

**INTERMEDIATE EFFECTS OF A SOCIAL ECOLOGICAL MODELED,
COMMUNITY-BASED INTERVENTION ON THE FOOD SECURITY
AND DIETARY INTAKE OF RURAL, MIDWESTERN, ADULT FOOD
PANTRY CLIENTS**

by

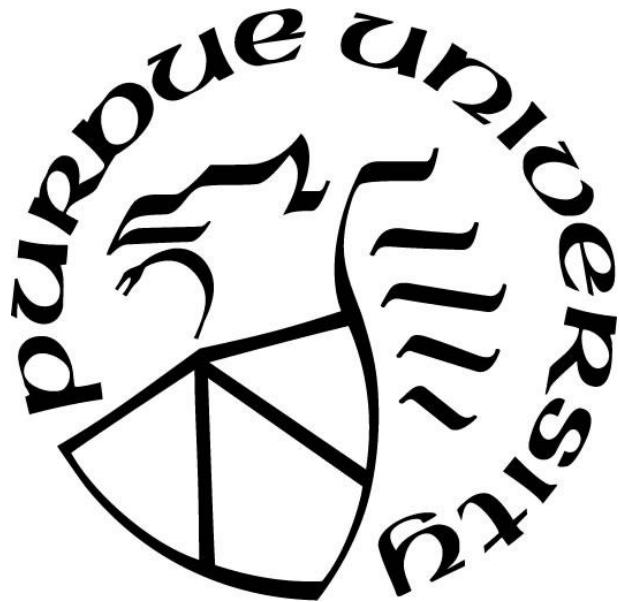
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To my family, born and chosen, for their endless love and support.

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LIST OF ABBREVIATIONS

FS: Food secure

FI: Food insecure

LFS: Low food secure

VLFS: Very low food secure

US HFSSM: US Household Food Security Survey Module

DGA: Dietary Guidelines for Americans

VFF: Voices for Food

SEM: Social Ecological Model

GCC: Guided client choice

FPC: Food Policy Council

USDA: United States Department of Agriculture

NCI: National Cancer Institute

HEI: Healthy Eating Index

EAR: Estimated Average Requirement

AI: Adequate Intake

ASA24: Automated Self-Administered 24-hour Dietary Recall

TEFAP: The Emergency Food Assistance Program

FPED: Food Patterns Equivalents Database

FNDDS: Food and Nutrient Database for Dietary Studies

RD: Registered Dietitian

ABSTRACT

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Title: Intermediate Effects of a Social Ecological Modeled, Community-Based Intervention on the Food Security and Dietary Intake of Rural, Midwestern, Adult Food Pantry Clients

Committee Chair: Heather Eicher-Miller

Food insecurity, or limited access to enough foods for an active, healthy life, characterizes the situation of 65% of US food pantry clients. Food insecurity is associated with poor dietary intake of key food groups and nutrients, diet-related chronic disease, poor physical and mental health, and reduced quality of life. Although food pantry clients are prevalently food insecure, there is a sizeable proportion of food pantry clients who are classified as food secure (FS), or report having adequate access to healthy foods. Previous studies suggest that food secure pantry clients may use pantry resources differently, and have diets that differ in quality and intake, compared to food insecure clients (including low food secure [LFS] and very low food secure [VLFS] clients). The high prevalence of food insecurity among food pantry clients suggests that food pantries may be an important venue to reach food insecure individuals and intervene to improve dietary outcomes. Since dietary intake and use of food pantries may differ by food security status, the efficacy of interventions to improve dietary outcomes in the food pantry setting may also differ by food security status. A social ecological modeled (SEM), community-based intervention in the food pantry setting is promising in sustaining local change efforts and may facilitate long-term implementation of strategies to improve food security and dietary intake among food pantry clients. Therefore, the aims of this dissertation were to 1) characterize differences in dietary intake between FS, LFS and VLFS pantry clients in a cross-sectional analysis; 2) explore associations between the nutritional quality of the food pantry environment (foods stocked and distributed by food pantries) and pantry client diet quality by food security status in a cross-sectional analysis; and 3) evaluate the intermediate effects of a SEM, community-based intervention to improve dietary outcomes among pantry clients with comparison by food security status in a longitudinal analysis.

This dissertation begins with an introductory chapter that will provide an overview of the problem of food insecurity and the venue food pantries represent as a food assistance resource, the evidence base for conducting nutrition interventions in the food pantry setting, the rationale and

design of the Voices for Food (VFF) intervention, and a detailed review of contemporary food security and dietary assessment tools that were utilized in analyses. The first chapter ends with a description of the research aims, hypotheses, and objectives, as well as a guide to the structure of the dissertation. The research studies presented in chapters 2-4 fill a gap in the literature by addressing how food security status may be related to dietary intake, the foods clients consume and are exposed to at food pantries, and the capability for improvements in the nutritional quality of the pantry food environment to influence their dietary patterns.

The second chapter describes a cross-sectional analysis at baseline that compared dietary quality and usual intake of energy, nutrients that are currently under-consumed in the US, and related food groups by FS, LFS, and VLFS status. Adult food pantry clients ($n = 617$) completed a demographic survey, the US Household Food Security Survey Module, and up to three 24-hour dietary recalls (24-HRs) on non-consecutive days including weekdays and weekend days. Healthy Eating Index-2010 (HEI-2010) total and component scores and usual intake using the National Cancer Institute method were estimated using ≥ 3 client 24-HRs. Mixed multiple linear regression models adjusting for confounders determined associations between food security status and both diet quality and usual intake (in separate models). Cross-sectional analyses at baseline determined that FS status was associated with a higher HEI-2010 whole grains score, as well as a higher mean usual intake of whole grains and iron, compared to LFS status. FS status was also associated with higher mean usual intakes of dark green vegetables and total dairy compared to LFS and VLFS status.

The third chapter describes a cross-sectional analysis at baseline that evaluated the relationship between the quality of the mix of foods in stock (pantry inventories) and distributed (client food bags) by food pantries with client diet quality, and investigated how these relationships varied by food security status. Pantry inventories, client food bags, and client diets were scored using the HEI-2010. Multiple linear regression models adjusting for confounders determined associations between HEI-2010 total and component scores for pantry inventories and client food bags (in separate models) and the corresponding scores for client dietary intake. Client food bag HEI-2010 scores were positively associated with client diet scores for the total vegetables, total fruit, total protein foods, and sodium components, while pantry inventory HEI-2010 scores were negatively associated with client diet scores for the total score and for the total fruit and fatty acids

component scores. VLFS clients consumed more whole grains from client food bags compared to FS clients, and consumed more greens and beans compared to LFS clients from pantry inventories.

The fourth chapter describes a longitudinal analysis that evaluated intermediate changes in adult food security and dietary patterns over the first two years (baseline to midpoint) of a social ecological modeled, community-based food pantry intervention– VFF. The VFF intervention (Clinical Trial Registry: NCT0356609) targeted rural, Midwestern, impoverished communities to aid in the implementation of a multi-component toolkit and guide (VFF materials) that contained written instructions on forming food policy councils (FPCs) and converting food pantries from a traditional distribution model to a guided client choice (GCC) distribution model. In each of six Midwestern states, two food pantry communities were identified to receive the intervention and matched to a comparison community. All participating communities (intervention and comparison) received the VFF materials; however, the intervention group only was assigned a community coach, or a field staff modeled after a Cooperative Extension paraprofessional, to support communities in the implementation of the VFF materials. Of the 617 participants recruited at baseline, 590 completed all assessments and 160 completed these assessments again at midpoint. Mixed multiple linear regression models adjusting for confounders determined changes in adult food security, dietary quality, and usual intake from baseline to midpoint by treatment group, and whether changes in diet differed by food security status. Adult food security score improved in the intervention group, while diet quality scores improved in the comparison group, from baseline to midpoint. When comparing the change in dietary outcomes over time between the intervention and comparison groups, no favorable differences were observed. There was a decrease in the greens and beans dietary component score from baseline to midpoint for the intervention group compared to the comparison group. Neither usual intake of nutrients nor food groups changed from baseline to midpoint for pantry clients in comparison or intervention communities.

Summary of the chapter findings suggest that although all participants relied on food pantries for emergency food assistance, food security status was a strong enough predictor to differentiate dietary quality and usual intake among clients at baseline. The nutritional quality of client food bags was positively associated with client diet quality, while pantry inventories scores were negatively associated with client scores, suggesting potential aversion to utilizing healthier foods. Nutritional quality of pantry offerings associated with client diet quality differently for FS, LFS, and VLFS pantry clients, with VLFS clients benefitting more than other groups from pantry

offerings. This supports the idea that food security subgroups may use pantry resources differently. Food pantry interventions have the potential to positively influence food access and dietary intake in rural, high-poverty communities. Improvements in food security and/or diet quality occurred in both treatment groups in the short term. Evaluation of the final study time point, as well as further investigation of the dose-dependent effect of each intervention component and other individual community characteristics, may elucidate the relationship between the VFF intervention and client dietary outcomes.

CHAPTER 1. INTRODUCTION

1.1 The Problem of Food Insecurity

Food security for a household means having access by all members at all times to enough food for an active, healthy life (1). Food insecurity, on the other hand, is the limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways (1). Food insecurity can be parsed into two subgroups: low food security and very low food security. Low food security is characterized by reduced quality, variety, and desirability of the diet, but the quantity of food intake and normal eating patterns are not substantially disrupted (2). Very low food security is the worst form of food insecurity, and is characterized by disruption of eating patterns and reduction of food intake by one or more household members at times during the year because of inadequate money and other resources for food (2). The current prevalence of food insecurity in the US is 11.8% (3) (**Figure 1-1**).

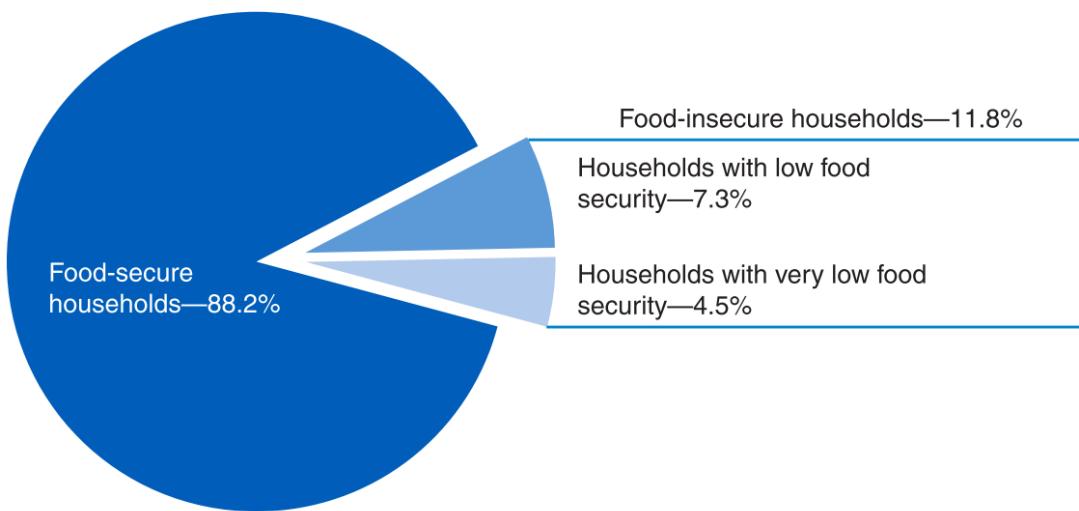


Figure 1-1 US household by food security status in 2017. Source: USDA, Economic Research Service using data from US Department of Commerce, US Census Bureau, 2017 Current Population Survey Food Security Supplement.

The prevalence of food insecurity peaked following the recession in 2008, and has been trending towards a decrease since (3) (**Figure 1-2**). However, one of the United States Department of Agriculture (USDA)'s Healthy People 2020 objectives (a set of nationwide health-promotion and disease-prevention goals to be achieved by the year 2020) is to reach a food insecurity prevalence of 6%. Thus, substantial improvement is needed.

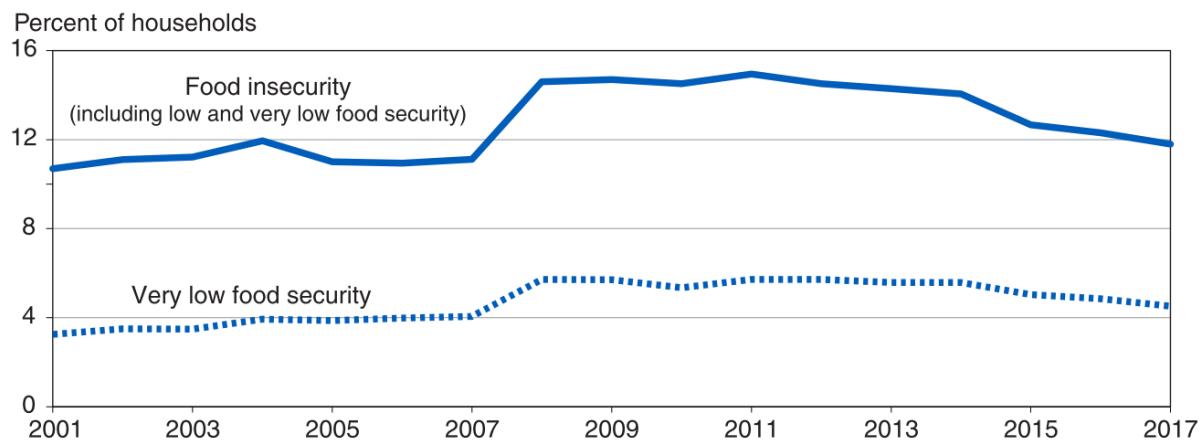


Figure 1-2 Prevalence of food insecurity and very low food security in 2017. Source: USDA, Economic Research Service using data from US Department of Commerce, US Census Bureau, Current Population Survey Food Security Supplement.

1.2 Food Insecurity is Prevalent in the Rural Midwest

Rural, Midwestern communities may be particularly vulnerable to food insecurity. Rates of household food insecurity in 2012 were highest in nonmetropolitan (rural) areas, at 15.5% (**Figure 1-3**) (4). The recovery rate from the 2008 recession in rural areas has lagged behind metropolitan areas (4), suggesting that rural US communities may face additional barriers to accessing healthy foods (4,5). One potential barrier is the consolidation of large grocers, which has resulted in a decrease in the number of local stores in favor of large supermarkets, and ultimately more distance between stores in rural areas (4). Additional barriers include a lack of public transportation and employment opportunities (4).

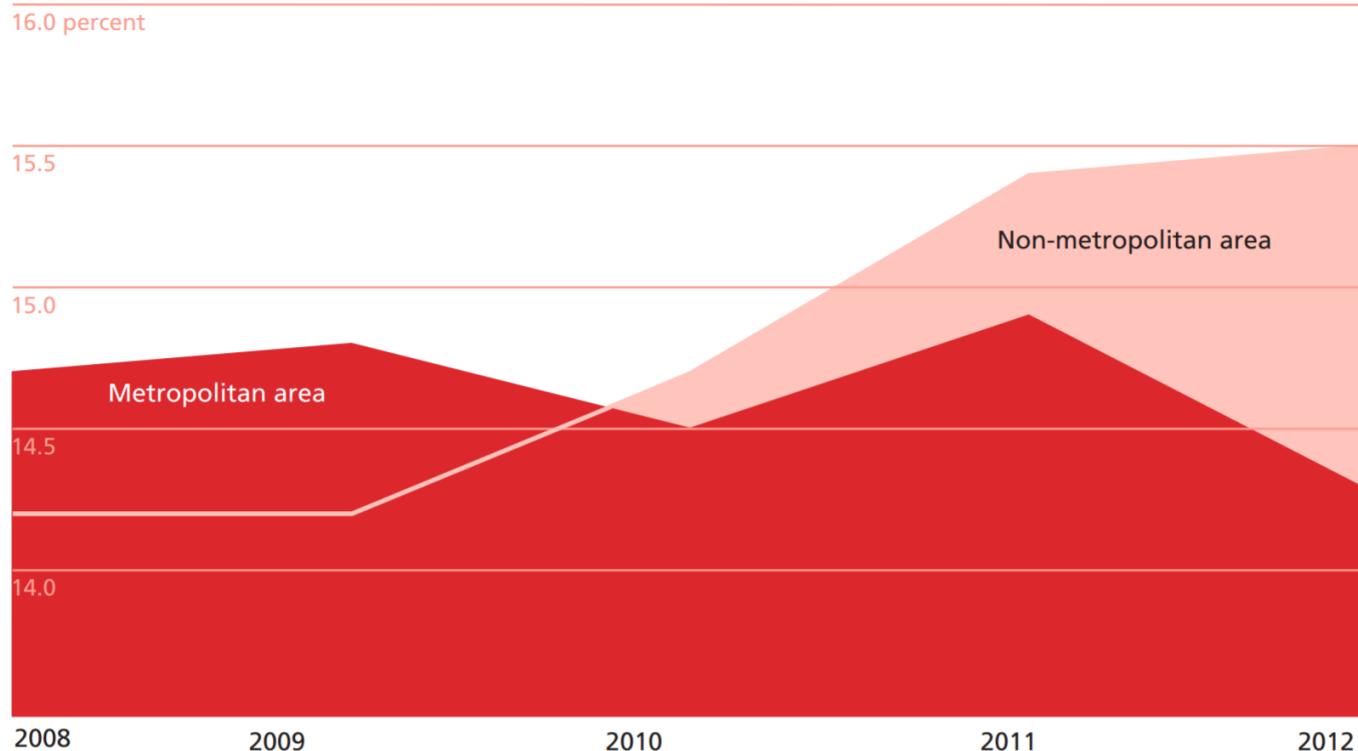


Figure 1-3 Percentage of Food Insecure Households by Metropolitan Status. Source: USDA Household Food Security. Annual Reports 2008-2012.

Food insecurity prevalence has increased in Midwestern US states. **Figure 1-4** shows a rise in food insecurity prevalence in the Midwest, ranging from an increase of 2.8 to 6.3 percentage points, from 1999-2001 to 2009-11 when studies described in this dissertation were conceived (6).

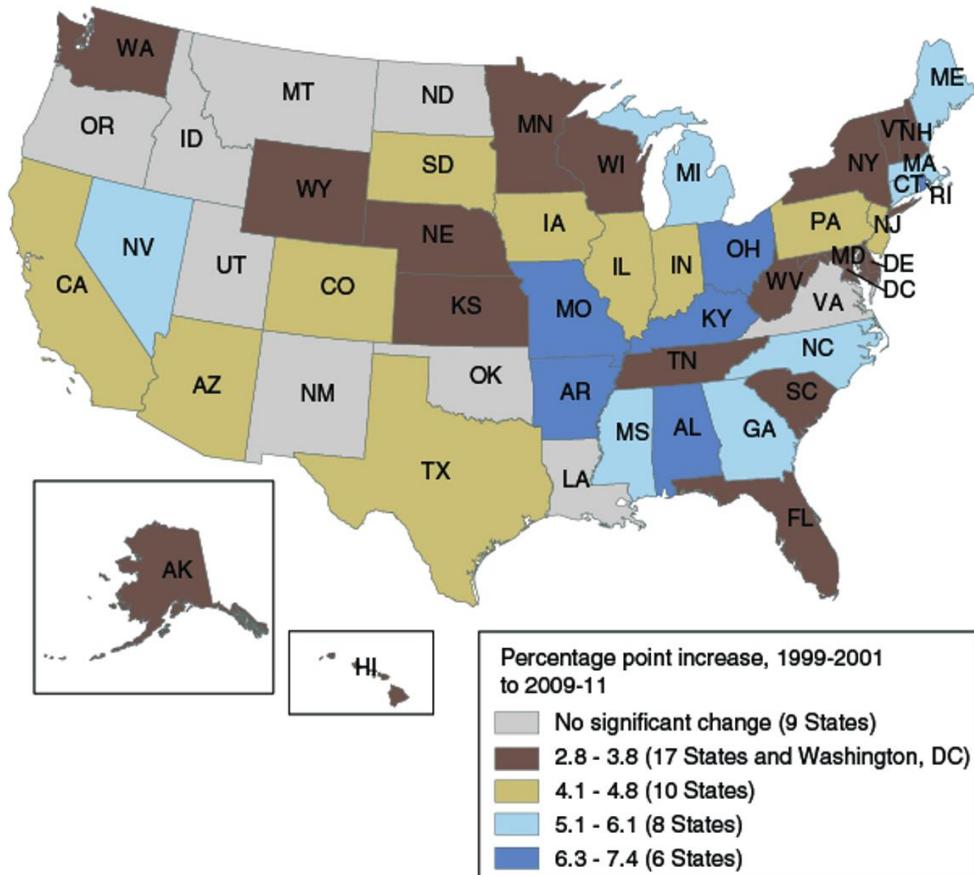


Figure 1-4 Changes in food security prevalence from 1999-2001 to 2009-11 across the US
Source: USDA, Economic Research Service using data from US Department of Commerce, US Census Bureau, Current Population Survey Food Security Supplement.

1.3 Food Insecurity is associated with Negative Dietary and Health Outcomes in the US

Food insecurity is a public health concern, as it is associated with negative dietary and health outcomes. A recent systematic review documented associations between food insecurity and consumption of fewer vegetables, fruits, and dairy and lower intake of vitamin A, calcium, and magnesium (4). Furthermore, food insecurity is associated with diet-related chronic diseases among low-income Americans (5). In a population-based sample of 5,094 poor adults, food insecurity was associated with cardiovascular risk factors, including hypertension and hyperlipidemia (5). Other studies have shown associations between food insecurity and obesity (6), as well as poorer physical and mental health (7–11), compared to food security.

1.4 Food Pantries are a Resource for Food Insecure Americans

Food pantries are a community resource with reach in many rural communities and may be an important point of contact and place to intervene to improve food security and dietary outcomes. Food pantries are non-profit organizations that provide food at no cost and with minimal restrictions or eligibility requirements directly to those in need. Food pantries often partner with other community resources and programs to obtain foods; these include donations from food drives and collaborations with local grocery stores and restaurants that donate excess foods or foods nearing expiration. Another source of foods is donations from food banks, which are large warehouse-like distribution centers that receive food from government programs, like The Emergency Food Assistance Program (TEFAP) (7), as well as community resources. Recent cuts in federal food assistance programs, such as the Supplementation Nutrition Assistance Program (SNAP, previously known as the Food Stamp program), have increased reliance on food pantries (8). Historically, the goal of the emergency food system was to provide a high quantity, not quality, of food for households in emergency situations. The trend for households to rely on pantry foods for dietary staples, rather than emergency foods for short-term situations, press a need to consider the quality of foods offered to clients over the long term (9). A recent systematic review of the nutritional quality of food provided to clients from food pantries indicated shortcomings in pantries providing the amounts and types of foods that were adequate for a balanced diet for the intended number of days the food bags were declared to last; food bags were especially low in dairy, vitamin A and vitamin C (9).

1.5 Food Secure, Low Food Secure, and Very Low Food Secure Clients may use Food Pantries Differently

Food pantries are a resource prevalently used by food insecure (FI) households. As shown in **Figure 1-5**, roughly two-thirds of US pantry-users are FI. This leaves a sizeable proportion of households who are using pantries but are classified as food secure (FS). Investigation into why there is a substantial proportion of pantry clients who consider themselves to be FS reveals a very limited body of research that suggests that FS and FI clients may use pantries differently. The first investigation that suggested there may be different subgroups within what was previously thought to be a homogeneous population of pantry users was by Kicinski in 2012 (10). Kicinski identified two distinct groups of pantry users; one group had been using the food pantry for over a decade,

and a second group had recently begun using pantry services within the last 24 months. This author suggested that the long-term pantry users might be using pantry resources consistently as a supplement and buffer to maintain food security, while the short-term pantry users might be using pantries in concordance with their original purpose—they were relying on pantry resources due to an acute, emergency situation or change in economic status. Although few, additional studies have surfaced that support the idea that within the food pantry setting, FS, low food secure (LFS), and very low food secure (VLFS) clients may use pantries differently (11), and that dietary intake may differ between FS, LFS, and VLFS pantry clients (12). With the recent increase in prevalence of chronic food pantry use, it is important to investigate the foods pantries are providing to supplement clients' diets, client dietary quality and intake, and their relationship with food security status. These ideas are addressed in the second and third chapters of this dissertation.

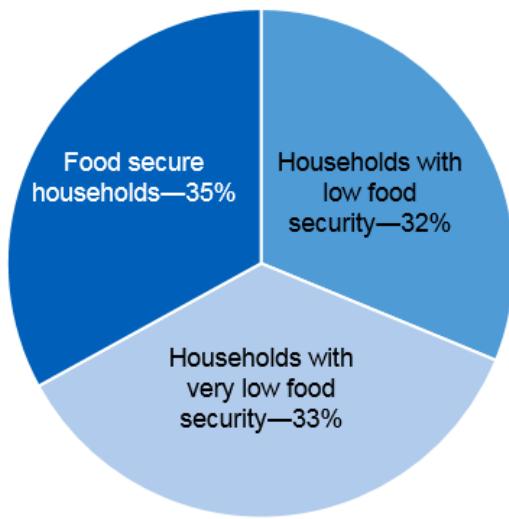


Figure 1-5 Prevalence of food security, low food security, and very low food security among a national sample of households who use food pantries. USDA, Economic Research Service using data from US Department of Commerce, US Census Bureau, 2017 Current Population Survey Food Security Supplement.

1.6 Evidence Base for Interventions at Food Pantries to Improve Dietary Outcomes

Evidence supports the use of food pantries as a promising mechanism to improve diet-related outcomes among clients (13). There have been limited interventions in the food pantry setting aimed at improving food security and/or dietary intake prior to the studies presented in the second, third, and fourth chapters of this dissertation (14). A study in 2012 implemented a six-week cooking program including plant-based recipes that utilized extra virgin olive oil (15). The main outcomes of fruit and vegetable intake, grocery purchases, food security score, and body mass index were evaluated at baseline, after the six-week cooking class, and six months post-intervention by administering a frequency questionnaire, analyzing grocery receipts, the US HFSSM, and recording height and weight, respectively. Pre-post analysis showed an increase in the variety of fruit and vegetable intake, a decrease in meat, carbonated beverages, desserts, snacks and total groceries purchased, and improvements in food security and BMI from baseline to six-month follow-up. A study in 2013 evaluated the effects of a nutrition education intervention that included the tasting of, and provision of ingredients to prepare, a whole grain pasta dish (16). The main outcomes of self-reported whole grain consumption and self-efficacy on choosing/preparing whole grain foods were assessed over four weeks using a newly developed questionnaire for low literacy populations. Findings showed improvement in whole grain consumption and self-efficacy in the intervention group compared to the control group. Another study in 2013 examined the impact of a food pantry intervention, Freshplace, that included a client-choice pantry, monthly meetings with a project manager to receive motivational interviewing, and targeted referrals to community services (17). A control group went to traditional food pantries where they received food bags. The main outcomes of food security, self-efficacy, and fruit and vegetable intake were evaluated over a 12-month follow-up period using the US HFSSM, the Missouri Community Action Family Self-Sufficiency Scale, and the 7-Item Block Food Frequency Screener, respectively. Findings showed improved food security, self-efficacy, and fruit and vegetable intake over one year compared to the control group. Despite all of these studies using different intervention strategies, they have all found improvements in food security and/or diet quality, which suggests that the pantry environment may be an effective target setting for interventions to improve these outcomes.

1.6.1 Gaps in previous literature

The previous food pantry intervention studies did present some limitations. Firstly, these studies had a short follow-up period of one year or less. Secondly, these studies mainly used individualized approaches where the intervention tools targeted the pantry clients only (i.e., targeted referrals to primary care and community resources, cooking instruction). There is growing evidence that an ecological approach that targets not only the individual, but also the surrounding food environment, is more effective for changing dietary behaviors (18,19). Thirdly, these prior interventions measured dietary intake using different versions of a food frequency questionnaire (FFQ).

There are three main dietary assessment tools that are commonly used to measure dietary intake: food records, FFQs, and dietary recalls. They each have their own associated biases. Benefits of the FFQ are that this survey asks questions about the usual (long-run average) intake of food groups and nutrients that comprise the items specified in the survey, it is associated with low respondent burden, and it is inexpensive to administer and process. However, shortcomings are that the finite list of foods clients are able to choose from in the FFQ, and the cognitive difficulty of estimating the amount of a given food consumed over an extensive time frame, introduces error (20). Dietary recalls and food records, on the other hand, capture virtually all of the foods consumed by allowing participants to report all foods. However, these tools have limitations as well. Food records may introduce reactivity bias. Since the participant diaries their foods as they consume them, the dietary assessment process could motivate the participant to choose a different food. Food records are also associated with high respondent and investigator burden.

Dietary recalls generally have a reference period of only the last 24 hours, which is less burdensome to recall, but captures only a one-day snapshot that may not be representative of what a participant usually consumes. Although relatively most costly to administer, they have less inherent non-random error and bias. Thus, an alternative method is to use multiple 24-hour dietary recalls (meaning, administering several 24-hour recalls over the course of several days or longer). Using multiple 24-hour recalls allows within-person variation to be minimized and, paired with sophisticated statistical techniques described later, allows more accurate estimation of a population's distribution of the usual intake of nutrients or food groups (20,21).

In addition to the limitations of previous food pantry intervention studies, there are gaps in the literature regarding the relationship between food (in)security and food pantry use. Although evidence supports the use of food pantries as a promising mechanism to improve dietary patterns among clients, little is known about the relationship between food security, pantry use, and, by extension, whether the efficacy of nutrition interventions in the food pantry setting may differ for FS, LFS, or VLFS clients. Thus, a major component of the proposed intervention evaluation was to characterize dietary intake, the foods acquired from food pantries, and the effects of a food pantry intervention by food security status.

1.7 The Voices for Food Intervention

The Voices for Food (VFF) intervention was created to improve upon the gaps described above. VFF was a collaboration between Cooperative Extension programs across six states (Indiana, Michigan, Missouri, Nebraska, Ohio, South Dakota) in the Midwestern US (**Figure 1-6**) that targeted rural food pantries to improve access to health foods among clients (Clinical Trial Registry: NCT0356609). A full description of VFF is published (**Appendix A**) (22).

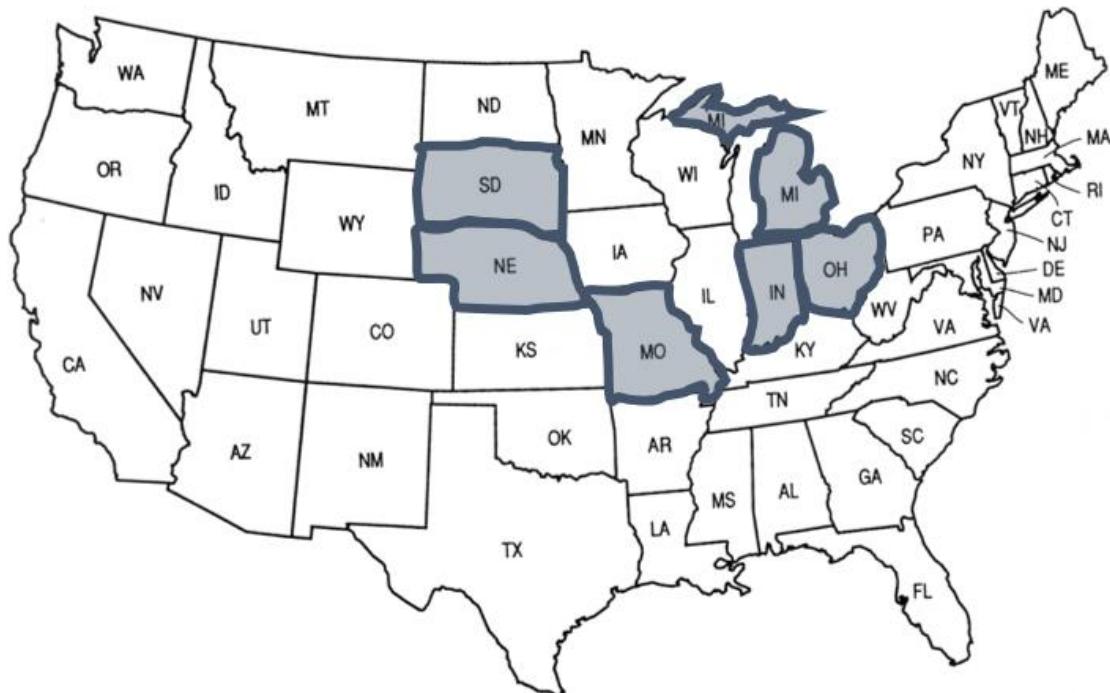


Figure 1-6 Voices for Food intervention: participating states.

VFF had a quasi-experimental study design (**Figure 1-7**). Two pantries in rural, high-poverty communities in each state were selected to receive an intervention, and were each matched with a “comparison” pantry based on several pantry characteristics, including: level of client choice, number of households served, receipt of government commodity program assistance, infrastructure and capacity (i.e., number of refrigerators and freezers to store foods) and predominant racial/ethnic group served at the pantry (22).



Figure 1-7 Voices for Food intervention: quasi-experimental study design.

The VFF intervention was guided by a socio-ecological construct. The VFF toolkit and guide (VFF materials) were a written compilation of various strategies supported by the literature that aimed to improve dietary outcomes. In designing the VFF materials, strategies were incorporated that targeted each level of the social ecological model (SEM) (**Figure 1-8**). The VFF materials provided guidance on how to: 1) create food policy councils (FPCs) comprised of

stakeholders within the food system that met regularly to address food insecurity in the community (22–24) (community level of the SEM); 2) implement a MyChoice distribution model where food pantries were organized into the USDA MyPlate food groups (25), and encouraged clients to “shop” through the pantry and select their own foods (22,26) (organizational level of the SEM); 3) administer nutrition education (27), food safety (28), and cultural competency (29) training to pantry staff, volunteers, clients, and community stakeholders (30,31) (community, organizational, and individual levels of the SEM). Additionally, all pantries (intervention and comparison) were given the opportunity to apply for \$2,500 mini-grants on an annual basis to use towards initiatives that were aligned with the goals of VFF.

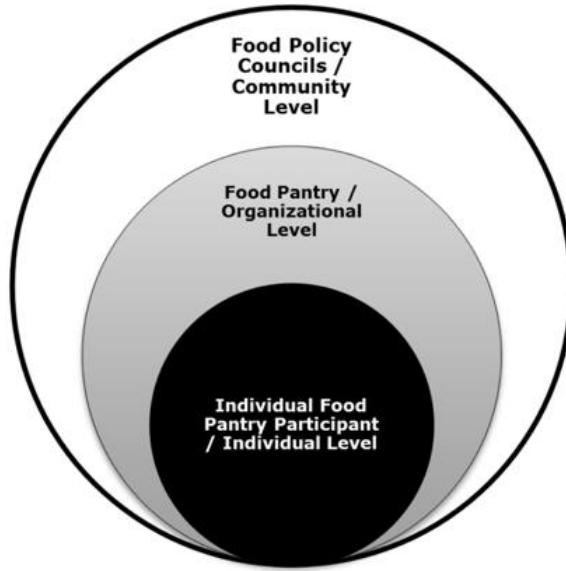


Figure 1-8 Voices for Food intervention: social ecological framework.

The VFF study was developed by an interdisciplinary group that consisted mainly of investigators from Cooperative Extension programs at the partnering universities. Extension programs educate, and extend new findings to, the communities surrounding land grant universities. With this in mind, since the early 2000s, Extension programs across the US have provided Extension staff to guide local change efforts (32). These programs have found that these

Extension staff, which they describe as “community coaches,” are effective in sustaining change in communities (32). Therefore, VFF investigators hypothesized that providing the VFF materials alone may not be as effective in improving outcomes of interest compared to providing a community coach in addition to the VFF materials to facilitate the implementation of proposed activities. Therefore, the VFF materials were distributed to all communities, while the intervention, or distinguishing factor between intervention and comparison communities, was the presence of a community coach to aid communities in carrying out the activities described in the VFF materials (listed above).

1.8 Voices for Food Assessments and Analytical Methods

Main outcomes of the VFF study were client food security scores, dietary quality scores, and usual intake of nutrients and food groups. The 2015-2020 Dietary Guidelines for Americans (DGA) recommend shifts in eating patterns to promote health and prevent disease among the US population. The recommended shifts in eating patterns are designed to increase consumption of nutrients that are currently consumed below the Estimated Average Requirement (EAR) or do not exceed Adequate Intake (AI) levels; these include potassium, dietary fiber, choline, magnesium, calcium, vitamins A, D, E, C and iron (among adolescent girls and women ages 19 to 50 years) (19). Of these under-consumed nutrients, calcium, potassium, dietary fiber, and vitamin D are considered “nutrients of public health concern” because the prevalently low intakes of these nutrients are associated with health consequences. The DGA recommends shifts to eating more vegetables, fruits, whole grains, and dairy to increase intake of nutrients of public health concern. Because of these recommendations, these nutrients and food groups were selected to include in usual intake analyses.

The VFF intervention was evaluated at three time points: baseline (2014), midpoint (2016), and follow-up (2017). However, only the first two time points were addressed to evaluate intermediate effects of the intervention in this dissertation (**Figure 1-9**). The VFF intervention was evaluated using various assessments and analytical methodologies that are described in this section. Similar to the design of the VFF intervention, assessments were also collected to evaluate findings using a SEM approach. On the organizational level of the SEM, nutritional quality of the pantry food environment was evaluated by applying the Healthy Eating Index (HEI) to the foods in stock at the participating pantries (pantry inventories) and the foods distributed to clients (client food

bags). On the individual level, the food security and diet (including quality and usual intake) of pantry clients were assessed by administering the US HFSSM (food security), the HEI (dietary quality), and the National Cancer Institute (NCI) method (usual intake). In addition to quantifying main study outcomes on their respective levels of the SEM, associations between outcomes on different levels were investigated to elucidate the relationship between the layers of influence.

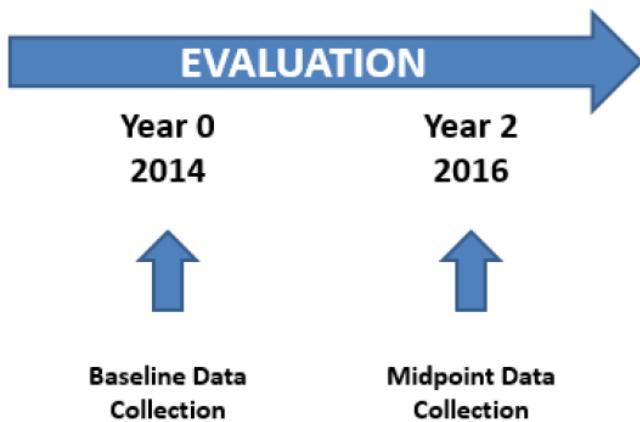


Figure 1-9 Voices for Food intervention: evaluation schematic.

1.8.1 Assessments

1.8.1.1 Food Pantry Characteristics

Before the start of the VFF study, research staff administered a “site selection” survey to pantry directors through open-ended interview questions to identify eligible communities for participation (22). Notably, food pantries with the least amount of client choice of the foods distributed in client food bags, and pantries that had not established FPCs, were preferred in site selection because these were planned components of the intervention. Authors gleaned pantry-level characteristics from site selection survey responses that were later used to create the following variables: average number of households served per month, predominant racial/ethnic group served, number of refrigerators, number of freezers, government commodity program participation, and guided client choice (GCC) score.

GCC was conceptualized as a variable component of the pantry environment that may foster or hinder client pantry use (33). The term “GCC” includes choice of the foods clients receive from the pantry, but is also used in this study to capture other components of the food acquisition process that contribute to clients’ experiences—namely, nutrition education and cultural sensitivity towards clients. Six questions from the site selection survey were grouped as a rudimentary tool to quantify and score GCC by adding the number of negative responses (indicating fewer indications of GCC) to “yes or no” questions regarding the food distribution system and staff-client interactions in the food pantry. A score of zero indicated a high level of GCC, while a score of six indicated no GCC. Questions included: 1) “Is there a food distribution system in place where clients get a specific number of choices from certain categories (cereals, soups, vegetables, etc.)?”; 2) “Are clients allowed a limited number of choices from MyPlate food groups, in addition to combination and miscellaneous groups?”; 3) “Are clients allowed to physically remove food from the shelf and place in their cart or bag?”; 4) “Is there an effort to integrate nutrition education within the act of choice (MyPlate posters visible, etc.)?”; 5) “Do volunteers promote nutrition?; and 6) Are volunteers trained in cultural competency?”

1.8.1.2 Pantry Inventory and Client Food Bag Logs

Research staff recorded an inventory of all food and beverage items available at each food pantry on a single day at the start of the client recruitment period (pantry inventories). Staff also recorded all food/beverage items that were distributed to clients by the pantry on recruitment day (client food bags). Food/beverage item name, brand name, additional description (i.e., “low sodium, “sugar free”), weight/volume, food form (fresh, frozen, etc.), and quantity were recorded and compiled into a database.

1.8.1.3 Client Characteristics and Food Security Questionnaire

Upon recruitment and at each study time point, participants were interviewed at one of the participating food pantries (or followed up via phone or email) by trained research staff and completed an electronic or paper version of a characteristics and food security questionnaire (**Appendix B**) that elicited information on demographic and pantry use characteristics, including age, sex, race, ethnicity, annual household income, education level, employment status, number of household members, number of children <18 years in the household, usual mode of transportation,

participation in federal food assistance programs, frequency of visits to this pantry in the past year, and length of time that food from pantries lasts.

1.8.1.3.1 US Household Food Security Survey Module

This survey also contained the 18-item US Household Food Security Survey Module—a validated measure of food security in the US (34,35)—to quantify and classify food security. Development of the US HFSSM began in 1992 with partnership from the federal government and the private sector. These entities were tasked with creating a standard measure of the food insecurity and hunger experienced in the US for use at national, state, and local levels (34). After its launch in 1995 as a supplement to the Current Population Survey (CPS), this measure was tested and analyzed to ultimately create the now broadly used US HFSSM. Further investigation of the tool following successive distributions of the CPS has deemed the US HFSSM to be stable and robust over time and among major population subgroups (34).

The US HFSSM contains 18 questions (or items) listed in order of severity that query the food situation of the household. The US HFSSM employs a numerical scale and categorical measure to describe the situation of food security in US households as a whole, household adults, and household children over a specified reference period by summing the number of affirmative responses (one point per question) for all 18 items, the 10 items corresponding to the situation for adults, or the 8 items corresponding to the situation of children, respectively. Analyses described in this dissertation specify a reference period of one year for baseline food security assessment and two years for midpoint assessment. Unanswered items of the US HFSSM were imputed for each participant according to previously described methods (34).

1.8.1.3.2 Food Security Classification

Adult food security was quantified as a main outcome variable for the analyses presented in the fourth chapter of this dissertation. The numerical score was categorized and used as a main predictor and covariate in the second and third chapters of this dissertation, respectively. Using the summation of the 10 items corresponding to household adults, a raw score of zero was assigned as “high food security; a raw score of 1-2 was classified as “marginal food security”; a raw score of 3-5 was classified as “low food security”; a raw score of 6-10 was classified as “very low food security” (35). Participants classified into the high and marginal food security groups were

combined into one group, “food security”, because of the low proportion of high and marginal food secure participants in the prevalently food insecure food pantry client population. The classification of food security used in this study was a strength, as limited studies have characterized differences between the LFS and VLFS subgroups.

1.8.1.4 Automated Self-Administered 24-Hour Dietary Recall

In addition to the characteristics and food security questionnaire, participants also completed up to three Automated Self-Administered 24-Hour Dietary Recalls (ASA24s), an internet-based 24-hour dietary recall (36), with optional staff assistance at each evaluation time point (**Appendix C**). The ASA24 was developed by the National Cancer Institute, under contract with Westat, and originally based on an automated, self-administered recall developed by Dr. Tom Baranowski of the Baylor College of Medicine (37). The ASA24 uses a modified version of USDA’s automated multiple pass method (AMPM), which is a computerized method for collecting interviewer-administered recalls that employs five steps designed to ensure complete and accurate food recall and reduce respondent burden. The AMPM approach features five main strategies: 1) a “Quick List” to collect a list of foods consumed during the previous 24-hour recall period from midnight to midnight; 2) a “Forgotten Foods” probe to query any foods forgotten during the Quick List; 3) collection of the “Time & Occasion” for each food; 4) a “Detail Cycle” to collect additional descriptions and amounts, and to review the 24-hour day; and 5) a “Final Probe” for anything else consumed. In addition to these strategies, the ASA24 includes a “Meal Gap Review” that asks if anything was eaten during any three-hour gaps between reported eating occasions, and a “Usual Intake Question” that asks whether the amount of food and drink consumed in the 24-hour recall period was more than usual, usual, or less than usual (37).

Dietary quality and intake were estimated using analytical methodologies that accommodate inclusion of multiple 24-hour recalls to address previously-described gaps in the literature. The Healthy Eating Index (HEI) was applied to measure diet quality and the National Cancer Institute (NCI) method was applied to estimate usual intake of nutrients and food groups and are described in analytical methods below.

1.8.2 Analytical Methods

A large emphasis of the research activities performed for this dissertation was placed on the development and adaptation of sophisticated statistical methods to estimate nutritional outcomes. This dissertation offers an innovative approach of adapting the Healthy Eating Index for application to all foods comprising the pantry food environment, and facilitating direct comparison between the nutrition quality of pantry offerings with the dietary quality of individual pantry clients. Additionally, this dissertation presents the novel application of the NCI method to a primary data collection setting.

1.8.2.1 Healthy Eating Index as a Measure of Dietary Quality

The HEI is a density-based score (e.g., amount per 1,000 kcal, ratio of fatty acids) that measures alignment with the DGA, allowing examination of overall diet quality in relation to federal dietary guidance, as well as patterns in terms of balance among multiple components to examine the quality of the mix of foods consumed (38). The 2010 rendition of the HEI (HEI-2010) is made up of nine adequacy components: total fruit (max score=5), whole fruit (max score=5), total vegetables (max score=5), greens and beans (max score=5), whole grains (max score=10), total dairy (max score=10), total protein foods (max score=5), seafood and plant proteins (max score=5), and fatty acids (max score=10), and three moderation components: refined grains (max score=10), sodium (max score=10), and empty calories [i.e., solid fat, alcohol, and added sugars; max score=20]), most of which are expressed relative to energy intake (i.e., as densities) and then scored according to standards (38).

The standards for achieving the maximum and minimum HEI-2010 score for each component are as follows using the format “(standard for maximum, standard for minimum)": total fruit (≥ 0.8 cup equiv. / 1,000 kcal, no fruit), whole fruit (≥ 0.4 cup equiv. / 1,000 kcal, no whole fruit), total vegetables (≥ 1.1 cup equiv. / 1,000 kcal, no vegetables), greens and beans (≥ 0.2 cup equiv. / 1,000 kcal, no dark green vegetables, beans, or peas), whole grains (≥ 1.5 ounce equiv. / 1,000 kcal, no whole grains), total dairy (1.3 cup equiv. / 1,000 kcal, no dairy), total protein foods (≥ 2.5 ounce equiv. / 1,000 kcal, no protein foods), seafood and plant proteins (≥ 0.8 ounce equiv. / 1,000 kcal, no seafood or plant proteins), fatty acids ((polyunsaturated fatty acids + monounsaturated fatty acids) / saturated fatty acids > 2.5 , (polyunsaturated fatty acids + monounsaturated fatty acids) / saturated fatty acids ≤ 1.2), refined grains (≤ 1.8 ounce equiv. /

1,000 kcal, \geq 4.3 ounce equiv. / 1,000 kcal), sodium (\leq 1.1 gram / 1,000 kcal, \geq 2.0 grams / 1,000 kcal), and empty calories (\leq 19% of energy, \geq 50% of energy).

For the adequacy components, a higher score indicates higher consumption; moderation components are reverse-scored, and thus a higher score indicates lower consumption. The 12 component scores are weighted to yield a HEI-2010 Total Score with maximum value of 100, indicating full adherence to the 2010 DGA. Because the data analyzed for this dissertation were collected prior to the release of the 2015 DGA and HEI-2015, the HEI-2010 was used for this study to reflect the dietary standards and food supply composition at the time of data collection.

1.8.2.1.1 Application of the HEI in the Context of Community Food Environments

In addition to individuals' dietary consumption, a given set of foods on any level of the food system (i.e., individual's diet, food environment, or national food supply) may be a unit of analysis to which the HEI may be applied by following three main steps: 1) identify the set of foods under consideration, 2) determine the amount of each relevant dietary constituent in the set of foods, and 3) derive the pertinent ratios and score each HEI component using the relevant standard (39). However, a documented shortcoming of applying the HEI to higher levels of the food system is that there are currently no databases available to convert unprepared foods (such as raw meats and untrimmed produce) and processed but not fully prepared foods (such as cake mixes) into their appropriate food group and nutrient equivalents (39). Thus, unprepared foods must be translated by hand or treated as prepared (i.e., "raw chicken" treated as "cooked chicken").

