EXAMINING THE HOME FOOD ENVIRONMENT:

OBSERVATIONAL FINDINGS FROM THE TAKE ACTION STUDY

A DISSERTATION

SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL

OF THE UNIVERSITY OF MINNESOTA

BY

ERICKA WELSH

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

ROBERT W. JEFFERY, ADVISER

FEBRUARY 2010

Acknowledgements

I would like to acknowledge Drs. Simone French and Melanie Wall for their expert guidance throughout this project, and Dr. Jennifer Linde for carefully editing this document. I would also like to acknowledge Nathan Mitchell for his assistance with data management and statistical programming. Finally, I would like to thank my adviser, Dr. Robert Jeffery, for his continued support during my time as a graduate student.

Table of Contents

List of Table **vi**

List of Figures **viii**

Introduction **1**

Why focus research on the home food environment? 1

Primary aims 2

Chapter overview 3

Chapter 1 – Background **4**

1.1 The home food environment: Home food availability 4

1.1a. Home food availability and dietary intake 5

1.1b. Measures of home food availability 6

1.1c. Limitations of previous research 9

1.2. The home food environment: Family meals 10

1.2a. Family meals and diet quality 11

1.2b. Family cohesion 13

1.2c. Limitations of previous research 15

1.3. Theoretical framework and conceptual model 16

Chapter 2 – Methods 18

2.1 Take ACTION study overview 18

2.2 Participant recruitment 18

2.3 Sample characteristics 19

2.4 Data collection 19

2.5 Measures 20

2.6 Institutional Review Board approval 29

Chapter 3 - Manuscript One: Examining the association between two objective measures of home food availability and reported dietary intake in 90 U.S. community households: an observational study 30

3.1 Background 30

3.2 Methods 33

3.3 Results 40

3.4 Discussion 43

3.5 Tables 47

Chapter 4 - Manuscript Two: Examining the relationship between family meal frequency and individual dietary intake: Does family cohesion play a role? 51

4.1 Background 51

4.2 Methods 54

4.3 Results 59

4.4 Discussion 63

4.5 Tables 67

4.7 Figures 69

Chapter 5 - Manuscript Three: Describing patterns of home food availability: Findings from an exploratory latent class analysis 70

5.1 Background 70

5.2 Methods 71

5.3 Results 77

5.4 Discussion 81

5.5 Tables 86

5.6 Figures 94

Chapter 6 – Summary and Suggestions for Future Research **96**

References **99**

Appendices **103**

Appendix A 103

Appendix B 108

List of Tables

Methods

Table 2.5a. – Demographic survey questions 20

Table 2.5b. – Family meals survey questions 22

Table 2.5c. – FACES-III survey questions 22

Table 2.5d. – Food choice survey questions 25

Manuscript One

Table 3.5a. - Participant characteristics 47

Table 3.5b. - Total ounces of targeted foods measured by the home food inventory (HFI) and annotated receipt forms for a 4-week period (n=90 households) 48

Table 3.5c. - Mean servings per week of foods consumed among adults by home food availability tertile as measured by the home food inventory (HFI) and annotated receipt forms (n=153 adults) 49

Table 3.5d. - Mean servings per week of foods consumed among adolescents by home food availability tertile as measured by the home food inventory and annotated receipt forms (n=75 adolescents) 50

Manuscript Two

Table 4.5a. - Participant-reported family cohesion and eating behaviors for adults and adolescents 67

Table 4.5b. - Regression coefficients for food servings per week regressed on family meal frequency and family cohesion among adults and adolescents 68

Manuscript Three

Table 5.5a. – Total ounces of foods in targeted categories measured by the home food inventory (HFI) and annotated receipt forms for a 4-week period (n=90 households) 86

Table 5.5b. – Total ounces of foods in targeted categories, by cluster, as measured by the home food inventory (HFI) (n=90 households) 88

Table 5.5c. – Household characteristic means and frequencies by cluster patterns of home food availability as measured by the home food inventory (HFI) (n=90 households) 89

Table 5.5d. – Total ounces of foods in targeted categories, by cluster, as measured by annotated receipt forms over a 4-week period (n=90 households) 91

Table 5.5e. – Household characteristic means and frequencies by cluster patterns of home food availability as measured by annotated 92

List of Figures

Background

Figure 1.3a. – Observed and suspected associations between household characteristics, the home food environment, individual factors, and individual food choice 17

Manuscript Two

Figure 4.6a. – Mediation analysis 69

Manuscript Three

Figure 5.6a. – Standardized means for total ounces/person of foods in targeted categories as measured by the home food inventory (HFI), by cluster (n=90 households) 94

Figure 5.6b. – Standardized means for total ounces/person of foods in targeted categories as measured by annotated receipt forms over a 4-week period, by cluster (n=90 households) 95

Introduction

Why focus research on the home food environment?

According to recent estimates, the majority of Americans do not meet dietary guidelines for healthy eating (1, 2). National surveys have demonstrated that most individuals do not eat adequate amounts of fruits and vegetables, and tend to consume too many energy dense foods, such as high-fat snacks and sweets or sugar-sweetened beverages (3). Such diet profiles are associated with adverse health outcomes, including obesity, type II diabetes, cardiovascular disease, and certain types of cancer (4, 5). Improvements in the quality of the American diet would arguably lessen the impact of these adverse health outcomes. Thus, strategies to improve individual dietary intake are sorely needed.

Food choices are influenced by a variety of factors at the individual, social, and environmental level. Individuals are exposed to food in a variety of settings, including school, work, and home. The home food environment is of particular interest due to the fact that individuals have control over what foods and beverages they purchase, store, and ultimately consume in their homes. Despite increasing interest, research in this area is relatively new and many questions regarding the home food environment remain unanswered.

Primary aims

The primary aim of this dissertation is to examine more closely two different components within the household context—objective home food availability and family meals—and their associations with individual food choice. Specifically, this paper seeks to provide additional support for a positive association between objective home food availability and individual food choice, such as fruit and vegetable availability and consumption. Findings which demonstrate such an association, in this study and others, may prompt interventionists to develop and implement strategies to alter the home food environment. If no relationship is found between home food availability and individual food choice, then researchers may consider channeling their resources and efforts away from the home food environment and into alternative food environments, such as school, work, or restaurants. Despite the home food environment's potential influence on individual dietary intake, relatively little is known about the types and amounts of foods that households purchase and bring into their homes (6). Thus, an additional aim of this dissertation is to characterize patterns of objective home food availability using latent class analysis.

Current literature suggests that family meals may also have an impact on individual food choice. Family meals may help improve diet quality by providing a setting for positive role modeling and social support for healthy eating and weight management. This dissertation aims to elucidate one potential mechanism

underlying the relationship between family meals and food choice: family cohesion. If family cohesion is found to be a mediator of family meals and dietary intake, health promoters can enhance dietary interventions by implementing strategies to improve family cohesion. If family cohesion is not indicated as a mediator of family meals and dietary intake, then it will be important to investigate other potential mediators in order to better understand how family meals influence dietary intake.

Chapter overview

This document is organized into six main chapters. Chapter 1 provides an overview of the relevant literature examining the factors of interest and how they are related to food choice. Chapter 2 outlines the methods used to carry out the research described, including the study sample and data collection measures. Chapters 3, 4, and 5 each detail the background, methods, results, and discussion sections of the three manuscripts that constitute this dissertation. Chapter 6 provides a summary of all three manuscripts and is followed by a comprehensive list of references.

Chapter 1 – Background

1.1 The home food environment

The home food environment is comprised of both physical and social factors (7). The physical home food environment includes both food availability and accessibility within the home (8). Home food availability is defined by what foods and beverages are available for consumption within a home, while home food access is defined by how easily a food or beverage item can be consumed. A food item displayed on a kitchen countertop that requires minimal preparation prior to consumption would be considered a relatively accessible food item, whereas a food item stored in a closed pantry that requires chopping and cooking prior to eating would be considered a less accessible food item. As discussed later, research demonstrates that home food availability may be associated with dietary intake.

Social aspects of the home food environment include household food rules, parental feeding practices, dietary role modeling, and family meal patterns (9). Household food rules include both concrete and abstract rules regarding foods in the home. For example, some parents may overtly prohibit their child's consumption of soda or snacks at home while others have no such restrictions. Parental feeding practices incorporate a variety of behaviors including pressuring children to eat, restricting access to food, or using food to reward a child's behavior. Dietary role modeling occurs when an individual, such as a child,

observes the eating behaviors of another influential person, such as a parent or older sibling. Such modeling of behavior is thought to influence the behavior of the observer. Family meal patterns include the frequency and location of family meals, as well as the types and quantities of foods served at mealtime. As discussed below, research has shown positive associations between family meal frequency and diet quality, particularly among adolescents.

1.1a. Measures of home food availability

Researchers have developed a variety of methods to measure home food availability (10, 11). In their review of 23 studies which examined home food availability, Bryant and Stevens identified two main categories of home food availability measures: the open shelf inventory and predefined inventory checklists (10). Open shelf inventories are completed by trained staff members who visit the homes of participants and record all the foods present. Although this particular method is comprehensive and avoids social desirability bias of participants, it is very time-intensive and costly.

Predefined inventory checklists, on the other hand, include only a limited selection of foods identified as present or absent in a home. Checklists can be administered over the telephone or completed as a mailed questionnaire. Although this method is more feasible and less expensive than open shelf inventories, it is limited in its ability to capture information about foods available in the home, including the presence of less common foods (e.g. ethnic or seasonal foods) and food quantities.

An additional method used to measure home food availability is food purchase receipts that document purchases from retail food outlets, such as grocery stores. Unlike open shelf inventories and predefined inventory checklists which capture a snapshot of available foods, receipt data provide information about the flow of foods into the home over time (11).

1.1b. Home food availability and dietary intake

Several observational studies have sought to better understand how the availability of foods in a given household influences the food choices of individuals living in that household. Specifically, researchers have examined whether or not greater exposure to healthy and unhealthy foods and beverages leads to increased consumption of these items. Research examining the relationship between home food availability and individual food choice has focused primarily on children and adolescents, as over 60% of this population's caloric intake has been shown to derive from home foods (12).

In their cross-sectional study of adolescent-parent dyads from Project EAT, Hanson and colleagues examined the association between parent report of home food availability and adolescent dietary intake (13). Home availability of fruits and vegetables was assessed with the question: 'How often would you say fruits and vegetables and soft drinks are available in your home?' (response options ranged from always to never). Adolescent dietary intake was assessed using the Youth Adolescent Food-Frequency Questionnaire (14). The authors found that most parents (90.4%) reported that fruits and vegetables were at least

usually available in their home, while roughly half (56.9%) reported that soft drinks were at least usually available. Fruit and vegetable intake was positively associated with home availability for girls, but not for boys. In addition, a significant linear trend suggested greater intake of dairy foods among girls when soft drinks were less available in the home. In a follow-up study of the Project EAT cohort, Arcan and colleagues found that parental report of home fruit and vegetable availability did not predict fruit and vegetable intake among adolescents five years later (15). This finding counters the results from the initial cross-sectional study, and the authors suggest that either the use of a single item question to assess availability, or low variability in parents' responses, may explain this discrepancy.

Other researchers have examined the influence of home food availability on unhealthy food choices, in addition to fruit, vegetable, and dairy intake. In their cross-sectional study of non-Hispanic black and white adolescents, Befort and colleagues examined the association between home food availability of fruits, vegetables, and fatty foods, and adolescent intake of these foods (16). Home food availability was assessed by asking parents to report whether particular food items, including 17 fruits, 15 vegetables, and 13 regular-fat foods, were or were not available in their homes. Adolescent dietary intake was assessed using the National Cancer Institute (NCI) Fruit and Vegetable Screener (17) and the NCI Fat Screener (18). Parents reported that roughly half of surveyed fruits and three-quarters of surveyed vegetables were available in their homes. Results indicated

that home food availability was not associated with vegetable or fat intake, but home availability of fruits did predict greater fruit intake among white adolescents.

In contrast to the findings of Befort et al. (16) which showed no association between home food availability of fatty foods and adolescent intake, others have found a positive association between home availability of unhealthy foods and adolescent consumption of such foods (19, 20). In their cross-sectional study of seventh and eighth graders, Haerens and colleagues assessed students' perceived availability of healthy and unhealthy foods with five questions asking about the presence of water and fruit (healthy) and soft drinks, candy, and chips (unhealthy) in their homes (19). Responses were selected on a four-point scale ranging from never to always. A previously validated food frequency questionnaire was administered to participants to assess fat and fruit intake, as well as water and soft drink consumption. Results indicated that boys with more unhealthy food products at home were more likely to have fat in their diet and to consume more soft drinks. Among girls, those who reported more healthy food products at home were more likely to consume more fruit.

Similar positive associations between perceived unhealthy food availability and consumption were found by Campbell and colleagues in their cross-sectional study of twelve and thirteen year old adolescents and their parents (20). A factor analysis of ten food items yielded three factors, one of which described the perceived availability of junk foods, including chips and snack foods,

confectionary, and soft drinks. Adolescent dietary intake was measured by a 56-item food frequency questionnaire which asked the frequency that adolescents consume the listed foods and beverages. Results indicated that, for adolescent girls, home availability of unhealthy foods at home was the strongest correlate of sweets consumption. Home availability of unhealthy foods was also positively associated with increased consumption of snacks among boys and girls.

Researchers have also observed positive associations between grocery store purchases and intake of vegetables and total amounts of fat and calories among households members (21, 22). Sekula et al., for example, compared household budget survey data and individual nutrition survey data in a sample of Polish households and found positive associations between 1 month household purchases of vegetables and vegetable consumption reported in 24-hour recalls of all household members (21). In a similar study, Ransley and colleagues observed positive associations between the amount of fat and energy purchased from supermarkets over a 28-day period and the amount of fat and energy consumed by households as measured by 4-day food diaries (22).

1.1c. Limitations of previous research

It appears that home food availability is associated with food choice, particularly for fruit intake, among adolescents. However, much of the research in this area has been cross-sectional and comparisons across studies are limited due to different methods for assessing both home food availability and dietary

intake. An important limitation of the previous research reviewed above is the use of perceived rather than objective home food availability. Perceived home food availability may not accurately reflect objective home food availability, as individuals who consume more of a certain type of food may be better able to recall the presence of those foods in their homes compared to those who do not consume those foods. Also, measuring home food availability using questions such as ‘How often would you say fruits and vegetables are available in your home?’, which was used in previous analyses (13, 15), does not lend itself to highly variable responses. As mentioned before, most parents report the presence of fruits, vegetables, and soft drinks in their home, yet little is known about the magnitude of quantity differences between homes. Similarly, patterns of home food availability and household characteristics associated with such patterns have not been adequately described in the literature.

1.2. The home food environment: Family meals

Family meals are an additional component of the household environment which may influence individual food choice. Family meals incorporate foods purchased and brought into the home, and may also provide a setting for shaping attitudes and behaviors regarding food. As discussed below, research suggests that family meals have a positive impact on individual food choice; however, the mechanisms underlying this positive association are unclear. Current literature suggests that family cohesion may play a role.

1.2a. Family meals and diet quality

In recent years, the impact of family meals on adolescent eating patterns has received increasing attention. In their analysis of over 18,000 adolescents participating in the National Longitudinal Study of Adolescent Health, Videon and colleagues examined how parents may or may not influence their adolescent's food consumption by simply eating together (23). Adolescents were asked to indicate the frequency which they ate fruits, vegetables, and dairy foods, as well as whether or not they usually ate something for breakfast. Participants were also asked how frequent at least one parent was present when they ate their evening meal during the past week, as well as whether or not their parents let them make decisions about the foods they eat. Nearly half of adolescents reported eating six or seven evening meals with at least one parent present (referred to as a "family meal") in the past week, while roughly one-third ate less than three family meals in the past week. Analyses revealed that as the number of evening meals eaten with a parent increased, the more likely the adolescent was to report eating something for breakfast, as well as consuming more adequate amounts of fruits, vegetables, and dairy foods.

Similar results were found by Neumark-Sztainer and colleagues in their cross-sectional study of over 4,700 adolescents (24). Family meal frequency was assessed with the question, "During the past seven days, how many times did all, or most, of your family living in your house eat a meal together?" Adolescents also completed the Youth and Adolescent Food Frequency Questionnaire (YAQ),

which yields valid estimates of dietary intake (14). Respondents reported eating meals with all of most of their family 4.5 times (SD=3.3) in the past week, on average. Results indicated that family meal frequency was positively associated with fruit, vegetable, grains, and dairy-food consumption, and negatively associated with soft drink intake.

In a recent study by Utter and colleagues, the authors extended previous findings by examining the relationship between family meal frequency and body mass index (BMI), other aspects of the home food environment, and related eating behaviors in over 3,000 socio-economically disadvantaged youth in New Zealand (25). Family meal frequency was assessed with the question, “In the last 5 days, how many times did all or most of your family living in your house eat an evening meal together?” Adolescents also reported frequency of breakfast and soft drink consumption in the last five school days, as well as usual consumption of fruit and vegetables, fast food/takeaway food, fried food, chocolates, sweets or ice cream, and fruit as after school snacks. Results indicated that among adolescents, frequency of family meals was positively associated with eating five fruits and vegetables a day, eating fruit as an afternoon snack, bringing lunch from home, and eating breakfast at home before school. The association between family meal frequency and BMI failed to reach statistical significance after adjusting for demographic characteristics.

Finally, support for the positive influence of family meals on adolescents’ eating patterns is found in Woodruff and Hanning’s review of the topic (26). The

authors completed a systematic review which yielded seven articles related to family meals and adolescent dietary intake, including the three previously mentioned studies. Their review found consistent evidence for the positive association between family meal frequency and improved diet profiles among adolescents.

Although the majority of research thus far has examined the influence of family meals on adolescent eating patterns, some researchers have considered the associations between family meals and parental food choices. Boutelle and colleagues examined this particular question among a sample of nearly 300 mostly married, female adults (27). Fruit and vegetable consumption was assessed using the Block Fruit and Vegetable Screener, and fat intake was assessed using the Block Fat Screener (28). The authors also collected information on parents' perception and satisfaction of the dinner environment, including whether or not the family finds time to eat together and is satisfied with their meals together. No association was observed between parents' reported frequency of family meals and parent dietary intake.

1.2b. Family cohesion

In an attempt to improve clinical assessment, treatment planning, and research with married couples and families, Olson and colleagues developed the Circumplex Model, which conceptualizes three primary dimensions of marital and family dynamics: family cohesion, flexibility, and communication (29). Family cohesion is defined as "the emotional bonding that family members have towards

one another", while family adaptability, or flexibility, is "the amount of change in leadership, role relationships and relationship rules" (30). The family cohesion and adaptability dimensions of the Circumplex Model underlie the self-report measure, FACES III (31). The FACES III questionnaire identifies 16 types of family systems by dividing the dimensions of cohesion and adaptability into four levels, from low to high. These 16 types can be further summarized into 3 general family systems: balanced, midrange, and extreme. Balanced families are those which are balanced on both dimensions; midrange families are those that are extreme on one dimension but balanced on the other; and extreme families are those that are extreme on both cohesion and adaptability dimensions. It is thought that balanced families will function best, as too little or too much cohesion or adaptability is thought to characterize a dysfunctional family (31).

Although family cohesion is thought to be related to family functioning, the relationship between this particular dimension and health behaviors within families is understudied. Family cohesion may be linked to healthy eating in a variety of ways, including increased acceptance of family rules and role modeling surrounding food choice, or the development of healthy attitudes and behaviors in general due to improved psychological well-being. In their cross-sectional analyses of family cohesion and eating behaviors in 9-19 year old girls, Franko and colleagues found that family cohesion as measured by FACES III was associated with more days of breakfast consumption and lower soda intake (32). Results also indicated a trend toward more milk, fruit, and vegetable

consumption as family cohesion increased. The authors suggested that family cohesion may serve as a proxy measure for time spent with family, as opposed to time spent with peers, and it could be that girls who spend more time with family are exposed to more messages about healthy eating compared to girls who spend more time with friends. In subsequent analyses, the authors found that greater frequency of family meals predicted an increase in family cohesion over time (33). Separately, these analyses suggest that family meals influence family cohesion, which in turn is associated with diet quality, at least for girls. However, the association between these three factors was not directly examined by the authors.

