,111]. When you combine this perception with the fact that many females in this age group are also mothers of young children, it is realistic to consider that annual wellness screenings, and thus testing for chronic disease indicators, may not be a high priority in this population. This low-priority status may be even greater for low-income or ethnic populations where there is a disparate burden of chronic disease and obesity coupled with lower access to affordable medical care[112].

From a population perspective, it was challenging to find local, state, or national statistics that describe the overall health of adult females, ages 18-40 years. In most cases, health data were split into three age groups (children ages 2-17 years, adults 18-64 years, and elderly >65 years), by gender, or by ethnicity. Females, ages 20-40 years, the most prevalent ages for childbearing, were typically lumped within the adult category of ages 18-64 years. Various sources were used to compile prevalence percentages for six risk factors for CVD and T2DM that have been calculated for age ranges that are similar to, or encompass, the age range of 20-40 years, and are presented in Table 3. The sources selected all used survey data from the National Health and Nutrition Examination Survey[113-116].

Table 3: Prevalence Percentages for Six Independent Risk Factors for Developing Cardiovascular Disease or Type 2 Diabetes Mellitus for Females Ages 20-64 years

Risk Factor	**All Ethnicities Combined**				**Non-Hispanic White**	**Hispanic**
	Age 20-64 y	**Age 20-44 y**	**Age 20-39 y**	**Age 20-34 y**	**Age 20-64 y**	**Age 20-64 y**
Overweight/ Obesity[a]	66.2%				63.5%	77.1%
High Total Cholesterol[b]	13.0%		6.8%		13.8%	12.5%
Low HDL-C[b]	10.0%		11.7%		10.3%	11.8%
Hypertension[c,d]		10.2%		4.3%	28.0%	28.6%
HbA1c >6.4[d]	9.5%					
HbA1c = 5.7-6.4[d]	33.8%					

y: years. HDL: high density lipoprotein-C; HbA1c: Hemoglobin A1c
[a]National Diabetes Statistics Report: Estimates of Diabetes and Its Burden in the United States, 2014[115]
[b]Total and High-Densitity Lipoprotein Cholesterol in Adults: United States, 2011-2014[113]
[c]Health, United States, 2015: With Special Feature on Racial and Ethnic Health Disparities[116]
[d]Prevalence of and Trends in Diabetes Among Adults in the United States, 1988-2012[114]

Until recently, it was thought that these chronic diseases would only impact individuals once they reached later ages[126], thus annual screenings were only recommended for individuals over the age of 40 years unless multiple risk factors were present[127]. In recent years, both CVD risk factors and T2DM have been diagnosed in younger populations, including youth[126]. Because mothers play a distinct role in forming the home food and activity environment of young children[128], and function as role models for health-related behaviors[129], it would be reasonable to examine if and how maternal physical health factors, such as those that are risk factors for CVD and T2DM, add to the shaping of the home environment[130]. With both the American Heart Association and the American Diabetes Association recommending lifestyle modifications of diet and exercise as a first line treatment for CVD and DM[131,132], identifying parents who may have multiple risk factors for these conditions (among others) is a public health priority. Further, connecting maternal health to home food and dietary strategies in the context of family health interventions could affect positive health changes in parents and children.

Maternal Health Factors: Examining Utility of Risk Profiles

When a sufficient number of risk factors have been collected, they may be grouped into a composite risk profile, such as the Framingham risk profile[117], the American Heart Association/American College of Cardiology Atherosclerotic Cardiovascular Disease risk score (ASCVD)[18], or Metabolic Syndrome[118]. Both the Framingham Risk Profile and ASCVD calculate risk for CVD, are intended for use in older populations, and thus are maximized for individuals over the age of 40. They include the following common factors: age, sex, smoking status, total cholesterol, HDL cholesterol, systolic blood pressure, and the presence of diabetes (Table 4). The FRS was originally developed in 1998 using the data from the Framingham Heart Study[119], with an update to the algorithm in 2008[117]. The ASCVD risk score was developed in 2013 by the ACC/AHA Task Force in conjunction with the NHLBI[18], using a comprehensive review of the literature, which included the Framingham Heart Study. The ASCVD risk score also includes race (dichotomous variable, African American or not African American).

In contrast to the Framingham and ASCVD risk scores, the Metabolic Syndrome does not include age, gender, or smoking status. Additionally, waist circumference has been added as a measure of central adiposity. Metabolic Syndrome has been found to be an independent risk factor for the development of CVD[120] and T2DM[121], and has been applied to younger populations[122,123]. Metabolic Syndrome was formally named in 2001[124], with the criteria being formalized to having three or more of five factors (waist circumference, triglycerides, high-density lipoprotein, blood sugar, and blood pressure) in accordance with the guidelines recommended by the National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) in 2009[118] (Table 4).

Table 4: Risk Profile Factors for the Framingham Cardiovascular Risk Profile, the Atherosclerotic Cardiovascular Disease Risk Score, and the Metabolic Syndrome

	Framingham	**ASCVD**	**Metabolic Syndrome**
Sex	x	x	
Age	x	x	
Race		x	
Blood Pressure	x	x	x
Total Cholesterol	x	x	x
HDL Cholesterol	x	x	x
Blood Sugar			x
Diabetes	x	x	
Smoking status	x	x	
Body Mass Index	x[a]		
Waist Circumference			x

ASCVD: Atherosclerotic Cardiovascular Disease Risk Score
[a]The original model of the Framingham Risk Score does not include body mass index, however, select interactive calculators and reduced models developed in later years do. Reduced models may be found at: https://www.framinghamheartstudy.org/risk-functions/cardiovascular-disease/10-year-risk.php

Given that it is generally believed that health factors such as blood pressure, lipids, and blood sugar are reflective of intake of specific micro and macronutrients, such as sodium[125], trans- and saturated fats[126,127], and refined carbohydrates[128], it would be reasonable to believe that four of the five factors that contribute to Metabolic Syndrome would be reflective of dietary patterning. Greater adherence to patterns with higher nutrient density, such as the Mediterranean diet[129], the DASH diet[130], or the Healthy Eating Index[47], has been reported as negatively correlated with the presence Metabolic Syndrome[131].

Linking Maternal Health Factors, the Home Food Environment, and Child Weight Status

One area of inquiry that is currently limited within the literature is how the home food environment and maternal dietary intake may influence or associate with child weight status. Two studies support this concept, but do not address all aspects. The first, Hermstead et al. (2010), evaluated self-report chronic disease diagnoses in relation to the home food environment for adults, however did not specifically focus on families[149]. Second is Byrd-Bredbenner et al.'s study (2008), which used a complex analysis to evaluate if various maternal characteristics (including BMI and diet) and home environment characteristics (including HFE) would successfully cluster into different categories that would predict maternal dietary quality[105]. These two studies illustrate that there is interest in the HFE and maternal health, however, the literature is currently lacking in studies that attempt to concurrently examine the HFE, maternal dietary intake, multiple facets of maternal health (factors in addition to BMI, and child weight status.

Specific Aims of this Research Project

As previously noted, this dissertation covers two topic areas that are related, but presented separately. The topic areas both center on factors that exist within the home environment that may influence child weight status, focusing on home environments of families with young children. The two specific aims are presented below with research objectives relative to each topic area.

Specific Aim 1: To create a tool, the Home-IDEA Quality Score, that will describe the overall quality or patterning of the home food environment (Chapters 3 & 4). Research Objectives are to:

1) Build a Nutrition Database to support the Home-IDEA Checklist,
2) Merge the Nutrition Database with the Home-IDEA Checklist,
3) Examine content and internal criterion validity of the Nutrition Database through iterative testing, and
4) Examine the resulting Home-IDEA Quality Score for range and sensitivity.
5) Examine external criterion validity and,
6) Test reliability.

Specific Aim 2: To assess relationships among the quality of the home food environment, maternal dietary quality, maternal health indicators and child weight status in a sample of families with young children (Chapters 5 & 6). Research objectives are to:

1) Examine associations among the quality of the home food environment and maternal dietary intake quality, and
2) Explore associations for maternal cardiovascular risk factors with child weight status.

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[1]CHAPTER 3: DEVELOPMENT OF A QUALITY SCORE FOR THE HOME FOOD ENVIRONMENT USING THE HOME-IDEA CHECKLIST AND THE HEI-2010 SCORING ALGORITHM

Summary

Background: Currently, there is not a home food environment tool that addresses the overall quality or patterning of foods in the home that man be directly compared to dietary intake data outside of comparisons of individual foods or by food group. The development of a tool that examines the overall quality of the home food environment would provide the missing component for comprehensive examinations of the contributions of foods from various food outlets with dietary intake quality. **Objective:** Develop a quality score for the home food environment (HFE) using the **Home I**nventory **D**escribing **E**ating and **A**ctivity (Home-IDEA) Checklist and the Healthy Eating Index (HEI)-2010 scoring algorithm. **Design:** The National Food Acquisition and Purchase Survey (FoodAPS) food-at-home dataset was used to construct a Home-IDEA Nutrition Database meeting the criteria to apply the HEI-2010. **Analysis:** Face validity was examined throughout development. Domain and internal criterion validity were analyzed through iterative testing for individual contribution of each food to the HEI components and total score. Range and sensitivity were evaluated on five sample HFEs**. Results:** Content validity was confirmed as most of the selected foods loaded into the HEI components as theorized. Internal criterion validity was demonstrated by most foods impacting the theorized component score with little to no impact on the total score. Range and sensitivity were confirmed by variation in components and total scores for each of the sample HFEs**.**

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[1] The contents of this chapter will be submitted for publication as a manuscript.

Conclusions and Implications: To our knowledge, this is the first quality score for assessing the home food environment. Examining the HFE from a quality perspective, especially one that may be directly compared to HEI scores for individual dietary intake, contributes substantially to the future potential of HFE research.

Key Words: Home Food Environment, Quality Score, Healthy Eating Index, FoodAPS, Tool Development

Introduction

The home food environment (HFE) has received increasing attention as an important factor in the development of food preferences and habits, as a contributor to obesogenic environments, and as a modifiable factor for nutritional interventions; especially those targeting childhood obesity.[1-3] As HFE research has increased in frequency, quantifying foods in the home has resulted in a diversity of measurement tools. Pinard and colleagues (2012) conducted a review of HFE assessment tools and reported that, while a wide variety of tools exist, few have achieved standardization in terms of psychometric testing.[4] Often tools have been designed to fit the researchers' immediate questions, are brief, focus on only one aspect of food availability - such as high-fat foods, sugar-sweetened beverages, or fruits & vegetables - and have limited psychometric testing performed. Checklists are the most common form of tool; completed either by the participant and/or by a trained observer. More comprehensive tools such as bar-code scanning, can reduce coding errors, but are burdensome from a research perspective and often cost- and resource-prohibitive.[5] Inconsistency in content and incomplete psychometric testing make comparisons across studies difficult,[4] and understanding both common and unique aspects of the HFE have been challenging.

Foods in the home are typically reported under categories of similar food groupings (e.g. sugar-sweetened beverages, sweet snacks),[6,7] within the context of food groups (e.g. fruits, vegetables, whole grains),[8,9] or as a composite group of foods promoting an obesogenic environment (core vs non-core).[10,11] Determining the overall food patterning within the HFE in a manner similar to dietary intake patterning (i.e., Healthy Eating Index (HEI), Mediterranean diet pattern, or the Dietary Approaches to Stop Hypertension (DASH) diet pattern) may improve comparisons across studies and facilitate synthesizing data from HFE investigations.[12,13]

The HEI is one approach to dietary patterning that has been formalized to include rules and analysis algorithms that allow for effective comparisons in the overall patterning of foods across different levels of the food supply[14,15]. The HEI is updated to conform to each edition of the Dietary Guidelines for Americans (DGA), with the HEI-2010[16] reflecting diet patterning in conformance with the 2010-DGAs.[17] Briefly, the HEI-2010 scores 12 dietary components for a total score ranging from 0-100. The 12 components are scored on a 5-, 10-, or 20-point basis, and include total vegetables, greens and beans, total fruit, whole fruit, whole grains, dairy, total protein, seafood and plant proteins, fatty acid ratio, sodium, refined grains, and “empty calories” –solid fats, added sugars, and alcohol. All components are scored on a density basis (nutrient content per 1000 kcal).

The HEI may be applied at any food supply level using three steps: 1) identification of a set of foods, 2) determination of the amount of each dietary constituent associated with each food in the set, and 3) deriving ratios to score each HEI component using developed algorithms[18] (Figure 1). The HEI algorithms have been applied to the US food supply level,[19] the community food environment (e.g. food assistance program offerings,[20] supermarket sales circulars,[21] menu offerings,[22] corner stores,[23] grocery purchases,[24] by multiple food purchase locations[25]), and at the individual food intake level (e.g. comparing diet cost to diet quality,[26] comparing different dietary patterns,[27-30] and evaluating differences in mortality outcomes by diet quality[31]).

To date, the HEI-2010 algorithm has not been applied to the HFE, either from a research study specifically examining the HFE or as secondary application to a previously developed measurement tool. Application of the HEI to the HFE would provide a complementary facet in assessing overall food environment patterning. Assessing foods in the home may provide a more comprehensive assessment of available foods over time than assessing grocery carts or other foods obtained away from home alone. Additionally, having a method to assess the overall food quality or patterning in the home environment would allow for direct comparisons to dietary intake quality.

The **Home** **I**nventory for **D**escribing **E**ating and **A**ctivity (Home-IDEA) is a semi-comprehensive checklist designed to assess the foods present in the home at a single point in time. It is the updated version of the original Home Health Environment (HHE) assessment,[32] and includes 108 foods sourced from the Allowable Foods List from the US Special Supplemental Nutrition Program for Women, Infants, and Children (WIC Program), the Block Food Frequency Questionnaire,[33] and the modified Harvard Food Frequency Questionnaire (FFQ).[34] The Home-IDEA was chosen as the basis for developing a HFE quality score using the HEI for three reasons: 1) the high feasibility for individuals to complete the survey, 2) the included foods are relevant to socioeconomically, racially/ethnically, and geographically diverse families with young children, and 3) it has been psychometrically validated.[35,36] The overarching goal of this project was to develop a valid method for calculating an HFE quality score that can be compared to the HEI quality score for individual dietary intake. This project's four main objectives were: 1) develop a nutrition database for the foods included in the Home-IDEA Checklist, 2) merge the Home-IDEA Checklist with the nutrition database to generate a composite data set congruent with the HEI-2010 scoring requirements, 3) examine content and internal criterion validity of the Home-IDEA nutrition database, and 4) test the range and sensitivity of the resulting Home-IDEA HFE Quality Score.

Methods

The Home-IDEA Checklist's 108 foods include 55 individual foods (e.g., apple, banana, 2% milk), 49 composite foods, such as citrus (examples of citrus include oranges, tangerines, grapefruit, clementines) or sweetened cereals, and four write-in options for "other". Participants are asked check "yes" if the listed food item is present in the home at the time of survey completion. All foods in the tool are listed generically and without amounts, therefore a 'representative' food identifying a specific food code that links to the Food and Nutrition Database for Dietary Studies (FNDDS) and a representative food amount for each Home-IDEA Checklist item must be assigned to apply nutrient values. The representative foods and food amounts were sourced from the National Household Food Acquisition and Purchase Survey database (FoodAPS). The FoodAPS is a national survey of 4,826 ethnically and income-diverse households conducted by the USDA Economic Research Service (ERS) and Food and Nutrition Service (FNS) between April 2012 and January 2013.[37] The publicly available, de-identified food-at-home dataset was used for this study (faps_fahnutrients, downloaded January 26, 2017*)*.[37] Figure 2 depicts the tool and datasets used during application of the HEI to the Home-IDEA checklist (following the Center for Nutrition Policy and Promotion's recommended 3-step process), including validity tests for each step.

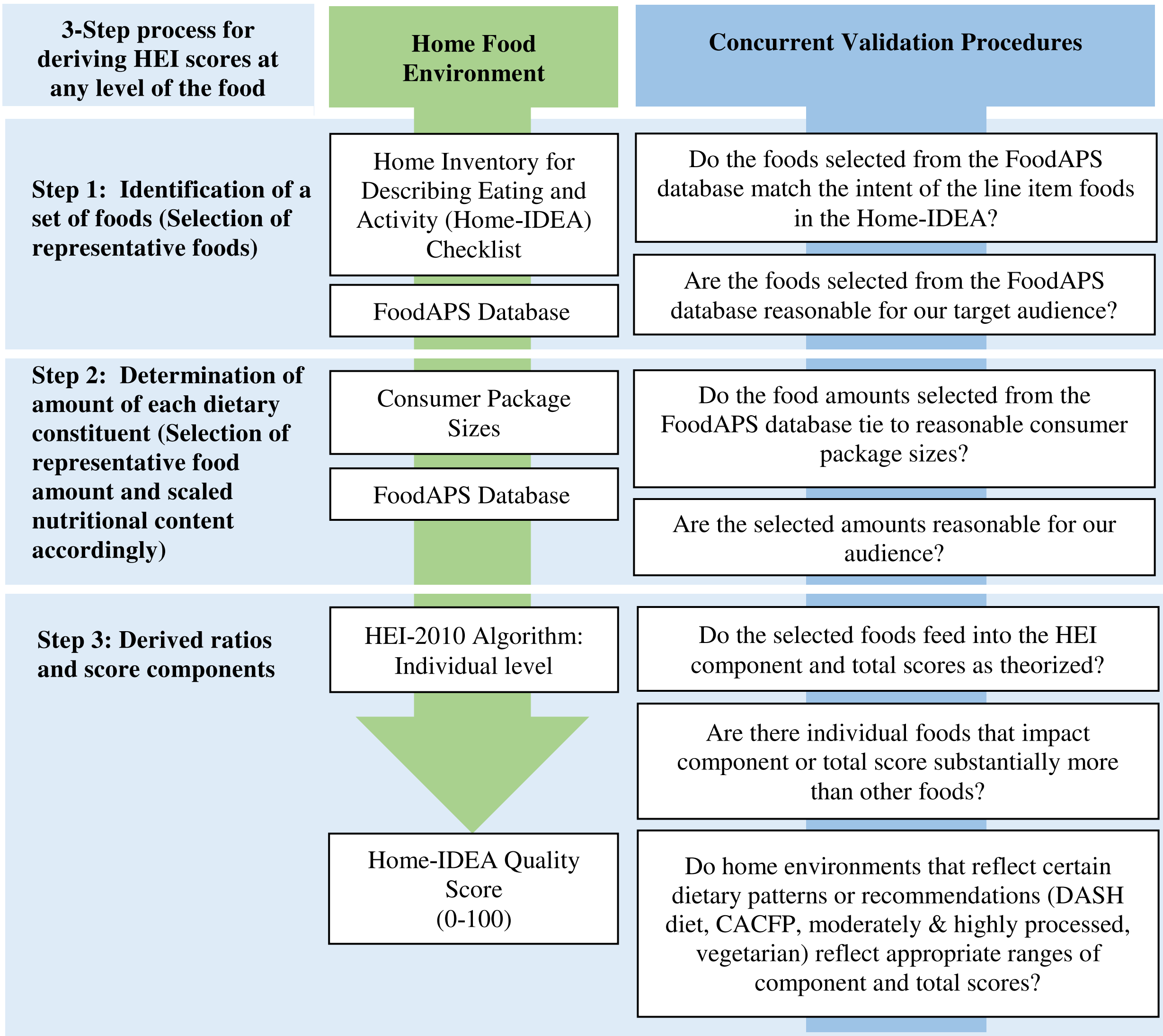

Figure 2: Summary of the three steps for deriving Healthy Eating Index (HEI) scores for the Home Food Environment and the content validation procedures employed at each step.
Figure adapted from Calculating HEI Scores at Different Levels, the HEI scoring illustration, https://epi.grants.cancer.gov/hei/tools.html.

Development of the Home-IDEA Nutrition Database and Quality Score (Objectives 1 & 2).

<u>Step 1: Identify a set of representative foods.</u>

A three-part process was employed to identify a representative food for each Home-IDEA item (Figure 3). First, a key word search within the FoodAPS file was conducted for foods that matched each Home-IDEA Checklist item. Second, investigators with expertise in nutrition and HFE measurement evaluated the identified foods for face validity with Home-IDEA Checklist items and reasonableness for low-income, multi-ethnic households. Third, remaining options were evaluated for key nutrients/nutrient categories (e.g. sodium, whole fruit, whole grains) theorized to load into the HEI-2010 algorithm, with the food closest to the mean or median for the majority of the key nutrients/nutrient categories selected as the 'representative' food for each Home-IDEA Checklist item.

Part 1: Key Word Search	Part 2: Face Validity		Part 3: Nutritional Content
Home-IDEA line item: Berries (such as blackberries, strawberries, blueberries, raspberries) **Key word search:** Berr (for berry, berries)	**Does the option match the intent of the Home-IDEA item?**	**Could this food be reasonably found in our target population?**	**Closest to mean or median for selected key nutritional component?** (Total sugar identified as key nutritional component for berry example)
Blackberry, frozen	✓[a]	✓	✓
Blackberry, raw	✓	✓	✓
Blackberries, cooked or canned, in heavy syrup	No, candied or pie-berries are not included in the Home-IDEA	Not applicable, removed food from list of options	Not applicable, removed food from list of options
Berries, frozen, NFS	✓	✓	✓
Blueberries, frozen, unsweetened	✓	✓	✓
Blueberries, raw	✓	✓	✓
Raspberries, frozen, NS as to added sweetener	No, sweetened berries, similar to candied or pie berries are not included in the Home-IDEA	Not applicable, removed food from list of options	Not applicable, removed food from list of options
Strawberries, cooked or canned, in syrup	No, candied or pie-berries are not included in the Home-IDEA	Not applicable, removed food from list of options	Not applicable, removed food from list of options
Strawberries, frozen, NS as to added sweetener	No, sweetened berries, similar to candied or pie berries are not included in the Home-IDEA	Not applicable, removed food from list of options	Not applicable, removed food from list of options
Strawberries, raw	✓	✓	✓ *Retained as representative food, all berries were similar in nutritional content*

Figure 3: Example of the 3-Part Process for Identifying a Representative Food to be Included in the Home-IDEA Nutrition Database

Home-IDEA: Home Inventory for Describing Eating and Activity; NFS: No Further Specification; NS: No Specification

[a]Checkmark (√) indicates item met requirements of step.

Step 2: Determine the Total Edible Grams of Each Food.

Once representative foods were identified, a two-part process was used to select food amounts. First, within the FoodAPS dataset, the mean, median, and mode of available total edible gram weights were calculated for each representative food. Second, an internet search for typical consumer package sizes was performed. Calculated weights were adjusted to reflect reasonable package sizes for consistency across foods (e.g., milk varieties were normalized to 1 gallon), and for realistic purchase quantities (e.g. vegetable oil was reduced from 1 gallon to 32 ounces).

Step 3: Derive Ratios and Component Scores by Applying the HEI Algorithm.

The nutritional content for the representative foods was merged with the Home-IDEA Checklist to create the Home-IDEA Nutrition Database. The Home-IDEA captures a snapshot of the home at a single point in time, similar to a single dietary recall for one person; therefore, the algorithm selected was "*Calculating an individual's HEI-2010 score, using FPED, and one day of 24HR recall",* available at https://epi.grants.cancer.gov/hei/tools.html. Because the nutrient variable names in the FoodAPS database were slightly different from the variable names found in the HEI-2010 algorithm, variables were renamed to match the requisite variable names. Two nutrient files were created mirroring the layout of individual dietary intake nutrient analysis files obtained from the Automated Self-Administered 24-hour Recall System (ASA24), the INFMYPHEI (Items/Individuals Foods and Pyramid Equivalents Data) and TNMYPHEI (Total/Daily Total Nutrient and Pyramid Equivalents Data) files, https://asa24.nci.nih.gov/researchersite/). The algorithm was then applied to the Home-IDEA Nutrition Database to generate HEI component and total scores.

Validation Procedures for the Home-IDEA Nutrition Database (Objective 3).

Face validity for the selection of representative foods and food amounts occurred as part of the food and food amount selection processes in Steps 1 and 2. Domain and internal criterion validity were tested with over three hundred rounds of iterative testing at Step 3 (Figure 2). Iterative testing served to determine if the representative foods were loading into the component scores as theorized (domain validity) and to test the individual and cumulative group contributions of each food to component and total scores (internal criterion validity).

Range and Sensitivity Testing of the Home-IDEA Quality Score (Objective 4).

Five sample HFEs were created to represent various diet patterns ranging from minimally healthful (theorized low HEI score) to very healthful (theorized high HEI score). These patterns included a highly processed pattern, a moderately processed pattern, a vegetarian pattern with minimal processed foods, a DASH diet,[38] and a pattern based on the Child and Adult Care Food Program (CACFP)[39] recommendations for children. The CACFP recommendations were selected to test the adherence of our Home-IDEA checklist to the Dietary Guidelines for Americans, as the CACFP guidelines should result in an optimal/maximum score. These food patterns were selected to examine sensitivity and direction of change in the component and total scores and to evaluate if our tool and the resulting quality score would result in different scores for different home food environments.

All analyses were conducted using SAS (version 9.4; SAS Institute Inc., Cary, NC). The HEI-2010 algorithm was provided by the National Cancer Institute.[18]

Results

Development of the Home-IDEA Nutrition Database and Quality Score (Objectives 1 & 2).

Step 1: Identify a Set of Representative Foods.

During Step 1, the nutrition database was reduced from 108 to 106 foods by eliminating two Home-IDEA Checklist items. "Unprepared mixes" was eliminated due to the complexity of options available which did not allow for an accurate selection of a single representative food, and there were no options for "tortilla, other" outside of corn or flour, which were already captured as individual Checklist items.

Step 2: Determine the Total Edible Grams of Each Food.

Two additional Home-IDEA Checklist items were removed due to a complete lack of TEG weights (rice cakes), and a TEG weight that had no comparable consumer purchase size (deer – the TEG from the FoodAPS database represented an entire deer carcass), leaving 104 foods in the Home-IDEA Nutrition Database. To create consistency across similar foods (e.g., varieties of milk, cheese, condiments, meat), a reasonable package size was selected and set for a given type of food at that weight (i.e., whole, 2%, 1%, skim, and chocolate milk were all set at 1 gallon, rather than the means of 0.75-1.25 gallons that were calculated directly from the FoodAPS database).

Step 3: Derive Ratios and Component Scores by Applying the HEI Algorithm.

Changes were made to the representative foods initially selected for chocolate/candy and unsweetened cereal to correct component score loading and maintain the original intent of the food within the Home-IDEA Checklist. Inconsistent effects in component outcomes were observed for processed food items and cooking oils/fats. Food amounts were adjusted to create similar effect sizes on component scores within each food category (e.g. fruits, processed foods, grains, cooking oils). The iterative testing was then repeated to confirm changes in effect sizes for component and total scores. Of the 104 foods in the Home-IDEA Nutrition Database, 42 effected a change of at least 5% in one or more component scores when removed from analysis. Of those 42 foods, 13 effected a 10-20% change, with 2 effecting over a 20% change (broccoli: -21.1% change in Greens and Beans; vegetable oil: -31.1% change in Fatty Acid Ratio). There was no single food that resulted in a change of greater than 5% to the Total Score (Table 5).

Table 5: Percent (%) Change Values for HEI-2010 Components and Total Score when Specified Food was Removed from the Home-IDEA Nutrition Database

HEI-2010 Component	Percent (%) Change[a]				
	Ramen	**Brown Rice**	**Broccoli**	**Grapes**	**Vegetable Oil**
Total Vegetables	2.0	0.7	-3.8	0.3	5.4
Greens and Beans	0.7	0.3	-21.1	0.1	2.0
Total Fruit	2.0	0.7	0.1	-5.3	5.5
Whole Fruit	3.3	1.2	0.1	-10.7	5.1
Whole Grains	2.2	-7.3	0.1	0.3	5.9
Dairy	2.6	0.9	0.1	0.3	7.0
Total Protein Foods	3.0	1.1	0.1	0.4	8.2
Seafood and Plant Proteins	0.0	0.0	0.0	0.0	0.0
Fatty Acid Ratio	4.2	-0.1	0.0	0.0	-31.1
Sodium	11.4	-1.7	0.0	-0.6	-12.7
Refined Grains	5.4	-1.4	-0.1	-0.5	-10.5
SoFAAS Calories	1.5	-0.9	-0.1	-0.3	-7.0
Total Score	3.4	-0.9	-1.2	-0.9	-4.2

HEI: Healthy Eating Index; Home-IDEA: Home Inventory Describing Eating and Activity; DGA: Dietary Guidelines for Americans; SoFAAS: Solid Fats, Alcohol, Added Sugars

[a]Percent change was calculated relative to the maximum score for each component category, so the values presented are normalized to accurately reflect the correct weighting across categories. For example, if there was a change of 0.05 in a component with a maximum score of 5, the relative percent change is 1.0%, whereas a maximum score of 10 yields a percent change of 0.5%. Positive percent change values indicate that the component or total score has increased (become more aligned with the 2010 DGAs). Negative percent change values indicate that the component or total score has decreased (become less aligned with the 2010 DGAs).