A community food environment, or the places where individuals acquire food in the locality, represents one layer of the food system (39). For food pantry clients, the pantry food environment, which defines both the foods available at the pantry (pantry inventories) and foods distributed to clients (client food bags), represents one such community food environment. A previous study by Nanney and colleagues applied the HEI to invoices of foods that were ordered by food pantries (40). In this dissertation, a similar method was created to model the application of the HEI to both the pantry inventory and client food bags. Specifically, a database was created containing all food/beverage item names, brand names, descriptions, weight/volume, and quantity for each item. Using these descriptors, each food item was searched in the USDA "What's in the Foods You Eat" online tool (41) to assign the appropriate USDA food code. The assigned food code was used to merge each food item with the appropriate databases containing their food group

composition (42) and nutrient composition (43). The total weight of each food item was calculated by converting each food to units of grams; this required converting non-dry foods using a density database (44). Final weight/100g for each food item was multiplied by the weight/100g for all food groups and nutrients that comprised the food item. Publicly available Statistical Analysis Software (SAS) macros were used to calculate HEI-2010 scores (45).

1.8.2.2 National Cancer Institute Method for Determining Usual Intake

The NCI method is optimal for estimating usual intake because it reduces biases associated with usual intake determination by: 1) accounting for reported days with non-consumption or skewed consumption; 2) distinguishing within-person from between-person variation; 3) allowing for the correlation between the probability of consumption and the consumption-day amount; and 4) relating covariate information to usual intake (46). The NCI method can be used to estimate the usual dietary intakes of single dietary components that are consumed daily or episodically. In the third and fifth chapters of this dissertation, the NCI method (21,46,47) was used to calculate the usual dietary intake of under-consumed nutrients and food groups, to determine cross-sectional associations between food security and usual intake, and to compare longitudinal changes in usual intake by treatment group and food security status. Up to three ASA24s per participant were included in the usual intake analysis. When the percentage of participants who did not consume a given food group/nutrient on each recall day was $\leq 5\%$, the food group/nutrient was treated as ubiquitously consumed (or consumed daily); when the percentage of non-consumption was $> 5\%$, the food group/nutrient was treated as episodically consumed (23). In this study, all nutrients were determined to be ubiquitously consumed, and all food groups episodically consumed. Publicly available SAS macros may be used to implement the NCI's statistical method for estimating usual intake. Descriptions of these macros, along with methodology developed in this dissertation to adapt the macros for use in a primary data collection setting, are provided in this section.

1.8.2.2.1 The NCI MIXTRAN Macro

The MIXTRAN macro (48) was used to evaluate the effects of individual covariates on food or nutrient consumption. The MIXTRAN macro uses the SAS NL MIXED procedure to simultaneously fit a two-part statistical model accounting for the probability of consumption and consumption-day amount on a given day, while accommodating repeat 24-hr recalls and allowing

the random effects for both parts of the model to be correlated. In cross-sectional analyses, the main predictor specified in the MIXTRAN macro was food security; in longitudinal analyses, the main predictors were time, treatment group, food security, and the two-way and three-way interactions between these variables. For ubiquitously consumed nutrients, the macro fits a one-part (i.e. amount-only) model of the amount consumed, since the probability of consumption is assumed to be 1.

For episodically consumed food groups, the macro fits a two-part model that defines the usual intake as the probability of consumption multiplied by the amount consumed on a consumption day. One challenge with using the NCI method is that the MIXTRAN macro generates estimates for the individual covariate effects on the probability of consumption and amount of consumption separately. Therefore, an additional statistical method developed by Dr. Janet Tooze (one of the developers of the NCI method) was employed to estimate the combined effect of individual covariates on the *probability x amount* (or, usual intake) (**Appendix D**) (49). This required authors to adapt the MIXTRAN macro to include user-defined estimate statements that employed the delta method to compute the ratios of the usual intake between two levels of the covariate of interest. For example, in a cross-sectional analysis, the comparison of usual intake by food security status was of interest. Thus, this comparison was achieved by estimating the ratio of usual intake between food security subgroups in three pairwise comparisons: $\frac{\text{usual intake (FS)}}{\text{usual intake (LFS)}}$, $\frac{\text{usual intake (FS)}}{\text{usual intake (VLFS)}}$, and $\frac{\text{usual intake (LFS)}}{\text{usual intake (VLFS)}}$. In order to capture the range of possible effects of covariate(s) of interest on the usual intake of food groups, the ratios of usual intake were computed for “low risk” and “high risk” covariate patterns. A low risk covariate pattern assigned covariate levels that were associated with higher intake of food groups (i.e., higher income, older age), while a high risk covariate pattern reflected poor dietary intake.

1.8.2.2.2 The NCI DISTRIB macro

The DISTRIB SAS macro (48) uses parameter estimates and linear predictor values generated from the MIXTRAN macro and a Monte Carlo method to estimate the distribution of usual intake for the population, including the mean usual intake for a given food group and the proportions of participants with intake below a cut point (for example, the Estimate Average Requirement). A second challenge with using the NCI method is that DISTRIB does not generate a measure of variation (i.e., standard deviation). Therefore, additional calculations were required

in order to obtain standard errors and confidence intervals for the percentiles and mean from the distribution of usual intake. A SAS program was written to call the macros using the bootstrap method. One hundred bootstrap samples of the MIXTRAN and DISTRIB macros were generated with a sample size equal to the number of participants in the analysis in order to obtain the standard deviation of the mean usual intake for each nutrient and food group.

The assessments and analytical methods described in this section were implemented via the following objectives and hypotheses to investigate the research aims presented in this dissertation.

1.9 Research Aims, Objectives and Hypotheses

The overarching goal of this dissertation was to investigate differences in dietary intake, consumption of food pantry offerings, and intermediate effects of a SEM, community-based food pantry intervention on dietary outcomes by food security status. Specific aims, hypotheses and objectives are described below:

Aim 1: Characterize cross-sectional differences in dietary quality and usual intake between food secure (FS), low food secure (LFS), and very low food secure (VLFS) adult pantry clients in a multistate sample of rural, Midwestern food pantries.

Aim 1 hypothesis: A high proportion of participants overall were expected have intakes below the EAR and to not exceed the AI for nutrients (potassium, dietary fiber, choline, magnesium, calcium, vitamins A, D, E, C and iron), and below Dietary Guidelines for Americans (DGA) recommendations for food groups (total fruits, total vegetables, dark green vegetables, whole grains and total dairy). FS clients were expected to consume diets of higher quality and usual intake compared to VLFS clients, and to a lesser extent, LFS clients.

Aim 1 objectives:

1. Determine food security status among household adults for a multistate sample of rural, Midwestern food pantry clients using the 18-item US Household Food Security Survey Module.
2. Determine Healthy Eating Index-2010 (HEI-2010) total and component scores, as a measure of dietary quality, for a multistate sample of adult, rural, Midwestern, food pantry client participants.

3. Determine the usual intake of shortfall nutrients and food groups, as a measure of long-run dietary intake, for a multistate sample of adult, rural, Midwestern, food pantry client participants.
4. Determine demographic, household, pantry use, and food assistance program participation characteristics for a multistate sample of adult, rural, Midwestern, food pantry client participants.
5. Compare mean dietary quality and usual intake by food security status (i.e., FS vs LFS, FS vs VLFS, LFS vs VLFS), controlling for potential confounders.
6. Determine the proportion of FS, LFS, and VLFS clients who are consuming usual intakes below the Estimated Average Requirement or not exceeding the Adequate Intake level for selected nutrients, or below DGA recommendations for food groups.

Aim 2: Explore cross-sectional associations between the quality of the mix of foods, measured by applying the Healthy Eating Index 2010 (HEI-2010), of both pantry inventories (food stocked) and client food bags (foods distributed) with client diet quality, as well as whether FS, LFS, or VLFS status interacts with these associations, in a multistate sample of rural, Midwestern food pantries.

Aim 2 hypothesis: HEI-2010 total and component scores of client food bags were hypothesized to predict corresponding HEI-2010 scores for client diet quality; similarly, HEI-2010 total and component scores of food pantry inventories were expected to be associated with corresponding client diet quality HEI-2010 scores but to a lesser extent compared to client food bags. Client food security status was hypothesized to interact with these associations, indicating differential pantry use among FS, LFS, and VLFS clients.

Aim 2 objectives:

1. Apply HEI-2010 total and component scores to the foods stocked (pantry inventories) and distributed (client food bags) to clients, as a measure of pantry food environment nutritional quality, for a multistate sample of rural, Midwestern food pantries.
2. Determine HEI-2010 total and component scores, as a measure of client individual dietary quality, for a multistate sample of adult, rural, Midwestern, food pantry client participants.
3. Determine food security status among household adults for a multistate sample of rural, Midwestern food pantry clients.

4. Determine associations between pantry food environment HEI-2010 scores and client individual HEI-2010 scores, and the interaction of adult food security status, while controlling for potential confounders.

Aim 3: Evaluate the intermediate effects of the Voices for Food intervention on adult food security, diet quality (measured using Healthy Eating Index-2010 total and component scores), and usual intake of traditionally under-consumed food groups and related nutrients (estimated using the National Cancer Institute method) between treatment groups from baseline (2014) to midpoint (2016), and to compare the treatment effect by food security status.

Aim 3 hypothesis: VFF intervention will improve food security, diet quality, and usual intake of potassium, dietary fiber, choline, magnesium, calcium, vitamins A, D, E, C, iron, total fruit, total vegetables, dark green vegetables, whole grains, and total dairy among pantry clients and effects of the intervention will differ by food security subgroup.

Aim 3 objectives:

1. Determine an estimate of baseline dietary quality, usual intake, food security, and demographic, household, pantry use, and food assistance program participation characteristics, for a multistate sample of rural, Midwestern food pantry clients and compare estimates between participants recruited to the intervention group and participants recruited to the comparison group.
2. Determine changes in dietary quality and intake and food security for all participants over the first two years of the VFF intervention in a multistate sample of rural, Midwestern food pantry clients, controlling for potential confounders at baseline.
3. Determine changes in dietary quality and intake and food security for participants stratified by treatment group over the first two years of the VFF intervention in a multistate sample of rural, Midwestern food pantry clients, controlling for potential confounders at baseline.
4. Compare changes in dietary quality, usual intake, and food security over the two-year period in the intervention group – comparison group).
5. Compare the effect of the VFF intervention on dietary quality and usual intake by food security status.

1.10 Dissertation Organization

This dissertation is organized by chapters consisting of manuscripts that have been submitted to or prepared for submission to peer-reviewed journals. Each dissertation aim outlined in section 1.7 corresponds to the three chapters that follow this section. Chapter 2 addresses Aim 1 and characterizes differences in dietary quality and intake between FS, LFS and VLFS pantry clients in a cross-sectional analysis. Chapter 3 addresses Aim 2 and explores associations between the nutritional quality of the food pantry environment (pantry inventories and client food bags) and pantry client diet quality by food security status in a cross-sectional analysis. Chapter 4 addresses Aim 3 and evaluates the intermediate effects of the VFF intervention on food security and diet quality and intake among pantry clients and by food security subgroup in a longitudinal analysis.

1.11 References

1. Anderson SA. Core Indicators of Nutritional State for Difficult-to-Sample Populations. *J Nutr.* 1990;120:1555–600.
2. United States Department of Agriculture Economic Research Service. Definitions of Food Security [Internet]. [cited 2018 Oct 18]. Available from: <https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/definitions-of-food-security.aspx>
3. Coleman-Jensen A, Rabbitt MP, Gregory CA, Singh A. Household Food Security in the United States in 2017. 2018.
4. Piontak JR, Schulman MD. Food Insecurity in Rural America. *Contexts.* 2014;13:75–7.
5. Casey AA, Elliott M, Glanz K, Haire-Joshu D, Lovegreen SL, Saelens BE, Sallia JF, Brownson RC. Impact of the food environment and physical activity environment on behaviors and weight status in rural U.S. communities. *Prev Med.* 2008;47:600–4.
6. Coleman-Jensen, A., Nord, M., Andrews, M., Carlson S. Economic Research Report Number 141: Household Food Security in the United States in 2011. 2012; Available from: <http://www.ers.usda.gov/media/884525/err141.pdf>
7. United States Department of Agriculture Food and Nutrition Service. The Emergency Food Assistance Program (TEFAP): About TEFAP [Internet]. [cited 2018 Oct 16]. Available from: <https://www.fns.usda.gov/tefap/about-tefap>
8. Johnson K, Rawlings-blake S, Schneider H, Cochran T. Hunger and Homelessness Survey:

- A Status Report on Hunger and Homelessness in America's Cities. 2013;1–120.
9. Simmet A, Depa J, Tinnermann P, Stroebele-benschop N. The Nutritional Quality of Food Provided from Food Pantries: A Systematic Review of Existing Literature. *J Acad Nutr Diet* [Internet]. 2016; Available from: <http://dx.doi.org/10.1016/j.jand.2016.08.015>
 10. Kicinski LR. Characteristics of Short and Long-Term Food Pantry Users. 2012;26:58–74.
 11. Kaiser ML, Cafer AM. Exploring Long-term Food Pantry Use: Differences Between Persistent and Prolonged Typologies of Use. *J Hunger Environ Nutr* [Internet]. Taylor & Francis; 2017;12:46–63. Available from: <http://dx.doi.org/10.1080/19320248.2016.1157554>
 12. Tarasuk VS, Beaton GH. Women's dietary intakes in the context of household food insecurity. *Am Soc Nutr Sci*. 1999;129:672–9.
 13. Wright BN, Bailey RL, Craig BA, Mattes RD, McCormack L, Stluka S, Franzen-Castle L, Henne B, Mehrle D, Remley D, et al. Daily dietary intake patterns improve after visiting a food pantry among food-insecure rural midwestern adults. *Nutrients*. 2018;10.
 14. An R, Wang J, Liu J, Shen J, Loehmer E, McCaffrey J. A systematic review of food pantry-based interventions in the USA. *Public Health*. 2019;1–13.
 15. Flynn MM, Reinert S, Schiff AR. A Six-Week Cooking Program of Plant-Based Recipes Improves Food Security, Body Weight, and Food Purchases for Food Pantry Clients. *J Hunger Environ Nutr*. 2013;8:73–84.
 16. Yao P, Ozier A, Brasseur K, Robins S, Adams C, Bachar D. Food Pantry Nutrition Education about Whole Grains and Self-Efficacy. *Family and Consumer Sciences Research Journal*. 2013. p. 426–37.
 17. Martin KS, Wu R, Wolff M, Colantonio AG, Grady J. A novel food pantry program: Food security, self-sufficiency, and diet-quality outcomes. *Am J Prev Med* [Internet]. Elsevier; 2013;45:569–75. Available from: <http://dx.doi.org/10.1016/j.amepre.2013.06.012>
 18. U.S. Department of Health and Human Services and U.S. Department of Agriculture. Dietary Guidelines for Americans 2010. 2010.
 19. U.S. Department of Health and Human Services and U.S. Department of Agriculture. Dietary Guidelines for Americans 2015-2020 [Internet]. 8th ed. 2015. Available from: https://health.gov/dietaryguidelines/2015/resources/2015-2020_Dietary_Guidelines.pdf
 20. Shim J-S, Oh K, Kim HC. Dietary assessment methods in epidemiologic studies. *Epidemiol Health*. 2014;36:1976–95.
 21. Tooze JA, Midthune D, Dodd KW, Freedman LS, Krebs-Smith SM, Subar AF, Guenther PM, Carroll RJ, Kipnis V. A new method for estimating the usual intake of episodically-consumed foods with application to their distribution. 2006;106:1575–87.

22. [Blinded for review]. Voices for food: Methodologies for implementing a multi-state community-based intervention in rural, high poverty communities. [Blinded for Review];
23. Harper A, Shattuck A, Holt-Giménez E, Alkon A, Lambrick F. Food Policy Councils: Lessons Learned. 2009; Available from: <https://foodfirst.org/publication/food-policy-councils-lessons-learned/>
24. Centers for Disease Control Division of Nutrition Physical Activity and Obesity. State Program Highlights: Food Policy Councils. Public Health. 2010;
25. United States Department of Agriculture. ChooseMyPlate.gov [Internet]. [cited 2019 Feb 13]. Available from: <https://www.choosemyplate.gov/>
26. Remley DT, Zubieta AC, Lambea MC, Quinonez HM, Taylor C. Spanish- and English-speaking client perceptions of choice food pantries. J Hunger Environ Nutr. 2010;5:120–8.
27. Maulding MK. Small Steps to Health [Internet]. [cited 2019 Feb 13]. Available from: <https://snaped.fns.usda.gov/library/materials/small-steps-health>
28. South Dakota State University Extension. SAFE AID: Food Safety Training for Food Pantry Programs Sanitary Surroundings: Setting Up for Safe Food [Internet]. 2013 [cited 2019 Feb 13]. Available from: <http://igrow.org/healthy-families/food-safety/safe- aid-food-pantries/>
29. Michigan State University Extension. Ready to go: mentor training: cultural competency [Internet]. 2012 [cited 2019 Feb 13]. Available from: http://msue.anr.msu.edu/resources/ready_to_go_mentor_training_toolkit_4h1642.pdf
30. Eicher-Miller HA, Mason AC, Abbott AR, McCabe GP, Boushey CJ. The Effect of Food Stamp Nutrition Education on the Food Insecurity of Low-income Women Participants. J Nutr Educ Behav. Elsevier Inc.; 2009;41:161–8.
31. Rivera RL, Maulding MK, Abbott AR, Craig BA, Eicher-Miller HA. SNAP-Ed (Supplemental Nutrition Assistance Program-Education) Increases Long-Term Food Security among Indiana Households with Children in a Randomized Controlled Study. J Nutr [Internet]. 2016;146:2375–82. Available from: <http://jn.nutrition.org/cgi/doi/10.3945/jn.116.231373>
32. Hubbell K, Emery M. Guiding Sustainable Community Change: An introduction to Coaching. 2009;1–48.
33. Martin KS, Colantonio AG, Picho K, Boyle KE. Self-efficacy is associated with increased food security in novel food pantry program. SSM - Popul Heal [Internet]. Elsevier; 2016;2:62–7. Available from: <http://dx.doi.org/10.1016/j.ssmph.2016.01.005>
34. Bickel G, Nord M, Price C, Hamilton W, Cook J. Guide to Measuring Household Food Security [Internet]. 2000. Available from: <https://fns-prod.azureedge.net/sites/default/files/FSGuide.pdf>

35. United States Department of Agriculture Economic Research Service. U.S. Adult Food Security Survey Module: Three-Stage Design, with Screeners [Internet]. 2012. Available from: <https://www.ers.usda.gov/media/8279/ad2012.pdf>
36. Subar AF, Kirkpatrick SI, Mittl B, Zimmerman TP, Thompson FE, Bingley C, Willis G, Islam NG, Baranowski T, McNutt S, et al. The Automated Self-Administered 24-Hour Dietary Recall (ASA24): A Resource for Researchers, Clinicians and Educators from the National Cancer Institute. 2012;112:1134–7.
37. National Cancer Institute Division of Cancer Control & Population Sciences Epidemiology and Genomics Research Program. Automated Self-Administered 24-Hour (ASA24®) Dietary Assessment Tool [Internet]. [cited 2019 Mar 16]. Available from: <https://epi.grants.cancer.gov/asa24/>
38. Guenther PM, Kirkpatrick SI, Reedy J, Krebs-Smith SM, Buckman DW, Dodd KW, Casavale KO, Carroll RJ. The Healthy Eating Index-2010 Is a Valid and Reliable Measure of Diet Quality According to the 2010 Dietary Guidelines for Americans. *J Nutr* [Internet]. 2014;144:399–407. Available from: <http://jn.nutrition.org/cgi/doi/10.3945/jn.113.183079>
39. National Cancer Institute Division of Cancer Control & Population Sciences. Research Uses of the HEI [Internet]. [cited 2018 Sep 1]. Available from: <https://epi.grants.cancer.gov/hei/uses.html>
40. Nanney MS, Grannon KY, Cureton C, Hoolihan C, Janowiec M, Wang Q, Warren C, King RP. Application of the Healthy Eating Index-2010 to the hunger relief system. *Public Health Nutr*. 2016;19:2906–14.
41. United States Department of Agriculture Agricultural Research Service. What's In The Foods You Eat Search Tool [Internet]. [cited 2018 Sep 26]. Available from: [https://reedir.arsnet.usda.gov/codesearchwebapp/\(S\(cbsohcqfr2zjhlylcv4ytwa5\)\)/CodeSearch.aspx](https://reedir.arsnet.usda.gov/codesearchwebapp/(S(cbsohcqfr2zjhlylcv4ytwa5))/CodeSearch.aspx)
42. United States Department of Agriculture Agricultural Research Service. Food Patterns Equivalents Database: Databases and SAS Data Sets [Internet]. [cited 2018 Sep 26]. Available from: <https://www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-research-center/food-surveys-research-group/docs/fped-databases/>
43. United States Department of Agriculture Agricultural Research Service. Food and Nutrient Database for Dietary Studies: FNDDS Documentation and Databases [Internet]. [cited 2018 Sep 26]. Available from: <https://www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-research-center/food-surveys-research-group/docs/fndds-download-databases/>
44. Charrondiere UR, Haytowitz D, Stadlmayr B. FAO/INFOODS Density Database Version 2.0. Fao/Infofoods [Internet]. 2012;2:24. Available from: <http://www.fao.org/docrep/017/ap815e/ap815e.pdf>
45. National Cancer Institute Division of Cancer Control & Population Sciences. Healthy

- Eating Index SAS Code [Internet]. [cited 2018 Sep 1]. Available from: <https://epi.grants.cancer.gov/hei/sas-code.html>
46. Tooze JA, Kipnis V, Buckman DW, Carroll RJ, Freedman LS, Guenther PM, Krebs-Smith SM, Subar AF, Dodd KW. A mixed-effects model approach for estimating the distribution of usual intake of nutrients: The NCI method. 2010;29.
 47. National Cancer Institute Division of Cancer Control & Population Sciences Epidemiology and Genomics Research Program. User's Guide for Analysis of Usual Intakes. :19. Available from: https://epi.grants.cancer.gov/diet/usualintakes/Users_Guide_v2.1.pdf
 48. National Cancer Institute. Usual Dietary Intakes: SAS Macros for the NCI Method [Internet]. [cited 2019 Jan 11]. Available from: <https://epi.grants.cancer.gov/diet/usualintakes/macros.html>
 49. Tooze JA, Grunwald GK, Jones RH. Analysis of repeated measures data with clumping at zero. Stat Methods Med Res. 2002;

CHAPTER 2. DIETARY QUALITY AND USUAL INTAKE OF UNDER-CONSUMED NUTRIENTS AND RELATED FOOD GROUPS DIFFER BY FOOD SECURITY STATUS FOR RURAL, MIDWESTERN FOOD PANTRY CLIENTS^{1,2,3}

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FOOTNOTES:

¹ Abbreviations used:

- FS: Food secure
- FI: Food Insecure
- LFS: Low food secure
- VLFS: Very low food secure
- HEI-2010: Healthy Eating Index-2010
- EAR: Estimated Average Requirement
- AI: Adequate Intake
- ASA24: Automated Self-Administered 24-hour Dietary Recall
- NCI: National Cancer Institute
- US HFSSM: US Household Food Security Survey Module
- TEFAP: The Emergency Food Assistance Program
- DGA: Dietary Guidelines for Americans
- VFF: Voices for Food
- USDA: United States Department of Agriculture

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2.1 Abstract

Background: Food insecurity, or uncertain access to adequate foods, characterizes the situation of 65% of US food pantry clients. Although clients share the common experience of using food pantries, usual dietary intake and quality may differ by food security status.

Objective: Dietary quality and usual intake of energy, nutrients that are currently under-consumed in the US, and related food groups were compared by FS, low food secure (LFS), and very low food secure (VLFS) status, and usual intakes were compared to federal guidance and markers of adequacy.

Methods: This study was a cross-sectional, secondary analysis drawn from a multi-state intervention (Clinical Trial Registry: NCT0356609). Adult food pantry clients (n=579) from 24 rural, Midwestern food pantries completed a demographic and food security assessment and up to three 24-hour dietary recalls on non-consecutive days including weekdays and weekends. Healthy Eating Index-2010 total and component scores and usual intake using the National Cancer Institute method were estimated. Proportions of participants' usual intakes not meeting federal guidance and markers of adequacy were described. Multiple linear regression models adjusting for confounders determined associations between food security status and both diet quality and usual intake (in separate models).

Results: FS status was associated with a higher whole grains score, as well as a higher mean usual intake of whole grains and iron, compared to LFS status. FS status was associated with higher mean usual intakes of dark green vegetables and total dairy compared to LFS and VLFS status. FS, LFS, and VLFS clients' usual intakes were below federal guidance for all food groups and usual intake of all nutrients except iron were below dietary reference intakes.

Conclusions: Findings suggest that although all clients were relying on food pantries, food security status differentiates dietary quality and intake among clients. However, improvements are needed among clients regardless of food security subgroup.

2.2 Introduction

Emergency food pantries are non-profit organizations that provide food at no cost and with minimal eligibility requirements to a primarily (65%) food insecure (FI) clientele (1). Food insecurity, defined as lacking access to the quality and quantity of foods needed for an active,

healthy lifestyle (2), can be parsed into two subcategories: low food security (LFS) and very low food security (VLFS). LFS is characterized by reduced quality and desirability, but not quantity of foods, while VLFS is additionally characterized by reduced quantity of food and disruption of eating patterns (3). FI is associated with consumption of fewer vegetables, fruits, and dairy and lower intake of several nutrients, including vitamin A, calcium, and magnesium (4). Furthermore, food insecurity is associated with diet-related chronic disease among low-income Americans (5).

The 2015-2020 Dietary Guidelines for Americans (DGA) recommend shifts in eating patterns to promote health and prevent disease among the US population. The recommended shifts in eating patterns are designed to increase consumption of nutrients that are currently consumed below the Estimated Average Requirement (EAR) or do not exceed Adequate Intake (AI) levels; these include potassium, dietary fiber, choline, magnesium, calcium, vitamins A, D, E, C and iron (among adolescent girls and women ages 19 to 50 years) (6). Of these under-consumed nutrients, calcium, potassium, dietary fiber, and vitamin D are considered “nutrients of public health concern” because the prevalently low intakes of these nutrients are associated with health consequences (6). The DGA recommends shifts to eat more vegetables, fruits, whole grains, and dairy to increase intake of nutrients of public health concern (6). The relationship between FI and diet quality was specifically identified in the Scientific Report of the 2015 Dietary Guidelines Advisory Committee to have insufficient evidence available (7). Thus, there is a critical need for studies that evaluate and specify the relationship between food security and diet. The highly-FI food pantry population serves as an opportune setting to evaluate dietary intake and quality.

Previous research suggests that although food pantry clients share a need for food assistance resources, this common experience may not result in similar diet quality or intake patterns among all clients (8). Very limited research has documented differences in the diets of FS, LFS, and VLFS groups who rely on emergency food assistance (9). Determining dietary pattern differences, including dietary quality, food groups and nutrients, by food security status is especially important among the pantry client population that may be particularly limited in terms of dietary selection. Furthermore, determination of the dietary patterns of FS, LFS, and VLFS food pantry clients will critically inform the creation of innovative strategies that are tailored to reach FI populations, as encouraged by the DGA (6). Differences among food pantry client dietary patterns by FS, LFS, and VLFS may also provide insight to the way that clients use food pantries as a resource to enhance food access.

The aim of this study was to compare dietary quality and the usual intake of under-consumed nutrients and related food groups in relation to the DGA among FS, LFS, and VLFS adult food pantry clients. Objectives were to 1) compare the diet quality of FS, LFS, and VLFS adult pantry clients using the Healthy Eating Index-2010 (HEI-2010), 2) compare the usual intake of nutrients and food groups of concern among FS, LFS, and VLFS clients using the National Cancer Institute (NCI) method, and 3) determine the proportion of FS, LFS, and VLFS clients who are consuming usual intakes below the EAR or not exceeding the AI for selected nutrients (10,11), as well as the proportions of clients consuming below DGA recommendations for selected food groups (6,12), in a multistate sample of 24 rural, Midwestern food pantries. FS clients were expected to consume diets of higher quality (HEI-2010) and usual intake (NCI method) compared to VLFS clients, and to a lesser extent, LFS clients. A high proportion of participants overall were expected have intakes below the EAR and to not exceed the AI for nutrients, and below DGA recommendations for food groups.

2.3 Methods

2.3.1 Study Design

Data from this cross-sectional, secondary analysis were drawn from the baseline assessment of a multi-state intervention study, Voices for Food (VFF), which was carried out in 24 rural, high poverty counties in Indiana (IN), Michigan (MI), Missouri (MO), Nebraska (NE), Ohio (OH), and South Dakota (SD) and aimed to improve food security among rural, Midwestern food pantry clients (Clinical Trial Registry: NCT0356609). A full description of VFF methods has been published in detail elsewhere (13).

2.3.2 Food Pantry Selection, Recruitment and Client Participants

In each state, four rural food pantries were selected according to previously-described criteria (13). Briefly, pantries were selected from counties defined as non-metro with poverty rates higher than 16% in 2011 (14), with Cooperative Extension presence, and without well-established food policy councils. A convenience sample of clients was recruited from the pantries from August to November 2014 through flyers that advertised the study during pantry operation hours, and by research staff approaching clients while they waited to receive food. Participants, screened by a trained interviewer, were English-speaking, adults age ≥ 18 years (or ≥ 19 years in Nebraska

indicating legal adult status) who used the food pantry at least one time in the previous 12 months, and who were receiving foods from the pantry on the day of recruitment. The [Blinded for Review] University and [Blinded for Review] University Institutional Review Boards approved research activities prior to beginning the study, and participants gave written or verbal consent before completing study materials. A total of 613 pantry clients were eligible and recruited; 579 (94%) with complete dietary and food security data were included in this analysis.

2.3.3 Assessments and Measures

2.3.3.1 Food pantry clients

Participants were interviewed at one of the participating food pantries by trained research staff and completed an electronic or paper version of a questionnaire that elicited information on demographic and pantry use characteristics, including age, sex, race, ethnicity, annual household income, education level, employment status, number of household members, number of children <18 years in the household, usual mode of transportation, participation in federal food assistance programs, frequency of visits to this pantry in the past year, and length of time that food from pantries lasts. The 18-item US Household Food Security Survey Module (US HFSSM) quantified food security status among household adults over the past year (15,16). Participants also completed the Automated Self-Administered 24-h Dietary Recall (ASA24™-2014), an internet-based 24-hour dietary recall (17), with optional staff assistance. Up to two additional dietary recalls were self-completed, or completed through an assisted phone interview, within two weeks of the pantry visit on non-consecutive days and including a weekend day (18). Participants received \$10 as compensation in the form of a grocery store gift card upon completion of the initial interview, and an additional gift card for each dietary recall completed.

2.3.4 Statistical Analysis

2.3.4.1 Characteristics tables

Variables were classed for analysis as follows: state (IN, MI, MO, NE, OH, SD); age (18-44, 45-64, ≥65 years); gender (woman, man); race (White, Black, American Indian, Other); ethnicity (of Hispanic, Latino or Spanish origin, not of Hispanic, Latino or Spanish origin); annual household income (<\$10,000, \$10,000-15,000, >\$15,000); education level (≤high school graduate or equivalent, ≥some college/trade school); employment status (employed for ≥6 months of the

past year, employed for <6 months of the past year); number of household members (1, 2, ≥ 3), number of children <18 years in the household (≥ 1 , 0); usual mode of transportation used to acquire food (drive themselves, other); frequency of visits to this pantry in the past year (<5 times, ≥ 5 times); number of different pantries visited in the past year (1, >1); length of time that food from pantries lasts (a few days' worth, 1-2 weeks' worth, more than half of food for the month); and having ≥ 1 family member participating in the following federal food assistance programs: Supplemental Nutrition Assistance Program, Meals on Wheels, Soup Kitchens, the Special Supplemental Nutrition Program for Women, Infants, and Children, free or reduced-price school meals, and free or reduced-price meals at summer programs (participating in ≥ 1 program, participating in 0 programs). Food security scores were used to create the following categories: FS, LFS, and VLFS. Total numbers and prevalence of pantry client demographic characteristics were calculated. Characteristics were compared across FS, LFS and VLFS groups using chi-squared analysis.

2.3.4.2 Application of the HEI-2010 to quantify client diet quality

Dietary information from ASA24™-2014 was used to determine HEI-2010 scores for each client over all recorded intake days (≤ 3) using the Simple HEI Scoring Algorithm – Per Person (19). The HEI-2010 is a density-based score (e.g., amount per 1,000 kcal, ratio of fatty acids) that measures adherence to the DGA, allowing examination of overall diet quality in relation to federal dietary guidance, as well as dietary patterns in terms of balance among multiple components to examine the quality of the mix of foods. The HEI-2010 is made up of nine adequacy components: total fruit (max score=5), whole fruit (max score=5), total vegetables (max score=5), greens and beans (max score=5), whole grains (max score=10), total dairy (max score=10), total protein foods (max score=5), seafood and plant proteins (max score=5), and fatty acids (max score=10), and three moderation components: refined grains (max score=10), sodium (max score=10), and empty calories [i.e., solid fat, alcohol, and added sugars; max score=20], most of which are expressed relative to energy intake (i.e., as densities) and then scored according to standards (20). For the adequacy components, a higher score indicates higher consumption; moderation components are reverse-scored, and thus a higher score indicates lower consumption. The 12 component scores are weighted to yield a HEI-2010 Total Score with maximum value of 100 (20). Because the data were

collected prior to the release of the 2015 DGA and HEI-2015, the HEI-2010 is appropriate to reflect the dietary standards in place at the time of data collection.

Multiple linear regression models with food security status as the main independent variable and total or component HEI-2010 scores (one score per person) as the outcome variables compared the mean difference in HEI-2010 score between FS, LFS, and VLFS groups controlling for potential confounding by state, age, gender, race, income, participation in federal food assistance programs, and frequency of visits to this pantry in the past year. Between-group comparisons for HEI-2010 scores were determined using ANOVA with the Least Squares Mean statement and Tukey adjustment for multiple comparisons. Statistical significance was determined at $p < 0.05$.

2.3.4.3 Application of the NCI method to quantify usual intake of nutrients and food groups of concern

The NCI method (21,22) was used to calculate the usual dietary intake of nutrients and food groups of public health concern. Up to three ASA24™-2014 recalls per participant were included in the analysis. When the percentage of participants who consumed a given food group/nutrient on each recall day was $\leq 5\%$, the food group/nutrient was treated as ubiquitously-consumed; when the percentage of non-consumption was $> 5\%$, the food group/nutrient was treated as episodically consumed (23). In this study, all nutrients were determined to be ubiquitously consumed, and all food groups episodically consumed. The NCI method uses a two-part model accounting for the probability of consumption and consumption-day amount on a given day, while allowing the random effects for both parts of the model to be correlated.

For the nutrients (ubiquitously-consumed), the probability of daily consumption was assumed to be one, and therefore a one-part “amount only” model was used. In this model, a Box-Cox transformation was applied to ≤ 3 days of 24-hour recall data and transformed observations were modeled using linear mixed effects models, with adjustment for covariates via fixed effects. The %MIXTRAN SAS macro (24) compared the pairwise effects of food security status (i.e., FS vs LFS, FS vs VLFS, LFS vs VLFS) on usual intake of nutrients. The %DISTRIB SAS macro (24) produced the mean usual intake for each food security subgroup and the proportions of participants consuming below the EAR (or exceeding the AI for nutrients without established EAR values). One hundred bootstrap samples of the %DISTRIB macro were generated with samples of 601 participants to obtain the standard deviation of the mean usual intake for each nutrient. Nutrients

(from foods and beverages only) included calcium (mg), magnesium (mg), potassium (mg), vitamin A (μg , RAE), vitamin C (mg), vitamin D (μg), iron (mg), choline (mg), vitamin B12 (μg), fiber (g), and vitamin E (mg). The main predictor in the models (separate model for each nutrient) for estimating usual intake was food security status. Potential confounders adjusted in the models were compressed into two levels to facilitate analysis; variable groupings with the lowest Akaike Information Criterion (AIC) were selected to ensure optimal model fit. Potential confounders were classed as follows: age (<65 , ≥ 65), gender (woman, man), race (White, Black/American Indian/Asian/Hawaiian/Other), annual household income ($<\$10,000$, $\geq \$10,000$), participation in food assistance programs (0 programs, ≥ 1 program), frequency of visits to this pantry over the past year (≥ 5 times, <5 times), state (MI/NE/SD, IN/MO/OH), and day of the week of dietary recall (weekday/weekend); interview sequence of the dietary recall (indicating the first 24-hour recall) and total energy intake (a continuous variable) were also included as covariates in all models.

For the food groups (episodically-consumed), the probability of daily consumption was not assumed to be one, and therefore the two-part model was used. The first part estimated the probability of consuming a food using logistic regression, while the second part was identical to the “amount only” model described for nutrients above. Potential confounders adjusted in the models were similarly compressed into two levels to facilitate analysis identical to that described in the nutrient analysis above. In order to compare the pairwise effects of food security status (i.e., FS vs LFS, FS vs VLFS, LFS vs VLFS) on usual intake of food groups, authors adapted the %DISTRIB macro to include an estimate statement described here (25). The ratio of means were computed for “low risk” and “high risk” covariate patterns, which were assigned using the covariate categories explained previously to determine the range of the effect of food security status on usual intake. Low risk reflected a pattern associated with higher intake of food groups: age ≥ 65 ; sex = Male; race = White; annual household income = $\geq \$10,000$; participation in food assistance programs = 0 programs; frequency of visits to this pantry over the past year ≥ 5 times; state = IN/MO/OH; day of the week of dietary recall = weekday. All models controlled for mean energy intake (1506.86 kilocalories) and a variable representing the interview sequence of the dietary recalls (indicating the first 24-hour recall). Effects of food security status on usual intake were expressed for high risk and low risk groups separately as ratios ($\frac{FS}{LFS}$, $\frac{FS}{VLFS}$, $\frac{LFS}{VLFS}$). Means and standard deviations of the usual intake and the proportions of clients consuming below the DGA recommended intakes for food groups were determined as described above for nutrients. Food

groups included total fruit (cup equivalents), total vegetables (cup equivalents), dark green vegetables (cup equivalents), whole grain (ounce equivalents), and total dairy (cup equivalents). All analyses were performed using SAS version 9.4 (26).

2.4 Results

Pantry clients (n=579) were predominantly white (79%), women (72%) between 18-64 years (81%), who achieved an education level of ‘high school graduate or equivalent’ or below (67%), were employed for <6 months over the course of the previous year (76%), participated in ≥1 federal food assistance program over the course of the previous year (80%), and were classified as FI (FI=78%; LFS=30%; VLFS=48%) (**Table 1**). When participants were compared by food security status, significant differences in characteristics were observed for state, age, participation in ≥1 federal food assistance program, and the number of times this pantry (where the participant was recruited) was visited in the previous 12 months. A lower proportion of VLFS clients (11%) reported being >65 years old compared to FS (31%) and LFS (47%) clients. A greater proportion of VLFS clients (86%) reported being enrolled in ≥1 federal food assistance program compared to FS (73%) and LFS (78%) clients. A greater proportion of LFS (52%) and VLFS (55%) clients reported visiting this pantry <5 times in the past year compared to FS (40%) clients.

Whole grains HEI-2010 score differed between FS and LFS pantry clients ($p=0.02$), with FS clients achieving an average of one point higher compared to LFS clients (**Table 2**). Mean usual intake of iron differed between FS and VLFS clients ($p=0.004$), with VLFS clients consuming an average of 0.7 milligrams less iron daily (**Table 3**). Over 90% of all clients (including FS, LFS and VLFS clients) consumed below the EARs for vitamin D and vitamin E and less than 10% of all clients exceeded the AIs for potassium, fiber, and choline (**Table 3**). Over 90% of all clients consumed below target recommendations for total fruit, total vegetables, dark green vegetables, total grains and total dairy food groups (**Table 4**). FS status compared to LFS status was associated with increased mean usual intakes of whole grains, dark green vegetables, and total dairy; increases ranged from 1.49 (for participants with otherwise ‘low risk’ covariate patterns, $p=0.009$) to 1.67 times higher (for subjects with otherwise ‘high risk’ covariate patterns, $p=0.005$) for whole grains, from 2.56 ($p=0.0005$) to 2.50 ($p=0.0009$) times higher for dark green vegetables, and from 1.28 ($p=0.02$) to 1.30 ($p=0.04$) times higher for total dairy (**Table 5**). FS status compared to VLFS status was associated with increased mean usual intakes of dark green

vegetables and total dairy; increases ranged from 2.44 ($p=0.001$) to 2.38 ($p=0.002$) times higher for dark green vegetables and from 1.32 ($p=0.007$) to 1.41 ($p=0.004$) times higher for total dairy (**Table 5**).

2.5 Discussion

This study represents the first comparison of diet quality (quantified using the HEI-2010) and usual intake of under-consumed nutrients and related food groups (quantified using the NCI method) among food pantry clients by FS, LFS, and VLFS subgroups. Evaluating these differences informs interventions to improve diet among the food pantry population and provides rationale for considering differences in food security. FS clients were expected to consume diets of higher quality (HEI-2010) and usual intake (NCI method) compared to VLFS clients and, to a lesser extent, LFS clients. FS status was associated with a higher whole grains HEI-2010 score, as well as a higher mean usual intake of whole grains and iron, compared to LFS status. FS status was associated with a higher mean usual intake of dark green vegetables and total dairy compared to both LFS and VLFS status. Contrary to the hypothesis, FS status had more associations with improved HEI scores and usual intake compared to LFS status, rather than VLFS status. A high proportion of clients were expected to have mean usual intakes of nutrients and food groups that did not meet dietary recommendations. Consistent with this hypothesis, over 90% of clients had intakes below the EAR for vitamin D and E, less than 10% of all clients exceeded the AI for potassium, fiber, and choline, and over 90% of all clients consumed below target recommendations for total fruit, total vegetables, dark green vegetables, total grains and total dairy food groups.

Similar to recent studies that evaluated dietary patterns in samples of rural, Midwestern food pantry clients, diet quality (measured by HEI-2010 total and component scores) was low (8,27). Diet quality in the present study was also low compared to the most recent estimate among the US population (HEI-2015 total score: 58.0) (28). HEI-2010 component scores for whole grains, greens and beans, whole fruit, and seafood and plant proteins were especially low in the present study. As with previous studies (8,27), these findings indicate a need to improve access to these dietary components in the food pantry setting. The very high prevalence (78%) of food insecurity among study participants in this rural, Midwestern sample was higher than the national prevalence of food insecurity among pantry clients (65%) and validates the known dietary quality deficits classified by food insecurity (1). This confirms a critical need for interventions to improve food

security through access to high quality foods in the extremely vulnerable subpopulation of food pantry clients.

One previous study investigated differences between dietary patterns of FS and FI clients in rural, Midwestern food pantries by evaluating changes in dietary patterns before and after pantry use by food security status (8). This previous study found more improvements in dietary patterns from before to after visiting a food pantry for FI clients compared to FS clients. Although this previous study focused on dichotomized food security status (i.e., FS vs FI) rather than the three levels of food security investigated in the present study, it laid the foundation for considering food security status when examining dietary intake among pantry clients. The present study expands upon this notion, providing evidence that, in addition to FS and FI clients consuming different quality diets, there are also differences in nutrient and food group intakes and dietary quality between FS clients and both the LFS and VLFS subgroups. Regarding dietary quality, FS client diets were higher in whole grains relative to calories compared to LFS clients, and were closer to DGA recommendations. Improving the access to and availability of whole grains at food pantries may ultimately improve client diet quality scores for all clients and for LFS clients in particular.

In addition to differences in diet quality, the present study established differences in usual intake (quantity consumed) among FS, LFS, and VLFS pantry clients. FS clients consumed more whole grains over the ≤ 3 recall days compared to LFS clients, consistent with the finding that FS clients' diets conformed more closely to the DGA regarding whole grain quality compared to LFS clients. Thus, FS clients not only consumed a higher proportion of whole grains relative to other food groups in their diets, but also consumed a higher quantity of whole grain foods compared to LFS clients. FS clients also consumed more iron compared to LFS clients over the recall period. Because cereal flours contain whole grains and are a common avenue of iron fortification (29), it is not surprising that FS clients had a higher intake of both whole grains and iron compared to LFS clients. FS clients consumed a higher mean usual intake of dark green vegetables and total dairy food groups compared to both LFS and VLFS clients, but did not have higher HEI-2010 components scores for total vegetables, greens and beans, and total dairy components. This finding suggests that although FS clients consumed a higher amount of dark green vegetables and dairy foods, they did not consume a higher proportion of these foods relative to other food groups in their diets compared to LFS and VLFS clients.

A recent systematic review documented lower intake of vegetables, fruit, dairy, vitamin A, calcium, and magnesium for FI adults compared to FS adults (4). Consistent with these findings, FS clients in the present study consumed more dark green vegetables and dairy compared to LFS and VLFS clients. Although the present study did not find significant differences in the intake of vitamin A, calcium, or magnesium between FS and FI clients (at $p < 0.0167$ to adjust for the three pairwise food security subgroup comparisons using Bonferroni method), p -values were <0.05 , suggesting a trend toward significance, for these nutrients. The present study did not find differences in fruit intake between FS and FI clients suggesting similar limited access among all food pantry clients.

Although the present study provided evidence for differences in diet quality and quantity by food security status, usual intake analysis showed that most nutrients and all food groups were under-consumed by almost all pantry clients, regardless of food security classification. This is not surprising since the nutrients and food groups investigated in this study are documented as under-consumed for all Americans, yet the overwhelming percentage in this sample not meeting the EAR or exceeding the AI was alarming (6). Under-consumption by all food security groups highlights the importance of interventions to improve dietary quality for all pantry clients. Discrepancies in intake between food security subgroups suggest there are particular foods and nutrients that dietary interventions should focus on to improve dietary disparities between clients and may cautiously inform other food-insecure population sub-groups. Findings from this study provide novel insights into differences in food security status that go beyond the common experiences of pantry clients relying on emergency food assistance.

2.5.1 Strengths

This study presented the first investigation of both diet quality and usual intake among food pantry clients. Both the proportions of food groups consumed relative to federal guidance, as well as the actual amounts consumed, were characterized by food security status. Investigation of both dietary quality and intake is critical to determining dietary patterns. HEI-2010 measures diet quality independent of quantity, specifically, how closely one's diet adheres to the Dietary Guidelines for Americans. Although this measure is meaningful, in low-income communities it is also important to consider the quantities of food groups and nutrients consumed. The authors responded to this critical need by applying the NCI method to determine usual intake of nutrients

and food groups of public health concern in the pantry-user population while also mitigating measurement error. The very high prevalence of FI allowed researchers to stratify the study sample by LFS and VLFS contributing the first comparison of consumption patterns between FS, LFS, and VLFS pantry clients and establishing differences between the dietary patterns of these subgroups. Another strength of this study is the collection of up to three 24-hour dietary recalls on non-consecutive days. This provided a more representative measure of client dietary intake compared to using a single dietary recall.

2.5.2 Limitations

Nutrient intake in the present study was compared to EAR and AI values for females between 31-50 years. Although the study population was mostly females in this age range, it also included a small proportion of males and older adults; federal guidance for markers of adequacy for nutrients are generally higher for males, and thus the proportion not meeting requirements may have been under-estimated for males in the sample. The 24-hour recalls used to measure diet quality and quantity in this study did not account for supplements; resulting estimates do not represent total intake. Under-reporting of energy intake when using 24-hour dietary recalls is known (30) and could have contributed to bias in this study; however, a recent study reported the ASA24 to perform relatively well among women with low incomes (18). Compensation of up to \$30 in the form of grocery store gift cards could have resulted in higher quality and/or quantity of foods being purchased at stores and may have introduced bias to the second and third dietary recalls that were collected after the day of recruitment. Food security status was associated with dietary quality and intake in this study; however, food security assessment has a reference intake period of 12 months while the reference period of dietary assessment was \leq two weeks. Thus, food security status did not necessarily reflect the household's experience during data collection, as households might experience episodes of food insecurity throughout the year due to changes in circumstances (1).

2.5.3 Conclusions

Food security was associated with a higher whole grains HEI-2010 score, as well as a higher mean usual intake of whole grains and iron, compared to low food security among food pantry clients. Food security was also associated with a higher mean usual intake of dark green

vegetables and total dairy compared to both low food security and very low food security among food pantry clients. FS, LFS and VLFS pantry clients showed differences in dietary quality and usual intake, suggesting that food security status may be associated with dietary patterns, even among the vulnerable food pantry client sample. However, all pantry clients, regardless of food security status, consumed less than federal guidelines and markers of adequacy for most nutrients and food groups evaluated in this study. Further research is needed to characterize differences in dietary patterns between the food security subgroups, and whether FS, LFS, and VLFS pantry clients use pantry resources differently.

2.6 Author Contributions

B.N.W. and H.A.E.-M. conceived the research question; B.N.W. analyzed the data; H.A.E.-M. and J.A.T. supervised analysis of the data; B.N.W. interpreted the data; B.N.W., L.M., S.S., L.F.-C., B.H., D.M., D.R. and H.A.E.-M. acquired the data; B.N.W. drafted the manuscript; B.N.W., J.A.T., R.L.B., Y.L., R.L.R., L.M., S.S., L.F.-C., B.H., D.M., D.R. and H.A.E.-M. critically reviewed the manuscript for important intellectual content and approved the final version.