1.2c. Limitations of previous research

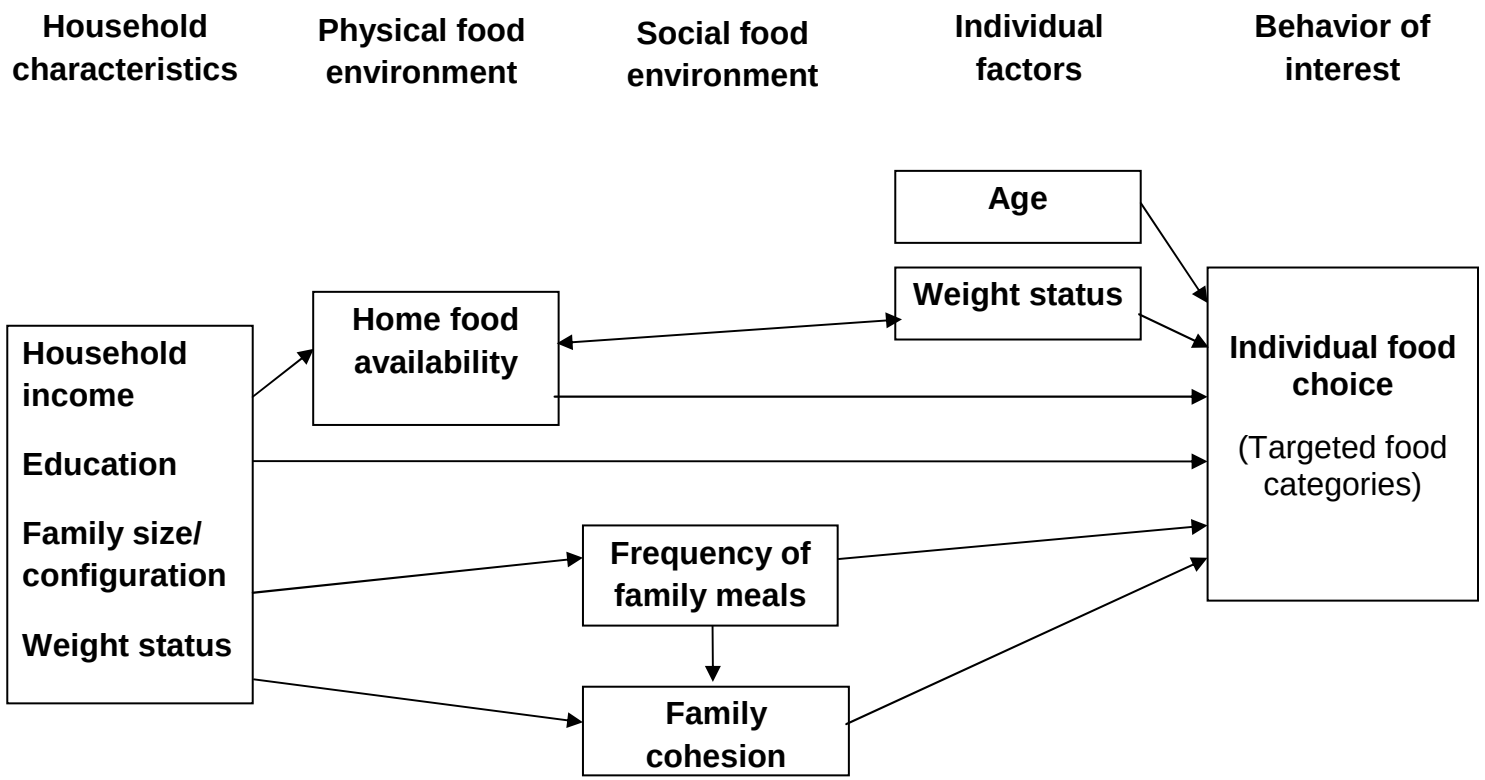
As previously discussed, the relationship between family cohesion and health behaviors, such as food choice, is understudied. However, further research in this area is warranted as interventions to improve diet quality within families may benefit from incorporating messages or activities which enhance family cohesion and/or increase the frequency or quality of family meals. While family cohesion has been shown to mediate the effect of family meals on other adolescent health behaviors, such as smoking (33), the indirect effect of family meals via family cohesion on adolescent food choice has not been examined. Furthermore, previous research has focused on the influence of family meals on adolescents' eating patterns; however, it may be worthwhile to examine this type

of influence on parent eating patterns as well due to the importance of diet quality and weight management for adults' health.

1.3. Theoretical framework and conceptual model

The following three manuscripts are guided by a socio-ecological framework, which attempts to explain individual behavior by examining the micro- and macro-level social and environmental influences surrounding a person (34). In the context of individual food choice, these influences may include global household characteristics (e.g. household income, family size or configuration); the physical environment (e.g. objective home food availability); the family social environment (e.g. frequency of family meals, family cohesion); and individual characteristics (e.g. weight status, age). The first two manuscripts examine the association between two important aspects of the home food environment—home food availability and family meal frequency—and individual food choice. The third manuscript looks more closely at patterns of home food availability and the household characteristics associated with such patterns. The following diagram illustrates the observed and suspected associations between various factors of the home food environment that guided the present research.

Figure 1.3 – Observed and suspected associations between household characteristics, the home food environment, individual factors, and individual food choice



Chapter 2 - Methods

2.1 Take ACTION study overview

The Take ACTION study was a 12-month randomized household weight gain prevention trial conducted at the University of Minnesota, Division of Epidemiology and Community Health. Households enrolled in the study were randomly assigned to one of two treatment arms: treatment vs. control. The treatment condition directed participants to engage in a variety of activities designed to prevent weight gain among household members, including attending monthly group educational sessions, setting household diet and physical activity behavioral goals, regular self-weighing, and restricting household weekly television viewing frequency. The control group was only contacted for data collection purposes and did not receive any intervention messages or materials.

2.2 Participant recruitment

Ninety households (n=153 adults, n= 75 adolescents) were recruited from the Minneapolis/St. Paul metropolitan area via flyers and brochures posted in community settings, including schools and libraries, as well as postcards mailed to University of Minnesota employees. Eligible households had at least one child ≥12 years of age when only one adult was present or at least one child ≥5 years of age when more than one adult was present. Additional eligibility requirements for households included: reside within 20 miles of the Epidemiology Clinical Research Center; have at least 10 hours of total household television viewing time per week; and no household members with dietary, medical, psychological,

or physical limitations that would prevent their participation in intervention activities. Eligibility was assessed during an initial telephone call conducted by trained staff members and confirmed at the baseline clinic visit.

2.3 Sample characteristics

Households ranged in size from 2-6 members with 1-4 adults and 0-3 adolescents. The most common household configurations were two adults and one child ≥ 5 years of age (30%) and two adults and two children ≥ 5 years of age (29%). Twenty-eight percent of all households were headed by single parents. Approximately 30% of households reported a mean annual household income ≤$45,000, while another 30% reported a mean household income of ≥$100,000/year. Most adult participants were female, White, had a college degree or more education, were currently employed, and currently married. Approximately 70% of adults, 37% of adolescents aged 12-17 years, and 33% of children aged 5-11 years in the sample were overweight or obese.

2.4 Data collection

After a household was deemed eligible and agreed to participate in the study, household members attended a clinic visit at the Epidemiology Clinical Research Center where participants ≥5 years of age were weighed and had their heights measured, and participants ≥12 years of age completed a battery of questionnaires (described below). After completion of the clinic visit, a trained staff member visited each household to conduct a home food inventory (HFI) to measure the foods and beverages in targeted categories (described below). The

primary shopper of each household was also instructed by the trained staff member about how to collect receipts and annotate receipt forms, which provided additional information about the food and beverage purchasing habits of the household.

2.5 Measures

Demographic information for both adults and adolescents in the Take ACTION study was collected via questionnaire.

Table 2.5a. – Demographic survey questions

Variable	Survey question/item	Response options
Family configuration	Number of people living in your household, including yourself. # of adults 18 years or older; 3 of children ages 12-17; # of children ages 5-11; # of children ages 4 and under	≥0
Housing type	Housing type	House, apartment building, duplex, condo/townhome, other
Age	Your date of birth	Month/day/year
Gender	Your gender	Male, female
Race	What is your race?	American Indian or Alaskan Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, White, other
Highest level	What is the highest level of	Less than high school, high school or GED,

of education	education you have competed?	vocational training, some college, college/university degree, graduate or professional degree
Current marital status	What is your current marital status?	Never been married, married, not married/living with significant other, separated, divorced, widowed
Employment status	Are you currently working for pay full or part time?	Yes, no
Personal income	What is your personal income before taxes?	$0-10,000, $10,001-20,000, $20,001-30,000…$140,001-150,000, $150,001 or above

Home food availability

Home food availability was assessed using a staff-completed home food inventory (HFI) and participant-completed annotated receipt forms over a 4-week period. The HFI captured item name, size (ounces), and quantity of all foods present in the home from the following categories: snacks, sweets, fruits, vegetables, 100% juices, and sugar-sweetened beverages (e.g. soda, fruit drinks, energy drinks). Annotated receipt forms provided similar information on foods and beverages purchased from home food outlets, such as grocery stores.

Family meals

Information about family meals was collected via questionnaire.

Table 2.5b. – Family meals survey question

Variable	Survey question	Response Options
Family meal frequency	During the past seven days, how many times did all or most of your household eat a meal together?	≥0

Family cohesion

Family cohesion (and adaptability) was assessed using a previously validated 20-item survey, FACES III (31). Higher summary scores on the cohesion sub-scale indicate higher family cohesion.

Table 2.5c. FACES-III survey questions

Survey Item	Response Options
Family/household members ask each other for help.	1-Almost never, 2-Once in a while, 3-Sometimes, 4-Frequently, 5-Almost always
We approve of each other's friends.	
We like to do things with just our immediate family/household.	
Different persons act as leaders in our family/household.	
Family household members feel closer to other family household members than to people outside the family/household.	
Our family/household changes its way of handling	

tasks.	
Family/household members like to spend free time with each other.	
When our family/household gets together for activities everybody is present.	
Rules change in our family/household.	
We can easily think of things to do together as a family/household.	
We shift household responsibilities from person to person.	
Family/household members consult other members on their decisions.	
It is hard to identify the leader(s) in our family/household.	
Family/household togetherness is very important.	
It is hard to tell who does which household others.	
In solving problems, the children's suggestions are followed.	
Children have a say in their discipline.	
Adults and children discuss punishment together.	
The children make the decisions in our family/household.	
Family cohesion score	0-50
Family adaptability score	0-50

Parent and adolescent weight status

Weight and height were measured by a trained staff member. Weight was measured using a calibrated digital scale while participants' shoes were removed. Height was measured using a wall-mounted ruler. Body mass index (BMI) was calculated by dividing a participant's weight in kilograms by their height in meters-squared (kg/m^2).

Parent and adolescent food choice

Parent and adolescent food choice was assessed using a modified version of the Diet History Questionnaire (DHQ) (35). Foods and beverages captured by the survey include the following: snacks (incl. chips, popcorn, and pretzels), sweets (incl. ice cream, cookies, brownies, cakes, pie, pastries, muffins, chocolate, and candy), fruit, vegetables (incl. lettuce salad and fried potatoes), 100% juice, and sugar-sweetened beverages (incl. regular soda and fruit drinks). Information is available on frequency of consumption, as well as usual serving size.

Table 2.5d. – Food choice survey questions

Survey question	**Response options**
Over the past month, how many times did you drink 100% juice such as orange, apple, grape or grapefruit juice?	Never, 1-3 times last month, 1-2 times per week, 3-4 times per week, 5-6 times per week, 7 or more times per week
Each time you drank 100% juice, how much did you	Less than 6 ounces, 6-10 ounces, 10-16 ounces,

usually drink?	more than 16 ounces
Over the last month, how many times did you eat fruit?	Never, 1-3 times last month, 1-2 times per week, 3-4 times per week, 5-6 times per week, 7 or more times per week
Each time you ate fruit, how much did you usually eat?	Less than 1 medium fruit, 1 medium fruit, 2 medium fruits, more than 2 medium fruits
Over last month, how many times did you eat lettuce salad?	Never, 1-3 times last month, 1-2 times per week, 3-4 times per week, 5-6 times per week, 7 or more times per week
Each time you ate lettuce salad, how much did you usually eat?	About ½ cup, about 1 cup, about 2 cups, more than 2 cups
Over the last month, how many times did you eat French fries or fried potatoes?	Never, 1-3 times last month, 1-2 times per week, 3-4 times per week, 5-6 times per week, 7 or more times per week
Each time you ate French fries or fried potatoes, how much did you usually eat?	Small order or less, medium order, large order, supersize order
Over the last month, how many times did you eat other vegetables?	Never, 1-3 times last month, 1-2 times per week, 3-4 times per week, 5-6 times per week, 7 or more times

	per week
Each of these times that you ate other vegetables, how much did you usually eat?	Less than ½ cup, ½ to 1 cup, 1 to 2 cups, more than 2 cups
Over the last month, how many times did you drink fruit drinks?	Never, 1-3 times last month, 1-2 times per week, 3-4 times per week, 5-6 times per week, 7 or more times per week
Each time you drank regular fruit drinks, how much did you usually drink?	Less than 12 ounces, 12 to 20 ounces, more than 20 ounces
Over the last month, how many times did you drink regular soft drinks, soda, or pop?	Never, 1-3 times last month, 1-2 times per week, 3-4 times per week, 5-6 times per week, 7 or more times per week
Each time you drank regular soft drinks, soda, or pop, how much did you usually drink?	Less than 12 ounces, 12 to 20 ounces, more than 20 ounces
Over the last month, how many times did you eat potato chips, tortilla chips, or corn chips?	Never, 1-3 times last month, 1-2 times per week, 3-4 times per week, 5-6 times per week, 7 or more times per week
Each time you ate potato chips, tortilla chips, or corn chips, how much did you usually eat?	Fewer than 10 chips, 10-25 chips, more than 25 chips
Over the last month, how many times did you eat popcorn?	Never, 1-3 times last month, 1-2 times per

	week, 3-4 times per week, 5-6 times per week, 7 or more times per week
Each time you ate popcorn, how much did you usually eat?	Less than 2 cups popped, 2-5 cups popped, more than 5 cups popped
Over the last month, how many times did you eat pretzels?	Never, 1-3 times last month, 1-2 times per week, 3-4 times per week, 5-6 times per week, 7 or more times per week
Each time you are pretzels, how many did you usually eat?	Fewer than 5 average twists, 5-20 average twists, more than 20 average twists
Over the last month, how many times did you eat ice cream, ice cream bars, or sherbet?	Never, 1-3 times last month, 1-2 times per week, 3-4 times per week, 5-6 times per week, 7 or more times per week
Each time you ate ice cream, ice cream bars, or sherbet, how much did you usually eat?	Less than 1 scoop, 1 to 2 scoops, more than 2 scoops
Over the last month, how many times did you eat cookies, brownies, cake, or pie?	Never, 1-3 times last month, 1-2 times per week, 3-4 times per week, 5-6 times per week, 7 or more times per week
Each time you ate cookies, brownies, cake or pie	Less than 2 cookies or 1 small piece, 2 to 4

how much did you usually eat?	cookies or 1 medium piece, more than 4 cookies or 1 large piece
Over the past month, how many times did you eat doughnuts, sweet rolls, Danish, or Pop-Tarts?	Never, 1-3 times last month, 1-2 times per week, 3-4 times per week, 5-6 times per week, 7 or more times per week
Each time you ate doughnuts, sweet rolls, Danish, or Pop-Tarts, how much did you usually eat?	Less than 1 piece, 1 to 2 pieces, more than 2 pieces
Over the last month, how many times did you eat sweet muffins or dessert breads?	Never, 1-3 times last month, 1-2 times per week, 3-4 times per week, 5-6 times per week, 7 or more times per week
Each time you ate sweet muffins or dessert breads, how much did you usually eat?	Less than 1 medium piece, 1 medium piece, more than 1 medium piece
Over the last month, how many times did you eat chocolate candy?	Never, 1-3 times last month, 1-2 times per week, 3-4 times per week, 5-6 times per week, 7 or more times per week
Each time you ate chocolate candy, how much did you usually eat?	Less than 1 average bar, 1 average bar, more than 1 average bar
Over the last month, how many times did you eat other candy?	Never, 1-3 times last month, 1-2 times per week, 3-4 times per

	week, 5-6 times per week, 7 or more times per week
Each time you are other candy, how much did you usually eat?	Fewer than 2 pieces, 2 to 9 pieces, more than 9 pieces

2.6 Institutional Review Board (IRB) Approval

The University of Minnesota IRB: Human Subjects Committee determined that the present dissertation (study number: 0903E60741) is exempt from review under federal guidelines 45 CFR Part 46.101(b) category #4 EXISTING DATA; RECORDS REVIEW; PATHOLOGICAL SPECIMENS.

Chapter 3 - Manuscript One: Examining the association between two objective measures of home food availability and reported dietary intake in 90 U.S. community households: an observational study

3.1 Background

According to recent estimates, most adults and adolescents do not eat adequate amounts of fruits and vegetables (1, 2, 36) and tend to overconsume snacks, sweets and sugar-sweetened beverages (3, 37, 38). Such dietary habits are associated with adverse health outcomes, including obesity, type II diabetes, cardiovascular disease, and certain types of cancer (4, 5). Improving individual dietary quality to achieve better health is clearly an important public health goal (5).

According to social-ecological theory, individual behavior, such as dietary intake, is influenced by numerous factors at the individual, social, environmental, and policy levels, and effective interventions to promote behavior change require action at these various levels (34). The home food environment is one of many factors which may influence individual food choice. For example, characteristics of the primary food shopper (e.g. body mass index, education level) and household characteristics (e.g. household income, family size) may shape home food availability, which may directly impact individual food choice. Individual characteristics of the household members (e.g. age, gender, taste preferences) and other non-home food environment factors (e.g. local food culture, food advertising) may further influence individual dietary intake. Research that

examines the relationship between the home food environment and individual dietary intake can improve the understanding of influences on individual food choice which, in turn, can help inform interventions that seek to improve dietary quality and overall health.

There are several existing methods for measuring the home food environment, including open shelf inventories and predefined inventory checklists (10, 11). Open shelf inventories are completed by trained staff members who visit the homes of participants and record all the foods present. Although this particular method is comprehensive and avoids social desirability bias of participants, it is very time-intensive and costly. Predefined inventory checklists, on the other hand, include only a limited selection of foods identified as present or absent in the home. Although this method is feasible and relatively inexpensive, it is limited in its ability to capture detailed information about foods available in the home, including the presence of less common foods (e.g. ethnic or seasonal foods) and food quantities. An additional tool used to measure home food availability is food purchase receipts that document purchases from retail food outlets, such as grocery stores. Unlike open shelf inventories and predefined inventory checklists which capture a snapshot of available foods, receipt data provide information about the flow of foods into the home over time (11).

Despite the development of various methods to assess home food availability, relatively few studies have examined the relationship between home

food availability and individual dietary intake among adults. Researchers have observed positive cross-sectional associations between home food availability and adults' intake of dietary fat (39), fruits and vegetables, and total energy (40). A limitation of previous studies is the use of home food inventory checklists which do not assess food quantities. Thus, household availability may appear high when quantity is limited for several foods or low when quantity is high for only a few foods. Additional studies among adults have examined the relationship between dietary intake and home food availability as measured by food purchase receipts from grocery stores. One study conducted in Poland observed a positive association between household vegetable purchases made from supermarkets over a one-month period and individual vegetable consumption measured by a 24-hour dietary recall (21). Another study conducted in the UK observed a strong positive association between the amount of fat and energy purchased by households from supermarkets over a 28-day period and the total amount of fat and energy consumed by all household members according to 4-day food diaries (R=0.69 and 0.77, respectively) (22).

In studies of adolescents, positive cross-sectional associations have been observed between parent-reported home food availability and adolescent intake of fruits and vegetables (13, 16) as well as between adolescent-reported home food availability and adolescent intake of dietary fat and soft drinks (19), and snacks and sweets (20). An important limitation of previous research with adolescents is the use of perceived rather than objective home food availability.

Perceived home food availability may not accurately reflect objective home food availability, as individuals who consume more of a certain type of food may be better able to recall the presence of those foods in their homes compared to those who do not consume those foods. Also, most parents report the presence of fruits, vegetables, and soft drinks in their home (13, 16), yet little is known about total food quantities in the home and whether total food quantities are associated with dietary intake.

In order to better examine the association between home food availability and dietary intake, this study used two objective measures of home food availability that provide information about total quantities of home foods: the staff-completed home food inventory and participant-completed annotated receipt forms. Based on previous research, it was hypothesized that greater total quantities of snacks, sweets, fruits, vegetables, and sugar-sweetened beverages in the home and from home food purchases would be associated cross-sectionally with more frequent reported consumption of these foods among both adults and adolescents. However, stronger associations were expected among adults as they are primarily responsible for purchasing and preparing home foods (40).