Validation Procedures for the Home-IDEA Nutritional Database (Objective 3).

Face validity (content) was demonstrated throughout selection of representative foods and food amounts (Steps 1 and 2). Domain validity (content) was demonstrated in the iterative testing phase (Step 3), given that only two foods (those representing chocolate/candy and unsweetened cereal) did not load into the component scores as initially hypothesized. Internal criterion validity was demonstrated during the iterative testing phase (Step 3), as each representative food had larger percentage effect sizes in the relevant component score(s) than in the Total Score (Table 5).[15] This demonstrated internal criterion validity with regard to the intent of the algorithm (i.e., component scores represent individual food contribution, whereas the Total Score represents the overall patterning).[15]

Range and Sensitivity Testing of the Home-IDEA Quality Score (Objective 4).

The analyses of the five sample HFEs resulted in a range of scores, in the expected directions, for both component and total scores (Table 6). The minimally processed/vegetarian, DASH, and CACFP home food inventory patterns resulted in high scores for most components. While the CACFP total score was lower than the vegetarian and DASH scores, this was expected as the CACFP menus used to create the home food environment did not include any food items that would contribute to the seafood and plant proteins and fatty acid ratio components. All other component scores, excluding sodium, were maximized by the CACFP environment, thus indicating a high ability of our tool to detect adherence to the DGAs within the bounds of our pre-determined food list. The moderately and highly processed HFEs scored lower for most component scores and generated lower total scores than the more healthful HFEs, suggesting measurement sensitivity to different patterns in the anticipated directions.

To further examine sensitivity, broccoli was included in all five sample HFE patterns; broccoli is the only vegetable in the Home-IDEA Nutrition Database that contributed to the Greens and Beans component. The Home-IDEA Nutrition Database and the Highly Processed sample HFE had non-maximum scores for the Greens and Beans component, whereas the Minimally Processed household, DASH household, and CACFP households scored the maximum of 5. This demonstrates that the presence of a single food within the total patterning of a given household may result in a range of scores within a component.

Table 6: HEI-2010 Component and Total Scores for the Home-IDEA Nutritional Database and Five Sample Household Food Environments

HEI-2010 Components	Relationship to 2010 DGA: Maximum score (5, 10, 20)[a] Per 1000 calories	Relationship to 2010 DGA: Minimum score (0)[a] Per 1000 calories	Complete Home-IDEA Nutritional Database	Sample Household Food Environments: Highly processed	Moderately processed	Minimally processed, Vegetarian	DASH	CACFP
Total Vegetables[b]	≥1.1 cup equiv.	No Vegetables	2.8	2.0	3.4	5.0	5.0	5.0
Greens and Beans[b]	≥0.2 cup equiv.	No Dark Greens or Beans/Peas	1.1	2.1	0.0	5.0	5.0	5.0
Total Fruit[c]	≥0.8 cup equiv.	No Fruit	2.9	2.0	3.0	4.4	3.3	5.0
Whole Fruit[d]	≥0.4 cup equiv.	No Whole Fruit	4.7	3.7	4.1	5.0	3.6	5.0
Whole Grains	≥1.5 oz equiv.	No Whole Grains	6.2	0.5	0.5	10.0	8.0	10.0
Dairy[e]	≥1.3 cup equiv.	No Dairy	7.4	6.1	4.4	4.4	4.0	9.1
Total Protein Foods[f]	≥2.5 oz equiv.	No Protein Foods	4.3	4.7	4.3	5.0	5.0	5.0
Seafood and Plant Proteins[f,g]	≥0.8 oz equiv.	No Seafood or Plant Proteins	5.0	5.0	2.6	5.0	5.0	0.0
Fatty Acid Ratio[h]	≥2.5	≤1.2	8.1	6.5	10.0	10.0	10.0	0.0
Sodium	≤1.1 gram	≥2.0 grams	8.9	6.9	7.7	10.0	10.0	6.4
Refined Grains	≤1.8 oz equiv.	≥4.3 oz equiv.	6.2	0.8	5.0	10.0	10.0	10.0
SoFAAS Calories[i]	≤19% of energy	≥50% of energy	17.6	15.7	20.0	20.0	20.0	18.4
Total Score			75.2	56.0	64.9	93.8	88.9	78.9

HEI: Healthy Eating Index; Home-IDEA: Home Inventory for Describing Eating and Activity; DGA: Dietary Guidelines for Americans; DASH: Dietary Approaches to Stop Hypertension; CACFP: Child and Adult Care Food Program; equiv.: equivalents; oz: ounces; PUFA: Polyunsaturated fatty acid; MUFA: Monounsaturated fatty acid; SFA: Saturated fatty acid; SoFAAS: Solid fats, alcohol, and added sugars

[a]Intakes between the minimum and maximum standards are scored proportionately. Nine components are scored for intakes in terms of nutritional adequacy; three components (Sodium, Refined Grains, SoFAAS calories) are scored for moderation of nutritional intake, that is, reverse scored so higher intakes result in lower component scores. Development of the scoring rubric has been previously described in detail.[40]

[b]Includes any beans and peas not counted as Total Protein Foods.

[c]Includes 100% fruit juice.

[d]Includes all forms except juice.

[e]Includes all milk products, such as fluid milk, yogurt, and cheese, and fortified soy beverages.

[f]Beans and peas are included here (and not with vegetables) when the Total Protein Foods standard is otherwise not met.

[g]Includes seafood, nuts, seeds, soy products (other than beverages) as well as beans and peas counted as Total Protein Foods.

[h]Ratio of PUFAS and MUFAS to SFAs. (PUFAs + MUFAs)/SFAs

[i]Calories from solid fats, alcohol, and added sugars; threshold for counting alcohol is >13 grams/1000 kcal.

Discussion

In this study, a home food quality score that can be compared directly to an HEI dietary intake quality score was successfully developed. Construct and internal criterion validity were established throughout development and testing. The development process and validity constructs mirrored those employed for the HEI-2010.[15,16] Examining the relative percent change of individual foods to component and total scores confirmed that the vast majority of representative foods had negligible impact on the total score when considered individually. This lent credence to the foundational aspect of the HEI, that the algorithm takes into account overall patterning and is not unduly affected by any individual food.[15] Enhanced understanding of the underlying statistical and dietary assumptions of the HEI-2010 algorithm was critical to ensure that the interpretation of the Home-IDEA Quality Score output would have transparent and meaningful comparisons to HEI-2010 scores for dietary intake data. Because of the myriad ways to reach the same total score, the component scores and data generating those scores were carefully examined to understand what actual values represented in terms of adherence to the DGA.

The sample HFE created by randomly selecting one week’s worth of food items from monthly Head Start preschool CACFP menus resulted in scores of zero for the Seafood & Plant Proteins and Fatty Acid Ratio components. Further examination indicated that these component scores were zero because the selection process did not include foods that loaded into these components. This same result could have occurred if the menus did not include these types of foods, representing an HFE that was missing these components, or if the Home-IDEA Checklist did not include items that would load into these components. Upon further examination, the monthly menus did include these types of foods, and the Home-IDEA Checklist did have corresponding options that would have loaded into these components. This type of examination of the data that underlies a given component score is critical to interpretation of component and total scores across food stream other than dietary intake.

While the HEI has been applied at various levels of the food stream, it has not been previously applied at the HFE level. Having a comprehensive measure of HFE overall quality in addition to dietary intake quality provides a more complete picture of how the HFE may impact dietary intake at the pattern level, thus aligning HFE research with current trends in dietary intake research examining dietary patterning in addition to individual food groups or nutrients.[41-44] Further, having an HFE quality score provides opportunities to measure the overall quality of food environments as an intervention target, as well as to more easily summarize measures food quality in the home and other food environments across multiple target audiences.

There are several limitations in this project. First, the Home-IDEA Checklist was not designed with the HEI in mind, thus, the retrospective application of the HEI has identified gaps in the foods included in the Checklist. The Checklist was unbalanced with fewer options for less healthful/processed foods compared with greater variety and higher number of more healthful foods. Finally, while having a pre-determined list of foods reduces participant and researcher burden, the fairly comprehensive Home-IDEA Checklist was not all-inclusive and potentially placed limits on capturing the full diversity of foods in the home.

The strengths of this research include using a tool that has been validated and successfully used in low-income, multi-ethnic families with young children[35,36] and the use of the FoodAPS database to select representative food and food amounts. The FoodAPS dataset enhanced validity in that the selections of food choices and amounts had been previously documented to be present in homes in similar quantities to those selected.[37] Considerable effort was undertaken to model development and validation procedures using steps similar to those employed by the Center for Nutrition Policy and Promotion, U.S. Department of Agriculture in the development and validation of both the HEI-2005 and HEI-2010.[14,15,40] Finally, the extensive validation procedures employed during development directly answers Pinard and colleagues' call for "deliberate action…to improve and validate existing tools and create new ones with greater emphasis on appropriate measurement models and forms of psychometric testing."[4]

Conclusions and Implications for Future Research

The HEI has been applied broadly across multiple research areas,[45] however the literature to date has no examples of HEI application to the HFE. As such, having a validated HFE assessment tool with the capacity to calculate HEI scores adds to the literature and to future intervention studies desiring to measure impacts on the HFE. In reviewing the literature of HEI application at various food stream levels, significant detail in describing the overarching processes taken in achieving steps 1 and 2 of applying the HEI is clearly documented.[19,22] However, there appeared to be limited detail regarding evaluation of the data feeding into the algorithm (internal validity). One endeavor of this study was to clarify the process in hopes of creating more transparency during interpretation of findings, especially when applying the Home-IDEA Quality Score in a real-world study setting.

Next steps include examining concurrent external criterion validity of the Home-IDEA Nutrition Database by applying it to real-world data, to see how the tool performs in describing the quality of the HFE with its limited set of foods in comparison to a fully measured HFE. Additionally, the Home-IDEA checklist will be revised in accordance with the aforementioned limitations to improve sensitivity and enhance the ability to accurately measure the overall quality of the HFE with a constrained number of food items.

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CHAPTER 4: EVALUATION OF THE HOME-IDEA QUALITY SCORE USING NATIONAL FOOD ACQUISITION AND PURCHASE SURVEY (FOODAPS) FOOD AT HOME DATA[2]

Summary

Background: Research on the home food environment (HFE) currently lacks a tool that examines the overall quality of the HFE. A semi-comprehensive home food environment survey, the **Home I**nventory **D**escribing **E**ating and **A**ctivity (Home-IDEA) Checklist, was used to create the Home-IDEA Quality Score using the Healthy Eating Index-2010 algorithm. **Objective:** Examine external criterion validity, sensitivity, range, and reliability of the Home-IDEA Quality Score. **Design:** The National Food Acquisition and Purchase Survey (FoodAPS) food-at-home dataset was used to examine external criterion validity, sensitivity, range, and reliability of the Home-IDEA Quality Score. **Analysis:** Paired t-tests were conducted to examine **e**xternal criterion validity by comparing the FoodAPS HEI-2010 component and total scores to the Home-IDEA Quality Scores as applied to the FoodAPS food-at-home database. Sensitivity and range were examined by comparing the distribution of component and total scores across nine percentiles that approximated a normal curve. Internal reliability was assessed using Pearson's correlations. **Results:** Pearson's correlations were significant and moderately to strongly correlated for the components and Total Score when comparing the FoodAPS components to the Home-IDEA Quality Score components across all areas of validity testing, with ranges 0.42 to 0.97. Generally, the Home-IDEA Quality Score had similar sensitivity to detect differences within a given percentile and similar range when compared to the FoodAPS

[2] The contents of this chapter will be submitted for publication as a manuscript.

distribution. Pearson correlations between total energy and Total Score were low (.00 to .10), and correlations among components and Total Score were similar to those seen for the validation of the HEI-2010 for dietary intake. **Conclusions and Implications:** The Home-IDEA Quality Score is a valid and reliable tool, as assessed against the FoodAPS food-at-home dataset. Having a valid and reliability tool to assess the overall quality of the HFE is a substantial contribution to future research in the HFE, with promising implications for comparisons to dietary quality.

Key Words: Home Food Environment, Quality Score, Evaluation, Healthy Eating Index, FoodAPS, Validity, Reliability

Introduction

In recent years, dietary research has expanded to assess not only the foods eaten, but also the context in which the food is eaten (e.g. at home versus away from home)[1-3], and the where the food was obtained (e.g. fast-food[4], or sit down restaurant[5], convenience store[6,7], grocery store[8,9], school/cafeteria[10], vending machine[9])[11,12]. This increasing focus on the environmental context of dietary intake has led to a large increase in the number of tools available for assessing a given environment with regard to availability of foods[13]. One of the areas of expanding research is the home food environment, which provides context for individual and family dietary intake[14]. The availability of foods within the home has been shown to reflect intake in both adults and children[15-17], and as such, provides a potential dietary intervention point[18].

There are a variety of ways to measure the home food environment, including questionnaires that may be completed as self-report or observer-based[19,20] and barcode scanning[21]. Each method has strengths and limitations, and the method selected depends on the population of interest, research burden, and cost to implement and analyze. The least expensive option is typically the self-report questionnaire method. These tools are often limited in their assessment of the home food environment, focus on a limited selection of foods, such as fruits, vegetables, whole grains, high-fat foods, or foods such as sugar-sweetened beverages that contribute mainly to non-nutritive food intake[22-24]. Furthermore, the lack of consistent or thorough testing for psychometric properties[13,25], responsiveness[25], or testing in different population groups[25] provide limited ability for synthesis of literature across the home food environment discipline.

Currently, no home food environment assessment tools measure the overall quality of the home food environment in a way that is consistent with assessing the quality of dietary intake. This limits opportunities to examine if changes in the overall quality of the home food environment could lead to concurrent changes in the overall quality of dietary intake. In most cases, the home food environment is analyzed for the presence of a particular type or category of food, then compared to dietary intake of that same type or category of food, e.g. presence of fruit in the home is analyzed in conjunction with total fruit intake. To fill this gap in assessment methods, a current self-report home food environment checklist, the Home Inventory for Describing Eating and Activity (Home-IDEA) Checklist[20], was used in conjunction with the Healthy Eating Index (HEI) 2010 algorithm to develop an overall quality score for the home food environment (the Home-IDEA Quality Score), as described in Chapter 3 of this dissertation. Although development and internal validation was successfully completed (Chapter 3), several questions remained regarding the underlying structure of the Home-IDEA Quality Score, including how this Quality Score functions when assessing a real-world sample of home food environments, and if limitations in the current underlying structure create limitations in the interpretation of the Component and Total Scores.

This paper presents a brief overview of the development of the Home IDEA Quality Score and describes the steps undertaken to test external criterion validity and reliability of the Home-IDEA Quality Score using the household food availability data from the National Food Acquisition and Purchase Survey food at home database (FoodAPS)[26]. External criterion validity was tested with respect to the following objectives: 1) validating the selection of food amounts as applied to the representative foods, 2) validating the ability of the Home-IDEA checklist to adequately capture the overall patterning of foods without having to record all foods found in the HFE, 3) testing the complete tool, and 4) examining the range and sensitivity of the Component and Total Scores to detect difference in household food environments. Reliability was tested with respect to examining the relationships between Component scores and the Total Score. These external criterion validity and reliability methods are similar to those employed in testing both the HEI-2005 and HEI-2010 algorithms.[27,28]

Methods

Development of Home IDEA Quality Score

The Home-IDEA Checklist (the self-report tool that participants complete regarding availability of select food items in the home) has been shown to have validity and reliability with low-income, multi-ethnic audiences as a self-report tool[20]. There are currently 104 food items that represent a wide variety of potential types of foods in the home. For example, there are single-items, such as “apple”, that represent all types of raw apples (Granny Smith, Macintosh, Red Delicious). There are also composite items that represent a “category” of similar items, such as “citrus fruits” representing oranges, tangerines, mandarins, grapefruit, lemons, limes, etc. All items, whether single or composite, are asked in terms of “Yes/No” availability in the home. No information is obtained as to how much of these items are in the home, rather it assess the presence or absence of the listed foods.

In researching how to create a pattern or quality score, the Healthy Eating Index (HEI) 2010, was selected as the basis for development. The HEI-2010 is a density-based pattern measure, in that the foods are scored as to how well they match the specified intake level per 1000 kcals (Table 7)[27-29]. There are 12 components that directly reflect intake levels for select food-group and nutrient recommendations specified in the 2010 Dietary Guidelines for Americans (DGA), plus a Total Score (sum of the 12 Component scores) which reflects the overall pattern adherence as a summary measure. This density basis allows the HEI to be applied across multiple levels of the food stream. The National Cancer Institute provides several algorithms for researchers to use, depending on the type of data available and level of the food stream. Application of the HEI has been successfully demonstrated at the national food supply level[30], at the community level (grocery store carts[31], restaurant menus[4], Food Banks[32], multiple food outlets[33]), and at the individual dietary intake level[34-37]. There is also a prescribed 3-step method for applying the algorithm: Step 1: Identify Foods, Step 2: Identify Food Amounts, Step 3: Derive Ratios (Figure 4)[38].

Table 7. The Healthy Eating Index 2010 Components and Total Score as a Density Measure for Dietary Intake, as Assessed by Adherence to the 2010 Dietary Guidelines for Americans.

Variable Name	Range of Scores	Concept[a]	What the score means in relation to the 2010-DGA recommended intake	Result of 1-point increase in terms of dietary intake (dietary meaning)
			Per 1,000 calories	
Total Vegetables[b]	0-5	Adequacy	Minimum: 0 Maximum: ≥1.1 cup eq.	Increase 0.22 cup eq.
Greens & Beans[b]	0-5	Adequacy	Minimum: 0 Maximum: ≥0.2 cup eq.	Increase 0.04 cup eq.
Total Fruit[c]	0-5	Adequacy	Minimum: 0 Maximum: ≥0.8 cup eq.	Increase 0.16 cup eq.
Whole Fruit[d]	0-5	Adequacy	Minimum: 0 Maximum: ≥0.4 cup eq.	Increase 0.08 cup eq.
Whole Grain	0-10	Adequacy	Minimum: 0 Maximum: ≥1.5 oz eq.	Increase 0.3 oz eq.
Total Dairy[e]	0-10	Adequacy	Minimum: 0 Maximum: ≥1.3 cup eq.	Increase 0.13 cup eq.
Total Protein[f]	0-5	Adequacy	Minimum: 0 Maximum: ≥2.5 oz eq.	Increase 0.5 oz eq.
Seafood & Plant Proteins[g]	0-5	Adequacy	Minimum: 0 Maximum: ≥0.8 oz eq.	Increase 0.16 oz eq.
Fatty Acid Ratio[h]	0-10	Adequacy	Minimum: ratio ≤1.2 Maximum: ratio ≥2.5	Increase 0.13 in ratio
Sodium	0-10	Moderation	Minimum: ≥2.0 grams Maximum: ≤1.1 gram	Decrease 0.09 gram
Refined Grains	0-10	Moderation	Minimum: ≥4.3 oz eq. Maximum: ≤1.8 oz eq.	Decrease 0.25 oz eq.
SoFAAS[i]	0-20	Moderation	Minimum: ≥50% Maximum: ≤19%	Decrease 1.55%
Total Score[j]	0-100			Increase 1%

DGA: Dietary Guidelines for Americans; eq.: equivalents; oz: ounce; SoFAAS: Solid Fats, Alcohol, Added Sugars

[a]Concept includes two methods – adequacy components are scored so that higher intakes result in higher scores, whereas moderation components are reverse scored so that lower intakes result in higher scores.

[b]Includes any beans and peas not counted as Total Protein Foods

[c]Includes 100% fruit juice

[d]Includes all forms except juice

[e]Includes all milk products, including fluid milk, yogurt, cheese, and fortified soy beverages

[f]Beans/peas included in Total Protein (and not with vegetables) when Total Protein Foods standard is not met

[g]Includes seafood, nuts, seeds, soy products (no beverages), beans and peas counted as Total Protein Foods

[h]Fatty Acid Ratio uses the following formula: total unsaturated fats divided by total saturated fats [(total monounsaturated fat + total polyunsaturated fats)/total saturated fats

[i]Calories from solid fats, alcohol, and added sugars; threshold for counting alcohol is >13 grams/1000 kcal

[j]Sum of the Component Scores

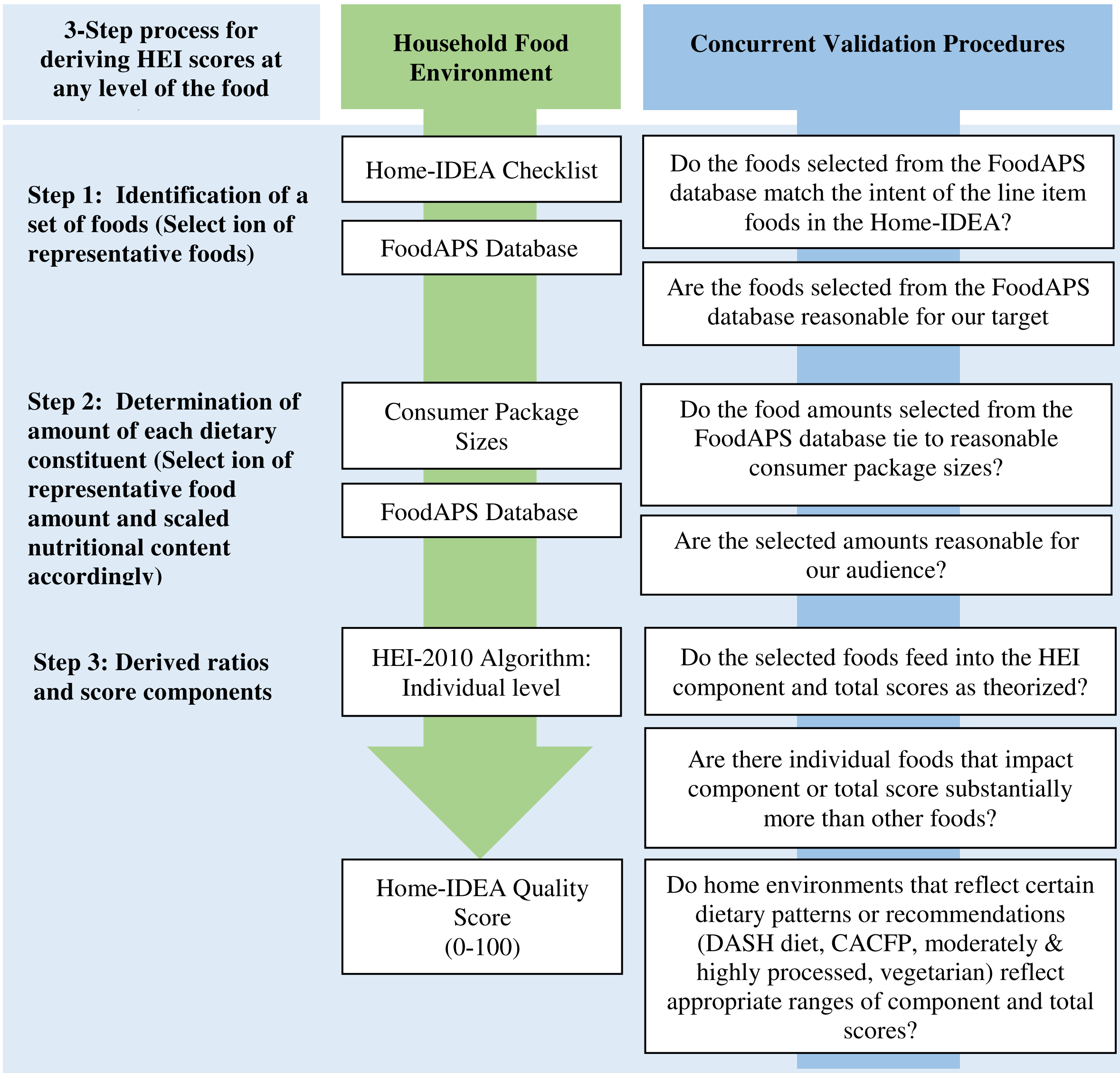

Figure 4: Summary of the three steps for deriving Healthy Eating Index scores for the Household Food Environment and the content validation procedures employed at each step.

HEI: Healthy Eating Index; Home-IDEA: Home Inventory for Describing Eating and Activity; FoodAPS: National Food Acquisition and Purchase Survey; DASH: Dietary Approaches to Stop Hypertension; CACFP: Child and Adult Care Food Program
Adapted from https://epi.grants.cancer.gov/hei/tools.html.

The Home-IDEA Checklist provided a list of foods for Step 1. However, because the Checklist is generic (does not contain food amounts, or specific nutritional content), the development of the Home-IDEA Nutrition Database required a way to identify valid options for nutrient content and food amounts that would tie to each Home-IDEA Checklist item. The

National Food Acquisition and Purchase Survey (FoodAPS) food at home database was utilized to identify representative foods for each Home-IDEA food item, as well as identify a representative food amount to go with that food item. The FoodAPS is a nationally representative survey of 4,826 households conducted between April 2012 and January 2013. It includes high- and low-income households, i.e. households participating in the Supplemental Nutrition Assistance Program (SNAP), households with income below or between 100-185% poverty guideline but not participating in SNAP, and those with income equal to or greater than 185% of poverty guideline. For the study outlined within, the publically available, de-identified dataset that details information for foods found in the home was used (faps_fahnutrients, downloaded January 26, 2017)[26]. The resulting Home-IDEA Nutritional Database was tested extensively for internal validity (Figure 1).

The Home-IDEA Checklist was merged with the Home-IDEA Nutrition Database to support application of the HEI algorithms at the home food environment level. However, it was important to further understand if the limited sample of food items in the Checklist was truly representative of foods in the home in a way that would accurately reflect overall quality or patterning. Even though the HEI is a density measure, and thus removes much of the issue of total calories, the internal validation procedures revealed that the pattern could be overwhelmed if the caloric contribution of a single food was excessive. Therefore, the amount of food selected for the nutrition content is important and should be additionally tested for impact in a more practical way prior to implementation of the Home-IDEA Quality Score as an assessment tool. These considerations require that the Home-IDEA Quality Score as a complete tool (limited number of foods, nutrition content, and amount of food) be evaluated for pattern effects in a real-world sample to confirm that the independent validity measures are accurately reflected in the complete tool when used as intended. The USDA Economic Research Service (ERS) and Food and Nutrition Service (FNS) provided the real-world sample used in the validation, through the FoodAPS database.

Evaluating External Criterion Validity

To complete external validity testing, the FoodAPS food at home database was used to compare households' food inventories "as-is" (complete food list) with Home-IDEA inventories. The FoodAPS database contains food codes linked to the Food and Nutrient Database for Nutrient Studies (FNDDS), total edible gram amounts, and nutrient information for each food reported in the home during the survey period[26]. As the intent of the following validation procedures was to compare HEI Component and Total Scores for the Home-IDEA Quality Score to the FoodAPS household quality score, data within the FoodAPS food at home database was prescreened for missing values for key variables needed to apply the HEI-2010 algorithm (e.g. food codes, total edible gram amounts). Households that did not report any foods, as well as foods that were reported but did not have corresponding total edible gram amounts were removed from the analysis set. The final analysis set included 4,202 households, each of which contained a minimum of 1 food code with a corresponding food amount.

For objectives 1-3 (examining food amounts, the reduced food set, and the complete tool), the resulting Home-IDEA and FoodAPS Components and Total Score means were examined three ways: Paired t-tests to compare means (absolute values), percent difference in the means (relative values), and what the mean difference is in terms of dietary intake in relation to the standards used to set the maximum scores (dietary meaning). Due to expectations that very small differences would be statistically significant with the large sample size, relative values and dietary meaning were calculated to provide context for interpretation. Percent differences were calculated by dividing the mean difference by the maximum value possible (5, 10, 20) for the respective Component or Total Score. Dietary meaning values were calculated by converting the mean difference to the representative dietary intake value (indicated by the change in value for a 1-point increase in respective Component or Total Score, Table 7).