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2.8 References

1. Coleman-Jensen A, Rabbitt MP, Gregory CA, Singh A. Statistical Supplement to Household Food Security in the United States in 2016. 2017; Available from: <https://www.ers.usda.gov/webdocs/publications/84981/ap-077.pdf?v=42979>
2. Anderson SA. Core Indicators of Nutritional State for Difficult-to-Sample Populations. *J Nutr*. 1990;120:1555–600.
3. United States Department of Agriculture Economic Research Service. Definitions of Food Security [Internet]. [cited 2018 Oct 18]. Available from: <https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/definitions-of-food-security.aspx>
4. Hanson KL, Connor LM. Food insecurity and dietary quality in US adults and children : a systematic review. 2014;684–92.

5. Seligman HK, Laraia BA, Kushel MB. Food Insecurity Is Associated with Chronic Disease among Low-Income. *J Nutr.* 2011;141:542.
6. U.S. Department of Health and Human Services and U.S. Department of Agriculture. Dietary Guidelines for Americans 2015-2020 [Internet]. 8th ed. 2015. Available from: https://health.gov/dietaryguidelines/2015/resources/2015-2020_Dietary_Guidelines.pdf
7. U.S. Department of Health and Human Services and U.S. Department of Agriculture. Scientific Report of the 2015 Dietary Guidelines Advisory Committee. 2015.
8. Wright BN, Bailey RL, Craig BA, Mattes RD, McCormack L, Stluka S, Franzen-Castle L, Henne B, Mehrle D, Remley D, et al. Daily dietary intake patterns improve after visiting a food pantry among food-insecure rural midwestern adults. *Nutrients.* 2018;10.
9. Tarasuk VS, Beaton GH. Women's dietary intakes in the context of household food insecurity. *Am Soc Nutr Sci.* 1999;129:672–9.
10. National Academies Institute of Medicine Food and Nutrient Board. Dietary Reference Intakes: Macronutrients [Internet]. 2005. Available from: http://www.nationalacademies.org/hmd/~/media/Files/Activity%20Files/Nutrition/DRI-Tables/8_Macronutrient%20Summary.pdf
11. National Academies Institute of Medicine Food and Nutrient Board. Dietary References Intakes: Estimated Average Requirements [Internet]. 2011. Available from: <http://www.nationalacademies.org/hmd/~/media/Files/Activity%20Files/Nutrition/DRI-Tables/5Summary%20TableTables%2014.pdf?la=en>
12. United States Department of Agriculture Center for Nutrition Policy and Promotion. Healthy US-Style Pattern-Recommended Intake Amounts [Internet]. 2018. Available from: https://www.cnpp.usda.gov/sites/default/files/usda_food_patterns/HealthyUS-StylePattern-RecommendedIntakeAmounts.pdf
13. [Blinded for review]. Voices for food: Methodologies for implementing a multi-state community-based intervention in rural, high poverty communities. [Blinded for Review];
14. U.S. Department of Agriculture Economic Research Service. County-Level Data Sets. 2011.
15. Bickel G, Nord M, Price C, Hamilton W, Cook J. Guide to Measuring Household Food Security [Internet]. 2000. Available from: <https://fns-prod.azureedge.net/sites/default/files/FSGuide.pdf>
16. United States Department of Agriculture Economic Research Service. U.S. Adult Food Security Survey Module: Three-Stage Design, with Screeners [Internet]. 2012. Available from: <https://www.ers.usda.gov/media/8279/ad2012.pdf>

17. Subar AF, Kirkpatrick SI, Mittl B, Zimmerman TP, Thompson FE, Bingley C, Willis G, Islam NG, Baranowski T, McNutt S, et al. The Automated Self-Administered 24-Hour Dietary Recall (ASA24): A Resource for Researchers, Clinicians and Educators from the National Cancer Institute. 2012;112:1134–7.
18. Kirkpatrick SI, Guenther PM, Douglass D, Zimmerman T, Kahle LL, Atoloye A, Marcinow M, Savoie-Roskos MR, Dodd KW, Durward C. The Provision of Assistance Does Not Substantially Impact the Accuracy of 24-Hour Dietary Recalls Completed Using the Automated Self-Administered 24-Hour Dietary Assessment Tool among Women with Low Incomes. *J Nutr* [Internet]. 2019;1–9. Available from: <https://academic.oup.com/jn/advance-article/doi/10.1093/jn/nxy207/5271166>
19. National Cancer Institute Division of Cancer Control & Population Sciences. Healthy Eating Index SAS Code [Internet]. [cited 2018 Sep 1]. Available from: <https://epi.grants.cancer.gov/hei/sas-code.html>
20. Guenther PM, Kirkpatrick SI, Reedy J, Krebs-Smith SM, Buckman DW, Dodd KW, Casavale KO, Carroll RJ. The Healthy Eating Index-2010 Is a Valid and Reliable Measure of Diet Quality According to the 2010 Dietary Guidelines for Americans. *J Nutr* [Internet]. 2014;144:399–407. Available from: <http://jn.nutrition.org/cgi/doi/10.3945/jn.113.183079>
21. Tooze JA, Midthune D, Dodd KW, Freedman LS, Krebs-Smith SM, Subar AF, Guenther PM, Carroll RJ, Kipnis V. A new method for estimating the usual intake of episodically-consumed foods with application to their distribution. 2006;106:1575–87.
22. Tooze JA, Kipnis V, Buckman DW, Carroll RJ, Freedman LS, Guenther PM, Krebs-Smith SM, Subar AF, Dodd KW. A mixed-effects model approach for estimating the distribution of usual intake of nutrients: The NCI method. 2010;29.
23. National Cancer Institute. Describing Dietary Intake [Internet]. [cited 2019 Jan 11]. Available from: <https://dietassessmentprimer.cancer.gov/approach/intake.html>
24. National Cancer Institute. Usual Dietary Intakes: SAS Macros for the NCI Method [Internet]. [cited 2019 Jan 11]. Available from: <https://epi.grants.cancer.gov/diet/usualintakes/macros.html>
25. Tooze JA, Grunwald GK, Jones RH. Analysis of repeated measures data with clumping at zero. *Stat Methods Med Res*. 2002;
26. SAS Institute Inc. Cary, NC, USA: Version 9.4;
27. Wright BN, MacDermid Wadsworth S, Wellnitz A, Eicher-Miller HA. Reaching rural veterans: a new mechanism to connect rural, low-income US Veterans with resources and improve food security. *J Public Health (Bangkok)* [Internet]. 2018;1–10. Available from: <https://academic.oup.com/jpubhealth/advance-article/doi/10.1093/pubmed/fdy203/5187707>

28. United States Department of Agriculture Center for Nutrition Policy and Promotion. What We Eat in America/National Health and Nutrition Examination Survey, 2013-2014. Healthy Eating Index-2015 Scores. 2015;2020. Available from: https://www.cnpp.usda.gov/sites/default/files/healthy_eating_index/HEI2015-ScoresForAmericans.pdf
29. Uauy R, Hertrampf E, Reddy M. Iron Fortification of Foods: Overcoming Technical and Practical Barriers. *J Nutr.* 2002;132:806S–812S.
30. Murakami K, Livingstone MBE. Prevalence and characteristics of misreporting of energy intake in US adults: NHANES 2003-2012. *Br J Nutr.* 2015;114:1294–303.

2.9 Results Tables

Table 2-1 Unadjusted sociodemographic characteristics of food pantry clients from rural, Midwestern, food pantries in the Voices for Food study by adult food security status ($n=579$)

Characteristics	All Clients	Food secure	Low food secure	Very low food secure	Chi-squared
	<i>n</i> (%) ^a	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>p</i> -value
Total	579 (100)	131 (23)	172 (30)	276 (48)	
State					0.01*
Indiana	151 (26)	30 (23)	39 (23)	82 (30)	
Michigan	98 (17)	17 (13)	33 (19)	48 (17)	
Missouri	140 (24)	33 (25)	37 (22)	70 (25)	
Nebraska	50 (9)	10 (8)	24 (14)	16 (6)	
Ohio	78 (13)	20 (15)	18 (10)	40 (14)	
South Dakota	62 (11)	21 (16)	21 (12)	20 (7)	
Gender					0.51
Men	137 (28)	34 (30)	46 (30)	57 (26)	
Women	350 (72)	79 (70)	105 (70)	166 (74)	
Age, years					0.0002*
18-44	182 (37)	36 (32)	50 (33)	96 (42)	
45-64	215 (44)	43 (38)	66 (43)	106 (47)	
≥65	96 (19)	35 (31)	36 (47)	25 (11)	
Race					0.40
White	380 (79)	87 (78)	116 (80)	177 (78)	
Black	40 (8)	12 (11)	12 (8)	16 (7)	
American Indian	38 (8)	10 (9)	12 (8)	16 (7)	
Other ^b	25 (5)	3 (3)	5 (3)	17 (8)	
Highest education level					0.60
≤High school graduate or equivalent	331 (67)	77 (68)	105 (70)	149 (65)	
≥Some college/trade school	162 (33)	37 (32)	45 (30)	80 (35)	
Employment status ^c					0.39

Characteristics	All Clients	Food secure	Low food secure	Very low food secure	Chi-squared
	n (%) ^a	n (%)	n (%)	n (%)	p-value
Employed ≥6 months	133 (24)	32 (25)	45 (26)	56 (21)	
Employed <6 months	428 (76)	94 (75)	125 (74)	209 (79)	
Income ^d					0.06
<\$10,000	292 (54)	56 (56)	77 (50)	159 (60)	
\$10,000 - \$15,000	112 (21)	31 (25)	37 (24)	44 (17)	
>\$15,000	136 (25)	35 (29)	40 (26)	61 (23)	
Household size ^c					0.34
1 member	173 (30)	41 (32)	57 (33)	75 (27)	
2 members	135 (23)	36 (28)	35 (20)	64 (23)	
≥3 members	268 (47)	53 (41)	79 (46)	136 (49)	
Participation in food assistance programs ^{c,e}					0.009*
≥1 program	466 (80)	96 (73)	134 (78)	236 (86)	
0 programs	113 (20)	35 (27)	38 (22)	40 (14)	
Estimated amount of household foods from all pantries in the last month					0.12
A few days' worth	243 (45)	44 (39)	67 (42)	132 (51)	
1-2 weeks' worth	187 (35)	40 (35)	61 (38)	86 (33)	
More than half of food for the month	105 (20)	29 (26)	33 (21)	43 (16)	
Number of pantries visited ^c					0.16
1 pantry	265 (48)	67 (55)	79 (47)	119 (45)	
>1 pantry	291 (52)	55 (45)	88 (53)	148 (55)	
Number of times this pantry was visited ^c					0.02*
<5 times	294 (51)	53 (40)	89 (52)	152 (55)	
≥5 times	285 (49)	78 (60)	83 (48)	124 (45)	

^aTotals may not add up to total participants due to missing values.

^b Includes Native Hawaiian, Asian, and any combinations of races.

^c Over the past 12 months.

^d Self-reported total combined income of all household members over the past 12 months including income from jobs, business, pensions, Social Security or retirement payments, disability payments, and any other money income received.

^c Includes the Supplemental Nutrition Assistance Program; Meals on Wheels; Soup Kitchens; the Special Supplemental Nutrition Program for Women, Infants, and Children; free or reduced-price school meals; and free or reduced-priced meals at summer programs.

* Statistical significance is $p<0.05$ for chi-squared comparisons between food secure, low food secure and very low food secure households.

Table 2-2 Association^a of adult food security status and Healthy Eating Index-2010 (HEI-2010) scores in a sample of rural, Midwestern, food pantry clients

HEI-2010 component (maximum score)	Mean ± standard deviation ^b			<i>p</i> -values for Mean Differences ^{b,c}		
	Food secure (FS)	Low food secure (LFS)	Very low food secure (VLFS)	FS vs LFS	FS vs VLFS	LFS vs VLFS
Total score (100)	45.3 ± 1.5	42.2 ± 1.4	43.2 ± 1.4	0.13	0.36	0.74
Total vegetables (5)	3.3 ± 0.2	3.4 ± 0.2	3.3 ± 0.2	0.75	0.94	0.89
Greens and beans (5)	1.4 ± 0.2	1.3 ± 0.2	1.0 ± 0.2	0.81	0.14	0.36
Total fruit (5)	1.9 ± 0.2	1.8 ± 0.2	1.9 ± 0.2	0.98	1.00	0.96
Whole fruit (5)	1.6 ± 0.3	1.4 ± 0.2	1.5 ± 0.2	0.79	0.85	0.99
Whole grains (10)	2.8 ± 0.4	1.8 ± 0.3	2.4 ± 0.3	0.02*	0.51	0.15
Total dairy (10)	4.4 ± 0.4	3.9 ± 0.4	3.4 ± 0.4	0.47	0.06	0.49
Total protein foods (5)	4.3 ± 0.2	4.5 ± 0.1	4.4 ± 0.1	0.48	0.88	0.69
Seafood & plant proteins (5)	1.4 ± 0.2	1.2 ± 0.2	1.0 ± 0.2	0.68	0.20	0.64
Fatty acids (10)	4.1 ± 0.4	4.3 ± 0.4	4.5 ± 0.4	0.88	0.62	0.89
Sodium (10)	2.6 ± 0.4	2.7 ± 0.4	2.9 ± 0.4	1.00	0.74	0.75
Refined grains (10)	6.9 ± 0.5	6.2 ± 0.4	6.8 ± 0.4	0.30	1.00	0.24
Empty calories (20)	10.6 ± 0.8	9.7 ± 0.7	10.1 ± 0.7	0.49	0.78	0.83

^a Models were structured as follows: HEI_{client}= client_food_security_status + covariates. All models were evaluated for potential confounding presented by the following covariates: state, age, sex, race and income, participation in ≥1 federal food assistance programs, number of times visited this pantry in the last 12 months.

^b Least Squares Means separation

^c Tukey's adjustment for multiple comparisons

* Statistical significance was determined at *p* < 0.05.

Table 2-3 Association^a of adult food security status and usual intake of under-consumed nutrients in rural, Midwestern, food pantry clients

Table 3: Association^a of adult food security status and usual intake of under-consumed nutrients in rural, Midwestern, food pantry clients

Nutrient (Estimated Average Requirement [EAR] or Adequate Intake [AI] level)	Proportion below EAR or above AI			Mean usual intake \pm standard deviation by food security status ($n = 448$)			<i>p</i> -values for mean differences		
	Food secure (FS)	Low food secure (LFS)	Very low food secure (VLFS)	FS	LFS	VLFS	FS vs LFS	FS vs VLFS	LFS vs VLFS
Energy, kcal/day	-	-	-	1134 \pm 134	1113 \pm 127	1065 \pm 120	0.50	0.06	0.01
Potassium, mg/day (4700 ^b)	0.01	0.03	0.01	1407 \pm 93	1481 \pm 99	1224 \pm 84	0.27	0.42	0.68
Dietary fiber, g/day (25 ^c)	0.02	0.03	0.02	7.9 \pm 0.5	8.3 \pm 0.5	6.9 \pm 0.5	0.10	0.02	0.57
Choline, mg/day (425 ^b)	0.06	0.08	0.05	184 \pm 12	195 \pm 13	160 \pm 11	0.10	0.08	0.99
Magnesium, mg/day (265 ^d)	0.89	0.87	0.91	141 \pm 9	149 \pm 9	123 \pm 8	0.03	0.14	0.28
Calcium, mg/day (800 ^d)	0.84	0.79	0.86	476 \pm 34	515 \pm 40	433 \pm 38	0.19	0.04	0.41
vitamin A, μ g, RAE/day (500 ^d)	0.79	0.74	0.86	342 \pm 25	364 \pm 30	300 \pm 26	0.02	0.02	0.96
vitamin D, μ g/day (10 ^d)	0.98	0.97	0.98	2.4 \pm 0.2	2.6 \pm 0.2	2.1 \pm 0.2	0.34	0.19	0.76
vitamin E, alpha-tocopherol, mg/day (12 ^d)	0.98	0.96	0.98	3.7 \pm 0.3	4.0 \pm 0.3	3.3 \pm 0.2	0.80	0.14	0.28
vitamin C, mg/day (60 ^d)	0.78	0.77	0.82	38.1 \pm 3.2	40.5 \pm 3.7	33.9 \pm 3.7	0.96	0.95	0.97
Iron, mg/day (8.1 ^d)	0.53	0.52	0.63	8.2 \pm 0.6	8.9 \pm 0.7	7.4 \pm 0.6	0.04	0.004*	0.47

^a Model followed guidelines described for calculating usual intake according to the National Cancer Institute method, and were structured as: HEI_{client}= energy + weekday/weekend identifier + 24-hour recall sequence identifier + client food security status + covariates. All models were evaluated for potential confounding presented by the following covariates: state, age, sex, race and income, participation in ≥ 1 federal food assistance programs, number of times visited this pantry in the last 12 months.

^b AI for micronutrients – females 31-50 years (11)

^c AI for fiber – females 31-50 years (10)

^d EAR for micronutrients – females 31-50 years (11)

* Statistical significance was determined at $p < 0.0167$ to adjust for multiple comparisons using Bonferroni method.

Table 2-4 Mean usual intakes of food groups and proportions below target recommendations by adult food security status in rural, Midwestern, food pantry clients

Food group (target ^a)	Food security status	Mean ± standard deviation (n = 448)	Proportion below target
Total fruit (1.5 cup equiv./day)	Food secure	0.53 ± 0.06	0.95
	Low food secure	0.53 ± 0.06	0.94
	Very low food secure	0.45 ± 0.05	0.96
Total vegetables (2 cup equiv./day)	Food secure	1.23 ± 0.09	0.93
	Low food secure	1.33 ± 0.09	0.90
	Very low food secure	1.14 ± 0.08	0.94
Dark green vegetables (0.2 ^b cup equiv./day)	Food secure	0.06 ± 0.01	0.96
	Low food secure	0.06 ± 0.01	0.96
	Very low food secure	0.05 ± 0.01	0.97
Whole grains (3 ounce equiv./day)	Food secure	0.56 ± 0.06	1.00
	Low food secure	0.58 ± 0.05	0.99
	Very low food secure	0.46 ± 0.06	1.00
Total dairy (3 cup equiv./day)	Food secure	1.10 ± 0.11	0.97
	Low food secure	1.27 ± 0.11	0.95
	Very low food secure	1.06 ± 0.12	0.97

^a Target values based on Healthy US-style Food Patterns recommendations from the 2015-2020 Dietary Guidelines for Americans for minimal calorie intake for adults (1600 kcal) because the average calorie intake in the sample was 1506.86 kcal (12). The study population mean kcal was 1506.86.

^b Dark green vegetables recommendation is 1.5 cup equiv./week. 1.5/7=0.214 cup equiv./day

Table 2-5 Association^a of adult food security status and usual intake of food groups for ‘high risk’ and ‘low risk’ covariate patterns in rural, Midwestern, food pantry clients

Food group	Covariates (a-h)								Ratios of mean usual intake between adult food secure (FS), low food secure (LFS), and very low food secure (VLFS)			
	Risk	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	clients	(<i>p</i> -values)	
	Level	Age	Sex	Race	Income	Participation	Frequency	State	Weekday/ Weekend	$\frac{FS}{LFS}$	$\frac{FS}{VLFS}$	$\frac{LFS}{VLFS}$
Total fruit	High	<45y	F	Black, Other	<\$10,000	≥1 program	<5 times	MI, NE, SD	Weekend	1.15 (0.54)	1.25 (0.28)	1.09 (0.69)
	Low	≥45y	M	White	≥\$10,000	0 programs	≥5 times	IN, MO, OH	Weekday	1.19 (0.51)	1.39 (0.18)	1.16 (0.55)
Total vegetables	High	<45y	F	Black, Other	<\$10,000	≥1 program	<5 times	MI, NE, SD	Weekend	1.05 (0.58)	1.02 (0.84)	0.97 (0.70)
	Low	≥45y	M	White	≥\$10,000	0 programs	≥5 times	IN, MO, OH	Weekday	1.05 (0.60)	1.02 (0.83)	0.92 (0.73)
Dark green vegetables	High	<45y	F	Black, Other	<\$10,000	≥1 program	<5 times	MI, NE, SD	Weekend	2.50 (0.0009*)	2.38 (0.002*)	0.97 (0.94)
	Low	≥45y	M	White	≥\$10,000	0 programs	≥5 times	IN, MO, OH	Weekday	2.56 (0.0005*)	2.44 (0.001*)	0.94 (0.91)
Whole grains	High	<45y	F	Black, Other	<\$10,000	≥1 program	<5 times	MI, NE, SD	Weekend	1.67 (0.005*)	1.37 (0.11)	0.82 (0.42)

	Low	$\geq 45y$	M	White	$\geq \$10,000$	0 programs	≥ 5 times	IN, MO, OH	Weekday	1.49	1.25	0.83
										(0.009*)	(0.18)	(0.35)
Total dairy	High	<45y	F	Black, Other	<\$10,000	≥ 1 program	<5 times	MI, NE, SD	Weekend	1.30	1.41	1.09
										(0.04*)	(0.004*)	(0.53)
	Low	$\geq 45y$	M	White	$\geq \$10,000$	0 programs	≥ 5 times	IN, MO, OH	Weekday	1.28	1.32	1.02
										(0.02*)	(0.007)	(0.82)

^a Authors adapted the National Cancer Institute method to include estimate statements described by Tooze et al., 2002 that calculated ratios of usual intake by food security subgroups ($\frac{FS}{LFS}$, $\frac{FS}{VLFS}$, $\frac{LFS}{VLFS}$). Energy was set equal to the mean, 1506.86 kilocalories.

^b Interpretation: [numerator of ratio (food security category)] compared to [denominator of ratio (food security category)] is associated with an increased mean usual intake of [food group]. The increase ranged from ['low risk' ratio] times (for participants with otherwise 'low risk' covariate patterns) to ['high risk' ratio] times (for participants with otherwise 'high risk' covariate patterns). Example: "Food secure status compared to low food secure status was associated with increased mean usual intake of whole grains. The increase ranged from 1.5 times (for participants with otherwise 'low risk' covariate patterns) to 1.7 times (for subjects with otherwise 'high risk' covariate patterns).

CHAPTER 3. THE QUALITY OF FOOD BAGS DISTRIBUTED TO CLIENTS IS POSITIVELY ASSOCIATED WITH CLIENTS' DIET QUALITY IN A MULTISTATE SAMPLE OF RURAL, MIDWESTERN FOOD PANTRIES^{1,2,3}

Wright BN, Vasquez-Mejia CM, Guenther PM, McCormack L, Stluka S, Franzen-Castle L, Henne B, Mehrle D, Remley D, Eicher-Miller HA. The quality of food bags distributed to clients is positively associated with clients' diet quality in a multistate sample of rural, Midwestern food pantries. Submitted to J Nutr on February 4, 2019.

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FOOTNOTES:

¹ Abbreviations used:

FS: Food secure
 FI: Food Insecure
 LFS: Low food secure
 VLFS: Very low food secure
 HEI-2010: Healthy Eating Index-2010
 ASA24: Automated Self-Administered 24-hour Dietary Recall
 US HFSSM: US Household Food Security Survey Module
 TEFAP: The Emergency Food Assistance Program
 DGA: Dietary Guidelines for Americans
 GCC: Guided client choice
 VFF: Voices for Food
 USDA: United States Department of Agriculture
 FPED: Food Patterns Equivalents Database
 FNDDS: Food and Nutrient Database for Dietary Studies
 RD: Registered Dietitian
 SEM: Social Ecological Model

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³ The authors have no conflicts of interest to declare.

3.1 Abstract

Background: Food provided by food pantries has the potential to improve the dietary quality of food pantry clients.

Objective: This study evaluated the relationship between the quality of the mix of foods in pantry inventories and client food bags (separately) with client diet quality, and how these relationships varied by food secure (FS), low food secure (LFS), or very low food secure (VLFS) status.

Methods: This study was a cross-sectional secondary analysis drawn from a larger multi-state intervention (Clinical Trial Registry: NCT0356609). Adult clients ($n=618$) from 24 rural, Midwestern food pantries completed a demographic survey, the US Household Food Security Survey Module, and up to three 24-hour dietary recalls. Pantry inventories, client food bags, and client diets were scored using the Healthy Eating Index-2010 (HEI-2010). Multiple linear regression models determined associations between HEI-2010 total and component scores for pantry inventories and client food bags (in separate models) and the corresponding scores for client dietary intake. The interaction of client food security status, and several pantry- and client-level potential confounders, was considered.

Results: Client food bag HEI-2010 scores were positively associated with client diet scores for the Total Vegetables, Total Fruit, Total Protein Foods, and Sodium components, while pantry inventory HEI-2010 scores were negatively associated with client diet scores for the total score and for the Total Fruit and Fatty Acids components. Client food bag Whole Grains scores were more positively associated with corresponding client diet scores for VLFS clients compared to FS clients. Inventory Greens and Beans scores were more positively associated with corresponding client scores for VLFS clients compared to LFS clients. ($p<0.05$ for all results).

Conclusions: The nutritional quality of client food bags, but not pantry inventories, is positively associated with client diet in a sample of rural, Midwestern food pantry clients; associations differ by food security status.

3.2 Introduction

Food insecurity, or limited or uncertain ability to acquire nutritionally adequate and safe foods (1), is a persistent public health concern (2). Food insecurity is associated with lower intakes of fruits, vegetables, and dairy (3), diet-related health conditions, including diabetes, hypertension,

and hyperlipidemia (4), and was recently recognized by the Dietary Guidelines for Americans as a critical contextual factor to consider to enhance interventions (5). Individuals who are food insecure (FI) may seek out assistance from food pantries, which provide food at no cost and with minimal eligibility requirements, in an effort to maximize all resources in their environments. Although most clients are not completely reliant on pantries for food, food pantries may be responsible for up to 25% of the household food supply (6). Food pantries were traditionally a short-term solution for acute “emergency” situations like job loss, illness, or natural disasters. More recently, prevalence of chronic food pantry use has increased (7).

The quality of the mix of foods offered by pantries, rather than quantity only, is important in this context of long-term food pantry use. A recent systematic review documented that food bags distributed to clients at food pantries did not provide adequate amounts and types of food necessary for a balanced diet (8). The diets of pantry clients were similarly of low quality, particularly low in fruits and vegetables, dairy products, and calcium (9,10). Together, these findings suggest there may be a link between client dietary intake and the “pantry food environment,” defined here as the mix of foods stocked at the pantry (“pantry inventory”) and the mix of foods distributed to clients (“client food bags”). Client food bags are derived from food pantry inventory; client diets may be partially derived from client food bags, although they receive foods from other sources as well. Understanding the association of both pantry inventory quality and client food bag quality with client diet quality can serve to inform future initiatives to improve food pantry offerings by indicating the potential to improve client dietary quality through increasing the quality of the mix of foods available or distributed to clients at pantries.

Food security status of the food pantry client may mediate links between the pantry food environment and client diet quality. Although most US food pantry clients (65%) are FI, a substantial proportion (35%) are food secure (FS) (11). Previous research suggests that FS and FI clients may use pantries differently (12–15). FI pantry clients who may be experiencing low food security (LFS), which is characterized as having reduced quality, variety, and desirability of diet, or very low food security (VLFS), which is additionally characterized by reduced quantity of food (16), may generally use pantries short-term in response to a dire situation. FS pantry clients, on the other hand, generally use pantries as a long-term buffer to maintain food security (10). Thus, the relationship between the quality of the pantry food environment and client diet quality may differ based on food security status.

The aim of this study was to determine associations of the quality of the mix of foods, measured by applying the Healthy Eating Index 2010 (HEI-2010), of both pantry inventories and client food bags with client diet quality, as well as whether FS, LFS, or VLFS status interacts with these associations. HEI-2010 total and component scores of client food bags were hypothesized to predict corresponding HEI-2010 scores for client diet quality; similarly, HEI-2010 total and component scores of food pantry inventories were expected to be associated with corresponding client diet quality HEI-2010 scores but to a lesser extent compared to client food bags. Client food security status was hypothesized to interact with these associations, indicating differential pantry use among FS, LFS, and VLFS clients.

3.3 Methods

3.3.1 Study Design

Data for this cross-sectional, secondary analysis were drawn from the baseline assessment of a larger multi-state intervention, Voices for Food (VFF), which was conducted in 24 rural, high poverty counties in Indiana (IN), Michigan (MI), Missouri (MO), Nebraska (NE), Ohio (OH), and South Dakota (SD), and aimed to improve food security among rural, Midwestern food pantry clients (Clinical Trial Registry: NCT0356609). A full description of VFF methods has been reported (17).

3.3.2 Pantry Selection, Recruitment and Client Participants

Four rural food pantries per state were selected in 2013 (24 pantries total); selection criteria were described previously (17). A convenience sample of clients were recruited from the pantries from August to November 2014 through flyers that advertised the study during pantry operation hours and by research staff approaching clients while they waited to receive food. Participants, screened by a trained interviewer, were English-speaking, adults age ≥ 18 years (or ≥ 19 years in Nebraska indicating legal adult status) who had used the food pantry at least one time in the previous 12 months prior to the day of recruitment and who were receiving foods from the pantry on the day of recruitment. The [Blinded for Review] University and [Blinded for Review] University Institutional Review Boards approved research activities prior to beginning the study, and participants gave written or verbal consent before completing study materials. A total of 618

pantry clients were eligible and recruited; 604 (98%) with complete dietary and food security data were included in this analysis.

3.3.3 Assessments and Measures

3.3.3.1.1 Pantry food environment

Research staff recorded an inventory of all food and beverage items available at each food pantry on a single day at the start of the client recruitment period. Staff also recorded all food/beverage items that were distributed to clients by the pantry on recruitment day (client food bags). Food/beverage item name, brand name, additional description (i.e., “low sodium,” “sugar free”), weight/volume, food form (fresh, frozen, etc.), and quantity were recorded and compiled into a database (N=152,408 pantry inventory items; N=17,831 client food bag items). Before the start of the VFF study, research staff administered a “site selection” survey to pantry directors through open-ended interview questions to identify eligible communities for participation (17). Notably, food pantries with the least amount of client choice of the foods distributed in client food bags, and pantries that had not established food policy councils, were preferred in site selection because these were planned components of the intervention. Authors gleaned pantry-level characteristics from site selection survey responses that were later classed into the following variable levels: average number of households served per month (<100, ≥ 100), predominant racial/ethnic group served (White, Other), number of refrigerators (<2, ≥ 2), number of freezers (<4, ≥ 4), government commodity program participation (None, The Emergency Food Assistance Program (TEFAP), TEFAP and the Commodity Supplemental Food program), and “guided client choice (GCC) score” (<5, ≥ 5). GCC was conceptualized as a variable component of the pantry environment that may foster or hinder client pantry use (18). The term “GCC” includes client choice of the foods received from the pantry, but is also used in this study to capture other components of the food acquisition process that contribute to clients’ experiences—namely, nutrition education and cultural sensitivity towards clients. Six questions from the site selection survey were grouped as a rudimentary tool to quantify and score GCC by adding the number of negative responses (indicating fewer indications of GCC) to “yes or no” questions regarding the food distribution system and staff-client interactions in the food pantry. A score of 0 indicated high GCC, while a score of 6 indicated no GCC. Questions included: 1) “Is there a food distribution system in place where clients get a specific number of choices from certain categories (cereals,

soups, vegetables, etc.)?"; 2) "Are clients allowed a limited number of choices from MyPlate food groups, in addition to combination and miscellaneous groups?"; 3) "Are clients allowed to physically remove food from the shelf and place in their cart or bag?"; 4) "Is there an effort to integrate nutrition education within the act of choice (MyPlate posters visible, etc.)?"; 5) "Do volunteers promote nutrition?; and 6) Are volunteers trained in cultural competency?"

3.3.3.1.2 Food pantry clients

Participants were interviewed at the pantry by trained research staff and completed an electronic or paper version of a questionnaire that elicited information on demographic and pantry use characteristics via categorical responses that were later classed into the following variable levels: state, age (18-44, 45-64, \geq 65 years), sex (male, female), race (White, Black, Other), ethnicity (of Hispanic, Latino or Spanish origin, not of Hispanic, Latino or Spanish origin), household income ($<$ \$10,000, \$10,000-15,000, $>$ \$15,000) over the past year, highest education level achieved (\leq high school graduate or equivalent, \geq some college/trade school), employment status (employed for \geq 6 months of the past year, employed for $<$ 6 months of the past year), number of household members (1, 2, \geq 3), number of children $<$ 18 years in the household (\geq 1, 0), usual form of transportation used to acquire food (drive themselves, other), participation in the following federal food assistance programs: Supplemental Nutrition Assistance Program, Meals on Wheels, Soup Kitchens, the Special Supplemental Nutrition Program for Women, Infants, and Children, free or reduced-price school meals, and free or reduced-price meals at summer programs (participating in \geq 1 program, participating in 0 programs), frequency of visits to this pantry in the past year ($<$ 5 times, \geq 5 times), number of different pantries visited in the past year (1, $>$ 1), length of time that food from pantries lasts (a few days' worth, 1-2 weeks' worth, more than half of food for the month), and the 18-item US Household Food Security Survey Module (US HFSSM) to quantify adult food security status (FS, LFS, VLFS) over the past year (19,20). Following this questionnaire, participants completed the Automated Self-Administered 24-hour Dietary Recall (ASA24™-2014), an internet-based 24-hour recall (21), with optional staff assistance. Up to two additional dietary recalls were self-completed, or completed through an assisted phone interview, within two weeks of the pantry visit on non-consecutive days and including a weekend day (22). Participants received \$10 as compensation in the form of a grocery store gift card upon completion of the initial interview, and an additional gift card for each dietary recall completed.

3.3.3.1.3 Application of the HEI-2010 to the pantry food environment and pantry clients' diets

Dietary information from ASA24™-2014 was used to determine HEI-2010 scores for each client over all recorded intake days (1-3) according to previous direction (23). The HEI-2010 is a density-based score (e.g., amount per 1,000 kcal, ratio of fatty acids) that measures alignment of the mix of foods with the 2010 DGA, allowing examination of overall diet quality in relation to federal dietary guidance, as well as dietary patterns in terms of balance of multiple components to examine the quality of the mix of foods. The HEI-2010 is made up of nine adequacy components: Total Fruit (max score=5), Whole Fruit (max score=5), Total Vegetables (max score=5), Greens and Beans (max score=5), Whole Grains (max score=10), Total Dairy (max score=10), Total Protein Foods (max score=5), Seafood and Plant Proteins (max score=5), and Fatty Acids (max score=10), and three moderation components: Refined Grains (max score=10), Sodium (max score=10), and Empty Calories (i.e., solid fats, alcohol, and added sugars) (max score=20), most of which are expressed relative to energy intake (i.e., as densities) and then scored according to standards (24). For the adequacy components, a higher score indicates higher consumption; moderation components are reverse-scored, and a higher score indicates lower consumption. The 12 component scores are summed to yield a HEI-2010 Total Score with maximum value of 100 (24). Because the data were collected prior to the release of the 2015 DGA and HEI-2015, the HEI-2010 was used for this study to reflect the dietary guidelines in place at the time of data collection.

The HEI-2010 was applied to each pantry inventory and each client food bag using the following steps (25): 1) create database containing food/beverage item names, brand names, additional descriptions, weight/volume, food form, and quantity of each item; 2) search each item in the United States Department of Agriculture (USDA) ‘What’s in the Foods You Eat’ search tool (26) to assign the appropriate USDA food code (utilizing independent dual-coding by trained research personnel with discrepancies reconciled by a registered dietitian (RD) or an advanced dietetic intern who was eligible for the RD exam; 3) calculate weight totals for each food item by converting all units to grams (the FAO/INFOODS Density Database Version 2.0 [2012] was used for conversion of volume to weight for liquid foods) (27) and multiplying by the quantity of each food item; 4) divide total gram weight of each food item by 100 to convert to units per 100g (to be consistent with food composition database units required in subsequent steps); 5) merge the database with the Food Patterns Equivalents Database 2013-2014 (FPED) (28) to determine the

food group composition, and the Food and Nutrient Database for Dietary Studies 2013-2014 (FNDDS) (29) to determine the nutrient composition; 6) multiply the total weight/100g for each food/beverage item by the weight/100g for all food groups and nutrients provided by the FNDDS and FPED databases; 7) use SAS macros to calculate HEI-2010 scores for each item according to previous direction (30); 8) calculate and average the HEI-2010 total and component score for each pantry inventory and for each client food bag. A known shortcoming of applying this methodology to community food environments is the lack of a database that can translate unprepared foods (such as raw meats and untrimmed produce) and processed but not fully prepared foods (such as cake mixes) into their appropriate food group and nutrient equivalents (31). Since the current databases available to translate foods into their components (FPED) and nutrients (FNDDS) contain the prepared versions only, in this study, all foods, whether prepared or unprepared, were treated as prepared. For example, “raw chicken” was coded as “cooked chicken, not specified as to cooking method” and “yellow cake mix” was coded as “yellow cake.” No appropriate UDSA food code was identified for certain food/beverage items (e.g., unlabeled/damaged foods and seasonings mixes) in pantry inventories (2% of items) and client food bags (11% of items). These items were excluded from the analyses.

3.3.4 Statistical Analysis

Total numbers and prevalence of characteristics for both food pantries and pantry client participants were calculated. Participant characteristics were compared across FS, LFS and VLFS groups using chi-squared analysis. General linear mixed models were created for each HEI-2010 component score for both pantry inventories and client food bags. Main indicators were the pantry inventory HEI-2010 score and the client food bag HEI-2010 score, the client food security status, and the interaction between pantry inventory/client food bag HEI-2010 score with client food security status. The outcome variable for each model was the corresponding client HEI-2010 total or component score. All models were evaluated for potential confounding presented by state; client-level characteristics, including age, sex, race, and household income; and pantry-level characteristics, including the number of households served, number of refrigerators, number of freezers, GCC score, and participation in government commodity programs. Final models included only significant covariates. Least square means estimates were determined for each food security group, and t-tests were used to perform group pairwise comparisons of FS vs LFS, FS vs VLFS,

and LFS vs VLFS. The Bonferroni method was specified in models to adjust for the three pairwise comparisons of food security groups. Statistical significance was determined at $p < 0.05$. R version 2.11.1 (32) was used to download and merge FPED and FNDDS databases. The mean total and component HEI-2010 scores for pantry inventories, client food bags, and clients' diets are found in a supplementary table. All analyses were completed using SAS version 9.4 (33).

3.4 Results

The majority of pantries participated in at least one government commodity program (67%) and served predominantly white clients (83%). Fifty-four percent of pantries scored ≥ 5 out of 6 points on the GCC tool, indicating limited client empowerment to choose the foods they received from participating food pantries (**Table 1**).

Pantry clients (n=603) were predominantly White (78%), not of Hispanic, Latino or Spanish origin (97%), female (72%), ≥ 45 years (63%), had a household income $< \$10,000$ (54%), and were employed < 6 months out of the previous year (77%) (**Table 2**). Most lived in a household of ≥ 2 members (70%) and participated in ≥ 1 federal food assistance program (80%). Most also reported that pantries provided less than half of their household food for the month (81%). Compared to LFS and VLFS clients, FS pantry clients tended to be older, had higher incomes, participated in fewer federal food assistance programs, and visited the participating food pantry more frequently.

Inventory and client food bag HEI-2010 scores were associated with client diet scores. Inventory HEI-2010 total score ($p=0.008$) and Total Fruit ($p=0.01$) and Fatty Acids ($p=0.01$) component scores were negatively associated with client diet HEI-2010 scores (**Table 3**). Client food bag Total Vegetables ($p=0.008$), Total Fruit ($p=0.006$), Total Protein Foods ($p=0.03$), and Sodium ($p=0.005$) component scores were positively associated with client scores (**Table 4**).

Associations between both inventory and client food bag HEI-2010 scores with client diet scores differed by food security status. When the inventory Greens and Beans component score increased by one point, VLFS clients' Greens and Beans component score increased by 0.3 times the amount of LFS clients ($p=0.04$) (Table 3). When the client food bag Whole Grains component score increased by one point, VLFS clients' Whole Grains component score increased by 0.3 times the amount of FS clients ($p=0.009$) (Table 4).

3.5 Discussion

This study represents the first application and direct association of the HEI-2010 to the foods stocked on the shelves (pantry inventories), foods distributed to clients (client food bags), and foods consumed by clients (individual intake) in food pantries. Evaluating the relationships between HEI-2010 scores of these different levels quantified the relationship of the more distant (i.e., inventory) and more proximal (i.e., food bags) aspects of food environments with client diet quality, and distinguished whether the foods stocked at the pantry or the foods clients take home were more highly associated with client diet quality. Recent Dietary Guidelines for Americans (DGAs) promote the use of a social ecological model (SEM) to explain how layers of influence, including both individual factors and the surrounding environment, shape one's food choices (5,34). This idea supports investigation of the nutritional quality of the pantry food environment in relation to individual client diet quality. Client food bag nutritional quality was expected to have a closer relationship with pantry client dietary quality compared with the pantry inventory. Consistent with the hypothesis, client food bag HEI-2010 scores were positively associated with client diet quality scores for several components; while contrary to the hypothesis, pantry inventory scores were negatively associated with client dietary quality scores.

There were significant positive cross-sectional associations between food bag scores and client scores for Total Vegetables, Total Fruit, Total Protein Foods, and Sodium components. These findings suggest that clients consume more foods that comprise the Total Vegetables, Total Fruit, Total Protein Foods, and Sodium components relative to other foods that are distributed in their food bags. The reason for this is unclear. Perhaps, clients are aware that these are key components of a healthy diet and prioritize purchasing these items elsewhere. The 40% of clients living in households with ≥ 1 child under age 18 may generally reserve these items for children in the household. Thus, when these components are offered at food pantries and in excess of what children need, clients have the opportunity to consume these foods themselves. Alternatively, pantry clients may have a higher preference for and acceptance of such foods, or the potential monetary value of these particular foods enhances clients' ability to economize; this may explain why their consumption increases with higher food bag quality.

Contrary to expectation, the pantry inventory HEI-2010 total scores as well as the Total Fruit and Fatty Acids component scores were negatively associated with corresponding client diet scores. One potential explanation for this surprising finding is that clients may have less familiarity

with, or inadequate resources to prepare, “healthier” foods. For example, instant meals and non-perishable snacks may be less healthy but more appealing to clients who lack resources, such as time to cook, adequate kitchen equipment, and who lack of nutrition knowledge (35). This may cause food pantries with higher HEI-2010 total scores to be less appealing for clients to visit, as these pantries may provide less of the foods that clients are able to prepare. Authors explored this hypothesis via a two-sample independent t-test that compared pantry inventory HEI-2010 scores by the number of times participants visited the food pantry in the past 12 months (<5 times vs ≥5 times). Results indicated a significant difference ($p=0.009$) in the mean HEI-2010 inventory score between clients visiting <5 times (inventory HEI-2010 total score = 65) and clients visiting ≥5 times (inventory HEI-2010 total score = 62). These results suggest that clients of “healthier” pantries may visit these pantries less frequently, which could result in lower client diet quality because these clients may rely on non-pantry foods that offer lower quality for sustenance. Advertising the benefits of higher quality foods, providing clients with nutrition education (including recipes and food demonstrations), and identifying and informing donors of additional non-food resources that clients need to prepare healthy foods (e.g., utensils, appliances) may increase the appeal for high quality foods, frequency of pantry visits, and ultimately client diet quality (36,37). An alternative explanation for the negative association between the quality of food pantry inventories and the quality of clients’ diets is that other, unidentified characteristics that are common among “healthier” pantries may present barriers to clients visiting.

The positive relationship between the qualities of several components of client food bags, but not pantry inventories, with clients’ diets quality suggests that the foods clients take home, and not the foods stocked on the shelves at pantries, have a greater influence on clients’ diets. Based on the statistically significant effect of GCC in several mixed models to evaluate associations between the pantry food environment nutritional quality and client diet quality (data not shown), GCC deserves further consideration as an important factor that may moderate the relationship between the foods available and the foods consumed. Previous research supports the idea that clients’ empowerment to select their own foods from the pantry may indeed be an important factor to further investigate through intervention (17,37,38). Not all pantries offer a client choice model where clients are able to choose their own foods, and therefore pantry foods provided might be discarded/wasted because of dietary restrictions, taste preferences, or lack of resources (e.g., recipes, appliances) to prepare these foods. GCC score, representing a preliminary measure of the

opportunity and empowerment for clients to choose foods at the pantry, was treated as a potential confounder in this study; a more comprehensive tool is under development by the authors.

Associations between foods distributed to and consumed by clients were expected to differ by client food security status. Consistent with this hypothesis, VLFS clients benefited more from whole grains provided in food bags compared to FS clients. This suggests that VLFS clients consumed more of the whole grain items supplied in their food bags compared to FS clients. One potential explanation is that VLFS clients rely on the foods they receive from the pantry more compared to FS clients; they may be more limited to consuming the foods they receive in food bags, while FS clients may have the financial means to obtain more foods from non-pantry sources. Whole grain items, in particular, may be relatively expensive to acquire by purchase, and therefore VLFS clients may especially rely on the pantry for these items. VLFS clients also saw a greater increase in the Greens and Beans component score compared to LFS clients when pantry inventory Greens and Beans score increased, suggesting that VLFS clients utilize the dark green vegetables and dried beans and peas provided by food pantries more than LFS clients.

Since 20% of the foods consumed by participants during the week following recruitment/receipt of their food bag were reported to have come from a food pantry (data not shown), the foods derived from food pantries may have a substantial impact on clients' diets. The average HEI-2010 score for clients in this study was low at 43 (**Supplementary Table 1**) compared to the estimated HEI-2010 score of 59 for the average US adult (39). A lower HEI-2010 score is linked to increased risk for diet-related chronic diseases (39). Previous studies of food pantry clients, although few, show a high prevalence of obesity and severe obesity (14) and poor diabetes management (40). Pantry inventory and client food bag HEI-2010 total scores (62 and 58, respectively) were higher relative to the low client diet quality scores found in this study (significance not tested)—a biologically meaningful difference that is associated with a difference in risk of disease (41)—and also higher compared to the US food supply (42). The quality of the mix of foods in the pantry food environment determined here was consistent with another study where a scoring system similar to the HEI-2010 was applied to food pantry invoices (25). High HEI-2010 scores for the pantry food environment were, perhaps, expected since commodity foods delivered to food pantries by TEFAP are of very high quality (HEI-2005 total score = 85) (43).

Chi-square results support the notion that FS and FI clients use pantries differently. FS clients visited the pantry more frequently compared to LFS and VLFS clients. This is consistent

with the idea that FS clients use pantries as a long-term buffer to maintain food security compared to FI clients who may use pantries in short-term, emergency situations (10). However, this does not necessarily translate to FS clients consuming more of the foods received from pantries compared to LFS or VLFS clients, as evidenced by VLFS clients consuming more whole grains from food bags compared to FS clients.

3.5.1 Strengths and Limitations

This is the first study, to our knowledge, to have characterized associations between the food pantry environment and the diet quality of clients served by these pantries with consideration of food security status and controlling for pantry-level and client-level characteristics. Additionally, most studies evaluating food security have not parsed food insecurity into the LFS and VLFS to explore differences between these subgroups. The very high prevalence of food insecurity found here, including high proportions of both low and very low food security, allowed the unique determination of differences between FS, LFS, and VLFS in client demographic and pantry use characteristics, diet quality, and the relationship of the pantry food environment to client diet.

A known limitation of the HEI methodology for evaluating the quality of the food environment is the application of this scoring system to unprepared foods. Although the recent development of a Grocery Purchase Quality Index overcomes the problem of not having a food composition database for foods in their as-purchased forms, this index is based on expenditure shares and thus is not applicable to items at food pantries that are offered to clients for free rather than for purchase (44). In the present study, error is introduced by treating all foods as if they were in their as-consumed form. In addition, a small proportion food items were not available in the food composition databases and were not included in analysis. Pantries operate on a spectrum of monthly to near-daily basis, and inventory may overturn rapidly so pantry inventory may not directly reflect the day when clients were recruited. Thus, pantry inventory foods, as measured in this study, may not have been an accurate reflection of the inventory that was available to clients on the day that they received their food bags. Participants received compensation of up to \$30 in the form of grocery store gift cards, which could have resulted in higher quality foods being purchased at stores, and ultimately introduced bias to the second and third dietary recalls that were collected after the day of recruitment.

3.5.2 Conclusions

In this study, client food bag scores were positively associated with client diet scores for the Total Vegetables, Total Fruit, Total Protein Foods, and Sodium components of the HEI-2010, which suggests that clients are especially relying on pantries for vegetables, fruit, and protein foods. Pantry inventory scores were negatively associated with client scores for the HEI-2010 total score and for the Total Fruit and Fatty Acids component scores. Associations between pantry inventory and client food bag HEI-2010 scores with client scores differed by food security status. Food pantries may be an important venue to target interventions that improve overall dietary quality for the clients they serve, and reduce dietary disparity between the subgroups of food security.

3.6 Author Contributions

B.N.W. and H.A.E.-M. conceived the research question. B.N.W., L.M., S.S., L.F.-C., B.H., D.M., D.R., and H.A.E.-M. acquired the data. B.N.W. and C.M.V.-M. analyzed the data. P.M.G. contributed to the analysis plan. B.N.W. interpreted the data. H.A.E.-M. supervised analysis and interpretation of the data. B.N.W. drafted the manuscript. B.N.W., C.M.V.-M., P.M.G., L.M., S.S., L.F.-C., B.H., D.M., D.R. and H.A.E.-M. critically reviewed for important intellectual content and approved the final version.