3.2 Methods

Data for the present study were collected at baseline, prior to any intervention activities, as part of a 12-month community-based household weight gain prevention trial, the Take ACTION study. The University of Minnesota

Institutional Review Board approved this study and documented informed consent was obtained from all participants.

Participants

Ninety households (n=153 adults, n=75 adolescents ages 12-18) were recruited from the Minneapolis/St. Paul metropolitan area via flyers and brochures posted in community settings, such as schools and libraries, as well as postcards mailed to University of Minnesota employees. Eligible households had at least one child ≥12 years of age when only one adult was present or at least one child ≥5 years of age when more than one adult was present. Additional eligibility requirements for households included: reside within 20 miles of the Epidemiology Clinical Research Center; have at least 10 hours of total household television viewing time per week (for intervention purposes); and no household members with dietary, medical, psychological, or physical limitations that would prevent their participation in intervention activities. Eligibility was assessed during an initial telephone call conducted by trained staff members and confirmed in-person during a baseline clinic visit.

Procedure

All household members attended a baseline clinic visit at the University of Minnesota Epidemiology Clinical Research Center where participants ≥5 years of age were weighed and had their heights measured, and participants ≥12 years of age completed a battery of questionnaires about their dietary and physical

activity behaviors. Approximately one week after the initial clinic visit, a trained staff member visited each household to conduct a home food inventory (HFI) to observe and record foods and beverages in targeted categories that were the focus of the intervention. During the home visit, the primary shopper of each household was instructed by the trained staff member about how to collect and annotate receipts to provide information about the food and beverage purchasing habits of the household over a four-week period. Households were compensated $200 upon completing all baseline data collection activities (i.e. clinic and home visits plus four-week receipt collection and annotation).

Measures

Demographic information was self-reported by each of the adults and adolescents in the household and included age, sex, and race for all participants, and marital status, annual individual income, and highest education level attained for adults only. Household level information was reported by the household's primary shopper and included household configuration and household size.

Weight and height of all participants ≥5 years of age were assessed by a trained and certified research staff member. Weight was measured using a calibrated digital scale while participants' shoes were removed. Height was measured using a wall-mounted ruler. Body mass index (BMI) was calculated by dividing weight in kilograms by height in meters-squared. For adolescents, BMI was plotted on the CDC BMI-for-age growth charts to obtain a percentile ranking

(41). Adolescents with a BMI between the 85th and 95th percentiles were considered overweight, while those with a BMI greater than the 95th percentile were considered obese.

Home food availability was assessed using a staff-completed home food inventory (HFI) and participant-completed annotated receipt forms over a four-week period (described above). The HFI captured quantity (in ounces) of all foods present in the home for the following targeted categories: snacks (e.g. potato/corn chips, pretzels, popcorn, crackers, and nuts), sweets (e.g. cookies, bars, candy, pastries, puddings, and frozen desserts), fruits (e.g. fresh, frozen, canned, and dried fruits), vegetables (e.g. fresh, frozen, canned, and dried vegetables; excluding condiments and potatoes), and sugar-sweetened beverages (e.g. soda, sports drinks, fruit drinks with less than 100% juice). The annotated receipt forms were completed by the household's primary shopper and captured information on items in the same targeted categories as the HFI. Primary shoppers were trained to collect all household members' food and beverage receipts from home food outlets, such as grocery stores, supercenters and farmer's markets, as well as from eating out sources, such as restaurants and fast food establishments, during a consecutive four-week period. Data from home food outlets are the focus of this paper in order to make direct comparisons with the HFI. Shoppers were trained to record the item name, size, quantity, and price of targeted foods and beverages purchased on annotated receipt forms. These forms were then mailed at the end of each week to staff members who

systematically coded food items into one of the targeted categories. Further details of the receipt collection methodology are reported elsewhere (42).

Targeted home food availability categories were selected for two primary reasons: (1) foods and beverages in these categories are associated with body weight and participants were encouraged to increase (e.g. fruit and vegetables) or decrease (e.g. snacks, sweets, and sugar-sweetened beverages) their purchase and intake of these foods throughout the weight-gain prevention trial; and (2) restricting foods and beverages to these categories minimizes the staff and participant burden that would occur if all available home foods (e.g. meat, dairy, grains) were measured.

Parent and adolescent food choice was assessed using a self-administered questionnaire adapted from the Diet History Questionnaire (DHQ), a previously validated food frequency questionnaire developed by the National Cancer Institute (35, 43, 44). The DHQ was modified to measure intake of specific food items; however, the original format for questions and response options was retained. This method is not a comprehensive measure of dietary intake, but instead captures intake of foods and beverages within the targeted categories of the HFI and annotated receipt forms. These targeted categories were the focus of intervention messages and activities, and are thus the focus of dietary measurement in this study. Foods and beverages captured by the survey include the following: snacks (3 items: chips, popcorn, and pretzels), sweets (9 items: ice cream, cookies, brownies, cakes, pie, pastries, muffins, chocolate, and

candy), fruit (1 item: all fruits), vegetables (2 items: all vegetables and lettuce salad), and sugar-sweetened beverages (2 items: regular soda and fruit drinks).

Individuals were asked to report their frequency of consuming various food and beverage items: “Over the past month, how many times did you eat/drink…” Response options consisted of 6 ordinal categories: never, 1-3 times last month, 1-2 times per week, 3-4 times per week, 5-6 times per week, 7 or more times per week. Response options were recoded to reflect an average frequency of consumption per week: 0, 0.5, 1.5, 3.5, 5.5, and 7 times per week, respectively. In addition, participants were asked to report their average serving size of consumed items: “Each time you ate [type of food], how much did you usually eat?” Response options consisted of 4 ordinal categories (e.g. about ½ cup, about 1 cup, about 2 cups, more than 2 cups). Average serving sizes were recoded as 0.5, 1, 1.5, and 2 servings. Average number of servings per week of given items was calculated by multiplying frequency of consumption by average servings.

Statistical Analysis

All data were analyzed using SAS version 9.2 (SAS Institute, Cary, NC, USA). Unpaired t-tests were used to compare mean servings per week of foods in targeted categories for adolescents versus adults. Pearson’s correlation (*r*) was used to measure the linear dependence of total ounces of food captured by the HFI and annotated receipt forms. In order to examine the associations

between home food availability and individual dietary intake, a series of hierarchical multiple linear regression models were fit whereby individual level weekly servings of a targeted food category (e.g. snacks, sweets, fruits, vegetables, sugar-sweetened beverages) were regressed on household level total quantity of home foods in that same category. For example, individual weekly servings of snacks were regressed on total ounces of snacks available in the home. In addition, each hierarchical linear regression model included a random effect for household, household and individual level demographic covariates, an individual level main effect indicating adult versus adolescent respondent, and the interaction between the respondent type and the household level home food availability variable in order to estimate differential effects for adults versus adolescents. Hierarchical linear regression models are appropriate when working with nested data, such as individual family members nested within households (45). Analyses were conducted separately for home food inventory and annotated receipt forms data. Home food availability was modeled as both a continuous and a categorical (i.e. tertiles) variable, which produced similar findings. Results are presented for home food availability modeled as tertiles and are summarized for adults and adolescents separately.

Mean household income was identified *a priori* as a theoretical confounder of the home food availability–dietary intake association and was thus included in all regression models. Pearson correlation coefficients and analysis of variance test statistics were calculated for additional plausible covariates, including total

household size and body mass index, education level, marital status, race, and sex of the primary shopper. Bivariate relationships which approached statistical significance ($p<0.10$) were included as covariates in regression analyses. In addition, individual level gender and age were included as covariates in all regression models to improve statistical precision.

3.3 Results

Participant Characteristics

Adult and adolescent participant characteristics are shown in **Table 1**. Most adult participants were female, White, had a college degree or more education, were currently employed, and currently married. Approximately 70% of adults and 37% of adolescents were considered overweight or obese. Of adults who were indicated as the primary shopper, 84% were female. Unpaired t-tests comparing mean servings per week of foods in targeted categories for adolescents versus adults show that adolescents consumed more sugar-sweetened beverages ($P=0.05$), and fewer vegetables ($P<0.001$), compared to adults.

Household Characteristics

Households ranged in size from 2-6 members with 1-4 adults and 0-3 adolescents. The most common household configurations were two adults and one child ≥ 5 years of age (30%) and two adults and two children ≥ 5 years of age (29%). Twenty-eight percent of all households were headed by single

parents. Approximately 30% of households reported a mean annual household income ≤$45,000, while another 30% reported a mean household income of ≥$100,000/year.

Home food availability

Table 2 describes home food availability of targeted food categories in the 90 households as measured by the home food inventory and annotated receipt forms. Based on the HFI, vegetables were the largest category in total ounces, while snacks were the smallest category. According to the receipt data, sugar-sweetened beverages were the largest category in total ounces, while snacks were the smallest category. Pearson correlations showed significant positive associations between the HFI and annotated receipt forms for total ounces of fruits ($P<0.001$) and vegetables ($P<0.001$), and trends toward positive associations for total ounces of snacks ($P=0.09$) and sweets ($P=0.07$). Visual comparisons of availability between the HFI and the receipt annotation forms show that quantities of vegetables and sweets were greater in the home than purchased, while total quantity of sugar-sweetened beverage purchases were greater than total quantity found in the home.

Association between objective home food availability and dietary intake among adults

Adults' servings per week of foods in targeted categories by tertile of home food availability, as well as p-values for tests for trend from hierarchical

linear regression models, are shown in **Table 3**. Among adults, statistically significant relationships between home food availability of snacks and vegetables as measured by the HFI and reported servings per week of these foods were observed after adjusting for household income and size, and participant age and gender. Annotated receipt data revealed highly statistically significant positive associations between availability of purchased fruits and vegetables and reported consumption of these same foods after adjusting for household income and size, and participant age and gender. Specifically, adults in households with the greatest availability of fruit and vegetable purchases reported consuming more than twice as many servings per week of fruits and vegetables compared to those with the least availability (e.g. 10.1 vegetable servings versus 4.2 vegetable servings, $P<0.0001$).

Associations between objective home food availability and dietary intake among adolescents

Adolescents' servings per week of foods in targeted categories by tertile of home food availability, as well as p-values for tests for trend from hierarchical linear regression models, are shown in **Table 4**. Among adolescents, no statistically significant relationships between home food availability as measured by the HFI and servings per week of foods in targeted categories were observed after adjusting for household income and size, and individual age and gender. For annotated receipts data, analyses revealed a statistically significant positive

association between household purchase and adolescent intake of vegetables after adjusting for household income and size, and individual age and gender.

3.4 Discussion

It was hypothesized that greater quantity of available home foods and beverages would be associated with intake of these items, and that this association would be stronger for adults. Our findings partly support this hypothesis. For adults, annotated receipt data showed a significant dose-response relationship between household purchase and individual reported intake of fruits and vegetables, while data from the HFI showed a significant dose-response relationship between home availability and individual reported intake of snacks and vegetables. Total quantities of home foods as measured by the HFI were only moderately correlated with quantities of home food purchases as measured by annotated receipt forms. Thus, one would expect different results from hierarchical linear regression analyses using these two measures of home food availability. The HFI measures a snapshot of foods in the home and may be limited by the fact that preferred items are consumed prior to measurement. The HFI also captures foods and beverages that are suitable for long-term storage, such as canned goods, which may not be associated with regular dietary intake. Annotated receipt forms, on the other hand, measure the flow of foods and beverages into the home, which may be a better indication of usual availability (11).

Fruits and vegetables showed the strongest associations between purchase availability and intake among adults, a finding similar to that of Fulkerson et al. (40). One plausible explanation for this finding may lie in the modified food frequency questionnaire which was used in this study. This measure may have better captured intake of fruits and vegetables by asking respondents to describe intake of all fruits and all vegetables, while reported consumption of snacks and sweets was limited to only select sub-categories (i.e. chips, popcorn, and pretzels; ice cream, cookies, brownies, cakes, pie, pastries, muffins, chocolate, and candy). Although these sub-categories encompass typical snacks and sweets, they are not a comprehensive list and thus reported servings of snacks and sweets may be measured with error. Another plausible explanation for the stronger association between availability and intake of fruits and vegetables among adults is simply that the home environment is more influential for these categories because fruits and vegetables are eaten at home more often than at eating out sources.

It was hypothesized that associations between home food availability and dietary intake among adolescents would be similar in direction but weaker in strength compared to adults. However, significant associations were only observed for household purchase and adolescent intake of vegetables in this study. Previous studies that examined this association among adolescents have produced mixed results; however, several studies have observed a significant relationship between home availability of fruits and adolescent fruit intake (13,

16, 19). Two possible explanations for the absence of statistically significant associations among adolescents are lack of power and the use of a dietary intake measure not previously validated for adolescents. The sample size of adolescents in this study was small, with data on only 75 children ages 12-18 years, while the number of adults in this study was roughly twice that amount. The modified food frequency questionnaire used in this study has only been validated for adults (43, 44), and may not have been appropriate for use with adolescents.

Differences between associations for adults and adolescents might also reflect true differences about how the home food environment impacts adult versus adolescent food choice. Environments outside of the home, such as school, may play a more pivotal role in influencing dietary intake for adolescents. Or, perhaps associations between availability and intake are more pronounced among adults because they are the persons typically responsible for purchasing and preparing home foods. Home food availability and purchases may simply reflect the foods that adults prefer themselves or think should be available in the home.

Limitations of the current study include a small sample size, which may yield inadequate power to detect an association between home food availability and dietary intake, particularly among adolescents. In addition, cross-sectional analyses do not allow for estimation of causal effects. The home food environment can be thought of as both a cause of and response to food choice.

Availability may influence what people choose to eat, but what people prefer to eat may also dictate what they purchase and make available in their home. Despite these limitations, this particular study is a unique addition to the literature examining the relationship between home food availability and dietary intake due to the inclusion of two objective measures of home food availability: the home food inventory and annotated receipt forms. Both methods provide objective information about total quantities of select food categories that builds upon previous studies that relied on inventory checklists or perceived home food availability.

3.5 Tables

Table 3.5a. - Participant characteristics

	Adults (n=153)	Adolescents (n=75)	P
Mean age (SD)	41.5 (7.9)	14.7 (1.7)	
% Female	61.4	40.0	
% White	79.6	66.7	
% ≥College degree	57.9	n/a	
% Currently employed	85.5	n/a	
% Current married	67.8	n/a	
% Overweight	70.6	37.3	
Mean servings/week (SD):			
Snacks	2.9 (2.5)	3.0 (3.0)	0.95
Sweets	7.1 (6.0)	8.1 (8.4)	0.37
Fruits	4.6 (3.1)	4.1 (3.3)	0.24
Vegetables	7.5 (5.3)	4.8 (5.2)	<0.001
Sugar-sweetened beverages	2.7 (3.8)	3.8 (3.6)	0.05

SD: standard deviation

P: p-value for t-test comparing the mean servings/week for adults versus adolescents

Table 3.5b. - Total ounces of targeted foods measured by the home food inventory (HFI) and annotated receipt forms for a 4-week period (n=90 households)

	Mean	SD	Tertile 1	Tertile 2	Tertile 3	*r*
Snacks						0.18*
HFI	164.9	158.4	0-80	80-170	170-862	
Receipts	109.1	103.3	0-50	50-124	124-602	
Sweets						0.19*
HFI	328.7	286.1	0-157	157-373	373-1355	
Receipts	209.9	166.4	0-111	111-258	258-722	
Fruits						0.40**
HFI	301.7	247.5	0-167	167-336	336-1327	
Receipts	370.1	255.7	0-243	243-400	400-1261	
Vegetables						0.31**
HFI	408.4	250.8	54-252	252-472	472-1282	
Receipts	231.2	208.2	0-112	112-250	250-1201	
SSB						-0.06
HFI	239.8	300.9	0-47	47-288	288-1540	
Receipts	437.1	525.9	0-64	64-188	188-2206	

SD: standard deviation; SSB: sugar-sweetened beverages

r: Pearson correlation coefficient measuring linear dependence of total ounces of food/beverage measured by HFI versus total ounces of food/beverage measured by annotated receipt forms; *p<0.01, **p<0.05

Table 3.5c. - Mean servings per week of foods consumed among adults by home food availability tertile as measured by the home food inventory (HFI) and annotated receipt forms (n=153 adults)

	Tertile 1		Tertile 2		Tertile 3		P
	Mean	**SE**	**Mean**	**SE**	**Mean**	**SE**	
Snacks							
HFI	2.74	0.47	3.22	0.49	4.05	0.50	0.04
Receipts	2.80	0.48	3.30	0.45	3.89	0.51	0.08
Sweets							
HFI	5.54	1.19	7.03	1.18	6.12	1.25	0.70
Receipts	5.19	1.14	6.56	1.17	7.32	1.28	0.15
Fruits							
HFI	4.31	0.58	3.97	0.50	5.18	0.56	0.19
Receipts	3.08	0.51	4.71	0.51	6.51	0.87	<0.001
Vegetables							
HFI	5.52	0.97	6.90	0.91	8.32	0.97	0.02
Receipts	4.21	0.88	6.18	0.88	10.06	0.86	<0.001
SSB							
HFI	3.08	0.63	3.64	0.60	2.77	0.62	0.68
Receipts	2.31	0.62	3.62	0.61	3.53	0.62	0.10

SE: standard error; SSB: sugar-sweetened beverages

P: p-value for test for trend from hierarchical linear regression models after adjusting for households income and size, and individual age and gender

Table 3.5d. - Mean servings per week of foods consumed among adolescents by home food availability tertile as measured by the home food inventory and annotated receipt forms (n=75 adolescents)

	Tertile 1		Tertile 2		Tertile 3		P
	Mean	**SE**	**Mean**	**SE**	**Mean**	**SE**	
Snacks							
HFI	2.18	0.74	2.11	0.77	2.32	0.79	0.87
Receipts	1.86	0.72	1.80	0.77	3.37	0.78	0.06
Sweets							
HFI	10.44	1.86	9.63	1.97	9.62	2.02	0.69
Receipts	9.00	1.98	9.12	1.85	11.63	2.00	0.23
Fruits							
HFI	4.52	0.86	4.17	0.91	4.11	0.91	0.65
Receipts	3.02	0.84	4.04	0.88	3.88	0.87	0.34
Vegetables							
HFI	5.20	1.52	6.28	1.50	6.00	1.47	0.61
Receipts	4.13	1.37	6.04	1.38	8.41	1.45	<0.01
SSB							
HFI	2.97	0.98	2.37	0.98	3.23	1.04	0.80
Receipts	3.68	1.06	2.33	1.02	2.73	0.94	0.35

SE: standard error; SSB: sugar-sweetened beverages

P: p-value for test for trend from hierarchical linear regression models after adjusting for households income and size, and individual age and gender

Chapter 4 - Manuscript Two: Examining the relationship between family meal frequency and individual dietary intake: Does family cohesion play a role?

4.1 Background

Positive associations have been observed for family meals and diet quality, particularly among adolescents, in both cross-sectional (23-26) and longitudinal (46, 47) studies. Despite these findings, there is no established theory to explain observed associations between family meals and dietary intake. Some researchers have suggested that family meals provide an opportunity for parents to model healthful eating behaviors or make healthful foods available to family members (26). Another possible explanation is that the frequency of family meals reflects the broader family social environment whereby more frequent family meals are associated with better overall family functioning. One important dimension of family functioning is family cohesion, “the emotional bonding that family members have towards one another” (30). Too little or too much cohesion is thought to characterize a dysfunctional family (31), which may have negative implications for the adoption and maintenance of healthful behaviors, including healthy eating.

The perception of a cohesive family may be associated with healthy eating in a variety of ways, including increased acceptance of family rules and role modeling surrounding food choice, or the development of healthy attitudes and behaviors in general due to improved psychological well-being. While family cohesion has been shown to mediate the effect of family meals on other

adolescent health behaviors such as smoking (33), the indirect effect of family meals via family cohesion on food choice has not been reported in the literature. We are aware of only two studies that have directly examined the relationships between family meal frequency, family cohesion, and dietary intake. In their cross-sectional analyses of family cohesion and eating behaviors in 9-19 year old girls, Franko and colleagues found that family cohesion was associated with more days of breakfast consumption and lower quantities of soda intake (32). Results also indicated a trend toward greater quantities of milk, fruit, and vegetable consumption as family cohesion increased. In subsequent longitudinal analyses, the authors found that greater frequency of family meals predicted an increase in family cohesion over time (33). These analyses suggest that family meals may influence family cohesion, which in turn is associated with diet quality, at least for girls.