Examining Food Amounts

To test whether representative food amounts selected for the Home-IDEA Nutrition database affect HEI-2010 pattern scores differently than when the food amounts reflect what is actually in the home (Objective 1), the analysis set was further reduced to include only those foods found in the Home-IDEA Nutrition database. The HEI-2010 algorithm was then applied to each household to generate two sets of HEI scores; one based on FoodAPS total edible gram amounts, the second based on Home-IDEA Nutrition database food amounts. The resulting Component and Total Scores were compared using paired t-tests to examine differences, and converted to percent mean differences and values describing dietary meaning.

Examining the Reduced Inventory for Patterning

To test whether the reduced number of food items that are reflected by the Home-IDEA Checklist affect HEI-2010 Component and Total Scores differently than when all foods found in the home are included in the inventory (Objective 2), the food amounts were "held steady" to the total edible gram amounts included in the FoodAPS database. This allowed the researchers to examine the pattern effects of having a limited set of food items represent a household food inventory when compared to a fully measured household food inventory.

All food codes that mapped to a given Home-IDEA Checklist item, e.g., food codes that represented citrus fruits (oranges, tangerines, mandarins, lemons, limes, grapefruit, etc. – all forms raw, frozen, canned, with or without syrup), were linked to the representative Home-IDEA Checklist item (citrus fruit). Approximately 1600 of the 3200 food codes in the FoodAPS database mapped to the 104 Home-IDEA Checklist items. The HEI-2010 algorithm was run on the complete FoodAPS database to generate Component and Total Scores. The food codes that did not map to a Home-IDEA item were removed from the analysis set, and then the HEI-2010 algorithm was run on the reduced food item set that represented all of the foods that would potentially map to the Home-IDEA Checklist. The resulting Component and Total Scores were compared using paired t-tests to examine differences, converted to percent mean differences, and values to describe dietary meaning. The approximately 1600 food codes that did not map to a Home-IDEA Checklist item were examined to determine what types of foods were missing from the Checklist and inform revisions for future versions of the Home-IDEA Checklist.

<u>Examining the Complete Tool: The Home-IDEA Quality Score: the Home-IDEA Checklist combined with the Nutrition database</u>

To test how the Home-IDEA Quality Score performed when compared to the full household inventory (Objective 3), Home-IDEA Checklists were created for each of the 4,202 households in the FoodAPS database, and merged with the Home-IDEA Nutrition database. The HEI-2010 algorithm was applied to the merged Home-IDEA household files to generate a Home-IDEA Quality Score, and also applied to the complete FoodAPS household food inventories to create a FoodAPS Quality Score per household. The resulting Component and

Total Scores were compared using paired t-tests to examine differences, and converted to percent mean differences and values describing dietary meaning.

Examining Sensitivity and Range of Component and Total Scores

To test for sensitivity and range (Objective 4), the mean Component and Total Scores for the Home-IDEA Quality Score and the FoodAPS database were split into nine percentiles, to approximate the ranges that would be expected within a normal distribution (1st, 5th, 10th, 25th, 50th, 75th, 90^{th}, 95^{th}, 99^{th}). The distribution of mean scores was examined for comparability in terms of absolute magnitude of the mean scores at each percentile (sensitivity), as well as for breadth of scores across the distribution (range).

Evaluating Reliability

To evaluate reliability within Component and Total Scores, independence from household energy density was examined. Pearson's correlations were calculated for each Home-IDEA Quality Score Component and the Total Score to their respective household energy density. Due to the large sample size, it was expected that many of the correlations would be statistically significant, however, if independence was maintained, the correlations would be negligible to weak in nature, below 0.20-.30[39].

All HEI-2010 analyses were conducted using SAS (version 9.4; SAS Institute Inc., Cary, NC). The HEI-2010 algorithm was provided by the National Cancer Institute [38]. Pearson's correlations and paired t-tests were conducted using SPSS (version 24, IBM Corp., Armonk, NY). As 13 pairwise comparisons are conducted concurrently within each analysis set, significance has been adjusted accordingly and set at $p \leq 0.003$.

Results

External Criterion Validity

Examining Food Amounts

Pearson's correlations (Table 8) for the Components and Total Score comparing the FoodAPS food amounts to the Home-IDEA Nutrition database food amounts ranged from 0.64 to 0.93. Sodium scored the lowest with a 0.64, whereas Whole Grains scored the highest with 0.93. This indicates that the food amounts selected to represent the Home-IDEA Checklist items were well represented within the FoodAPS database. The strong correlation values were expected due to the method employed to select the representative food amount, i.e. selecting the mean/median total edible gram amount in the FoodAPS database for a given food in conjunction with scaling to reasonable consumer purchase sizes. (Chapter 3 of this dissertation).

Paired t-tests of the Components and Total Score means for the FoodAPS food amounts versus the Home-IDEA Nutrition database food amounts indicated that most differences in the means were significant at $p \leq 0.003$, with the exception of the Components Sodium ($p=0.013$) and Fatty Acid Ratio ($p=0.770$) (Table 8). When examining practical relevance of the difference in the means, percent difference in the means between the Home-IDEA and FoodAPS ranged from 0% to -7%, with the greatest differences seen in Total Vegetables (-7%), Whole Fruit (-6%), and Dairy (-7%). Twelve of the Components had differences that were in favor of the Home-IDEA (negative percent differences), indicating that the Home-IDEA food amounts slightly over-estimate the contribution of the representative food to the relevant Component score in a way that consistently, across these Components, improved the Component score. Refined Grains was the only Component score in which the FoodAPS food amounts indicated a higher Component mean score (6.40 (±4.45)) than the Home-IDEA food amounts (5.79 (±4.56)), although the magnitude of the percent mean difference was 0% when rounded. Given that there are no standards for interpretation of mean differences in regard to the application of the HEI-2010 algorithm to tool development, the values are shown to give perspective to the mean difference raw scores. The difference in terms of intake are also provided in Table 9, with most falling at less than one-tenth of a cup or ounce equivalent.

Examining the Reduced Inventory for Patterning

Pearson's correlations for the Component and Total Scores when comparing the FoodAPS household item pattern to the Home-IDEA Checklist item pattern ranged from 0.62 to 0.97 (Table 8). Sodium scored the lowest with a 0.62, whereas Whole Fruit scored the highest with 0.97. This indicates that the limited item set of the Home-IDEA Checklist identifies the major food items that would contribute to the overall HEI-2010 pattern. The strong correlation values support that a small but representative sample of food items can adequately capture overall food patterns of the home food environment.

Paired t-tests of the Components and Total Score means for the FoodAPS household item pattern versus the Home-IDEA reduced inventory pattern indicated that all differences in the means were significant at $p \leq .003$. When examining practical relevance of the difference in the means, the percent difference in the means ranged from 0-11%, with the greatest differences seen in Sodium. Unlike the consistency in the direction of the mean differences found for food amounts, the directions of the mean differences for the pattern testing vary. When the FoodAPS pattern resulted in a higher mean score, the percent mean differences were positive: Total Vegetables (4%), Greens & Beans (5%), Seafood & Plant Proteins (4%), and Fatty Acid Ratio (1%). When the Home-IDEA pattern resulted in a higher mean score, the percent mean differences were negative: Total Fruit (-5%), Whole Fruit (-3%), Dairy (-5%), Total Protein (-1%), Sodium (-11%), Refined Grains (-5%), SoFAAS (-9%), and Total Score (-3.65%). The difference in terms of intake are similar to those reported for food amounts, with most falling at less than one-tenth of cup or ounce equivalent.

Examining the Home-IDEA Quality Score: the Complete Tool - Home-IDEA Checklist combined with the Nutrition database

Pearson's correlations for the Component and Total Scores when comparing the FoodAPS Quality Score to the Home-IDEA Quality Score resulted in a more diffuse pattern and larger range of scores (0.42 to 0.83), with Sodium being the lowest at 0.42, and Total and Whole Fruit being the highest at 0.83; Table 8). The variation in the strength of correlations was expected, as it was assumed that the variance in the food amount examination and the variance in the pattern examination would be compounded when tested together in the complete tool.

Paired t-tests of the Components and Total Score means when comparing the FoodAPS Quality Score to the Home-IDEA Quality Score indicated that all differences in the means were significant at $p \leq 0.003$. Percent difference in the means ranged from 4-17%, with the greatest difference found in SoFAAS (Table 9). Similar to the variation in direction seen for pattern examination, the directions of the mean differences for the complete tool testing indicate that several FoodAPS pattern Components had higher mean scores (resulting in positive percent mean differences): Total Vegetables (9%), Greens & Beans (9%), Seafood & Plant Proteins (8%), Fatty Acid Ratio (4%), and Refined Grains (6%). The Home-IDEA Quality Score resulted in higher mean scores (negative percent mean differences) for the following Components: Total

Fruit (-9%), Whole Fruit (-9%), Whole Grain (-10%), Dairy (-12%), Total Protein (-6%), Sodium (-12%), SoFAAS (-17%), and Total Score (-6%).

The difference in terms of intake are similar to those of pattern effects for Total Vegetables, Greens & Beans, Total Fruit, Whole Fruit, Seafood & Plant Protein and Fatty Acid Ratio falling at less than one-tenth of cup or ounce equivalent. Whole Grains, Dairy, Sodium, and SoFAAS had mean differences of greater than 1 point (percent mean difference of 10% or more), indicating that the dietary meaning in relation to intake values increased to greater than one-tenth of a cup or ounce equivalent. When considering the Total Score mean difference of 5.66 points, SoFAAS contributed the largest single variation in points (3.36), with Sodium, Dairy, and Whole Grains contributing the second largest set of variations over 1 point, with 1.24, 1.16, and 1.01 points, respectively.

Table 8: Pearson's Correlations between the FoodAPS Household Inventory and the Home-IDEA Inventory for Component and Total Scores for Examining Food Amounts, the Reduced Pattern, and the Home-IDEA Quality Score (Complete Tool), Objectives 1-3

	Objective 1	**Objective 2**	**Objective 3**
	Examining Food Amounts (r)	**Examining the Reduced Inventory** (r)	**Examining the Home-IDEA Quality Score (Complete Tool)** (r)
Total Vegetables	.76	.87	.74
Greens & Beans	.81	.81	.60
Total Fruit	.85	.96	.83
Whole Fruit	.87	.97	.83
Whole Grain	.93	.92	.63
Dairy	.85	.95	.81
Total Protein	.80	.92	.80
Seafood & Plant Protein	.89	.90	.75
Fatty Acid Ratio	.76	.90	.69
Sodium	.64	.62	.42
Refined Grains	.71	.80	.52
SoFAAS	.74	.81	.57
Total Score	.75	.88	.71

FoodAPS: National Food Acquisition and Purchase Survey; Home-IDEA: Home Inventory for Describing Eating and Activity; SoFAAS: Solid Fats, Alcohol, Added Sugars
All correlations shown in this table are significant at $p<0.003$.

Table 9: Means, Percent Mean Differences, and Dietary Intake Context for Component and Total Scores for Examining Food Amounts, the Reduced Pattern and the Home-IDEA Quality Score (Complete Tool)

Component	Tool	Objective 1			Objective 2			Objective 3		
		Examining Food Amounts			Examining a Reduced Pattern			Examining the Home-IDEA Quality Score (Complete Tool)		
		Mean (SD)	Percent Mean Difference	Dietary Intake Context[a]	Mean (SD)	Percent Mean Difference	Dietary Intake Context[a]	Mean (SD)	Percent Mean Difference	Dietary Intake Context[a]
Total Vegetables	FoodAPS	1.86 (2.16)	-7%	-.07 cup equiv.	2.60 (1.94)	4%	.05 cup equiv.	2.60 (1.94)	9%	-09 cup equiv.
	Home-IDEA	2.20 (2.13)			2.38 (2.02)			2.16 (2.00)		
Greens & Beans	FoodAPS	0.52 (1.51)	-3%	-.01 cup equiv.	1.41 (2.09)	5%	.01 cup equiv.	1.41 (2.09)	9%	.02 cup equiv.
	Home-IDEA	0.68 (1.70)			1.18 (2.03)			0.93 (1.92)		
Total Fruit	FoodAPS	2.30 (2.28)	-5%	-.04 cup equiv.	2.17 (1.98)	-5%	-.04 cup equiv.	2.17 (1.98)	-9%	-.02 cup equiv.
	Home-IDEA	2.56 (2.28)			2.40 (2.09)			2.64 (2.07)		
Whole Fruit	FoodAPS	2.54 (2.41)	-6%	-.02 cup equiv.	2.30 (2.14)	-3%	-.01 cup equiv.	2.30 (2.14)	-9%	-.03 cup equiv.
	Home-IDEA	2.82 (2.39)			2.42 (2.23)			2.73 (2.28)		
Whole Grain	FoodAPS	1.26 (3.17)	0%	-.01 oz equiv.	2.41 (3.35)	0%	-.01 cup equiv.	2.41 (3.35)	-10%	-.30 oz equiv.
	Home-IDEA	1.31 (3.18)			2.45 (3.58)			3.42 (4.09)		
Dairy	FoodAPS	5.06 (4.70)	-7%	-.09 cup equiv.	5.07 (3.81)	-5%	-.07 cup equiv.	5.07 (3.81)	-12%	-.15 cup equiv.
	Home-IDEA	5.77 (4.58)			5.59 (4.08)			6.23 (3.98)		

Table 9: Means, Percent Mean Differences, and Dietary Intake Context for Component and Total Scores for Examining Food Amounts, the Reduced Pattern and the Home-IDEA Quality Score (Complete Tool)

		Objective 1			**Objective 2**			**Objective 3**		
		Examining Food Amounts			**Examining a Reduced Pattern**			**Examining the Home-IDEA Quality Score (Complete Tool)**		
Component	**Tool**	**Mean (SD)**	**Percent Mean Difference**	**Dietary Intake Context[a]**	**Mean (SD)**	**Percent Mean Difference**	**Dietary Intake Context[a]**	**Mean (SD)**	**Percent Mean Difference**	**Dietary Intake Context[a]**
Total Protein	FoodAPS	1.67 (2.13)	-4%	-.11 cup equiv.	2.78 (2.02)	-1%	-.04 cup equiv.	2.78 (2.02)	-6%	-.16 oz equiv.
	Home-IDEA	1.88 (2.10)			2.85 (2.10)			3.10 (2.11)		
Seafood & Plant Protein	FoodAPS	0.78 (1.78)	-1%	-.01 oz equiv.	1.92 (2.20)	4%	.03 oz equiv.	1.92 (2.20)	8%	.06 oz equiv.
	Home-IDEA	0.85 (1.81)			1.73 (2.21)			1.55 (2.11)		
Fatty Acid Ratio	FoodAPS	4.31 (4.45)	-1%	-.02	4.86 (4.06)	1%	.02	4.86 (4.06)	4%	.06
	Home-IDEA	4.43 (4.42)			4.73 (4.22)			4.42 (4.06)		
Sodium	FoodAPS	8.10 (3.34)	0%	.00 gram	6.75 (3.82)	-11%	.10 gram	6.75 (3.82)	-12%	.11 gram
	Home-IDEA	8.11 (3.30)			7.84 (3.21)			7.99 (2.92)		
Refined Grains	FoodAPS	6.40 (4.45)	0%	-.15 oz equiv.	6.65 (3.85)	-5%	.13 oz equiv.	6.65 (3.85)	6%	-.15 oz equiv.
	Home-IDEA	5.79 (4.56)			7.18 (3.77)			6.05 (4.07)		
SoFAAS	FoodAPS	14.83 (7.44)	-2%	0.61% of energy	10.90 (7.26)	-9%	.28% of energy	10.90 (7.26)	-17%	5.21% of energy
	Home-IDEA	15.23 (6.91)			12.73 (7.18)			14.26 (6.49)		

Table 9: Means, Percent Mean Differences, and Dietary Intake Context for Component and Total Scores for Examining Food Amounts, the Reduced Pattern and the Home-IDEA Quality Score (Complete Tool)

Component	Tool	Objective 1			Objective 2			Objective 3		
		Examining Food Amounts			Examining a Reduced Pattern			Examining the Home-IDEA Quality Score (Complete Tool)		
		Mean (SD)	Percent Mean Difference	Dietary Intake Context[a]	Mean (SD)	Percent Mean Difference	Dietary Intake Context[a]	Mean (SD)	Percent Mean Difference	Dietary Intake Context[a]
Total Score	FoodAPS	49.63 (18.06)	-2%	-2.01	49.82 (15.37)	-4%	-3.65	49.82 (15.37)	-6%	-5.66%
	Home-IDEA	51.64 (16.13)			53.47 (15.79)			55.48 (15.67)		

FoodAPS: National Food Acquisition and Purchase Survey; Home-IDEA: Home Inventory for Describing Eating and Activity; equiv.: equivalent; oz: ounces; SoFAAS: Solid Fats, Alcohol, Added Sugars

[a]Dietary Intake Context is the relative measure where the mean difference was converted to dietary intake in terms of the intake amount that represents a change of 1 point based on the dietary intake requirement to receive a maximum score for a given Component.

Examining Sensitivity and Range of Component and Total Scores

The Home-IDEA Quality Score showed comparable range and sensitivity (Objective 4) in describing Component and Total Scores when compared to the FoodAPS Quality Score (Table 10). For most Components, the Home-IDEA Quality Score had similar sensitivity to detect differences within a given percentile. The FoodAPS Quality Score showed differences in means for Total Fruit, Seafood & Plant Proteins, and Fatty Acid Ratio one percentile earlier than the Home-IDEA Quality Score, whereas the Home-IDEA Quality Score reported differences earlier for Sodium. Ranges for Total Score were wide enough to allow detection of meaningful differences, without a potential floor or ceiling issue, as there is still room for lower scores below the 1st percentile or higher scores at the 99th percentile. All components showed minimum scores at the low percentile ranges, with maximum scores topping out at the 95th percentile for the FoodAPS Quality Score, and the 90th percentile for the Home-IDEA Quality Score.

Table 10: Estimated Means and Percentiles of the Components and Total Score for Home-IDEA versus the FoodAPS Quality Scores

			Percentiles								
Components	**Quality Score**	**Mean (±SE)**	**1st**	**5th**	**10th**	**25th**	**50th**	**75th**	**90th**	**95th**	**99th**
Total Vegetables	FoodAPS	2.60 (0.03)	0.00	0.00	0.00	0.71	2.42	5.00	5.00	5.00	5.00
	Home-IDEA	2.38 (0.03)	0.00	0.00	0.00	0.05	2.09	5.00	5.00	5.00	5.00
Greens & Beans/Peas	FoodAPS	1.41 (0.03)	0.00	0.00	0.00	0.00	0.00	3.26	5.00	5.00	5.00
	Home-IDEA	1.18 (0.03)	0.00	0.00	0.00	0.00	0.00	1.84	5.00	5.00	5.00
Total Fruit	FoodAPS	2.17 (0.03)	0.00	0.00	0.00	0.10	1.66	4.47	5.00	5.00	5.00
	Home-IDEA	2.40 (0.03)	0.00	0.00	0.00	0.00	2.12	5.00	5.00	5.00	5.00
Whole Fruit	FoodAPS	2.30 (0.03)	0.00	0.00	0.00	0.00	1.81	5.00	5.00	5.00	5.00
	Home-IDEA	2.43 (0.03)	0.00	0.00	0.00	0.00	2.18	5.00	5.00	5.00	5.00
Whole Grain	FoodAPS	2.41 (0.05)	0.00	0.00	0.00	0.00	0.28	4.01	9.11	10.00	10.00
	Home-IDEA	2.45 (0.06)	0.00	0.00	0.00	0.00	0.00	4.21	10.00	10.00	10.00
Total Dairy	FoodAPS	5.07 (0.06)	0.00	0.00	0.00	1.21	4.92	9.46	10.00	10.00	10.00
	Home-IDEA	5.59 (0.06)	0.00	0.00	0.00	0.95	6.13	10.00	10.00	10.00	10.00
Total Protein	FoodAPS	2.78 (0.03)	0.00	0.00	0.00	0.65	2.97	5.00	5.00	5.00	5.00
	Home-IDEA	2.85 (0.03)	0.00	0.00	0.00	0.34	3.30	5.00	5.00	5.00	5.00
Seafood & Plant Proteins	FoodAPS	1.92 (0.03)	0.00	0.00	0.00	0.00	0.46	5.00	5.00	5.00	5.00
	Home-IDEA	1.73 (0.03)	0.00	0.00	0.00	0.00	0.00	5.00	5.00	5.00	5.00
Fatty Acid Ratio	FoodAPS	4.86 (0.06)	0.00	0.00	0.00	0.15	4.56	10.00	10.00	10.00	10.00
	Home-IDEA	4.73 (0.07)	0.00	0.00	0.00	0.00	4.18	10.00	10.00	10.00	10.00
Sodium	FoodAPS	6.75 (0.06)	0.00	0.00	0.00	3.69	8.61	10.00	10.00	10.00	10.00
	Home-IDEA	7.84 (0.05)	0.00	0.00	1.90	6.51	10.00	10.00	10.00	10.00	10.00
Refined Grains	FoodAPS	6.65 (0.06)	0.00	0.00	0.00	3.35	8.56	10.00	10.00	10.00	10.00
	Home-IDEA	7.18 (0.06)	0.00	0.00	0.00	4.50	10.00	10.00	10.00	10.00	10.00
SoFAAS	FoodAPS	10.90 (0.11)	0.00	0.00	0.00	4.28	11.58	18.18	20.00	20.00	20.00
	Home-IDEA	12.73 (0.11)	0.00	0.00	0.00	7.35	14.63	20.00	20.00	20.00	20.00
Total Score	FoodAPS	49.82 (0.24)	16.84	25.64	30.08	38.77	49.54	60.16	70.00	76.17	84.92
	Home-IDEA	53.47 (0.24)	18.76	28.03	32.40	42.36	54.13	64.79	74.12	79.38	87.13

Home-IDEA: Home Inventory Describing Eating and Activity; FoodAPS: National Food Acquisition and Purchase Survey; SE: Standard Error of the Mean; SoFAAS: Solid Fats, Alcohol, Added Sugars

Reliability

To confirm that the pattern depicted by the Home-IDEA Quality Score was independent of energy intake, Pearson's correlations were run for each component and the total score with household food inventory energy (Table 11). The correlations were generally low, ranging from .00 to .10, indicating negligible relationships with household energy, thus supporting the fundamental underlying concept of the HEI application, that it is a density measure and independent from energy. Additionally, correlations between component scores were generally low, excluding those that should be highly related, e.g. foods that load into Whole Fruit also load into Total Fruit, those that load into Seafood & Plant Proteins also load into Total Protein. Correlations between Components and Total Score were consistently higher, as expected since each component contributes directly to the Total Score, with the highest correlation for SoFAAS, which contributes a larger portion of points (20) to the Total Score than any other component (5 or 10 points). The magnitude of the correlations is similar to those seen for the validation of the HEI-2010 for dietary intake.[29]

Table 11: Estimated Pearson's Correlations for the HEI-2010 Components, Total Score, and Energy Density of FoodAPS Household Food Inventories as Represented by the Home-IDEA Quality Score

HEI-2010 Components	**HEI-2010 Component number**												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1 Total Vegetables	1.00												
2 Greens & Beans/Peas	.49*	1.00											
3 Total Fruit	.21*	.17*	1.00										
4 Whole Fruit	.25*	.19*	.84*	1.00									
5 Whole Grain	.02	.08*	.08*	.10*	1.00								
6 Total Dairy	-.00	.05*	.03	.06*	.13*	1.00							
7 Total Protein	.18*	.31*	.01	.06*	.07*	.07*	1.00						
8 Seafood & Plant Proteins	.18*	.34*	.08*	.10*	.13*	.06*	.55*	1.00					
9 Fatty Acid Ratio	.13*	.04*	-.02	.00	.04*	-.47*	.03*	.16*	1.00				
10 Sodium	.01	.01	.19*	.16*	-.02	-.06*	-.21*	.04	.01	1.00			
11 Refined Grains	.05*	.01	.11*	.08*	.01	.04	.02	.05*	-.04	.23*	1.00		
12 SoFAAS	.25*	.13*	.20*	.20*	.18*	-.06*	.08*	.13*	.38*	-.04*	-.23*	1.00	
13 Total Score	.47*	.43*	.49*	.51*	.41*	.17*	.34*	.47*	.38*	.26*	.23*	.65*	1.00
Household Energy (kcal)	-.00	.07*	-.03	.00	.04	.03	.10*	.10*	.05*	.04	-.02	-.01	.06*

HEI: Healthy Eating Index; Home-IDEA: Home Inventory Describing Eating and Activity; FoodAPS: National Food Acquisition and Purchase Survey; SoFAAS: Solid Fats, Alcohol, Added Sugars
*p≤.01
n = 4202

Discussion

The evaluation of the external criterion validity of the Home-IDEA Quality Score was completed through comparisons to the FoodAPS database, a real-world data sample of home food availability. Additionally, internal reliability was assessed to confirm that the underlying pattern structure assumptions were consistent with the underlying assumptions found in the development of the HEI-2010. This evaluation process was mirrored on the methods used to evaluate the HEI-2010.[29]

Examining the pattern effects of the food *amount* selections (Objective 1) separately from the food *item* selections (Objective 2) allowed for critical assessment of potential areas for refinement that could reduce over or under-specification of the overall quality of a home food environment when using the Home-IDEA Quality Score. Overall, both the assessment of food amounts and the assessment of the food items resulted in statistically significant, albeit practically negligible differences in Component and Total Scores when assessed independently. The differences in terms of intake were small enough that they would have little meaning in comparing groups when discussing nutrient adequacy at a single point in time.

When examining the Home-IDEA Quality Score versus the FoodAPS Quality Score there were minimal variations seen during individual concept testing (Objectives 1 (food amounts) and 2 (reduced pattern). When testing the complete tool, , the variations compounded (potentially expected, as you are adding the food amounts and the reduced pattern together), resulting in four components that had greater than a 1 point difference in the mean when comparing the Home-IDEA Quality Score to the FoodAPS Quality Score. As the percent mean difference exceeds 10% (the equivalent of a 1 point change in the score for a component with a 10 point maximum score), the intake values increase to greater than one-tenth of a cup or ounce equivalent. While this may still seem like a dietarily small value, it could result in meaningful differences in the overall patterning of intake. The Home-IDEA Quality Score Components for SoFAAS, Sodium, Dairy, and Whole Grains all had percent mean differences of 10% or greater. This indicates that even though the food amounts and the reduced pattern performed well when evaluated separately, when combined, the complete tool should be evaluated for potential improvements to the items that directly load into these Component scores.

The variation in Sodium and SoFAAS was expected as the Home-IDEA Checklist was developed to provide the best possible chance for capturing the diversity of healthful foods in the home, rather than developed with application of the HEI in mind. Therefore, it is weighted toward capturing raw/perishable foods rather than packaged/processed foods, which are typically the largest contributors of sodium and SoFAAS to the diet. When examining the food amount and pattern evaluations, it appears that the majority of variation occurred during testing of the food items rather than the food amounts. In reviewing the food items that did not map to the Home-IDEA checklist, ready-to-eat baked goods and sweets, puddings, and canned soups make up the bulk of foods that are not currently captured. Additionally, as sugar sweetened beverages, chips, and candy are single line-items, it is challenging to adequately reflect households that have extensive inventories of these items. Having the same foods affect multiple components lends further credence to careful evaluation of these foods as individual items or composite items that should be added to future versions of the Home-IDEA Checklist.

For Dairy there was slight variation seen in both the food amount and pattern evaluations, so there is not a clear recommendation as to how to reduce this potential variation. This level of variation was unexpected as the Home-IDEA Checklist captures several varieties of dairy product. Additionally, there were minimal food codes in the FoodAPS database that contributed to Dairy that did not map to a Home-IDEA checklist item. The variation seen for Whole Grains was also unexpected as this Component performed well both for the food amount examination and the reduced pattern examination. Detailed examination of individual households may reveal instances in which either Dairy or Whole Grains performed poorly, thus shedding light on ways to improve sensitivity for these Components.

Overall, the Home-IDEA Quality Score performed well, both for the individual Component scores and the Total Score. The Home-IDEA Quality Score Components that reflect food groups to increase had very similar scores to their respective FoodAPS Components, indicating that any interpretations made based on the limited inventory are likely to reflect adequately the reality in households. Even with the minimal issues noticed for Whole Grains, Dairy, Sodium, and SoFAAS, the Total Score was comparably similar as well. By examining both the Component scores and the overall effects on the Total Score, the Home-IDEA Quality Score can be interpreted with confidence in a real-world sample.