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3.8 References

1. Andersen SA. Core Indicators of Nutritional State for Difficult-to-Sample Populations. *J Nutr.* 1990;120:1555–600.
2. Coleman-Jensen A, Rabbitt MP, Gregory CA, Singh A. Household Food Security in the United States in 2017. 2018.
3. Hanson KL, Connor LM. Food insecurity and dietary quality in US adults and children : a systematic review. 2014;684–92.
4. Gundersen C, Ziliak JP. Food insecurity and health outcomes. *Health Aff.* 2015;1830–9.

5. U.S. Department of Health and Human Services and U.S. Department of Agriculture. Dietary Guidelines for Americans 2015-2020 [Internet]. 8th ed. 2015. Available from: https://health.gov/dietaryguidelines/2015/resources/2015-2020_Dietary_Guidelines.pdf
6. Verpy H, Smith C, Riecks M. Attitudes and behaviors of food donors and perceived needs and wants of food shelf clients. *J Nutr Educ Behav.* 2003;35:6–15.
7. Johnson K, Rawlings-blake S, Schneider H, Cochran T. Hunger and Homelessness Survey: A Status Report on Hunger and Homelessness in America's Cities. 2013;1–120.
8. Simmet A, Depa J, Tinnermann P, Stroebele-benschop N. The Nutritional Quality of Food Provided from Food Pantries: A Systematic Review of Existing Literature. *J Acad Nutr Diet* [Internet]. 2016; Available from: <http://dx.doi.org/10.1016/j.jand.2016.08.015>
9. Simmet A, Depa J, Tinnermann P, Stroebele-benschop N. The Dietary Quality of Food Pantry Users: A Systematic Review of Existing Literature. *J Acad Nutr Diet* [Internet]. 2016;39–41. Available from: <http://dx.doi.org/10.1016/j.jand.2016.08.014>
10. Wright BN, Bailey RL, Craig BA, Mattes RD, McCormack L, Stluka S, Franzen-Castle L, Henne B, Mehrle D, Remley D, et al. Daily dietary intake patterns improve after visiting a food pantry among food-insecure rural midwestern adults. *Nutrients.* 2018;10.
11. Coleman-Jensen A, Rabbitt MP, Gregory CA, Singh A. Statistical Supplement to Household Food Security in the United States in 2016. 2017; Available from: <https://www.ers.usda.gov/webdocs/publications/84981/ap-077.pdf?v=42979>
12. Kicinski LR. Characteristics of Short and Long-Term Food Pantry Users. 2012;26:58–74.
13. Kaiser ML, Cafer AM. Exploring Long-term Food Pantry Use: Differences Between Persistent and Prolonged Typologies of Use. *J Hunger Environ Nutr* [Internet]. Taylor & Francis; 2017;12:46–63. Available from: <http://dx.doi.org/10.1080/19320248.2016.1157554>
14. Kaiser ML, Cafer A. Understanding High Incidence of Severe Obesity and Very Low Food Security in Food Pantry Clients: Implications For Social Work. *Soc Work Public Health.* 2018;33:125–39.
15. Spees CK, Clark JE, Hooker NH, Watowicz RP, Taylor CA. Dietary Intake Contributions of Food and Beverages by Source and Food Security Status in US Adults. *J Nutr Educ Behav* [Internet]. Elsevier Inc.; 2017;49:667–673.e1. Available from: <http://dx.doi.org/10.1016/j.jneb.2017.01.009>
16. United States Department of Agriculture Economic Research Service. Definitions of Food Security [Internet]. [cited 2018 Oct 18]. Available from: <https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/definitions-of-food-security.aspx>

17. [Blinded for review]. Voices for food: Methodologies for implementing a multi-state community-based intervention in rural, high poverty communities. [Blinded for Review];
18. Martin KS, Colantonio AG, Picho K, Boyle KE. Self-efficacy is associated with increased food security in novel food pantry program. *SSM - Popul Heal* [Internet]. Elsevier; 2016;2:62–7. Available from: <http://dx.doi.org/10.1016/j.ssmph.2016.01.005>
19. Bickel G, Nord M, Price C, Hamilton W, Cook J. Guide to Measuring Household Food Security [Internet]. 2000. Available from: <https://fnssprod.azureedge.net/sites/default/files/FSGuide.pdf>
20. United States Department of Agriculture Economic Research Service. U.S. Adult Food Security Survey Module: Three-Stage Design, with Screeners [Internet]. 2012. Available from: <https://www.ers.usda.gov/media/8279/ad2012.pdf>
21. Subar AF, Kirkpatrick SI, Mittl B, Zimmerman TP, Thompson FE, Bingley C, Willis G, Islam NG, Baranowski T, McNutt S, et al. The Automated Self-Administered 24-Hour Dietary Recall (ASA24): A Resource for Researchers, Clinicians and Educators from the National Cancer Institute. 2012;112:1134–7.
22. Kirkpatrick SI, Guenther PM, Douglass D, Zimmerman T, Kahle LL, Atoloye A, Marcinow M, Savoie-Roskos MR, Dodd KW, Durward C. The Provision of Assistance Does Not Substantially Impact the Accuracy of 24-Hour Dietary Recalls Completed Using the Automated Self-Administered 24-H Dietary Assessment Tool among Women with Low Incomes. *J Nutr* [Internet]. 2019;1–9. Available from: <https://academic.oup.com/jn/advance-article/doi/10.1093/jn/nxy207/5271166>
23. National Cancer Institute. Healthy Eating Index-2010 [Internet]. [cited 2019 Jan 8]. Available from: <http://riskfactor.cancer.gov/tools/hei>
24. Guenther PM, Kirkpatrick SI, Reedy J, Krebs-Smith SM, Buckman DW, Dodd KW, Casavale KO, Carroll RJ. The Healthy Eating Index-2010 Is a Valid and Reliable Measure of Diet Quality According to the 2010 Dietary Guidelines for Americans. *J Nutr* [Internet]. 2014;144:399–407. Available from: <http://jn.nutrition.org/cgi/doi/10.3945/jn.113.183079>
25. Nanney MS, Grannon KY, Cureton C, Hoolihan C, Janowiec M, Wang Q, Warren C, King RP. Application of the Healthy Eating Index-2010 to the hunger relief system. *Public Health Nutr*. 2016;19:2906–14.
26. United States Department of Agriculture Agricultural Research Service. What's In The Foods You Eat Search Tool [Internet]. [cited 2018 Sep 26]. Available from: [https://reedir.arsnet.usda.gov/codesearchwebapp/\(S\(cbsohcqfr2zjhlylcv4ytwa5\)\)/CodeSearch.aspx](https://reedir.arsnet.usda.gov/codesearchwebapp/(S(cbsohcqfr2zjhlylcv4ytwa5))/CodeSearch.aspx)
27. Charrodiere UR, Haytowitz D, Stadlmayr B. FAO/INFOODS Density Database Version 2.0. Fao/Infofoods [Internet]. 2012;2:24. Available from: <http://www.fao.org/docrep/017/ap815e/ap815e.pdf>

28. United States Department of Agriculture Agricultural Research Service. Food Patterns Equivalents Database: Databases and SAS Data Sets [Internet]. [cited 2018 Sep 26]. Available from: <https://www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-research-center/food-surveys-research-group/docs/fped-databases/>
29. United States Department of Agriculture Agricultural Research Service. Food and Nutrient Database for Dietary Studies: FNDDS Documentation and Databases [Internet]. [cited 2018 Sep 26]. Available from: <https://www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-research-center/food-surveys-research-group/docs/fndds-download-databases/>
30. National Cancer Institute Division of Cancer Control & Population Sciences. Healthy Eating Index SAS Code [Internet]. [cited 2018 Sep 1]. Available from: <https://epi.grants.cancer.gov/hei/sas-code.html>
31. National Cancer Institute Division of Cancer Control & Population Sciences. Research Uses of the HEI [Internet]. [cited 2018 Sep 1]. Available from: <https://epi.grants.cancer.gov/hei/uses.html>
32. R Studio. Boston, MA, USA: Version 2.11.1;
33. SAS Institute Inc. Cary, NC, USA: Version 9.4;
34. U.S. Department of Health and Human Services and U.S. Department of Agriculture. Dietary Guidelines for Americans 2010. 2010.
35. Dave JM, Thompson DI, Svendsen-Sanchez A, Cullen KW. Perspectives on Barriers to Eating Healthy Among Food Pantry Clients. *Heal Equity* [Internet]. 2017;1:28–34. Available from: <http://www.liebertpub.com/doi/10.1089/heq.2016.0009>
36. Flynn MM, Reinert S, Schiff AR. A Six-Week Cooking Program of Plant-Based Recipes Improves Food Security, Body Weight, and Food Purchases for Food Pantry Clients. *J Hunger Environ Nutr*. 2013;8:73–84.
37. Greer AE, Cross-Denny B, McCabe M, Castrogiovanni B. Giving economically disadvantaged, minority food pantry patrons' a voice: Implications for equitable access to sufficient, nutritious food. *Fam Community Heal*. 2016;39:199–206.
38. Remley DT, Zubieta AC, Lambea MC, Quinonez HM, Taylor C. Spanish- and English-speaking client perceptions of choice food pantries. *J Hunger Environ Nutr*. 2010;5:120–8.
39. United States Department of Agriculture Center for Nutrition Policy and Promotion. HEI-2010 Total and Component Scores for Children, Adults, and Older Adults During 2011–2012 [Internet]. 2016. Available from: <https://www.cnpp.usda.gov/healthyeatingindex/reports>
40. Ippolito MM, Lyles CR, Prendergast K, Marshall MB, Waxman E, Seligman HK. Food insecurity and diabetes self-management among food pantry clients. *Public Health Nutr*.

2017;20:183–9.

41. Kirkpatrick SI, Reedy J, Krebs-Smith SM, Pannucci TRE, Subar AF, Wilson MM, Lerman JL, Tooze JA. Applications of the Healthy Eating Index for surveillance, epidemiology, and intervention research: considerations and caveats. *J Acad Nutr Diet* [Internet]. Elsevier Inc; 2018;118:1603–21. Available from: <https://doi.org/10.1016/j.jand.2018.05.020>
42. Miller PE, Reedy J, Kirkpatrick SI, Susan M Krebs-Smith. The United States food supply is not consistent with dietary guidance: evidence from an evaluation using the Healthy Eating Index-2010. *J Acad Nutr Diet*. 2015;115:95–100.
43. Zimmerman TP. Nutrient and Food Group Analysis of USDA Foods in Five of Its Food and Nutrition Programs – 2014. 2016;3129.
44. Brewster PJ, Durward CM, Hurdle JF, Stoddard GJ, Guenther PM. The Grocery Purchase Quality Index-2016 Performs Similarly to the Healthy Eating Index-2015 in a national survey of household food purchases. *J Acad Nutr Diet* [Internet]. Elsevier Inc; 2018;119:45–56. Available from: <https://doi.org/10.1016/j.jand.2018.08.165>

3.9 Results Tables

Table 3-1 Characteristics^a of rural, Midwestern food pantries participating in the Voices for Food study (*n*=24)

Characteristics	<i>n</i> (%)
Average number of households served per month at each pantry	
< 100	11 (46)
≥ 100	13 (54)
Number of refrigerators to store perishable foods at each pantry	
< 2	10 (42)
≥ 2	14 (58)
Number of freezers to store perishable foods at each pantry	
< 4	13 (54)
≥ 4	11 (46)
Guided Client Choice score ^b	
< 5	11 (46)
≥ 5	13 (54)
Government commodity program participation of each pantry	
None	8 (33)
The Emergency Food Assistance Program (TEFAP)	11 (46)
TEFAP and the Commodity Supplemental Food Program	5 (21)
Predominant racial/ethnic group served at each pantry	
White	20 (83)
Other ^c	4 (17)

^a Food pantry-level characteristics were recorded by research staff through pantry director interview with open-ended questions that were later categorized.

^b Guided Client Choice scores were calculated by adding the number of negative responses to six “yes or no” questions, which gauged the food distribution system and staff-client interactions in the food pantry (6=low GCC, 0=high GCC).

^c The two responses in the “Other” category included “Native American,” “50% White and 50% Native American,” and “50% White and 50% Hispanic.”

Table 3-2 Characteristics of food pantry clients in a sample of rural, Midwestern food pantries in the Voices for Food (VFF) study by food security status (n=603)

Characteristics	All clients	Food secure	Low food secure	Very low food secure	Chi- squared
	n (%) ^a	n (%)	n (%)	n (%)	p-value
Total	603	138 (23%)	178 (30)	287 (48%)	
		(100%)			
State					0.01*
Indiana	157 (26)	34 (25)	40 (22)	83 (29)	
Michigan	102 (17)	17 (12)	36 (20)	49 (17)	
Missouri	146 (24)	33 (24)	38 (21)	75 (26)	
Nebraska	50 (8)	10 (7)	24 (13)	16 (6)	
Ohio	81 (13)	21 (15)	18 (10)	42 (15)	
South Dakota	67 (11)	23 (17)	22 (12)	22 (8)	
Sex					0.5
Male	143 (28)	36 (30)	48 (31)	59 (26)	
Female	364 (72)	83 (70)	109 (69)	172 (74)	
Age					<0.0001*
18-44 years	189 (37)	38 (32)	53 (34)	98 (42)	
45-64 years	223 (43)	45 (38)	66 (42)	112 (48)	
≥65 years	101 (20)	37 (31)	39 (25)	25 (11)	
Race					0.8
White	394 (78)	92 (78)	120 (79)	182 (78)	
Black	42 (8)	12 (10)	13 (9)	17 (7)	
Other ^b	67 (13)	14 (12)	178 (12)	35 (15)	
Ethnicity					
Of Hispanic, Latino, or Spanish origin	16 (3)	1 (1)	7 (5)	8 (3)	0.2
Not of Hispanic, Latino, or Spanish origin	478 (97)	113 (99)	144 (95)	221 (97)	
Highest Education Level					0.4
≤High school graduate or equivalent	345 (67)	81 (68)	111 (71)	153 (65)	
≥Some college/trade school	167 (33)	39 (33)	45 (29)	83 (35)	
Employment status ^c					0.3
Employed ≥6 months	137 (23)	34 (26)	46 (26)	57 (21)	
Employed <6 months	448 (77)	99 (74)	130 (74)	219 (79)	
Income ^d					0.04*
<\$10,000	304 (54)	59 (46)	79 (49)	166 (61)	

Characteristics	All clients	Food secure	Low food secure	Very low food secure	Chi- squared
	n (%) ^a	n (%)	n (%)	n (%)	p-value
\$10,000 - \$15,000	117 (21)	32 (25)	38 (24)	47 (17)	
>\$15,000	142 (25)	38 (29)	43 (27)	61 (23)	
Household size ^c					0.4
1 member	180 (30)	43 (31)	58 (33)	79 (28)	
2 members	143 (24)	39 (28)	37 (21)	67 (24)	
≥3 members	275 (46)	55 (40)	82 (46)	138 (49)	
Children (<18 years) in household					0.4
≥1 child under 18 years	226 (40)	56 (35)	68 (41)	112 (41)	
No children under 18 years	344 (60)	86 (65)	98 (59)	160 (59)	
Usual transportation used to acquire food					0.008*
Drive themselves	367 (62)	93 (69)	118 (67)	156 (55)	
Other: uses public transportation, someone else drives, walks, rides a bicycle	227 (38)	42 (31)	59 (33)	126 (45)	
Participation in food assistance programs ^{c,e}					0.01*
≥1 program	482 (80)	102 (74)	136 (76)	244 (85)	
0 programs	121 (20)	36 (26)	42 (24)	43 (15)	
Estimated amount of household food from all pantries in the last month					0.07
A few days' worth	254 (46)	47 (39)	68 (41)	139 (51)	
1-2 weeks' worth	196 (35)	43 (36)	64 (39)	89 (33)	
More than half of all food	107 (19)	30 (25)	34 (20)	43 (16)	
Number of pantries visited ^c					0.2
1 pantry	278 (48)	70 (54)	83 (48)	125 (45)	
>1 pantry	301 (52)	59 (46)	89 (52)	153 (55)	
Number of times this pantry was visited ^c					0.01*
<5 times	309 (51)	56 (41)	94 (53)	159 (55)	
≥5 times	294 (49)	82 (59)	84 (47)	128 (45)	

^aTotals may not add up to total participants due to missing values.

^b Includes Native American, Native Hawaiian, Asian, and any combinations of races.

^c Over the past 12 months.

^d Self-reported total combined income of all household members over the past 12 months including income from jobs, business, pensions, Social Security or retirement payments, disability payments, and any other money income received.

^e Includes the Supplemental Nutrition Assistance Program, Meals on Wheels, Soup Kitchens, the Special Supplemental Nutrition Program for Women, Infants, and Children, free or reduced-price school meals, and free or reduced-priced meals at summer programs.

* Statistical significance is p<0.05 for chi-squared comparisons between food secure, low food secure and very low food secure households.

Table 3-3 Association of pantry inventory Healthy Eating Index-2010 (HEI-2010) scores and client diet HEI-2010 scores in a sample of rural, Midwestern, food pantries and their clients

HEI-2010 component	Inventory HEI-2010		Inventory HEI-2010*client food security status	Food secure vs low food		Food secure vs very low		Low food secure vs very low food secure	
Total Score	-0.13	0.008*	0.5	0.14	0.6	0.09	1.0	-0.05	1.0
Total Vegetables	-0.11	0.1	0.7	0.06	1.0	0.08	1.0	0.02	1.0
Greens and Beans	0.12	0.7	0.04*	0.22	0.3	-0.04	1.0	-0.26	0.04*
Total Fruit	-0.21	0.01*	0.9	-0.02	1.0	0.03	1.0	0.05	1.0
Whole Fruit	-0.14	0.2	0.4	0.13	1.0	0.17	0.5	0.04	1.0
Whole Grains	0.01	0.9	0.9	0.03	1.0	-0.01	1.0	-0.03	1.0
Total Dairy	0.14	0.5	0.1	0.15	1.0	-0.20	0.7	-0.35	0.1
Total Protein Foods	-0.002	0.4	0.7	-0.06	1.0	-0.16	1.0	0.09	1.0
Seafood and Plant Proteins	-0.05	0.4	0.8	-0.11	1.0	-0.05	1.0	0.06	1.0
Fatty Acids	-0.13	0.01*	0.8	-0.04	1.0	0.02	1.0	0.06	1.0
Sodium	-0.04	0.3	0.3	0.15	0.4	0.06	1.0	-0.09	1.0
Refined Grains	0.07	0.4	0.3	0.26	0.5	0.10	1.0	-0.16	0.7
Empty Calories	-0.05	0.1	0.8	0.07	1.0	-0.01	1.0	-0.08	1.0

^a Inventory HEI beta (β) represents the increase in client HEI-2010 score per one-unit increase in pantry inventory HEI-2010 score. Models were structured as follows: $HEI_{client} = HEI_{inventory} + Client_Food_Security_Status + HEI_{inventory}*Client_Food_Security_Status + Covariates$. All models were evaluated for potential confounding presented by state, client-level characteristics: age, sex, race and income; and pantry-level characteristics: number of households served, number of refrigerators, number of freezers, Guided Client Choice score, and government commodity programs; final models included only significant covariates. Least square means estimates were determined, and t-tests were used to perform pairwise comparisons of food security groups (i.e. Food Secure vs Low Food Secure, Food Secure vs Very Low Food Secure, Low Food Secure vs Very Low Food Secure). The Bonferroni method was used to adjust for multiple comparisons.

^b Food secure vs low food secure β represents the magnitude of the increase in food secure client HEI-2010 score compared to low food secure client HEI-2010 score per one-unit increase in pantry inventory HEI-2010 score.

^c Food secure vs very low food secure β represents the magnitude of the increase in food secure client HEI-2010 score compared to very low food secure client HEI-2010 score per one-unit increase in pantry inventory HEI-2010 score.

^d Low food secure vs very low food secure β represents the magnitude of the increase in low food secure client HEI-2010 score compared to very low food secure client HEI-2010 score per one-unit increase in pantry inventory HEI-2010 score.

* Statistical significance was determined at $p < 0.05$.

Table 3-4 Association of client food bag Healthy Eating Index-2010 (HEI-2010) scores and client diet HEI-2010 scores in a sample of rural, Midwestern, food pantries and their clients

HEI-2010 (maximum score)	component	Food bag HEI- 2010	Food bag HEI- 2010*client food security status	Food secure		Food secure vs very low food		Low food secure vs very low food secure				
				vs low food secure		secure		secure				
				β^a	p	p	$\Delta\beta^b$	p	$\Delta\beta^c$	p	$\Delta\beta^d$	p
Total Score (100)				0.08	0.6	0.4	-0.10	1.0	-0.14	0.6	-0.05	1.0
Total Vegetables (5)				0.15	0.008*	0.2	0.21	0.3	0.08	1.0	-0.12	0.8
Greens and Beans (5)				0.10	0.2	0.5	0.10	1.0	-0.005	1.0	-0.11	0.8
Total Fruit (5)				0.08	0.006*	0.4	0.09	1.0	0.16	0.5	0.07	1.0
Whole Fruit (5)				0.14	0.1	0.8	0.001	1.0	-0.07	1.0	-0.07	1.0
Whole Grains (10)				0.12	0.9	0.01*	-0.13	0.6	-0.25	0.009*	-0.12	0.5
Total Dairy (10)				-0.02	0.5	0.9	0.06	1.0	0.006	1.0	-0.06	1.0
Total Protein Foods (5)				0.06	0.03*	0.5	0.11	0.8	0.11	0.8	-0.002	1.0
Seafood and Plant Proteins (5)				0.07	0.3	0.4	0.14	0.6	0.02	1.0	-0.12	0.6
Fatty Acids (10)				-0.03	0.3	0.9	0.03	1.0	0.01	1.0	-0.02	1.0
Sodium (10)				0.05	0.005*	0.4	0.06	1.0	0.13	0.5	0.07	1.0
Refined Grains (10)				0.03	0.7	0.7	0.13	1.0	0.05	1.0	-0.08	1.0
Empty Calories (20)				0.08	0.4	0.6	-0.14	1.0	-0.12	1.0	-0.02	1.0

^a Client food bag HEI beta (β) represents the increase in client HEI-2010 score per one-unit increase in pantry client food bag HEI-2010 score. Models were structured as follows: $HEI_{client} = HEI_{food bags} + Client_Food_Security_Status + HEI_{food bags} * Client_Food_Security_Status + Covariates$.

All models were evaluated for potential confounding presented by state, client-level characteristics including age, sex, race and income, and pantry-level characteristics including the number of households served, number of refrigerators, number of freezers, Guided Client Choice, and government commodity programs; final models included only significant covariates. Least square means estimates were determined, and t-tests were used to perform pairwise comparisons of food security groups (i.e. Food Secure vs Low Food Secure, Food Secure vs Very Low Food Secure, Low Food Secure vs Very Low Food Secure). The Bonferroni method was used to adjust for multiple comparisons.

^b Food secure vs low food secure β represents the magnitude of the increase in food secure client HEI-2010 score compared to low food secure client HEI-2010 score per one-unit increase in client food bag HEI-2010 score.

^c Food secure vs very low food secure β represents the magnitude of the increase in food secure client HEI-2010 score compared to very low food secure client HEI-2010 score per one-unit increase in client food bag HEI-2010 score.

^d Low food secure vs very low food secure β represents the magnitude of the increase in low food secure client HEI-2010 score compared to very low food secure client HEI-2010 score per one-unit increase in client food bag HEI-2010 score.

* Statistical significance was determined at $p < 0.05$.

Table 3-5 (Supplementary Table 1) Mean Healthy Eating Index-2010 (HEI-2010) scores for pantry inventories, client food bags, and client dietary intake in a sample of rural, Midwestern, food pantries and their clients

HEI-2010 component (maximum score)	Inventories <i>n</i> =24	Food bags <i>n</i> =607	Clients' diets			
			All clients <i>n</i> =614	Food secure <i>n</i> =137	Low food secure <i>n</i> =176	Very low food secure <i>n</i> =283
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Total Score (100)	61.5 (15.6)	58.4 (13.8)	42.9 (12.6)	45.7 (14.1)	42.8 (12.0)	41.6 (12.3)
Total Vegetables (5)	3.3 (1.8)	3.6 (1.6)	3.2 (1.6)	3.3 (1.7)	3.3 (1.6)	3.1 (1.7)
Greens and Beans (5)	1.8 (1.9)	1.6 (2.1)	1.0 (1.8)	1.3 (1.8)	1.2 (1.9)	0.8 (1.7)
Total Fruit (5)	3.2 (1.8)	3.3 (2.0)	1.8 (2.0)	1.9 (2.0)	1.9 (2.0)	1.8 (2.0)
Whole Fruit (5)	3.6 (2.0)	3.0 (2.0)	1.5 (2.0)	1.8 (2.2)	1.5 (2.0)	1.4 (1.9)
Whole Grains (10)	4.3 (3.8)	3.2 (3.8)	2.2 (2.9)	2.7 (3.2)	2.0 (2.5)	2.1 (3.0)
Total Dairy (10)	2.3 (2.3)	2.6 (3.5)	5.1 (3.5)	5.7 (3.2)	5.1 (3.3)	4.8 (3.6)
Total Protein Foods (5)	4.6 (0.8)	4.2 (1.5)	4.3 (1.3)	4.3 (1.3)	4.5 (1.1)	4.2 (1.4)
Seafood and Plant Proteins (5)	4.3 (1.6)	3.3 (2.2)	1.2 (1.8)	1.5 (1.9)	1.3 (1.9)	1.1 (1.7)
Fatty Acids (10)	5.6 (4.4)	4.9 (4.4)	3.9 (3.2)	3.8 (2.8)	3.9 (3.4)	3.9 (3.3)
Sodium (10)	4.3 (4.0)	4.5 (3.9)	2.8 (3.1)	2.6 (3.0)	2.6 (3.0)	2.9 (3.3)
Refined Grains (10)	8.5 (3.1)	7.8 (3.1)	6.0 (3.4)	6.2 (3.3)	5.9 (3.4)	6.0 (3.6)
Empty Calories (20)	15.8 (6.0)	16.5 (5.0)	9.8 (6.1)	10.6 (5.7)	9.7 (5.9)	9.4 (6.4)

CHAPTER 4. VOICES FOR FOOD: INTERMEDIATE FINDINGS FROM A MULTI-STATE COMMUNITY-BASED INTERVENTION IN RURAL, HIGH POVERTY COMMUNITIES^{1,2,3}

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FOOTNOTES:

¹ Abbreviations used:

VFF: Voices for Food
 SEM: Social Ecological Model
 GCC: Guided client choice
 FPC: Food Policy Council
 FS: Food secure
 LFS: Low food secure
 VLFS: Very low food secure
 ASA24: Automated Self-Administered 24-hour Dietary Recall
 US HFSSM: US Household Food Security Survey Module
 HEI-2010: Healthy Eating Index-2010
 NCI: National Cancer Institute
 USDA: United States Department of Agriculture
 DGA: Dietary Guidelines for Americans
 NCI: National Cancer Institute

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4.1 Abstract

Background: Food pantries may be an important intervention contact point to improve food security and dietary quality in rural, impoverished communities. Voices for Food (VFF; Clinical

Trial Registry: NCT0356609) is a socio-ecological modeled (SEM), community-based intervention in rural communities and food pantries designed to improve food security and dietary intake.

Objective: The goal of this analysis was to evaluate intermediate changes in client food security and dietary outcomes, including diet quality and usual intake, from baseline to the “midpoint” assessment of VFF, and also whether food security was implicated in the relationship of VFF on dietary outcomes.

Methods: In each of six Midwestern states, two food pantry communities were selected in 2014 to receive the intervention and matched to a comparison community. Adult food pantry clients ($n = 590$) completed a demographic survey, the 18-Item US Household Food Security Survey Module, and up to three 24-hour dietary recalls at baseline and midpoint ($n = 160$). Recalls were used to calculate Healthy Eating Index-2010 (HEI-2010) scores and to estimate the usual intake of nutrients and food groups using the National Cancer Institute method. Linear mixed effect models with time, treatment, and their interaction as the main predictors and adult food security score, HEI-2010 total and component scores, or usual intake amounts as the main outcome (in separate models) determined changes in outcomes from baseline to midpoint by treatment group. The intervention effect on diet quality and usual intake was also compared by food security status.

Results: In intervention group alone, mean adult food security and empty calories scores increased whereas HEI-2010 total score, and greens and beans, total protein foods, fatty acids, and empty calories component scores increased in the comparison group. There were no improvements in dietary outcomes in the intervention group when compared with the comparison group.

Conclusions: The VFF model may be a promising mechanism for improving dietary outcomes in a food pantry setting.

4.2 Introduction

Food pantries may be an important setting to carry out interventions to improve dietary outcomes among groups experiencing food insecurity, defined as limited or uncertain availability or ability to acquire nutritionally adequate and safe foods (1,2). According to United States (US) census data, two-thirds of pantry-users are food insecure (3). Food insecurity is associated with the consumption of fewer vegetables, fruits, and dairy, and lower intakes of vitamin A, calcium, and magnesium in a nationally-representative sample (4), as well as diet-related chronic diseases

among low-income Americans (5). Rural, Midwestern communities may be particularly vulnerable to food insecurity; Midwestern households experienced an increase in food insecurity in 2013 during the conception of the present study (6) suggesting rural US communities may face additional barriers to accessing healthy foods relative to other geographical areas in the US (7). Food pantries are non-profit organizations with reach in many rural, low-income communities that provide food at no cost and with minimal eligibility requirements. Food pantry use and, by extension, the use of food pantries as an intervention contact point may differ for food secure (FS) and food insecure (including low food secure [LFS] and very low food secure [VLFS]) clients (2,8,9). With the recent increase in prevalence of long-term food pantry use (10), it is critical to investigate the efficacy of interventions in the food pantry setting to improve food security and dietary quality among food insecure subpopulations.

Various strategies to improve dietary outcomes in food pantry clients have been proposed and previously described, but not yet evaluated in a food pantry setting (11): 1. Guided client choice (GCC) is a model of food distribution in pantries in which foods are organized into food groups according to US Department of Agriculture (USDA) MyPlate, and clients are empowered to choose foods based on family size, contrasting with the traditional model where foods are pre-packaged and distributed to clients (12). The GCC model has the potential to better support the nutritional needs of clients while increasing choice and limiting waste (13). 2. The formation of food policy councils (FPCs), or diverse networks of food stakeholders from the public, private, and non-profit sectors of the food system (i.e., farmers, food retailers, policy makers, food assistance programs), may have the potential to improve the nutritional quality of foods available in communities (14,15). 3. Community coaching, or the presence of field staff who support communities in local change efforts, has been recognized by Cooperative Extension systems as a viable approach to sustaining positive community change (16).

Voices for Food (VFF) is a USDA-funded, three-year, multistate, socio-ecological modeled (SEM) (17–19) community-based intervention that supports the implementation or strengthening of GCC and FPCs in rural food pantries and their surrounding communities. All communities participating in VFF received a Food Council Guide and Food Pantry Toolkit (VFF materials), while the communities allocated to the intervention group were also provided an additional intervention component – a community coach who supported communities in the implementation of the VFF materials. This coaching component of the VFF intervention was

hypothesized to improve food security and dietary outcomes, including dietary quality and usual intake, among a multistate sample of rural, Midwestern, adult food pantry clients to a greater extent compared to provision of the VFF materials alone. The VFF materials alone were expected to improve outcomes in comparison communities over time. This intermediate analysis of the primary outcomes of VFF aimed to evaluate changes from baseline (2014) to midpoint (2016) (final study time point completed in 2017). Objectives were to evaluate changes by treatment group in: 1) adult food security scores; 2) Healthy Eating Index-2010 (HEI-2010) scores; and 3) usual intake of key food groups (total fruit, total vegetables, dark green vegetables, whole grains and total dairy) and nutrients (potassium, dietary fiber, choline, magnesium, calcium, vitamins A, D, E, C and iron) recommended to increase according to the most recent Dietary Guidelines for Americans (18). The intervention effect on diet quality and usual intake was also compared by food security status.

4.3 Methods

4.3.1 Study Design

Voices for Food (VFF) was a quasi-experimental, longitudinal, multistate intervention study with a matched intervention and comparison design that is fully described elsewhere (11). Briefly, VFF was a collaboration between the Cooperative Extension programs of six land grant universities across the Midwestern US, including the following states: Indiana, Michigan, Missouri, Nebraska, Ohio, and South Dakota. In each state, four rural food pantries were identified in non-metro counties with poverty rates higher than 16% in 2011 (20), with a Cooperative Extension presence, without well-established food policy councils or similar organizations, and without a full guided client choice model in place at the local food pantry. Two pantries in each state were assigned to the intervention group; each “intervention” pantry was matched with a “comparison” pantry according to previously-described criteria (11). Intervention communities received 1) community coaching by a project staff, and 2) provision of a written Food Council Guide and Food Pantry Toolkit (VFF materials) that describes: a) food policy council development and/or support, and b) food pantry transition to a MyChoice distribution model. Comparison communities received the VFF materials without community coaching. All communities were given the opportunity to apply for mini-grant funds on an annual basis. All participants in both treatment groups were blinded to the intervention (11). Demographic, food security, and dietary

assessments were administered to pantry clients at three time points over the course of VFF (2014, 2016 and 2017). Data from two time points (2014 and 2016) were examined in this analysis.

4.3.2 Study Participants and Recruitment

A convenience sample of clients was recruited from the selected pantries from August to November 2014 through flyers that advertised the study during pantry operation hours, and by research staff approaching clients while they waited to receive food. Participants, screened by a trained interviewer, were English speaking, adults age ≥ 18 years (or ≥ 19 years in Nebraska indicating legal adult status) who used the food pantry at least one time in the previous 12 months, and who were receiving foods from the pantry on the day of recruitment. The [Blinded for Review] University and [Blinded for Review] University Institutional Review Boards approved research activities prior to beginning the study, and participants gave written or verbal consent before completing study materials. Six hundred and seventeen pantry clients were eligible and recruited; 590 (98%) completed all initial assessments and were included in the baseline analysis (**Figure 1**). Of the baseline participants with complete data, 160 participants completed all midpoint assessments in 2016 and were included in this intermediate analysis (73% attrition rate).

4.3.3 Assessments and Measures

Participants were interviewed by trained research staff and completed an electronic or paper version of a characteristics and food security survey at baseline recruitment in participating food pantries. This questionnaire elicited information on demographic and pantry use characteristics, including age, sex, race, ethnicity, annual household income, education level, employment status, number of household members, participation in federal food assistance programs, frequency of visits to this pantry in the past year, number of different pantries visited in the last year, and length of time that food from pantries lasts. The 18-item US Household Food Security Survey Module (US HFSSM) was administered as part of this questionnaire (21,22). Participants also completed the Automated Self-Administered 24-h Dietary Recall (ASA24TM-2014), an internet-based 24-hour dietary recall (23), with optional staff assistance as part of the initial interview. Up to two additional dietary recalls were self-completed, or completed through an assisted phone interview, within two weeks of the pantry visit on non-consecutive days and including a weekend day (24). Participants received \$10 as compensation in the form of a grocery store gift card upon completion of the initial interview, and an additional \$10 gift card for each

dietary recall completed. At midpoint, the same participants were reached through phone, email, or on-site at the pantry of recruitment to complete assessments and receive compensation similar to baseline.

Questionnaire data were classed to variables for analysis as follows: state (IN, MI, MO, NE, OH, SD); age (18-44, 45-64, \geq 65 years); gender (woman, man); race (White, Black, American Indian, Other); ethnicity (of Hispanic, Latino or Spanish origin, not of Hispanic, Latino or Spanish origin); annual household income ($<$ \$10,000, \$10,000-15,000, $>$ \$15,000); education level (\leq high school graduate or equivalent, \geq some college/trade school); employment status (employed for \geq 6 months of the past year, employed for $<$ 6 months of the past year); number of household members (1, 2, \geq 3), number of children $<$ 18 years in the household (\geq 1, 0); usual mode of transportation used to acquire food (drive themselves, other); frequency of visits to this pantry in the past year ($<$ 5 times, \geq 5 times); number of different pantries visited in the past year (1, $>$ 1); length of time that food from pantries lasts (a few days' worth, 1-2 weeks' worth, more than half of food for the month); and having \geq 1 family member participating in the following federal food assistance programs: Supplemental Nutrition Assistance Program, Meals on Wheels, Soup Kitchens, the Special Supplemental Nutrition Program for Women, Infants, and Children, free or reduced-price school meals, and free or reduced-price meals at summer programs (participating in \geq 1 program, participating in 0 programs). An independent variable classifying treatment group was structured as a simple categorical variable with two levels: comparison group (VFF materials only) or intervention group (VFF materials + community coach).

Adult food security scores were quantified according to previous direction (21,22). A survey reference period of 12 months was used for the baseline and a reference period of two years was used at midpoint to quantify long-term changes in food security. Previously-described imputation methods were used to assign missing values and adult food security scores and categories were derived from responses to the 10 appropriate US HFSSM items (21). Participants in the high and marginal food security categories were combined into one “food secure” category because of the low proportion of participants in each of these categories.

Dietary information from ASA24™-2014 was used to determine HEI-2010 scores for each client over all recorded intake days (\leq 3) using the Simple HEI Scoring Algorithm – Per Person (25). The HEI-2010 is a density-based score that measures adherence to the DGA, allowing examination of overall diet quality in relation to federal dietary guidance, as well as dietary patterns

in terms of balance among multiple components to examine the quality of the mix of foods. The HEI-2010 is made up of nine adequacy components: total fruit, whole fruit, total vegetables, greens and beans, whole grains, total dairy, total protein foods, seafood and plant proteins, and fatty acids, and three moderation components: refined grains, sodium, and empty calories (i.e., solid fat, alcohol, and added sugars), most of which are expressed relative to energy intake (i.e., as densities) and then scored according to standards (26). For the adequacy components, a higher score indicates higher consumption; moderation components are reverse-scored, and thus a higher score indicates lower consumption. The 12 component scores are summed to yield a HEI-2010 total score with maximum value of 100 (26). Because the data were collected prior to the release of the 2015 DGA and HEI-2015, the HEI-2010 is appropriate to reflect the nutrition standards in place at the time of data collection.

4.3.4 Statistical Analysis

4.3.4.1 Client Characteristics

Total numbers and prevalence of pantry client demographic characteristics were calculated. Characteristics were compared across treatment groups using chi-squared analysis to determine if the intervention and comparison groups differed at baseline. Chi-square tests also compared the distributions of baseline characteristics between participants who were retained at midpoint compared to those who were not retained. Independent two-sample *t* tests compared the means of HEI-2010 total and component scores, and adult food security scores, between participants who were retained at midpoint and those who were not retained.

4.3.4.2 Comparison of Adult Food Security Scores over Time

A linear mixed model accommodated treatment group, time (modeled as baseline and midpoint), and their interaction as fixed variables, with adult food security score as the main dependent variable (one score per person). Two random effects were specified in the model: 1) to account for the correlation due to multiple observations made on the same subject, and 2) to account for variation within intervention-comparison food pantry matched pairs. All models controlled for potential confounding by age, gender, race, and income, as well as potential confounders that were distributed differently between treatment groups in the baseline chi-square and *t* tests: household size, estimated amount of household foods from all pantries in the last month,

and number of times this pantry was visited in the last year. Changes in scores from baseline to midpoint by treatment group, and differences in changes between treatment groups, were estimated with the Least Squares Mean (LSM) statement. Statistical significance was determined at $p < 0.05$.

4.3.4.3 Comparison of HEI-2010 Scores over Time and by Food Security Status

Similar to the comparison of adult food security score over time, linear mixed models accommodated treatment group, time, and their interaction as fixed variables, with main dependent variables of total or component HEI-2010 scores in separate models (one score per person). All model characteristics were similar to those described in the “*Comparison of adult food security scores over time*” section. Linear mixed models with food security status, treatment, and their interaction as main predictors, and the difference between each HEI-2010 total and component score (midpoint – baseline) as main outcome variables, and including the two random effects described above, were created to compare the effect of the intervention over time on HEI-2010 scores by food security subgroup. Differences using the LSM estimate statement and Bonferroni adjustment for three pairwise food security subgroup comparisons were structured for the FS-LFS comparison as:

$$FS [(Intervention: Time2 - Time1) - (Comparison: Time2 - Time 1)] -$$

$$LFS [(Intervention: Time 2 - Time 1) - (Comparison: Time 2 - Time 1)]$$

Similar estimate statements calculated differences between FS-VLFS and LFS-VLFS subgroups.

4.3.4.3.1 Application of the NCI Method to Quantify Usual Intake of Nutrients and Food Groups over Time

The NCI method (27,28) was used to calculate the usual dietary intake of key food groups and nutrients recommended to increase according to the most recent DGAs. Up to three ASA24™-2014 recalls per participant at each time point were included in the analysis. When the percentage of participants who consumed a given food group/nutrient on each recall day was $\leq 5\%$, the food group/nutrient was treated as ubiquitously-consumed; when the percentage of non-consumption was $> 5\%$, the food group/nutrient was treated as episodically consumed (29). In this study, all nutrients were determined to be ubiquitously consumed, and all food groups episodically consumed. The NCI method fits a two-part nonlinear mixed model accounting for the probability of consumption and consumption-day amount on a given day, while allowing the random effects for both parts of the model to be correlated.

Nutrients (from foods and beverages only) included calcium (mg), magnesium (mg), potassium (mg), vitamin A (μg , RAE), vitamin C (mg), vitamin D (μg), iron (mg), choline (mg), vitamin B12 (μg), fiber (g), and vitamin E (mg). For the nutrients (ubiquitously consumed), the probability of daily consumption was assumed to be one, and therefore a one-part “amount only” model was used. In this model, a Box-Cox transformation was applied to ≤ 3 days of 24-hour recall data and transformed observations were modeled using linear mixed effects models, with adjustment for covariates via fixed effects. The main predictors in the models (separate model for each nutrient) for estimating usual intake were time, treatment group, and their interaction. Potential confounders adjusted in the models were compressed into two levels to facilitate analysis by combining variables levels that yielded the lowest Akaike Information Criterion (AIC) to ensure optimal model fit. Potential confounders were classed as follows: age ($<65, \geq 65$), gender (woman, man), race (White, Other: Black/American Indian/Asian/Hawaiian), annual household income ($<\$10,000, \geq \$10,000$), household size (1, >1), estimated amount of household foods from all pantries in the last month (<1 week, ≥ 1 week), frequency of visits to this pantry over the past year (≥ 5 times, <5 times), state (MI/NE/SD, IN/MO/OH), and day of the week of dietary recall (weekday/weekend). Interview sequence of the dietary recall (indicating the first 24-hour recall) and total energy intake (a continuous variable) were also included as covariates in all models. Random unit (participant) effect was incorporated into the model to account for the correlation due to multiple observations made on the same subject. The %MIXTRAN SAS macro (30), adapted to include an estimate statement, compared changes in usual intake of nutrients from baseline to midpoint between the intervention and comparison groups using a difference of differences approach. The %DISTRIB SAS macro (30) produced the mean usual intake for each treatment group at each time point. One hundred bootstrap samples of the %DISTRIB macro were generated with samples of 160 participants to obtain the mean and standard deviation for usual intake for each nutrient.

Food groups included total fruit (cup equivalents), total vegetables (cup equivalents), dark green vegetables (cup equivalents), whole grain (ounce equivalents), and total dairy (cup equivalents). However, dark green vegetables was not included in the final analysis because of the high frequency of zero intake reported (88% of observations). For the food groups (episodically consumed), the probability of daily consumption was not assumed to be one, and therefore the two-part model was used. The first part estimated the probability of consuming a food using

logistic regression, while the second part was identical to the “amount only” model described for nutrients above. For both parts of the model, random unit (participant) effects were added to account for the correlation due to multiple observations made on the same subject. Random unit effects for the probability of consumption and for the amount of consumption were allowed to be correlated with each other. This allowed participants with higher probability of consumption to also have higher (or lower) mean consumption-day amount (31). Potential confounders adjusted in the models were compressed as described in the nutrient analysis above. In order to quantify the change from baseline to midpoint for both comparison and intervention groups, authors adapted the %MIXTRAN macro to include an estimate statement described by Tooze et al., 2002 (31). Briefly, the estimate statement specified in the two-part model computes the ratio of mean amounts from baseline to midpoint for each treatment group. In order to capture the range of possible effects of the intervention over time on the usual intake of food groups, the ratio of usual intake at midpoint compared to baseline for both treatment groups were computed for “low risk” and “high risk” covariate patterns. “Low risk” reflected a pattern associated with higher intake of food groups: age ≥ 65 ; gender = Man; race = White; annual household income = $\geq \$10,000$; household size= 1; estimated amount of household foods from all pantries in the last month= ≥ 1 week; frequency of visits to this pantry over the past year ≥ 5 times; state = IN/MO/OH; day of the week of dietary recall = weekday. All models controlled for mean energy intake (1508.60 kilocalories) and a variable representing the interview sequence of the dietary recalls (indicating the first 24-hour recall). Effects of time*treatment on usual intake were expressed for high risk and low risk groups separately as ratios ($Intervention \frac{mean\ usual\ intake\ (2-y\ follow-up)}{mean\ usual\ intake\ (baseline)}$ - $Comparison \frac{2-y\ follow-up}{baseline}$). Means and standard deviations of the usual intake for food groups were determined by applying the bootstrap technique to the %DISTRIB macro as described above for nutrients.

A nonlinear mixed model was also used to investigate whether food security had an effect on the change in usual intake over time. The main predictors in the models (separate model for each nutrient/food group) for estimating usual intake were extended to include food security status and its two-way and three-way interactions with time and treatment group. For the one-part model, estimate statements in the %MIXTRAN macro were used to compare the treatment effect by food security status (one estimate statement for each pairwise comparison of food security). Similarly, for the two-part model, authors included estimate statements described by Tooze et al., 2002 (31)

to compare ratios of changes in usual intake over time by treatment group by food security status. In both cases, a test statistic was calculated for testing the difference in the change from baseline to midpoint for treatment groups by food security status. All analyses were performed using SAS version 9.4 (32).

4.4 Results

The following baseline characteristics were significantly differently distributed between participants who were retained at midpoint compared to those who were not retained: treatment allocation, age, number of times this pantry was visited in the past 12 months, the length of time food from this pantry lasts. A greater proportion of participants who completed the midpoint than those who did not were allocated to the comparison group, older age, visited the participating food pantry more frequently, and reported food from the pantry lasting longer. There were no differences in adult food security or HEI-2010 scores between those who completed midpoint assessment versus those who did not (data not shown).

Significant differences were observed between the comparison and intervention groups at baseline; the intervention group had a higher proportion of men, larger household size, reported visited the participating food pantry more frequently in the past 12 months, and had a higher proportion who reported acquiring 1-2 weeks' worth of food from pantries (**Table 1**). A significant baseline difference was also observed between the comparison and intervention group for dairy HEI-2010 score; the comparison group had a higher mean score (data not shown). There were no other differences in main outcomes between treatment groups at baseline.

The primary research question in the study focused on changes in adult food security score, HEI-2010 total and component scores, and usual intake of under-consumed nutrients and related food groups from baseline to midpoint within each treatment group and comparisons between changes in the intervention group and the comparison group. The intervention group showed an improvement in adult food security score and empty calories score, and a decrease in total fruit score, from baseline to midpoint (p -values <0.05) (**Table 2**). The comparison group showed an increased HEI total score, and greens and beans, total protein foods, fatty acids, and empty calories component scores from baseline to midpoint (p -values <0.05). There was no improvement in usual intake of nutrients (**Table 3**) or food groups (**Table 5**) in either treatment group over time.

Determination of whether improvement occurred as a result of the intervention was the focus of the hypotheses. There was no improvement with regard to food security and diet quality, or usual intake between groups over time. However, there was a significant decrease in the greens and beans component score in the intervention group compared to the comparison group at this intermediate time point. There were no differences in the treatment effect on HEI-2010 scores or usual intake of nutrients or food groups by food security status (**Supplementary Tables 1, 2, and 3**).

4.5 Discussion

This study presents a midpoint progress report for the first SEM, community-based intervention in the food pantry setting aimed at improving food security and dietary outcomes among clients. At midpoint, improvements in main outcomes within both treatment groups were observed. The intervention group improved adult food security and empty calories scores, but total fruit score worsened over time. The comparison group improved HEI-2010 total score, as well as greens and beans, total protein foods, fatty acids, and empty calories component scores over time. When comparing the change in dietary outcomes over time between the intervention and comparison groups, no favorable differences were observed. There was a decrease in the greens and beans HEI-2010 component score from baseline to midpoint for the intervention group compared to the comparison group. Neither usual intake of nutrients nor food groups changed from baseline to midpoint for pantry clients in comparison or intervention communities. However, it should be noted there was an overall 73% attrition rate, which differed by treatment group. Thus, results should be interpreted with caution.