Unfortunately, the relationship between family meals, family cohesion, and dietary intake is not clear. Elucidating the mechanism through which family meals have a positive influence on dietary intake may benefit interventionists seeking to improve diet quality within families. If family cohesion is found to be a mediator of family meals and dietary intake, health promoters can enhance dietary interventions by implementing strategies to improve family cohesion. If family cohesion is not indicated as a mediator of family meals and dietary intake, then it will be important to investigate other potential mediators in order to better understand how family meals influence dietary intake.

Previous research has largely focused on the influence of family meals on adolescents' eating behaviors. We are aware of only one study to date that has reported on the relationship between family meal frequency and dietary intake among adults. Among a sample of 300 women, no association was observed between reported frequency of family meals and dietary intake (27). More research is needed to confirm the association between family meal frequency and dietary intake in adults, as well as to examine the possibility of family cohesion as a mediator of this relationship, if one exists. Improving the understanding of the influence of family meals on adults' eating patterns is worthwhile due to the importance of diet quality and weight management for adults' health (5).

This paper examined the cross-sectional relationships between family meal frequency, family cohesion, and individual dietary intake. In light of previous findings, it was hypothesized that greater frequency of family meals would be associated with higher fruit and vegetable intake, and lower intake of snacks, sweets, and sugar-sweetened beverages among adolescents. It was also hypothesized that greater frequency of family meals would be positively associated with greater family cohesion in adolescents, and that the association between family meal frequency and individual food choice would be mediated by family cohesion. We hypothesized similar findings for adults based on the theoretical rationale that family meals have a positive impact on dietary intake via

family cohesion, a reflection of general family functioning that pertains to both adults and adolescents.

4.2 Methods

Participants and Recruitment

Ninety households (n=153 adults ages 18+ years, n=75 adolescents ages 12-17 years) were recruited from the Minneapolis/St. Paul metropolitan area via flyers and brochures posted in community settings, such as schools and libraries, as well as postcards mailed to University of Minnesota employees. Eligible households had at least one child ≥12 years of age when only one adult was present or at least one child ≥5 years of age when more than one adult was present. Additional eligibility requirements for households included: reside within 20 miles of the Epidemiology Clinical Research Center; have at least 10 hours of total household television viewing time per week; and no household members with dietary, medical, psychological, or physical limitations that would prevent their participation in intervention activities. Eligibility was assessed during an initial telephone call conducted by trained staff members and confirmed in-person during a baseline clinic visit. The University of Minnesota's Institutional Review Board approved this study.

Procedures

Data for the present study were collected at baseline, prior to intervention activities, as part of a 12-month community-based household weight gain

prevention trial, the Take ACTION study. All household members attended a baseline clinic visit at the Epidemiology Clinical Research Center where participants ≥5 years of age were weighed and had their heights measured, and participants ≥12 years of age completed a battery of questionnaires about their dietary and physical activity behaviors. Households were compensated $200 upon completing all baseline data collection activities.

Measures

Demographic information was self-reported by each of the adults and adolescents in the household and included age, sex, and race for all participants, and highest education level attained, employment status, and marital status for adults only. Weight and height of all participants ≥5 years of age was assessed by a trained and certified research staff member. Weight was measured using a calibrated digital scale while participants' shoes were removed. Height was measured using a wall-mounted ruler. Body mass index (BMI) was calculated by dividing weight in kilograms by height in meters-squared. For adolescents, BMI was plotted on the CDC BMI-for-age growth charts to obtain a percentile ranking (41). Adolescents with a BMI between the 85th and 95th percentiles were considered overweight, while those with a BMI greater than the 95th percentile were considered obese.

Frequency of family meals was reported by adults and adolescents and was assessed with the question, "During the past seven days, how many times

did all or most of your household eat a meal together?" Responses were open-ended. Family cohesion was assessed using a previously validated survey, FACES III (31). Participants were asked to "describe [their] family/household as it is now by checking the appropriate number (1-5) in the boxes for each item." Examples of statements measuring family cohesion include, "We like to do things with just our immediate family/household," and "Family/household members feel very close to each other." Responses ranged from "1-almost never" to "5-almost always". The cohesion scale of FACES III was comprised of 10 items, and higher summary scores on the scale indicated greater perceived family cohesion (theoretical range: 0-50).

Parent and adolescent food choice was assessed using a self-administered questionnaire adapted from the Diet History Questionnaire (DHQ) (35), a previously validated food frequency questionnaire developed by the National Cancer Institute (43, 44). The DHQ was modified to measure intake of specific food items; however, the original format for questions and response options were retained. This method is not a comprehensive measure of dietary intake, but instead captures intake of foods and beverages within the targeted categories of the HFI and annotated receipt forms. These targeted categories were the focus of intervention messages and activities, and are thus the focus of dietary measurement in this study. Foods and beverages captured by the survey include the following: snacks (3 items: chips, popcorn, and pretzels), sweets (9 items: ice cream, cookies, brownies, cakes, pie, pastries, muffins, chocolate, and

candy), fruit (1 item: all fruits), vegetables (2 items: all vegetables, lettuce salad), and sugar-sweetened beverages (2 items: regular soda and fruit drinks).

Individuals were asked to report their frequency of consuming various food and beverage items: “Over the past month, how many times did you eat/drink…” Response options consisted of 6 ordinal categories: never, 1-3 times last month, 1-2 times per week, 3-4 times per week, 5-6 times per week, 7 or more times per week. Response options were recoded to reflect an average frequency of consumption per week: 0, 0.5, 1.5, 3.5, 5.5, and 7 times per week, respectively. In addition, participants were asked to report their average serving size of consumed items: “Each time you ate [type of food], how much did you usually eat?” Response options consisted of 4 ordinal categories (e.g. about ½ cup, about 1 cup, about 2 cups, more than 2 cups). Average serving sizes were recoded as 0.5, 1, 1.5, and 2 servings. Average number of servings per week of given items was calculated by multiplying frequency of consumption by average servings.

Statistical Analysis

All data were analyzed using SAS Version 9.2 (Cary, NC: SAS Institute Inc.). Statistical significance was indicated at the $\alpha<0.05$ level. Simple t-tests and chi-square statistics were used to compare participant demographic characteristics, family cohesion scores, and eating behaviors for adults and adolescents. Pearson correlation coefficients were used to examine cross-

sectional associations between participant-reported family cohesion and family meal frequency.

The Baron & Kenny approach to mediation analysis was the primary statistical method used in this paper (48). In mediation analysis, four steps are taken to provide evidence for the presence of a mediator. First, it should be demonstrated that the independent variable X is associated with the outcome variable Y. Second, it should be demonstrated that the independent variable X is associated with the mediator variable M. Third, it should be demonstrated that the mediator variable M is associated with the outcome variable Y after controlling for X. Note that X must be controlled when establishing the relationship between the mediator and the outcome to avoid finding a spurious relationship due to confounding of X. Finally, if the effect of X on Y is reduced when M is included in a regression model, there is evidence that the effect of X on Y is partially mediated by M. If the path between X and Y disappears entirely when M is included, complete mediation by M is indicated.

Figure 1 depicts the various associations that were tested in this paper. A series of hierarchical multiple linear regression models were fit whereby each individual's average weekly servings of a targeted food category (e.g. fruits, vegetables, snacks, sweets, sugar-sweetened beverages) were regressed on frequency of family meals, both of which were entered as continuous variables. In addition, each hierarchical linear regression model included a random effect for household to take into account the correlation of responses for members

within a household; individual level demographic covariates to improve statistical precision; an individual level indicator variable for respondent type (i.e. adult vs. adolescent); and the interaction between the respondent type and reported frequency of family meals in order to estimate regression estimates separately for adults and adolescents. Hierarchical linear regression models are appropriate when working with nested data, such as individual-level data nested within households (45).

Similar regression models were subsequently fit regressing family cohesion scores on frequency of family meals, as well as regressing average weekly servings of a targeted food category on family cohesion scores after controlling for frequency of family meals. Finally, regression models regressing weekly servings of a targeted food category on both family meal frequency *and* family cohesion score were fit in order to provide evidence for mediation. When mediation was indicated, the percent reduction for the association of family meals and dietary intake as mediated by family cohesion was calculated by subtracting the adjusted regression coefficient for family meal frequency from its unadjusted counterpart, and then dividing by the unadjusted regression coefficient for frequency of family meals. Sobel's test was used to assess statistical significance of the indirect (mediation) effect (49, 50).

4.3 Results

Participant Characteristics

Roughly 60% of adult participants were female, 80% White, 58% had a college degree or more education, 86% were currently employed, and 68% were currently married. Approximately 70% of adults and 37% of adolescents were considered overweight or obese. Participant-reported family cohesion and eating behaviors are shown in **Table 1**. Adults reported significantly higher scores on the FACES cohesion scale (37.4 vs. 31.7, P<0.001), as well as more family meals per week (6.3 vs. 5.0, P=0.03), compared to adolescents. Statistical comparisons of mean servings per week of foods in targeted categories show that adults consumed more vegetables (P<0.001) and fewer sugar-sweetened beverages (P=0.05) than adolescents.

Relationship between Family Meal Frequency and Dietary Intake (X→Y)

Regression coefficients (β) for hierarchical linear regression models regressing servings of foods in targeted categories on frequency of family meals are displayed in the first column of **Table 2**. For adults, significant positive associations were shown for family meal frequency and fruit (P<0.01) and vegetable (P<0.05) intake, while a significant negative association was observed for family meal frequency and sugar-sweetened beverage (P<0.05) intake. An increase of one meal for the number of family meals per week was associated with increases of 0.20 weekly servings of fruit and 0.23 weekly servings of vegetables, and a decrease of 0.18 weekly servings of sugar-sweetened beverages among adults. For adolescents, a significant negative association was observed for family meal frequency and sweets (P<0.05) intake, while a positive

trend was shown for family meal frequency and vegetable (P<0.10) intake and a negative trend was shown for family meal frequency and sugar-sweetened beverage (P<0.10) intake. An increase of one meal for the number of family meals per week was associated with an increase of 0.25 weekly servings of vegetables and decreases of 0.37 weekly servings of sweets and 0.16 weekly servings of sugar-sweetened beverages among adolescents.

Relationship between Family Meal Frequency and Family Cohesion (X→M)

Pearson correlations demonstrated a significant positive association between participant-reported family meal frequency and family cohesion score (r=0.43, P<0.01). Regression coefficients (β) for hierarchical linear regression models regressing family cohesion score on frequency of family meals were approximately the same for adults (β=0.56, SE=0.13) and adolescents (β=0.55, SE=0.16).

Relationship between Family Cohesion and Dietary Intake (M→Y)

Regression coefficients (β) for hierarchical linear regression models regressing servings of foods in targeted categories on family cohesion scores are displayed in the second column of **Table 2.** These estimates are not adjusted for frequency of family meals. For adults, a significant negative association was observed for family cohesion score and sugar-sweetened beverage (P<0.05) intake, while a negative trend was shown for family cohesion score and intake of sweets (P<0.10). For adolescents, a significant negative association was

observed for family cohesion score and intake of sweets (P<0.05), while a positive trend was shown for family cohesion score and vegetable intake and a negative trend was shown for family cohesion score and sugar-sweetened beverage intake (P<0.10).

Regression coefficients (β) for hierarchical linear regression models regressing servings of foods in targeted categories on family cohesion scores, after controlling for frequency of family meals, are displayed in the fourth column of **Table 2.** For adults, a negative trend was observed for family cohesion score and sugar-sweetened beverage intake (P<0.10). For adolescents, a negative trend was observed for family cohesion score and intake of sweets (P<0.10).

Mediation Analysis (X→M→Y)

Regression coefficients (β) for hierarchical linear regression models regressing servings of foods in targeted categories on frequency of family meals, after adjusting for family cohesion score, are displayed in the third column of **Table 2**. For adults, an increase of one meal for the number of family meals per week was associated with a decrease of 0.13 weekly servings of sugar-sweetened beverages after controlling for family cohesion score. This indicates a 28% reduction for the association of family meals and sugar-sweetened beverage intake as mediated by family cohesion. For adolescents, an increase of one for the number of family meals per week was associated with a decrease of 0.29 weekly servings of sweets after controlling for family cohesion. This

indicates a 22% reduction for the association of family meals and sweets intake as mediated by family cohesion. However, Sobel's test only suggested a trend toward partial mediation by family cohesion for the relationship between family meal frequency and sweets intake in adolescents (z=1.72, P=0.08).

4.4 Discussion

The primary aim of this paper was to examine the relationships between family meal frequency, family cohesion, and average weekly intake of foods in targeted categories. It was hypothesized that family meal frequency would be positively associated with fruit and vegetable intake and negatively associated with snacks, sweets, and sugar-sweetened beverage intake for both adults and adolescents. Among adults, results suggested that greater family meal frequency was associated with significantly more servings per week of fruits and vegetables, and fewer sugar-sweetened beverages. In contrast, Boutelle and colleagues found no significant associations between frequency of family meals and parents' dietary intake (27). Such differences may be due to dissimilar research methods, instruments, or sample populations. Boutelle et al. utilized a phone interview to assess usual dietary intake in a sample of women, while the current study used an in-person questionnaire to measure dietary intake of a targeted subset of foods in a sample of men and women.

Among adolescents, family meal frequency was associated with significantly fewer weekly servings of sweets, and there were trends toward greater intake of vegetables and lower intake of sugar-sweetened beverages.

Our findings are somewhat consistent with previous literature, which suggests that among adolescents, greater family meal frequency is positively associated with fruit and vegetable intake (23-25), and negatively associated with sugar-sweetened beverage intake (24). We did not observe a significant relationship between family meal frequency and fruit intake among adolescents. Differences in results from the present study may be due to our use of a modified food frequency questionnaire which has only been validated for adults, and may not have been appropriate for use with adolescents (51).

We also hypothesized significant associations between family cohesion and dietary intake. Among adolescents, results indicated a negative trend between family cohesion and sweets intake, while a negative trend was observed for family cohesion and sugar-sweetened beverage intake among adults. These associations were observed after adjusting for family meal frequency and were considerably weaker compared to results from models that did not adjust for family meal frequency.

Finally, it was hypothesized that family cohesion partially mediated the association between frequency of family meals and dietary intake. However, mediation analysis could only be considered in instances where both frequency of family meals and family cohesion demonstrated significant associations with dietary intake. Unfortunately, there was not strong evidence for mediation by family cohesion in any of our models. A lack of significant findings may be due to measurement error associated with our assessment tools, or may simply reflect

the fact that family cohesion does not play an important role in explaining the effect of family meals on dietary intake. This latter notion is supported by results from our adjusted models, which indicated that regression estimates for family meal frequency were largely unchanged by the inclusion of the family cohesion covariate, while family cohesion scores changed dramatically after controlling for frequency of family meals.

Limitations of the present study include a small sample size which may yield null results due to inadequate power, and the use of cross-sectional data. Because our data are cross-sectional, it is unknown if family meal frequency determines family cohesion or family cohesion determines frequency of family meals. It is similarly plausible that the two variables continuously influence one another. However, previous longitudinal research suggests that frequency of family meals predicts improved family cohesion over time (33). Thus, our regression models fit family cohesion as the mediator between frequency of family meals and individual food choice. Finally, the use of Sobel's test to indicate the statistical significance of a mediated effect may not be appropriate for use with hierarchical models.

This study is unique in that it utilized a validated questionnaire to measure family cohesion among a sample of adolescents and their parents. Previous researchers have considered the role of family dynamics when examining the influence of family meal frequency on adolescent health outcomes. For example, researchers have adjusted for family connectedness in their analyses in order to

describe the association between family meal frequency and outcomes such as disordered eating (52), substance use (53), and problem behaviors (54), above and beyond family connectedness. However, in these studies, family connectedness was not measured with validated instruments, but instead characterized by adolescent self-report of their perceived closeness to their mother and/or father using a limited number of questions. In effect, what has been described as family connectedness may not truly reflect perceived family cohesion per se. The measure of family cohesion in the present study, on the other hand, provided a valid assessment of both adult and adolescent perceived family cohesion.

The present study also builds upon previous research by examining the association between family meal frequency, family cohesion, and dietary intake among adults. As previously discussed, we observed significant associations between family meal frequency and adult intake of fruits, vegetables, and sugar-sweetened beverages. These findings suggest that family meals may have a positive impact on all family members, and not just adolescents. However, evidence for the mediating role of family cohesion for this relationship was lacking.

4.5 Tables

Table 4.5a. - Participant-reported family cohesion and eating behaviors for adults and adolescents

	Adults (n=152)		Adolescents (n=75)		P
	Mean	**SD**	**Mean**	**SD**	
FACES cohesion score	37.4	6.5	31.7	8.6	<0.001
Family meals per week	6.3	4.1	5.0	4.4	0.03
Servings per week:					
Fruits	4.6	3.1	4.1	3.3	0.24
Vegetables	7.5	5.3	4.8	5.2	0.95
Snacks	2.9	2.5	3.0	3.0	0.37
Sweets	7.1	6.0	8.1	8.4	0.37
SSB	2.7	3.8	3.8	3.6	0.05

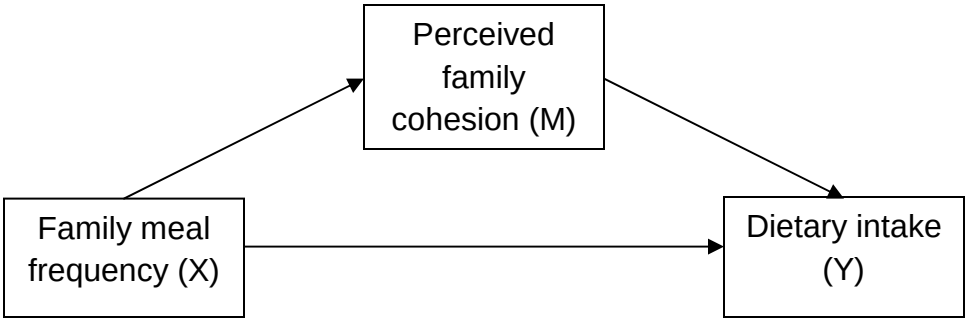
Table 4.5b. - Regression coefficients for food servings per week regressed on family meal frequency and family cohesion among adults and adolescents

	Independent variable			
	Family meal frequency only	**Family cohesion score only**	**Family meal frequency (adjusted for cohesion score)**	**Family cohesion score (adjusted for meal frequency)**
Dependent variable	**B (SE)**	**B (SE)**	**B (SE)**	**B (SE)**
Servings per week:				
Fruits				
Adults	0.20 (0.06)**	0.06 (0.04)	0.19 (0.06)**	0.004 (0.006)
Adolescents	-0.008 (0.08)	0.02 (0.04)	-0.02 (0.08)	-0.001 (0.006)
Vegetables				
Adults	0.23 (0.10)*	0.01 (0.07)	0.22 (0.11)*	-0.006 (0.01)
Adolescents	0.25 (0.13)†	0.12 (0.07)†	0.24 (0.14)†	0.01 (0.01)
Snacks				
Adults	-0.04 (0.05)	-0.006 (0.03)	-0.05 (0.06)	0.006 (0.005)
Adolescents	0.05 (0.07)	0.04 (0.03)	0.04 (0.07)	-0.0005 (0.005)
Sweets				
Adults	-0.11 (0.14)	-0.16 (0.09)†	-0.02 (0.14)	-0.02 (0.01)
Adolescents	-0.37 (0.18)*	-0.19 (0.09)*	-0.29 (0.18)	-0.02 (0.01)†
SSB				
Adults	-0.18 (0.07)*	-0.12 (0.05)*	-0.13 (0.08)	-0.01 (0.007)†
Adolescents	-0.16 (0.10)†	-0.09 (0.05)†	-0.11 (0.10)	-0.01 (0.007)

†p<0.10, *p<0.05, **p<0.01
Note: all regression models controlled for participant age and gender

4.6 Figures

Figure 4.6a. – Mediation analysis



Chapter 5 - Manuscript Three: Describing patterns of home food availability: Findings from an exploratory latent class analysis

5.1 Background

It has been estimated that nearly three-quarters of dietary consumption, in terms of total food mass, occurs at home (55). Although individuals are exposed to food options in a variety of settings, the home is a uniquely modifiable food environment in that individuals have control over the foods and beverages they purchase and keep in their homes. Cross-sectional research shows that home food availability is associated with individual dietary intake. For example, greater availability of fruits and vegetables in the home is associated with greater intake of these foods among youth (13, 16). Researchers have also observed positive associations between grocery store purchases and intake of vegetables and total amounts of fat and calories among households members (21, 22). Despite the home food environment's potential influence on individual dietary intake, relatively little is known about the types and amounts of foods that households purchase and bring into their homes (6). Thus, the primary aim of this study was to characterize patterns of objective home food availability using latent class analysis.