Additional confidence in the use of and interpretation of findings for the Home-IDEA Quality Score may be garnered from the extensive validation and reliability testing, both during the development (Chapter 3 of this dissertation) and evaluation phases. This work further demonstrates how tool development may proceed through several rounds of evaluation before the tool is ready to be used in a study setting. By starting with a previously developed and validated tool, this research answers past calls for enhancing existing tools to further the home food environment research area[13,25], in this case by specifically completing extensive validation and reliability testing to provide a new way to assess the home food environment[25]. As a result of this process, the Home-IDEA Checklist may be used in its traditional intent, or may be converted to a Quality Score which may be directly compared to other HEI measures, such as those used for assessing restaurant menus[4], grocery store circulars[40], corner stores[41], and dietary intake[37].

There are limitations and strengths in this evaluation project, several of them are intertwined and have to do with using the FoodAPS database. One of the overarching considerations in using the FoodAPS food at home database was that it provided a way to evaluate the Home-IDEA Checklist and Nutritional Database against foods that were actually found in homes in specified amounts. This is both a strength and a limitation in that there are strengths in using an outside database as well as limitations inherent in the FoodAPS study itself. Among the FoodAPS limitations is the self-report nature of the food at home component, which included a survey book in which to attach receipts from food purchases and a bar code scanner to scan all foods brought into the home[26]. As with all self-report food data, there are always situations in which certain types of foods may be over or under-reported. Additionally, there were households present in the FoodAPS food at home database that did not report any foods that had food codes, reported foods without corresponding food amounts, and households that reported very few foods. As the intent of this project was to evaluate the adequacy of the Home-IDEA Checklist to represent an entire household food inventory, the data in the FoodAPS database was used as-is for all households that had at least one food code with a corresponding food amount, without any consideration given to the sampling limitations found within their study process. The total and component scores reported for the FoodAPS database in this project should not be interpreted for meaningful commentary about the quality of foods found in the homes in that sample.

An additional consideration of this evaluation is that the HEI was retrospectively applied to both the FoodAPS dataset and Home-IDEA checklist, for a use that they were not originally designed. Using the FoodAPS database was a strength in our design in that the data represents real homes, with real food amounts, and with sufficient quantity to examine the scope of food items missing from the Home-IDEA Checklist; as well as to examine how well the selected representative food items represent broad food concepts in the home. A final strength of this evaluation project is that considerable effort was undertaken to model development and validation procedures using steps similar to those employed by the Center for Nutrition Policy and Promotion, U.S. Department of Agriculture in the development and validation of both the HEI-2005 and HEI-2010.[28,29,42]

Conclusions and Implications for Future Research.

Overall, the external validation of the Home-IDEA Quality Score was successfully demonstrated. With this additional validation step, the researchers believe that the Home-IDEA Checklist may be used to capture types of foods found in homes, as well as to examine the overall quality of the home food environment in terms of adherence to the 2010-DGA. This study validated that a relatively small selection of food items (104) can accurately assess the overall quality of the home food environmentpotentially reducing the burden for sampling the complete household with exact food amounts in order to understand the overall patterning of the food environment. This could substantially move home food environment research forward by contributing a less-burdensome and less-costly way to explore questions about the overall quality of the about the home food environment. Future research could examine what the HFE looks like in various populations, how individuals' dietary intake quality aligns with home food quality, and if family members' selectively eat from the home environment.

It is noteworthy that while the intent of this evaluation was to examine the Home-IDEA Quality Score, the HEI-2010 algorithm was successfully applied to the FoodAPS database. The methods demonstrated in this study, as well as those undertaken in the development of the Home-IDEA Nutritional Database that makes calculating a Quality Score possible (Chapter 3 of this dissertation), may be applied to other Home Food Inventory tools. Additionally, these methods may be applied directly to the FoodAPS databases, to examine population scores for the overall quality of the home food environment for that study sample. By examining the overall home food quality of the FoodAPS population, researchers could better compare the quality of food in the home to the quality of dietary intake across and within populations.

Finally, when considering that multiple family members consume foods from the same household food inventory, having a home food quality score combined with dietary assessment of multiple individuals within the household environment, researchers could clearly assess both individual and group dietary quality within the context of the overall household food inventory. The next steps in research on the Home-IDEA Quality Score will be to apply it in a research setting where dietary intake is concurrently measured, to gain better understanding of how the overall patterning of the home food environment may be reflected in individual family member dietary intakes. Additionally, revisions to the Home-IDEA Checklist will be explored, to better reflect sensitivity in assessing Sodium and SoFAAS.

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[3]CHAPTER 5: THE FAMILY HEALTH STUDY – EXAMINING THE HOME FOOD ENVIRONMENT AND MATERNAL DIETARY INTAKE

Summary

Background: The home food environment (HFE) has been described as a potential modifiable factor in dietary intake. Currently, the HFE has not been described in terms of overall quality or as a pattern, making it challenging to compare the HFE to dietary intake quality. **Objective: To** evaluate the use of the novel **Home I**nventory **D**escribing **E**ating and **A**ctivity (Home-IDEA) Quality Score to describe the overall HFE quality and associations among the Home-IDEA Quality Score and maternal dietary quality. **Design:** The Family Health Study was a cross-sectional exploratory study conducted with 85 mother-child dyads from 16 preschools in rural, eastern Colorado communities. Mothers completed the Home-IDEA Checklist, a demographics questionnaire, and a facilitated Automated Self-Administered 24-hour dietary recall (ASA24). **Analysis:** The Healthy Eating Index-2010 was used to calculate maternal dietary quality (Maternal HEI). Means were calculated for components and Total Scores for the Home-IDEA Quality Score and Maternal HEI. Relationships between components and Total Scores for the Home-IDEA Quality Score and Maternal HEI were assessed with Spearman and Pearson correlations, respectively. Linear regression models examined if the Home-IDEA Quality Score Total Score explained variance in the Maternal HEI Total Score. **Results:** There were no differences in the components or Total Scores by income. The Home-IDEA Quality Score Total Scores ranged from 73.2-76.0. Maternal HEI was poor, with Total Scores ranging from 45.8-52.7. The Home-IDEA Quality Score Total Score was

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[3] The contents of this chapter may be submitted for publication as a manuscript.

significantly related to the Maternal HEI Total Score (r=0.31, p=0.004). Individual component scores were not significantly related. Linear regression indicated that Maternal HEI Total Score increased by 0.65 points for each one-point increase in the Home-IDEA Quality Score Total Score. **Conclusions and Implications:** The Home-IDEA Quality Score successfully categorized the HFE and predicted maternal dietary quality. The Home-IDEA Quality Score is a promising tool for future HFE research.

Key Words: Home Food Environment, Maternal Dietary Quality, Healthy Eating Index, Home-IDEA Quality Score

Introduction

With the increased focus on addressing determinants of adult obesity and preventing child overweight and obesity, the home food environment (HFE) has been identified as a potential modifiable factor to impact dietary intake[1]. Consistent results have been reported for positive relationships between home food availability and dietary intake in both adults and children, especially for fruits and vegetables[2-9], sugar-sweetened beverages[10], and core/non-core foods[11,12]. In families with young children, parents often control the home food environment (HFE), and serve as role models for dietary intake and physical activity[13-16].

Within the context of parent role modeling of dietary behaviors, maternal dietary intake has been reported as an important predictor of child intake, across several dietary components[11,17]. Less work has been done examining relationships between maternal dietary quality with child dietary quality. One study, performed by Fisk, et al. (2011), examined relationships among family members in accordance with a 'prudent' dietary pattern, characterized by fruit, vegetable, and whole grain intake; a greater adherence to the 'prudent' dietary pattern by mothers was the largest predictor of child dietary intake, explaining 24-30.5% variance.[18]

In addition to limited research on overall dietary quality relationships among family members, there is little to no research available describing the overall quality of the HFE. Determining the overall quality or pattern of food within the home environment, similar to dietary intake patterning (i.e., Healthy Eating Index (HEI), Mediterranean diet pattern, or the Dietary Approaches to Stop Hypertension (DASH) diet pattern) may improve comparisons across studies and facilitate synthesis of findings in HFE research.[19,20] Additionally, it would allow for comparisons of the HFE quality to dietary intake quality, which would substantially add to the literature.

In the United States, the Healthy Eating Index (HEI)[21] is an overall quality score that was initially developed in the mid-1990's to describe dietary quality in accordance with the recommendations of the Dietary Guidelines for Americans[22]. The HEI has been updated to reflect each new release of the DGAs[23,24]. In the last several years, the HEI has been applied at multiple levels of the food stream (e.g. national food supply[25], community food streams[26-28]), and more recently, formed the basis for the development of the **Home I**nventory **D**escribing **E**ating and **A**ctivity (Home-IDEA) Quality Score, a tool that describes the overall quality or patterning of foods in the HFE based on the semi-comprehensive, self-report Home-IDEA Checklist (Chapters 3 & 4).

The objectives of this chapter are to: 1) examine the use of the Home-IDEA Quality Score to describe the HFE in a sample of multi-ethnic mothers with young children ages 3-5 years living in rural communities and, 2) evaluate relationships among the components and Total

Scores for the Home-IDEA Quality Score and maternal overall dietary quality, as characterized by the Healthy Eating Index-2010.

Methods

Recruitment

A convenience sample of mothers who served as the main caregiver of a child aged 3-5 were recruited from 16 Colorado preschools. Participants were provided a recruitment flier and interest form (Appendix 2, 3) via their child's backpack, with instructions to return the interest form to their child's teacher if interested. Once interest sheets were received (n=150), mothers were screened by phone for inclusion criteria. Eligible mothers (n=94) were assigned a participant ID number and scheduled for an in-person visit. A study flow diagram is provided in Appendix 4.

Procedures

The Family Health Study consisted of three parts:

- Part 1: Mailed Self-Report Surveys - Qualified participants were mailed the informed consents and the study surveys;
- Part 2: In-Person Parent Assessments - Participants returned the informed consent and study surveys to the in-person assessment visit where they additionally completed several health measures and a dietary recall; and
- Part 3: In-Person Child Assessments - Child weight status was collected either during the parent in-person assessment or at a later time during school hours.

This research project was reviewed and approved by the Colorado State University Institutional Review Board (Protocol ID: 15-6120H; Appendix I). Adult participants received up to fifty dollars for participating in the study. All measurements are described following Table 12: Schedule of Procedures.

Table 12: Schedule of Procedures for the Family Health Study

	Screening	**Part 1**	**Part 2**	**Part 3**
Procedure	**Telephone**	**Mailed Self-Report Surveys**	**In-Person Parent Assessment**	**In-Person Child Assessment**
Verbal Informed Consent	X			
Eligibility	X			
Scheduling	X			
Informed Consent		X		
Health History and Demographic Form		X		
International Physical Activity Questionnaire		X		
Home Inventory for Describing Eating and Activity Checklist		X		
Collection of Informed Consent			X	
Collection of Surveys			X	
Maternal Cardiovascular Risk Factors Assessment			X	
Facilitated 24 Hour Dietary Recall using the Automated Self-Administered recall system (ASA-24)			X	
Child Verbal Assent				X
Child Weight Status				X

Part 1: Mailed Self-Report Surveys

Three surveys were provided to all participants: a Health History and Demographic Form, the International Physical Activity Questionnaire (IPAQ) to capture recent physical activity, and the Home Inventory for Describing Eating and Activity (Home-IDEA) Checklist to capture the home food environment. These surveys were to be completed 1-3 days prior to the in-person visit.

Maternal Health History and Family Demographic Form:

The Health History and Demographic Form (Appendix 5) was developed using the Behavioral Risk Factor Surveillance Survey (BRFSS)[29]. BRFSS questions were selected for their widespread use in multiple populations and comparability to state and national data. The self-report health history variables for hypercholesterolemia, hyperglycemia, and hypertension were used in conjunction with the in-person measures of cardiovascular risk factors. Results for maternal health are presented in Chapter 6.

Self-report income and household size (sum of the mother, spouse, and number of children) were used to calculate income thresholds for low-income at 185% of Federal income guidelines as of 2016. The 185% of Federal income level was selected as it is a determining factor for several federal and state assistance programs, such as the special Supplemental Nutrition Program for Women, Infants, and Children (WIC), and Title V – Maternal & Child Health Services[30].

International Physical Activity Questionnaire (IPAQ):

Recent PA levels were captured using the IPAQ, short form (Appendix 6)[31]. The IPAQ quantifies time spent in vigorous and moderate physical activities, and walking over the last 7 days (weekdays and weekend), and sitting during the past 5 weekdays. Vigorous and moderate are defined by the level of physical effort (hard, moderate) and breathing rate (much harder, somewhat harder than normal, respectively). Participants are asked to specify the number of days in the past week and the total time (only include time spent in blocks of 10 minutes or greater) on one average day for each level of physical activity. The data for the IPAQ short form was handled as instructed under the Guidelines for Data Processing and Analysis, revised April 2004[32]. Maternal PA is discussed in Chapter 6.

Home Inventory for Describing Eating and Activity (Home-IDEA) Checklist:

The Home-IDEA was used to assess home food availability, physical activity equipment, and electronic devices (Appendix 7). The Home-IDEA survey consists of 155 questions, which include 7 for shopping behaviors & household demographics, 113 for food items, 17 for physical activity devices, and 18 for sedentary/electronic devices found in the home. The Home-IDEA was selected as it has been previously validated in multi-ethnic and low-income families with young children.[33] The Home-IDEA Checklist data was analyzed using the Home-IDEA Quality Score (development and validation discussed in Chapters 3 and 4).

The Home-IDEA Quality Score consists of 12 component Scores and a Total Score (sum of the component Scores, range of 0-100), which are calculated using the Healthy Eating Index-2010 algorithm (https://epi.grants.cancer.gov/hei/sas-code.html). The code selected for the calculation was for an individual, single 24-hr recall, to mimic the code used for dietary intake analysis. Within the components, eight represent food group components to be examined in terms of nutrient adequacy (Total Vegetables, Greens & Beans, Total Fruit, Whole Fruit, Whole Grains, Total Dairy, Total Protein, Seafood & Plant Protein), one represents a ratio describing the relative contribution of saturated and unsaturated fats to the pattern (Fatty Acid Ratio), and the remaining three represent a nutrient and food group components to be examined in terms of moderation (Sodium, Refined Grains, SoFAAS).

It is important to note the Home-IDEA Checklist was not initially constructed with the HEI in mind; it has a greater number of food items that represent foods to consume for nutrient adequacy than those that represent foods to consume in moderation. Examining a subset of HEI components that represent just the nutrient adequacy portion of the HEI may yield valuable information that the total score may not reflect, as it is expected that the components for nutrient moderation (Sodium, Refined Grains, SoFAAS) may result in slightly higher scores than are truly representative of the overall density of those foods in the HFE, thus creating a slightly higher Total Score. The mean values for the eight components representing nutrient adequacy (Total Vegetables, Greens & Beans, Total Fruit, Whole Fruit, Whole Grains, Total Dairy, Total Protein, Seafood & Plant Protein) will be summed to create a nutrient adequacy subscore, with a maximum score of 50. This score will be converted to percentage (calculated nutrient adequacy subscore/maximum score of 50), so that the percentage of the pattern that meets nutrient adequacy as recommended by the 2010 DGAs may be interpreted separately from the Total Score.

Part 2: Parent In-Person Assessments

Participants met with study staff at their child's preschool for the in-person appointment. Informed consent and surveys were collected prior to beginning any measurements. Study staff then measured maternal cardiovascular risk factors for each participant. Finally, a 24hr dietary recall was facilitated with participants.

Maternal Cardiovascular Risk Factors Assessment and Child Weight Status.

Measurements of maternal cardiovascular risk factors were collected in-person by trained staff and included a non-fasting standard lipid panel with glucose, HbA1c blood pressure, body mass index (BMI), and waist circumference. Two point-of-care units (the Alere Cholestech

LDX system (lipid-glucose panel), and the Alere Afinion AS100 (HbA1c), Alere North America, Scarborough, ME), were used to collect lipids and HbA1c. NHANES techniques were used for blood pressure, height and weight (maternal and child; for the calculation of BMI), and waist circumference assessments [34,35]. Detailed methods and results of the maternal cardiovascular risk factors assessment and child weight status are presented in Chapter 6.

Maternal Dietary Assessment.

Study staff facilitated a 24-hour recall with each participant using the National Cancer Institute's (NCI) Automated, Self-Administered 24-hour recall system (ASA24)[36,37]. The ASA24 Respondent website (https://asa24.nci.nih.gov/) follows a multi-pass recall method to help a participant recall all foods eaten the previous day (midnight to midnight). The website provides a script and specific questions regarding food preparation, portion size, food additions/alterations, meal time, where food/ingredients were purchased and consumed, and if the food was consumed with others. Study staff facilitated the interview by placing the computer screen where participants could follow along while the staff member verbally followed the script on the screen and searched for the food selections, thus minimizing any potential technology discomfort of the participants A variety of dietary reports are produced from the ASA24 data, including reports for individual level nutrients and food group estimates based on the Food and Nutrient Database for Dietary Surveys (FNDDS)[38] and the Food Pattern Equivalents Database (FPED)[39] from the USDA. All dietary data were downloaded from the ASA24 Researcher website (https://asa24.nci.nih.gov/researchersite/) upon completion of the study.

Dietary intake data were examined for plausibility using cut points of 500 and 3,500 kilocalories for a single intake in females ages 20-40[40]. No scores were below 500 kilocalories.

Two participants had scores greater than 3,500 kilocalories. The two outliers were examined for maternal physical and reported attributes that would indicate reasonableness in reporting a higher intake. Dietary data were then converted to a pattern or overall quality score using the Healthy Eating Index (HEI) 2010 algorithm (https://epi.grants.cancer.gov/hei/sas-code.html, code for an individual, single 24-hr recall). By converting to an index score, the nutrient density of the diet is dissociated from the total energy intake, thus removing the bias of positive correlations of nutrient intake with energy intake[23]. The resulting Maternal Dietary Quality Score includes the HEI-2010 12 components and a Total Score (sum of the 12 components, range 0-100). These are the same component and Total Score variables as seen with the Home-IDEA Quality Score; eight components representing food groups for nutrient adequacy, one ratio, and three components examining nutrients/food groups to consume in moderation.

Data Management and Analysis

Study data were collected and managed using REDCap (Research Electronic Data Capture) electronic data capture tools, a HIPPA compliant, secure, web-based application designed to support data capture for research studies hosted by the Colorado Clinical & Translational Sciences Institute (CCTSI).[41] Data were entered directly into database tables with the exception of the ASA24 data, which was obtained directly from the ASA24 website as an Excel spreadsheet. Double data entry was performed for all other measures. Data entry files were compared using the Compare Files function in SPSS. All flagged differences were compared back to the original data documents with the appropriate change made directly in the REDCap database. Files were repeatedly compared until no discrepancies remained.

All continuous data were inspected for normality using standard normality tests, Kolmogorov-Smirnov and Shapiro-Wilk, and by visually assessing histograms and box plots. The continuous variables for dietary intake data by food group were not normally distributed. After transforming the home food environment and dietary intake data to the Home-IDEA Quality Score and the maternal dietary quality score using the HEI-2010 algorithm, the resulting Total Scores were normally distributed, however components retained non-normal distributions.

Analyses were completed for the full study sample and by income. Means, standard deviations, and frequencies were computed for participant demographics as applicable, and the following outcome variables: the Home-IDEA Quality Score components and Total Score, Maternal dietary intake by food group, and Maternal Dietary Quality HEI-2010 components and Total Score. Independent samples Kolmogorov-Smirnov Z-tests and chi-square tests were used to determine differences in participant characteristics and maternal dietary intake by income. Correlations were used to assess the relationships between the Home-IDEA Quality Score components (Spearman's) and Total Score (Pearson's) with their corresponding Maternal Dietary Quality HEI-2010 components and Total Score. Regression modeling was used to evaluate if the overall quality of the home food environment (Home-IDEA Quality Score Total Score) would explain variance in overall maternal dietary quality (HEI-2010 Total Score). Hierarchical linear regression models were constructed by adding variables in the following order: ethnicity, income, Home-IDEA Quality Score Total Score. As this is an exploratorystudy, significance was set at $p \leq 0.05$ for all tests, with appropriate adjustment made for multiple comparisons among the component scores ($p \leq 0.003$).

Descriptive statistics, tests for normality of distributions, Kolmogorov-Smirnov Z tests, Chi-square tests, Spearman and Pearson's correlations, and linear regression models were calculated with SPSS v.24 (IBM Corporation, Armonk, NY). Dietary Quality and Home-IDEA Quality scores were calculated using SAS (version 9.4; SAS Institute Inc., Cary, NC). The HEI-2010 algorithms (SAS code) were provided by the National Cancer Institute[42].

Results

Participant Characteristics

Recruitment through 16 preschools resulted in the return of 150 interest forms for screening (n=150). Once screened, eligible study participants (n=94) had a high completion rate, with 94% completing all study procedures (n=88; Appendix IV: Family Health Study Flow Diagram). Data were collected from 85 mothers, characteristics are presented in Table 13. Mothers had a mean age of 32.4 years, 68% were low-income, 29% had a high school education or less, and 55% identified as Hispanic. Low income mothers were younger (p=0.05), reported a greater predominance of English as the main language spoken at home (p=0.05), lower educational attainment (p=0.02), and had greater mean BMI (p=0.02) than moderate income mothers. While not statistically significant, there was considerable overlap of Hispanic and low-income in this study sample, as 62% of low-income households (n=58) were also Hispanic.

Table 13: Maternal Characteristics for the Family Health Study for the Full Study and Split by Income

Maternal Characteristics	Full Study (n=85)		Low income[a] (n=58)		Moderate income (n=27)		
	% (#)[b] or Mean (SD)	**Range**	**% (#)[b] or Mean (SD)**	**Range**	**% (#)[b] or Mean (SD)**	**Range**	***p*-value[c,d]**
Age (years)	32.4 (6.5)	20.7-51.0	31.9 (7.0)	21.5-51.0	33.5 (5.0)	20.7-41.2	**0.05[c]**
Race							1.00[d]
White	93% (79)		93% (54)		93% (25)		
Black/African American	1% (1)		2% (1)		--		
Asian	2% (2)		2% (1)		4% (1)		
African American/Native Alaskan	1% (1)		2% (1)		--		
Pacific Islander/Native Hawaiian	1% (1)		2% (1)		--		
Other/Declined	1% (1)		--		1% (1)		
Ethnicity: Hispanic	55% (47)		62% (36)		41% (11)		0.10[d]
Main Language Spoken at Home							**0.05[d]**
English	86% (73)		91% (53)		74% (20)		
Spanish	13% (11)		7% (4)		26% (7)		
Other	1% (1)		2% (1)		--		
Low Income[a]	68% (58)		--		--		
Education							**0.02[c]**
≤ High School diploma	29% (25)		36% (21)		15% (4)		
Some college (no degree)	27% (23)		26% (15)		30% (8)		
Associates or Bachelor's degree	31% (26)		29% (17)		33% (9)		
Graduate or Professional degree	13% (11)		9% (5)		22% (6)		

Table 13: Maternal Characteristics for the Family Health Study for the Full Study and Split by Income

Maternal Characteristics	Full Study (n=85)		Low income[a] (n=58)		Moderate income (n=27)		*p*-value[c,d]
	% (#)[b] or Mean (SD)	Range	% (#)[b] or Mean (SD)	Range	% (#)[b] or Mean (SD)	Range	
Body Mass Index (BMI)	29.3 (7.1)	17.4-53.5	30.6 (7.6)	17.4-53.5	26.4 (4.7)	19.4-35.8	**0.02[c]**
Underweight (<19kg/m^2)	4% (3)		5% (3)		--		
Normal weight (19-24.9 kg/m^2)	29% (25)		21% (11)		44% (12)		
Overweight (25-29.9 kg/m^2)	26% (22)		24% (14)		30% (8)		
Obese (≥30 kg/m^2)	41% (35)		50% (29)		22% (6)		

[a] Low-Income is defined by a household income of ≤ 185% of the Federal income guideline for 2016[30]
[b] Values presented as a percent of the study population will not always sum to 100%, due to rounding.
[c] Kolmogorov-Smirnov Z test for differences in the medians between low-income and moderate income households for continuous variables: significance p≤0.05.
[d]Chi-square test for differences between low-income and moderate income households for categorical variables , significance p≤0.05

The Home Food Environment: Home-IDEA Quality Score

The mean Total Scores for the Home-IDEA Quality Score ranged from 73.2 (low income) to 76.0 (moderate income), with a mean value for the full sample of 74.1. The Total Scores fall at the high end of the "needs improvement" range of 50-79[21]. As for the individual components, Whole Grains (4.6, 4.3) and Dairy (4.6, 4.8) were the only two components to have a mean score of less than half the maximum value of 10 points, indicating low availability of these foods within the HFE for both the full sample and low income subset, respectively. Total Protein and Seafood & Plant Protein components were close to the maximum score of 5 across the full study sample (4.8, 4.9, respectively) and low income subset (4.8, 4.8, respectively), indicating high availability within the home food environment. Total Vegetables, Total Fruit, and Whole Fruit had fair representation in the home food environment for the full study sample and subsets with component scores ranging from 2.88 to 4.55 out of a maximum score of 5. No component had scores close to zero.

An analysis of the nutrient adequacy sub score (50 points) was conducted to include the 8 components that represent food groups to consume for nutrient adequacy (Total Vegetables, Greens & Beans, Total Fruit, Whole Fruit, Whole Grains, Total Dairy, Total Protein, Seafood & Plant Proteins). For the full sample, the sum of the mean scores for these eight components is 32.3 points out of 50, or 64.6% of the possible total points; with a correspondingly low availability also seen in low income households, mean subscore sum of 31.81 (63.6%). There were no statistically significant differences by income for the components ($p \leq 0.004$, adjustment for 12 multiple comparisons), or for the subscore for nutrient adequacy or Total Score ($p \leq 0.025$, adjustment for two comparisons).

Table 14: Means and Standard Deviations for Components and Total Score of the Home-IDEA Quality Score for the Full Sample and when comparing Low Income to Moderate Income Households

Home-IDEA Quality Score Components & Total Score	Max Score	Full Sample (n=85) Mean (SD)	Low Income[a] (n=58) Mean (SD)	Moderate Income (n=27) Mean (SD)	p-value[b]
Total Vegetables	5	3.3 (0.9)	3.2 (0.8)	3.5 (1.1)	0.16
Greens & Beans	5	2.7 (1.9)	2.6 (1.9)	3.0 (1.8)	0.24
Total Fruit	5	3.1 (0.9)	3.1 (0.9)	3.1 (0.7)	0.38
Whole Fruit	5	4.4 (1.0)	4.3 (1.1)	4.6 (0.7)	0.25
Whole Grains	10	4.6 (2.2)	4.3 (2.2)	5.4 (2.1)	0.13
Dairy	10	4.6 (1.2)	4.8 (1.2)	4.1 (0.8)	0.05
Total Protein	5	4.8 (0.7)	4.8 (0.4)	4.8 (0.4)	0.69
Seafood & Plant Protein	5	4.9 (0.6)	4.8 (0.6)	4.9 (0.4)	0.90
Sub score: Nutrient Adequacy Components Sum[c]	50	32.3 (4.7)	31.8 (4.7)	33.3 (4.7)	0.16
Fatty Acid Ratio	10	8.4 (1.2)	8.4 (1.2)	8.5 (1.0)	0.84
Sodium	10	9.4 (0.9)	9.3 (0.9)	9.5 (0.8)	0.53
Refined Grains	10	6.6 (0.2)	6.5 (2.1)	6.8 (1.9)	0.95
SoFAAS / Empty Calories	20	17.4 (2.0)	17.2 (2.2)	17.9 (1.5)	0.04
Total Score	100	74.1 (7.7)	73.2 (7.5)	76.0 (7.9)	0.12

Home-IDEA: Home Inventory for Describing Eating and Activity; SoFAAS: Saturated Fat, Alcohol, Added Sugars

[a] Low-Income is defined by a household income of ≤ 185% of the Federal income guideline for 2016[30].

[b] Significance is 2-tailed, exact: Component Scores were assessed with independent samples Kolmogorov-Smirnov Z test, $p \leq 0.004$ after adjustment for 12 comparisons; Subscore and Total Score were assessed with independent samples t-test, $p \leq 0.025$, after adjustment for 2 comparisons.