Interestingly, HEI-2010 total score and several component scores improved in the comparison group from baseline to midpoint. Since both the intervention and comparison communities received the VFF materials with instructions to carry out the formation of FPCs and conversion to a GCC distribution model, it is possible that receipt of the VFF materials alone was effective and improved dietary outcomes. However, if the VFF materials alone were responsible for improving dietary outcomes, similar improvement in both treatment groups would be expected, as both groups received the VFF materials. Contrarily, similar dietary quality improvements did not result in the intervention group. Instead, improvement in the mean adult food security score and ambiguous results regarding dietary quality scores in the intervention group resulted.

One explanation is that the intervention (community coaching and VFF materials) was successful in improving the availability of and access to healthy foods over the short-term, but longer follow-up is needed to see consequent changes in dietary intake. This is supported in the present study findings by an improvement in adult food security, defined as access to adequate food for an active, healthy life, in the intervention group only. There are documented barriers to clients utilizing healthy foods at food pantries, which may require a longer follow-up to capture acclimation to these new offerings. Previous literature suggests that clients may have less familiarity with, or inadequate resources to prepare, “healthier” foods. For example, instant meals and non-perishable snacks may be less healthy but more appealing to clients who lack resources, such as time to cook, adequate kitchen equipment, and lack of nutrition knowledge (33). This may result in food pantries ultimately providing less of the foods that clients are able to prepare and consequently less dietary improvement. This idea led authors to investigate the relationship between the nutritional quality of foods available at food pantries and the dietary quality of clients who use these pantries. Cross-sectionally at baseline, there was a statistically significant inverse association between the HEI-2010 total scores of the foods available at food pantries and the HEI-2010 total score for clients’ diets (unpublished data). Furthermore, a simple comparison of the nutritional quality of foods available in the participating food pantries showed a non-significant increase in the intervention group from baseline to midpoint, while the comparison group decreased (unpublished data). These preliminary findings support the overall idea that the VFF materials may be associated with positive changes in the pantry environment, but positive changes may take further time to be translated to improved dietary outcomes among clients.

With this idea in mind, it is possible that a smaller “dose” of VFF materials, likely experienced by the comparison group, was advantageous in this short-term scenario. Comparison pantries that may have experienced fewer improvements in pantry offerings and some (limited) conversion to a GCC model may have had the benefit of retaining most of their desired food pantry selections with added capability to choose desired food items. This could have resulted in improved dietary intake, but not food security, in the comparison group, which is supported by the present study findings. A longer follow-up period and quantification of the dose of VFF materials may inform the changes observed here.

Another explanation is that a potentially higher dose of the intervention may have improved the quality and quantity of foods provided at the intervention pantries and in the surrounding

community, and thus clients may not have needed to rely on pantry services as often at midpoint. Clients may rely less on food assistance resources, such as food pantries, as they become more food secure. This begs the question, “what defines success in a food pantry intervention?” In an ideal situation, participants would not need to rely on the food assistance provided by food pantries. If clients in the intervention group began using pantries less frequently, then they would not gain the dietary benefit of the improved pantry foods provided in intervention pantries. This may explain why the intervention group did not improve dietary quality despite reporting improved food security, which could imply that they are relying on other, less nutritious food sources outside of the pantry. The idea that improvement in food security may translate to reduced pantry use was supported by the significantly higher attrition rate in the intervention group compared to the comparison group. This idea led authors to investigate whether characteristics of pantry use changed over time between treatment groups. Findings showed no statistically significant changes, but found a non-significant decrease in the number of times the participating pantry was visited and a decrease in the amount of household food acquired from food pantries over time in the intervention group compared to the comparison group (unpublished data). The findings that clients are using pantries less frequently and are acquiring less of their household food supply from pantries over time in the intervention group compared to the comparison group support the notion that clients may decrease reliance on food assistance through pantries due to the intervention.

4.5.1 Strengths

This study used a socio-ecological approach to implement novel intervention components (i.e., community coaching, FPCs, GCC) that have previously not been evaluated in a food pantry setting. Recent DGAs promote the use of the social ecological model (SEM) to explain how layers of influence, including both individual factors and the surrounding environment, shape one’s food choices (17,18). Thus, using intervention strategies that influenced all layers of the ecological framework regarding food pantries was timely and promising. This study estimated both diet quality and usual intake among food pantry clients. Investigation of both dietary quality and intake is critical to determining dietary patterns. Although measuring diet quality independent of quantity using the HEI-2010 is meaningful, it is also important to consider the quantities of food groups and nutrients consumed in low-income communities. The authors measured the quantity of nutrients and food groups consumed while also mitigating measurement error by applying current gold-standard measures for quantifying dietary intake and estimating dietary outcomes including

the NCI method in the pantry-user population. Another strength of this study is the collection of up to three 24-hour dietary recalls on non-consecutive days. This provided a more representative measure of client dietary intake compared to using a single dietary recall.

4.5.2 Limitations

The high attrition rate of 73% was a limitation in determining how the intervention and change over time truly affected food pantry clients as the group included in the final sample does not represent those who left the study and the sample is less random compared with the group recruited at baseline. A greater proportion of participants who completed the midpoint than those who did not were allocated to the comparison group, older in age, visited the participating food pantry more frequently, and reported acquired food from the pantry lasting longer. Possible explanations for these differences are that clients who report visiting the food pantry frequently and who report a larger proportion of their household foods coming from food pantries exhibited a pattern of using the food pantry as a long-term supplement to their household foods and thus were more likely to still be visiting the pantry two years later during the midpoint assessment. The food pantry client population is known to be transient, however older clients may more likely be settled in their current location and thus easier to reach at midpoint. A greater proportion of participants who completed the midpoint assessment was allocated to the comparison group; reasons for this are unclear. Final results may not apply as fully to the participants in the intervention group, those who use pantries less frequently, those who report a smaller amount of their household foods being acquired at pantries, younger participants, and may include other endogenous factors which may bias the representativeness of the results presented here.

Under-reporting of energy intake when using 24-hour dietary recalls is documented (34) and could have also contributed to bias in this study; however, a recent study reported the ASA24 to perform relatively well among women with low incomes (24). The 24-hour recalls used to measure diet quality and quantity in this study did not account for supplements; therefore, resulting estimates do not represent total intake. Participants received compensation of up to \$30 in the form of grocery store gift cards, which could have resulted in higher quality foods being purchased at stores, and ultimately introduced bias to the second and third dietary recalls that were collected after the day of recruitment.

4.5.3 Conclusions

Food pantries are a critical resource to supplement the diets of clients, and thus food pantry interventions have the potential to positively influence food access and dietary patterns in rural, high-poverty communities. Improvements in food security and/or diet quality occurred in both treatment groups in the short term, yet positive short-term intervention changes did not result. Evaluation of the final study time point, as well as further investigation of the dose-dependent effect of each intervention component and other individual community characteristics, may elucidate the relationship between the VFF intervention and client outcomes.

4.6 References

1. Anderson SA. Core Indicators of Nutritional State for Difficult-to-Sample Populations. *J Nutr.* 1990;120:1555–600.
2. Wright BN, Bailey RL, Craig BA, Mattes RD, McCormack L, Stluka S, Franzen-Castle L, Henne B, Mehrle D, Remley D, et al. Daily dietary intake patterns improve after visiting a food pantry among food-insecure rural midwestern adults. *Nutrients.* 2018;10.
3. Coleman-Jensen A, Rabbitt MP, Gregory CA, Singh A. Statistical Supplement to Household Food Security in the United States in 2016. 2017; Available from: <https://www.ers.usda.gov/webdocs/publications/84981/ap-077.pdf?v=42979>
4. Hanson KL, Connor LM. Food insecurity and dietary quality in US adults and children : a systematic review. 2014;684–92.
5. Seligman HK, Laraia BA, Kushel MB. Food Insecurity Is Associated with Chronic Disease among Low-Income. *J Nutr.* 2011;141:542.
6. Coleman-Jensen A, Gregory C, Singh A. Household Food Security in the United States in 2013, ERR-173, U.S. Department of Agriculture, Economic Research Service. 2014; Available from: <http://www.ers.usda.gov/publications/err-economic-research-report/err173.aspx>
7. Casey AA, Elliott M, Glanz K, Haire-Joshu D, Lovegreen SL, Saelens BE, Sallis JF, Brownson RC. Impact of the food environment and physical activity environment on behaviors and weight status in rural U.S. communities. *Prev Med.* 2008;47:600–4.
8. Kicinski LR. Characteristics of Short and Long-Term Food Pantry Users. 2012;26:58–74.
9. Kaiser ML, Cafer AM. Exploring Long-term Food Pantry Use: Differences Between Persistent and Prolonged Typologies of Use. *J Hunger Environ Nutr [Internet].* Taylor & Francis; 2017;12:46–63. Available from:

<http://dx.doi.org/10.1080/19320248.2016.1157554>

10. Johnson K, Rawlings-blake S, Schneider H, Cochran T. Hunger and Homelessness Survey: A Status Report on Hunger and Homelessness in America's Cities. 2013;1–120.
11. [Blinded for review]. Voices for food: Methodologies for implementing a multi-state community-based intervention in rural, high poverty communities. [Blinded for Review];
12. United States Department of Agriculture. ChooseMyPlate.gov [Internet]. [cited 2019 Feb 13]. Available from: <https://www.choosemyplate.gov/>
13. Remley DT, Zubieta AC, Lambea MC, Quinonez HM, Taylor C. Spanish- and English-speaking client perceptions of choice food pantries. J Hunger Environ Nutr. 2010;5:120–8.
14. Harper A, Shattuck A, Holt-Giménez E, Alkon A, Lambrick F. Food Policy Councils: Lessons Learned. 2009; Available from: <https://foodfirst.org/publication/food-policy-councils-lessons-learned/>
15. Centers for Disease Control Division of Nutrition Physical Activity and Obesity. State Program Highlights: Food Policy Councils. Public Health. 2010;
16. Hubbell K, Emery M. Guiding Sustainable Community Change: An introduction to Coaching. 2009;1–48.
17. U.S. Department of Health and Human Services and U.S. Department of Agriculture. Dietary Guidelines for Americans 2010, 7th Edition, U.S. Department of Agriculture and U.S. Department of Health and Human Services. 2010;
18. U.S. Department of Health and Human Services and U.S. Department of Agriculture. Dietary Guidelines for Americans 2015-2020 [Internet]. 8th ed. 2015. Available from: https://health.gov/dietaryguidelines/2015/resources/2015-2020_Dietary_Guidelines.pdf
19. Kaiser ML. Food security: An ecological-social analysis to promote social development. J Community Pract. 2011;19:62–79.
20. U.S. Department of Agriculture Economic Research Service. County-Level Data Sets [Internet]. 2011 [cited 2013 Aug 1]. Available from: <https://data.ers.usda.gov/reports.aspx?ID=14843>
21. Bickel G, Nord M, Price C, Hamilton W, Cook J. Guide to Measuring Household Food Security [Internet]. 2000. Available from: <https://fns-prod.azureedge.net/sites/default/files/FSGuide.pdf>
22. United States Department of Agriculture Economic Research Service. U.S. Adult Food Security Survey Module: Three-Stage Design, with Screeners [Internet]. 2012. Available from: <https://www.ers.usda.gov/media/8279/ad2012.pdf>
23. Subar AF, Kirkpatrick SI, Mittl B, Zimmerman TP, Thompson FE, Bingley C, Willis G, Islam NG, Baranowski T, McNutt S, et al. The Automated Self-Administered 24-Hour

- Dietary Recall (ASA24): A Resource for Researchers, Clinicians and Educators from the National Cancer Institute. 2012;112:1134–7.
24. Kirkpatrick SI, Guenther PM, Douglass D, Zimmerman T, Kahle LL, Atoloye A, Marcinow M, Savoie-Roskos MR, Dodd KW, Durward C. The Provision of Assistance Does Not Substantially Impact the Accuracy of 24-Hour Dietary Recalls Completed Using the Automated Self-Administered 24-H Dietary Assessment Tool among Women with Low Incomes. *J Nutr* [Internet]. 2019;1–9. Available from: <https://academic.oup.com/jn/advance-article/doi/10.1093/jn/nxy207/5271166>
 25. National Cancer Institute Division of Cancer Control & Population Sciences. Healthy Eating Index SAS Code [Internet]. [cited 2018 Sep 1]. Available from: <https://epi.grants.cancer.gov/hei/sas-code.html>
 26. Guenther PM, Kirkpatrick SI, Reedy J, Krebs-Smith SM, Buckman DW, Dodd KW, Casavale KO, Carroll RJ. The Healthy Eating Index-2010 Is a Valid and Reliable Measure of Diet Quality According to the 2010 Dietary Guidelines for Americans. *J Nutr* [Internet]. 2014;144:399–407. Available from: <http://jn.nutrition.org/cgi/doi/10.3945/jn.113.183079>
 27. Tooze JA, Midthune D, Dodd KW, Freedman LS, Krebs-Smith SM, Subar AF, Guenther PM, Carroll RJ, Kipnis V. A new method for estimating the usual intake of episodically-consumed foods with application to their distribution. 2006;106:1575–87.
 28. Tooze JA, Kipnis V, Buckman DW, Carroll RJ, Freedman LS, Guenther PM, Krebs-Smith SM, Subar AF, Dodd KW. A mixed-effects model approach for estimating the distribution of usual intake of nutrients: The NCI method. 2010;29.
 29. National Cancer Institute. Describing Dietary Intake [Internet]. [cited 2019 Jan 11]. Available from: <https://dietassessmentprimer.cancer.gov/approach/intake.html>
 30. National Cancer Institute. Usual Dietary Intakes: SAS Macros for the NCI Method [Internet]. [cited 2019 Jan 11]. Available from: <https://epi.grants.cancer.gov/diet/usualintakes/macros.html>
 31. Tooze JA, Grunwald GK, Jones RH. Analysis of repeated measures data with clumping at zero. *Stat Methods Med Res*. 2002;
 32. SAS Institute Inc. Cary, NC, USA: Version 9.4;
 33. Dave JM, Thompson DI, Svendsen-Sanchez A, Cullen KW. Perspectives on Barriers to Eating Healthy Among Food Pantry Clients. *Heal Equity* [Internet]. 2017;1:28–34. Available from: <http://www.liebertpub.com/doi/10.1089/heq.2016.0009>
 34. Murakami K, Livingstone MBE. Prevalence and characteristics of misreporting of energy intake in US adults: NHANES 2003-2012. *Br J Nutr*. 2015;114:1294–303.

4.7 Results Tables and Figures

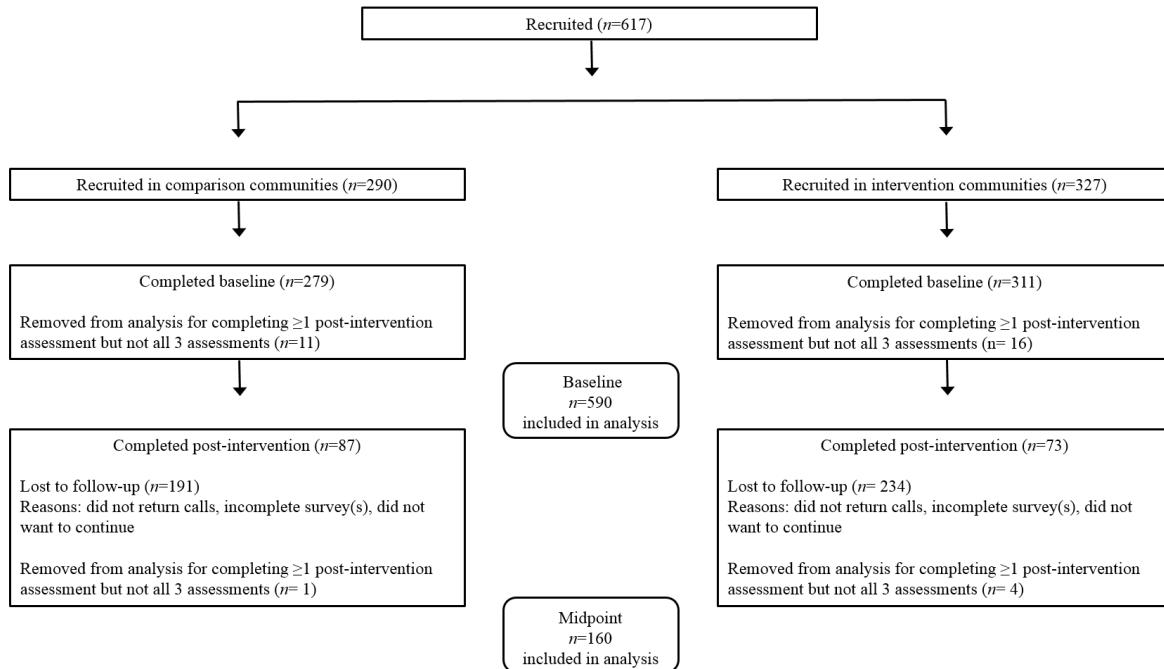


Figure 4-1 Participant flow chart for assessment completion and loss to follow-up among Voices for Food participants during the study period of August 2014 through December 2016.

Table 4-1 Unadjusted sociodemographic characteristics by treatment group for a multistate sample of rural, Midwestern, adult food pantry clients

Characteristics	Baseline		Midpoint		
	Comparison group	Intervention group	Comparison	Intervention	
			n (%) ¹	n (%)	P(χ^2)
Total	279 (47)	311 (53)		87 (54)	73 (46)
Adult food security status				0.41	0.22
Food secure	59 (21)	74 (24)		30 (34)	28 (38)
Low food secure	79 (28)	97 (31)		21 (24)	24 (33)
Very low food secure	141 (51)	140 (45)		36 (41)	21 (29)
State				0.19	0.47
Indiana	75 (27)	76 (24)		25 (29)	21 (29)
Michigan	49 (18)	53 (17)		13 (15)	13 (18)
Missouri	68 (24)	76 (24)		24 (28)	16 (22)
Nebraska	30 (11)	20 (6)		12 (14)	7 (10)
Ohio	34 (12)	45 (14)		3 (3)	8 (11)
South Dakota	23 (8)	41 (13)		10 (11)	8 (11)
Gender				0.003	0.17
Men	50 (22)	89 (34)		18 (21)	22 (30)
Women	182 (78)	175 (66)		69 (79)	51 (70)
Age				0.26	0.76
18-44	90 (38)	95 (36)		13 (15)	13 (19)
45-64	94 (39)	124 (47)		39 (46)	34 (49)
≥ 65	52 (22)	47 (18)		32 (38)	23 (33)
Race				0.35	0.04
White	187 (83)	200 (77)		77 (90)	58 (81)
Black	14 (6)	27 (10)		1 (1)	8 (11)
American Indian	17 (8)	22 (8)		6 (7)	3 (4)
Other ²	8 (4)	11 (4)		2 (2)	3 (4)
Highest education level				0.39	0.19
\leq High school graduate or equivalent	163 (69)	175 (66)		64 (75)	48 (66)
\geq Some college/trade school	72 (31)	91 (34)		21 (25)	25 (34)
Employment status ³				0.05	0.60
Employed ≥ 6 months	54 (20)	79 (27)		18 (21)	13 (18)

Characteristics	Baseline				Midpoint
	Comparison		Intervention		
	group	group	group	group	
	n (%) ¹	n (%)	P(χ^2)	n (%)	n (%)
Employed <6 months	220 (80)	219 (73)		66 (79)	59 (82)
Income ⁴			0.049		0.15
<\$10,000	143 (55)	156 (54)		41 (50)	37 (51)
\$10,000 - \$15,000	63 (24)	50 (17)		22 (27)	11 (15)
>\$15,000	56 (21)	83 (29)		19 (23)	24 (33)
Household size ³			0.03		0.04
1 member	90 (33)	85 (28)		32 (37)	18 (25)
2 members	74 (27)	65 (21)		29 (33)	19 (26)
≥3 members	112 (41)	159 (51)		26 (30)	36 (49)
Participation in food assistance programs ^{3,5}			0.76		0.27
≥1 program	226 (95)	247 (94)		64 (94)	55 (89)
0 programs	13 (5)	16 (6)		4 (6)	7 (11)
Estimated amount of household foods from all pantries in the last month			0.01		0.78
A few days' worth	126 (49)	121 (42)		20 (30)	21 (36)
1-2 weeks' worth	75 (29)	117 (41)		30 (45)	25 (42)
More than half of food for the month	58 (22)	48 (17)		17 (25)	13 (22)
Number of pantries visited ³			0.21		0.27
1 pantry	120 (45)	151 (50)		15 (18)	8 (12)
>1 pantry	146 (55)	149 (50)		67 (82)	60 (88)
Number of times this pantry was visited ³			0.04		0.48
<5 times	155 (56)	146 (47)		37 (43)	27 (37)
≥5 times	124 (44)	165 (53)		50 (57)	46 (63)

¹Totals may not add up to total participants due to missing values.

²Includes Native Hawaiian, Asian, and any combinations of races.

³Over the past 12 months.

⁴Self-reported total combined income of all household members over the past 12 months including income from jobs, business, pensions, Social Security or retirement payments, disability payments, and any other money income received.

⁵Includes the Supplemental Nutrition Assistance Program; Meals on Wheels; Soup Kitchens; the Special Supplemental Nutrition Program for Women, Infants, and Children; free or reduced-price school meals; and free or reduced-priced meals at summer programs.

* Statistical significance is p<0.05 for chi-squared comparisons between food secure, low food secure and very low food secure households

Table 4-2 Mean adult food security and Healthy Eating Index-2010 scores at baseline and midpoint, changes from baseline to midpoint, and difference in changes between treatment groups among a multistate sample of rural, Midwestern, adult food pantry clients¹

Score	Comparison (n = 87)				Intervention (n = 73)				Difference	P
	Baseline	Midpoint	Change ²	P	Baseline	Midpoint	Change ²	P		
Adult food security	5.3 ± 0.4	4.8 ± 0.5	-0.5 ± 0.4	0.23	4.8 ± 0.4	3.8 ± 0.5	-1.0 ± 0.4	0.01*	-0.5 ± 0.5	0.36
HEI total score	42.7 ± 1.4	48.6 ± 1.9	5.9 ± 1.5	0.0001*	43.6 ± 1.4	46.0 ± 1.9	2.5 ± 1.5	0.10	-3.4 ± 2.1	0.11
Total vegetables	3.3 ± 0.2	3.5 ± 0.3	0.2 ± 0.2	0.44	3.3 ± 0.2	3.1 ± 0.3	-0.2 ± 0.2	0.34	-0.4 ± 0.3	0.22
Greens and beans	1.0 ± 0.2	1.7 ± 0.3	0.7 ± 0.3	0.01*	1.1 ± 0.2	0.9 ± 0.3	-0.1 ± 0.3	0.62	-0.8 ± 0.4	0.02*
Total fruit	1.7 ± 0.2	1.3 ± 0.3	-0.5 ± 0.3	0.08	2.0 ± 0.2	1.3 ± 0.3	-0.6 ± 0.3	0.02*	-0.2 ± 0.4	0.69
Whole fruit	1.2 ± 0.2	1.0 ± 0.3	-0.1 ± 0.3	0.56	1.5 ± 0.2	1.1 ± 0.3	-0.4 ± 0.3	0.12	-0.3 ± 0.4	0.47
Whole grains	1.9 ± 0.3	2.2 ± 0.5	0.2 ± 0.4	0.56	2.3 ± 0.3	2.5 ± 0.5	0.2 ± 0.4	0.57	-0.0 ± 0.6	1.00
Total dairy	4.0 ± 0.4	4.0 ± 0.5	0.1 ± 0.4	0.84	3.3 ± 0.3	4.0 ± 0.5	0.7 ± 0.4	0.09	0.6 ± 0.6	0.29
Total protein foods	4.4 ± 0.1	4.8 ± 0.2	0.3 ± 0.1	0.04*	4.5 ± 0.1	4.7 ± 0.2	0.2 ± 0.1	0.13	-0.1 ± 0.2	0.69
Seafood & plant proteins	1.2 ± 0.2	1.6 ± 0.3	0.4 ± 0.3	0.14	1.1 ± 0.3	0.8 ± 0.3	-0.3 ± 0.3	0.33	-0.7 ± 0.4	0.08
Fatty acids	4.6 ± 0.3	5.6 ± 0.5	1.0 ± 0.4	0.02*	4.8 ± 0.3	5.5 ± 0.5	0.7 ± 0.4	0.10	-0.3 ± 0.6	0.58
Sodium	2.7 ± 0.3	2.2 ± 0.5	-0.5 ± 0.4	0.20	2.9 ± 0.3	2.5 ± 0.5	-0.4 ± 0.4	0.33	0.1 ± 0.6	0.83
Refined grains	6.5 ± 0.4	6.8 ± 0.5	0.3 ± 0.4	0.57	6.5 ± 0.4	6.3 ± 0.5	-0.2 ± 0.4	0.58	-0.5 ± 0.6	0.43
Empty calories	10.2 ± 0.7	14.2 ± 0.7	4.1 ± 0.7	<0.0001*	10.4 ± 0.7	13.2 ± 1.0	2.8 ± 0.7	0.0002*	-1.2 ± 1.0	0.24

¹ Values are adjusted least-squares means ± SEMs unless otherwise indicated. Models adjusted for age, gender, race, income, household size, estimated amount of household foods from all pantries in the last month, and number of times this pantry was visited in the last year.

² Values are the difference between baseline and midpoint adjusted least-squares means ± SEMs.

³ Values are the difference in changes of adjusted least-squares means ± SEMs between treatment groups from baseline to midpoint.

Table 4-3 Mean usual intake of nutrients at baseline and midpoint, changes in β estimates from baseline to midpoint, and difference in changes between treatment groups among a multistate sample of rural, Midwestern, adult food pantry clients¹

Nutrient	Comparison			Intervention			Intervention – Comparison
	Baseline ²	Midpoint ²	P-value for change ³	Baseline ²	Midpoint ²	P-value for change ⁴	
Potassium, mg/day	1300 ± 172	1472 ± 175	0.12	1387 ± 193	1509 ± 206	0.48	0.47
Dietary fiber, g/day	7.7 ± 0.9	7.8 ± 0.9	0.36	8.3 ± 0.9	7.9 ± 1.2	0.49	0.90
Choline, mg/day	180 ± 19	200 ± 19	0.64	193 ± 19	207 ± 25	0.12	0.39
Magnesium, mg/day	131 ± 78	138 ± 15	0.09	141 ± 88	169 ± 18	0.05	0.70
Calcium, mg/day	458 ± 152	562 ± 156	0.05	486 ± 140	558 ± 156	0.02	0.63
vitamin A, µg, RAE/day	353 ± 65	401 ± 41	0.25	360 ± 52	365 ± 40	0.59	0.22
vitamin D, µg/day	2.3 ± 0.3	3.0 ± 0.4	0.46	2.4 ± 0.3	3.0 ± 0.4	0.06	0.38
vitamin E, alpha-tocopherol, mg/day	3.3 ± 0.4	4.0 ± 0.4	0.08	3.5 ± 0.4	4.2 ± 0.6	0.27	0.68
vitamin C, mg/day	29.4 ± 4.4	26.6 ± 5.0	0.76	31.7 ± 4.6	29.0 ± 6.0	0.30	0.32
Iron, mg/day	7.8 ± 1.1	8.4 ± 1.0	0.10	8.4 ± 1.0	8.6 ± 1.1	0.69	0.38

¹ Models adjusted for age, gender, race, income, household size, estimated amount of household foods from all pantries in the last month, and number of times this pantry was visited in the last year.

² Values are bootstrapped means ± standard deviations estimated from %DISTRIB macro.

³ P-value for testing the difference from baseline to midpoint for the comparison group. This test was run using an estimate statement within the %MIXTRAN macro.

⁴ P-value for testing the difference from baseline to midpoint for the comparison group. This test was run using an estimate statement within the %MIXTRAN macro.

⁵ P-value for testing the difference in the change from baseline to midpoint for comparison and treatment groups. This test was run using an estimate statement within the %MIXTRAN macro.

* Statistical significance was determined at $p < 0.0167$ to adjust for multiple comparisons using Bonferroni method.

Table 4-4 Mean usual intake of food groups at baseline and midpoint among a multistate sample of rural, Midwestern adult food pantry clients¹

Food group	Comparison		Intervention	
	Baseline ²	Midpoint ²	Baseline ²	Midpoint ²
Total fruit	0.5 ± 0.1	0.4 ± 0.1	0.5 ± 0.1	0.4 ± 0.1
Total vegetables	1.4 ± 0.2	1.5 ± 0.2	0.3 ± 0.2	0.4 ± 0.2
Dark green vegetables	0.2 ± 0.8	0.0 ± 0.6	0.1 ± 0.9	0.0 ± 0.6
Whole grains	0.6 ± 0.1	0.7 ± 0.1	0.5 ± 0.1	0.6 ± 0.1
Total dairy	1.2 ± 0.2	1.4 ± 0.2	1.1 ± 0.2	0.3 ± 0.1

¹ Models adjusted for age, gender, race, income, household size, estimated amount of household foods from all pantries in the last month, and number of times this pantry was visited in the last year.

² Values are bootstrapped means ± standard deviations

Table 4-5 Ratios of the usual intake of food groups from baseline to midpoint and changes in ratios between treatment groups among a multistate sample of rural, Midwestern adult food pantry clients¹

Food group	Covariates (a-i)									Ratios of usual intake at baseline and midpoint for comparison (com.) and intervention (int.) groups			
	Risk level	(a) Age	(b) Sex	(c) Race	(d) Income	(e) Household size	(f) Household food	(g) Frequency	(h) State	(i) Weekday/weekend	P-value ²	P-value ³	P-value ⁴
	High	<45y	F	Other	<\$10,000	>1 person	<1 week	<5 times	MI,NE,SD	Weekend	0.62	0.54	0.99
Total fruit	Low	≥45y	M	White	≥\$10,000	1 person	≥1 week	≥5 times	IN,MO,OH	Weekday	0.57	0.54	0.97
Total vegetables	High	<45y	F	Other	<\$10,000	>1 person	<1 week	<5 times	MI,NE,SD	Weekend	0.64	0.97	0.76
Whole grains	Low	≥45y	M	White	≥\$10,000	1 person	≥1 week	≥5 times	IN,MO,OH	Weekday	0.65	0.84	0.68
Total dairy	High	<45y	F	Other	<\$10,000	>1 person	<1 week	<5 times	MI,NE,SD	Weekend	0.75	0.22	0.46
	Low	≥45y	M	White	≥\$10,000	1 person	≥1 week	≥5 times	IN,MO,OH	Weekday	0.69	0.08	0.25

¹ Authors adapted the National Cancer Institute method to include estimate statements described by Tooze et al., 2002 that calculated ratios of changes in usual intake over time by treatment group ($\frac{\text{Intervention}_{\text{baseline}}^{2-y \text{ follow-up}} - \text{Comparison}_{\text{baseline}}^{2-y \text{ follow-up}}}{\text{baseline}}$). Energy was set equal to the mean, 1508.60 kilocalories.

² P-value for testing the difference from baseline to midpoint for the comparison group. This test was run using an estimate statement within the %MIXTRAN macro.

³ P-value for testing the difference from baseline to midpoint for the treatment group. This test was run using an estimate statement within the %MIXTRAN macro.

⁴ P-value for testing the difference in the change from baseline to midpoint for comparison and treatment groups. This test was run using an estimate statement within the %MIXTRAN macro.

* Statistical significance was determined at $p < 0.0167$ to adjust for multiple comparisons using Bonferroni method.

Table 4-6 Supplementary Table: Association of food security with the change in Healthy Eating Index-2010 scores from baseline to midpoint among a multistate sample of rural, Midwestern, adult food pantry clients¹

Response	ΔFS-ΔLFS		ΔFS-ΔVLFS		ΔLFS-ΔVLFS	
	β	P	β	p	β	p
Δ HEI total score	4.5 ± 3.6	0.63	6.4 ± 3.5	0.20	1.8 ± 3.1	1.00
Δ Total vegetables	0.8 ± 0.5	0.42	0.5 ± 0.5	0.96	-0.3 ± 0.5	1.00
Δ Greens and beans	-1.3 ± 0.8	1.00	-0.5 ± 0.7	1.00	0.8 ± 0.6	1.00
Δ Total fruit	-0.5 ± 0.6	1.00	-1.1 ± 0.6	1.00	-0.6 ± 0.5	1.00
Δ Whole fruit	-0.9 ± 0.6	1.00	-1.8 ± 0.6	0.60	-0.9 ± 0.5	0.99
Δ Whole grains	2.0 ± 1.1	0.93	1.0 ± 1.0	1.00	-1.0 ± 0.9	1.00
Δ Total dairy	-1.1 ± 1.0	1.00	0.0 ± 1.0	1.00	1.1 ± 0.9	1.00
Δ Total protein foods	-0.1 ± 0.3	1.00	0.7 ± 0.3	0.79	0.8 ± 0.3	0.61
Δ Seafood & plant proteins	1.2 ± 0.8	1.00	1.5 ± 0.7	0.89	0.3 ± 0.6	1.00
Δ Fatty acids	4.0 ± 1.0	0.48	3.2 ± 1.0	0.58	-0.8 ± 0.9	1.00
Δ Sodium	-1.4 ± 1.0	1.00	-0.0 ± 1.0	1.00	1.4 ± 0.8	1.00
Δ Refined grains	-1.5 ± 1.1	1.00	-1.0 ± 1.0	1.00	0.5 ± 0.9	1.00
Δ Empty calories	3.6 ± 1.8	0.90	3.8 ± 1.8	0.83	0.2 ± 1.6	1.00

¹ Values are adjusted least-squares means ± SEMs unless otherwise indicated. Models adjusted for age, gender, race, income, household size, estimated amount of household foods from all pantries in the last month, and number of times this pantry was visited in the last year. The outcomes variable was the difference in each component from baseline to midpoint. The main predictors were time, food security status, and the interaction between these predictors.

² Values are the difference between baseline and midpoint for FS-LFS, FS-VLFS, and LFS-VLFS subgroups.

Table 4-7 Supplementary Table: Association of food security with the change in usual intake of nutrients from baseline to midpoint among a multistate sample of rural, Midwestern, adult food pantry clients¹

Response	FS-LFS: Δ Int. - Δ Com.		FS-VLFS: Δ Int. - Δ Com.		LFS-VLFS: Δ Int. - Δ Com.	
Δ = T2-T1 ²	t (141) ²	p	t (141)	p	t (141)	p
Potassium	1.02	0.31	1.77	0.08	0.98	0.33
Dietary fiber	-0.18	0.86	0.99	0.32	1.22	0.22
Choline	0.71	0.48	1.99	0.05	1.33	0.19
Magnesium	1.44	0.15	1.82	0.07	0.22	0.83
Calcium	1.08	0.28	1.58	0.12	0.50	0.62
vitamin A	1.53	0.13	1.52	0.13	-0.11	0.91
vitamin D	1.30	0.20	0.54	0.59	0.54	0.38
vitamin E	0.08	0.94	1.50	0.14	1.48	0.14
vitamin C	0.50	0.62	0.47	0.64	-0.06	0.95
Iron	1.27	0.21	2.16	0.03*	0.86	0.39

¹ Authors adapted the National Cancer Institute method to include estimate statements within the %MIXTRAN macro to compare changes in usual intake over time by treatment group [*Intervention (Time 2 – Time 1) – Comparison (Time 2 – Time 1)*] by food security status. Energy was set equal to the mean, 1508.60 kilocalories. Models adjusted for age, gender, race, income, household size, estimated amount of household foods from all pantries in the last month, number of times this pantry was visited in the last year, weekend/weekday, and the sequence of 24-hour recalls. Main predictors were time, treatment, food security status, and the two-way and three-way interactions of these predictors.

² Test statistic (degrees of freedom) for testing the difference in the change from baseline to midpoint for comparison and treatment groups by food security status.

Table 4-8 Supplementary Table: Association of food security with the change in usual intake of nutrients from baseline to midpoint among a multistate sample of rural, Midwestern, adult food pantry clients¹

Food group	Covariates (a-i)										Differences in ratios of usual intake by food security status at baseline and midpoint for comparison and intervention groups		
	Risk level	(a) Age	(b) Sex	(c) Race	(d) Income	(e) Household size	(f) Household food	(g) Frequency	(h) State	(i) Weekday/weekend	FS-LFS:	FS-VLFS:	LFS-VLFS:
											t (141) ² (p)	t (141) (p)	t (141) (p)
Total fruit	High	<45y	F	Other	<\$10,000	>1 person	<1 week	<5 times	MI,NE,SD	Weekend	0.87 (0.38)	-0.32 (0.75)	-0.97 (0.34)
	Low	≥45y	M	White	≥\$10,000	1 person	≥1 week	≥5 times	IN,MO,OH	Weekday	0.86 (0.39)	-0.06 (0.95)	-0.87 (0.39)
Total vegetables	High	<45y	F	Other	<\$10,000	>1 person	<1 week	<5 times	MI,NE,SD	Weekend	0.73 (0.47)	1.88 (0.06)	1.14 (0.25)
Whole grains	Low	≥45y	M	White	≥\$10,000	1 person	≥1 week	≥5 times	IN,MO,OH	Weekday	0.64 (0.53)	1.83 (0.07)	1.16 (0.25)
Total dairy	High	<45y	F	Other	<\$10,000	>1 person	<1 week	<5 times	MI,NE,SD	Weekend	0.45 (0.66)	-0.29 (0.77)	-0.62 (0.54)
	Low	≥45y	M	White	≥\$10,000	1 person	≥1 week	≥5 times	IN,MO,OH	Weekday	0.72 (0.47)	0.13 (0.90)	-0.62 (0.53)
Total	High	<45y	F	Other	<\$10,000	>1 person	<1 week	<5 times	MI,NE,SD	Weekend	0.07 (0.94)	1.07 (0.29)	1.03 (0.30)
	Low	≥45y	M	White	≥\$10,000	1 person	≥1 week	≥5 times	IN,MO,OH	Weekday	0.23 (0.81)	0.28 (0.78)	0.03 (0.98)

¹ Authors adapted the National Cancer Institute method to include estimate statements described by Tooze et al., 2002 to compare ratios of changes in usual intake over time by treatment group ($\frac{\text{Intervention } 2\text{-y follow-up}}{\text{baseline}} - \frac{\text{Comparison } 2\text{-y follow-up}}{\text{baseline}}$) by food security status. Energy was set equal to the mean, 1508.60 kilocalories.

Models adjusted for age, gender, race, income, household size, estimated amount of household foods from all pantries in the last month, number of times this pantry was visited in the last year, weekend/weekday, and the sequence of 24-hour recalls. Main predictors were time, treatment, food security status, and the two-way and three-way interactions of these predictors.

² Test statistic (degrees of freedom) for testing the difference in the change from baseline to midpoint for comparison and treatment groups by food security status. This test was run using an estimate statement within the %MIXTRAN macro.

CHAPTER 5. CONCLUSIONS

5.1 Summary of Aims

The overarching goal of this dissertation was to investigate differences in dietary patterns, consumption of food pantry offerings, and intermediate effects of a food pantry intervention on dietary outcomes by food security status. The specific aims were to 1) characterize differences in dietary quality and intake between food secure (FS), low food secure (LFS) and very low food secure (VLFS) pantry clients in a cross-sectional analysis; 2) explore associations between the nutritional quality of the food pantry environment (foods stocked and distributed by foods pantries) and pantry client diet quality by food security status in a cross-sectional analysis; and 3) evaluate the intermediate effects of a SEM, community-based intervention to improve dietary outcomes among pantry clients by food security subgroup in a longitudinal analysis.

The first aim was addressed in the second chapter by quantifying food security and estimating dietary quality and usual intake in a multistate sample of food pantry clients. A cross-sectional, mixed multiple linear regression analysis showed differences between FS, LFS and VLFS pantry clients in dietary quality and usual intake, suggesting that food security status may be associated with dietary patterns, even among the vulnerable food pantry client population. Food security was associated with a higher whole grains HEI-2010 score, as well as a higher mean usual intake of whole grains and iron, compared to low food security among food pantry clients. Food security was also associated with a higher mean usual intake of dark green vegetables and total dairy compared to both low food security and very low food security among food pantry clients. However, all pantry clients, regardless of food security status, consumed less than federal guidelines and markers of adequacy for all nutrients and food groups evaluated.

The second aim was addressed in the third chapter by scoring the nutritional quality of the pantry food environment (pantry inventories and client food bags) and the dietary quality of pantry clients using a comparable scoring system. A cross-sectional, multiple linear regression analysis showed positive associations between client food bag nutritional quality scores and client diet quality scores for total vegetables, total fruit, and total protein foods, which suggests that clients are especially relying on pantries for these food groups. Negative associations between pantry inventory scores and client scores suggests that encouraging higher quality foods may present

barriers for clients. VLFS clients benefitted more from food pantry offerings compared to FS and LFS clients, which supports the notion that FS, LFS, and VLFS may rely on pantry resources differently. Broader implications of these findings remain ambiguous; further investigation of pantry client perceptions of pantry offerings and reasons for visiting food pantries may aid in elucidating the relationship between pantry inventories, client food bags, and clients' diets and food security status.

The third aim was addressed in the fourth chapter by evaluating the short-term effects of the VFF intervention on dietary outcomes from baseline to midpoint. A longitudinal, mixed multiple linear regression analysis with repeated measures showed improvement in food security in the intervention group and improvements in diet quality in the comparison group. Although the intervention did not positively impact the dietary outcomes of pantry clients differently between treatment groups, unforeseen factors, such as attrition and other mechanisms, may have introduced bias contributing to these results. The VFF materials promoting formation of FPCs and a GCC food pantry distribution model may be promising for long-term improvement in dietary outcomes, but further investigation of the dose-dependent effect of each intervention component, as well as changes in other pantry environment characteristics over the study period, are needed to elucidate the relationship between the VFF intervention and clients dietary outcomes.

Interestingly, the findings of the second and third aims both imply that a healthier food pantry environment may be associated with reduced pantry use among clients. The second aim found an inverse cross-sectional association between the nutritional quality of food pantry inventories and the diet quality of clients who visit that pantry, suggesting barriers to clients consuming the healthier foods provided. Similarly, findings from the third aim suggest that the VFF intervention led to a decrease in client dietary intake of greens and beans in the first two years. Although there were improvements in several dietary component scores in the comparison group, in the intervention group, which was hypothesized to have greater improvement in dietary outcomes due to facilitation of the VFF materials by a community coach, an improvement in food security but not diet quality was observed. Taken together, these findings suggest that greater access to healthy foods does not necessarily translate to intake. In fact, as shown in this dissertation, it could potentially have a negative effect in the short term and may require a period of acclimation to new food offerings; clients may need additional knowledge and other resources in order to utilize healthier foods that are introduced to the food pantry setting.

5.2 Future Work

Food pantries are a critical resource to supplement the diets of clients, and food security status may characterize differences in the dietary patterns and use of pantry offerings for clients. Future work is important to better understand how the dietary needs of FS, LFS, and VLFS clients may differ, and how these differences may be incorporated into future initiatives to improve dietary outcomes in the food pantry setting.

Although a community coaching intervention did not positively associate with changes in the food security and dietary patterns of pantry clients over a short-term two-year follow-up period differently compared to a comparison group, each treatment group improved either food security (intervention group) or dietary quality (comparison group). Since VFF materials promoting formation of food policy councils and conversion to a guided client choice food pantry distribution model was delivered to both intervention and comparison communities, it is possible that the VFF materials alone (without facilitation from a community coach) may improve dietary outcomes in the short term. Community coaching is hypothesized to sustain long-term change, and thus longer follow-up is needed to evaluate the long-term effect of the community coaching intervention on dietary outcomes. Future evaluations of the individual components of the VFF materials over time, as well as quantification of “doses” of each component, are needed to identify the source of dietary improvement in both treatment groups.

The social ecological modeled intervention approach was used in this analysis, where changes on community, organizational, and individual levels were hypothesized to influence each other. With this in mind, it is critical to investigate changes in the nutritional quality of the pantry food environment in order to further elucidate the mechanism for dietary improvement from baseline to midpoint among both treatment groups. Determining the mediating effect of changes in the food pantry environment would help determine the extent and breadth of influence between SEM levels, and explain how implementation of select components of the VFF materials may effect change at the individual pantry client level.

Previous interventions in pantry settings have been effective in improving diet quality and food security among clients in follow-up periods of less than one year. Future work may consider integrating the successful components of the present intervention with effective components of other interventions; these may include cooking classes to increase knowledge and utilization of

healthy foods, or leveraging the food pantry infrastructure to connect clients with other non-food resources and services.

In conclusion, food pantries do not comprise a homogeneous population of clients. Pantry clients have different quality diets and rely on pantries to acquire different types of foods depending on their food security status. Food pantries may be an important venue to target interventions that improve dietary quality, with consideration for the complex interplay between food security status, the pantry food environment and characteristics of food pantry use.

APPENDIX A: Stluka, S., Moore, L., Eicher-Miller, HA., Franzen-Castle, L., Henne, B., Mehrle, D., Remley, D., McCormack, L. Voices For Food: Methodologies for Implementing a Multi-State Community-Based Intervention in Rural, High Poverty Communities (2018)

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STUDY PROTOCOL

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Voices for food: methodologies for implementing a multi-state community-based intervention in rural, high poverty communities

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Abstract

Background: Rural communities experience unique barriers to food access when compared to urban areas and food security is a public health issue in rural, high poverty communities. A multi-leveled socio-ecological intervention to develop food policy councils (FPCs), and improve food security in rural communities was created. Methods to carry out such an intervention were developed and are described.

Methods: A longitudinal, matched treatment and comparison study was conducted in 24 rural, high poverty counties in South Dakota, Indiana, Missouri, Michigan, Nebraska and Ohio. Counties were assigned to a treatment ($n=12$) or comparison ($n=12$) group. Intervention activities focus on three key components that impact food security: 1) community coaching by Extension Educators/field staff, 2) FPC development, and 3) development of a MyChoice food pantry. Community coaching was only provided to intervention counties. Evaluation components focus on three levels of the intervention: 1) Community (FPCs), 2) Food Pantry Organization, and 3) Pantry Client & Families. Participants in this study were community stakeholders, food pantry directors, staff/volunteers and food pantry clients. Pantry food access/availability including pantry food quality and quantity, household food security and pantry client dietary intake are dependent variables.

Discussion: The results of this study will provide a framework for utilizing a multi-leveled socio-ecological intervention with the purpose of improving food security in rural, high poverty communities. Additionally, the results of this study will yield evidence-based best practices and tools for both FPC development and the transition to a guided-client choice model of distribution in food pantries.

Trial registration: ClinicalTrials.gov, NCT03566095. Retrospectively registered on June, 21, 2018.

Keywords: Food security, Food access, Nutrition, Community development, Community coaching

Background

Food security has been defined as "access by all people at all times to enough food for an active, healthy life" [1] and "includes the ready availability of nutritionally adequate, safe foods, and the assured ability to acquire them in socially acceptable ways" [2]. Rural communities (often characterized by a population of 2500 persons or less) [3]

experience unique barriers to food access when compared to urban areas, including, but not limited to, access and affordability of fruits and vegetables, [4] lack of transportation, [5] and chronic disease [6]. Communities with increased food insecurity prevalence when compared with the national average, may have a higher need for nutrition assistance, specifically food pantry services [7]. Integration of guided client-choice within pantries, development of food policy councils (FPCs) in communities, and support from community coaches may be a way to address food insecurity in rural, Midwestern areas.

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Most food pantry users are food insecure, which is linked with being overweight and is often associated with diet-related co-morbidities [8]. Food insecure individuals may avoid hunger by consuming low-cost and shelf-stable foods, eating a small variety of foods, and/or binging when food is abundant [9]. Because certain characteristics and food insecurity predispose individuals to diet-related co-morbidities, ensuring that food pantries are able to provide nutrient-rich foods to the food insecure population in rural communities is crucial. Guided client-choice is a model of distribution in which pantry clients choose the foods they would like from the pantry based upon family size and is formatted based upon USDA MyPlate [10]. The guided client-choice style of food distribution in food pantries has been shown to serve the needs of the food pantry clients better when compared to the traditional model of distribution (pre-selected box or bag) [11]. This model reduces the amount of waste spurred by unwanted food items not being used and offers a more dignified experience by allowing pantry clients to choose foods that will supplement their diets [11]. Thus, when using a guided client choice model of distribution, food pantries have the potential to address the nutritional needs of the food insecure population.

FPCs have the potential to improve the nutritional quality of available food, affect federal-, state-, and local-level policy, systems and environmental efforts, and connect a diverse network of 'food' stakeholders from the public, private and nonprofit sectors, which includes local food pantries [12, 13]. While FPCs have been shown anecdotally to be effective in addressing food system and food security issues in urban areas [12], effectiveness has not been scientifically quantified. Furthermore, the use of FPCs as an intervention to improve food security in rural communities has not been evaluated. Since FPCs are comprised of food systems stakeholders including food pantries, it is plausible that FPCs could support emergency food operations in rural communities, and positively impact food pantry client household food security.

Community coaching is a strategy that helps community leaders plan for and overcome challenges to community development [14]. Community development work is most effective when interventions are locally conceived, locally led, and consistent with the cultural identity of the community [15]. Community coaches can effectively support community development through capacity building, fostering a collaborative environment, problem solving, reframing operating systems, transitioning to new leadership, and negotiating partnerships. Previous coaching success in sustaining community change has led some Cooperative Extension systems to recognize community coaching as a viable approach to driving sustainable community work and to institutionalize coaching as a

value-added component of their work. Thus, utilizing Extension Specialists/field staff as community coaches may be an effective way to aid in the development and formation of FPCs in rural communities as they seek to develop long-term visions and goals to improve food security.