Latent class analysis is a model based statistical clustering method used to identify subgroups (clusters) of individuals that exhibit similar patterns of behavior (56). Such patterns of behavior can be used to identify high-risk subgroups, for example, individuals at risk for developing obesity (57, 58).

Information about these subgroups can then be used to guide the development and evaluation of behavioral interventions. Although cluster analysis has been used extensively to describe patterns of dietary intake (59), we are unaware of published studies that have used cluster analysis to distinguish patterns of home food availability.

Due to the novel application of this statistical technique, there were no a priori hypotheses regarding expected patterns of home food availability. However, we anticipated that unique patterns of home food availability would emerge from the data and that the clusters of households defined by these patterns would differ on important households characteristics. Previous research has shown differences in the quality or quantity of household food purchases according to race/ethnicity and education of the primary shopper (60), household income (61, 62), family size (63), and household overweight status (64). Based on previous research, it was hypothesized that relatively healthful patterns of home food availability (e.g. more fruits and vegetables) would be positively association with household income and highest educational attainment, while relatively unhealthful food availability (e.g. more snacks, sweets, and sugar-sweetened beverages) would be positively associated with household overweight status.

5.2 Methods

Data for the present study were collected at baseline, prior to any intervention activities, as part of a 12-month community-based household weight

gain prevention trial, the Take ACTION study. The University of Minnesota Institutional Review Board approved this study and documented informed consent was obtained from all participants.

Participants

Ninety households were recruited from the Minneapolis/St. Paul metropolitan area via flyers and brochures posted in community settings, such as schools and libraries, as well as postcards mailed to University of Minnesota employees. Eligible households had at least one child ≥12 years of age when only one adult was present or at least one child ≥5 years of age when more than one adult was present. Additional eligibility requirements for households included: reside within 20 miles of the Epidemiology Clinical Research Center; have at least 10 hours of total household television viewing time per week (for intervention purposes); and no household members with dietary, medical, psychological, or physical limitations that would prevent their participation in intervention activities. Eligibility was assessed during an initial telephone call conducted by trained staff members and confirmed in-person during a baseline clinic visit.

Procedure

All household members attended a baseline clinic visit at the Epidemiology Clinical Research Center where participants ≥5 years of age were weighed and had their heights measured, and participants ≥12 years of age completed questionnaires about their dietary and physical activity behaviors.

Approximately one week after the initial clinic visit, a trained staff member visited each household to conduct a home food inventory (HFI) to observe and record foods and beverages in targeted categories that were the focus of the intervention. During the home visit, the primary shopper of each household was instructed by the trained staff member about how to collect and annotate receipts to provide information about the food and beverage purchasing habits of the household over a four-week period. Households were compensated $200 upon completing all baseline data collection activities.

Measures

Individual demographic information collected at baseline included age, sex, and race of all participants. All adults reported their marital status, highest education level attained, and individual annual income. Total annual household income was calculated by summing the reported individual annual incomes of all adults residing in the home. Household level information was reported by the household's primary shopper and included total number of members residing in the household, number of children <18 years of age residing in the household, housing type (e.g. house, apartment building, duplex, condo/townhome, other), and weekly frequency of eating a meal together as a family.

Weight and height of all participants ≥5 years of age was assessed by a trained and certified research staff member. Weight was measured using a calibrated digital scale after participants' shoes were removed. Height was measured using a wall-mounted ruler. Body mass index (BMI) was calculated by

dividing weight in kilograms by height in meters-squared. For children and adolescents, BMI was plotted on the CDC BMI-for-age growth charts to obtain a percentile ranking (41). Adults with a BMI ≥25 kg/m^2 and youth with a BMI-for-age ≥85th percentile were considered overweight, while adults with a BMI ≥30 kg/m^2 and youth with a BMI-for-age ≥95th percentile were considered obese.

Home food availability of foods in targeted categories was assessed using a staff-completed home food inventory (HFI) and participant-completed annotated receipt forms over a four-week period. Targeted home food availability categories were selected for two primary reasons: (1) foods and beverages in these categories are associated with body weight and participants were encouraged to increase (e.g. fruit and vegetables) or decrease (e.g. snacks, sweets, and sugar-sweetened beverages) their purchase and intake of these foods throughout the weight-gain prevention trial; and (2) restricting foods and beverages to these categories minimizes the staff and participant burden that would occur if all home foods (e.g. meat, dairy, grains) were measured.

The HFI captured quantity, in ounces, of all foods present in the home for the following targeted categories: snacks (e.g. potato/corn chips, pretzels, popcorn, crackers, and nuts), sweets (e.g. cookies, bars, candy, pastries, puddings, and frozen desserts), fruits (e.g. fresh, frozen, canned, and dried fruits), vegetables (e.g. fresh, frozen, canned, and dried vegetables; excluding condiments and potatoes), and sugar-sweetened beverages (e.g. soda, sports drinks, fruit drinks with less than 100% juice). Primary shoppers also reported the

date of their most recent main grocery trip prior to the home visit, and staff recorded the date when the HFI was completed.

The annotated receipt forms were completed by the household's primary shopper and captured information on items in the same targeted categories as the HFI. Primary shoppers were trained to collect all household members' food and beverage receipts from home food outlets, such as grocery stores, supercenters (e.g. Sam's Club, Super Target) and farmer's markets, as well as from eating out sources, such as restaurants and fast food establishments, during a consecutive four-week period. Data from home food outlets are the focus of this paper due to an interest in the home food environment. Shoppers were trained to record the item name, size, quantity, and price of targeted foods and beverages purchased, as well as the date and source of purchases, on annotated receipt forms. The four-week collection period began the first day following the home visit and shoppers were instructed to mail forms at the end of each week to staff members who systematically coded food items into one of the targeted food categories. Further details of the receipt collection methodology are reported elsewhere (42).

Total quantities per person of home foods were calculated separately for HFI and annotated receipt form data by dividing a household's total ounces of food or beverage in a particular category (e.g. fruits, vegetables, snacks, sweets, and sugar-sweetened beverages) by the number of individuals in the home who were aged 5 years or older. A summer season variable was also created to

indicate whether the HFI or receipt collection period was completed during the summer months (June 1-September 30) or not.

Statistical Analysis

All data were analyzed using MPLUS version 5.21 (Muthén & Muthén, Los Angeles, CA, 2009) and SAS version 9.2 (SAS Institute, Cary, NC, 2008). Total quantities per person of home foods were square-root transformed and standardized to reduce the impact of outliers and to make comparisons across food categories which had different ranges of values. These continuous variables were then modeled with latent class analysis (LCA) separately for HFI and annotated receipt forms data. The latent class analysis model assumes that observed correlations between variables are completely explained by the existence of underlying subgroups (or clusters) of individuals (56). Given a fixed number of clusters, LCA estimates the expected mean values of the observed variables conditional on latent class membership. The means and standard errors for the means of each variable within each cluster are plotted and compared in order to describe the structure of the different clusters. Moreover, given a particular response pattern, the probability of latent class membership can be estimated from the fitted model allowing each individual to be assigned to their most probable class based on their particular responses. These models were repeated, fixing the number of clusters equal to 2, 3, 4, 5, and 6. There is no consensus on how to select the optimal number of clusters. Although measures of goodness of fit (e.g. AIC, BIC, adjusted BIC) were considered, final

cluster structures were ultimately based on descriptive meaning. Specific criteria for final cluster structure selections, as outlined by Boone-Heinonen et al. (58), included strength of food availability patterns within clusters, i.e. food category variables with standardized means ≤-0.5 or ≥0.5; discovery of unique food availability patterns when additional clusters were added; and structures resulting in sufficient cluster sizes (>5% of the sample). Clusters were named according to their distinguishing characteristics with regard to home food availability. Means and frequencies of household characteristics within these classes were calculated in SAS. T-tests and chi-square test statistics were conducted to statistically compare these characteristics between clusters. Statistical significance was set at α-level 0.05.

5.3 Results

Sample characteristics

Roughly 60% of adult participants were female, 80% White, and 58% had a college degree or more education. Approximately 70% of adults, 37% of adolescents aged 12-17 years, and 33% of children aged 5-11 years in the sample were overweight or obese. Households ranged in size from 2-6 members with 1-4 adults and 0-3 adolescents. The most common household configurations were two adults and one child ≥ 5 years of age (30%) and two adults and two children ≥ 5 years of age (29%). Twenty-eight percent of all households were headed by single parents. Approximately one-third of households reported a

mean annual household income ≤$45,000, while an equal number reported a mean household income of ≥$100,000/year.

Table 1 shows the means and ranges of home food availability, in ounces, as measured by the HFI and annotated receipts for targeted categories across households. Based on the HFI, vegetables were the largest category in total ounces, while snacks were the smallest category. According to the receipt data, sugar-sweetened beverages were the largest category in total ounces, while snacks were the smallest category. Pearson correlations showed significant positive associations between the HFI and annotated receipt forms for total ounces of fruits ($P<0.001$) and vegetables ($P<0.001$), and trends toward positive associations for total ounces of snacks ($P=0.09$) and sweets ($P=0.07$).

Latent class cluster analysis: HFI

As shown in **Figure 1**, the final structure for HFI data was comprised of 4 clusters. Cluster 1 (“Overall moderate availability”) was the largest cluster (n=62) and was characterized by home food availability that closely followed the standardized means across all food categories. The 3 remaining clusters are characterized as follows. Households in Cluster 2 (“Greatest availability of snacks, sweets, and sugar-sweetened beverages”) had relatively high availability of foods across all categories, and the overall greatest availability of snacks, sweets, and sugar-sweetened beverages. Cluster 3 (“Relatively high fruit and vegetable availability”) had relatively high availability of fruits and vegetables,

although not significantly different from Cluster 2, and moderate amounts of snacks, sweets and sugar-sweetened beverages. Cluster 4 (“Overall low availability”) had relatively low availability of foods across all categories, and the overall lowest availability of fruits, vegetables, snacks, and sweets. Unstandardized means for total quantities of home foods, by cluster, as measured by the HFI are shown in **Table 2**. Figures depicting home food availability patterns not selected as the final cluster structure can be found in **Appendix A**.

Household characteristics by cluster patterns of home food availability as measured by the HFI are shown in **Table 3**. There were significant differences across clusters for total number of household members, annual household income, members’ highest level of educational attainment, and percentage of households with 3 or more children. Cluster 4, (“Overall low availability”) had the lowest percentage of households with 1 or more members having a college degree and the highest percentage of households with 3 or more children. Households in Cluster 4 also had the lowest mean income across all clusters, although it was not significantly different from the mean household income for Cluster 3 (“Relatively high fruit and vegetable availability”). Cluster 4 households also reported significantly more days between their last main grocery trip and the date of their home visit, and also reported making fewer grocery trips over the ensuing 4-week receipt collection period, compared to households in the other clusters.

Latent class cluster analysis: Annotated-receipt forms

As shown in **Figure 2**, the final structure for annotated-receipt forms data was comprised of 3 clusters. Cluster 1 ("Overall low availability") was the smallest cluster (n=15) and was characterized by the lowest availability of fruits, vegetables, snacks, and sweets. The two larger clusters had very similar moderate availability of fruits, vegetables, and snacks, yet had disparate availability of sweets and sugar-sweetened beverages. Specifically, Cluster 2 ("Relatively low availability of sweets and sugar-sweetened beverages") had significantly lower availability of sweets and especially sugar-sweetened beverages compared to Cluster 3 ("Relatively high availability of sweets and sugar-sweetened beverages"). The standardized mean difference between Clusters 2 and 3 was approximately 1.7 standard deviations for household purchase of sugar-sweetened beverages. Unstandardized means for total quantities of home foods, by cluster, as measured by annotated receipt forms over a 4-week period, are shown in **Table 4**. Figures depicting home food availability patterns not selected as the final cluster structure can be found in **Appendix B.**

Household characteristics by cluster patterns of home food availability as measured by annotated receipt forms over a 4-week period are shown in **Table 5**. There were significant differences across clusters for annual household income, members' highest level of educational attainment, and frequency of family meals per week. There were also non-significant trends for differences

between clusters indicated for proportion of household members who were overweight or obese.

Cluster 1 (“Overall low availability”) was comprised of households with the lowest mean income, had the lowest percentage of households with 1 or more members having a college degree, and had the highest proportion of household members who were obese. Clusters 2 (“Relatively low availability of sweets and SSB”) and 3 (“Relatively high availability of sweets and SSB”) were quite similar in terms of mean household income and other household-level characteristics; however, there was a trend toward a significant between-group difference for the proportion of household members who were considered overweight. Specifically, households in Cluster 2 had a lower proportion of members who were overweight compared to households in Cluster 3 (0.46 vs. 0.59, p=0.08). Compared to households in Clusters 1 and 2, those in Cluster 3 made significantly more grocery trips over the four-week period.

A cross-tabulation of cluster membership for HFI vs. annotated receipt form data showed that HFI cluster membership was not significantly associated with annotated receipt form cluster membership (Chi-square test statistic: 6.5, DF=6, p=0.37).

5.4 Discussion

The primary aim of this study was to characterize patterns of home food availability in order to better understand the home food environment. Based on descriptive meaning, we determined that 4 clusters optimally characterized

patterns of home food availability as measured by the HFI for households in our sample. Cluster 4 had low overall availability of foods in the targeted categories and was comprised of households with relatively lower socio-economic status in terms of mean household income and household members' educational attainment. These households also reported making grocery trips less frequently compared to households in other clusters.

Interestingly, the proportion of household members who were overweight or obese did not differ significantly across clusters of home food availability as measured by the HFI. The lack of an association between the home food environment and overweight or obesity has been observed in other studies that have measured home food availability using open shelf inventory methods (65, 66). Coates et al., for example, found little evidence that foods stored in the home were related to maternal, paternal, or child weight status (66). Similarly, Byrd-Bredbenner et al. observed no significant differences between high maternal, paternal, or children BMI households and healthy BMI households with respect to the nutrient profiles of foods present in the homes of 100 families (65). The lack of an observed association between foods present in the home and participants' weight status in the present study may be due to a relative lack of variability for body weight in this sample. It is also plausible that other unmeasured characteristics of foods present in the home, such as accessibility or storage duration, are more closely related to body weight than the total quantity of foods available in the home.

For annotated receipt forms data, a 3-cluster solution was determined to best characterize patterns of grocery store purchases of foods in targeted categories. Similar to Cluster 4 from analysis with HFI data, Cluster 1, characterized by “overall low availability”, was comprised of households with the lowest mean income and the lowest percentage of households with a member having a college degree. There was also a trend toward fewer households in Cluster 1 to not live in a home but in multi-family residences compared to households in Clusters 2 or 3. Although this finding likely reflects the households’ inability to afford a house, living in an apartment, duplex, or condo may also entail physical space limitations for storing recently purchased food and beverage items.

Cross-tabulations of cluster membership according to HFI vs. annotated receipt collection data indicate that these two clusters of “overall low availability” are not necessarily comprised of the same households. In fact, the 9 households which comprised Cluster 4 from HFI data were evenly dispersed across the 3 clusters from annotated receipt forms data. This disparity in cluster membership, along with overall differences between the two cluster structures which emerge from HFI and annotated receipt forms data, highlights the fact the HFI and annotated receipt forms are really tapping into two distinct components of the home food environment. The HFI is a measure of home foods at a single time point, and may not accurately represent usual home food availability. On the other hand, annotated receipt forms track availability over a set time period and

may better capture usual availability, including highly preferred foods which may be consumed soon after purchase or perishable foods that have a short shelf-life.

One additional finding from the cluster analysis of the annotated receipt form data worth noting is the difference between Clusters 2 and 3 in the proportion of household members who were overweight. Clusters 2 and 3 were quite similar in terms of availability of fruits, vegetables, and snacks, as well as mean household income and other household characteristics. However, Cluster 3 was characterized by significantly higher purchase quantities of sweets, and sugar-sweetened beverages especially, compared to Cluster 2. In addition, there was a trend toward a greater proportion of household members who were overweight among households in Cluster 3 compared to those in Cluster 2. This finding is consistent with previously reported positive associations between individuals' sugar-sweetened beverage intake and body weight reported in the literature (67).

The results discussed here should be considered in light of the present study's limitations. The sample of participant households in this study was relatively small (n=90 households) and fairly homogenous in terms of racial, educational, and anthropometric composition. Future research should examine patterns of home food availability in a larger, more diverse population in order to generalize findings beyond the current sample. Furthermore, measures of home food availability were limited to targeted categories and did not capture the home food environment in its entirety. Nonetheless, foods in the targeted categories

were measured well in terms of their complete recording at the home visit. Also, restricting measurement of home food availability to targeted categories is advantageous in terms of reducing participant and staff burden related to data collection. Another potential limitation of this study is underreporting of receipt data by households, for example, if a household did not turn in a receipt or annotate a receipt form. Even so, the inclusion of receipt data is useful because it captures the flow of foods into the home and may better represent usual availability of home foods. Overall, the two methods used to measure home food availability provided objective information about actual quantities of food purchased and stored in the home.

The use of latent class cluster analysis in the present study was a novel approach to describing home food availability and its future use in this area of research is warranted. In studies of dietary intake, researchers have sought to describe patterns of food intake and subsequently link such patterns to health indicators, such as body weight, in order to develop informed public health messages related to nutrition (68). Similarly, examining associations between patterns of home food availability and dietary intake and other related food behaviors may be a useful approach to developing nutrition interventions that involve altering the home food environment.