[c] The subscore represents the sum of the eight nutrient adequacy components: Total Vegetables, Greens & Beans, Total Fruit, Whole Fruit, Whole Grains, Dairy, Total Protein, Seafood & Plant Proteins.

Maternal Dietary Intake: Food Groups and HEI-2010 Quality Score

Maternal dietary intake results are presented two ways, as mean intakes by food group for contextual comparison to the 2010 U.S. Dietary Guidelines for Americans (DGA),[43] MyPlate

Recommendations[44] (Table 15) and as an overall dietary quality score using the HEI-2010 component and Total Scores (Table 16).

Food Group Intake in Comparison to Recommendations of the Dietary Guidelines for Americans

Reported intakes for Vegetables, Fruit, Whole Grains, and Dairy (foods to increase consumption/nutrient adequacy) were below DGA recommendations within the full study sample and by income. The mean intake for Total Vegetables for the full study sample was 1.6 cup equivalents, which is almost a full cup below the recommendation of 2.5 cup equivalents for adult females, assuming an intake of 2000 calories (Table 15). Whole grain intake was very low, with a mean intake of 0.5 ounce equivalents, when compared to the recommendation of 3.0 ounce equivalents. Only Total Protein mean intakes met the recommended amounts for intake. When examining nutrients to limit, such as Sodium, Refined Grains, and SoFAAS, the findings are similarly poor. Sodium intake was consistently high (3261-3316 mg range) at almost 1.5 times the recommended intake level of 2400 mg for healthy individuals. Refined Grain intake was also 1.5 times the recommended intake level. Likewise, at an 1800 calorie level (which matches the mean intake range of 1790-1862 calories in this study), it is recommended that only 161 calories come from SoFAAS. The mean intake of calories from SoFAAS was approximately 3.5 times the recommendation, ranging from 576-590 kcal. There were no significant differences in energy intake (kilocalories), or in food groups/components of dietary intake when comparing low income to moderate income households ($p \leq 0.003$ after adjustment for 13 comparisons).

Table 15: Means and Standard Deviations for Maternal Dietary Intake by Food Group for the Family Health Study, Full Study Sample and by Income

Maternal Dietary Intake by Food Group	Full Study Sample (n=85)		Low Income[a] (n=58)		Moderate Income (n=27)		p-value[b]
	Mean ±SD	Range	Mean ±SD	Range	Mean ±SD	Range	
Total kilocalories	1839.4 ±776.6	536.0-5099.8	1862.2 ±877.5	536.0-5099.8	1790.3 ±506.6	825.1-3008.5	0.73
Total Vegetables (cup eq)	1.6 ±1.1	0.0-5.3	1.5 ±1.1	0.0-5.3	1.7 ±1.2	0.2-5.1	0.71
Greens & Beans (cup eq)	0.3 ±0.5	0.0-2.5	0.3 ±0.5	0.0-2.5	0.3 ±0.6	0.0-2.4	0.66
Total Fruit (cup eq)	1.0 ±1.0	0.0-4.0	0.9 ±1.0	0.0-4.0	1.2 ±1.0	0.0-3.3	0.08
Whole Fruit (cup eq)	0.7 ±0.9	0.0-3.3	0.6 ±0.8	0.0-3.0	1.0 ±1.0	0.0-3.3	0.14
Whole Grains (oz eq)	0.5 ±0.8	0.0-4.1	0.5 ±0.7	0.0-2.5	0.5 ±3.3	0.0-4.1	0.70
Dairy (cup eq)	1.4 ±1.2	0.0-5.5	1.3 ±1.2	0.0-4.8	1.5 ±1.3	0.0-5.5	0.42
Total Protein (oz eq)	6.1 ±5.7	0.0-44.0	6.0 ±6.6	0.0-44.0	6.3 ±3.4	1.3-14.0	0.47
Seafood, Plant Protein (oz eq)	1.2 ±2.6	0.0-12.4	1.2 ±2.9	0.0-12.4	1.3 ±2.1	0.0-9.7	0.09
Fatty Acid Ratio	1.8 ±0.1	0.5-5.4	1.8 ±0.6	0.5-3.5	1.8 ±0.9	0.8-5.4	0.56
Sodium (mg)	3271.2 ±1450.8	894.0-8083.6	3316.5 ±1599.9	894.0-8083.6	3173.8 ±1083.7	1016.4-5029.4	0.54
Refined Grains (oz eq)	4.9 ±3.5	0.0-18.7	5.1 ±3.6	0.0-18.7	4.4 ±3.3	0.0-13.2	0.54
SoFAAS / Empty Calories (kcal)	576.2 ±315.6	95.4-2230.1	576.2 ±353.9	95.4-2230.1	576.4 ±217.5	159.4-960.7	0.67

[a] Low-Income is defined by a household income of ≤ 185% of the Federal income guideline for 2016[30]
[b] Kolmogorov-Smirnov Z test for differences in the medians between low-income and moderate income households for continuous variables: significance p≤0.003.

Dietary Quality: HEI-2010 Component and Total Scores

The Dietary Quality score is measured in terms of adherence to the 2010 DGAs, with higher scores indicating greater adherence to the 2010 U.S. dietary recommendations. The Dietary Quality scores were reflective of the food group intake patterning, with the full sample and low income households having overall low Total Scores of 48.0 and 45.8, respectively, which falls within the "poor" category of the Healthy Eating Index interpretation (Table 16)[21]. When assessing component scores, seven of the twelve components were below half the maximum. The remaining components, Total Vegetables (range of 3.10-3.54 out of 5), Total Protein (range of 3.82-4.35 out of 5), Refined Grains (range of 6.13-6.80 out of 10), and SoFAAS (range of 10.01-13.19 out of 20) scored greater than half the maximum value across the full sample and income subsets. After adjustment for multiple comparisons ($p \leq 0.004$), there were no significant differences by income for the component scores. The Total Score for low income mothers trended toward statistical significance for a lower adherence to the 2010 DGA than moderate income mothers (45.8 vs. 52.7, $p=0.06$, respectively).

Table 16: Means and Standard Deviations for Component and Total Scores of Maternal Dietary Quality for the Full Sample and when comparing Low Income to Moderate Income Households

Maternal Dietary Quality Components and Total Score	**Max Score**	**Full Sample (n=85)**	**Low Income[a] (n=58)**	**Moderate Income (n=27)**	
		Mean (SD)	**Mean (SD)**	**Mean (SD)**	**p-value[b]**
Total Vegetables	5	3.3 (1.8)	3.2 (1.9)	3.5 (1.6)	0.48
Greens & Beans	5	1.4 (2.1)	1.4 (2.1)	1.4 (2.1)	0.74
Total Fruit	5	2.6 (2.1)	2.3 (2.2)	3.0 (2.0)	0.19
Whole Fruit	5	2.5 (2.3)	2.2 (2.2)	3.4 (2.2)	0.03
Whole Grains	10	2.0 (3.3)	2.1 (3.3)	1.8 (3.2)	0.49
Dairy	10	5.1 (3.6)	5.02(3.6)	5.2 (3.7)	0.56
Total Protein	5	4.0 (1.7)	3.8 (1.8)	4.4 (1.4)	0.28
Seafood & Plant Protein	5	1.8 (2.2)	1.7 (2.2)	1.9 (2.3)	0.91
Fatty Acid Ratio	10	4.2 (3.6)	4.2 (3.6)	4.2 (3.8)	0.97
Sodium	10	3.7 (3.6)	3.5 (3.5)	4.0 (3.8)	0.94
Refined Grains	10	6.4 (3.8)	6.2 (3.7)	6.8 (4.0)	0.34
SoFAAS / Empty Calories	20	11.0 (0.7)	10.1 (6.2)	13.2 (6.7)	0.08
Total Score	100	48.0 (15.9)	45.8 (15.4)	52.7 (16.3)	0.06

HEI: Healthy Eating Index; SoFAAS: Saturated Fat, Alcohol, Added Sugars
[a]Low-Income is defined by a household income of ≤ 185% of the Federal income guideline for 2016[30].
[b] Significance is 2-tailed, exact: Component Scores were assessed with independent samples Kolmogorov-Smirnov Z test, p≤0.004 after adjustment for 12 comparisons; Total Score was assessed with independent samples t-test, p≤0.05.

Exploring Potential Predictors of Maternal Dietary Quality

Prior to constructing hierarchical linear regression models, correlations were examined for the component scores and Total Score (Table 17). After adjustment for multiple comparisons within the component scores (p≤0.003), there were no statistically significant correlations between the Home-IDEA Quality Score components and their respective Maternal Dietary Quality components. Pearson's correlations confirmed that the Home-IDEA Quality Score Total Score was positively correlated with Maternal Dietary Quality Total Score for both the full sample and low income subset (r=0.31, p=0.004; r=0.32, p=0.016, respectively).

Table 17: Spearman's Correlations for Components and Pearson Correlations for Total Score between the Home-IDEA Quality Scores and Maternal Dietary Quality HEI-2010 Scores

	Full Sample (n=85)		**Low-Income[a] (n=58)**		**Moderate Income (n=27)**	
Components	**r**	**p-value**	**r**	**p-value**	**r**	**p-value**
Total Vegetables	0.19	0.09	0.19	0.15	0.03	0.87
Greens & Beans	0.16	0.14	0.16	0.22	0.16	0.43
Total Fruit	0.26	0.02	0.32	0.01	0.07	0.73
Whole Fruit	0.25	0.02	0.29	0.03	0.15	0.45
Whole Grains	0.17	0.13	0.14	0.31	0.29	0.14
Dairy	-0.05	0.67	-0.08	0.57	0.01	0.96
Total Protein	0.17	0.13	0.12	0.39	0.22	0.28
Seafood & Plant Protein	-0.06	0.59	-0.12	0.37	0.07	0.75
Fatty Acid Ratio	0.01	0.91	0.11	0.41	-0.18	0.37
Sodium	0.23	0.03	0.21	0.12	0.25	0.21
Refined Grains	0.14	0.42	0.20	0.13	0.03	0.87
SoFAAS / Empty Calories	0.18	0.10	0.13	0.35	0.12	0.57
Total Score	0.31	**0.004**	0.32	**0.02**	0.21	0.29

Home-IDEA: Home Inventory for Describing Eating and Activity; HEI: Healthy Eating Index; SoFAAS: Saturated Fat, Alcohol, Added Sugars

[a]Low-Income is defined by a household income of ≤ 185% of the Federal income guideline for 2016[30]

[b]Relationships across component scores were analyzed with Spearman's correlations, p≤0.003 after adjustment for 12 comparisons; Total score relationships were analyzed with Pearson's correlations, p≤0.05.

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The hierarchical linear regression full model (income, ethnicity, Home-IDEA Quality Score Total Score) was statistically significant (F=4.438, p=0.006), however, only the Home-IDEA Quality Score Total Score explained a unique amount of variance in Maternal Dietary Quality (R^2 change =0.091, p=.0004). After adjusting for covariates (e.g. income and ethnicity), for each one-point increase in the Home-IDEA Total Score, it was expected that the Maternal Dietary Quality Score would increase by 0.651 points (p=0.004; Table 18).

Table 18: Final Hierarchical Linear Regression Model for Maternal Dietary Quality for the Full Sample

Variables	β coefficient (95% CI)	p-value[a]
Maternal Dietary Quality: HEI-2010 Total Score (0-100) (intercept)	1.1 (-33.7,36.0)	--
Maternal ethnicity (non-Hispanic=0, Hispanic=1)	5.1 (-1.7,12.0)	0.138
Income[b] (moderate income=0, low income= 1)	-6.2 (-13.4, 0.9)	0.087
Home-IDEA Quality Score: Total Score (0-100)	0.651 (0.2, 1.1)	**0.004**

n=85; CI: confidence interval; BMI: body mass index; CVD: cardiovascular disease
[a] significance set at $p \leq 0.05$
[b] Low income is defined by a household income of ≤ 185% of the Federal income guideline for 2016[30].

Discussion

In this multi-ethnic sample of mothers with young children ages 3-5 years living in rural communities, the overall quality of the HFE was predictive of the overall quality of maternal dietary intake, with an increase of 0.65 points in maternal overall diet quality for each 1 point increase in the overall quality of the HFE. Currently, the greatest focus of HFE research has been on home food availability and child intake, with some focus on relationships for parent-child intake[9,45-47]. The literature is limited with regard to the home food availability and dietary intake for adults, and specifically, mothers with young children. This study provides novel data which fills this gap in the scientific literature.

Study participants' nutrient adequacy subscore (as represented by eight components of the 2010 DGAs) indicated a household food pattern that met 64.6% of the recommendations. This demonstrates considerable room for improvement in the quality of food available in the HFE, with the most room for improvement in Whole Grains and Dairy, closely followed by Greens & Beans. Participants' overall nutrient adequacy subscore percentage (64.6%) was lower than what their Total Score indicated when including all 12 components (74.1%) which represents both nutrient adequacy and foods to consume in moderation. The core foods, or food groups for nutrient adequacy, that make up the components for Total Vegetables, Total Fruit, Whole Grains, Dairy, and Total Protein are well represented within the Home-IDEA Checklist. The three components to consume in moderation (Sodium, Refined Grains, and SoFAAS) have lower representation on the Home-IDEA Checklist, which may have resulted in slightly inflated scores and an overestimation of the true overall quality of the HFE. It may be that the true overall quality of the HFE in this population lies somewhere between the 64.6% and 74.1% adherence to the 2010 DGAs as assessed by the HEI.

Along with the variability in the nutrient adequacy subscore percentage versus the Total Score percentage, there may be variability in the relationship between individual components in the HFE versus dietary intake. Individuals may selectively consume certain foods from the home food inventory in any given day, therefore, the concordance of any given Home-IDEA Quality Score component with a single day's intake representing that same food group could potentially be low, especially if the individual in question consumed food from outside the home within that timeframe. When considering how individual Home-IDEA Quality Score components aligned with maternal dietary quality components, after adjustment for multiple comparisons, none of the individual components were statistically significant. However, the Home-IDEA Quality Score Fruit components were trending for significant positive correlations with the HEI-2010 Fruit components, which is consistent with the literature for the presence of fruit in the home being associated with fruit intake[2,7,48]. The relationships would have been significant at a $p \leq 0.05$ if the original hypothesis was based on examining the fruit components individually, rather than all 12 components together. This finding supports the potential for using the Home-IDEA Quality

Score to provide pattern information about the HFE, especially when component scores align with dietary intake patterns for known food groups.

Maternal dietary quality scores for the full sample (48.0) and low income subset (45.8) were lower than the national averages from NHANES 2010 data for individuals aged 20-29 (48.8) and 30-44 years (53.8), with a population mean for individuals ≥20 years of 55.9[49]. HEI-2010 dietary quality scores have not been previously reported specifically for mothers (ages 20-50) with young children. It is unknown if the poor dietary quality found in this study is consistent with data collected at the national level, as said data have not specifically examined this population. Given that the literature supports a consistent positive relationship between maternal-child dietary intake for both core and non-core foods[11,17], this finding of poor maternal dietary quality is concerning as it has implications for child dietary intake and overall child health. This warrants further examination of the overall dietary quality of both mothers and their young children.

Limitations of this study include the cross-sectional nature, single time-point self-report measures, and a convenience sample. Cross-sectional data must be interpreted with care, as it is not designed to explain cause-effect outcomes. Therefore, none of the associations or models in this study should be considered causal. These data do, however, provide impetus and reason for larger, more comprehensive longitudinal investigations. Self-report measures are always problematic in that they are subject to report bias, whether from social desirability, difficulty remembering, or limited literacy and numeracy skills. The population was verbally screened for comfort and ability to read and understand English, however, there were instances during the in-person visit where questionnaire responses had to be clarified. Finally, this was a convenience sample of mothers with young children. It may be that only mothers with potential health concerns self-selected to return the interest sheets. While the sample participants were drawn from several counties in Colorado, the sample is not generalizable. Finally, while the sample size was sufficient for an exploratory study, it is limited for the number of comparisons possible within statistical tests.

The strengths of this study include the variety of assessments, from self-report to in-person data collection, the focus on multiple home environment/context factors that may contribute to the development of chronic diseases, and the use of a novel tool for assessing the overall quality of the home food environment. Using the ASA24 for dietary recall also reduced coding and interviewer error, as the system requires the interview to proceed in the same manner for all participants, provides standardized visual cues for intake amounts, and the data is coded automatically. By capturing data for the home food environment, maternal dietary intake, and maternal cardiovascular risk factors concurrently (all completed within a 1-3 day timeframe), the results may be interpreted as a true snapshot of a point in time for the participant. Finally, both in testing the feasibility and the use of a new tool for assessing the overall quality of the home food environment, the findings add to the literature in multiple, unique ways.

Implications for Future Research

It is unknown how individuals preferentially select food from their home food inventory, therefore being able to explain any unique variance in the overall pattern of the diet from a single 24-hr dietary recall is promising for future examinations of the quality of the home food environment. Future research on the quality of the HFE would benefit from studies examining which foods each household member consumes from the HFE, ideally using multiple dietary recalls. This would allow for a greater understanding of how individuals are selecting food from the household food inventory, as well as provide sufficient intake data to accurately assess the true representation of the HFE pattern to an individual's dietary intake pattern in relation to the current Dietary Guidelines for Americans. Additionally, it would be interesting to examine how the diets of children at different ages may reflect different consumption patterns from the HFE, particularly as children's independence in selecting foods within and away from the home changes with age. Finally, the Home-IDEA Checklist should be further refined to provide a more balanced representation of foods that load into the moderation components (i.e. Sodium, Refined Grains, and SoFAAS). This would increase the precision of the Total Score, allowing for enhanced confidence in generalizing the Home IDEA quality score to dietary intake quality.

The HFE literature consistently supports that the availability of certain foods in the home is associated with intake of those foods. Additionally, intake of certain micro- and macro-nutrients (such as sodium, trans/saturated fats, refined carbohydrates) has consistently been associated with health outcomes such as blood pressure, lipids, and blood sugar[50-53]. It is, thus, reasonable to consider that the HFE could be an important determinant of dietary intake and health factors, such as cardiovascular disease (CVD) or type 2 diabetes mellitus (T2DM). Both CVD and T2DM are considered largely preventable diseases, and as such, great public health emphasis has been placed on preventative measures and early detection of risk factors[54,55].

Given that overall diet quality has been associated with reduced risk factors for chronic diseases,[56-62] examining the overall quality of the HFE may provide additional information regarding points of intervention for preventative programming to improve the HFE and potentially affect both adult and child dietary intake. If the composition of the HFE influences dietary intake, as suggested by the Family Health Study, and if dietary intake in turn influences cardiovascular health characteristics, it would be important to understand the cardiovascular health characteristics of multi-ethnic mothers with young children ages 3-5 years living in rural communities. The next steps in research on the Family Health Study will be to examine the cardiovascular health characteristics of the participants, to gain better understanding of their cardiovascular health characteristics and how they might associate with child health.

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CHAPTER 6: MATERNAL HEALTH MATTERS – MATERNAL CARDIOVASCULAR RISK FACTORS AND CHILD WEIGHT STATUS

Summary

Introduction: The presence of multiple cardiovascular (CVD) risk factors in mothers may contribute to child weight status, especially for young children. **Objectives:** To determine the prevalence of CVD risk factors among a multi-ethnic sample of mothers with children ages 3-5 years living in rural communities, to explore differences in CVD risk factors by income status, and finally, to examine the relationship of maternal CVD risk factors with child weight status. **Methods**: This cross-sectional exploratory study was conducted with 85 mother-child dyads from 16 preschools in rural, eastern Colorado communities. Mothers completed self-report questionnaires for health history and physical activity, and underwent in-person assessments including blood pressure, height/weight, waist circumference, and non-fasting HDL-C, triglycerides, and blood glucose. Researchers measured child height and weight. Means and frequencies were calculated to determine the prevalence of CVD risk factors, and child overweight/obesity in the full sample and by income status. Linear regression models examined if overall maternal CVD health, as summed variables of maternal CVD risk factors, explained variance in child weight status. **Results:** The most common maternal CVD risk factors were increased waist circumference (69%), overweight/obesity (68%), low HDL-C (49%), high triglycerides (48%), and metabolic syndrome (39%). All CVD risk factors, other than hypertension, had greater prevalence in a low-income subset. Child BMI percentile average was 66.0 (± 27.2). Linear regression indicated that child BMI percentile increased by 6.2 percentile points for each additional maternal CVD risk factor present ($F=2.805$, $p=0.045$). **Conclusions:**

In this sample, mothers with young children had a high prevalence of multiple CVD risk factors, which may additively contribute to child weight status. This indicates the need for public health interventions at the family level to address maternal and child health.

Introduction

The prevalence of overweight and obesity among young children continues to be a public health concern[1], especially in low-income, ethnic, and rural communities[2-4]. Overweight and obese children face increased risk for developing chronic diseases[5-7] and other health conditions[8,9] earlier in life, as well as adverse social and psychological outcomes[10,11]. In families with young children, parents function as gatekeepers of the physical home environment and as role models of health-related behaviors[12,13]. Recent research has examined maternal-child relationships for both heritable and environmental aspects of weight status and chronic disease risk factors, such as those related to cardiovascular disease (CVD) or type 2 diabetes mellitus (T2DM)[14,15]. When considering maternal physical health factors, researchers have reported consistent positive correlations between parents and children for body mass index (BMI)[16,17], individual risk factors, such as blood pressure[18], and multiple health risk factors related to CVD or T2DM[14,15]. The majority of this research has examined these relationships for mothers with children ages 5 years and older; with limited research reporting on multiple cardiovascular risk factors of mothers with children ages 3-5 years.

The objectives for this chapter are to: 1) determine the prevalence of cardiovascular risk factors (low High Density Lipoprotein-C (HDL-C), high triglycerides, high blood glucose, hypertension, increased waist circumference, increased body mass index (BMI), low physical activity, and the presence of metabolic syndrome) in a multi-ethnic sample of mothers with children ages 3-5 years living in rural communities; 2) explore differences in maternal cardiovascular risk variables by income status; and 3) examine if overall maternal CVD risk explained variance in child weight status.

Methods

The Family Health Study is a cross-sectional exploratory study examining associations among the home food environment, maternal dietary intake, maternal cardiovascular risk factors, and child weight status. Methods for, and results of, assessing the home food environment and maternal dietary intake measures are reported in Chapter 5. As this was an exploratory study, formal power calculations for sample size were not performed; a desired sample size of 100 participants was estimated from a previous study demonstrating significant results for relationships between the home food environment to dietary intake in a sample of 82 families with young children[19]. This research project was approved by the Colorado State University Institutional Review Board (Appendix I).

A convenience sample of multi-ethnic mothers who served as the main caregiver of a child aged 3-5 years were recruited from 16 Colorado preschools from November 2015 through March 2017. Participants were provided a recruitment flier and interest form (Appendix 2, 3) via their child's backpack, with instructions to return the interest form to their child's teacher if they were interested in participating. Mothers (n=150) were screened by phone for inclusion criteria: 1) being premenopausal, 2) not having an illness or conditions that limited eating or physical activity in mother or preschool-aged child, 3) maternal weight >110 lb, 4) attested to being comfortable independently reading and completing forms in English. Eligible mothers (n=94, 63%) were assigned a participant ID number, scheduled for an in-person visit at their child's preschool, and mailed a packet of study surveys and an informed consent agreement. A total of 88 (94%) mothers completed study measures, of which 85 (90%) had complete data and were included in the analyses.

Three surveys were provided to all participants: a Health History and Demographic Form, the International Physical Activity Questionnaire (IPAQ) to capture recent physical activity, and the Home Inventory for Describing Eating and Activity (Home-IDEA) Checklist to capture the home food environment. Surveys were to be completed 1-3 days prior to the in-person visit. Maternal cardiovascular risk factors and dietary assessments were completed at the in-person visit. Child weight status was collected at the in-person visit or during a visit to the preschool.

Maternal Health History and Family Demographic Form:

The Health History and Demographic Form (Appendix 5) was developed using the Behavioral Risk Factor Surveillance Survey (BRFSS)[20]. BRFSS questions were selected for their previous widespread use in multiple populations and potential for comparability to state and national data. The self-report health history variables for hypercholesterolemia, hyperglycemia, and hypertension were used in conjunction with the in-person measures of cardiovascular risk factors. Data for participants who responded “yes” to the questions “has a doctor or health care professional ever told you that you had [condition]?” or “are you currently taking medication for [condition]”, were combined with their in-person health measure to indicate the presence of the respective condition. Self-reported income and household size (sum of the mother, spouse, and number of children) were used to calculate income thresholds for low-income status at 185% of Federal income guidelines as of 2016. The 185% of Federal income was selected as a criterion because it is a determining factor for several federal and state assistance programs, such as the special Supplemental Nutrition Program for Women, Infants, and Children (WIC), and Title V – Maternal & Child Health Services[21].

International Physical Activity Questionnaire (IPAQ):

PA levels over the past 7 days were captured using the IPAQ, short form (Appendix 6)[22]. The IPAQ quantifies time spent in vigorous and moderate physical activities, and walking over the last 7 days (weekdays and weekend), and sitting during the past 5 weekdays. Vigorous and moderate are defined by the level of physical effort (hard, moderate) and breathing rate (much harder, somewhat harder than normal, respectively). Participants are asked to specify the number of days in the past week and the total time (only including time spent in blocks of 10 minutes or greater) on one average day, for each level of physical activity. The data for the IPAQ short form was handled as instructed under the Guidelines for Data Processing and Analysis, revised April 2004[23].

Maternal Cardiovascular Risk Factor Assessment and Child Weight Status.

Maternal cardiovascular risk factor assessment included HDL-C, triglycerides, blood glucose, hypertension, waist circumference, BMI, physical activity, and metabolic syndrome. In-person measures included a standard lipid panel with blood glucose, HbA1c, blood pressure, height, weight, and waist circumference. The single, non-fasting lipid panel (total cholesterol, HDL-C, non-HDL-C, LDL-C, triglycerides, glucose), and HbA1C measures were collected using two point-of-care units (the Alere Cholestech LDX system, (lipid-glucose panel), and the Alere Afinion AS100 (HbA1c), Alere North America, Scarborough, ME). NHANES techniques were used for blood pressure, height, weight, and waist circumference assessments [24,25]. Blood pressure and resting heart rate were collected in triplicate using an automated blood pressure device (Omron 10 series automated monitor with semi-rigid cuff, Omron Healthcare, Inc.). Duplicate measures of height were collected to the nearest 0.1 cm in duplicate to the nearest 0.1 cm using a portable stadiometer (Seca Corp. Hamburg, Germany). A single weight measurement to the nearest 0.1 pound was collected using a digital scale (Lifesource ProFit UC321; Milpitas, CA). BMI was calculated using the NIH standard formula (weight (kilograms) / [height (meter)^2][26]. Duplicate waist circumference measurements to the nearest 0.1 cm were collected at the top of the iliac crest using a thin metal measuring tape specifically designed for circumference measurements (Lufkin Executive Thin Line, 2m, W606PM). Measures taken in duplicate or triplicate were averaged; averages were used for reporting and statistical analyses.

Metabolic syndrome was calculated as a dichotomous variable with a score of 1 representing the presence of three or more of the five health indicators defined by the National Cholesterol Education Program's Adult Treatment Panel III (NCEP ATP III) components[27]: HDL-C <50 mg/dL, triglycerides ≥ 150 mg/dL or medication to treat hypertriglyceridemia, fasting blood glucose ≥100 mg/dL or medication to manage blood glucose levels, blood pressure ≥130/85 mmHg or medication to treat hypertension, and waist circumference ≥35 inches. As blood-based measures were taken non-fasting, the cut-point for triglycerides was revised to 175 mg/dL[28,29], and HbA1c was substituted for blood glucose with a cut point of 5.7% (recommended cut point by the American Diabetes Association for screening for pre-diabetes[30]).

Maternal overall CVD risk was calculated as a sum score (0-5) that included five CVD risk factors: HDL-C <50 mg/dL=1, triglycerides ≥175 mg/dL or medication to treat hypertriglyceridemia=1, HbA1c ≥5.7% or medication to manage blood glucose levels=1, blood pressure ≥130/85 mmHg or medication to treat hypertension=1, and waist circumference ≥35 inches=1. BMI and maternal physical activity were not included in the sum of CVD risk factors variable; BMI was excluded due to collinearity issues with waist circumference and the physical activity data were excluded due to challenges with participant completion of the IPAQ.