Six states (Indiana, Michigan, Missouri, Nebraska, Ohio, and South Dakota) have combined efforts to implement an integrated, community-led intervention in diverse, rural, high poverty Midwestern counties to enhance food security, called *Voices for Food*. A trans-disciplinary team of specialists in nutrition, agriculture, youth, community development, evaluation, and researchers from the Cooperative Extension North Central Region, developed *Voices for Food*. *Voices for Food* is a five-year integrated Extension and research project guided by the Social-Ecological Model of Behavior Change¹² that addresses the United States Department of Agriculture (USDA), Agriculture and Food Research Initiative (AFRI) Food Security Challenge Area. The project team uses a multi-faceted approach to promote socio-ecological changes in rural communities to increase access to, availability of, and consumption of nutritious foods. The project team selected rural communities with high poverty rates to engage with community coaches in order to: 1) develop new or provide support to existing FPCs and 2) encourage FPCs to make socio-ecological changes in their communities to increase the availability of, and access to, healthy food, which includes transitioning food pantries toward guided client choice systems. The specific project hypotheses are that: 1) having Extension Educators/field staff engaged with communities as community coaches will lead to the establishment or strengthening of multi-stakeholder FPCs working on goals to improve healthy food access within the community, and 2) in those communities that have stronger FPCs that support food pantries in transitioning to a guided client choice model called *MyChoice*, there will be greater improvement in availability of healthy foods for pantry users leading to improvement in their food security and intake of healthy foods. The purpose of this manuscript is to describe the methodology used to achieve these goals and assess the identified hypotheses.

Methods/design

Study design

Voices for Food used a longitudinal matched intervention and comparison design. Two matched treatment and comparison communities per state ($n = 24$) were selected to participate in the study based upon community and food pantry attributes. Institutional Review Board approval was obtained for this study prior to all intervention activities.

Voices for Food utilized the *Voices for Food Model of Behavior Change* (Fig. 1) to guide implementation activities. To address the hypotheses, *Voices for Food* focused on two key components that work together to impact food security in selected treatment communities: 1) Community coaching by Extension Educators/field staff, 2) provision of *Voices for Food* materials that describe, a) FPC development and/or support, and b) the transition to a *MyChoice* food pantry. In comparison communities, *Voices for Food* activities focused on one component: the provision of a *Voices for Food* materials that describes, a) FPC development and/or support, and b) development of a *MyChoice* food pantry. The notable difference between the treatment and comparison communities is that comparison communities did not receive coaching from a community coach throughout the implementation of *Voices for Food*. All participants in both treatment and comparison groups were blinded to the intervention. There were no circumstances in which unblinding was permissible.

Materials

To guide the development or strengthening of FPCs in both intervention and comparison communities, the project team developed a *Voices for Food: Food Council Creation Guide*, which includes information on the following topics: importance of engaging FPCs in food systems work; how to develop/sustain a FPC; networking and communicating with stakeholders; developing a FPC structure; partnering with food banks and pantries; working with the agricultural community; finances; and community food assessments. The guide also provides information regarding the opportunity to apply for mini-grant funds provided by *Voices for Food*. Mini-grant funds were available to all intervention and comparison communities, which required collaboration between the FPC and pantry and consistency

with *Voices for Food* goals. All communities had the opportunity to submit a budget plan and justification, which was vetted and approved by the *Voices for Food* PD leadership team.

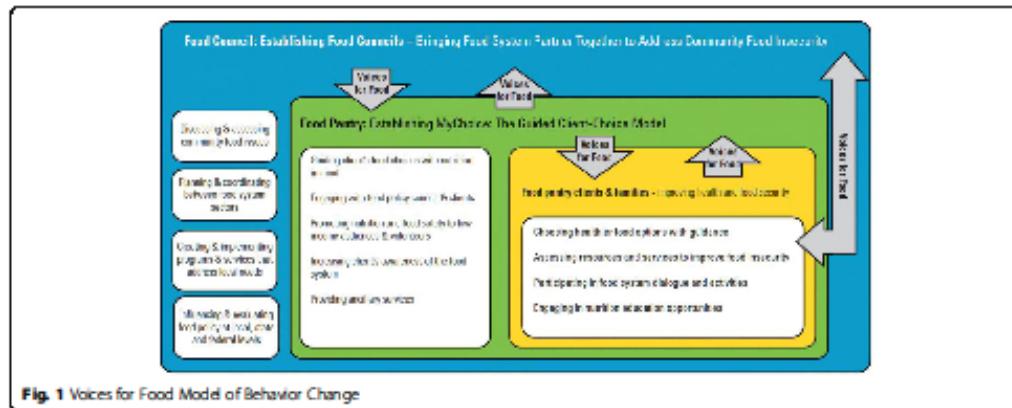
To guide the transition to *MyChoice* in the food pantry in both intervention and comparison communities, the project team developed a *Voices for Food: Food Pantry Toolkit* which includes information on the following topics: implementing the *MyChoice* guided client-choice model of distribution, a *Voices for Food Ambassador's Training* (includes Nutrition Education [16], Food Safety Training [17], and Cultural Competency Training [18]), shelf talkers (labels), and USDA MyPlate materials. Nutrition education [16] were delivered in partnership with SNAP-Ed as an approved, evidence based curriculum was used for this portion [19, 20]. Both Food Safety [17] and Cultural Competency Training [18] were delivered and completed by pantry staff using the resources included in the toolkit.

Identifying communities

Criteria were developed to identify eligible communities for the study. Eligible communities were those located in counties defined as non-metro with poverty rates > 16% [21], those that have a Cooperative Extension presence, do not have a well established FPC or similar organization in place, and do not already have a full guided client-choice model in their local food pantry in place.

Matching intervention and comparison communities

Prior to recruitment, intervention and comparison communities were matched based upon the criteria for identifying communities and the characteristics of the local food pantry in the community. Pantry characteristics that aided in matching communities were physical location, distance to another potential pantry, administering



organization, hours and days of operation, level of client-choice, interest in study participation and working with Cooperative Extension, number of households served, an estimate of long-term pantry users (greater than 2 years), pounds of food distributed per month, government commodity program assistance (e.g. The Emergency Food Assistance Program [TEFAP], Food Distribution Program on Indian Reservations [FDPIR], and Commodity Supplemental Food Program [CSFP]), food bank partnership, infrastructure and capacity (storage, shelving, etc.), and predominant racial/ethnic group served at the pantry.

Community & pantry recruitment

Food pantry

Pantry directors were invited to participate through an invitational letter. Upon confirmation, the coach scheduled an in-person meeting with the pantry director to discuss project details and explain the Memorandum of Understanding (MOU), which was signed upon agreement to participate. Once the treatment food pantries were recruited, project staff followed the same protocol in matched comparison communities.

Community champion

Community champions were recruited to receive coaching for FPC development in the implementation of *Voices for Food* in both treatment and comparison communities. With the assistance of the pantry directors, a list of potential local community champions and stakeholders was created. A letter was sent to the potential community champion in each community to introduce the project, identify the participating pantry, to inquire about interest in assisting with *Voices for Food* and to request confirmation of participation. Upon confirmation of participation, an in-person meeting was scheduled by the coach with the community champion to discuss project details and the MOU, which was signed upon agreement to participate.

Measures

Organization/scheduling data collection

Quantitative and qualitative data were collected Fall Year 02 (Y02; pre-intervention), Fall Year 04 (Y04; mid-intervention) and Fall Year 05 (Y05; post-intervention) from community stakeholders, food pantry directors, food pantry staff/volunteers, and food pantry clients. A longer timeframe between pre-intervention and mid-intervention data collection was observed to allow more time for the treatment activities to be implemented.

Determination of sample size

Assessments were conducted at three levels, which include community stakeholders, food pantry organization (food pantry, staff/volunteers), and food pantry clients. Convenience samples of community stakeholders, food pantry directors, and food pantry staff/volunteer participants were recruited and included all members of FPCs and all directors, staff/volunteers of the food pantries participating in the study. Sample size was based on the food pantry client expected improvement of 1 in adult food security score from pre-intervention to post-intervention on the food security scale (continuous score from 0 to 10). This unit of change in food security is practically meaningful as it could mean a change in food security level, for example an improvement from very low to low food secure which would indicate a change from not eating enough to an adequate amount of food. Pantry client participants were nested within food pantries. Previous research [22, 23] suggests $SD(Y04-Y02) = SD(Y05-Y02) = 2.6$ (using the largest conservative estimate) when Y02, Y04, Y05 represent the scores across years and SD represents the standard deviation. Thus, a power analysis was completed where $n =$ the number of paired intervention (trt) and comparison (ctrl) pantries as: $Var(\text{estimated trt } Y04 - Y02 - \text{estimated ctrl } Y04 - Y02) = 2 * 2.6^2 * 2.61 / n = 13.6242/n$ for a total of 224 clients, or 14 participants per pantry. An approximate 30% loss to follow up each year [19] was expected for a total estimate of 40 participants per pantry at baseline to be followed longitudinally throughout the project. An additional 40 new pantry clients were recruited at Y04 and Y05 in order to maintain power to detect a change in food security score in a cross-sectional study design.

Participant recruitment

Community stakeholders, pantry directors, pantry staff/volunteers, and pantry clients were recruited to participate in this study. All participants were enrolled using the IRB-approved consent process. Community stakeholders were recruited for survey completion during the first FPC meeting after the intervention started, as they joined the council and at each data collection time point. If a FPC had not formed, community stakeholders were recruited from the community. Food pantry directors were recruited to complete surveys and were identified by the coach. Food pantry staff/volunteers were identified by pantry directors and were recruited for survey completion at each data collection time point. All food pantry staff/volunteers, directors and community stakeholders received \$10 gift cards to local grocery stores when possible at each data collection time point for completing surveys.

Pantry client participants were recruited with fliers posted throughout the community, in high-traffic areas

within the pantry, and by word-of-mouth. On the day of data collection, food pantry clients were screened for eligibility to ensure they were legal adults, could read and speak English, had visited the pantry more than once in the last 12 months, had access to a computer or telephone to complete follow up assessments, and desired to participate in the study. Food pantry clients were eligible to receive \$30 total in stipends to a local grocery store at each data collection time point if all surveys were completed.

Assessment tool descriptions

Eleven assessment tools were used to evaluate the effectiveness of the intervention as a whole. All questionnaires were pilot tested for feasibility prior to collecting pre-intervention data. Where possible, the project team used previously validated assessment tools or questions. All assessments were completed at pre-, mid- and post-intervention unless otherwise indicated. Table 1 summarizes the assessment tools and data collection schedule.

Community-level assessment tools

Community stakeholders survey

A 23-question *Community Stakeholders Survey* assessed community stakeholder perceptions in participating communities. This survey collected demographic information, perceptions of food security in the community, past experience with FPCs or similar organizations and feedback on the *Voices for Food: Food Council Guide*, and experience with the community coach.

Food council implementation tracking form

A three-part *Food Council Implementation Tracking Form* tracked changes occurring in the FPC including activities and accomplishments. Additionally, FPCs will provide key

documents developed during the intervention, including meeting agendas, meeting minutes, press releases, organizational charts, mission/vision statements and strategic plans to the research team.

Training tracking form

A 5-question *Training Tracking Form* tracked the number of trainings completed from the *Voices for Food: Food Pantry Toolkit*, training topics, numbers of attendees, curriculum used, who was in attendance (e.g. FPC members, food pantry clients, pantry staff, etc.), and the use of resources from the *Voices for Food: Food Pantry Toolkit*. Throughout the intervention, project staff documented the nature of Extension coaching assistance provided to the intervention food pantries.

Food pantry organization level assessment tools

Food pantry director survey

The 42-question *Food Pantry Director Survey* collected key information about the food pantry director and the food pantry including: demographic information, perceptions on community food security, and information about the food pantry.

Food pantry staff/volunteer survey

A 34-question *Food Pantry Staff/Volunteer Survey* collected key information about food pantry staff/volunteers and the food pantry including demographic information, community perceptions on food security, perceptions of their abilities to interact with clients, and information about the food pantry.

Food pantry inventory log

One *Food Pantry Inventory Log* was maintained in a Microsoft Access database per state for all pantries to document

Table 1 Description of Assessment Tools

	Pre	Mid	Post	Subject
Community Level				
Community Stakeholders Survey	X	X	X	Project Staff
Food Council Implementation Tracking Form	X	X	X	Community Champion
Training Tracking Form	Ongoing			Pantry Director Community Champion
Food Pantry Organization Level				
Food Pantry Director Survey	X	X	X	Project Staff
Food Pantry Staff/Volunteer Survey	X	X	X	Project Staff
Food Pantry Inventory Log	X	X	X	Project Staff
Food Pantry MyChoice Observation Tool	X	X	X	Project Staff
Food Pantry Client Level				
Food Pantry Client Survey	X	X	X	Project Staff
ASA24® Dietary Recall	X	X	X	Project Staff
Participant Food Box Content Log	X	X	X	Project Staff

the type and amounts of foods in stock at each food pantry site. Food pantry inventory data was collected on a date when the director indicated inventory will be relatively high (e.g. soon after food comes in from the food bank). The logs will be assigned United States Department of Agriculture [USDA] food codes in Food and Nutrient Database for Dietary Studies 5.0 that can be used to determine healthfulness of available foods [24].

Food pantry MyChoice observation tool

A 15-question *Food Pantry MyChoice Observation Tool*, was completed by project staff, documented the extent to which key components of the *MyChoice* food pantry model were physically in place at the pantry and part of the food, food display, and distribution process.

Food pantry client-level assessment tools

Food pantry client survey

A 54-question *Food Pantry Client Survey* collected information from pantry clients including: demographic information, household information, and participation in food assistance programs such as Supplemental Nutrition Assistance Program [SNAP], household food security, where food is purchased, experience at the food pantry, perception of pantry food selection, and perception of food-related community activities. The United States Household Food Security Survey Module [25, 26] is embedded into the *Food Pantry Client Survey* and will assess food security in pantry clients. Individuals will be classified as very low food secure, low food secure, marginal food secure and high food secure.

ASA 24-h dietary recall

Dietary intake data (24-h recalls) were collected using the Automated Self-Administered 24-h (ASA24*) Dietary Assessment Tool, version 2014 and 2016, developed by the National Cancer Institute, Bethesda, MD [27]. The ASA24* was completed three times within the same week, on two week days and one weekend day. The first ASA24* was scheduled to be completed in-person with project staff on the day of the pantry visit. The second and third ASA24* recalls were self-completed or completed with project staff by telephone interview. The ASA24* allows for calculation of the Healthy Eating Index score, which is a measure of diet quality [28].

Participant food box content log

One *Pantry Food Box/Food Bag Log* was maintained in Microsoft Access per state for all pantries, which detailed all food items the pantry clients receive during that pantry visit. Participant Food Box Content Logs were collected on the day of data collection in the pantry. The logs will be assigned USDA food codes that can be used to

determine healthfulness of the foods that clients chose or were given at the pantry [24].

Statistical analysis

The first hypothesis is that having Extension Educators/field staff engaged with communities as community coaches will lead to the establishment or strengthening of multi-stakeholder FPCs working on goals to improve healthy food access within the community. This hypothesis will be assessed using several tools including the *Food Council Implementation Tracking Form*, *Community Stakeholders Survey*, *Training Tracking Form*, *Voices for Food Coaching Journal*, *Voices for Food Annual Budget Plan and Justification* and *Budget Follow-up Form*.

The second hypothesis is that in those communities that have stronger FPCs that support food pantries in transitioning to *MyChoice*, there will be greater improvement in availability of healthy foods for pantry users leading to improvement in their food security and intake of healthy foods. This hypothesis will be assessed using several tools including the *Food Pantry Inventory Log*, *Participant Food Box Content Log*, ASA24* [27] and *Food Pantry MyChoice Observation Tool*.

Descriptive statistics will be used to describe the study population at baseline. Analyses include examining changes in pantry food access/availability pantry client food security and dietary intake as a result of intervention or comparison group assignment. These outcomes will be compared longitudinally. T-tests and chi-square will be used for initial examination of mean and proportion differences in characteristics and outcome variables among treatment groups, followed by mixed-model regression analyses, which will allow adjustment for covariates and the examination of independent variables on outcomes.

Study status

This study was conducted in rural, high poverty communities from 2014 to 2017. The study is currently ongoing with the final data collection concluding in November 2017, and analysis of hypotheses and main outcomes concluding in 2018.

Discussion

There were four notable strengths of this study. First, the use of a multi-state collaborative team and the systems approach through the involvement of individuals with varying expertise and areas of interest contributed to a well-rounded, accurate protocol. Second, the use of a community-based approach that allowed the project team to meet each community where they were at in terms of readiness, and to recognize the individual strengths and weaknesses of each individual community and pantry strengthened this study. Each community was unique in where they were beginning and what they needed to

progress. Allowing coaches to meet communities where they were at ensured that solutions were community based and relevant. Third, the use of evidence-informed and some evidence-based tools when possible and pre-testing the tools for feasibility, allowed for a comprehensive set of assessments to measure the effectiveness of the intervention as whole. Last, alignment with policy, systems, and environmental focuses for long-term applicability and sustainability in communities. The project team maintained a commitment to long-term sustainability and in turn promoted that through careful selection of community coaches and Extension presence in each community.

This study faced four main challenges. First, community-based work is time-consuming because of the effort needed for development of community relationships and partnerships, which impacted timelines for this project and posed additional challenges of keeping community stakeholders engaged over the long term. Timelines were extended and frequent communication with communities and partners was completed. Additionally, due the time consuming nature of this work, a longer timeframe between baseline and mid-point data collection was observed to allow time for treatment conditions to be implemented. Second, selecting sites that fit the criteria across six unique states and were similar enough for comparison was challenging but it was critical for study design and evaluation. Third, completion of a longitudinal study with a transient population was a challenge as the project team attempted to retain food pantry clients as study participants. The project team developed a protocol for maintaining updated contact information for participants, which included sending a flyer to all participants quarterly to request updated contact information. Last, the complexity of managing a large multi-level research study across six states was a challenge as we attempted to maintain fidelity to the protocol in all states with many personnel. To promote fidelity to the protocol, frequent, clear communication, trainings, video recordings and management strategies were used to provide consistency across the states involved in this study. Furthermore, during each data collection time-point, fidelity checks were completed with each state to assess fidelity to the protocol and mitigate any deviation from the protocol.

As a result of this study, Best Practices for utilizing health professionals in conjunction with the *Voices for Food: Food Council Guide* and the *Voices for Food: Food Pantry Toolkit* will be released for use by health professionals to 1) develop or strengthen FPCs in rural, high poverty communities, and 2) transition local food pantries to a *MyChoice* model of distribution in order to enhance food security. Furthermore, this study can be used as a framework for future policy, systems and environment work completed by health professionals throughout the United States.

Abbreviations

FPC Food Policy Council

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Authors' contributions

SS is the lead Project Investigator. HBM, LFC, BH, DM and DR all serve as co-Project Investigators. SS, HBM, LFC, BH, DM and DR each played an integral role in the conception, design and implementation of this study. LMC & LM have also served integral roles in this study by participating in the design and implementation. All authors played a role in the Evaluation committee, which monitors data. They operate independent from the sponsor. All authors read and approved the final manuscript.

Ethics approval and consent to participate

Institutional Review Board (IRB) approval was obtained prior to the implementation of project conditions. South Dakota State University IRB provided approval for South Dakota State University, University of Missouri, Purdue, Michigan State University and University of Nebraska-Lincoln. For these five universities, an information sheet was used in lieu of a consent form prior to participation in this study due to the low risk nature of the study. Ohio State University operated under the approval of Ohio State University IRB. For this university, all participants signed the approved consent form prior to participation in this study. No personal identifying information was linked to data. Any personal information is stored in locked file cabinets or password protected files.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

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References

- Clay E. FAO expert consultation on trade and food security: Conceptualizing the linkages. London: Overseas Development Institute. Retrieved from <http://www.fao.org/docrep/005/y4671e/y4671e06.htm#fn82>; 2002.
- Holben DH. An overview of food security and its measurement. Nutr Today. 2002;37(4):56–62.

3. United States Department of Agriculture, Economic Research Service. <https://www.ers.usda.gov/topics/rural-economy-population/rural-classifications/what-is-rural/>. Accessed 1 Aug 2014.
4. Casey AA, Elliot M, Glanz K, Hahn-Joshu D, Lovegreen SL, Saelens BE, Sallis JF, Brownson RC. Impact of the food environment and physical activity environment on behaviors and weight status in rural U.S. communities. *Prev Med*. 2008;47:600–4.
5. Olson CM, Bove CF. Obesity in rural women: emerging risk factors and hypotheses. In: Coward RT, Davis LA, Gold CH, Smidtla-Wright H, Thomdyke LE, Vondracek FW, editors. *Rural Women's Health: linking mental, behavioral, and physical health*. New York: Springer Publishing; 2005.
6. Gunderson C, Zillak JP. Food Insecurity and Health Outcomes. *Health Aff*. 2015;34:1830–9.
7. Berner M, Ober T, Paynter S. A portrait of hunger, the social safety net, and the working poor. *Policy Stud J*. 2008;3(3):403–20.
8. Panterakou SLJ, Ryan DH, Bray GA. The relation of gender, race, and socioeconomic status to obesity and obesity co-morbidities in the United States. *Int J Obes Relat Metab Disord*. 2002;26:1205–10.
9. Seligman HK, Schilling D. Hunger and socioeconomic disparities in chronic disease. *N Engl J Med*. 2010;363(1):6–9. <https://doi.org/10.1056/NEJMoa100072>
10. United States Department of Agriculture. <http://www.choosemyplate.gov>. Accessed 15 June 2014.
11. Remley DT, Zublets AC, Lambie MC, Melgar-Quinonez H, Taylor C. Spanish and English-speaking client perceptions of choice food pantries. *J of Hunger and Environmental Nutrition*. 2010;1:120–8.
12. Harper A, Shattuck A, Holt-Gimenez E, Alton A, Lambright F. Food policy councils: lessons learned. Oakland Institute for Food and Development Policy; 2009.
13. Centers for Disease Control Division of Nutrition, Physical Activity and Obesity (DNPAO). State Program Highlights Food Policy Councils. Atlanta: Centers for Disease Control; 2010.
14. Hubbell K, & Emery, M. Guiding sustainable community change: An introduction to coaching. Retrieved from http://www.nclivingimages.org/GuidingSustainableCommunityChange/AnIntroToCoaching_5-2010.pdf; 2009.
15. Biswas-Mikhize HP, Rigt JP, Spector S. Scaling up Local and Community Driven Development: A Real World Guide to its Theory and Practice. World Bank, Washington, DC. © World Bank. 2009. License CC BY 3.0 IGO. <https://openknowledge.worldbank.org/handle/10986/28252>
16. Maulding MK. Small Steps to Health. Available from: <https://snaped.fns.usda.gov/materials/small-steps-health>.
17. South Dakota State University Extension. SAFE AID: Food Safety Training for Food Pantry Programs Sanitary Surroundings: Setting Up for Safe Food. April 2013. Available from: <http://igrow.org/healthy-families/food-safety/safe-aid-food-pantries/>
18. Michigan State University Extension. Ready to go: mentor training toolkit: cultural competency. 2012. Available from: http://msueanr.msu.edu/resources/ready_to_go_mentor_training_toolkit_4n164.pdf.
19. Rivera R, Maulding MK, Abbott AR, Craig B, Elcher-Miller HA. SNAP-Ed (supplemental nutrition assistance program education) increases long-term food security among Indiana households with children in a randomized controlled study. *J Nutr*. 2016;146(1):2375–82. Epub 2016 Sep 28.
20. Elcher-Miller HA, Mason AC, Abbott AR, McCabe GP, Boushey CJ. The effect of food stamp nutrition education on the food insecurity of low-income women participants. *J Nutr Educ Behav*. 2009;41(3):161–8. <https://doi.org/10.1080/jnep.2008.06.004>.
21. United States Department of Agriculture Economic Research Service. USDA/ERS Atlas of Rural and Small-Town America. Retrieved from: <http://www.ers.usda.gov/data-products/atlas-of-rural-and-small-town-america/go-to-the-atlas.aspx>; 2014–2015.
22. Martin KS, WUR, Wolff M, Colantonio AG, Grady J. A novel food pantry program: food security, self-sufficiency, and diet-quality outcomes. *Am J Prev Med*. 2013;45(5):569–75.
23. Martin K, Shuckrow M, O'Rourke C, Schmitz A. Changing the conversation about hunger: the process of developing Freshplace. *Progress In Community Health Partnerships: Research, Education, and Action*. 2012;6(4):29–34.
24. United States Department of Agriculture. Food and Nutrient Database for Dietary Studies, 5.0. March 2012. Available from: <https://www.ars.usda.gov/northeast-area/beltsville-md-blmc/beltsville-human-nutrition-research-center/food-surveys-research-group/docs/main-service-page/>.
25. United States Department of Agriculture, Food and Nutrition Service. Measuring Food Security in the United States Guide to Measuring Household Food Security. 2000. Available from: <https://fns-prod.azureedge.net/sites/default/files/FSGuide.pdf>.
26. United States Department of Agriculture, Economic Research Service. U.S. Household Food Security Survey Module: Three-stage design, with screens. September 2012. Available from: <https://www.ers.usda.gov/media/8271/hhs2012.pdf>
27. National Cancer Institute: Division of Cancer Control & Population Sciences Automated Self-Administered 24-hour (ASA24™) Dietary Assessment Tool. Available from: <https://epi.grants.cancer.gov/asa24>.
28. National Cancer Institute: Division of Cancer Control & Population Sciences Epidemiology and Genomics Research Program. HB Tools for Researchers. Available from: <https://epi.grants.cancer.gov/hb/tools.html>.

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APPENDIX B: Voices for Food Baseline Characteristics Survey



Respondent ID: _____

Date: _____

Pantry Name: _____

Data Collector: _____

Food Pantry User Pre-Questionnaire

INTRODUCTION

We are asking people in rural areas about the foods available in their communities. This survey is part of a project sponsored by the U.S. Department of Agriculture. It is being conducted by the (Department of XXX or XXX Extension at XXX University). We will use the answers that you provide to help create and strengthen local efforts to increase the amount and types of healthy foods available to low-income members of your community. We want to learn about you, your interest and involvement in how low-income members of your community obtain food. We also want to know your thoughts on how easy or hard it is to get healthy foods (specifically fruits, vegetables, low-fat dairy, whole grains, and lean protein foods) in your community.

Thank you for your honest and thoughtful responses. The survey will take about 30 minutes to complete. You do not have to take part in this research project. If you agree to take part you can stop at any time or choose to not answer any question. Your personal information will not be linked with your answers and all of the information you provide will be kept confidential. If you have any questions, please call XXX XXXX at :xxxxxx at - xxx-xxxx.

BACKGROUND ON YOU

1. What is your age? (Place and X in the box that best describes your age)
 - 18 to 24
 - 25 to 34
 - 35 to 44
 - 45 to 54
 - 55 to 64
 - 65 to 74
 - Over 74
 - Prefer not to answer
2. What is your sex?
 - Male
 - Female
 - Prefer not to answer
3. Are you of Hispanic, Latino, or Spanish origin?
 - Yes
 - No
 - Prefer not to answer
4. What is your race? (Please check all the responses that apply)
 - American Indian or Alaska Native
 - Asian

- Black or African American
- Native Hawaiian or other Pacific Islander
- White
- Other (please specify) _____
- Prefer not to answer

5. What is the highest grade or level of school you have completed or the highest degree you have received?

(Please check only one response)

- Did not graduate high school
- High School graduate
- GED or equivalent
- Business trade school
- Some college, no degree
- Associate degree: Occupational, technical or vocational program
- Bachelor's degree (Example: BA, AB, BS, BBA)
- Master's Degree (Example: MA, MS, MEd, MBA, MPH)
- Professional School (Example: MD, DDS, DVM, JD)
- Doctoral Degree (Example: PhD, EdD)
- Other (Please specify) _____
- Prefer not to answer

6. Please tell me the kind of place where you now live? Is it... (Check only one)
- A house, condo, or mobile home
 - An apartment
 - A room
 - A hotel/motel
 - A shelter or mission
 - A car, van, or other vehicle _____
 - An abandoned building
 - A public space, railroad/bus station
 - Anywhere outside (on the streets, in a park)
 - Other (Please specify) _____
7. In the last 12 months, have you lived in any other place besides where you now live?
- Yes
 - No
8. Do you have use of a place to make a meal?
- Yes
 - No SKIP TO QUESTION 9
- 8a. Do you own or have use of any of the following. (Please check all the responses that apply)
- A hotplate
 - A toaster
 - A toaster oven
 - A stove
 - A microwave
 - A refrigerator
9. The next questions are about your current job or business. Which of the following were you doing last week?
- Working at a job or business SKIP TO QUESTION 10
 - With a job or business but not at work SKIP TO QUESTION 10
 - Looking for work SKIP TO QUESTION 10
 - Not working at a job or business
 - Refused
 - SKIP TO QUESTION 10
 - Don't know SKIP TO QUESTION 10
- 9a. What is the main reason you did not work last week?
- Taking care of house or family
 - Going to school
 - Retired
 - Unable to work for health reasons
- On layoff
 Disabled
 Other
 Refused
 Other (Please specify) _____
 Don't know
10. In the last 12 months (52 weeks) have you been employed for 6 months or 26 weeks out of the year?
- Yes
 - No
 - Don't know
11. Which form of transportation do you usually use to get food for your household? (Check only one box)
- I drive
 - I take public transportation (taxis, buses)
 - Someone else drives me
 - I walk
 - I ride a bicycle
 - Other form of transportation (Please specify) _____
 - Don't know

About Your Household

The next set of questions refer to your household—including you and all the people who live with you.

12. How many people live in your household this month?

By household, we mean people who live together and share living expenses. Include any people who lived with you more than half of the time in the last month. Please include yourself in the count.

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10 or more

13. Among the people in your household...
- 13a. I am the only person in my household.
 13a. How many are ages 65 and above? _____
- 13b. How many are ages 19- 64? _____
- 13c. How many are ages 13-18? _____
- 13d. How many are ages 6-12? _____
- 13e. How many are ages 1-5? _____
- 13f. How many are under 1 year of age? _____
- I don't know the ages

Now we would like to ask you about your total household income.

14. I am going to read you a list of categories. Which category represents the total combined income of all members of your household during the past 12 months? This includes income from jobs, income from business, pensions, Social Security or retirement payments, disability payments, and any other money income received. Was it...

- Zero
- \$5,000 or less
- \$5,001 - \$10,000
- \$10,001 - \$15,000
- \$15,001 - \$20,000
- \$20,001 - \$25,000
- \$25,001 - \$30,000
- \$30,001 - \$35,000
- \$35,001 - \$50,000
- More than \$50,000
- Don't know

15. Have you been told by a doctor or other health professional that you or anyone in your household has any of the following health conditions:

- High blood pressure
- High cholesterol
- Diabetes
- Obesity
- Food allergies
- Don't know

FOOD PROGRAM PARTICIPATION

The next few questions are about food benefits and meals you or others in your household received from community or government programs in the last 12 months.

16. Did you or anyone in your household receive Food Stamps (also called SNAP) in the last 12 months?

- Yes
- No
- Don't know

17. In the last 12 months did you or anyone in your household receive any meals delivered to your home from community programs, "Meals on Wheels", or any other programs?

- Yes
- No
- Don't know

18. In the last 12 months, did you or anyone go to a soup kitchen, or other place where they receive prepared meals?

- Yes
- No
- Don't know

19. Did you or anyone in your household receive benefits from WIC, that is, the Women, Infants, and Children program, in the last 12 months? (WIC is short for the Special Supplemental Nutrition Program for Women, Infants, and Children. This program provides nutritional screening and specific foods to pregnant and postpartum women and their infants, and children up to age 5.)

- Yes
- No
- Don't know

20. In the last 12 months, did any of the children in your household receive free or reduced price meals at their school or child care?

- There are no children under 18 in my household
- Yes
- No
- No children attended school or child care
- Don't know

21. In the last 12 months, did any child in your household get a free or reduced price meal at any summer program he or she attended?

- There are no children under 18 in my household
- Yes
- No
- No children attended a summer program
- Don't know

Household Food Security

For questions 22-24 below, please answer whether the statement was OFTEN TRUE, SOMETIMES TRUE, or NEVER TRUE for your household in the last 12 months.

22. "I/We worried whether my/our food would run out before I/we got money to buy more."
- Often true
 Sometimes true
 Never true
 Don't know
23. "The food that I/we bought just didn't last, and I/we didn't have money to get more."
- Often true
 Sometimes true
 Never true
 Don't know
24. "I/we couldn't afford to eat balanced meals." For this question, a "balanced meal" includes all the types of food that you think should be in a healthy meal."
- Often true
 Sometimes true
 Never true
 Don't know
25. "I/We relied on only a few kinds of low-cost food to feed my/our child/children because I was/we were running out of money to buy food." Was that OFTEN, SOMETIMES, OR NEVER TRUE for you/your household in the last 12 months?
- There are no children under 18 in my household SKIP TO QUESTION 28
 Often true
 Sometimes true
 Never true
 Don't know
26. "I/We couldn't feed my/our child/the children a balanced meal, because I/we couldn't afford that." Was that OFTEN, SOMETIMES, OR NEVER TRUE for you/your household in the last 12 months?
- Often true
 Sometimes true
 Never true
 Don't know
27. "My/Our child was/the children were not eating enough because I/we just couldn't afford enough
- food." Was that OFTEN, SOMETIMES, OR NEVER TRUE for (you/your household) in the last 12 months?
- Often true
 Sometimes true
 Never true
 Don't know
28. In the last 12 months, did you/you or other adults in your household ever cut the size of your meals or skip meals because there wasn't enough money for food?
- Yes
 No SKIP TO QUESTION 29
 Don't know SKIP TO QUESTION 29
- 28a. How often did this happen—almost every month, some months but not every month, or in only 1 or 2 months?
- Almost every month
 Some months but not every month
 Only 1 or 2 months
 Don't know
29. In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money for food?
- Yes
 No
 Don't know
30. In the last 12 months, were you ever hungry but didn't eat because there wasn't enough money for food?
- Yes
 No
 Don't know
31. In the last 12 months, did you lose weight because there wasn't enough money for food?
- Yes
 No
 Don't know
32. In the last 12 months, did you or other adults in your household ever not eat for a whole day because there wasn't enough money for food?
- Yes
 No SKIP TO QUESTION 33
 Don't know SKIP TO QUESTION 33
- 32a. How often did this happen—almost every month, some months but not every month, or in only 1 or 2 months?
- Almost every month

- Some months but not every month
 Only 1 or 2 months
 Don't know
33. In the last 12 months, since (current month) of last year, did you ever cut the size of (your child's/any of the children's) meals because there wasn't enough money for food?
 There are no children under 18 in my household
SKIP TO QUESTION 37
 Yes
 No
 Don't know
34. In the last 12 months, did (your child/any of your children) ever skip meals because there wasn't enough money for food?
 Yes
 No **SKIP TO QUESTION 35**
 Don't know **SKIP TO QUESTION 35**
- 34a. How often did this happen—almost every month, some months but not every month, or in only 1 or 2 months?
 Almost every month
 Some months but not every month
 Only 1 or 2 months
 Don't know
35. In the last 12 months, was (your child/were any of the children) ever hungry but you just couldn't afford more food?
 Yes
 No
 Don't know
36. In the last 12 months, did (your child/any of the children) ever not eat for a whole day because there wasn't enough money for food?
 Yes
 No
 Don't know
- WHERE YOUR HOUSEHOLD GETS FOOD**
37. Other than from food pantries, where does your household usually get food and beverages that you eat at home? Is it from... Would you say.. (Check all that apply)
 A Supermarket (such as Food Lion, Wal-Mart, Sam's Club, HyVee, etc.)
- A Convenience store (such as a gas station with food store attached)
 A Farmers' Market or Roadside stand
 A Community garden
 Your own garden or farm
 A program that delivers free or low cost meals to your home (sometimes called Meals on Wheels)
 Friends, neighbors, or family
 A Place of worship
 Other (Please specify) _____
 Don't know
38. How many different food pantries have you gone to for food in the last 12 months?
 1
 2-3
 4-5
 6-7
 8-9
 10 or more
 Don't know
39. Thinking of all the food pantries, including this one, you visited in the past month, how much of your household food would you say was provided through these programs?
 A few days worth of food
 One to two weeks worth of food
 More than half of our food for the month
 Almost all of our food for the month
 Don't know

YOUR EXPERIENCE AT THIS FOOD PANTRY

The next set of questions is about your experience at this food pantry.

40. Not including today, during the past 12 months, how many times have you come to this pantry to get food?
 0
 1
 2-3
 4-5
 6-7

- 8-9
 10 or more

For the next two questions, please rate how satisfied you are with different aspects of this food pantry.

41. How satisfied are you with the amount of food that you and others in your household receive at this food pantry? Are you...

- Very satisfied
 Somewhat satisfied
 Somewhat dissatisfied
 Very dissatisfied
 Don't know

42. How satisfied are you with the variety of food that you and others in your household receive at this food pantry? Are you...

- Very satisfied
 Somewhat satisfied
 Somewhat dissatisfied
 Very dissatisfied
 Don't know

43. Which types of foods do you want but do not usually get from this food pantry?

- Fresh fruits and vegetables
 Low-fat protein food items such as lean meats
 Skim or low-fat dairy products, such as milk, yogurt or cheese
 Whole grain foods
 I get all the types of foods I want at this food pantry
 Don't know

44. When you come to this food pantry, how often are you treated with respect by the people who distribute food?

- Very often
 Sometimes
 Never
 Don't know

45. When you come to this food pantry, how comfortable do you feel talking with pantry workers about your food and other needs?

- Very comfortable

- Somewhat comfortable
 Not comfortable
 Don't know

46. Which of the following reasons are the main reasons you go to food pantries. (Check all responses that you think are the main reasons you go to food pantries)

- I go to food pantries when food is running low.
 I go to food pantries so I can use my money to pay for bills and other necessities.
 I go to food pantries to provide my household with extra foods.
 I go to food pantries to provide my household with more healthy foods.
 I go to food pantries for another reason
(Please specify other reason)

- Don't know

47. Please rate your agreement with the statement below about the My Choice food pantry model. In this model, food pantries allow people to walk through the aisles and choose items from different food categories such as vegetables, fruits, dairy, grains and protein.

Using a MyChoice model in a food pantry can help people eat a healthier diet.

- Strongly agree
 Agree
 Neither agree nor disagree
 Disagree
 Strongly disagree

48. How satisfied are you with the amount of choice you have in the foods you can take home from this food pantry? Are you...

- Very satisfied
 Somewhat satisfied
 Somewhat dissatisfied
 Very dissatisfied
 Don't know

Please explain your answer.

49. In the last 12 months, have you been to any food or nutrition-related classes, workshops or food demonstrations at this pantry?

Yes

How many did you attend? _____ #

No SKIP TO QUESTION 50

Don't Know SKIP TO QUESTION 50

50. Which of the following topics were covered by those classes, workshops, or food demonstrations? (Check all responses that apply)

Nutrition

Food safety

How to stretch limited food dollars and eat healthfully

Don't know

51. In the last 12 months, did you see any written information about nutrition at this food pantry, for example handouts, brochures, recipes, or posters?

Yes

No

Don't know

52. In the last 12 months, did pantry staff or volunteers ever talk to you about nutrition or healthy foods?

- Yes
- No
- Don't know

Food-Related Community Activities

53. Is there a Voices for Food Council active in your area?

- Yes
- No SKIP TO QUESTION 53
- Don't Know SKIP TO QUESTION 53

52a. During the last 12 months, have you gone to any meetings of the local Voices for Food Council?

- Yes SKIP TO QUESTION 53
- No

52b. What prevented you from going to meetings of the local Voices for Food Council?

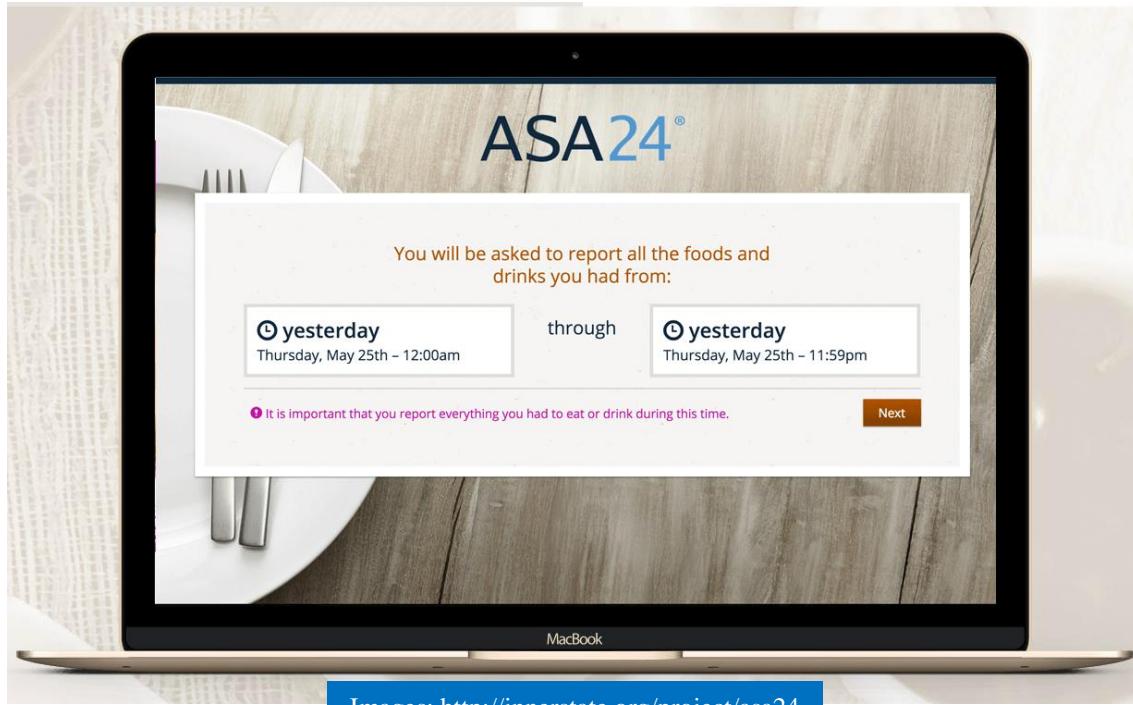
FINAL QUESTIONS

54. If there is anything else you would like to tell us about how this food pantry helps you, please include here.

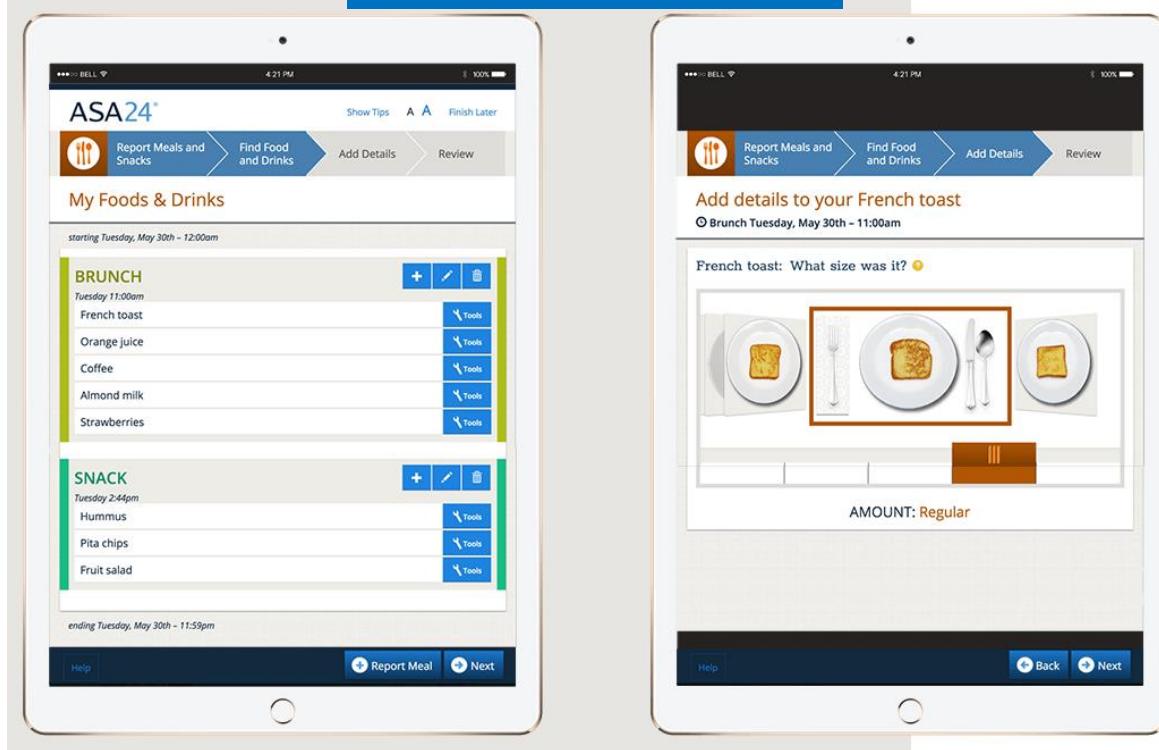
55. If there is anything else you would like to tell us about what should be improved at this food pantry, please include here.

APPENDIX C: Automated Self-Administered 24-Hour Dietary Recall

<https://epi.grants.cancer.gov/asa24/>



Images: <http://innerstate.org/project/asa24>



APPENDIX D: Tooze, JA., Grunwald, GK., Jones, RH. Analysis of Repeated Measures Data with Clumping at Zero (2002)

Statistical Methods in Medical Research 2002; **11**: 341–355

Analysis of repeated measures data with clumping at zero

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Longitudinal or repeated measures data with clumping at zero occur in many applications in biometrics, including health policy research, epidemiology, nutrition, and meteorology. These data exhibit correlation because they are measured on the same subject over time or because subjects may be considered repeated measures within a larger unit such as a family. They present special challenges because of the extreme non-normality of the distributions involved. A model for repeated measures data with clumping at zero, using a mixed-effects mixed-distribution model with correlated random effects, is presented. The model contains components to model the probability of a nonzero value and the mean of nonzero values, allowing for repeated measurements using random effects and allowing for correlation between the two components. Methods for describing the effect of predictor variables on the probability of nonzero values, on the mean of nonzero values, and on the overall mean amount are given. This interpretation also applies to the mixed-distribution model for cross-sectional data. The proposed methods are illustrated with analyses of effects of several covariates on medical expenditures in 1996 for subjects clustered within households using data from the Medical Expenditure Panel Survey.

1 Introduction

Data with clumping at zero commonly occur in biometrics. Typically the outcome variable measures an amount that must be non-negative and may in some cases be zero. The positive values are generally skewed, often extremely so. Examples include concentrations of compounds, amounts of health or insurance expenditures, or amounts of rainfall or pollutants. Distributions of data of this type follow a common form: there is a spike or discrete probability mass at zero, followed by a bump or ramp describing positive values. Since the variable of interest describes an amount there is often interest in estimating the mean amount, including zeros, perhaps in order to estimate total amounts. For example, in estimating mean per person medical expenditures, it must be taken into account that some subjects will have no expenditures during the period of interest. From these means, group totals could be estimated.

Various approaches to the problem of data clumped at zero have been proposed, but most of them have drawbacks.¹ If the data are treated as if they come from a normal distribution, the clumping at zero is ignored as well as the tendency of the positive data

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to be skewed. If a nonparametric approach utilizing the distribution of the ranks is employed, a large number of ties will exist corresponding to the zero observations, and the distribution will not be symmetric. In addition, it is not possible to obtain predictions of the response variable or to estimate totals using a nonparametric approach. Another approach to analyzing data of this type is to divide the data into two parts—those data with a value equal to zero and those greater than zero. If only the data greater than zero are used in the analysis, important information about subjects with zero response is lost, and estimates of totals will not include zero values. When one is relying on estimates from such analyses to make policy decisions, inaccurate conclusions may be made, which may lead to policies that are inadequate or inappropriate for the population of interest. In addition, this method does not account for the relationship that may exist between the probability of a nonzero response and the level of the nonzero response.

The majority of the literature in the area of data that are clumped at zero addresses the cross-sectional case where the unit of observation is measured once.^{1–4} Clumping at zero may also occur with repeated measures or longitudinal data. In addition to sharing the problems of cross-sectional data with clumping at zero, the correlation among measurements on the same unit of observation must be accounted for.