5.5 Tables

Table 5.5a. – Total ounces of foods in targeted categories measured by the home food inventory (HFI) and annotated receipt forms over a 4-week period (n=90 households)

	Mean	SD	Range	r
Fruits				0.40**
HFI	301.7	247.5	0-1327	
Receipts	370.1	255.7	0-1261	
Vegetables				0.31**
HFI	408.4	250.8	54-1282	
Receipts	231.2	208.3	0-1201	
Snacks				0.18*
HFI	164.9	158.4	0-862	
Receipts	109.1	103.3	0-602	
Sweets				0.19*
HFI	328.7	286.1	0-1355	
Receipts	209.9	166.4	0-722	
SSB				-0.06

HFI	239.8	300.9	0-1540	
Receipts	437.1	525.9	0-2206	

SSB: sugar-sweetened beverages; SD: standard deviation

r: Pearson correlation coefficient measuring linear dependence of total ounces of food/beverage measured by HFI versus total ounces of food/beverage measured by annotated receipt forms; *p<0.10, **p<0.05

Table 5.5b. – Total ounces of foods in targeted categories, by cluster, as measured by the home food inventory (HFI) (n=90 households)

	Cluster 1 (n=62)	**Cluster 2** (n=9)	**Cluster 3** (n=10)	**Cluster 4** (n=9)	**p**
Cluster name	"Overall moderate availability"	"Greatest availability of snacks, sweets, and SSB"	"Relatively high fruit and vegetable availability"	"Overall low availability"	
Fruits (SE)	236.3 (20.6) [a]	603.4 (54.0) [b]	678.9 (51.2) [b]	25.0 (54.0) [c]	<0.001
Vegetables (SE)	395.3 (28.0) [a]	702.9 (73.5) [b]	433.7 (69.7) [a]	158.2 (73.5) [c]	<0.001
Snacks (SE)	135.3 (13.1) [a]	521.2 (34.4) [b]	122.8 (32.6) [ac]	58.6 (34.4) [c]	<0.001
Sweets (SE)	309.5 (30.7) [a]	745.8 (80.7) [b]	315.6 (76.6) [a]	58.7 (80.7) [c]	<0.001
SSB (SE)	265.3 (37.7)	337.6 (98.8)	134.7 (93.8)	78.2 (98.8)	0.16

SSB: sugar-sweetened beverages; SE: standard error

p-values correspond to F-test statistics (DF=3)

Lettered superscripts denote significant between-class differences, p<0.05

Table 5.5c. – Household characteristic means and frequencies by cluster patterns of home food availability as measured by the home food inventory (HFI) (n=90 households)

	Cluster 1 69% (n=62)	**Cluster 2** 10% (n=9)	**Cluster 3** 11% (n=10)	**Cluster 4** 10% (n=9)	**P**
Cluster name	"Overall moderate availability"	"Greatest availability of snacks, sweets, and SSB"	"Relatively high fruit and vegetable availability"	"Overall low availability"	
Total members (SE)	3.9 (0.1) [a]	3.4 (0.3) [ab]	3.0 (0.3) [b]	4.3 (0.3) [a]	0.02
Annual income (SE)	$83,225 (6,137) [a]	$107,777 (12,107) [a]	$65,000 (15,280) [ab]	$43,888 (16,107) [b]	0.03
% with ≥1 member having college deg.	66% (n=41)	89% (n=8)	90% (n=9)	22% (n=2)	<0.01
% led by single parent	23% (n=14)	33% (n=3)	50% (n=5)	67% (n=6)	0.15
% with ≥3 children	24% (n=15)	0% (n=0)	10% (n=1)	67% (n=6)	<0.01
% residing in house	77% (n=48)	78% (n=7)	70% (n=7)	67% (n=6)	0.87
Proportion of HH members overweight (SE)	0.54 (0.04)	0.49 (0.10)	0.54 (0.10)	0.47 (0.10)	0.91

Proportion of HH members obese (SE)	0.25 (0.04)	0.26 (0.09)	0.28 (0.09)	0.23 (0.09)	0.98
Family meals per week (SE)	6.0 (0.5) [a]	9.7 (1.4) [b]	7.1 (1.3) [ab]	4.3 (1.4) [a]	0.04
Days since last grocery trip (SE)	4.7 (0.8) [a]	3.1 (2.1) [a]	4.4 (2.0) [a]	11.4 (2.3) [b]	0.04
Grocery trips during 4-week period (SE)	8.2 (0.6) [a]	9.4 (1.5) [a]	6.1 (1.5) [ab]	5.0 (1.6) [b]	0.11
% completed HFI during summer months	56% (n=35)	67% (n=6)	60% (n=6)	22% (n=2)	0.21

SSB: sugar-sweetened beverages; HH: household; SE: standard error

p-values correspond to Chi-square and F-test statistics (DF=3)

Lettered superscripts denote significant between-class differences, $p<0.05$

Table 5.5d. – Total ounces of foods in targeted categories, by cluster, as measured by annotated receipt forms over a 4-week period (n=90 households)

	Cluster 1	Cluster 2	Cluster 3	p
Cluster name	"Overall low availability"	"Relatively low availability of sweets and SSB"	"Relatively high availability of sweets and SSB"	
Fruits (SE)	115.8 (59.7) [a]	429.9 (35.3) [b]	409.0 (40.9) [b]	<0.001
Vegetables (SE)	61.9 (51.0) [a]	277.3 (30.1) [b]	258.1 (34.9) [b]	<0.01
Snacks (SE)	22.8 (24.7) [a]	113.6 (14.6) [b]	143.6 (16.9) [b]	<0.001
Sweets (SE)	99.5 (38.7) [a]	177.6 (22.8) [a]	303.5 (26.5) [b]	<0.001
Sugar-sweetened beverages (SE)	241.7 (84.8) [a]	96.6 (50.1) [a]	985.8 (58.1) [b]	<0.001

SE: standard error

p-values correspond to F-test statistics (DF=3)

Lettered superscripts denote significant between-class differences, p<0.05

Table 5.5e. – Household characteristic means and frequencies by cluster patterns of home food availability as measured by annotated receipt forms over a 4-week period (n=90 households)

	Cluster 1 16% (n=15)	**Cluster 2** 48% (n=43)	**Cluster 3** 36% (n=32)	**p**
Cluster name	"Overall low availability"	"Relatively low availability of sweets and SSB"	"Relatively high availability of sweets and SSB"	
Total members (SE)	3.8 (0.3)	3.7 (0.2)	3.8 (0.2)	0.96
Annual income (SE)	$50,667 (12,561) [a]	$89,070 (7,419) [b]	$80,782 (8,600) [b]	0.04
% with ≥1 member having college deg.	33% (n=5)	81% (n=35)	63% (n=20)	<0.01
% led by single parent	47% (n=7)	26% (n=11)	31% (n=10)	0.51
% with ≥3 children	33% (n=5)	21% (n=9)	25% (n=8)	0.85
% residing in house	53% (n=8)	84% (n=36)	75% (n=24)	0.06
Proportion of HH members overweight (SE)	0.59 (0.08)	0.46 (0.05)	0.59 (0.05)	0.15

Proportion of HH members obese (SE)	0.38 (0.07) [a]	0.20 (0.04) [b]	0.25 (0.05) [ab]	0.10
Family meals per week (SE)	3.9 (1.0) [a]	7.6 (0.6) [b]	5.8 (0.7) [ab]	<0.01
Grocery trips during 4-week period (SE)	4.6 (1.2) [a]	7.7 (0.7) [b]	9.3 (0.8) [b]	<0.01
% completed receipt collection during summer months	33% (n=5)	60% (n=26)	56% (n=18)	0.19

SSB: sugar-sweetened beverages; SE: standard error

p-values correspond to Chi-square and F-test statistics (DF=2)

Lettered superscripts denote significant between-group differences, p<0.05

5.6 Figures

Figure 5.6a. – Standardized means for total ounces/person of foods in targeted categories as measured by the home food inventory (HFI), by cluster (n=90 households)

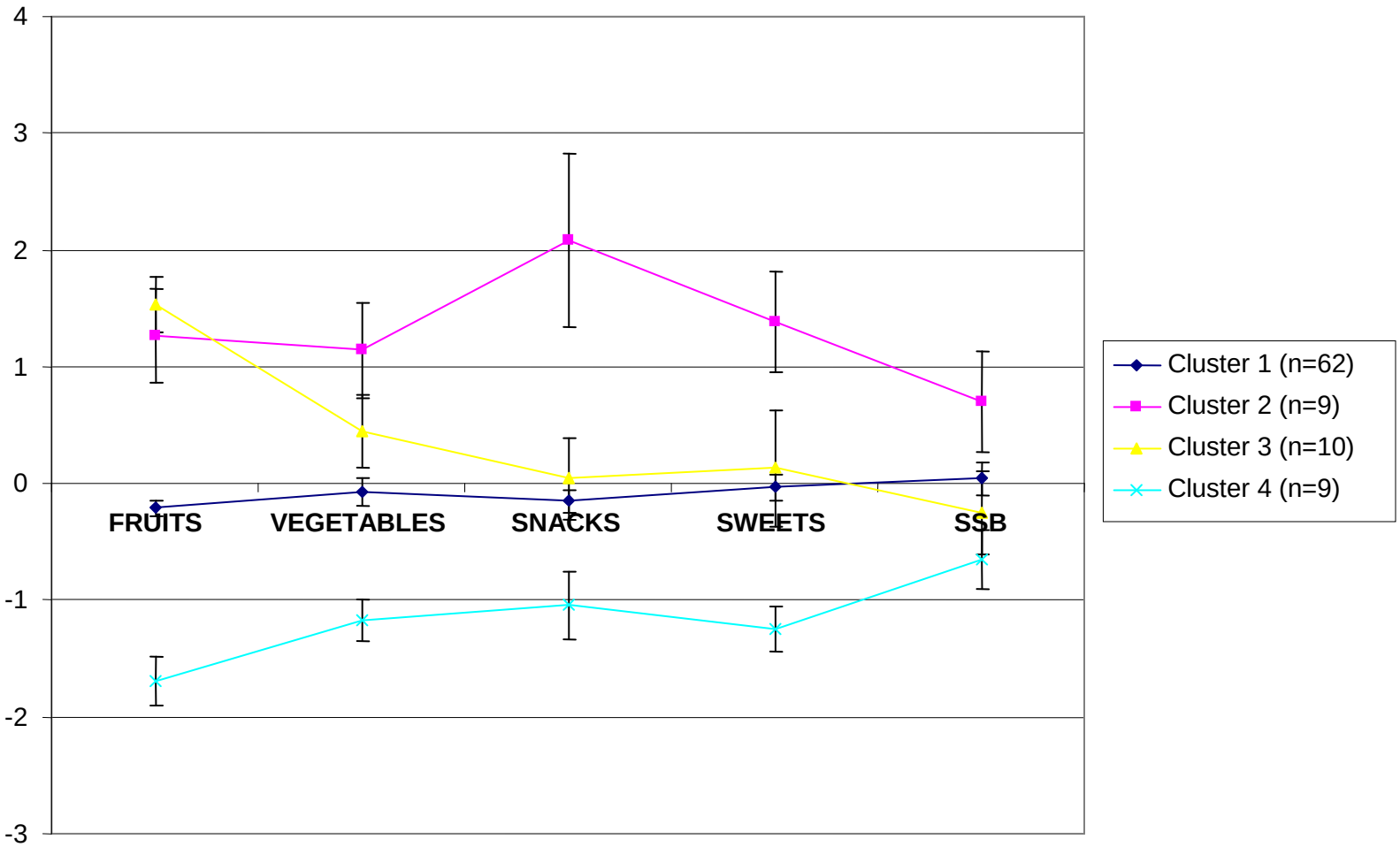
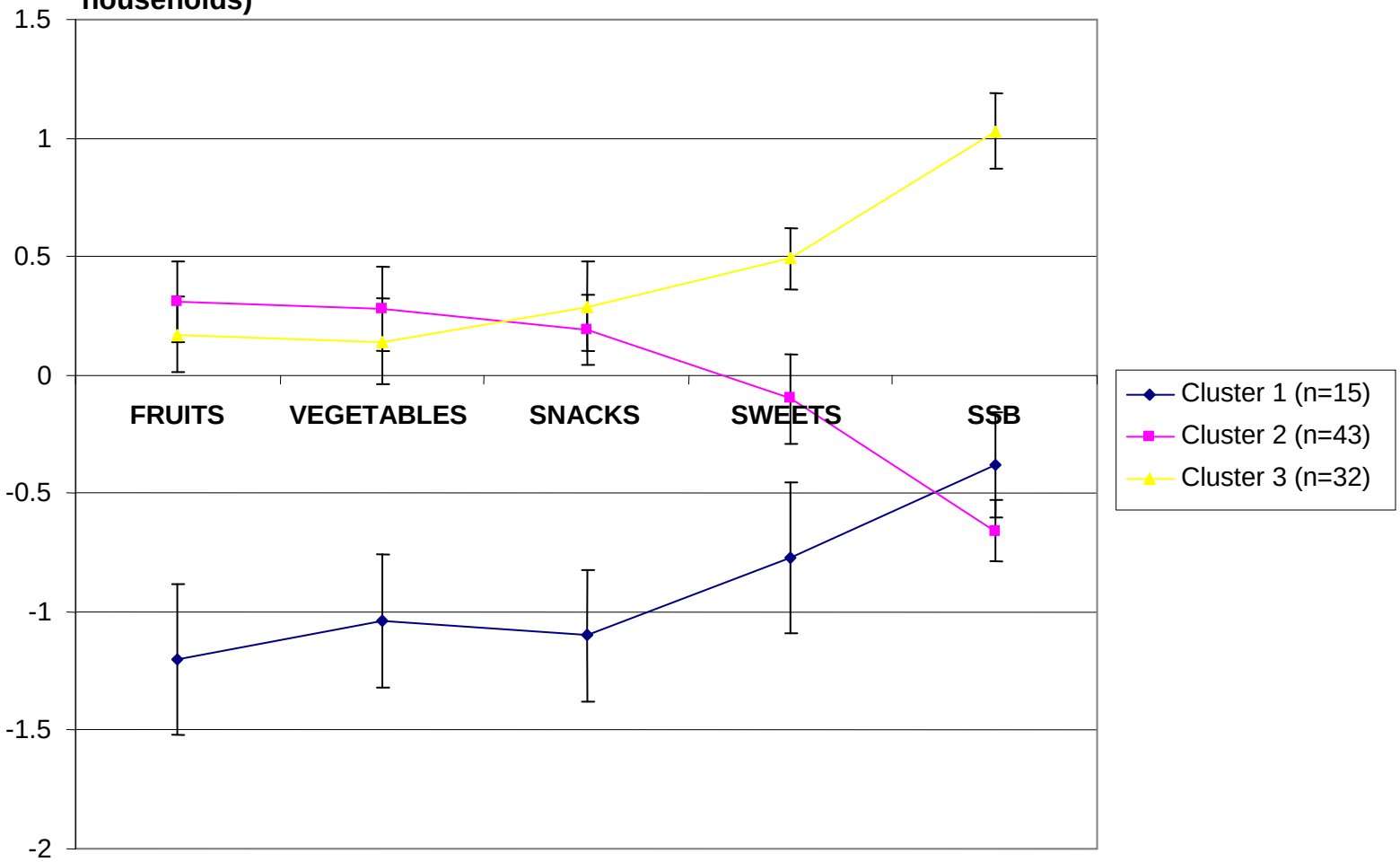


Figure 5.6b. – Standardized means for total ounces/person of foods in targeted categories as measured by annotated receipt forms over a 4-week period, by cluster (n=90 households)



Chapter 6 – Summary and Suggestions for Future Research

The present collection of research builds on existing literature examining the home food environment, including its association with food choice among adults and adolescents. In manuscript one, the observed associations between home food availability and dietary intake differed depending on the measure of home food availability used. This may be due to the fact that the HFI measures a snapshot of foods and beverages present in the home while annotated receipt forms measure the flow of foods and beverages into the home. There were also differences in the strengths of the observed associations when comparing adults to adolescents. Differences between associations for adults and adolescents might be due to the limitations of small sample size or measurement error associated with dietary assessment, or may reflect true differences about how the home food environment impacts adult versus adolescent food choice. Suggestions for future research in this particular area include collecting data from a larger sample, using more precise measures of dietary intake that have been validated in both adults and adolescents, and using a prospective study design.

Manuscript two examined one potential mechanism of the association between family meal frequency and dietary intake: family cohesion. It was hypothesized that frequency of family meals was positively associated with perceived family cohesion, which in turn would be related to healthier dietary

intake. Individuals who report greater closeness to their families may be more apt to mirror modeling of healthful diets, be more likely to accept household food rules, or engage in healthier behaviors in general due to improved psychological well-being. Unfortunately, the results were unable to establish family cohesion as a consistent mediator of the relationship between family meal frequency and dietary intake in adults or adolescents. Research in this area would improve from a clearer understanding of why family meals are beneficial. Future observational studies should include measures to assess potential mediators in addition to family cohesion, such as role modeling of dietary behavior, household food rules during and outside of mealtimes, and the types and quantities of food offered during meals. In addition, longitudinal analyses would shed light on temporal effects related to family meals, potential mediators, and individual dietary intake.

Finally, in manuscript three, latent class analysis was used to describe patterns of home food availability as measured by the home food inventory and annotated receipt forms over a 4-week period. Unique patterns of home food availability emerged from the data, and particular patterns demonstrated associations with household characteristics including household income, education level, and overweight status. The use of latent class cluster analysis was a novel approach to describing home food availability and its future application in a larger, more diverse sample of households is warranted. In addition, examining associations between patterns of home food availability and dietary intake and other related food behaviors may be a useful approach to

developing nutrition interventions that involve altering the home food environment.

References

1. Munoz KA, Krebs-Smith SM, Ballard-Barbash R, Cleveland LE. Food intakes of US children and adolescents compared with recommendations. *Pediatrics* 1997; **100**:323-9.
2. Brady LM, Lindquist CH, Herd SL, Goran MI. Comparison of children's dietary intake patterns with US dietary guidelines. *Br J Nutr* 2000; **84**:361-7.
3. Cavadini C, Siega-Riz AM, Popkin BM. US adolescent food intake trends from 1965 to 1996. *West J Med* 2000; **173**:378-83.
4. Van Duyn MA, Pivonka E. Overview of the health benefits of fruit and vegetable consumption for the dietetics professional: selected literature. *J Am Diet Assoc* 2000; **100**:1511-21.
5. U.S. Department of Health and Human Services and U.S. Department of Agriculture. Dietary guidelines for Americans, 6th edition. Washington DC: U.S. Government Printing Office, 2005.
6. Byrd-Bredbenner C, Abbot JM, Cussler E. Nutrient profile of household food supplies of families with young children. *J Am Diet Assoc* 2009; **109**:2057-62.
7. Rosenkranz RR, Dzewaltowski DA. Model of the home food environment pertaining to childhood obesity. *Nutr Rev* 2008; **66**:123-40.
8. Patrick H, Nicklas TA. A review of family and social determinants of children's eating patterns and diet quality. *J Am Coll Nutr* 2005; **24**:83-92.
9. Birch LL, Davison KK. Family environmental factors influencing the developing behavioral controls of food intake and childhood overweight. *Pediatr Clin North Am* 2001; **48**:893-907.
10. Bryant M, Stevens J. Measurement of food availability in the home. *Nutr Rev* 2006; **64**:67-76.
11. French SA, Shimotsu ST, Wall M, Gerlach AF. Capturing the spectrum of household food and beverage purchasing behavior: a review. *JADA* 2008; **108**:2051-2058.
12. Adair LS, Popkin BM. Are child eating patterns being transformed globally? *Obes Res* 2005; **13**:1281-99.
13. Hanson NI, Neumark-Sztainer D, Eisenberg ME, Story M, Wall M. Associations between parental report of the home food environment and adolescent intakes of fruits, vegetables and dairy foods. *Public Health Nutr* 2005; **8**:77-85.
14. Rockett HR, Wolf AM, Colditz GA. Development and reproducibility of a food frequency questionnaire to assess diets of older children and adolescents. *J Am Diet Assoc* 1995; **95**:336-40.
15. Arcan C, Neumark-Sztainer D, Hannan P, van den Berg P, Story M, Larson N. Parental eating behaviours, home food environment and adolescent intakes of fruits, vegetables and dairy foods: longitudinal findings from Project EAT. *Public Health Nutr* 2007; **10**:1257-65.
16. Befort C, Kaur H, Nollen N, Sullivan DK, Nazir N, Choi WS, Hornberger L, Ahluwalia JS. Fruit, vegetable, and fat intake among non-Hispanic black and non-Hispanic white adolescents: associations with home availability and food consumption settings. *J Am Diet Assoc* 2006; **106**:367-73.