Child assent was confirmed prior to collection of any measures. Measures of height were collected to the nearest 0.1 cm, in duplicate< using a portable stadiometer (Seca Corp. Hamburg, Germany). The duplicate measures were averaged; the average was used for statistical calculations. A single weight measurement to the nearest 0.1 pound was collected using a digital scale (Lifesource ProFit UC321; Milpitas, CA). Child weight status was calculated from child height and weight (kg/m^2), and converted to BMI percentiles (EpiInfo software, v.7 CDC, Atlanta, GA).

Data Management and Analysis

Study data were collected and managed via REDCap (Research Electronic Data Capture) electronic data capture tools. REDCap is a HIPPA compliant, secure, web-based application designed to support data capture for research studies hosted by the Colorado Clinical & Translational Sciences Institute (CCTSI).[31] All continuous data were inspected for normality using standard normality tests, Kolmogorov-Smirnov and Shapiro-Wilk tests, and by visually assessing histograms and box plots. Analyses were completed for the full study sample, and by income level (low-income vs. moderate-income). Means, standard deviations, range, and frequencies were computed for participant characteristics (where applicable), maternal cardiovascular risk factors, and child weight status. Z-tests of the medians, chi-square tests, and odds ratios were conducted to examine differences in factors by income status. Spearman's correlations were calculated to assess relationships among maternal cardiovascular risk factors and child weight status.

Exploratory hierarchical linear regression modeling was performed to determine if maternal CVD health explained variance in child weight status. Two variables representing CVD health were tested, the overall maternal CVD sum variable and the metabolic syndrome variable. Ethnicity and income were included as covariates in the models as both had significant correlations with select individual factors used to create the composite variables (HDL-C, waist circumference) and income was significantly correlated with both composite variables. Models were tested hierarchically[32] for the full sample by adding individual variables in this order: Model 1 - ethnicity, income, overall maternal CVD sum; Model 2 - ethnicity, income, metabolic syndrome. Analyses were performed using SPSS v.24 (IBM Corporation, Armonk, NY). Significance was set at $p \leq 0.05$ for all tests.

Results

Participant Characteristics

Data were collected from 85 mother-child dyads, their characteristics are presented in Table 19. Maternal participants had a mean (SD) age of 32.4 years (± 6.5), were predominantly of low-income status (68%), 29% had a high school education or less, and 55% identified as Hispanic. Child participants had a mean age of 4.5 years (± 0.7), 47% were female, and 59% were identified as Hispanic. When examining the subgroup labeled as low-income (n=58), it is important to note that there is considerable overlap between low-income and Hispanic households, with 62% of low-income households (n=58) being Hispanic (n=36). Income and ethnicity were not significantly correlated (r=.20, p=0.067), nor was there a significant difference in the number of Hispanic participants in low-income vs moderate-income households. Low-income mothers were younger (31.9 y (±7.0) vs. 33.5 y (±5.0), $p=0.05$), had a larger mean waist circumference (40.7 in (±7.1) vs. 36.0 in (±4.8), $p<0.01$), lower mean HDL-C (47.4 mg/dL (±13) vs 57 mg/dL (±16), $p<0.01$), and greater mean BMI (30.6 (±7.6) vs 26.4 (±4.7), $p=0.02$) than moderate-income mothers.

Table 19: Maternal and Child Characteristics for the Family Health Study for the Full Study and by Income

Characteristics	Full Study (n=85)		Low-Income[a] Group (n=58)		Moderate-Income Goup (n=27)		
	% (n)[b] or Mean (±SD)	Range	% (n)[b] or Mean (±SD)	Range	% (n)[b] or Mean (±SD)	Range	*p* value[c]
Maternal							
Age (years)	32.4 (±6.5)	20.7-51.0	31.9 (±7.0)	21.5-51.0	33.5 (±5.0)	20.7-41.2	0.05
Race							
White	93% (79)		93% (54)		93% (25)		1.00
Black/African American	1% (1)		2% (1)		--		
Asian	2% (2)		2% (1)		4% (1)		
African American/Native Alaskan	1% (1)		2% (1)		--		
Pacific Islander/Native Hawaiian	1% (1)		2% (1)		--		
Other/Declined	1% (1)		--		1% (1)		
Ethnicity: Hispanic	55% (47)		62% (36)		41% (11)		0.10
Main Language Spoken at Home							
English	86% (73)		91% (53)		74% (20)		**0.05**
Spanish	13% (11)		7% (4)		26% (7)		
Other	1% (1)		2% (1)		--		
Low-Income[a]	68% (58)		--		--		
Education							
≤ High School diploma	29% (25)		36% (21)		15% (4)		**0.02**
Some college (no degree)	27% (23)		26% (15)		30% (8)		
Associates or Bachelor's degree	31% (26)		29% (17)		33% (9)		
Graduate or Professional degree	13% (11)		9% (5)		22% (6)		
Metabolic Syndrome (≥3 factors)	39% (33)		47% (27)		22% (6)		0.06

Table 19: Maternal and Child Characteristics for the Family Health Study for the Full Study and by Income

Characteristics	Full Study (n=85)		Low-Income[a] Group (n=58)		Moderate-Income Goup (n=27)		
	% (n)[b] or Mean (±SD)	Range	% (n)[b] or Mean (±SD)	Range	% (n)[b] or Mean (±SD)	Range	*p* value[c]
Waist Circumference (inches)	39.8 (±7.0)	28.1-61.9	40.7 (±7.1)	28.1-61.9	36.0 (±4.8)	29.5-48.2	**0.00**
High Density Lipoprotein (HDL-C, mg/dL)	50 (±14)	23-82	47.4 (±13)	23-82	57 (±16)	30-82	**0.00**
Triglycerides (mg/dL)	174 (±114)	45-594	190 (±115)	47-594	147 (±113)	45-489	0.10
HbA1c (%)	5.6 (±1.1)	4.7-13.9	5.6 (±1.2)	4.7-13.9	5.3 (±0.2)	4.9-5.8	0.10
Systolic Blood Pressure (mmHg)	107 (10)	90-142	108 (±10)	90-135	108 (±13)	92-142	0.57
Diastolic Blood Pressure (mmHg)	76 (±8)	58-98	76 (±7)	62-98	76 (±10)	58-95	0.20
Body Mass Index (BMI)	29.3 (±7.1)	17.4-53.5	30.6 (±7.6)	17.4-53.5	26.4 (±4.7)	19.4-35.8	**0.02**
Underweight (<19kg/m^2)	4% (3)		5% (3)		--		
Normal weight (19-24.9 kg/m^2)	29% (25)		21% (11)		44% (12)		
Overweight (25-29.9 kg/m^2)	26% (22)		24% (14)		30% (8)		
Obese (≥30 kg/m^2)	41% (35)		50% (29)		22% (6)		
<u>Child</u>							
Sex: Female	47% (40)		50% (29)		41% (11)		0.49
Age (years)	4.5 (± 0.7)	3.0-5.7	4.5 (±0.7)	3.0-5.6	4.5 (±0.6)	3.6-5.7	0.35

Table 19: Maternal and Child Characteristics for the Family Health Study for the Full Study and by Income

Characteristics	Full Study (n=85)		Low-Income[a] Group (n=58)		Moderate-Income Goup (n=27)		
	% (n)[b] or Mean (±SD)	Range	% (n)[b] or Mean (±SD)	Range	% (n)[b] or Mean (±SD)	Range	*p* value[c]
Race							
White	97% (82)		95% (55)		100% (27)		0.55
Black/African American	1% (1)		2% (1)		--		
Asian	1% (1)		2% (1)		--		
African American/Native Alaskan	--		--		--		
Pacific Islander/Native Hawaiian	1% (1)		2% (1)		--		
Other/Declined	--		--		--		
Ethnicity: Hispanic	59% (50)		67% (39)		41% (11)		**0.03**
Main Language Spoken at Home							
English	92% (78)		91% (53)		93% (25)		1.00
Spanish	7% (6)		7% (4)		7% (2)		
Other	1% (1)		2% (1)		--		
BMI Percentile (child)[d]	66.0 (± 27.2)	1.3-99.6	66.1 (±28.0)	1.3-99.6	65.8 (±25.9)	3.1-98.5	0.93
Underweight (<2.5th percentile)	1% (1)		2% (1)		--		
Normal weight (2.5<85th percentile)	61% (50)		57% (32)		63% (17)		
Overweight (85th<95th percentile)	30% (25)		33% (16)		22% (6)		
Obese ($\geq$95th percentile)	7% (6)		5% (3)		11% (3)		

[a] Low-Income is defined by a household income of ≤ 185% of the Federal income guideline for 2016[21]
[b] Values presented as a percent of the study population will not always sum to 100%, due to rounding.
[c] Kolmogorov-Smirnov Z test for differences in the medians between low-income and moderate-income households for continuous variables (Maternal – age, waist circumferemce HDL-C, triglycerides, HbA1c, Systolic blood pressure, diastolic blood pressure, BMI; Child – age, BMI). Chi-square test for differences between low-income and moderate-income households for categorical variables (Maternal – race, ethnicity, language spoken at home, education, metabolic syndrome, Child – sex, race, ethnicity, language spoken at home), significance p≤0.05
[d]Child BMI percentiles (n=82)

Maternal Cardiovascular Risk Factors

Prevalence of maternal cardiovascular risk factors and odds ratios by income level are shown in Table 20. The most common individual risk factors were high waist circumference (69%), overweight/obesity (68%), low HDL-C (49%), high triglycerides (48%), and metabolic syndrome (39%). When examining prevalence separately by income level, all factors other than hypertension had greater prevalence in the low-income subgroup. Odds ratios by income level indicated that mothers with low HDL-C, increased HbA1c, maternal overweight/obesity, and metabolic syndrome were at increased odds of being low-income when compared to moderate-income.

Table 20: Prevalence of Maternal Cardiovascular Risk Factors and Child Weight Status for the Full Sample and by Income, with Odds Ratios by Income Level.

Factor	Full Sample (n=85)	Low-income[a] (n=58)	Moderate-income (n=27)	Odds Ratios: Low-Income vs Moderate-Income		
					95% CI	
				Exp (B)	Lower	Upper
HDL-C < 50 mg/dL	49%	60%	26%	**4.35**	**1.59**	**11.92**
Triglycerides >175 mg/dL	48%	51%	41%	1.56	0.62	3.93
HbA1c > 5.7%	27%	34%	11%	**4.21**	**1.13**	**15.71**
Hypertension (≥130 systolic or ≥85 diastolic mmHg)	13%	9%	26%	**0.33**	**0.10**	**1.10**
Waist Circumference ≥35 in	69%	76%	56%	2.51	.96	6.62
BMI ≥ 25 kg/m^2	67%	74%	52%	**2.66**	**1.02**	**6.93**
Low Physical Activity (Sedentary)	19%	21%	15%	1.50	0.44	5.17
Metabolic Syndrome ≥3 factors	39%	47%	22%	**3.05**	**1.07**	**8.66**
Child BMI > 85th Percentile[b]	38%	38%	33%	1.22	0.46	3.22

HDL: High Density Lipoprotein; HbA1c: Hemoglobin A1c; mmHg: millimeters mercury; BMI: body mass index; kg: kilogram; m: meter,
[a]Low-Income is defined by a household income of ≤ 185% of the Federal income guideline for 2016[21].
[b]n=82 for the Full Sample, n=57 Low-Income, n=25 Moderate-income

Exploring Potential Predictors of Child Weight Status, as Defined by Child BMI Percentile.

Prior to examining the hierarchical linear regression models, Spearman correlations were calculated to assess relationships among maternal CVD risk factors and child weight status. Maternal waist circumference was positively correlated with maternal BMI (r_s=0.94, p≤0.01), so only one of these factors was included in linear regression models. Waist circumference was selected for inclusion over BMI as it is considered an independent indicator of CVD risk even in normal weight individuals,[26] and is more appropriate at the individual level whereas BMI is intended for use as a population-level surveillance method.[33,34] The sum number of CVD risk factors was positively correlated with child BMI percentile across the full sample (r_s=0.28, p≤0.01), and within the low-income demographic (r_s=0.28, p≤0.05). Metabolic syndrome was not significantly correlated with child BMI percentile. There were no significant interactions between ethnicity or income and the sum of CVD factors or metabolic syndrome, therefore interaction terms were not included in the models.

After adjusting for covariates (e.g. income and ethnicity), the full model accounted for 9.7% of the variance in child BMI percentile (F = 2.805, p=0.045), with the sum of cardiovascular factors uniquely explaining 9.4% of variance in child BMI percentile (p=0.006). More specifically, when adjusted for maternal ethnicity and income, for each additional maternal cardiovascular risk factor, it was expected that child BMI percentile would increase by 6.2 percentile points (Table 21). The second model, controlling for covariates did not find metabolic syndrome to explain significant variance in child weight status (F=1.165, p=0.329; R^2 =0.040, p=0.076; data not shown).

Table 21: Final Hierarchical Linear Regression Model for Child Weight Status for the Full Sample

Variables	***B* coefficient (95% CI)**	***p* value[a]**
Child BMI Percentile (intercept)	59.2 (46.5, 71.9)	--
Maternal ethnicity[b]	-6.2 (-18.2, 5.8)	0.308
Income[c]	-3.8 (-16.8, 9.3)	0.567
Sum of maternal CVD risk factors (0-5)	6.2 (1.9, 10.5)	**0.006**

n=82; CI: confidence interval; BMI: body mass index; CVD: cardiovascular disease
[a] significance set at p≤0.05
[b] Reference group is non-Hispanic.
[c] Low-income is defined by a household income of ≤ 185% of the Federal income guideline for 2016[21], reference group is moderate-income.

Discussion

In this multi-ethnic sample of mothers with children ages 3-5 years living in rural communities, a very high prevalence of CVD risk factors was found with many of these factors being higher in the lower income participants. Further, findings show maternal CVD risk to be positively associated with child weight status with an increase of 6.2 percentile points in child weight status for each additional maternal cardiovascular risk factor. This finding has not been previously reported in the literature and, as such, warrants further examination.

The prevalence of overweight/obesity in this sample of mothers with young children was close to national statistics for mothers and greater than national statistics for children.[1] The prevalence of maternal low-HDL-C and metabolic syndrome were higher than estimated national statistics for females of all ethnicities, ages 20-64 (low HDL-C 49% vs 10%; metabolic syndrome 39% vs 36%, respectively).[35-37] While our HDL-C finding is unusual, Nichols, et al. (2017) also reported a higher low-HDL prevalence in a nationwide sample of overweight and obese adults aged 20-49 years; 39.1-41.1% for the total sample, with a range of 30.0-51.0% for overweight and obese, respectively.[38]

Prevalence of CVD risk factors is typically reported by sex, age, ethnicity, or in association with a specific disease state; these studies do not report findings for mothers with young children as a specific subset. Because it has been established that mothers play a distinct role in forming the home food and activity environment of young children,[128] and function as role models for health-related behaviors,[129] it is reasonable to hypothesize that these maternal physical health factors are related to the shaping of the home environment.[130] Therefore, these health factors may influence child weight status and development of corresponding CVD and T2DM risk factors at earlier ages.[126]

Mothers with low HDL-C, high HbA1c, overweight/obesity, or metabolic syndrome, also had statistically increased odds of being low-income, confirming the potential for health disparity issues in this population. Low-income and ethnic populations often carry a disparate burden of chronic disease and obesity coupled with lower access to affordable medical care[39]. Such factors may put the children at even higher risk for overweight/obesity.[40] Because parental weight status/obesity is strongly associated with child weight status/obesity[41-43], [44], and obese children are more likely to become obese adults[41,45], it is imperative that maternal health be further examined in this population. Findings from this study demonstrate a significant 6.2% increase in child weight status for the presence of each maternal CVD risk factor, not just maternal overweight/obesity. Thus, the cumulative burden of multiple CVD risk factors, coupled with an already high prevalence of child overweight/obesity, points to considerable need for additional public health outreach.

There are several limitations to this study. Although the sample size was sufficient for an exploratory study, it may have limited power within linear regression models with multiple outcomes and covariates. As this was a convenience sample of mothers with young children; it may be that only mothers with potential health concerns self-selected to return the interest sheets. While the sample participants were drawn from several counties in Colorado, the sample is not generalizable beyond eastern Colorado. Cross-sectional data must be interpreted with care, as it is not designed to explain cause-effect outcomes. Therefore, none of the associations or models in this study should be considered causal. Self-report measures are always problematic in that they are subject to report bias, whether from social desirability, memory bias, or limited literacy and numeracy skills. This population was verbally screened for comfort and ability to read and understand English, however, there were instances during the in-person visit where questionnaire responses had to be clarified, especially for the IPAQ. Finally, although blood samples were non-fasting, this should not have influenced our findings as the cut-points for triglycerides and HbA1c values were adjusted accordingly.[28-30] These data provide impetus and reason for larger, more comprehensive longitudinal investigations.

The strengths of this study include the variety of self-report and objective assessments, variability in outcome measures and demographic composition that allowed for comparisons by income. Having overlapping self-report and objective health measures enhanced confidence in the overall assessment of maternal health as there was 100% concordance in these two measures. By objectively measuring weight status in both mothers and children, issues with self-report bias for weight status were eliminated for this variable. Enrolling mothers from across rural, eastern Colorado increased variability and generalizability within this low-income, multi-ethnic population, however not enough to generalize outside of the region.

The implications of this study extend into the public health domain. The high prevalence of several cardiovascular risk factors found in this study could be indicative of a great need for additional public health programing in rural and low-income communities. With both the

American Heart Association and the American Diabetes Association recommend lifestyle modifications of diet and exercise as a first line treatment for CVD and DM[46,47], knowing if parents have these conditions (among others) would provide additional insight for public health strategies that could link the home food environment, dietary intake, and health outcomes together in a cohesive manner. Further, connecting maternal health to home food and dietary strategies in the context of family health interventions could affect positive health changes in parents and children and should be considered as a strategy to prevent childhood obesity.[48-50]

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CHAPTER 7: CONCLUSIONS

As the development and evaluation phases of the Home-IDEA Quality Score were presented in manuscript form, additional interpretation and discussion is warranted to cover content that was not addressed previously. The first section of Conclusions, The Home-IDEA Quality Score, will discuss the challenges in developing and evaluating the Home-IDEA Quality Score, and the practical considerations for interpretation when used as an assessment tool. The second section of the Conclusions, the Family Health Study, will address the feasibility of the study as it was not covered in the previous chapters. A summary conclusion will be provided that places both sets of results within the overall context of the home environment and family health. Finally, future research directions will be described.

The Home-IDEA Quality Score

Use of the Healthy Eating Index (HEI) in food streams other than direct dietary intake typically apply the HEI algorithms to data that can be directly linked to food codes through bar code scanning or dietary analysis software. These studies then report the overall quality of the given food stream, and compare their findings to national HEI dietary intake data or to the Dietary Guidelines for Americans for context[1-4]. Only one study was identified where the authors applied the HEI algorithm in the development of a separate tool, which would be used to quantify the overall quality of grocery store purchases[5]. This lack of comparable research methods resulted in challenges that had to be navigated without access to previous examples to inform decisions. Therefore, methods and processes were developed using general nutrition database, research best practices, and by modeling reliability and validation procedures on the HEI-2005 and 2010 process.

Development and Validation of the Home-IDEA Quality Score: Practical Considerations

Using the HEI reliability and validation procedures provided a structure during the development and external evaluation phases. Where feasible, evaluation methods were mimicked to those completed for the evaluation of the HEI-2005 and the HEI-2010 (Appendix 8). To fit the needs of the tool, additional evaluation methods were developed that explored underlying foundational concepts in ways that would expose issues in the representative food and food amount (iterative testing). Further, weaknesses were identified in the Home-IDEA Checklist items in terms of sampling from a larger home food inventory (comparisons to the FoodAPS complete home food inventories).

The iterative testing method enhanced understanding of the Home-IDEA Nutritional database structure and how the representative food items and food amounts loaded into the Components and Total Score, which also led to an enhanced understanding of the HEI. One of the most enlightening results of the iterative testing was that while the index is density-based, if a single food item occurs in a large quantity, such as an entire deer carcass, the pattern is overwhelmed and will not accurately portray the overall pattern of the household. Foods that are present in bulk quantities present problems in evaluating a home food inventory, specifically because these foods will be eaten over a considerably longer timeframe than perishable foods purchased for eating during a given week. Therefore, the Home-IDEA Nutrition database representative foods and food amounts not only needed to be grounded in foods that were actually found in homes, but also in reasonable purchase size quantities. Considerations for equalizing of purchase sizes for regular trips to the grocery store were made in a manner that would better reflect how individuals would consume food from a household food inventory over the course of a week. This is a continued challenge when considering shelf-stable items that are consumed in small amounts throughout multiple weeks or months, but are purchased in larger quantity sizes, such as cooking oils, condiments, dressings, and sandwich spreads.

The validity and reliability testing indicated that the Home-IDEA Quality Score performed similarly to the HEI 2005 and 2010 validity and reliability testing. Construct validity was supported by the ability of the Home-IDEA Quality Score to detect differences in home food environments that were constructed to reflect different dietary patterns (Chapter 3), as well as when evaluating the distribution of scores of the Home-IDEA Quality Score in comparison to the Food APS Quality Score (Chapter 4). The distribution of scores was wide enough that it suggests the Home-IDEA Quality Score has adequate sensitivity to detect meaningful differences in home food environment quality. Therefore, it should be sensitive to changes in the quality of individual home food environments over time. For example, if an intervention resulted in changing food purchases resulting in a higher vegetable and fruit pattern with fewer processed foods, the Home-IDEA Quality Score should increase. Additionally, the Home-IDEA Quality Score performed similarly to the HEI in that the Components and Total Scores were dissociated from household energy, as evidenced by low correlation scores (Chapter 4).

Two of the most common forms of reliability testing, test-retest and inter-rater reliability, were not applicable in this instance. Test-retest and inter-rater reliability would have tested the ability of the Home-IDEA Checklist to be completed consistently, rather than testing the Quality Score, as there is no variation in application of the algorithm once the data has been entered.

Therefore, reliability was assessed internally, using correlations between the Components and Total Score to describe relationships among the variables, and interpreted using the HEI-2005 and 2010 scores for comparison. Reliability was successfully demonstrated as the overall patterning of the correlations for the Home-IDEA Quality Score Components was similar to those seen with the HEI-2005[6] and HEI-2010[7] (Chapter 4). Additionally, in the HEI reliability testing, it was noted that Dairy had the lowest correlation, but was also negatively correlated with the Fatty Acid Ratio, indicating that much of dietary intake that contributed to Dairy was high-fat dairy; as the fat is fractionated into unsaturated and saturated fats and then transformed into the Fatty Acid Ratio. The same pattern was seen for the Home-IDEA Quality Score as well, further demonstrating similarities in reliability. Finally, by having similar patterning in validation and reliability outcomes, confidence in interpreting the Home-IDEA Quality Scores in relation to dietary intake quality scores was increased.

Using and Interpreting the Home-IDEA Quality Score: Practical Considerations

The findings from the extensive reliability and validity procedures undertaken during the development and evaluation phases of the Home-IDEA Quality Score supported that the tool would accurately reflect the overall quality of the home food environment. As there are no other tools that currently measure the overall quality of the home food environment, the Home-IDEA Quality Score fills a gap in home food environment assessment tools[8]. However, this is also a drawback, as there are limited direct comparisons that can be made to other tools, and interpretations of the Home-IDEA Quality Score currently have no comparable context. To demonstrate use in a study setting, the Home-IDEA Quality Score was applied to the Home-IDEA Checklist data from the Family Health Study.

Because the intent of the Family Health Study was not to further validate the Home-IDEA Quality Score, data and resulting discussions of factors relevant to its validation were not included in Chapter 6. Rather, they will be summarized here and immediately discussed. Generating the Home-IDEA Quality Score for the Family Health Study was straightforward, as expected. However, the means for the Components and Total Score were higher than expected based on the values obtained working with the FoodAPS database. Based on the range and sensitivity testing on the data from the FoodAPS database, it was expected that ceiling effects might occur in Sodium and SoFAAS, as these Components are not well represented by the food items in the Home-IDEA Checklist. However, ceiling effects were not expected below the 75th percentile for any of the other Components. Whole Fruit and Total Protein had ceiling effects at the 50th percentile, and Seafood & Plant Protein ceilinged at the 25th percentile. Floor effects were evident in the FoodAPS evaluation, with all Components' means being zero at the 10th percentile and below. In the Family Health Study, however, only Greens and Beans showed a similar floor effect – all other Components' mean scores were greater than zero by the 5th percentile. Finally, the distribution of the means for the Total Score was much smaller for the Family Health Study than for the FoodAPS evaluation. The distribution of the means for the Family Health Study ranged from 57.18 at the 1st percentile to 88.10 at the 95th percentile, whereas the FoodAPS distribution of the means for the Total Score ranged from 18.76-87.13. Therefore, in a study-based application, the Home-IDEA Quality Score did not perform similarly to the evaluation phase testing against the FoodAPS database. Because there are no comparison tools, it is unknown if this is a tool issue, or if this is a realistic assessment of the home food environments in the target population of rural, predominantly low-income, multi-ethnic families with young children.

If the foundations of development hold, and the Home-IDEA Quality Score is potentially comparable to dietary intake quality scores, then one would expect that there would be a fairly high degree of association between the Home-IDEA Quality Score Components and Total Score with the Maternal Dietary Quality Components and Total Score. This was not the case for 11 of the 12 Components in the Family Health Study. It did remain true, however, for the Whole Fruit Component and the Total Score. To further examine the Whole Fruit Component, the correlations within the Home-IDEA Quality Score were examined for the relationship between the Whole Fruit Component and the Total Score. This was also done for Maternal Dietary Quality. Both sets of data were consistent, in that the Whole Fruit Component had the second largest correlation with the Total Score. This finding is consistent with the internal pattern of correlations seen with the HEI-2005 and 2010 evaluations[6,7]. The consistency in significance for the Component Whole Fruit across the data sets could be indicative of underlying collinearity or relationship for intake of whole fruit as an indicator of overall higher quality diet. This would not be surprising, given that much of the home food environment literature already supports consistent positive relationships between fruit availability and fruit intake for both adults and children[9-22].

The Family Health Study

The Family Health Study clearly demonstrated feasibility for collecting these measures in sample of rural, predominantly low-income, multi-ethnic, mothers with young children. The high completion rate indicates that the study procedures, both the surveys and in-person measures, were well received by the participants. When evaluating the relative success of study measures, as evidenced by range of scores within each measure and ease of collection, the measures themselves were also feasible. All but two participants returned all of the surveys at the time of the in-person visit; these two participants successfully completed and mailed the missing survey (the Home-IDEA Checklist) within the week following the in-person visit.

The IPAQ was the only survey that presented challenges during data collection, analysis, and interpretation. The vast majority of these surveys had questions that needed follow-up at the time of the in-person visit. Many of the participants had problems reporting daily averages of PA or hours sitting and instead reported weekly totals for these questions. These questions were discussed with the participants during their in-person visit, however, there were still times when the participant visually struggled to generate a per-day average amount. It was clear that the tool was cognitively challenging, even with clarification. Lastly, the percentage of participants (81%) that were categorized with moderate/high physical activity, indicative of meeting the U.S. Physical Activity Guidelines, was unusually high Considering that recent US data for meeting physical activity guidelines indicates only about 52% of the adult population met the guidelines in 2016[23,24], the high prevalence in this sample adds to concerns about the validity of the data from the IPAQ.

Overall Conclusions

An initial exploratory goal of this project was to examine if these factors as quality constructs (Home-IDEA Quality Score, Maternal Dietary Quality, Maternal sum of CVD risk factors) would first explain any variance in Maternal Health, and second, child weight status. Multiple research studies provided support for the individual concepts, that the home food environment is consistently related to dietary intake in children and adults[16,18,22,25-33], that adult dietary intake is related to adult health outcomes[34-40], and that certain health outcomes are related parent – child, such as body mass index[41,42], blood pressure[43], and cardiovascular disease risk[44-

[46]. Less research was available for our quality construct of dietary intake (Healthy Eating Index) in relation to health outcomes, but what was available was consistent in reporting improved dietary patterns are associated with decreased risk of adverse health factors or outcomes[34,39,47-50]. However, there was no research for the use of a quality score for the home food environment in relation to either dietary intake, maternal health, or child weight status, as no literature was found describing home food environments in terms of quality scores. Finally, there was very little research published on the HFE, dietary intake, maternal CVD risk, and child weight status when examining all four aspects simultaneously. The linear regression models for the Home-IDEA Quality Score to maternal cardiovascular risk, Home-IDEA Quality Score to child weight status, and maternal dietary quality to child weight status were not significant. The lack of significance may be due to limitations in the data collected, sample size, or both. These models were not included in the dissertation.