We propose a mixed-distribution model based on the work of Lachenbruch^{1,2} for cross-sectional data and Grunwald and Jones⁵ for time series data. The model is also similar to the ‘two-part model’ used for cross-sectional data in econometrics.^{3,6} All of these approaches combine models for the probability of occurrence of a nonzero value (a probit or logit model) and for the probability distribution of the nonzero values (a lognormal or exponential family distribution). The term ‘mixed-distribution model’ refers to a mixture-of-distributions model that takes the general form

$$f(y) = \begin{cases} \Pr(Y = 0), & \text{if } y = 0 \\ [1 - \Pr(Y = 0)]b(y) & \text{if } y > 0 \\ 0 & \text{if } y < 0 \end{cases} \quad (1)$$

where $b(y)$ is a probability density defined when $y > 0$.^{1,2} We draw on methods for modeling non-normal responses with random effects⁷ to incorporate random unit (subject) effects into the two parts of the model to account for the correlation due to multiple observations made on the same subject or unit. We also allow the random unit effects for the probability of a nonzero value and for the distribution of nonzero values to be correlated with each other. This allows units with higher rates of occurrence to also have higher (or lower) mean nonzero responses. Correlation between the random effects in the two model components is similar to the cross-sectional correlation between the random normal errors in the two model components of the Heckman, or Type II Tobit model.⁸

Section 2 outlines the proposed mixed-distribution model for longitudinal data with correlated random effects, shows how the methods of generalized linear mixed models (GLMM) and nonlinear mixed models may be used to fit the model, and addresses the interpretation of the model parameters in terms of the total amount, including zeros. In particular, a covariate may affect the mean amount by affecting both the probability of

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occurrence of a nonzero value and also the mean of the nonzero values, and we give an approach to quantifying and separating these two effects. In Section 3, results from simulation studies are presented. Section 4 illustrates application of the mixed-distribution model for repeated measures data using data from the Medical Expenditure Panel Survey, and Section 5 provides a summary and discusses areas for further research.

2 Mixed-distribution model with correlated random effects

In this section a mixed-distribution model for repeated measures data with clumping at zero and correlated random effects is introduced. This model will be referred to as the correlated mixed-distribution model. An extension of the mixed-distribution model was chosen to model repeated measures data because it provides a general statistical modeling approach using existing methodologies (generalized linear and nonlinear mixed-effects models). The model gives information about the separate occurrence and nonzero amount components of the model as well as the overall mean. The correlated mixed-distribution model relates the two components of the model by assuming a bivariate normal distribution for the random effects.

2.1 Model

For a random variable Y_{ij} , which represents the *amount* of a quantity with observed value y_{ij} for a unit of observation i at time j , let R_{ij} represent the *occurrence variable* where

$$R_{ij} = \begin{cases} 0, & \text{if } Y_{ij} = 0 \\ 1, & \text{if } Y_{ij} > 0 \end{cases}$$

R_{ij} has conditional probabilities

$$\Pr(R_{ij} = r_{ij} | \boldsymbol{\theta}_1) = \begin{cases} 1 - p_{ij}(\boldsymbol{\theta}_1), & \text{if } r_{ij} = 0 \\ p_{ij}(\boldsymbol{\theta}_1), & \text{if } r_{ij} = 1 \end{cases}$$

where $\boldsymbol{\theta}_1 = [\boldsymbol{\beta}'_1, \boldsymbol{u}_{1i}]'$ is a vector of fixed occurrence effects $\boldsymbol{\beta}_1$, and random unit occurrence effect \boldsymbol{u}_{1i} . We assume a logistic model for occurrence so that

$$\text{logit}(p_{ij}(\boldsymbol{\theta}_1)) = \mathbf{X}'_{1ij}\boldsymbol{\beta}_1 + \boldsymbol{u}_{1i} \quad (2)$$

where \mathbf{X}'_{1ij} is a vector of covariates for occurrence.

Define $S_{ij} \equiv [Y_{ij} | R_{ij} = 1]$ to be the *intensity variable* with p.d.f. $f(s_{ij} | \boldsymbol{\theta}_2)$ for $s_{ij} > 0$ and mean $E(S_{ij} | \boldsymbol{\theta}_2) = \mu_{s_{ij}}(\boldsymbol{\theta}_2)$ where $\boldsymbol{\theta}_2 = [\boldsymbol{\beta}'_2, \boldsymbol{u}_{2i}]'$ is a vector of fixed intensity effects $\boldsymbol{\beta}_2$ and random unit intensity effect \boldsymbol{u}_{2i} . We assume a lognormal model for intensity so that

$$\log(S_{ij} | \boldsymbol{\theta}_2) \sim N(\mathbf{X}'_{2ij}\boldsymbol{\beta}_2 + \boldsymbol{u}_{2i}, \sigma_e^2) \quad (3)$$

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where \mathbf{X}_{2ij} is a vector of covariates for intensity. We allow the random effects for occurrence and intensity to be correlated by assuming that

$$\begin{bmatrix} u_{1i} \\ u_{2i} \end{bmatrix} \sim BVN\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_1^2 & \rho\sigma_1\sigma_2 \\ \rho\sigma_1\sigma_2 & \sigma_2^2 \end{bmatrix}\right). \quad (4)$$

Under this assumption the subject-specific mean intensity is

$$E(S_{\bar{i}} | \boldsymbol{\theta}_2) = \exp\left(\mathbf{X}'_{2\bar{i}}\boldsymbol{\beta}_2 + u_{2i} + \frac{\sigma_e^2}{2}\right) \quad (5)$$

and the marginal mean intensity is

$$E(S_{\bar{i}} | \boldsymbol{\beta}_2) = \exp\left(\mathbf{X}'_{2\bar{i}}\boldsymbol{\beta}_2 + \frac{\sigma_2^2}{2} + \frac{\sigma_e^2}{2}\right) \quad (6)$$

Note in particular that the values and interpretations of the fixed effects parameters $\boldsymbol{\beta}_2$ are identical in (5) and (6) except for the intercept.⁷

The p.d.f. of $Y_{\bar{i}}$ is

$$\begin{aligned} f(y_{\bar{i}} | \boldsymbol{\theta}) &= \Pr(R_{\bar{i}} = 0 | \boldsymbol{\theta}_1)\delta_0(y_{\bar{i}}) + \Pr(R_{\bar{i}} = 1 | \boldsymbol{\theta}_1)f(s_{\bar{i}} | \boldsymbol{\theta}_2) \\ &= [1 - p_{\bar{i}}(\boldsymbol{\theta}_1)]\delta_0(y_{\bar{i}}) + p_{\bar{i}}(\boldsymbol{\theta}_1)f(s_{\bar{i}} | \boldsymbol{\theta}_2) \end{aligned}$$

where $\boldsymbol{\theta} = [\boldsymbol{\theta}_1, \boldsymbol{\theta}_2]$ and $\delta_0(y)$ is a Dirac delta function⁹ such that

$$\begin{cases} \int_{-\infty}^{\infty} \delta_0(y) dy_{\bar{i}} = 1 \\ \delta_0(y) = 0 \text{ when } y_{\bar{i}} \neq 0 \end{cases}$$

The conditional expectation of $Y_{\bar{i}}$ is:

$$E(Y_{\bar{i}} | \boldsymbol{\theta}) = p_{\bar{i}}(\boldsymbol{\theta}_1)\mu_{S_{\bar{i}}}(\boldsymbol{\theta}_2), \quad (7)$$

and the conditional variance is:¹⁰

$$\text{var}(Y_{\bar{i}} | \boldsymbol{\theta}) = p_{\bar{i}}(\boldsymbol{\theta}_1)\text{var}(S_{\bar{i}} | \boldsymbol{\theta}_2) + (p_{\bar{i}}(\boldsymbol{\theta}_1))[1 - (p_{\bar{i}}(\boldsymbol{\theta}_1))]\mu_{S_{\bar{i}}}(\boldsymbol{\theta}_2)^2.$$

The contribution to the likelihood for the i th subject ($i = 1, \dots, m$) is

$$\begin{aligned} L_i(\boldsymbol{\beta}_1, \boldsymbol{\beta}_2, \sigma_1, \sigma_2, \sigma_e, \rho; y_{i1}, \dots, y_{im_i}) \\ = \int_{u_{1i}} \int_{u_{2i}} \prod_{j=1}^{m_i} f(y_{ij} | \boldsymbol{\beta}_1, \boldsymbol{\beta}_2, u_{1i}, u_{2i})f(u_{1i}, u_{2i} | \sigma_1, \sigma_2, \sigma_e, \rho)du_{1i}du_{2i}. \end{aligned}$$

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The likelihood is then

$$\begin{aligned}
 L(\beta_1, \beta_2, \sigma_1, \sigma_2, \sigma_e, \rho) &= \prod_{i=1}^m \int_{u_{1i}} \int_{u_{2i}} \prod_{j=1}^{n_i} f(y_{ij} | \beta_1, \beta_2, u_{1i}, u_{2i}) f(u_{1i}, u_{2i} | \sigma_1, \sigma_2, \sigma_e, \rho) du_{1i} du_{2i} \\
 &= \prod_{i=1}^m \int_{u_{1i}} \int_{u_{2i}} \prod_{j=1}^{n_i} [1 - p_{ij}(\beta_1, u_{1i})]^{1-r_{ij}} [p_{ij}(\beta_1, u_{1i})]^{r_{ij}} \\
 &\quad \times f(s_{ij} | \beta_2, u_{2i}) f(u_{1i}, u_{2i} | \sigma_1, \sigma_2, \sigma_e, \rho) du_{1i} du_{2i} \tag{8}
 \end{aligned}$$

In the correlated mixed-distribution model, it is not assumed that the random effects are independent and, as a result, the components of (8) for occurrence and intensity contain a common parameter, ρ . Therefore, the two components of the likelihood cannot be maximized separately as in Lachenbruch² or Grunwald and Jones.³ In model (8) it is also possible for β_1 and β_2 to share common parameters. However, because β_1 and β_2 are on different scales, doing so may lead to parameter estimates that are difficult to interpret.

With the assumptions that u_{1i} and u_{2i} are independent, i.e. that $\rho = 0$, the likelihood may be factored into two parts that correspond to the occurrence process and the intensity process:

$$\begin{aligned}
 L(\beta_1, \beta_2, \sigma_1, \sigma_2, \sigma_e) &= \prod_{i=1}^m \int_{u_{1i}} \prod_{j=1}^{n_i} [1 - p_{ij}(\theta_1)]^{1-r_{ij}} [p_{ij}(\theta_1)]^{r_{ij}} f(u_{1i} | \sigma_1) du_{1i} \\
 &\quad \times \prod_{i=1}^m \int_{u_{2i}} \prod_{j=1}^{n_i} f(s_{ij} | \theta_2) f(u_{2i} | \sigma_2, \sigma_e) du_{2i}
 \end{aligned}$$

The first component is the likelihood for the occurrence process, $L_R(\beta_1, \sigma_1)$, and the second component is the likelihood for the intensity process, $L_S(\beta_2, \sigma_2, \sigma_e)$. With the further assumption that θ_1 has no parameters in common with θ_2 , $L(\beta_1, \beta_2, \sigma_1, \sigma_2, \sigma_e)$ is maximized when each component is maximized separately. When $\rho = 0$, the model is referred to as the uncorrelated mixed-distribution model.

2.2 Model fitting

If u_{1i} and u_{2i} are assumed to be independent, then maximum likelihood methods may be used to maximize both components of the likelihood separately. Wolfinger and O'Connell's pseudo-likelihood approach,¹¹ Breslow and Clayton's penalized quasi-likelihood approach,¹² or optimization of the likelihood approximated by adaptive Gaussian quadrature,¹³ may be used to maximize $L_R(\beta_1, \sigma_1)$ and $L_S(\beta_2, \sigma_2, \sigma_e)$ separately. The overall likelihood $L(\beta_1, \beta_2, \sigma_1, \sigma_2, \sigma_e)$ is the product of $L_R(\beta_1, \sigma_1)$ and $L_S(\beta_2, \sigma_2, \sigma_e)$, and the maximum of $L(\beta_1, \beta_2, \sigma_1, \sigma_2, \sigma_e)$ occurs when $L_R(\beta_1, \sigma_1)$ and $L_S(\beta_2, \sigma_2, \sigma_e)$ are maximized separately. If the models contain no random effects, this allows the mixed-distribution model to be estimated using standard software of generalized linear models¹⁴. When correlated random effects are present these special cases are useful for obtaining initial estimates when optimizing the correlated model likelihood (8).

The full likelihood (8) for the correlated mixed-distribution model can be maximized using quasi-Newton optimization of a likelihood approximated by adaptive Gaussian quadrature.¹³ This method is implemented in the SAS PROC NLMIXED procedure (SAS Institute, Cary, NC, Version 8). This procedure allows the user to specify a general likelihood, in particular one of the form (8), and also allows great flexibility for specification of the distribution of $S_{\bar{y}}$. We assume a logistic-lognormal-normal model, where 'logistic' refers to the modeling of the occurrence part of the model (2), 'lognormal' to the modeling of the intensity part of the model (3), and 'normal' to the assumption that the random effects are assumed to have a bivariate normal distribution (4).

To fit this model we developed a SAS macro (MIXCORR, available from the authors) that calls PROC GENMOD and PROC NLMIXED. The user must specify the dataset, the outcome variable, covariates for the binomial component of the model and for the lognormal component of the model, and the variable that identifies the random unit. The macro estimates a binomial model for the occurrence and a lognormal model for the intensity (both without random effects) using PROC GENMOD. These parameter estimates are used as starting values in estimating the separate occurrence and intensity models with uncorrelated random effects using SAS PROC NLMIXED. Finally, the parameter estimates from the two uncorrelated random effects models are used as starting values for the mixed-distribution model with correlated random effects in a final PROC NLMIXED run. The starting value for the covariance of the random effects is calculated using the estimates of σ_1^2 and σ_2^2 and $\rho = 0.5$.

2.3 Model checking

The model assumes normality and constant variance of random effects, μ_{1i} and μ_{2i} , and the residuals of the intensity distribution. Standard regression diagnostics may be used to assess the goodness of fit of the model. Quantile-quantile plots can be constructed for $\hat{\mu}_{1i}$ and $\hat{\mu}_{2i}$, and for the residuals for the intensity variable, given by $\ln(s_{\bar{y}}) - (\mathbf{X}'_{2i}\beta_2 + u_{2i})$. If the normality assumption is not violated, the data will fall in a straight line. A plot of the residuals for the intensity distribution versus fitted values will indicate if the assumption of constant variance is violated. A nonrandom pattern indicates departure from this assumption.

2.4 Interpretation of Fixed-Effects Parameters

The separate effects of the fixed-effect occurrence and intensity parameters, β_1 and β_2 , have the same interpretations for occurrence and intensity as they would have if the two components of the model were fit separately (e.g., logistic and lognormal regression). If a variable is used in both the occurrence and intensity models, however, there may be interest in quantifying the overall effect of the variable on the total amount Y . This can be carried out as follows.

Assume that Z is a covariate in both the occurrence and intensity models (2) and (3), and that \mathbf{X}_1 and \mathbf{X}_2 are vectors of the other occurrence and intensity covariates, respectively. For simplicity we suppress the subscripts i and j . Then from (2) and (3),

$$\Pr(R = 1 \mid \theta_1) = \frac{\exp(\mathbf{X}'_1\beta_1 + \alpha_1 z + u_1)}{1 + \exp(\mathbf{X}'_1\beta_1 + \alpha_1 z + u_1)} \quad (9)$$

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and

$$E(S | \theta_2) = \exp\left(\mathbf{X}_2'\boldsymbol{\beta}_2 + \alpha_2 z + u_2 + \frac{\sigma_e^2}{2}\right). \quad (10)$$

Then the ratio of mean amount of Y when $Z = z + 1$ to that when $Z = z$ is

$$\frac{E(Y | Z = z + 1, \theta)}{E(Y | Z = z, \theta)} = \left[\frac{\Pr(R = 1 | Z = z + 1, \theta_1)}{\Pr(R = 1 | Z = z, \theta_1)} \right] \left[\frac{E(S | Z = z + 1, \theta_2)}{E(S | Z = z, \theta_2)} \right] \quad (11)$$

From (10) the second term in (11) is $\exp(\alpha_2)$. In general the first term in (11) depends on $\mathbf{X}_1'\boldsymbol{\beta}_1 + u_1$ as well as on α_1 and z . However, some insight can be gained by substituting (9) into (11) and noting that the function

$$\left(\frac{\exp(k + \alpha_1)}{1 + \exp(k + \alpha_1)} \right) / \left(\frac{\exp(k)}{1 + \exp(k)} \right) \rightarrow 1 \text{ as } k \rightarrow \infty$$

and

$$\left(\frac{\exp(k + \alpha_1)}{1 + \exp(k + \alpha_1)} \right) / \left(\frac{\exp(k)}{1 + \exp(k)} \right) \rightarrow \exp(\alpha_1) \text{ as } k \rightarrow -\infty.$$

Thus in (11),

$$\frac{E(Y | Z = z + 1, \theta)}{E(Y | Z = z, \theta)} \approx \begin{cases} \exp(\alpha_2) & \text{when } \mathbf{X}_1'\boldsymbol{\beta}_1 + u_1 \text{ is large and positive} \\ \exp(\alpha_1)\exp(\alpha_2) & \text{when } \mathbf{X}_1'\boldsymbol{\beta}_1 + u_1 \text{ is large and negative} \end{cases}$$

When $\mathbf{X}_1'\boldsymbol{\beta}_1 + u_1$ is large and positive, $\Pr(R = 1) \approx 1$ so there are few zeros, $E(Y) \approx E(S)$, and the effect of Z on Y is mainly via the mean of the nonzero values. When $\mathbf{X}_1'\boldsymbol{\beta}_1 + u_1$ is large and negative, the ratio of means in (11) is a combination of occurrence and intensity effects. The term $\Pr(R = 1 | Z = z + 1, \theta_1)/\Pr(R = 1 | Z = z, \theta_1)$ is the risk ratio for occurrence per one unit change in Z . When $\Pr(R = 1) \approx 0$, as when $\mathbf{X}_1'\boldsymbol{\beta}_1 + u_1$ is large and negative, this term is close to the odds ratio for occurrence per one unit change in Z , which is $\exp(\alpha_1)$ as in the usual logistic regression interpretation. Special cases of all of these results hold if Z enters into only the occurrence model ($\alpha_2 = 0$) or only into the intensity model ($\alpha_1 = 0$).

In practice, neither of the limiting cases of (11) may apply. In order to determine the range of the effect of a common covariate Z on Y , the ratio of the means in (11) can be computed for the minimum, maximum, and median values of Z , and for the minimum and maximum values of the other covariates. The limit $\exp(\alpha_1)\exp(\alpha_2)$ in (11) provides an upper (lower) limit for the combined effect of Z on Y when α_1 is positive (negative). Note that these results also hold when no random effects are present and thus provide an interpretation of the combined effect of a variable in a mixed-distribution regression model.

2.5 Interpretation of random effects

The random effects in the correlated mixed-distribution model, μ_{1i} and μ_{2i} , account for unobserved heterogeneity among units. In the occurrence part of the model, the random intercept on the link (e.g., logit) scale, $\beta_{10i} = \beta_{10} + \mu_{1i}$, allows some units to have a consistently low or high probability of a nonzero response. The variance of the random effect, σ_1^2 , indicates the variability of the probability of a nonzero response among units with similar covariate patterns. The random intercept, $\beta_{20i} = \beta_{20} + \mu_{2i}$, in the intensity part of the model, allows some units to have consistently low or high mean of nonzero values. If σ_2^2 is large it indicates that there is a great deal of heterogeneity of mean nonzero responses among units with similar covariate patterns.

Allowing correlation of the random effects μ_{1i} and μ_{2i} allows units with consistently high occurrence probability to have consistently high (low) mean of nonzero values when the correlation between μ_{1i} and μ_{2i} , ρ , is positive (negative).

3 Simulation results

A simulation study was performed to study the performance of the parameter estimates from Section 2.2. Using a method adapted from Zeger and Karim,¹³ data were simulated from the logistic-lognormal-normal mixed-distribution model with

$$\begin{aligned} p_{ij}(\theta_i) &= \beta_{10} + \beta_{11}t_j + \beta_{12}x_i + \beta_{13}x_it_j + \mu_{1i} \\ \log(S_{ij} | \mu_{2i}) &\sim N(\beta_{20} + \beta_{21}t_j + \beta_{22}x_i + \mu_{2i}, \sigma_e^2), \end{aligned}$$

and correlated random effects μ_{1i} and μ_{2i} as in (4).

One hundred datasets with $m=100$ units (clusters or subjects) of size $n_i=7$ were generated using each of the two sets of parameter values shown in Table 1. The number of quadrature points specified in NLMIXED was held to the maximum number

Table 1 Simulation results for the correlated mixed-distribution model using $m=100$ simulated datasets from the model given in Section 3 with each of the two sets of true parameter values

True value	Mean of 100 estimates		True value	Mean of 100 estimates	
β_{10}	2.50	2.51	β_{10}	2.50	2.58
β_{11}	0.10	0.10	β_{11}	0.10	0.09
β_{12}	-1.00	-1.04	β_{12}	-1.00	-1.13
β_{13}	0.05	0.05	β_{13}	0.05	0.06
σ_1^2	1.00	0.97	σ_1^2	10.00	9.98
β_{20}	4.00	4.00	β_{20}	4.00	3.98
β_{21}	0.50	0.50	β_{21}	0.50	0.50
β_{22}	1.50	1.49	β_{22}	1.50	1.39
σ_2^2	1.44	1.41	σ_2^2	14.40	14.33
σ_e^2	1.00	1.00	σ_e^2	1.00	1.01
$\rho\sigma_1\sigma_2$	0.60	0.58	$\rho\sigma_1\sigma_2$	6.00	6.15

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determined adaptively, seven. The estimates from NLMIXED appear to be unbiased (Table 1).

4 Application

The Medical Expenditure Panel Survey (MEPS) is a longitudinal survey conducted by the Agency for Healthcare Research and Quality (AHRQ) and the National Center for Health Statistics (NCHS). MEPS data may be used to obtain estimates of health care use, medical expenditures, and insurance coverage in the United States. In the Household Component of the MEPS, data were collected on health care use and expenditures, demographic characteristics, medical conditions, health status, and insurance coverage on 22 601 persons in 10 596 households. Although the expenditure and use data are collected longitudinally, they are aggregated by year; only data for 1996 were analyzed. However, due to the multiple subjects within households, these data exhibit clustering, and the techniques described in this paper are applicable with household as the unit of repeated measurement. Although the MEPS is a representative sample and weighted and unweighted frequencies are provided in order to provide data analysts the ability to make population-level estimates, the analysis presented in this paper was not weighted.

For this analysis, the impact of age, sex, health rating, the presence of a medical condition, census region (Northeast, Midwest, South, West), the presence of physical limitations, and insurance status on total medical expenditures in 1996 were modeled. The health rating was assessed on a scale of 1 to 5 with 1 corresponding to 'Excellent' and 5 corresponding to 'Poor'. Whether or not a subject had a medical condition was based on household-reported medical conditions collected in 1996. A subject was considered to have a limitation if they were found to have any type of limitation with activities of daily living (ADLs: including bathing, dressing, and getting around the house), instrumental activities of daily living (IADLs: including using the telephone, paying bills, taking medications, preparing light meals, doing laundry, and going shopping), physical limitations (such as walking, climbing stairs, grasping objects, reaching overhead, lifting, bending or stooping, and standing for long periods of time), any limitation that impeded their work, housework, or school activities, or vision or hearing limitations. The presence or absence of any insurance (including coverage under CHAMPUS/CHAMPVA, Medicare, Medicaid or other public hospital/physician or private hospital/physician insurance) was reported for each month in 1996. The portion of the year that the respondent was insured was used as a covariate in the analysis. There were from one to fourteen persons in a family; the median number of family members was three. Owing to missing data on the limitation, health rating variable, insurance status, region, age, or sex, 746 respondents were excluded from the analysis.

Both models with and without correlated random effects were fit using the MIXCORR macro and a backwards selection procedure. In all cases the model with correlated random effects was found to be better than the model with uncorrelated random effects (based on a likelihood ratio test and AIC). A model with all covariates was the best of the models considered. Parameter estimates from the models with uncorrelated and correlated random effects are given in Table 2.

Table 2 Parameter estimates and model comparisons for final model fit to MEPS data

Parameter	Uncorrelated		Correlated	
	Estimate (S.E.)	p > t	Estimate (S.E.)	p > t
<i>Occurrence (Logistic)</i>				
Intercept	-2.8292(0.1129)	< 0.0001	-2.8131(0.1129)	< 0.0001
Medical condition (N=0/Y=1)	3.0342(0.0724)	< 0.0001	2.9792(0.0717)	< 0.0001
Limitations (N=0/Y=1)	0.5574(0.0894)	< 0.0001	0.5498(0.0897)	< 0.0001
Portion of year insured (0-1)	1.7152(0.0680)	< 0.0001	1.7262(0.0679)	< 0.0001
Age (years)	0.0051(0.0014)	0.0003	0.0040(0.0014)	0.0043
Health rating (1-5)	0.1782(0.0292)	< 0.0001	0.2181(0.0296)	< 0.0001
Sex (M=0/F=1)	0.6122(0.0509)	< 0.0001	0.6318(0.0510)	< 0.0001
Region 1 (Northeast)	0.5173(0.0881)	< 0.0001	0.5184(0.0884)	< 0.0001
Region 2 (Midwest)	0.5547(0.0867)	< 0.0001	0.5465(0.0869)	< 0.0001
Region 3 (South)	0.1359(0.0724)	0.0806	0.1236(0.0728)	0.0886
σ_1^2	1.1502(0.1140)	< 0.0001	1.1852(0.1149)	< 0.0001
<i>Intensity (Lognormal)</i>				
Intercept	3.0459(0.0619)	< 0.0001	2.8653(0.0641)	< 0.0001
Medical condition (N=0/Y=1)	1.0485(0.0473)	< 0.0001	1.1503(0.0482)	< 0.0001
Limitations (N=0/Y=1)	0.5681(0.0299)	< 0.0001	0.5743(0.0299)	< 0.0001
Portion of year insured (0-1)	0.8702(0.0347)	< 0.0001	0.9047(0.0348)	< 0.0001
Age (years)	0.0189(0.0005)	< 0.0001	0.0187(0.0005)	< 0.0001
Health rating (1-5)	0.2609(0.0111)	< 0.0001	0.2697(0.0112)	< 0.0001
Sex (M=0/F=1)	0.2235(0.0206)	< 0.0001	0.2366(0.0206)	< 0.0001
Region 1 (Northeast)	0.1188(0.0355)	0.0008	0.1237(0.0356)	0.0005
Region 2 (Midwest)	0.1314(0.0341)	0.0001	0.1383(0.0342)	< 0.0001
Region 3 (South)	0.0126(0.0313)	0.6878	0.0145(0.0313)	0.6435
σ_2^2	1.8959(0.0239)	< 0.0001	1.8960(0.0239)	< 0.0001
$\sigma_1 \sigma_2$	0.2368(0.0190)	< 0.0001	0.2468(0.0192)	< 0.0001
$\rho \sigma_1 \sigma_2$	—	—	0.3523(0.0347)	< 0.0001
($\rho = 0.6514$)				
Name	Value	Value	Difference in -2 log likelihood	
AIC	293.107.6	293.002.0		
-2 LL	293.061.6	292.954.0	107.59	($p < 0.0001$)

Checks of the goodness of fit of the model, as described in Section 2.3, were performed. The quantile-quantile plots for the random effects showed no indication of departure from a straight line. Plots of residuals versus fitted values for the lognormal intensity model did not show any indications of heteroscedasticity of variance.

The separate and combined effects of the variables included in the model are presented in Table 3. In this table each column is referenced by a lower case letter. Recall that from (11) the ratio of the overall mean for a one unit change in a common covariate Z may be represented as follows:

$$\left[\frac{E(Y | Z = z + 1)}{E(Y | Z = z)} \right] = \underbrace{\exp(\alpha_2)}_{(k)} \underbrace{\exp(\alpha_1)}_{(j)} \underbrace{\left[\frac{\Pr(R = 0 | Z = z + 1)}{\Pr(R = 0 | Z = z)} \right]}_{(g)} \quad (12)$$

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Table 3 Effects on medical expenditure in 1996 MEPS data for covariates (a-f) on probability of occurrence (β_0), on intensity (β_1) and on mean amount (β_2)

Variable	(a) Medical condition	(b) Limitation	(c) Health rating	(d) Sex	(e) Insurance	(f) Region	(g) Ratio of Prob.*	(h) e^{β_1}	(i) e^{β_1} * ratio (f)	(j) e^{β_2}	(k) Ratio of means
Any medical condition (N = 0/Y = 1)	N/Y N/Y	N Y	Ex Poor	M F	0 1	4 2	0.404 0.058	19.672 19.672	7.946 1.145	3.159 3.159	25.101 3.617
Any limitation (N = 0/Y = 1)	N Y	N/Y N/Y	Ex Poor	M F	0 1	4 2	0.945 0.580	1.733 1.733	1.638 1.096	1.776 1.776	2.909 1.786
Health rating (1 = Ex, 2 = Very Good, 3 = Good, 4 = Fair, 5 = Poor)	N Y	N Y	Ex/VG Ex/VG	M F	0 1	4 2	0.981 0.807	1.244 1.244	1.220 1.004	1.310 1.310	1.598 1.314
Sex (M = 0/F = 1)	N Y	N Y	Ex Poor	M/F M/F	0 1	4 2	0.935 0.535	1.881 1.881	1.759 1.007	1.267 1.267	2.228 1.276
Portion of year insured (0-1)	N Y	N Y	Ex Poor	M F	0/1 0/1	4 2	0.733 0.184	5.619 5.619	4.116 1.036	2.471 2.471	10.172 2.560
Region (1 = Northeast, 2 = Midwest, 3 = South, 4 = West)	N Y	N Y	Ex Poor	M F	0 1	4/2 4/2	0.946 0.582	1.727 1.727	1.633 1.006	1.148 1.148	1.876 1.155

*Age set equal to the mean, 34.8 years.

Ex = excellent, VG = very good.

The terms are as given in equation (12).

The variable listed in the first column of Table 3 is z in the equation. Because the values of the other variables in the model impact the ratio of probabilities (g), various scenarios for values of the other variables are given in columns (a)–(f). In general, the 'low' condition, in which the other covariates in the model are at their lowest value, is given on the first row for the variable, and the 'high' condition, in which the other covariates in the model are at their highest value, is given on the following row.

Presence of a medical condition was associated with increased mean medical expenditure in 1996. The increase ranged from 3.6 times (for subjects with otherwise 'high risk' covariate patterns) to 25.1 times (for subjects with otherwise 'low risk' covariate patterns). Differences in this effect were due to differences in the effect of a medical condition on the probability of some medical expenditure. The mean medical expenditure for respondents with a physical limitation was from 1.8 to almost 3 times the mean of respondents without physical limitations. Having insurance for the entire year was associated with increased mean medical expenditures from 2.5 to 10.2 times that of persons who did not have insurance for the entire year, with the larger increase for patients with an otherwise low risk covariate pattern. A one unit increase in the health rating scale, which actually corresponded to a decline in health, increased the mean amount of health expenditures by 1.3 to 1.6 times. The difference between a male subject and a similar female increased the mean amount of expenditure from 1.3 to 2.2 times. Lastly, living in the Midwest increased the mean amount of expenditure from 1.2 to 1.9 times that of those living in the West. In none of these cases was there a uniform dominance of the occurrence effect over the intensity effect (or vice versa) on total expenditure.

The significant random effects variance for the occurrence shows that after accounting for covariate differences among subjects, some families have a greater probability of seeking medical care than others. Similarly, the highly significant random effect variance for intensity indicates that after accounting for covariate differences, some families have consistently higher (or lower) expenditures when they do seek medical care than the norm. The positive correlation between the occurrence and intensity random effects indicates that after accounting for covariate differences, families with a greater tendency to seek medical care tended also to report a higher mean amount of positive expenditures.

5 Discussion

We have proposed a model for longitudinal or repeated measures data with clumping at zero, using a mixed-effects, mixed-distribution model. The model includes features of the cross-sectional statistical models of Lachenbruch,^{1,2} the cross-sectional econometric models of Heckman,⁸ Duan et al.,³ and Manning et al.,⁶ and the time series model of Grunwald and Jones.⁵ In addition, by including correlated random errors, the occurrence and intensity parts of the model are linked. An interpretation of fixed-effects parameters was given, which also applies to mixed-distribution models for cross-sectional data.

We have shown how the proposed model may be estimated using standard software for non-linear and generalized linear mixed models such as SAS PROC NLMIXED.

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Simulations indicate that this method of estimation gives unbiased results for both fixed and random effects. We chose this method due to its good performance on simulation studies, and because it can be easily implemented in SAS. However, other methods of model fitting appropriate for GLMMs and nonlinear mixed-effects models¹³ potentially could be used to fit our model, including penalized quasi-likelihood¹² or a Monte Carlo method within a Bayesian framework.¹³

We used the approach to model the association between several covariates including demographic characteristics, insurance coverage, and health status on health care expenditures of subjects, using random effects to account for clustering of subjects into families. We noted strong fixed effects of most covariates on total amount of expenditure, through both the probability of nonzero expenditure and the mean of nonzero expenditures. We also noted strong random effects due to clustering of subjects within families. Further, adjusting for covariates, there was a tendency for subjects in families that had a higher probability of some health care expenditure to also have higher mean nonzero expenditure.

The model proposed in this paper is appropriate for data with true zeros. Although this method may appear to be applicable to the case where data are left censored or missing, a zero in these cases is not a real zero and should not be treated as such when calculating the mean amount.

One byproduct of our work is a method for interpreting effects of covariates. Estimation of the mean amount, including the probability of zeros, is in our view one of the main reasons for developing models for the combined response when zeros are included. Totals, such as total expenditure for a group over a period of time including the fact that some subjects will have no expenditures, can be estimated from these means. The method we propose gives information about the effect of a covariate on this mean amount and how that effect arises as a combination of the covariate's effect on occurrence probability and on mean nonzero amount. The methods we propose are also applicable in the cross-sectional case.

Many modifications and extensions of our methods are possible. Some types of data with clumping at zero may exhibit serial correlation, particularly if repeated measurements are made longitudinally. One possible extension of the model described in this paper is to a transition model or an autoregressive error structure to account for the type of autoregressive pattern that longitudinal data might exhibit. Another direction for extension would be toward the Heckman⁸ econometric model, which uses correlated random errors to allow the probability of occurrence and the mean intensity to be related in a cross-sectional model. We have adapted that approach to include correlated random unit effects, our main interest. Our model could be modified to include correlated within-subject random components as well. Such a model could again be estimated using standard methods for GLMMs and SAS PROC NLMIXED. Further extensions might include both a transition component and a random effect. Other extensions of the correlation structure, such as a stochastic parameter model including random slopes as well as random intercepts, would be possible as well. However, as the correlation structures become more complex and additional parameters are added to the model, the model becomes less parsimonious and more difficult to fit.

In this paper we have assumed that the nonzero amounts follow a lognormal distribution, as in the two-part models of Duan *et al.*³ This distribution is appropriate

for skewed, positive, continuous data and is frequently used for analysis of cost data. The gamma distribution would be an alternative choice for the intensity distribution, as in Grunwald and Jones⁵ and Hyndman and Grunwald.¹⁶ The Weibull distribution could also be chosen. All of these are distributions on $(0, \infty)$ and can be accommodated by the model. Because all of these distributions are capable of modeling a variety of positively skewed shapes, the exact form assumed for the errors would not be expected to have a substantial effect on the estimated model parameters or inferences. However, if quantiles of the nonzero amounts are to be estimated (as in Grunwald and Jones⁵), more care is needed to specify and check the form of the error distribution. A nonparametric density estimate¹⁷ could also be considered for estimating the shape of the error distribution. This approach potentially could provide better estimation of quantiles, although sparse data in the tails of the highly skewed distributions may cause difficulties. We are not aware of any applications of nonparametric density estimation to data with clumping. Some care would be needed so that the estimates were applied only to the nonzero data rather than smoothing across the zeros as well. It is unclear how multiple covariates and random effects could be included.

In our model, an intensity model appropriate for $y_i > 0$ was chosen so that it may be assumed that zeros only arise when $r_i = 0$. Otherwise, it is unknown whether the zeros arise from the distribution for the occurrence component of the model, or from the intensity component of the model. An example of a mixture of distributions that contains both type of zeros is a Binomial-Poisson mixture. Lambert¹⁸ has proposed zero-inflated Poisson (ZIP) regression for handling data that arise from this mixture of distributions. Dunson and Haseman¹⁹ extended ZIP regression to a transition model for longitudinal data with an application to carcinogenicity in animal studies. Hall²⁰ adapted Lambert's methodology to an upper-bounded count situation by using a zero-inflated binomial model. He also incorporated random effects into the ZIP regression model to accommodate repeated measures data. Our model was developed for the case where the nonzero data arise from a continuous distribution. The Poisson would not be an appropriate distribution for the intensity variable for the medical expenditure data described in this paper, as these data are not independent counts.

In the econometric literature there has been an increased interest in semiparametric approaches to fitting data with clumping at zero.^{21,22} In addition, Hyndman and Grunwald¹⁶ have developed a generalized additive mixed-distribution model with a first-order Markov structure for time series data. Another extension to the model described in this paper could involve a semiparametric modeling approach.

Because the correlated mixed-distribution model is a nonlinear model that incorporates the models and methods of GLMMs, as the methodology advances in the area of nonlinear models and GLMMs, especially with regard to model fitting and diagnostics, the methodology of the correlated mixed-distribution model will be advanced as well.

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References

- 1 Lachenbruch P. Analysis of data with clumping at zero. *Biometrische Zeitschrift* 1976; **18**: 351–56.
- 2 Lachenbruch P. Utility of regression analysis in epidemiologic studies of the elderly. In: Wallace R, Woolson R, eds. *The epidemiologic study of the elderly*. Oxford University Press, 1992.
- 3 Duan N, Manning WG, Morris CN, Newhouse JP. *A comparison of alternative models for the demand for medical care*. Santa Monica, California: The RAND Corporation, 1982. R-2754-HHS.
- 4 Amemiya T. *Advanced econometrics*. Cambridge, Massachusetts: Harvard University Press, 1985.
- 5 Grunwald GK, Jones RH. Markov models for time series with mixed distribution. *Environmetrics* 2000; **11**: 327–39.
- 6 Manning W, Duan N, Rogers W. Monte Carlo evidence on the choice between sample selection and two-part models. *Journal of Econometrics* 1987; **35**: 59–82.
- 7 Diggle PJ, Liang K-Y, Zeger SL. *Analysis of longitudinal data*. Oxford: Oxford University Press, 1994.
- 8 Heckman JJ. The common structure of statistical models of truncation, sample selection, and limited dependent variables and a simple estimator of such models. *Annals of Economic and Social Measurement* 1976; **5**: 475–92.
- 9 Robertson JS, Bolinger K, Glasser LM, Sloane NJ, Gross R. Chapter 1. In: Zwillinger D, ed. *CRC standard mathematical tables and formulae*. Boca Raton: CRC Press, 1996: 71.
- 10 Aitchinson J. On the distribution of a positive random variable having a discrete probability mass at the origin. *Journal of the American Statistical Association* 1955; **50**: 901–8.
- 11 Wolfinger R, O'Connell M. Generalized linear models. *Journal of Statistical Computer Simulation* 1993; **48**: 233–43.
- 12 Breslow N, Clayton D. Approximate inference in generalized linear models. *Journal of the American Statistical Association* 1993; **88**: 9–25.
- 13 Pinheiro JC, Bates DM. Approximations to the log-likelihood function in the nonlinear mixed-effects model. *Journal of Computational and Graphical Statistics* 1995; **4**: 12–35.
- 14 McCullagh P, Nelder J. *Generalized linear models* (2nd ed). London: Chapman & Hall, 1989.
- 15 Zeger SL, Karim MR. Generalized linear models with random effects. *Journal of the American Statistical Association* 1991; **86**: 79–86.
- 16 Hyndman RJ, Grunwald GK. Generalized additive modeling of mixed distribution markov models with application to Melbourne's rainfall. *Australian and New Zealand Journal of Statistics* 2000; **42**: 145–58.
- 17 Silverman BW. *Density estimation for statistics and data analysis*. London: Chapman and Hall, 1986.
- 18 Lambert D. Zero-inflated Poisson regression, with an application to defects in manufacturing. *Technometrics* 1992; **34**: 1–14.
- 19 Dunson D and Haseman J. Modeling tumor onset and multiplicity using transition models with latent variables. *Biometrics* 1999; **55**: 965–70.
- 20 Hall D. Zero-inflated Poisson and binomial regression with random effects: A case study. *Biometrics* 2000; **56**: 1030–39.
- 21 Maddala G. Limited dependent variable models using panel data. *Journal of Human Resources* 1987; **22**: 307–38.
- 22 Vella F. Estimating models with sample selection bias. *Journal of Human Resources* 1998; **33**: 127–69.

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- Applied the National Cancer Institute Method for determining usual dietary intake using multiple 24-hour recalls
- Applied the Healthy Eating Index to individual dietary intake and the emergency food pantry environment
- Imputed and classified food security using the 18-Item US Household Food Security Survey Module
- Led the preparation and submission of the IRB protocol for the *Reaching Rural Veterans* pilot study
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2. **Wright, BN.**, Tooze JA., Bailey RL., Liu, Y., Rivera RL., McCormack, LA., Stluka, S., Contreras, D., Franzen-Castle, L., Henne, B., Mehrle, D., Remley, D., Eicher-Miller, HA. Dietary quality and usual intake of under-consumed nutrients and related food groups differ by food security status for rural, Midwestern, food pantry clients. (*Submitted*)
3. **Wright, BN.**, Vasquez-Mejia, CM., Guenther, PM., McCormack, LA., Stluka, S., Contreras, D., Franzen-Castle, L., Henne, B., Mehrle, D., Remley, D., Eicher-Miller, HA. The quality of food bags distributed to clients is positively associated with clients' diet quality in a multistate sample of rural, Midwestern food pantries. (*Submitted*)
4. **Wright, BN.**, MacDermid Wadsworth, S., Wellnitz, A., Eicher-Miller, HA. Reaching Rural Veterans: A New Mechanism to Connect Rural, Low-Income U.S. Veterans with

- Resources and Improve Food Security. *Journal of Public Health*. 2018; 1-10. doi:10.1093/pubmed/fyd203
5. **Wright, BN.**, Bailey, RL., Craig, BA., Mattes, RD., McCormack, LA., Stluka, S., Contreras, D., Franzen-Castle, L., Henne, B., Mehrle, D., Remley, D., Eicher-Miller, HA. Daily dietary intake patterns improve after visiting a food pantry among food-insecure rural Midwestern adults. *Nutrients*. 2018 May 9; (10)583. doi: 10.3390/nu10050583
 6. Mischler, RA., Armah, SM., **Wright, BN.**, Mattar, SG., Rosen, AD., Gletsu-Miller, NA. Influence of diet and supplements on iron status following gastric bypass surgery. *Surgery for Obesity and Related Diseases*. 2015 Sep 21; 12(3):651-658. doi: 10.1016/j.sobrd.2015.09.007
 7. **Wright, BN.** and Gletsu-Miller, N. Iron nutrition following bariatric surgery. *Bariatric Surgical Practice and Patient Care*. 2014 Dec. 11. doi: 10.1089/bari.2014.0038
 8. Gletsu-Miller, N. and **Wright, BN.** Mineral malnutrition following bariatric surgery. *Advances in Nutrition*. 2013 Sep 1; 4(5):506-17. doi: 10.3945/an.113.004341
 9. Montgomery, JR., Whitt, JP., **Wright, BN.**, Lai, MH. and Meredith, AL. Mis-expression of the BK K⁺ channel disrupts suprachiasmatic nucleus circuit rhythmicity and alters clock-controlled behavior. *American Journal of Physiology – Cell Physiology*. 2013 Feb 15; 304(4):C299-311. doi: 10.1152/ajpcell.00302.2012

SCIENTIFIC PRESENTATIONS:

1. **Wright, BN.**, McCormack, LA., Stluka, S., Contreras, D., Franzen-Castle, L., Henne, B., Mehrle, D., Remley, D., Eicher-Miller, HA. The Voices for Food intervention improves dairy intake and decreases pantry use over a two-year period among a multi-state sample of rural, Midwestern food pantry clients. Poster, *Interdepartmental Nutrition Program (INP) Day*, 2019.
2. **Wright, BN.**, McCormack, LA., Stluka, S., Contreras, D., Franzen-Castle, L., Henne, B., Mehrle, D., Remley, D., Eicher-Miller, HA. Findings from a social ecological modeled coaching intervention to improve food security and dietary quality among a multi-state sample of adult rural, Midwestern emergency food pantry clients. Poster, *'Partners & Posters' Session- Purdue Extension Health and Human Sciences Update*, 2018.
3. **Wright, BN.**, McCormack, LA., Stluka, S., Contreras, D., Franzen-Castle, L., Henne, B., Mehrle, D., Remley, D., Eicher-Miller, HA. Food group intake differs among adult food secure, low food secure and very low food secure rural, Midwestern emergency food pantry users. Poster, *Interdepartmental Nutrition Program Corporate Affiliates*, 2018. [Award winner in the division of Population Nutrition/Public Health]
4. **Wright, BN.**, McCormack, LA., Stluka, S., Contreras, D., Franzen-Castle, L., Henne, B., Mehrle, D., Remley, D., Eicher-Miller, HA. Pantry Use Predicts Food Security among Rural, Midwestern Emergency Food Pantry Users. Oral, *Society for Nutrition Education and Behavior*, 2017.

5. **Wright, BN.**, McCormack, LA., Stluka, S., Contreras, D., Franzen-Castle, L., Henne, B., Mehrle, D., Remley, D., Eicher-Miller, HA. Food group intake differs among adult food secure, low food secure and very low food secure rural, Midwestern emergency food pantry users. Poster, *Experimental Biology*, 2017.
6. **Wright, BN.**, Sternberg, M., Wellnitz, A., MacDermid Wadsworth, S., Eicher-Miller, HA. Food security, dietary quality, and use of resources are low among rural U.S. Veteran food pantry users in a Reaching Rural Veterans pilot intervention. Poster, *Experimental Biology*, 2017.
7. **Wright, BN.**, McCormack, LA., Stluka, S., Contreras, D., Franzen-Castle, L., Henne, B., Mehrle, D., Remley, D., Eicher-Miller, HA. Diet quality and characteristics differ among food secure and food insecure emergency food pantry users. Oral, *Society for Nutrition Education and Behavior*, 2016.
8. Mundia, M., **Wright, BN.**, Rafferty, A., Eicher-Miller, HA. Application of the National Nutrient Database for Standard Reference and Food and Nutrient Database for Dietary Studies at four Indiana rural food pantries. Poster, *SROP/LSAMP Poster Presentation*, 2016.
9. **Wright, BN.**, McCormack, LA., Stluka, S., Contreras, D., Franzen-Castle, L., Henne, B., Mehrle, D., Remley, D. Eicher-Miller, HA. Diet quality and characteristics differ among food secure and food insecure emergency food pantry users. Poster, *Interdepartmental Nutrition Program Corporate Affiliates*, 2016.
10. **Wright, BN.**, Prohaska, JR. and Gletsu-Miller, N. Copper supplementation in marginal and deficient gastric bypass patients. Poster, *Trace Elements in Man and Animals*, 2014.
11. **Wright, BN.** and Gletsu-Miller, N. Characterizing anemia due to malnutrition in roux-en-y gastric bypass surgery patients. Oral, *Experimental Biology*, 2014.
12. **Wright, BN.**, Myers, C., Van Meter, MA., Mattar, SG., and Gletsu-Miller, N. A surveillance of micronutrient status in bariatric surgery patients. Oral, *Experimental Biology*, 2013.
13. Lai, MH., **Wright, BN.**, Witt, JP. And Meredith, AL. Anti-phase expression of the BK channel (Kcnma1) alters circadian locomotor activity in mice. Poster, *Experimental Biology*, 2012.
14. **Wright, BN.**, Coakley, K., Alvarez, J. and Tangpricha, V. Baseline vitamin D status in patients with chronic kidney disease. Oral, *MARC U*STAR Scholars Program Seminar*, 2012.
15. **Wright, BN.**, Coakley, K., Alvarez, J. and Tangpricha, V. Baseline vitamin D status in patients with chronic kidney disease. Poster, *Summer Undergraduate Research at Emory*, 2011.
16. **Wright, BN.** and Meredith, AL. The effect of transgenic manipulation of the BK channel (Kcnma1) on circadian rhythmicity in mice. Poster, *Experimental Biology*, 2011

17. **Wright, BN.** and Meredith, AL. The effect of transgenic manipulation of the BK channel (Kcnma1) on circadian rhythmicity. Poster, *Annual Biomedical Research Conference for Minority Students*, 2010. [Award winner in the Physiological Sciences division]

INVITED TALKS TO NON-TECHNICAL AUDIENCES:

1. **Wright, BN.** "Reaching Rural Veterans: A New Mechanism to Connect Rural, Low-Income Veterans with Resources and Improve Food Security. Purdue Center for Families Advisory Council Meeting, 2018.
2. **Wright, BN.** "Effects of a social ecological modeled coaching intervention on food security and diet quality among a multistate sample of rural, Midwestern adult emergency food pantry clients." Voices for Food Team Update, 2018.
3. **Wright, BN.** and Eason, J. "Best Practices for a Successful First Year of College." Purdue Academic Boot Camp (ABC), 2018.
4. **Wright, BN.** and Clark, Q. "Navigating Graduate School." Purdue Louis Stokes Alliance for Minority Participation Summer Program, 2018.
5. **Wright, BN.**, Liu, Y. and Eicher-Miller, HA. "Food insecurity, dietary patterns, and health of Midwestern Food Pantry Clients." Food Finders Food Bank, 2017.
6. **Wright, BN.** and Liu, Y. "Food Insecurity: What Does It Mean and What Can We Do?" Indiana Youth Institute Youth Worker Café, 2017.
7. **Wright, BN.** Case Study- Vitamin D. Purdue University NUTR 438, 2013.
8. **Wright, BN.** "Inside View: College Students Sharing their Stories." Baltimore City Community College Upward Bound Program, 2011.
9. **Wright, BN.** Junior Reflections. University of Maryland, Baltimore County MARC U*STAR Scholars Program, 2011.