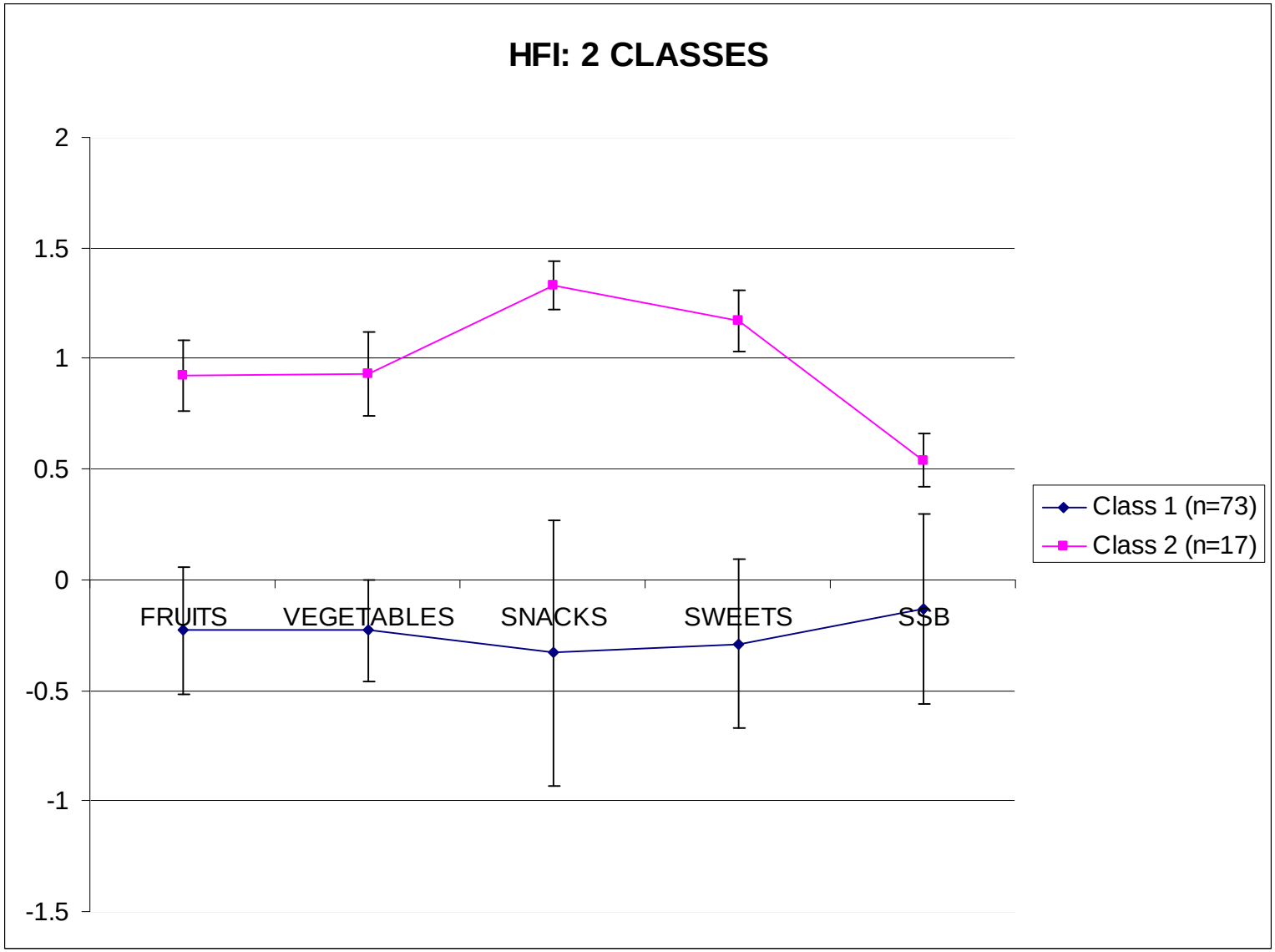
17. Thompson FE, Midthune D, Subar AF, Kahle LL, Schatzkin A, Kipnis V. Performance of a short tool to assess dietary intakes of fruits and vegetables, percentage energy from fat and fibre. *Public Health Nutr* 2004; **7**:1097-105.
18. Thompson FE, Kipnis V, Subar AF, Schatzkin A, Potischman L, Kahle L, McNutt S. Performance of a short instrument to estimate the usual dietary intake of percent calories from fat. *Eur J Clin Nutr* 1998; **52**:S63.
19. Haerens L, Craeynest M, Deforche B, Maes L, Cardon G, De Bourdeaudhuij I. The contribution of psychosocial and home environmental factors in explaining eating behaviours in adolescents. *Eur J Clin Nutr* 2008; **62**:51-9.
20. Campbell KJ, Crawford DA, Salmon J, Carver A, Garnett SP, Baur LA. Associations between the home food environment and obesity-promoting eating behaviors in adolescence. *Obesity (Silver Spring)* 2007; **15**:719-30.
21. Sekula W, Nelson M, Figurska K, Oltarzewski M, Weisell R, Szponar L. Comparison between household budget survey and 24-hour recall data in a nationally representative sample of Polish households. *Public Health Nutr* 2005; **8**:430-9.
22. Ransley JK, Donnelly JK, Khara TN, Botham H, Arnot H, Greenwood DC, Cade JE. The use of supermarket till receipts to determine the fat and energy intake in a UK population. *Public Health Nutr* 2001; **4**:1279-86.
23. Videon TM, Manning CK. Influences on adolescent eating patterns: the importance of family meals. *J Adolesc Health* 2003; **32**:365-73.
24. Neumark-Sztainer D, Hannan PJ, Story M, Croll J, Perry C. Family meal patterns: associations with sociodemographic characteristics and improved dietary intake among adolescents. *J Am Diet Assoc* 2003; **103**:317-22.
25. Utter J, Scragg R, Schaaf D, Ni Mhurchu C. Relationships between frequency of family meals, BMI and nutritional aspects of the home food environment among New Zealand adolescents. *Int J Behav Nutr Phys Act* 2008; **5**:50.
26. Woodruff SJ, Hanning RM. A review of family meal influence on adolescents' dietary intake. *Can J Diet Pract Res* 2008; **69**:14-22.
27. Boutelle KN, Birnbaum AS, Lytle LA, Murray DM, Story M. Associations between perceived family meal environment and parent intake of fruit, vegetables, and fat. *J Nutr Educ Behav* 2003; **35**:24-9.
28. Block G, Gillespie C, Rosenbaum EH, Jenson C. A rapid food screener to assess fat and fruit and vegetable intake. *Am J Prev Med* 2000; **18**:284-8.
29. Olson DH, Sprenkle DH, Russell CS. Circumplex Model of Marital and Family Systems: I. Cohesion and Adaptability Dimensions, Family Types, and Clinical Applications. *Family Process* 1979; **18**:3-28.
30. Olson DH. Circumplex Model of Marital and Family Sytems. *Journal of Family Therapy* 2000; **22**:144-167.
31. Olson DH. Circumplex Model VII: validation studies and FACES III. *Fam Process* 1986; **25**:337-51.
32. Franko DL, Thompson D, Bauserman R, Affenito SG, Striegel-Moore RH. What's love got to do with it? Family cohesion and healthy eating behaviors in adolescent girls. *Int J Eat Disord* 2008; **41**:360-7.
33. Franko DL, Thompson D, Affenito SG, Barton BA, Striegel-Moore RH. What mediates the relationship between family meals and adolescent health issues. *Health Psychol* 2008; **27**:S109-17.

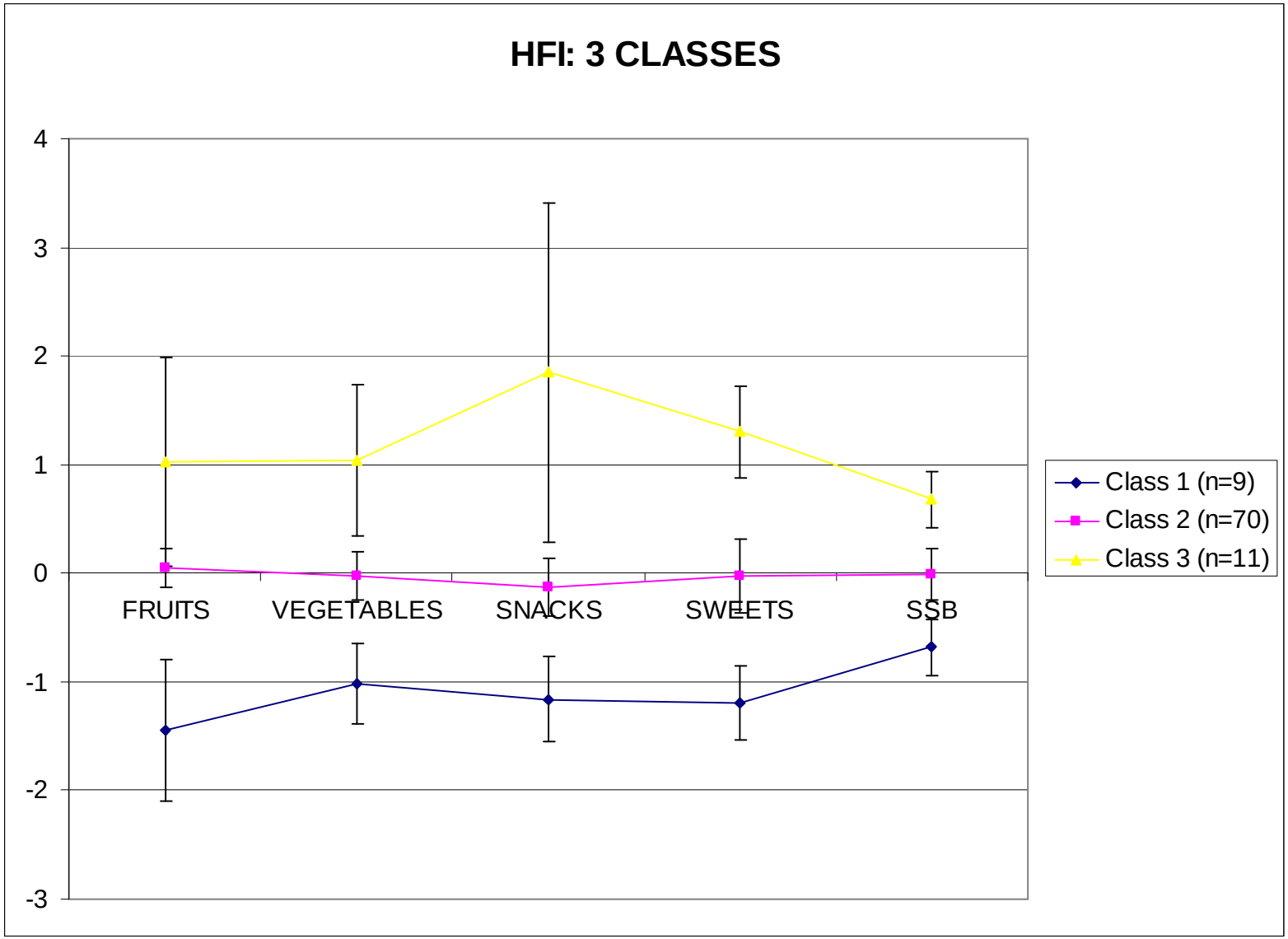
34. Sallis JF, Owen N. Ecological Models of Health Behavior. In: Glanz K, Rimer BK, Lewis FM, eds. Health Behavior and Health Education. San Francisco: Jossey-Bass, 2002:462-484.
35. Diet History Questionnaire, Version 1.0: National Institutes of Health, Applied Research Program, National Cancer Institute., 2007.
36. Serdula MK, Gillespie C, Kettel-Khan L, Farris R, Seymour J, Denny C. Trends in fruit and vegetable consumption among adults in the United States: behavioral risk factor surveillance system, 1994-2000. *Am J Public Health* 2004; **94**:1014-8.
37. Bleich SN, Wang YC, Wang Y, Gortmaker SL. Increasing consumption of sugar-sweetened beverages among US adults: 1988-1994 to 1999-2004. *Am J Clin Nutr* 2009; **89**:372-81.
38. Kant AK. Consumption of energy-dense, nutrient-poor foods by adult Americans: nutritional and health implications. The third National Health and Nutrition Examination Survey, 1988-1994. *Am J Clin Nutr* 2000; **72**:929-36.
39. Raynor HA, Polley BA, Wing RR, Jeffery RW. Is dietary fat intake related to liking or household availability of high- and low-fat foods? *Obes Res* 2004; **12**:816-23.
40. Fulkerson JA, Nelson MC, Lytle L, Moe S, Heitzler C, Pasch KE. The validation of a home food inventory. *Int J Behav Nutr Phys Act* 2008; **5**:55.
41. Kuczmarski RJ, Ogden CL, Guo SS, al e. 2000 CDC growth charts for the United States: Methods and development. *Vital Health Stat* 2002; **11**.
42. French SA, Wall M, Mitchell NR, Shimotsu ST, Welsh E. Annotated receipts capture household food purchases from a broad range of sources. *Int J Behav Nutr Phys Act* 2009; **6**:37.
43. Thompson FE, Subar AF, Brown CC, Smith AF, Sharbaugh CO, Jobe JB, Mittl B, Gibson JT, Ziegler RG. Cognitive research enhances accuracy of food frequency questionnaire reports: results of an experimental validation study. *J Am Diet Assoc* 2002; **102**:212-25.
44. Subar AF, Thompson FE, Kipnis V, Midthune D, Hurwitz P, McNutt S, McIntosh A, Rosenfeld S. Comparative validation of the Block, Willett, and National Cancer Institute Food Frequency Questionnaires: The Eating at America's Table Study. *Am J Epidemiol* 2001; **154**:1089-99.
45. Raudenbush SW, Bryk AS. Hierarchical Linear Models: Applications and Data Analysis Methods. Second ed. Thousand Oaks: Sage Publications, 2001.
46. Burgess-Champoux TL, Larson N, Neumark-Sztainer D, Hannan PJ, Story M. Are family meal patterns associated with overall diet quality during the transition from early to middle adolescence? *J Nutr Educ Behav* 2009; **41**:79-86.
47. Larson NI, Neumark-Sztainer D, Hannan PJ, Story M. Family meals during adolescence are associated with higher diet quality and healthful meal patterns during young adulthood. *J Am Diet Assoc* 2007; **107**:1502-10.
48. Baron RM, Kenny DA. The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *J Pers Soc Psychol* 1986; **51**:1173-82.
49. Sobel ME. Asymptotic confidence intervals for indirect effects in structural equation models. *Sociol Methodol* 1982; **13**:290-312.
50. Preacher KJ, Leonardelli GJ. An interactive calculation tool for mediation tests, 2003.
51. Thompson FE, Subar AF. Dietary Assessment Methodology. In: Coulston A, Boushey C, eds. Nutrition in the Prevention and Treatment of Disease. Second ed. Burlington, MA: Academic Press, 2008.

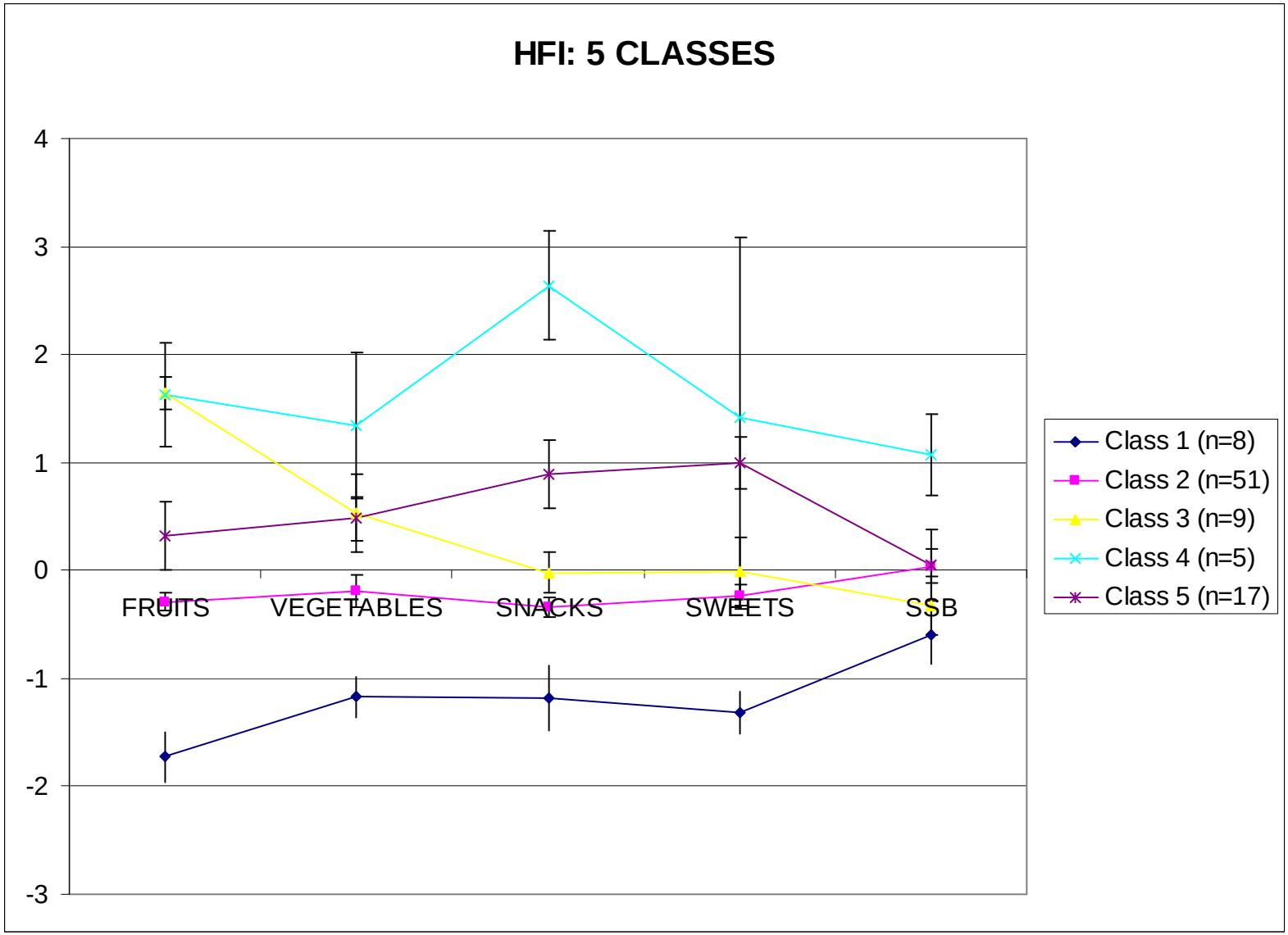
52. Neumark-Sztainer D, Eisenberg ME, Fulkerson JA, Story M, Larson NI. Family meals and disordered eating in adolescents: longitudinal findings from project EAT. *Arch Pediatr Adolesc Med* 2008; **162**:17-22.
53. Eisenberg ME, Neumark-Sztainer D, Fulkerson JA, Story M. Family meals and substance use: is there a long-term protective association? *J Adolesc Health* 2008; **43**:151-6.
54. Sen B. The relationship between frequency of family dinner and adolescent problem behaviors after adjusting for other family characteristics. *J Adolesc* 2009.
55. Carlson A, Kinsey J, Nadav C. Who eats what, when and from where? Department of Applied Economics, The Retail Food Industry Center. St. Paul, MN: University of Minnesota, 1998.
56. Vermunt JK, Magidson J. Latent class cluster analysis. In: Hagenaars J.A., A.L. M, eds. Applied Latent Class Analysis. Cambridge, UK: Cambridge University Press, 2002.
57. Nelson MC, Gordon-Larsen P, Adair LS, Popkin BM. Adolescent physical activity and sedentary behavior: patterning and long-term maintenance. *Am J Prev Med* 2005; **28**:259-66.
58. Boone-Heinonen J, Gordon-Larsen P, Adair LS. Obesogenic clusters: multidimensional adolescent obesity-related behaviors in the U.S. *Ann Behav Med* 2008; **36**:217-30.
59. Newby PK, Tucker KL. Empirically derived eating patterns using factor or cluster analysis: a review. *Nutr Rev* 2004; **62**:177-203.
60. Cullen K, Baranowski T, Watson K, Nicklas T, Fisher J, O'Donnell S, Baranowski J, Islam N, Missaghian M. Food category purchases vary by household education and race/ethnicity: results from grocery receipts. *J Am Diet Assoc* 2007; **107**:1747-52.
61. Blisard N, Stewart H, Jolliffe D. Low-income households' expenditures on fruits and vegetables: Economic Research Service/USDA, 833, 2004.
62. Turrell G, Hewitt B, Patterson C, Oldenburg B, Gould T. Socioeconomic differences in food purchasing behaviour and suggested implications for diet-related health promotion. *J Hum Nutr Diet* 2002; **15**:355-64.
63. Rankin JW, Winett RA, Anderson ES, Bickley PG, Moore JF, Leahy M, Harris CE, Gerkin RE. Food purchase patterns at the supermarket and their relationship to family characteristics. *J Nutr Educ* 1998; **30**:81-88.
64. Ransley JK, Donnelly JK, Botham H, Khara TN, Greenwood DC, Cade JE. Use of supermarket receipts to estimate energy and fat content of food purchased by lean and overweight families. *Appetite* 2003; **41**:141-8.
65. Byrd-Bredbenner C, Abbot JM. Differences in food supplies of U.S. households with and without overweight individuals. *Appetite* 2009; **52**:479-84.
66. Coates TJ, Jeffrey RW, Wing RR. The relationship between persons' relative body weights and the quality and quantity of food stored in their homes. *Addict Behav* 1978; **3**:179-84.
67. Malik VS, Schulze MB, Hu FB. Intake of sugar-sweetened beverages and weight gain: a systematic review. *Am J Clin Nutr* 2006; **84**:274-88.
68. Togo P, Osler M, Sorensen TI, Heitmann BL. Food intake patterns and body mass index in observational studies. *Int J Obes Relat Metab Disord* 2001; **25**:1741-51.