The linear regression model for maternal dietary quality supports that the overall quality of the home food environment is associated with and explained 9.1% of the overall quality of maternal dietary intake. As no measure for calculating the overall quality of the home food environment previously existed, this finding is novel and there are no current standards for comparison. Additionally, it is unknown how individuals select food from their home food inventory, therefore being able to explain any unique variance in a single 24-hour dietary recall is promising for future examinations of the home food environment. That said, multiple 24-hour dietary recalls should be employed in future studies. The low percentage of variance explained by the HFE in this regression model may be due to several factors: the sample size, which was sufficient for a pilot study, but potentially low to test for several regression predictors; a single time-point measure for the home food environment and maternal dietary intake; lack of understanding as to how individuals preferentially select certain foods from the home food inventory; or any combination of these factors.

The linear regression model for child weight status supports that the overall quality of Maternal Health, as a sum score of cardiovascular risk factors, was associated with and explained 9.4% child weight status. Because of the significant correlation between child BMI percentile and maternal BMI, along with the collinearity between maternal waist circumference and maternal BMI, separate linear regression models were run to evaluate if the CVD risk factor of waist circumference was driving the relationship. These models (data not shown) indicated that while maternal waist circumference, HDL-C, and diastolic blood pressure were all significant in the model, waist circumference was the only factor that explained a unique amount of variance in child weight status. In examining the cardiovascular risk factors separately, it was instructive to find that HDL-C and blood pressure were significantly correlated with the Maternal Dietary Quality Components Total Fruit, Whole Fruit, and Seafood & Plant Proteins. This points to dietary constructs that underlie these health factors from a nutrient density perspective rather than an energy balance perspective.

Finally, from a public health perspective, it is troubling that the percentages of risk factors were unexpectedly high – and as in the case of low HDL-C, substantially higher than available national averages[51-54]. Colorado has long been considered a healthier state from an obesity perspective[55]; however, the data from the Family Health Study indicates that this is simply not the case in this sample of rural, predominately low-income, multi-ethnic mothers of young children. This data clearly suggests that more than a third already have sufficient risk factors to be diagnosed with Metabolic Syndrome, which is, in and of itself, an independent risk factor for early development of cardiovascular disease and Type 2 diabetes[56]. If these women are not accessing regular preventative medical care, or community health screenings, they may not be aware that they have any additional risk factors outside of weight status.

The Family Health Study also demonstrated that the mean Maternal Dietary Quality Total Score for the full sample (48.0 ± 15.9) was lower than the national averages from NHANES 2010 data for individuals aged 20-29 (48.8 (CI: 47.2-50.5)) and 30-44 years 53.8 (CI: 51.6-56.0), with a population mean for individuals ≥20 years of 55.9 (CI: 54.4-57.3)[57]. The poor overall dietary quality combined with increased risk factor prevalence warrants concerted community efforts at the family level. This work supports the need for interventions that target improvements in diet and physical activity and longitudinal follow-up, which could then lead to improvements in maternal cardiovascular risk factors, and potentially have downstream effects on child health.

From a feasibility perspective, adding screening measures or developing family interventions in preschool and school settings where nurses are on staff could be fairly cost effective and low-burden. By screening mothers for cardiovascular risk indicators, motivation to change the food and activity environment could potentially be increased, as mothers would be addressing both their own health and their child's simultaneously.

Future Research Directions

Findings during development of the Home-IDEA Quality Score clearly indicated that there is room for improvement in the items included in the Home-IDEA Checklist. Three main considerations include adding items that are missing, separating select composite items into individual items, and examining the foods amounts of shelf-stable items. Items that are missing, but that regularly appear in homes, include canned soup and ready-to-eat baked goods.

Composite items could be separated into individual items that better profile the wide differences in nutrition across specific types of similar items (e.g. lettuce encompasses regular lettuces (head lettuce, butter lettuce, leaf lettuce) and dark green lettuces (kale, spinach, chard)). Finally, examining shelf-stable foods may reduce ceiling effects, such as the food quantity that was included for peanut butter, which could be contributing to ceiling effects for Seafood & Plant Proteins. Changes to the Home-IDEA Checklist would necessitate re-evaluation of validity and reliability measures as performed in Chapters 3 and 4 of this dissertation. By refining the Home-IDEA Checklist, sensitivity should increase, potentially reducing the floor and ceiling issues that are currently present.

Additional examinations of the food details from the comparison of the FoodAPS Quality Score to the Home-IDEA Quality Score would also shed more light on issues where the representative food as selected for the Home-IDEA Checklist does not represent the actual food found in the home. This could be the case for foods such as the composite item 'hot dogs, chicken nuggets, fish sticks.' If the difference is a high-fat hot dog versus an all-white meat, baked chicken nugget – the difference in how those foods contribute to the Components and Total Score in a household with a limited number of food items could be quite large. One other construct to examine would be to compare the Home-IDEA Checklists from the FoodAPS to the Family Health Study – this would provide some measure of context for the average number of food items, which items are more prevalent, and how the two sets of data may fundamentally differ. The FoodAPS database could be reduced to households that more closely match the demographics of the Family Health Study to create a matched sample.

When considering the results from use on the Family Health Study, it is advised that the Home-IDEA Quality Score be evaluated in additional populations, in a way where there would be concurrent measures that could be used for comparison or to provide context for interpretation. This would provide a better understanding of the limitations of the tool and also more confidence in interpreting the Components and Total Score in a meaningful way that provides clarity and accurately describes the current state of home food environments. One of the challenges in interpreting the Home-IDEA Quality Score in comparison to dietary intake is that multiple people consume foods from a home food inventory, and foods may be consumed preferentially. This means that one person's diet may only be reflective of a small portion of the full home food inventory, and so correlations would be expected to be low. This would also be true if certain individuals obtained more of their food away from home than in the home – thus limiting their consumption of the home food inventory. Ideally, the strongest correlations would occur for individuals who consumed the majority, if not all, food from the home food inventory, however, this would be challenging to find in the current environment.

With the development of the Home-IDEA Quality Score, the home food environment could be easily sampled with the Home-IDEA Checklist, and the Quality Score run consistently on future studies. This would provide more context and samples from which to achieve a better understanding of what the overall quality of the home food environment looks like. Additionally, intake data for all family members, would allow one to compare the Home-IDEA Quality Score to the full family intake, or just to specific family members to see how individuals may preferentially select foods from the full inventory. If constrained to a single family member, multiple recalls should be collected to better describe how that individual selects foods over time. By gathering a more generalizable assessment of dietary intake, the diet may better reflect the contents of the home food environment, given that individuals typically consume small portions of the home food inventory at any given time. Additionally, multiple levels of overall dietary quality may exist from one food inventory. Collecting multiple rounds of dietary intake data for each individual, as well as data from all family members, would enhance our understanding of the impact of the home food environment and provide scope for evaluating how individuals may selectively eat foods from the total inventory.

One final take on the Home-IDEA Quality Score is that it could be analyzed in conjunction with assessments performed concurrently for entire neighborhood food environments[58], such as restaurant scores[1,59], corner store scores[60], grocery stores[5,61]. If using the ASA24[62,63], the recall data collects where each food item or ingredient was purchased, so dietary data could be clearly delineated to how food is obtained from what ‘quality’ of outlet. This would provide an even greater context for where people obtain which foods, and how those foods/outlets come into play in the grand spectrum of food intake.

In terms of the findings from the Family Health Study, it is recommended that, when feasible, health screenings for parents with young children should include screening measures for maternal cardiovascular risk factors. These measures are fairly inexpensive and have low participant and research burden with the use of point-of-care instruments. With the high percentage of risk factors found in this study, it would be advisable to collect more data to determine if this was by chance, or if there is a critical need for public health intervention strategies for mothers with young children in low-income, multi-ethnic, rural populations.

Future home food environment research should also consider including health factor variables for mothers, and potentially children, when feasible. By including measures that reflect energy density and nutrient density for the food environment with their respective health factors that are used to diagnose risk, assessment of the true impact of the home food environment on child and adult health could be obtained. When combined with public health promotion, these findings could be used to develop community-based wellness programs that cohesively address chronic disease prevention at the family level.

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APPENDIX I: IRB APPROVAL LETTER & INFORMED CONSENT AGREEMENTS

Colorado State University
Knowledge to Go Places

Research Integrity & Compliance Review Office
Office of the Vice President for Research
321 General Services Building - Campus Delivery 2011 Fort Collins, CO
TEL: (970) 491-1553
FAX: (970) 491-2293

NOTICE OF APPROVAL FOR HUMAN RESEARCH

DATE:	October 06, 2015	
TO:	Bellows, Laura, 1571 Food Sci and Human Nutrition	
	Benz, Cris, 1571 Food Sci and Human Nutrition, Pagliassotti, Michael, 1571 Food Sci and Human Nutrition, Hibbs-Shipp, Sarah, 1571 Food Sci and Human Nutrition	
FROM:	Swiss, Evelyn, Coordinator, CSU IRB 1	
PROTOCOL TITLE:	The Home Food Environment in families with preschoolers: Linking home food availability with parent nutritional health and chronic disease risk	
FUNDING SOURCE:	Funding - Grants/Contracts	
PROTOCOL NUMBER:	15-6120H	
APPROVAL PERIOD:	Approval Date: October 03, 2015	Expiration Date: October 02, 2016

The CSU Institutional Review Board (IRB) for the protection of human subjects has reviewed the protocol entitled: The Home Food Environment in families with preschoolers: Linking home food availability with parent nutritional health and chronic disease risk. The project has been approved for the procedures and subjects described in the protocol. This protocol must be reviewed for renewal on a yearly basis for as long as the research remains active. Should the protocol not be renewed before expiration, all activities must cease until the protocol has been re-reviewed.

Important Reminder: If you will consent your participants with a signed consent document, it is your responsibility to use the consent form that has been finalized and uploaded into the consent section of eProtocol by the IRB coordinators. Failure to use the finalized consent form available to you in eProtocol is a reportable protocol violation.

If approval did not accompany a proposal when it was submitted to a sponsor, it is the PI's responsibility to provide the sponsor with the approval notice.

This approval is issued under Colorado State University's Federal Wide Assurance 00000647 with the Office for Human Research Protections (OHRP). If you have any questions regarding your obligations under CSU's Assurance, please do not hesitate to contact us.

Please direct any questions about the IRB's actions on this project to:

IRB Office - (970) 491-1553; RICRO_IRB@mail.Colostate.edu
Evelyn Swiss, Senior IRB Coordinator - (970) 491-1381; Evelyn.Swiss@Colostate.edu
Tammy Felton-Noyle, Assistant IRB Coordinator - (970) 491-1655; Tammy.Felton-Noyle@Colostate.edu

Evelyn Swiss

Swiss, Evelyn

Approval to recruit 250 mothers and their pre-school children enrolled in Food Friends Program with the approved recruitment and consent materials. The above-referenced project was approved by the Institutional Review Board with the condition that the attached consent form is signed by the subjects and each subject is given a copy of the form. NO changes may be made to this document without first obtaining the approval of the Committee. Subjects under the age of 18 years old must obtain parental permission. Approved documents include: Parent Measure Consent, dated 9/10/2015; Study 1 Child Measure Consent, dated 9/10/2015; Informed Minor Assent script, dated 9/10/2015; AES 2015, Bellows; PH Faculty Seed Grant; Draft Interview Questions fro eHome IDEA; Health Survey and demographics,

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dated 8/6/2015; Home IDEA 2 Final; IPAQ S7S Final, May 2001; Mailed Packet Cover Letter and Instructions, dated 9/10/2015; Recruitment Eligibility Screener, dated 9/10/2015; Recruitment Parent Flyer, dated 9/10/2015; Recruitment Preschool Email, dated 9/10/2015; Recruitment Preschool Follow Up, dated 9/10/2015; Recruitment Parent Interest Form, dated 9/10/2015; Recruitment Preschool Flyer, dated 9/10/2015. RICRO NOTE: Please submit a letter of cooperation from your recruitment sites as an amendment.

Approval Period:	October 03, 2015 through October 02, 2016
Review Type:	EXPEDITED
IRB Number:	00000202
Funding:	US Department of Agriculture, Colorado State University

COLORADO STATE UNIVERSITY
INFORMED CONSENT TO PARTICIPATE IN A RESEARCH PROJECT
(Parent activities)

TITLE OF PROJECT: The home food environment in families with preschoolers: Linking home food availability with parent nutritional health and chronic disease risk.

NAME OF PRINCIPAL INVESTIGATOR: Laura Bellows, PhD, MPH, RDN

CO-INVESTIGATOR(S): Sarah Hibbs-Shipp, MS, PhD student, Department of Food Science and Human Nutrition, 970-491-3444.

CONTACT NAME AND PHONE NUMBER FOR QUESTIONS/PROBLEMS: Laura Bellows, 970-491-1305

SPONSOR OF PROJECT: Colorado Agriculture Experiment Station and CSU School of Public Health

The purpose of this study is to find out how mothers' health, the home food environment, and child growth relate to each other.

This study has 2 parts. The first part includes a packet of forms which will be mailed to you. The second part includes an individual appointment where study staff will take several measurements of your health. The appointment will likely take place at your child's preschool or another convenient place.

Part 1: At-home questionnaires:
These forms will be mailed to you. **Please complete the forms within 1-3 days of your individual appointment**. You may complete them all at once, or spread them out over the 1-3 days prior to your appointment. We think it will take about 1 hour to fill out all the forms.

1. Home Food and Activity survey: You will look through your home for food items, physical activity items, and electronic items.

2. Physical Activity: You will answer 4 questions about your physical activity over the last 7 days.

3. Health History: You will tell us about your health history and your and your child's demographics (age, race, etc.).

Part 2: In-person Appointment:
You will come to you individual appointment at your scheduled time. The appointment will likely take place at your child's preschool or another convenient place. **You will bring with you this consent form (signed), and the completed forms.** Your forms will be checked and the study staff may ask you about your answers if any questions have missing or multiple answers. Study staff will take the following health-related measurements:

1. Lab tests: The study staff will collect 3-4 drops of blood from one of your fingertips to find out what your cholesterol and blood sugar levels are.

2. Blood Pressure and Pulse: The study staff member take your blood pressure and pulse using an automated blood pressure monitor.

3. Height: The study staff will measure you height. You will be asked to remove your shoes before the measurement.

4. Weight: The study staff will measure your weight. You will be asked to remove your shoes and any heavy clothing before the measurement.

5. Waist Circumference: The study staff will measure your waist size by placing a soft fabric tape measure around your waist even with your belly button. You will be asked to lift your shirt only as high as needed to set the tape measure against the skin in line with the belly button.

6. Dietary Assessment: You will tell us about what you ate in the last 24-hours using a computer. A study staff member will be available if you have any questions or would like help using the computer. We expect this to take 30-45 minutes.

CSU#: 15-6120H
APPROVED: 10/3/2015 * EXPIRES: 10/2/2016

Each family will receive a total of $50 for completing both study steps. You will be paid $20 when you return the 3 completed questionnaires (Part 1), and $30 when you complete the health measurements (Part 2). The number of participants in this study is limited. Study participants will be selected based on the order in which this form is returned.

Your name will not be used in any way. All measurement recording sheets will be kept in a locked cabinet at Colorado State University in the Department of Food Science and Human Nutrition. Your identity/record of receiving compensation (NOT your data) may be made available for an audit by CSU officials for financial audits.

There are no known risks to completing the at-home forms. Some participants may feel uncomfortable during the individual physical measurements, during the finger-stick procedures, or at the sight of blood. The finger-prick procedure may cause momentary discomfort to some participants. Our study staff are trained to deal with this discomfort. It is not possible to identify all potential risks in research procedures, but the researcher(s) have taken reasonable safeguards to minimize any known and potential, but unknown, risks.

A potential benefit of participating in the study will be that, at the end of the study, you will receive a health "report card", which will list out the results of your measurements taken during the individual visit (Part 2). This report will not diagnose any health issues, rather it will tell you what we measured and what the scores were. We encourage you to share this health report to your normal health care provider when you next see them.

There are no other direct benefits to taking part in this study. The anticipated benefits for completing the research study are that you will help the Investigator learn more about the home environment and parent health characteristics, and how those are associated with child growth. This information will help future researchers and public health agencies make decisions about what programs to put in place for helping parents and children engage in healthy behaviors.

Although confidentiality cannot be guaranteed in group settings, all results and any information you provide will be used for research purposes only. Your information will be assigned a number instead of using your name.

The Colorado Governmental Immunity Act determines and may limit Colorado State University's legal responsibility if an injury happens because of this study. Claims against the University must be filed within 180 days of the injury.

If you agree to take part in this study, it is your choice. You may stop your participation at any time without penalty or loss of benefits.

Your signature means that you have read and understand this consent form, you have willingly signed it, and you have received a copy of this form. If you have any questions about your rights as a volunteer in this research, *contact the IRB Coordinator at:* the CSU IRB at: RICRO_IRB@mail.colostate.edu; 970-491-1553.

WHAT ELSE DO I NEED TO KNOW?
Permission to re-contact:

Do you give permission for the researchers to contact you again in the future to follow-up on this study or to participate in new research projects? Please initial next to your choice below.

☐ Yes ______ (initials)
☐ No ______ (initials)

____
Adult Participant's name (printed)

____
Phone Number

____
Adult Participant's signature

____
Investigator or co-investigator's signature

____
Date

Page 2 of 2

CSU#: 15-0120H
APPROVED: 10/3/2015 * EXPIRES: 10/2/2016

COLORADO STATE UNIVERSITY
INFORMED CONSENT TO PARTICIPATE IN A RESEARCH PROJECT
(Child weight status)

TITLE OF PROJECT: The home food environment in families with preschoolers: Linking home food availability with parent nutritional health and chronic disease risk.

NAME OF PRINCIPAL INVESTIGATOR: Laura Bellows, PhD, MPH, RDN

CO-INVESTIGATOR: Sarah Hibbs-Shipp, MS, PhD student, Department of Food Science and Human Nutrition, 970-491-3444.

CONTACT NAME AND PHONE NUMBER FOR QUESTIONS/PROBLEMS: Laura Bellows, 970-491-1305

SPONSOR OF PROJECT: Colorado Agriculture Experiment Station and CSU School of Public Health

The purpose of this study is to find out how parent health, the home food environment and child growth relate to each other.

We would like your child, if he or she wants to, to be a part of our health assessments. We would like to measure your child's height and weight while your child is at school.

Your child's name will not be used in any way and your child will not be taped or video recorded. All assessment recording sheets will be kept in a locked cabinet at Colorado State University in the Department of Food Science and Human Nutrition.

There are no known risks of this study. Some children may feel nervous in the presence of new people. Our people will be trained to ease these feelings.

There are no direct benefits to you for being in this study. We hope this study will help us learn how parent health and what types of foods are in the home may relate to child weight. This will help us make better choices for future research projects and programs that we design to support a healthier home environment.

Although confidentiality cannot be guaranteed in group settings, all results and information you provide will be used for research purposes only. Your information will be assigned a number instead of using your name.

The Colorado Governmental Immunity Act determines and may limit Colorado State University's legal responsibility if an injury happens because of this study. Claims against the University must be filed within 180 days of the injury.

If you agree to allow your child to take part in this study, it is your choice. You may stop your child's participation at any time without penalty or loss of benefits.

Your signature means that you have read and understand this consent form, you have willingly signed it, and you have received a copy of this form .If you have any questions about your child's rights as a volunteer in this research, contact CSU IRB at RICRO_IRB@mail.colostate.edu; 970-491-1553.

____
Child's name (printed)

_____________________________ Gender: ______Male ______Female
Child's birthdate

CSU#: 15-6120H
APPROVED: 10/3/2015 * EXPIRES: 10/2/2016

PARENTAL SIGNATURE FOR MINOR

As parent or guardian you authorize ____ (print name) to become a participant for the described research. The nature and general purpose of the project have been satisfactorily explained to you by _____________________________ and you are satisfied that proper precautions will be observed.

____
Parent/Guardian name (printed)

____________________________   _________________
Parent/Guardian signature   Date

____________________________   ____
Phone Number   Email

____________________________   ________________
Investigator or co-investigator's signature   Date

APPENDIX II: RECRUITMENT MATERIALS – PARENT

Moms!

Colorado State University is interested in learning about your health and the health of your family.

We would like to measure your blood pressure, cholesterol, height/weight, physical activity, foods you eaten, and the foods that are in your home.

This study includes:

- Returning the interest sheet followed by a brief phone call.
- Filling out surveys at home.
- Completing an individual appointment to collect health measures
- We would also like to measure your child's height and weight.

What you get:

- A health 'report card' that tells you what we measured and what your scores were.
- Up to $50 for completing the study.

How to sign up:

- Return the attached interest form to your child's teacher.
- We will then call you to schedule an interview and give you more information.

Individual appointments will be at a convenient place, likely your child's preschool. We will work with you to pick a time that fits your schedule.

Questions? Contact: Sarah Hibbs-Shipp (970-491-3444), sarah.hibbs-shipp@colostate.edu
Laura Bellows (970-491-1305)

APPENDIX III: INTEREST FORM – PARENT

I'm interested in participating in the Family Health study at my child's preschool!

Your Name (print):______________________________________

Address: ______________________________________

____

Child's Name: ______________________________________ Age:______________

What is the best way to reach you?

Phone	Yes	No	Number:____________________________________
E-mail	Yes	No	Email:____________________________________
Text	Yes	No	(Cell phone number):____________________________
Mail	Yes	No	Address:____________________________________

What is the best time to reach you? (Please check all that apply)

	Morning (9 am- noon)	Midday (noon-5 pm)	Evening (5-8 pm)
Monday-Friday			
Saturday or Sunday			

What would be the best days/times for you to spend 1.5 hours at your child's preschool for the individual visit? (Please check all that apply)

	Tuesday	Wednesday	Thursday	Friday
Morning				
Afternoon				
Early Evening				

Please return in to your child's teacher. Thank you for your interest!

You may also contact Sarah Hibbs-Shipp at 970-491-3444, sarah.hibbs-shipp@colostate.edu; or Laura Bellows at 970.491.1305 or laura.bellows@colostate to sign up.

APPENDIX IV: FAMILY HEALTH STUDY FLOW DIAGRAM

Screening

Returned Interest Sheets (n=150)

Screen Failures (total n=56, 37%)

- Not meeting inclusion criteria (n=17)
  1 male, 1 wheelchair-bound, 1 undergoing cancer treatment, 4 only spoke Spanish, 1 child too young, 1 great grandmother, 1 pregnant, 5 repeat interest sheets, 2 no longer interested
- Could not be reached (n=39)

Allocation
Sent participant packets & scheduled for in-person visit, participant ID number assigned

Assigned Participant ID number (n= 94, 63%)

- Larimer County (n=12, 13%)
  - Sunshine House (Fort Collins, n= 3)
  - Young Peoples Learning Center (Fort Collins, n=4)
  - Thompson School District (Loveland, n=4)
  - Independent (referral, Loveland, n=1)
- Weld County (n=46, 49%)
  - Colorado Early Education Network (n=39)
    - Plaza Del Milagro (21)
    - Centennial (4)
    - La Salle (4)
    - Madison (3)
    - Milliken (3)
    - Dos Rios (4)
  - Greeley-Evans R6 (n=14)
    - ABC Aims (3)
    - ABC East (11)
  - Young Peoples Learning Center (Milliken, n=2)
  - Independent (referral, Greeley, n=1)
- Boulder County (Lafayette Head Start, n=9, 10%)
- Otero County (La Junta CDS Center, n=16, 17%)
- Logan County (Iliff Head Start, n=1, 1%)

Follow-Up

Lost to follow-up (n=6, 6%)
Never showed up to in-person visit: 1014, 1033, 1038, 1053, 1074, 1076

Enrolled/Signed

Participated in Study Procedures (n=88, 94%)
Potential Data Issues:

- Did not complete Home-IDEA sufficiently (returned via mail) (n=2; 1036, 1093)
- Did not complete waist circumference measure due to being pregnant) (n= 3; 1011, 1012, 1013)
- Dietary Recall questionable – potential language issue with food items (n=1; 1054)

Analysis

Analyzed (n=85, 90%)

- Excluded from analysis (n=3)
  - Participants 1011, 1012, 1013, were pregnant thus waist circumference was not measured and BMI is not applicable.

APPENDIX V: HEALTH HISTORY AND DEMOGRAPHICS FORM

Participant ID:__________ Date (mm/dd/yy): ____________

HEALTH HISTORY FORM

Thank you for taking the time to fill out this form. Please read each question about your health and select one of the listed answers. If you take a medication for a health problem, please write that medication in next to that condition. You may fill out the form all at once, or you may fill it out a little bit at a time. Please bring this completed form with you to your in-person appointment.

1. In general, would you say your health is:

- ☐ Excellent
- ☐ Very Good
- ☐ Good
- ☐ Fair
- ☐ Poor

Has any health care provider ever told you that you had any of these health conditions?

		Yes	No	Not Sure	Please write down medication you take to treat this condition
2.	High blood pressure or hypertension	☐	☐	☐	
3.	High blood cholesterol	☐	☐	☐	
4.	Heart attack or myocardial infarction	☐	☐	☐	
5.	Angina or coronary heart disease	☐	☐	☐	
6.	Stroke	☐	☐	☐	
7.	Cancer (malignancies of all kinds, excluding skin cancer)	☐	☐	☐	
8.	Skin Cancer	☐	☐	☐	
9.	Asthma	☐	☐	☐	
10.	Chronic Obstructive Pulmonary Disease (COPD), emphysema, or chronic bronchitis	☐	☐	☐	
11.	Depression	☐	☐	☐	
12.	Mental health problems or mental illness other than depression	☐	☐	☐	
13.	Diabetes or High Blood Sugar *If you only had diabetes when you were pregnant, please check NO.*	☐	☐	☐	

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		Yes	No	Not Sure	Please write down medication you take to treat this condition
14.	Obesity	□	□	□	
15.	Arthritis, rheumatoid arthritis, gout, lupus, or fibromyalgia	□	□	□	
16.	Kidney disease	□	□	□	
17.	Ulcer	□	□	□	
18.	Inflammatory Bowel Disease (IBD), colitis, or other GI issue	□	□	□	
19.	Other Disease **(Please describe)**	□	□	□	

Have you had any of the following surgeries?

		Yes	No	Not Sure
20.	Gastric-Band, gastric sleeve, gastric bypass	□	□	□
21.	Cholecystectomy (gall-bladder removal)	□	□	□

22. Have you smoked at least 100 cigarettes in your entire life? (5 packs = 100 cigarettes):

- □ Yes
- □ No
- □ Not sure

23. Do you now smoke cigarettes?

- □ Every day
- □ Some days
- □ Not at all
- □ Not sure

24. How often do you drink at least one alcoholic beverage at a time (beer, wine, a malt beverage or liquor)?
    - □ Every day
    - □ 1-6 days each week
    - □ 2-4 times each month
    - □ Less than monthly
    - □ I never drink alcohol
    - □ Don't know

25. When you drink alcohol, about how many drinks did you drink on average? (One drink is a 12-ounce beer, a 5-ounce glass of wine, or a drink with one shot of liquor)
    - □ 1 drink
    - □ 2 drinks
    - □ 3 drinks
    - □ 4 or more drinks
    - □ I don't drink alcohol
    - □ Don't know

25. Do you consider yourself to now be:
- □ Obese
- □ Overweight
- □ Underweight
- □ About the right weight

26. Which of the following are you trying to do about your weight?
- □ Lose
- □ Gain
- □ Stay the same
- □ Not trying to do anything

27. If I am overweight I may have more health problems, like diabetes or heart disease. (Circle the number that best matches your feeling).

1	2	3	4	5	6	7
Very likely						Not at all likely

Participant ID:________ Date (mm/dd/yy): __________

DEMOGRAPHICS

Thank you for taking the time to fill out this form. Please answer each question about your family's demographics. You may fill out the form all at once, or you may fill it out a little bit at a time. Please bring this completed form with you to your in-person appointment.

Please answer the following questions about YOU:

28. Date of Birth: ______________
Month/day/year

29. Sex: □ Female □ Male

30. Language you speak at home most of the time:

□ English
□ Spanish
□ Other: ____________

31. Ethnicity: □ Hispanic □ Non-Hispanic

32. Race:

□ White
□ Black/African American
□ American Indian/Alaskan Native
□ Pacific Islander
□ Other: ______________

Please answer the following questions about ________________ (insert child's name):

33. Date of Birth: ______________
Month/day/year

34. Sex: □ Female □ Male

35. Language your child speaks at home most of the time:

□ English
□ Spanish
□ Other: ____________

36. Ethnicity: □ Hispanic □ Non-Hispanic

37. Race:

□ White
□ Black/African American
□ American Indian/Alaskan Native
□ Pacific Islander
□ Other: ______________

38. How many children under 18 years of age live in your household?	39. What are their ages?
______________ (please write in the number of children)	______________ (please write in the ages of all the children living in your household)

40. What is your home zip code? ____________

41. What is your household annual income:

- ☐ <$10,000
- ☐ $10,000 - $14,999
- ☐ $15,000 - $19,999
- ☐ $20,000 - $24,999
- ☐ $25,000 - $34,999
- ☐ $35,000 - $49,999
- ☐ $50,000 - $74,999
- ☐ >$75,000

42. What is your marriage status:

- ☐ Married
- ☐ Separated
- ☐ Divorced
- ☐ Member of an unmarried couple
- ☐ Widowed
- ☐ Never married

43. What is your employment status?

- ☐ Employed for wages
- ☐ Self-employed
- ☐ Out of work for less than 1 year
- ☐ Out of work for 1 year or more
- ☐ Student
- ☐ Retired
- ☐ Homemaker
- ☐ Disabled
- ☐ Unable to work for another reason

44. What is your highest level of education?

- ☐ Less than 9th grade
- ☐ 9th - 11th grade (some high school, no diploma)
- ☐ 12th grade (high school diploma or GED)
- ☐ Some college (no degree)
- ☐ Associate's degree or professional certification
- ☐ Bachelor's degree
- ☐ Graduate or professional degree

For these next 6 statements, please mark whether the statement was <u>often</u> true, <u>sometimes</u> true, or <u>never</u> true for (you/your household) in the **last 12 months.**

45. "The food that (I/we) bought just didn't last, and (I/we) didn't have money to get more."

- ☐ Often true
- ☐ Sometimes true
- ☐ Never true
- ☐ I'm not sure

46. "(I/we) couldn't afford to eat balanced meals."

- ☐ Often true
- ☐ Sometimes true
- ☐ Never true
- ☐ I'm not sure

47. In the last 12 months, did (you/you or other adults in your household) ever cut the size of your meals or skip meals because there wasn't enough money for food?

- ☐ Yes
- ☐ No (go to question 49)
- ☐ Not Sure (go to question 49)

48. IF YES: How often did this happen—almost every month, some months but not every month, or in only 1 or 2 months?

- ☐ Almost every month
- ☐ Some months but not every month
- ☐ Only 1 or 2 months
- ☐ Not Sure

49. In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money for food?

- ☐ Yes
- ☐ No
- ☐ Not Sure

50. In the last 12 months, were you every hungry but didn't eat because there wasn't enough money for food?

- ☐ Yes
- ☐ No
- ☐ Not Sure

APPENDIX VI: INTERNATIONAL PHYSICAL ACTIVITY SURVEY (IPAQ) SHORT FORM

Participant ID:__________ Date (mm/dd/yy): ____/____/____

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. This is part of a large study being conducted in many countries around the world. Your answers will help us to understand how active we are compared with people in other countries.

The questions are about the time you spent being physically active in the last 7 days. They include questions about activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Your answers are important.

Please answer each question on the following pages even if you do not consider yourself to be an active person.

THANK YOU FOR PARTICIPATING.

This is the final SHORT LAST 7 DAYS SELF-ADMINISTERED version of IPAQ from the 2000/01 Reliability and Validity Study. Completed May 2001.

Participant ID:__________ Form Date (mm/dd/yy):____/____/____

In answering the first two questions:

vigorous physical activities refer to activities that take hard physical effort and make you breathe much harder than normal.

moderate activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal.

1a. During the last 7 days, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling,?

Think about *only* those physical activities that you did for at least 10 minutes at a time.

________days per week →

or

☐ **none**

1b. How much time in total did you usually spend on one of those days doing vigorous physical activities?

_____hours ______minutes

2a. Again, think *only* about those physical activities that you did for at least 10 minutes at a time. During the last 7 days, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

________days per week →

or

☐ **none**

2b. How much time in total did you usually spend on one of those days doing moderate physical activities?

_____hours ______minutes

This is the final SHORT LAST 7 DAYS SELF-ADMINISTERED version of IPAQ from the 2000/01 Reliability and Validity Study. Completed May 2001.

3a. During the last 7 days, on how many days did you **walk** for at least 10 minutes at a time? This includes walking at work and at home, walking to travel from place to place, and any other walking that you did solely for recreation, sport, exercise or leisure.

________days per week ⟶ 3b. How much time in total did you usually spend walking on one of those days?

_____hours ______minutes

or

☐ **none**

The last question is about the time you spent sitting on weekdays while at work, at home, while doing course work and during leisure time. This includes time spent sitting at a desk, visiting friends, reading traveling on a bus or sitting or lying down to watch television.

4. During the last 7 days, how much time in total did you usually spend **sitting** on a **week day?**

_____hours _____minutes

This is the end of questionnaire, thank you for participating.

APPENDIX VII: HOME INVENTORY FOR DESCRIBING EATING AND ACTIVITY (HOME-IDEA) CHECKLIST

Participant ID: ____________ Date (mm/dd/yy):____________

Assessment of your Home Health Environment

Please read all instructions before completing this form.

The purpose of the home health assessment is to see what foods and activity items are in the home. This information will help us understand how to make home based recommendations for improving the health of family members.

The following guidelines will help you complete the form:

- The form will take you about 30 minutes to complete.
- There are **3 sections** to this form: **Food, Child's Bedroom Electronics, and Physical Activity**
- Each section has its own instructions, which are at the top of each new section.
- Some items have examples next to them. They are in parenthesis.

TIPS

DO this:

- Get up to find items.
- Record all items (even if you do not have it).
- Look for hints and special reminders.

DO NOT do this:

- Rely on your memory (no one can remember all the foods they have in their home.
- Skip any item.

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Participant ID: ______________ Date (mm/dd/yy):_____________

Before you begin tell us:

- Where food is kept at your house. **Check all that apply**:

  ☐ Kitchen ☐ Pantry ☐ Basement ☐ Garage ☐ Bedroom ☐ Other

- When was the last time you went grocery shopping?

  ☐ Within the last 2 days ☐ Recently ☐ Been a long time

- What amount of food do you have in your house?

  ☐ More than usual ☐ Usual ☐ Less than usual

- What type of home do you live in (**check one box**):

  ☐ Apartment ☐ Duplex ☐ Condominium/townhome ☐ House ☐ Mobile Home

- Who is completing the form:

  ☐ Mother ☐ Father ☐ Both ☐ Other

Participant ID: ________________ Date (mm/dd/yy):____________

Section 1: Food Items

Instructions:

- A food is rated as "in the home" if it can be found **anywhere** that food is generally kept in the home, regardless of whether it is out in plain sight. This includes food in the **basement, deep freeze, or parent's bedroom**.
- When looking for foods, please **move food around** on shelves or in drawers to make sure you **record all items**.
- When more than 1 food is listed in ( ), you do **NOT** need to have all the examples in ( ), you only need 1 to mark "Yes."
- If a food is **NOT** in the home, check "No" and move on to the next item.

	Is this food in the home?	
Snacks and Sweet Treats	☐ **No**	☐ **Yes**
Chocolate and candy	☐	☐
Unprepared mixes (like cake, cookie, brownie, muffin, biscuit, or pancake)	☐	☐
Chips (like potato, tortilla, corn, baked, or pretzels)	☐	☐
Whole grain crackers (like Triscuit® , Wheat thins®, or Ritz® whole grain crackers) **(See picture)**	☐	☐
Saltine crackers	☐	☐
Rice cakes	☐	☐
Gummy fruit snacks (like gummy snacks, or fruit roll ups)	☐	☐
Dried fruit (Not chocolate, yogurt, or sugar coated)	☐	☐
Nuts (like peanuts, almonds, pistachios, mixed nuts, cashews or walnuts)	☐	☐
Frozen sweets (like ice cream, popsicles, fudgesicles , push-pops, frozen yogurt, sorbet, sherbet)	☐	☐

Participant ID: ______________ Date (mm/dd/yy):____________

Child Friendly Food	Is this food in the home? ☐ No	☐ Yes
Pizza (frozen or refrigerated)	☐	☐
Packaged dinners (frozen, refrigerated, or boxed)	☐	☐
Packaged child's meals (such as Lunchables® or Chef Boyardee®)	☐	☐
Mac and cheese (box, frozen, or refrigerated)	☐	☐
Instant Noodles (like Ramen® noodles)	☐	☐
Apple Sauce	☐	☐
Chicken nuggets, fish sticks, corn dogs, or hot dogs	☐	☐
French fries, tater tots, or hash browns	☐	☐

Cereal	Is this food in the home? ☐ No	☐ Yes
Sweetened breakfast cereal (more than 6g sugar per serving) (**See picture**)	☐	☐
Unsweetened breakfast cereal (less than or equal to 6g per serving) (**See picture**)	☐	☐

Grams of Sugar per Serving

How many boxes of each type of cereal do you have?

- Sweetened Breakfast Cereal (greater than 6g per serving) ____________
- Unsweetened Breakfast Cereal (less than or equal to 6g per serving ____________

Participant ID: ______________ Date (mm/dd/yy):____________

	Is this food in the home?	
Beans and Grains	☐ **No**	☐ **Yes**
Refried Beans	☐	☐
Beans - canned or dried (like black, pinto, kidney, navy, garbanzo, lentils, great northern, or lima)	☐	☐
Quinoa, barley, or couscous	☐	☐
Whole wheat bread **(See picture)**	☐	☐
White bread	☐	☐
Other bread: ________________________________	☐	☐
Whole wheat bagel **(See picture)**	☐	☐
White bagel	☐	☐
Other bagel: ________________________________	☐	☐
Whole wheat pasta **(See picture)**	☐	☐
Regular pasta	☐	☐
Other pasta: ________________________________	☐	☐
Corn tortillas	☐	☐
White flour tortillas	☐	☐
Whole wheat tortillas **(See picture)**	☐	☐
Other tortillas: ________________________________	☐	☐
White rice	☐	☐
Brown rice	☐	☐

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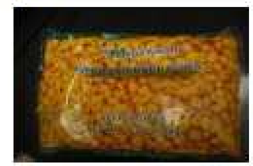
Participant ID: ______________ Date (mm/dd/yy):____________

Vegetables (Fresh, Frozen or Canned)	Is this food in the home? ☐ No	☐ Yes
Bell pepper	☐	☐
Broccoli	☐	☐
Carrot	☐	☐
Celery	☐	☐
Corn	☐	☐
Cucumber	☐	☐
Green beans	☐	☐
Mushrooms	☐	☐
Tomatoes	☐	☐
Asparagus	☐	☐
Avocado	☐	☐
Raw/unpeeled potato	☐	☐
Sweet potato	☐	☐
Beets, radish, turnips, jicama, daikon radish, or parsnip	☐	☐
Cauliflower, cabbage, or brussel sprouts	☐	☐
Lettuce, spinach, collards, kale, chard, or turnip greens	☐	☐
Yellow squash or zucchini	☐	☐
Butternut, acorn, or spaghetti squash	☐	☐
Peas, snap peas, or edamame	☐	☐

Hint: Vegetables can be:

Fresh

Frozen



Canned

Participant ID: ________________ Date (mm/dd/yy):________

Fruit (Fresh, Frozen or Canned)	Is this food in the home? ☐ No	☐ Yes
Apple	☐	☐
Banana	☐	☐
Pear	☐	☐
Grapes	☐	☐
Orange, tangerine, grapefruit, or clementine/cuties	☐	☐
Pineapple, mango, kiwi, guava, or papaya	☐	☐
Blueberries, strawberries, blackberries, or raspberries	☐	☐
Watermelon, cantaloupe, or honedew	☐	☐
Plums, peaches, nectarine or cherries	☐	☐

Fresh

Frozen

Canned

Participant ID: ______________ Date (mm/dd/yy):____________

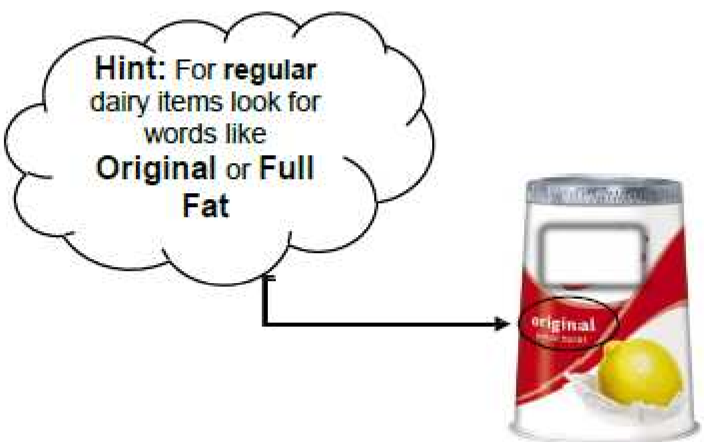
Meat	Is this food in the home? ☐ No	☐ Yes
Regular meat (like ground beef and chuck, rips, pork roast, poultry with skin, or ground turkey)	☐	☐
Lean meat (like beef, select or choice, trimmed of fat; ground round, roast, round, sirloin, tenderloin; or poultry without skin - chicken, turkey)	☐	☐
Deli meat (like ham, turkey, roast beef, or bologna)	☐	☐
Breakfast meat (like bacon or sausage)	☐	☐
Fish (fresh, frozen, or canned - like tuna)	☐	☐
Shellfish (like shrimp, clams, scallops, crab, or lobster)	☐	☐
Game (like deer, elk, moose, quail, duck, goose)	☐	☐

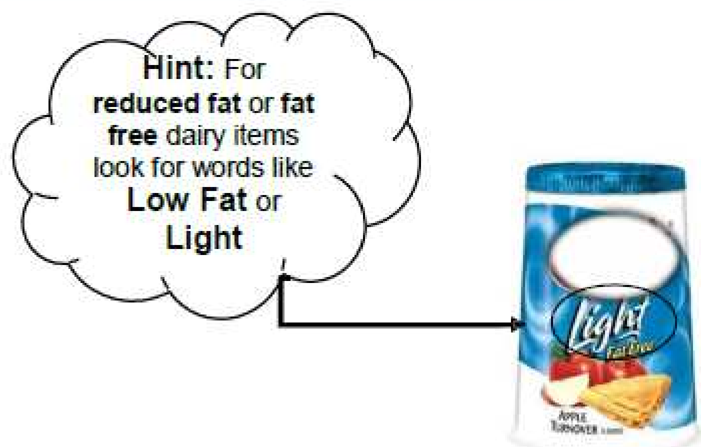
Hint: If the ground meat says lean or extra lean, then it is a lean meat.

Vegetarian Products	Is this food in the home? ☐ No	☐ Yes
Soy products (like tofu, tempeh, textured vegetable protein (TVP), soy crumbles, or veggie burgers	☐	☐
Cheese alternatives (like rice, soy, almond, or cashew cheese)	☐	☐
Eggs	☐	☐

Participant ID: ________________ Date (mm/dd/yy):____________

Dairy	Is this food in the home? □ No	□ Yes
Regular yogurt	□	□
Reduced fat or fat free/lite yogurt	□	□
Regular cottage cheese	□	□
Reduced fat or fat free/lite cottage cheese	□	□
Regular cheese	□	□
Reduced fat or fat free/lite cheese	□	□





Participant ID: ______________ Date (mm/dd/yy):____________

	Is this food in the home?	
Beverages	☐ **No**	☐ **Yes**
100% Fruit Juice (**must** say **100%** juice)	☐	☐
Fruit juice/drinks (**NOT** 100% juice)	☐	☐
Drink mixes (like Carnation® instant breakfast, hot cocoa, Kool-Aid®, and ice tea)	☐	☐
Sugar free drink mixes (like Crystal light®)	☐	☐
Whole milk (Vitamin D milk)	☐	☐
2% milk	☐	☐
1% milk	☐	☐
Skim/fat free milk	☐	☐
Other milks (like powdered milk, buttermilk, or goat milk)	☐	☐
Milk alternatives (like soy, almond, coconut, rice)	☐	☐
Chocolate milk	☐	☐
Regular soda	☐	☐
Diet soda	☐	☐
Sports Drinks (like Gatorade®, Powerade®	☐	☐
Bottled water	☐	☐

Hint: Must say **100% juice** to count. See picture.

Participant ID: ______________ Date (mm/dd/yy):____________

Other Foods	Is this food in the home? ☐ No	☐ Yes
Nut butters (like peanut, almond, or cashew)	☐	☐
Jam, jelly, syrup, or honey	☐	☐
Regular dressing	☐	☐
Reduced fat or fat free/lite dressing	☐	☐
Regular mayonnaise	☐	☐
Reduced fat or fat free/lite mayonnaise	☐	☐
Regular margarine	☐	☐
Reduced fat or fat free/lite margarine	☐	☐
Butter	☐	☐
Cooking oil (like canola, vegetable, olive oil, or peanut)	☐	☐
Shortening (like Crisco®) or lard	☐	☐

List any other foods you have: ______________________________

Additional Questions	☐ No	☐ Yes
Is there a fruit basket out that you can see with at least one fruit or vegetable inside it?	☐	☐
Is there a candy or sweet treat container out that you can see with at least one piece in it?	☐	☐
Are you a WIC participant?	☐	☐
Does your child ever use a chair or stool to reach food or drinks normally out of reach?	☐	☐

Participant ID: ____________ Date (mm/dd/yy):___________

Section 2: Child's Electronic Bedroom Environment

Instructions:

- Please **go to your child's bedroom** (do not rely on your memory) to complete this section.
- Count an electronic device in your child's bedroom even if the child does not use it, it isn't in sight (under bed or in a closet), or shares the room with another brother or sister or parent.
- An electronic device can have lots of uses. For example, a radio can also have a CD player. Each of these would be counted.
- If the device is not physically broken, then accept it as "working".
- If the device is **used only by the child** (for example, they have their own computer) mark **"Used only by this child."** If the device is **shared** among other family members, mark **"Shared with other children/adults."**

Electronic device	In this Child's Bedroom?		Who Uses this device?	
	☐ No	☐ Yes	☐ Used by this child only	☐ Shared with other children/ adults
TV	☐	☐	☐	☐
DVD player, Blu-ray player, or VCR	☐	☐	☐	☐
Digital TV recorder (TIVO)	☐	☐	☐	☐
Video game player (like X-Box, Play Station, or Game Boy)	☐	☐	☐	☐
Music devices (like IPOD, ZUNE, MP3 player, or CD player)	☐	☐	☐	☐
Radio	☐	☐	☐	☐
Computer	☐	☐	☐	☐
Tablet, IPAD, Kindle, or LEAP Pad	☐	☐	☐	☐
Other: ________________	☐	☐	☐	☐

Participant ID: ____________ Date (mm/dd/yy):____________

Section 3: Physical Activity Items

Instructions:

- Please read each item below and decide if you have the item at your home (inside or outside, backyard, or storage shed).
- Count the item even if your child does not use it.

Item	This item is located at my home (inside or outside) ☐ No	☐ Yes
Bike/trike/3-wheeler	☐	☐
Seated toy cars powered by child's feet on the ground (not motorized)	☐	☐
Basketball hoop (including child size versions)	☐	☐
Jump rope	☐	☐
Hula hoop	☐	☐
Sports equipment (like bats, balls, racquets, hockey sticks, or golf clubs)	☐	☐
Roller skates, skateboard, or scooter	☐	☐
Swing set, play house, or jungle gym	☐	☐
Trampoline	☐	☐
Snow equipment (like skis, snow shoes, or ice skates)	☐	☐
Outdoor equipment (like hunting, fishing, tents, backpacks, climbing, or gear)	☐	☐
Water equipment (like swimming pool - including plastic kiddy pool), slip-n-slide, canoe, row boat, or boogie/surf board)	☐	☐
Home aerobic equipment (like treadmill, stationary bike, cross trainer, stepper, or rower)	☐	☐
Weight lifting equipment or toning devices (like free weights, pull-up bar, or ankle weights)	☐	☐
Yoga or exercise mats, exercise balls, exercise/resistance bands, or medicine ball	☐	☐
Workout DVD (like aerobic, dance, or yoga)	☐	☐
Exercise, play, recreation room (a designated area for the child to play)	☐	☐

Participant ID: ________________ Date (mm/dd/yy):____________

Thank you for your time in filling out this home assessment. We really appreciate you helping us learn more about homes with young children.

Your comments and concerns are important to us. Please let us know if you have any other comments:

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APPENDIX VIII: RECRUITMENT MATERIALS - PRESCHOOLS

Appendix VIII: Recruitment Materials - Preschools

Colorado State University

invites your preschool and eligible families to participate in the:

Family Health Study

We believe that learning more about how parent health and the home environment relate to preschool child weight will help improve the health of Colorado families.

The study will look at:

- Mom's health
- Their preschool-age child's weight
- What foods and physical activity equipment participating families have in their home

To complete this research project, we need preschools that will:

1. Provide our fliers and interest sheets to each English-speaking family with a child ages 3-5 years via the child's backpack.
2. Allow the parents to return the interest sheets to their child's teacher. The teacher would compile the interest sheets.
3. We would collect the interest sheets either by mail or in-person. If by mail, we will provide a pre-paid, addressed mailer for the preschool to use.
4. Allow us on-site to collect each participating child's height/weight during the school day.
5. Provide (if possible) a central location for families to visit so we can gather in-person measures. We would like to do this at each preschool, so that families are comfortable with their surroundings.

If you have any questions or would like more information, please contact us:

Sarah Hibbs-Shipp (Study Coordinator) Phone: 970-491-3444 Email: sarah.hibbs-shipp@colostate.edu	**Laura Bellows (Principal Investigator)** Assistant Professor Department of Food Science & Human Nutrition Phone: 970-491-1305 Email: laura.bellows@colostate.edu

APPENDIX IX: STATION CHECKLIST / DATA COLLECTION FORM

Participant ID:__________

Station Checklist

Step	Assessor initials	Date ___/___/___
Check-in		Time:
Informed Consent		Complete: Y N
Home-IDEA2		Complete: Y N
Health History		Complete: Y N
IPAQ SF		Complete: Y N
Washed Hands		Complete: Y N
Cholestech LDX Lot #: Exp date:		*See label →*
Afinion Lot #: Exp date:		HbA1c:__________%
Blood Pressure & Pulse *Initials:*________ *clock scrolls through triplicate measurements, notepad shows average	Avg.______/______mmHg, Pulse:______ 1.______/______mmHg, Pulse:______ 2.______/______mmHg, Pulse:______ 3.______/______mmHg, Pulse:______	
Height *(to tenth of cm, round down – duplicates within 1 cm, retake both measures if not; record all measures, indicate which set to keep, make comments as to why multiple sets)*		1.__________cm 2.__________cm
Weight *(to tenth of lb, round down)*		__________lbs
Waist Circumference *(to tenth of cm, round down – duplicates within 1 cm, retake both measures if not; record all measures, indicate which set to keep, make comments as to why multiple sets)*		1.__________cm 2.__________cm
ASA24		Complete: Y N
Stipend paid & receipt obtained		Time:

Comments (more space on back)

Place Cholestech LDX Readout Label Here:

TC: __________.

HDL: __________.

TRG: __________.

LDL: __________.

Non-HDL: __________.

LDL:HDL ratio: __________.

Glu: __________.

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Additional comments:

APPENDIX X: PSYCHOMETRIC PROPERTIES EXAMINED FOR THE HEALTHY EATING INDEX 2005 AND 2010, AND FOR THE HOME INVENTORY DESCRIBING EATING AND ACTIVITY QUALITY SCORE

Healthy Eating Index 2005, 2010		**Home-IDEA Quality Score**	
Evaluation Question	**Analysis Strategy**	**Evaluation Question**	**Analysis Strategy**
Validity – Content (Face and Domain)			
Does the index capture the various key aspects of diet quality specified in the *DGA*?	Checked HEI components against the respective version of *DGA*	Do the representative foods load into the Component Scores as theorized?	Examined iterative runs of the HEI-2010 algorithm; each food was removed individually
Does the index measure what it is supposed to be measuring as judged by nutrition experts, i.e., does it have face validity?	Reviewed scores of selected NHANES 24-hr recall reports	Do the food items and food amounts selected to represent the Checklist item match the intent of the Checklist item? Would they be reasonably found in the target population homes?	Experts examined representative foods and food amounts in the Home-IDEA Nutrition database for face validity
Validity – Construct			
		Does any representative food within a set of like foods have an unusually large effect on component score compared to the other food set items?	Examined iterative runs of the HEI-2010 algorithm; each food was removed individually.
		Does any representative food have an unusually large effect on the Total Score compared to the other food items?	Examined iterative runs of the HEI-2010 algorithm; each food was removed individually.
Does the index give maximum scores to menus developed by nutrition experts to illustrate high diet quality?	Computed scores for menus from USDA's MyPyramid, NHLBI's DASH Eating Plan, Harvard's Healthy Eating Pyramid, and the American Heart	Does the Home-IDEA Quality Score identify different home food environments?	Home Food Environment experts developed different home food inventories to represent food patterns for

Healthy Eating Index 2005, 2010		Home-IDEA Quality Score	
Evaluation Question	**Analysis Strategy**	**Evaluation Question**	**Analysis Strategy**
	Association's No-Fad Diet		CACFP, DASH, vegetarian, moderately processed, and highly processed eating patterns.
Does the index distinguish between groups with known differences in diet quality, i.e., does it have concurrent criterion validity?	Compared scores of smokers and nonsmokers, men and women, younger and older adults	*Not currently possible – Home food environment research has no definitive assessment on this.*	*Could potentially be compared to dietary intake patterns – however currently it is unknown if home food environments reflect specific dietary patterns.*
Does the index measure diet quality independent of diet quantity?	Estimated Pearson correlations between component scores and energy intake	Does the tool measure diet quality independent of diet quantity?	Estimated Pearson correlations between component scores and energy intake for the Home-IDEA Quality Score (4,202 households)[1]
What is the underlying structure of the index components, i.e., does it have more than one dimension?	Examined structure by using a principal components analysis	How do the concepts of representative food amounts and a reduced food inventory affect the Component and Total Scores?	Examined food amounts, the reduced food inventory, and the complete tool separately – compared results to a matched set of households that portrayed 'reality' (4,202 households)
Are the total and component scores sufficiently sensitive to detect meaningful differences?	Examined population distributions of total and component scores	Are the total and component scores sufficiently sensitive to detect meaningful differences?	Examined population distributions of total and component scores for the Home-IDEA Quality

Healthy Eating Index 2005, 2010		Home-IDEA Quality Score	
Evaluation Question	**Analysis Strategy**	**Evaluation Question**	**Analysis Strategy**
			Score in comparison to the FoodAPS Quality Score (4,202 households)
Reliability – Internal Consistency			
How reliable is the total index score if diet quality is found to have one dimension?	Determined Cronbach's coefficient alpha	What is the internal reliability?	Determined Cronbach's coefficient alpha
What are the relationships among the index components?	Estimated Pearson correlations among component scores	What are the relationships among the index components?	Estimated Pearson correlations among component scores for the Home-IDEA Quality Score (4,202 households)
Which components have the most influence on the total score?	Estimated correlations between each component and the sum of all others (intercomponent correlations)	Which components have the most influence on the total score?	Estimated correlations between each component and the sum of all others (intercomponent correlations)

DGA: Dietary Guidelines for Americans, HEI: Healthy Eating Index, Home-IDEA: Home Inventory for Describing Eating and Activity, NHANES: National Health and Nutrition Examination Survey, USDA: U.S. Department of Agriculture, NHLBI: National Heart Lung and Blood Institute, DASH: Dietary Approaches to Stop Hypertension, CACFP: Child and Adult Care Food Plan, FoodAPS: National Food Acquisition and Purchase Survey

[1] The 4,202 households were from the FoodAPS database. These households were used 'as is' to reflect what the home food environment might look like in a real-world sample. They were additionally fitted to the Home-IDEA Checklist, or to the representative food amounts or reduced food inventory as described by the Home-IDEA Nutrition database to represent 'test' environments.