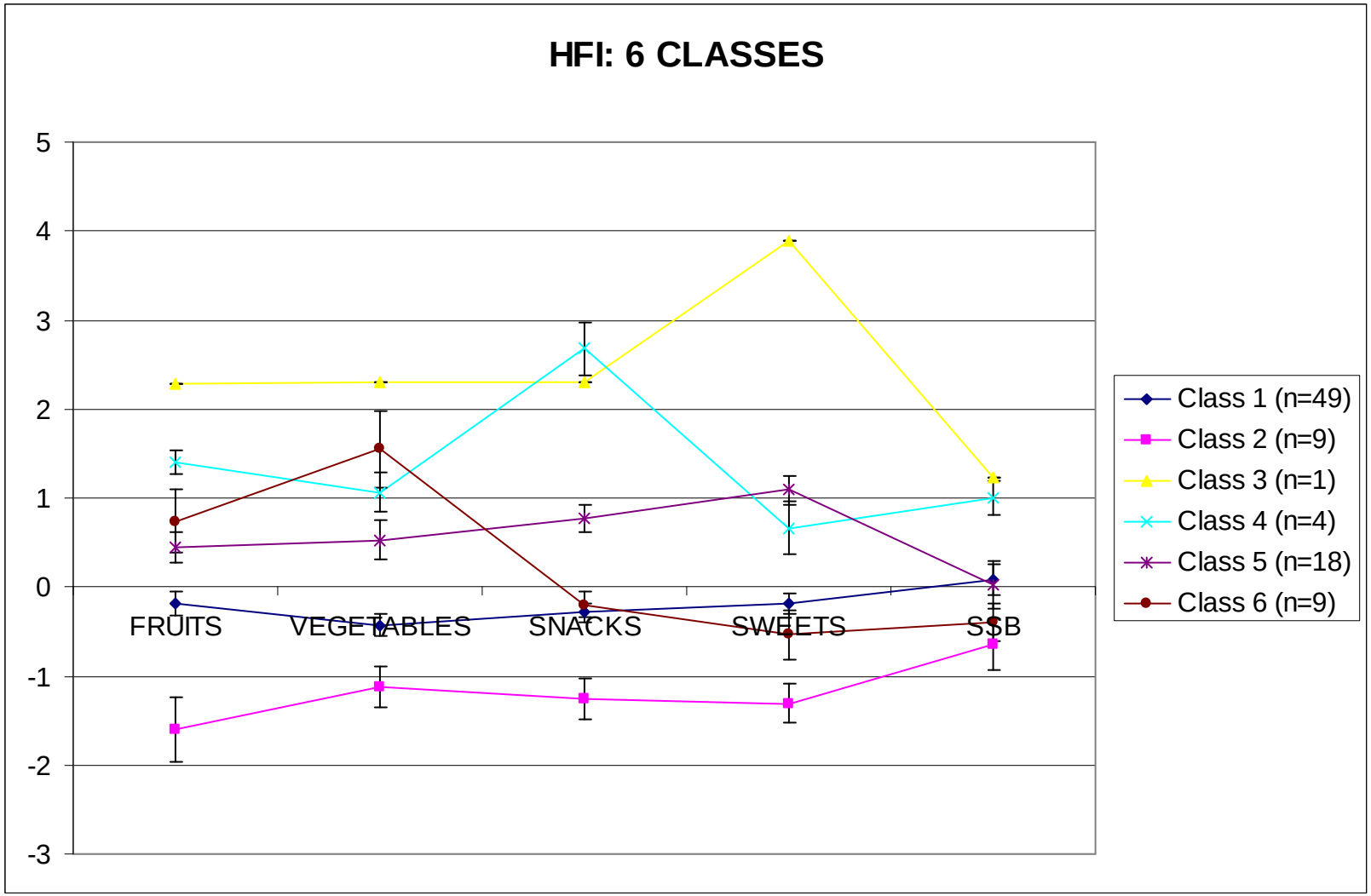
Appendices

<u>Appendix A:</u> Figures of standardized means for total ounces/person of foods in targeted categories as measured by the home food inventory (HFI) for 2-, 3-, 5-, and 6-class patterns

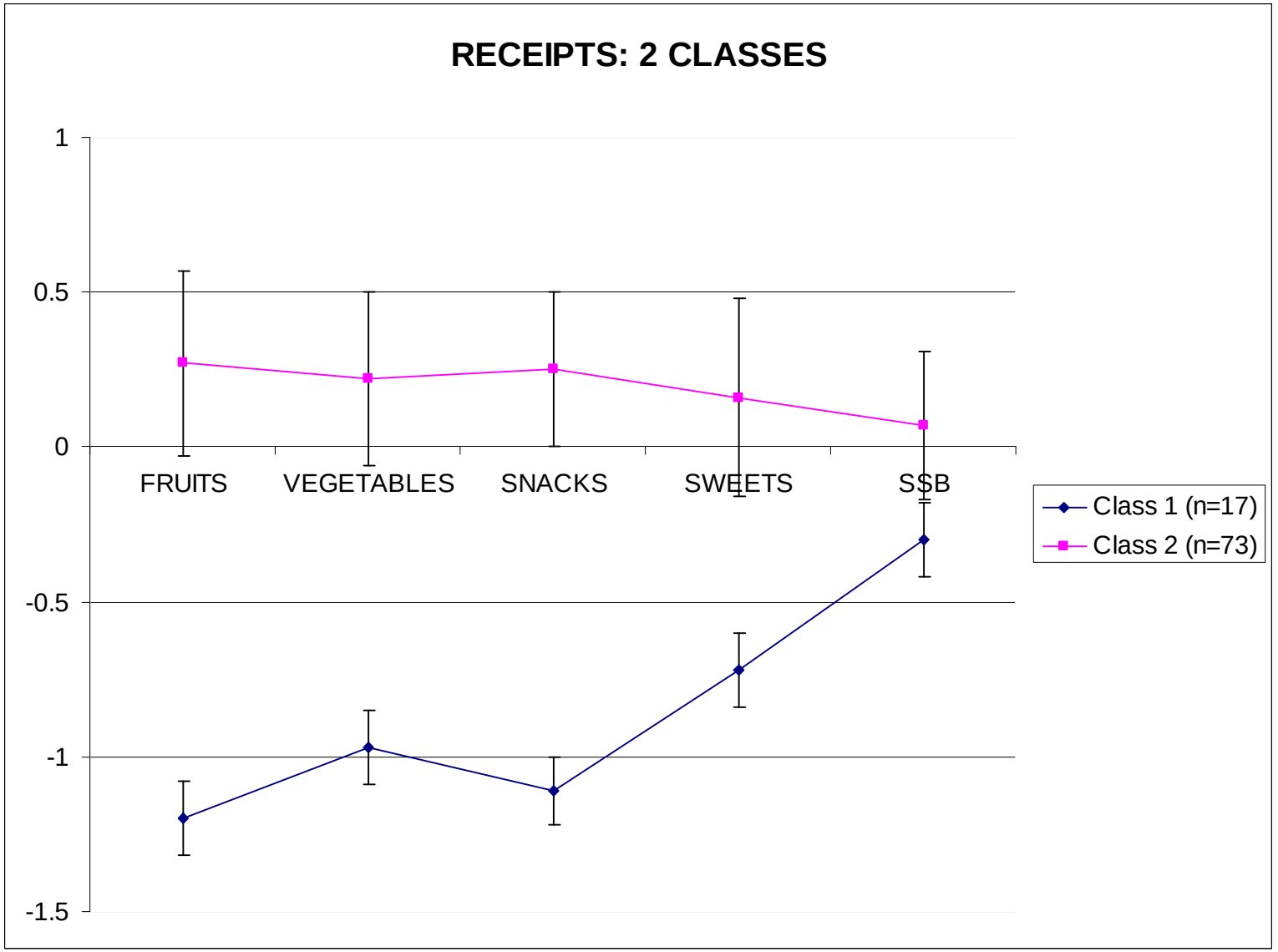

HFI: 2 CLASSES
2
1.5
1
0.5
0
-0.5
-1
-1.5
FRUITS
VEGETABLES
SNACKS
SWEETS
SSB
Class 1 (n=73)
Class 2 (n=17)

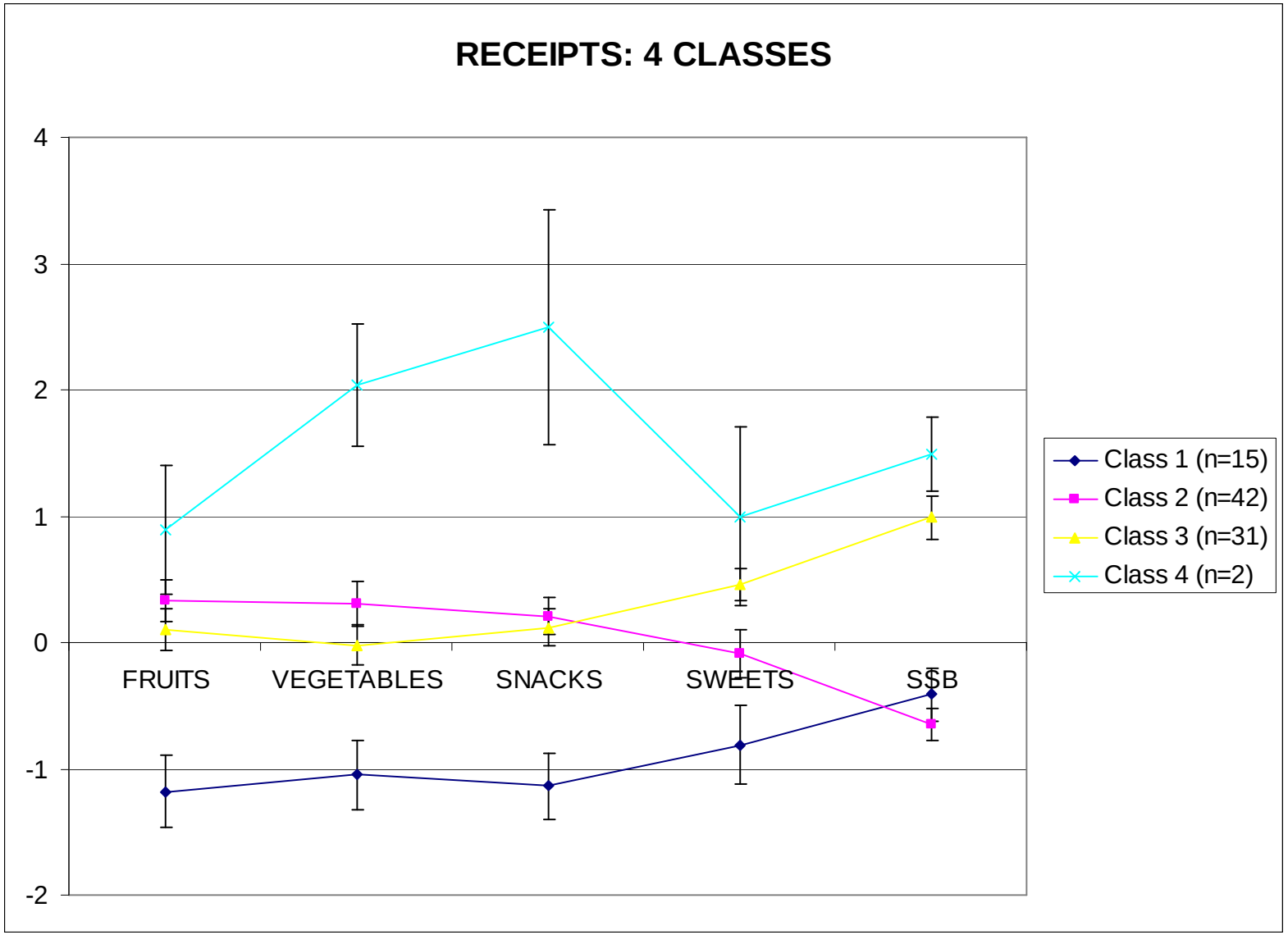

HFI: 3 CLASSES
4
3
2
1
0
-1
-2
-3
FRUITS
VEGETABLES
SNACKS
SWEETS
SSB
Class 1 (n=9)
Class 2 (n=70)
Class 3 (n=11)

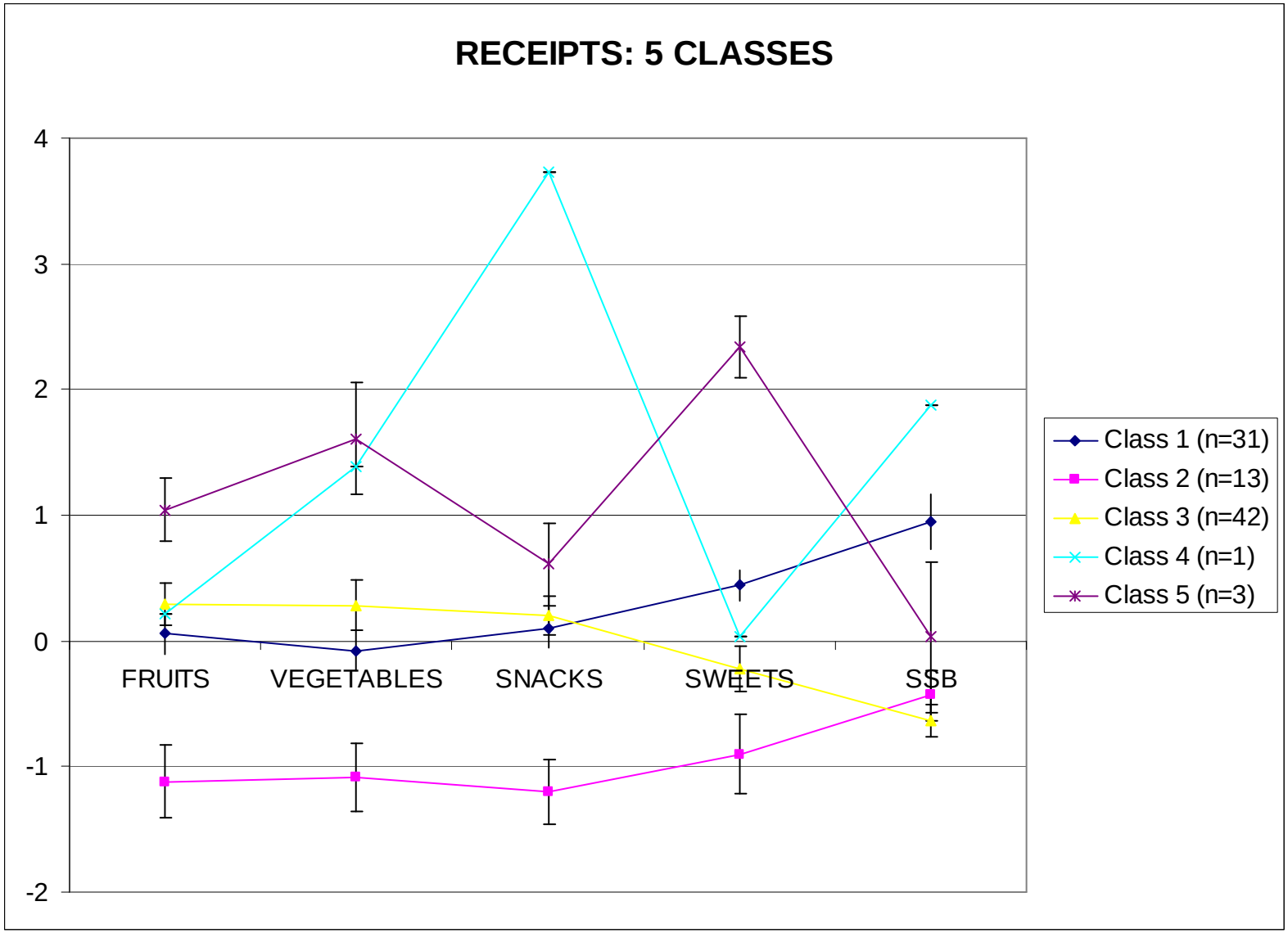

HFI: 5 CLASSES
4
3
2
1
0
-1
-2
-3
FRUITS
VEGETABLES
SNACKS
SWEETS
SSB
Class 1 (n=8)
Class 2 (n=51)
Class 3 (n=9)
Class 4 (n=5)
Class 5 (n=17)

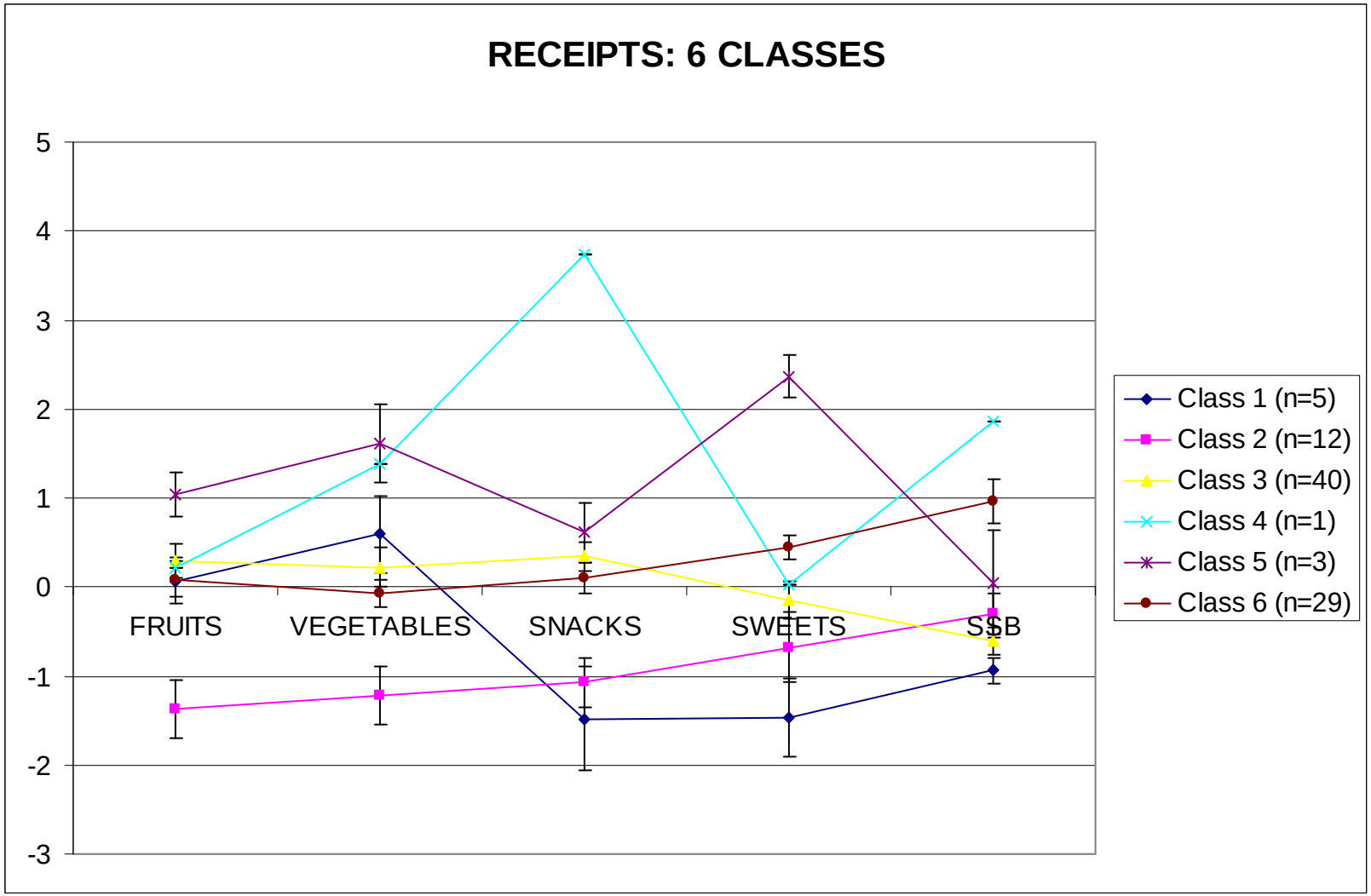

HFI: 6 CLASSES
5
4
3
2
1
0
-1
-2
-3
FRUITS
VEGETABLES
SNACKS
SWEETS
SSB
Class 1 (n=49)
Class 2 (n=9)
Class 3 (n=1)
Class 4 (n=4)
Class 5 (n=18)
Class 6 (n=9)

Appendix B: Figures of standardized means for total ounces/person of foods in targeted categories as measured by annotated receipt forms over a 4-week period for 2-, 4-, 5-, and 6-class patterns


RECEIPTS: 2 CLASSES
1
0.5
0
-0.5
-1
-1.5
FRUITS
VEGETABLES
SNACKS
SWEETS
SSB
Class 1 (n=17)
Class 2 (n=73)


RECEIPTS: 4 CLASSES
4
3
2
1
0
-1
-2
FRUITS
VEGETABLES
SNACKS
SWEETS
SSB
Class 1 (n=15)
Class 2 (n=42)
Class 3 (n=31)
Class 4 (n=2)


RECEIPTS: 5 CLASSES
4
3
2
1
0
-1
-2
FRUITS
VEGETABLES
SNACKS
SWEETS
SSB
Class 1 (n=31)
Class 2 (n=13)
Class 3 (n=42)
Class 4 (n=1)
Class 5 (n=3)


RECEIPTS: 6 CLASSES
5
4
3
2
1
0
-1
-2
-3
FRUITS
VEGETABLES
SNACKS
SWEETS
SSB
Class 1 (n=5)
Class 2 (n=12)
Class 3 (n=40)
Class 4 (n=1)
Class 5 (n=3)
Class 6 (n=29)