LEADERSHIP:

Secretary, Spring 2017 – Spring 2018
 Nutrition Science Graduate Student Organization Executive Board
 Purdue University, West Lafayette, IN

Social Chair, Spring 2015 – Fall 2015
 Nutrition Science Graduate Student Organization Executive Board
 Purdue University, West Lafayette, IN

Cohort Representative, Fall 2012- Spring 2013
 Meyerhoff Scholars Program Alumni Advisory Board
 University of Maryland – Baltimore County, Baltimore, MD

PROFESSIONAL DEVELOPMENT:**Professional Society Memberships**

Society for Nutrition Education and Behavior, Fall 2014 – Present
American Society for Nutrition, Winter 2012 – Present
Purdue Black Graduate Student Association, Fall 2012 – Present
American Physiological Society, Summer 2010 – Spring 2012

Credit-Granting Courses for Professional Development

Preparing Future Faculty, Spring 2015
Grant Writing, Fall 2014
Advanced Presentation Skills, Spring 2014
Ethics in Research, Fall 2013
Scientific Writing, Fall 2013

Collaborative Institutional Training Initiative (CITI) Courses

Social Behavioral Research Investigators and Key Personnel, Expires 12/2021
Social and Behavioral Research Best Practices for Clinical Research, Expires 12/2020
Avoiding Financial Conflicts of Interest in Veterans Affairs Research, No Expiration
Veterans Affairs ORD Biosecurity Training, No Expiration

OUTREACH AND MENTORING:

Graduate Student Research Mentor, Summer 2014 – Present
Louis Stokes Alliance for Minority Participation (LSAMP)
Purdue University, West Lafayette, IN

Peer Mentor, Spring 2018
Historically Black Institution (HBI) Visitation Program
Purdue University, West Lafayette, IN

Graduate Student Research Mentor, Summer 2016
Building Infrastructure Leading to Diversity (BUILD)
Purdue University, West Lafayette, IN

Peer Advisor, Fall 2010- Spring 2012
Meyerhoff Scholars Program
University of Maryland – Baltimore County, Baltimore, MD

Tutor, Fall 2009 – 2010
Upward Bound Math/Science
University of Maryland – Baltimore County, Baltimore, MD

RESEARCH SUPPORT:

Justice Family Nutrition Grant, 2018
Purdue University, West Lafayette, IN

Justice Family Nutrition Grant, 2017
Purdue University, West Lafayette, IN

Reaching Rural Veterans Grant, Summer 2015 – Summer 2016
Department of Veterans Affairs (VA) Office of Rural Health
VA Center for Faith-Based and Neighborhood Partnerships
Competitive Grant no. VA251-15-C-0041

Voices for Food USDA NIFA, Fall 2014 – Spring 2018
United States Department of Agriculture
Agriculture and Food Research Initiative
National Institute of Food and Agriculture, Sustainable Food Systems Program
Competitive Grant no. 2012-01823

International Copper Association, Ltd., Fall 2012 – Summer 2014

FELLOWSHIPS:

Alliance for Graduate Education and Professoriate Fellowship, Fall 2015 – Present
Purdue University, West Lafayette, IN

Purdue Doctoral Fellowship, Fall 2012 – Summer 2014
Purdue University, West Lafayette, IN

WORK EXPERIENCE:

Sloan Indigenous Graduate Partnership (SIGP) Graduate Assistant, Spring 2019 – Present
Employer's name: Dr. Kevin Gibson
Employer's address: Lilly Hall Room 1-359, 915 W. State Street, West Lafayette, IN 47907
Employer's telephone: 765-496-2161
Dates of employment: January 7, 2019 – Present
Hours per week: 10

Brief description of duties and accomplishments:

- Managed online social media platform to connect current and former SIGP scholars
- Planned and organized a workshop on “Mentoring and Graduating Underrepresented Minority Graduate Students” with invited speakers from successful mentoring programs across the United States.

Louis Stokes Alliance for Minority Participation (LSAMP) Graduate Assistant, Summer 2018 – Present

Employer's name: Dr. Ignacio Camarillo

Employer's address: HANS 131A, 915 W. State Street, West Lafayette, IN 47907

Employer's telephone: 765-494-0172

Dates of employment: May 14, 2018 – Present

Hours per week: 10-30

Brief description of duties and accomplishments:

- Evaluated program impact and composed annual impact reports and promotional materials
- Planned and organized events, including journal clubs, professional development, personal development and social events, for undergraduate students pursuing Bachelor's degrees in Science, Technology, Engineering and Mathematics (STEM)

Meyerhoff Summer Bridge Lead Counselor and Teaching Assistant, Summer 2012

Employer's name: Keith Harmon

Employer's address: Sherman Hall, Room 218 (B-Wing), 1000 Hilltop Circle, Baltimore, MD 21250

Employer's telephone: 410-455-3139

Dates of employment: June 12 – July 20, 2012

Hours per week: 40

Brief description of duties and accomplishments:

- Led a team of counselors tasked to teach and mentor incoming students pursuing Bachelor's degrees in Science, Technology, Engineering, and Mathematics (STEM)
- Teaching Assistant for Psychology 230: “Contemporary Ideas of Race and Science”
- Organized bonding and STEM-related activities for college students
- Scheduled meetings and provided feedback for Meyerhoff Scholars Program staff

UMBC Office of the Registrar Front Desk Assistant, Spring 2011 – Spring 2012

Employer's name: Hans Cooper

Employer's address: Sherman Hall (B-Wing), 1000 Hilltop Circle, Baltimore, MD 21250

Employer's telephone: 410-455-2500

Dates of employment: February 7, 2011 – June 16, 2012

Hours per week: Varied, 10 – 15

Brief description of duties and accomplishments:

- Provided customer service for students and faculty requesting academic calendar information, grade changes, and transcripts

Meyerhoff Summer Bridge Counselor and Teaching Assistant, Summer 2010

Employer's name: Keith Harmon

Employer's address: Sherman Hall, Room 218 (B-Wing), 1000 Hilltop Circle, Baltimore, MD 21250

Employer's telephone: 410-455-3139

Dates of employment: June 10 – July 31, 2010

Hours per week: 20

Brief description of duties and accomplishments:

- Served as part of a team of counselors tasked to teach and mentor incoming students pursuing Bachelor's degrees in STEM
- Teaching Assistant for Chemistry Workshop

Upward Bound Math/Science Resident Counselor, Summer 2009

Employer's name: Dr. Sundiata Jangha

Employer's address: Math/Psychology Bldg. Rm. 006, 1000 Hilltop Circle, Baltimore, MD 21250

Employer's telephone: 410-455-3677

Dates of employment: June 15 – August 12, 2009

Hours per week: 40

Brief description of duties and accomplishments:

- Served on a team of undergraduate student counselors tasked to mentor and tutor high school students interested in pursuing STEM studies

PUBLICATIONS

- Publication 1 Wright, BN., Bailey, RL., Craig, BA., et al. Daily dietary intake patterns improve after visiting a food pantry among food-insecure rural Midwestern adults. *Nutrients*. 2018 May 9; (10)583. doi: 10.3390/nu10050583
- Publication 2. Wright, BN., MacDermid Wadsworth, S., Wellnitz, A., et al. Reaching Rural Veterans: A New Mechanism to Connect Rural, Low-Income U.S. Veterans with Resources and Improve Food Security. *Journal of Public Health*. 2018; 1-10. doi:10.1093/pubmed/fyd203



Article

Daily Dietary Intake Patterns Improve after Visiting a Food Pantry among Food-Insecure Rural Midwestern Adults

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Abstract: Emergency food pantries provide food at no cost to low-resource populations. The purpose of this study was to evaluate single-day dietary intake patterns before and after visiting a food pantry among food-secure and food-insecure pantry clients. This observational cohort study comprised a paired, before-and-after design with a pantry visit as the intervention. Participants ($n = 455$) completed a demographic and food security assessment, and two 24-h dietary recalls. Adult food security was measured using the U.S. Household Food Security Survey Module. Dietary intake patterns were assessed using Automated Self-Administered 24-h Recall data and classified by Healthy Eating Index (HEI-2010) scores, dietary variety, number of eating occasions, and energy intake. Paired *t*-tests and Wilcoxon signed-rank tests compared outcomes before and after a pantry visit. Mean dietary variety increased after the pantry visit among both food-secure ($p = 0.02$) and food-insecure ($p < 0.0001$) pantry clients. Mean energy intake ($p = 0.0003$), number of eating occasions ($p = 0.004$), and HEI-2010 component scores for total fruit ($p < 0.001$) and whole fruit ($p < 0.0003$) increased among food-insecure pantry clients only. A pantry visit may improve dietary intake patterns, especially among food-insecure pantry clients.

Keywords: emergency food assistance; food pantry; food insecurity; dietary patterns; dietary quality

1. Introduction

Approximately 16 million Americans utilize emergency food pantries, most of whom (67%) are classified as food-insecure [1]. Food insecurity is characterized by reports of reduced dietary quality and variety, disrupted eating patterns, and reduced food intake [2]. Food insecurity in adults is associated with lower intake of vegetables, fruits, dairy products, vitamins A and B6, calcium, magnesium, and zinc compared to food-secure adults [3]. Food insecurity is also associated with indicators of diet-related chronic diseases, including increased rates of diabetes, hypertension and hyperlipidemia, as well as poorer physical and mental health, and quality of life [4]. These health

limitations may, in turn, increase the burden of food insecurity and perpetuate this cycle. Emergency food pantries provide food resources to food-insecure individuals at no cost and with minimal requirements. Use of emergency food pantries by clients was originally regarded as a response to a temporary situation, but may be increasingly used on a consistent basis as a dependable food source [5].

The nutritional contributions of food pantries to client diets is largely unknown [6]. Yet, it has been estimated that food pantries could be responsible for up to 25% of the household food supply among pantry users [6]. The impact of pantry foods on client diets may also vary based on food security status. There may be two distinct groups of emergency food pantry users; one group who relies on pantries because of a short-term or "emergency" change in their economic situation (indicating food insecurity), and another group who uses pantry resources for an extended period of time as one component of their ongoing food supply (as a buffer to retain food security) [7]. Consequently, the relationship between food insecurity and dietary intake patterns among food pantry clients should be evaluated to determine the differential potential of food pantries as an intervention to improve dietary intake patterns for households that may be using food pantries in different capacities.

The objectives of this study were to quantify and compare the short-term dietary intake patterns before and after a pantry visit among rural, Midwestern adult food pantry clients overall and then stratified by food security status. We hypothesized that dietary intake patterns, including the Healthy Eating Index-2010 (HEI-2010) score as a measure of dietary quality, the number of eating occasions, energy intake, and dietary variety, would increase significantly from before compared with after receipt of pantry foods, particularly for food-insecure pantry clients.

2. Materials and Methods

2.1. Study Design

This observational cohort study comprised a before-and-after design with a pantry visit as the intervention. This study was part of a larger multi-state intervention, "Voices for Food", which was administered through the Extension programs of universities in each of six states: Indiana, Michigan, Missouri, Nebraska, Ohio and South Dakota, and aimed to improve food security among rural, Midwestern food pantry clients. Four food pantries from counties defined as non-metro with poverty rates higher than 16% in 2011 [8] with Cooperative Extension presence, and without well-established food policy councils in each state were selected (totaling four food pantries per state). In each state, two of the food pantries were designated as "intervention" pantries and matched with "comparison" pantries based on several criteria, including: level of client choice, number of households served, pounds of food distributed per month, receipt of government commodity program assistance, food bank partnership, infrastructure and capacity (storage, shelving, etc.), and predominant racial/ethnic group served at the pantry.

2.2. Recruitment

From August to November 2014, a convenience sample of participants was recruited through flyers that advertised the study during pantry operation hours, and by approaching clients while they waited in line to receive food at selected pantries. Participants were screened by a trained interviewer. Only clients who were English speaking, adults ≥ 18 years (or ≥ 19 years in Nebraska where the legal age criteria classifying adult status is 19 years), who visited this food pantry at least one time prior to recruitment, and who were receiving foods from the pantry on the day of recruitment were invited to participate. The [Blinded for Review] University and [Blinded for Review] University Institutional Review Boards approved research activities prior to beginning the study and participants gave consent before completing study materials. A sample size goal of 78 pantry clients in each food security subgroup was sought based on a meaningful change in HEI total score from a previous study [9], and estimates of correlation and standard deviation of the paired sample using pilot study data.

2.3. Participants

A total of 613 pantry clients were confirmed eligible and recruited. Four hundred and seventy-four (77%) participants completed two single-day 24-h dietary recalls. However, because of incomplete dietary and food security data, only 455 (74%) participants were included in the final analysis. Significant differences were found between pantry clients who completed multiple recalls compared to pantry clients who completed the initial recall only; significant differences were noted only for state ($p < 0.0001$) and soup kitchen use ($p = 0.005$; data not shown).

2.4. Instruments

The initial interview was conducted at the pantry by trained research staff in a semi-private area. Participants completed an electronic or paper version of a questionnaire that elicited information on demographic and pantry use characteristics, and included the validated 18-item U.S. Household Food Security Survey Module (US HFSMM) [2]. Following this questionnaire, participants completed the Automated Self-Administered 24-h Dietary Recall (ASA24™-2014), an internet-based 24-h recall [10], with optional staff assistance. An additional dietary recall was self-completed, or completed through an assisted phone interview, within two weeks of the pantry visit. Participants received \$10 as compensation in the form of a grocery store gift card upon completion of the initial interview (including the questionnaire and first dietary recall), and an additional gift card for completing the second dietary recall. Sixteen percent of initial recalls and 45% of 2nd recalls captured a weekend day.

2.5. Data Analysis

Food security status over the past 12 months was measured using the US HFSSM. Ten of the items were used to classify food security among household adults as per previous direction [11]. A raw score (number of affirmative responses on the food security scale) of zero was categorized as high food-secure, a score of 1–2 was categorized as marginal food-secure, a score of 3–5 was categorized as low food-secure and a score of 6–10 was categorized as very low food-secure. Food security status was dichotomized into two groups: “food-secure” (included high and marginal food-secure groups) and “food-insecure” (included low and very low food-secure groups).

Dietary information from ASA24™-2014 was used to determine the single-day dietary intake patterns (including before-pantry and after-pantry single-day energy intake, HEI-2010 scores, number of eating occasions, and number of unique USDA food codes). The total number of eating occasions was determined from the self-reported intake of meals, snacks, and beverages. The number of unique food items consumed for each participant was determined using the USDA food code, a unique, eight-digit number that is assigned to identify each food and beverage item included in nutrient composition databases. The HEI-2010 is an overall measure of diet quality that indicates conformance to the Dietary Guidelines for Americans and is comprised of 12 component scores: Total Fruit, Whole Fruit, Total Vegetables, Greens and Beans, Whole Grains, Total Dairy, Total Protein, Seafood and Plant Proteins, Fatty Acids, Refined Grains, Sodium, and Empty Calories (i.e., solid fat, alcohol, and added sugars) [12]. Each of the 12 components are weighted to yield a HEI-2010 total score that has a maximum value of 100, indicating full adherence to the Dietary Guidelines for Americans (DGA), and a minimum value of 0, indicating no adherence to the DGA [12]. Because the data were collected prior to the release of the 2015 DGA and HEI-2015, the HEI-2010 was the appropriate metric to use for this study.

2.6. Statistical Analysis

Prevalence of participant characteristics was compared across food security status using chi-square analysis (significance $p < 0.05$). The mean number of unique USDA food codes, mean number of eating occasions, mean HEI-2010 total and component scores, and mean energy intake were estimated for the pre-pantry and post-pantry recall and compared for all clients as well as food-secure and

food-insecure subgroups. Wilcoxon signed rank tests determined differences in before-pantry and after-pantry intakes for the number of unique food codes (statistically significant when $p < 0.05$) and number of eating occasions (statistically significant when $p < 0.05/2$ sub-categories of eating occasions as 'Meals and Snacks' and 'Meals,' using Bonferroni-type adjustment for multiple comparisons of sub-groups). Paired *t*-tests determined differences in before-pantry and after-pantry intakes for mean energy intake (statistically significant when $p < 0.05$) and total and component HEI-2010 scores (statistically significant when $p < 0.05/13$ HEI total and component scores, using Bonferroni-type adjustment for multiple comparisons of sub-groups). A post-hoc analysis was performed to infer whether or not improvement in dietary outcomes was a direct result of the pantry visit. The mean, median and mode of lag time were determined. Linear regression models with the response being the change in HEI total and component scores (recall 2-recall 1) and the predictors being lag time and household size were performed (statistical significance $p < 0.05$). All analyses were completed using SAS version 9.4. (SAS Institute, Hong Kong, China) and R version 2.11.1.

3. Results

Pantry clients in the sample were predominately white (81%), female (72%), aged 45–65 (45%), and classified as food-insecure (78%) (Table 1). When characteristics were stratified by food security status, significant differences were observed for state, age, and the number of times the pantry was visited in the last 12 months. A greater proportion of food-secure pantry clients (35%) reported being >65 years old compared to food-insecure pantry clients (16%). A greater proportion of food-secure (63%) pantry clients reported visiting the pantry six or more times compared to food-insecure pantry clients (47%).

Table 1. Characteristics of a multistate sample of rural, Midwestern, adult emergency food pantry clients by food security status ($n = 455$).

	All Pantry Clients		Food-Secure		Food-Insecure		χ^2
	n	%	n	%	n	%	
Total ²	455		100	22	355	78	
State							0.04
Indiana	117	26	23	23	94	26	
Michigan	87	19	13	13	74	21	
Missouri	102	22	21	21	81	23	
Nebraska	49	11	10	10	39	11	
Ohio	50	11	14	14	36	10	
South Dakota	50	11	19	19	31	9	
Age							0.0004
18–44 years	136	35	28	32	108	35	
45–64 years	176	45	29	33	147	48	
>65 years	81	20	31	35	50	16	
Sex							0.3
Male	107	28	28	32	79	26	
Female	280	72	59	68	221	74	
Race							0.3
White	305	81	67	78	238	82	
Black	32	8	10	12	22	8	
American Indian	28	7	8	9	20	7	
Other	12	3	1	1	11	4	
Ethnicity							0.1
Hispanic	15	4	1	1	14	5	
Not Hispanic	362	96	82	99	280	95	
Income							0.2
<\$10,000	221	52	42	46	179	54	
\$10,001–\$15,000	91	22	26	28	65	20	
>\$15,000	110	26	24	26	86	26	

Table 1. Cont.

	All Pantry Clients		Food-Secure		Food-Insecure		χ^2
	n	%	n	%	n	%	
Number of Pantries Visited (past 12 months)							
1 pantry	203	46	50	53	153	44	
≥ 2 pantries	239	54	44	47	195	56	
Household Food From Food Pantry							
A few days' worth	191	45	34	40	157	46	
One to two weeks' worth	147	35	29	34	118	35	
More than half of the food for the month	86	20	23	26	63	19	
Times Visited This Pantry (past 12 months)							
0–1 times	73	16	14	12	59	17	
2–5 times	153	34	24	24	129	36	
≥ 6 times	229	50	62	63	167	47	

¹ Statistical significance is $p < 0.05$ for chi-square comparisons between food-secure and food-insecure adult food pantry clients. ² Total numbers do not always add to sample size due to missing values; Percentages do not always add to 100 due to rounding.

A significant increase in mean energy intakes (before: 1400 ± 870 , after: 1600 ± 880 , $p < 0.0001$), mean number of eating occasions (before: 3.2 ± 1.1 , after: 3.3 ± 1.1 , $p = 0.002$) and mean number of unique food codes (before: 9 ± 5 , after: 11 ± 5 , $p < 0.0001$) was observed among all adult emergency food pantry clients from before to after the pantry visit (Table 2). However, when separated by food security status, a significant increase in the mean energy intake (before: 1400 ± 890 , after: 1600 ± 890 , $p = 0.0003$) and number of eating occasions (before: 3.1 ± 1.1 , after: 3.3 ± 1.1 , $p = 0.004$) was only noted among food-insecure food pantry clients, while a significant increase in the mean number of unique food codes was noted among both the food-secure (before: 11 ± 4 , after: 12 ± 6 , $p = 0.02$) and food-insecure (before: 9 ± 5 , after: 11 ± 5 , $p < 0.0001$) groups (Table 2).

Table 2. Comparison of before and after pantry dietary intake patterns (number of eating occasions, number of unique food codes reported consumed, energy intake and total HEI-2010 score) for all, food-secure, and food-insecure pantry clients in a multistate sample of rural, Midwestern, adult emergency food pantry clients ($n = 455$).

#	All Pantry Clients					
	#	Before-Pantry		After-Pantry		p-value ¹
		Mean	SD	Mean	SD	
Number of Eating Occasions ²	3.2	1.1	3.3	1.1	0.002 ³	
Meals and Snacks	2.7	1.0	2.8	1.0	0.02 ³	
Meals	2.2	0.8	2.3	0.8	0.03 ³	
Number of Unique Food Codes ²	9	5	11	5	<0.0001 ³	
Energy Intake (kcal) ²	1400	870	1600	880	<0.0001 ⁴	
Total HEI Score ²	41	13	42	13	0.47 ⁴	
Food-secure						
#	#	Before-Pantry		After-Pantry		p-value
		Mean	SD	Mean	SD	
Number of Eating Occasions ²	3.4	1.0	3.5	1.0	0.2 ³	
Meals and Snacks	3.0	0.9	3.0	0.9	0.3 ³	
Meals	2.4	0.7	2.5	0.8	0.7 ³	
Number of Unique Food Codes ²	11	4	12	6	0.02 ³	
Energy Intake (kcal) ²	1500	770	1600	840	0.1 ⁴	
Total HEI Score ²	46	13	45	14	0.4 ⁴	

Table 2. Cont.

n = 355	Food-insecure				
	Before-Pantry		After-Pantry		
	Mean	SD	Mean	SD	p-value
Number of Eating Occasions ²	3.1	1.1	3.3	1.1	0.004 ³
Meals and Snacks	2.6	1.0	2.7	1.0	0.04 ³
Meals	2.1	0.8	2.2	0.8	0.1 ³
Number of Unique Food Codes ²	9	5	11	5	<0.0001 ³
Energy Intake (kcal) ²	1400	890	1600	890	0.0003 ⁴
Total HEI Score ²	40	13	41	13	0.2 ⁴

¹ Statistical significance is $p < 0.05$ for paired t-test and Wilcoxon signed rank test comparisons between before- and after-pantry energy intake and number of unique food codes; Statistical significance is $p < 0.025$ for paired t-test comparisons between before- and after-pantry number of eating occasions ($p < 0.05/2$ subcategory of 'Meals and Snacks' and 'Meals', Bonferroni-type adjustment for multiple comparisons of sub-groups); Statistical significance is $p < 0.004$ for paired t-test comparisons between before- and after-pantry HEI Scores ($p < 0.05/13$ HEI total and component groups, Bonferroni-type adjustment for multiple comparisons of sub-groups). ² Indicates inclusion of all eating/drinking occasions: meals, snacks, and just a drink. ³ Indicates p-value was determined using the Wilcoxon signed rank test. ⁴ Indicates p-value was determined using the paired t-test.

Despite this increased in dietary intake patterns after a pantry visit, overall dietary quality, quantified using the mean total HEI score, was poor (mean HEI-2010 total score of 41), and a statistically significant difference in HEI-2010 total score before and after a pantry visit was not observed, regardless of food security status (Table 3). A significant increase in the mean HEI-2010 total fruit (before: 1.2 ± 1.9 , after: 1.7 ± 2.2 , $p < 0.0001$) and whole fruit (before: 0.9 ± 1.8 , after: 1.4 ± 2.1 , $p < 0.0001$) scores was observed among all pantry clients. After stratifying by food security status, there was a significant increase observed only among food-insecure pantry clients for the mean total fruit (before: 1.1 ± 1.9 , after: 1.7 ± 2.1 , $p < 0.001$) and whole fruit (before: 0.8 ± 1.7 , after: 1.3 ± 2.0 , $p = 0.0003$) HEI-2010 component scores.

Table 3. Comparison of before and after pantry HEI-2010 total and component scores in a multistate sample of rural, Midwestern, adult emergency food pantry clients for all pantry clients and for food-insecure pantry clients ($n = 455$).

n = 455	Max Score	All Pantry Clients				
		Before-Pantry Score		After-Pantry Score		
		Mean	SD	Mean	SD	p-Value ¹
Total Vegetables	5	2.9	2.0	2.9	1.9	0.9
Green Beans	5	0.8	1.7	0.6	1.5	0.1
Total Fruit	5	1.2	1.9	1.7	2.2	<0.0001
Whole Fruit	5	0.9	1.8	1.4	2.1	<0.0001
Whole Grain	10	2.1	3.3	1.9	3.0	0.4
Total Dairy	10	4.8	3.9	5.0	3.8	0.3
Total Protein	5	3.9	1.7	4.0	1.5	0.1
Seafood and Plant Protein	5	0.9	1.7	1.0	1.8	0.3
Fatty Acid	10	4.0	3.7	4.0	3.7	0.9
Sodium	10	3.3	3.6	3.2	3.5	0.5
Refined Grain	10	6.1	3.9	6.0	3.7	0.8
Empty Calories	20	10.3	7.0	9.9	6.7	0.4
Total HEI	100	41	13.0	42	13.0	0.5

Table 3. Cont.

n = 355	Max Score	Food-insecure Pantry Clients ²				p-Value ¹
		Before-Pantry Score		After-Pantry Score		
		Mean	SD	Mean	SD	
Whole Fruit	5	0.8	1.7	1.3	2.0	0.0003
Total Fruit	5	1.1	1.9	1.7	2.1	<0.001
Total HEI	100	40	13	41	13	0.21

¹ p-value was determined using the paired t-test; Statistical significance is $p < 0.004$ for paired t-test comparisons between before- and after-pantry HEI Scores ($p < 0.05/13$ HEI total and components, Bonferroni-type adjustment for multiple comparisons of sub-groups). ² Only HEI-2010 component scores that significantly changed from before to after a pantry visit among food-insecure pantry clients are shown.

Post-hoc analysis showed that the average lag time was 3.7 days with both a median and mode of two days (results not shown), and lag time was inversely associated with change in Whole Fruit score (data not shown).

4. Discussion

Research regarding the relationship between food insecurity and dietary intake among food pantry clients is limited [13–17]. This study represents the first investigation of single-day dietary intake patterns before and after food pantry use for food-secure and food-insecure pantry clients. Dietary variety increased for both food-insecure and food-secure pantry clients from before compared to after visiting a pantry, while an indicator of the fruit intake component to dietary quality, energy intake, and the number of eating occasions improved only for food-insecure pantry clients.

Overall dietary quality among food pantry clients was poor, a finding that is consistent with other studies evaluating dietary quality among food pantry clients [15]. The estimated HEI-2010 total score and component scores, indicating adherence to the Dietary Guidelines for Americans, for pantry clients observed in this study were low compared to the most recent estimate among the U.S. population (59.0 ± 1.0) [18]. Component scores for total fruit, whole fruit, greens and beans, and seafood and plant protein were especially low in this group, and indicate a critical need for improvement. These results are perhaps expected considering the high prevalence of food insecurity in the sample. Seventy-eight percent of participants were classified as food-insecure. Although much higher than the U.S. population, as expected [19], the prevalence of food insecurity in this rural Midwestern food pantry-user participant sample was consistent with other studies that have evaluated food security among emergency food system clients [9,15,17,20].

Dietary quality, dietary variety, number of eating occasions, and energy intake were expected to increase significantly after receipt of pantry foods based on the premise that pantry users visit the pantry to obtain more foods. Results revealed no significant increase in overall dietary quality from before compared with after pantry use, but did reveal a significant increase in the quality of the fruit dietary component. Providing enough food (quantity) may be more of a concern to emergency food pantry providers compared with the quality of foods provided. In support of this, studies have found that food packages provided to clients by food pantries do not meet recommended nutritional requirements and may be low in fruits, dairy, whole grains and fish [21–23], all of which are key components of the HEI-2010 index. This may explain why the quantity of food may increase after using a pantry, while the overall quality measured by the HEI-2010 total score may remain unchanged. While lower than U.S. averages [18], component scores for total fruit and whole fruit (total fruit excluding juice) significantly increased after receipt of pantry foods. The increase in whole fruit score suggest that the increase in the total fruit component score may not be entirely due to an increase in juice intake. Although many pantries may not offer the recommended amount of fruit [21–23], results from this study suggest that the fruit offered by pantries is an improvement upon what clients are

otherwise able to obtain, or that foods offered by pantries allow clients to use other funds to purchase fruits and represents potential for the food pantry to enhance dietary quality.

Only food-insecure pantry clients experienced a significant increase in the number of eating occasions and energy intake after visiting the pantry. Food insecurity is characterized by reports of reduced dietary quality, dietary variety, disrupted eating patterns, and reduced food intake [2], suggesting greater need for resources to restore dietary patterns. This supports the hypothesis that food-secure and food-insecure groups may use pantries differently; food-insecure pantry clients may rely on pantries in response to a dire situation, while food-secure pantry clients may use pantries continually to serve as a buffer to maintain food security. In support of this idea, the results revealed a greater prevalence of pantry use (≥ 6 times in the past 12 months) among food-secure pantry clients (63%) compared to food-insecure pantry clients. Therefore, food-insecure pantry clients may exhibit a higher degree of dietary restriction due to circumstance before visiting the pantry and consequently have a higher potential for improving their dietary intake patterns upon receipt of pantry foods. Both food security subgroups experienced an increase in dietary variety. Food-insecure pantry clients may receive foods from pantries that they cannot receive otherwise using non-pantry resources and therefore pantry use increases their food choices and improves dietary variety. On the other hand, food-secure pantry clients may rely on pantries consistently to acquire staple foods which they are able to supplement using other non-pantry resources, thereby improving dietary variety.

4.1. Strengths

Most prior studies evaluating the dietary intake of food pantry clients used only a single 24-h recall [14,15,24–26] with assessment completed on the day the client presented at the food pantry [15,24,25]. This study characterized the dietary patterns of pantry clients before and after visiting the pantry among a large multi-state sample of rural, Midwestern U.S. adults by assessing the dietary intake from two 24-h recalls.

4.2. Limitations

The observed changes in dietary intake patterns before and after pantry use may not be a direct effect of pantry use since food pantries are not the only source of foods for clients. Participants received a \$10 grocery store gift card upon completion of the initial recall, which may have been used to purchase foods that clients otherwise would not have been able to afford and thus impacted dietary patterns in their second recall; however, it was unethical to withhold compensation or provide it only to participants who completed two recalls. Additionally, the research team did not assess whether or not clients visited additional pantries between the initial dietary recall and the follow-up recall, and the present study and others have reported that clients may use multiple pantries [7,27,28]. A large proportion of the secondary recalls were collected on a weekend day; previous research has indicated that diet quality is lower and energy intake is higher on weekends compared to weekdays [29], which may have biased the results. The lag time between the first and second 24-h recall could range from two days to two weeks, and it was noted that the amount of food provided by pantries is typically small. This study population had an average lag time of 3.7 days with both a median and mode of two days. Thus, in a study population where most participants reported foods lasting a few days to two weeks, application of the results is appropriate. In support of this conclusion, lag time was inversely associated with change in Whole Fruit score, suggesting that improvement in whole fruit intake decreases as time passes after visiting the pantry. Finally, because of the nature of the emergency food system, the study sample was disproportionately food-insecure and therefore there was a discrepancy in the sample sizes of the food security groups after stratification. This may have resulted in increased power for statistically significant changes in dietary intake patterns in the food-insecure group compared to the food-secure group, and thus underestimated the impact of pantry foods on diet for food-secure clients. The sample size of the present study was based on a meaningful change in HEI total score; thus, the study may not have had statistical power to detect differences in HEI component scores before and

after a pantry visit, and may explain the several non-significant results. This could be improved in future studies by increasing sample size, and ultimately statistical power.

5. Conclusions

Food pantries may be utilized to increase dietary variety for all patrons as well as energy intake, number of meals consumed, and fruit intake specifically among food-insecure pantry clients. Food pantries may be an ideal environment for a dietary intervention to improve food security and dietary intake patterns by improving the quality, quantity, and variety of foods offered. Future research should focus on determining the usual nutrient and food group intake of food pantry clients and comparing the intake by food security status while adjusting for potential confounders in efforts to examine how pantry foods may mediate dietary intake differently among and between food-secure and food-insecure pantry clients.

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References

1. Coleman-Jensen, A.; Rabbitt, M.; Gregory, C.; Singh, A. *Statistical Supplement to Household Food Security in the United States in 2016*; Economic Research Service, AP-077; U.S. Department of Agriculture: Washington, DC, USA, 2017. Available online: <https://www.ers.usda.gov/webdocs/publications/84981/ap-077.pdf?v=42979> (accessed on 17 April 2018).
2. Bickel, G.; Nord, M.; Price, C.; Hamilton, W.; Cook, J. *Guide to Measuring Household Food Security, Revised 2000*; Food and Nutrition Service; U.S. Department of Agriculture: Washington, DC, USA, 2000.
3. Hanson, K.L.; Connor, L.M. Food insecurity and dietary quality in US adults and children: A systematic review. *Am. J. Clin. Nutr.* **2014**, *100*, 684–692. [CrossRef] [PubMed]
4. Gundersen, C.; Ziliak, J.P. Food Insecurity and Health Outcomes. *Health Aff.* **2015**, *34*, 1830–1839. [CrossRef] [PubMed]
5. Kaiser, M.; Cafér, A. Understanding high incidence of severe obesity and very low food security in food pantry clients: Implications for social work. *Soc. Work Public Health* **2018**, *33*, 125–139. [CrossRef] [PubMed]
6. Verpy, H.; Smith, C.; Reicks, M. Attitudes and behaviors of food donors and perceived needs and wants of food shelf clients. *J. Nutr. Educ. Behav.* **2003**, *35*, 6–15. [CrossRef]
7. Kicinski, L. Characteristics of Short and Long-Term Food Pantry Users. *Mich. Sociol. Rev.* **2012**, *26*, 58–74.
8. U.S. Department of Agriculture Economic Research Service. County-Level Data Sets. 2011. Available online: <https://data.ers.usda.gov/reports.aspx?ID=14843> (accessed on 1 August 2013).
9. Petrogianni, M.; Karellakis, S.; Kallianioti, K.; Argyropoulou, D.; Pitsavos, C.; Manios, Y. A multicomponent lifestyle intervention produces favourable changes in diet quality and cardiometabolic risk indices in hypercholesterolaemic adults. *J. Hum. Nutr. Diet.* **2013**, *26*, 596–605. [CrossRef] [PubMed]
10. Subar, A.; Kirkpatrick, S.; Mittl, B.; Zimmerman, T.P.; Thompson, E.E.; Bingley, C.; Willis, G.; Islam, N.G.; Baranowski, T.; McNutt, S.; et al. The Automated Self-Administered 24-hour dietary recall (ASA24): A resource for researchers, clinicians, and educators from the National Cancer Institute. *J. Acad. Nutr. Diet.* **2012**, *112*, 1134–1137. [CrossRef] [PubMed]
11. U.S. Department of Agriculture Economic Research Service. U.S. Household Food Security Survey Module: Three-Stage Design, with Screeners. Available online: <https://www.ers.usda.gov/media/8271/hh2012.pdf> (accessed on 1 August 2014).

12. Guenther, P.; Casavale, K.; Reedy, J.; Kirkpatrick, S.I.; Hiza, H.A.; Kuczynski, K.J.; Kahle, L.L.; Krebs-Smith, S.M. Update of the Healthy Eating Index: HEI-2010. *J. Acad. Nutr. Diet.* **2013**, *113*, 569–580. [CrossRef] [PubMed]
13. Tarasuk, V.; Beaton, G. Household food insecurity and hunger among families using food banks. *Can. J. Public Health* **1999**, *90*, 109–113. [CrossRef] [PubMed]
14. Starkey, L.; Kuhnlein, H.; Gray-Donald, K. Food bank users: Sociodemographic and nutritional characteristics. *CMAJ* **1998**, *158*, 1143–1149. [PubMed]
15. Duffy, P.; Zizza, C.; Jacoby, J.; Tayie, F. Diet quality is low among female food pantry clients in Eastern Alabama. *J. Nutr. Educ. Behav.* **2009**, *41*, 414–419. [CrossRef] [PubMed]
16. Castelbon, K.; Mejean, C.; Deschamps, V.; Bellin-Lestierne, C.; Oleko, A.; Darmon, N.; Hercberg, S. Dietary behaviour and nutritional status in underprivileged people using food aid (ABENA study, 2004–2005). *J. Hum. Nutr. Diet.* **2011**, *24*, 560–571. [CrossRef] [PubMed]
17. Robaina, K.; Martin, K. Food insecurity, poor diet quality, and obesity among food pantry participants in Hartford, Ct. *J. Nutr. Educ. Behav.* **2013**, *45*, 159–164. [CrossRef] [PubMed]
18. U.S. Department of Agriculture Center for Nutrition Policy and Promotion. Health Eating Index. Available online: http://www.cnpp.usda.gov/sites/default/files/healthy_eating_index/HEI-2010-Table.pdf (accessed on 1 August 2016).
19. Coleman-Jensen, A.; Rabbitt, M.; Gregory, C.; Singh, A. *Household Food Security in the United States in 2015*; Economic Research Service, ERR-215; U.S. Department of Agriculture: Washington, DC, USA, 2016. Available online: <http://www.ers.usda.gov/media/2137663/err215.pdf> (accessed on 24 March 2017).
20. Martin, K.S.; Wu, R.; Wolff, M.; Colantonio, A.G.; Grady, J. A novel food pantry program: Food security, self-sufficiency, and diet-quality outcomes. *Am. J. Prev. Med.* **2013**, *45*, 569–575. [CrossRef] [PubMed]
21. Netter, J.; Dijkstra, S.; Visser, M.; Brouwer, I. Dutch food bank parcels do not meet nutritional guidelines for a healthy diet. *Br. J. Nutr.* **2016**, *116*, 526–533. [CrossRef] [PubMed]
22. Nanney, M.; Grannon, K.; Cureton, C.; Hoolihan, C.; Janowiec, M.; Wang, Q.; Warner, C.; King, R. Application of the Healthy Eating Index-2010 to the hunger relief system. *Public Health Nutr.* **2016**, *19*, 1–9. [CrossRef] [PubMed]
23. Akobundu, U.; Cohen, N.; Laus, M.; Schulte, M.; Soussloff, M. Vitamins A and C, calcium, fruit, and dairy products are limited in food pantries. *J. Am. Diet. Assoc.* **2004**, *104*, 811–813. [CrossRef] [PubMed]
24. Lenhart, N.; Read, M. Demographic profile and nutrient intake assessment of individuals using emergency food programs. *J. Am. Diet. Assoc.* **1989**, *89*, 1269–1272. [CrossRef] [PubMed]
25. Bell, M.; Wilbur, L.; Smith, C. Nutritional status of persons using a local emergency food system program in middle America. *J. Am. Diet. Assoc.* **1998**, *98*, 1031–1033. [CrossRef]
26. Jacobs Starkey, L.; Gray-Donald, K.; Kuhnlein, H. Nutrient intake of food bank users is related to frequency of food bank use, household size, smoking, education and country of birth. *J. Nutr.* **1999**, *129*, 883–889. [CrossRef] [PubMed]
27. Campbell, E.; Hudson, H.; Webb, K.; Crawford, P. Food Preferences of Users of the Emergency Food System. *J. Hunger Environ. Nutr.* **2011**, *6*, 179–187. [CrossRef]
28. Greger, J.L.; Maly, A.; Jensen, N.; Kuhn, J.; Monson, K.; Stocks, A. Food pantries can provide nutritionally adequate food packets but need help to become effective referral units for public assistance programs. *J. Am. Diet. Assoc.* **2002**, *102*, 1126–1128. [CrossRef]
29. Jahns, L.; Conrad, Z.; Johnson, L.K.; Scheett, A.J.; Stote, K.S.; Raatz, S.K. Diet Quality Is Lower and Energy Intake Is Higher on Weekends Compared with Weekdays in Midlife Women: A 1-Year Cohort Study. *J. Acad. Nutr. Diet.* **2017**, *117*, 1080–1086. [CrossRef] [PubMed]



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Reaching rural veterans: a new mechanism to connect rural, low-income US Veterans with resources and improve food security

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ABSTRACT

Background Rural, low-income US veterans face additional barriers to accessing food and resources compared to urban veterans. Based on both social-ecological and cultural competence approaches, the Reaching Rural Veterans (RRV) pilot intervention built on the existing infrastructure of food pantries to improve food security and connect rural, low-income veterans with resources. This article describes the process of implementing and evaluating RRV.

Methods Five rural food pantries within each of two states, Indiana and Kentucky, received training in cultural competence and held monthly outreach events where food and services were offered to veterans. Veteran adult participants completed an assessment at baseline and 3-month follow-up that measured food security using the US Household Food Security Survey Module and self-reported resource enrollment. Repeated measures logistic regression models evaluated the odds of improving food security and resource enrollment from baseline to follow-up (significance $P < 0.05$).

Results RRV recruited 234 participants; 53% completed the follow-up assessment. At follow-up, the odds of household ($P = 0.009$) and adult ($P = 0.01$) food security increased, as did enrollment in one or more of the following resources: Temporary Assistance for Needy Families, Supplemental Security Income, General Assistance or Assistance from the Township Trustee ($P = 0.005$).

Conclusions RRV yielded promising preliminary results of improved food security and resource use.

Keywords food and nutrition, services, war

Introduction

Previous studies have estimated that nearly one-fourth of US veterans are food insecure,^{1,2} or have uncertain ability to acquire nutritionally adequate and safe foods,³ an estimate more than 10 percentage points higher than the average US adult.⁴ Food insecure veterans experience worse diet-related health outcomes, such as poorer blood pressure and diabetes maintenance, compared with food secure veterans.² Disadvantaged veteran populations require additional support to address basic and health care needs, and accordingly, initiatives that target vulnerable Veterans Health Administration (VHA) patients have been promising;⁵ however millions of veterans are eligible and in need of care, but are not patients. Further, enrollment in 'safety net', or government assistance programs, such as

the Supplemental Nutrition Assistance Program (SNAP) and Temporary Assistance for Needy Families (TANF), is designed to help low-income families meet basic needs⁶ and associated with improved food security,^{7,8} but difficult for veterans in rural areas to access. Approximately 30% of veterans currently live in rural areas⁹ where food insecurity is more prevalent compared to the US average.⁴ Rural-dwelling in contrast with urban-dwelling veterans may face additional barriers of less access to transportation, employment, education;

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and increased likelihood for disabilities,³⁰ the latter two also associated with food insecurity.^{11,12} Delivery challenges and greater geographic barriers limit reach of these resources to improve food security among rural veterans.¹³

Food pantries are a community resource with reach in many rural communities. These non-governmental and often faith-based organizations provide direct emergency food assistance, or food at no cost.¹⁴ Food pantries may contribute ~25% of the household food supply among client households,¹⁵ and thus have the potential to impact food security and health among US veterans. Food pantries may also serve as a venue to connect food insecure veterans with other federal food assistance resources such as SNAP.³⁶ Faith-based organizations, which typically house food pantries, provide a source of support for veterans because they offer privacy and confidentiality when potential stigma is involved,¹⁷ but they may also lack awareness and experience with veterans.¹⁷

The Reaching Rural Veterans (RRV) pilot intervention aimed to capitalize on the existing infrastructure of faith-based food pantries to deliver resources to the low-density rural veteran population at locations where they are already present, a social-ecological strategy used for other health- and poverty-related initiatives.¹⁸ Ecological perspectives emphasize that individuals and families are embedded in nested layers of community and societal systems that shape conditions for risk and well-being, such as factors that facilitate or impede access to services.^{19,20} Social ecological perspectives have been applied to identify multiple community elements that are implicated in ensuring adequate food for all, particularly vulnerable populations.²¹ RRV aimed to overcome lack of veteran awareness at pantries using a cultural competence model, emphasizing teaching awareness and skills to effectively reach this unique population. Cultural competence is defined as awareness of and knowledge about veterans, comfort in working with them, and skills for doing so.²² Concerns about health disparities, veterans' problems, and stigma have underscored the importance of culturally sensitive approaches to interventions.²³⁻²⁵

Indiana (IN) and Kentucky (KY) provided an opportune environment to implement the RRV intervention; both states recently experienced significant increases in food insecurity prevalence⁴ and have moderately-sized veteran populations.²⁶ The intervention included training of food pantry staff and funds to support monthly outreach events at participating pantries where community resources and services were available. RRV was hypothesized to improve food security and resource use among rural veteran participants. The purpose of this pilot study²⁷ was to test various methodological components of the intervention; determine the

demographic, health and dietary characteristics of participants and changes in food security status and resource use after the intervention; and quantify assessment response rates in a sample of rural veteran food pantry clients.

Methods

Intervention implementation and procedures

Pantries

The RRV pilot intervention included cultural competence training administered to pantry representatives, and grant funds and technical assistance for food pantries to host special resource fairs to connect veterans with services. Five faith-based food pantries in rural locations in each state (IN and KY) were selected to participate based on rurality,²⁸ need for community programs, plans for sustained community partnerships, and grant budget proposals to extend resources to veterans. Representatives of the selected pantries participated in a veterans awareness training by Purdue University's Military Family Research Institute in IN and University of Kentucky's Department of Family and Consumer Sciences in KY, designed to educate pantry staff, volunteers and clergy on veteran cultural competency and the goals of RRV. Following the training, project staff assisted pantries with identifying relevant resources in their local communities such as veteran service organizations (e.g. American Legion, Disabled American Veterans), Local Veterans' Employment Representatives, Veteran Service Officers, and other resources, to host at special outreach events and assist participants with obtaining benefits. Pantries received \$5000 grants for the seven-month project period (October 2015 through April 2016) to support these outreach events, held at least once per month. Service sectors, descriptions of services, and example agencies represented at RRV outreach events are shown in Supplementary Table I. Outreach events were similar across pantry sites; resources were represented by booths that veterans and their families could approach while food pantry services were also offered.

Veterans

Any US veteran and his or her family members could participate in RRV outreach events. Food pantries prominently displayed recruitment flyers at outreach events and during regular food pantry hours that invited veterans to complete a demographic and food security assessment, and described eligibility requirements and incentives. Eligible veterans: (1) served in the active or reserve US military, (2) were English-speaking and reading, (3) ≥18 years, (4) visited participating food pantry between October 2015 and April 2016, and (5) indicated willingness to participate in the assessment to a

RRV team member. Interested individuals were provided with paper participant packets, and their names recorded. Packets contained a cover letter, screener form, consent form, demographic and food security assessment, participant contact sheet, description of an optional additional dietary assessment, and a postage-paid envelope for returning the completed materials. Packets were either self-completed or completed with a trained project staff member on site, or via phone if the participant desired assistance. The first assessment packet completed by each participant was designated as the 'baseline' assessment; a 'follow-up' assessment was offered via phone, e-mail or ground mail ~3 months following baseline, at the end of the project period. Participants received a \$10.00 grocery store gift card by post for each completed assessment. The project protocol was approved by Purdue University's Institutional Review Board.

Assessments and measures

Pantries

Cultural Competence Training Assessment. At least one representative from each pantry attended the RRV cultural competence training and completed an 18-item assessment regarding knowledge of veteran populations (e.g. 'which of the following characteristics is true of rural veterans?'; 'six months after returning home, roughly 1 in 5 experience PTSD symptoms (true/false)') that was administered at the beginning and end of the one-day training in order to determine improvement in knowledge.

Veteran Resource Tracking Assessment. RRV research staff recorded information on participating pantries monthly, and at 2-year follow-up, regarding whether the pantry tracked veteran traffic, was aware of veteran service organizations in the community, reported referring clients to veteran service organizations, and described which programs were present at outreach events.

Veterans

Demographic and Food Security Assessment. Personal and household characteristics were assessed using standard demographic questions drawn from previously-administered and validated surveys.^{29,30} The 18-Item USHFSMM was used to assess food security among households and household adults with a 3-month reference period, reflecting the 3-month follow-up period between assessments. Scores were calculated and categories were assigned per previous direction.^{31,32} Food security status was dichotomized as two groups: 'food secure' and 'food insecure.' Enrollment in assistance programs was assessed using a checklist asking whether individuals were currently receiving benefits or services from individual programs (e.g. SNAP, Meals on Wheels) or groups of programs (i.e.

TANF, Supplemental Security Income, General Assistance, or Assistance from the Township Trustee). Answer choices were 'enrolled' or 'not enrolled'. Participants received \$10.00 as a grocery store gift card that was mailed to them for each completed assessment.

Dietary Assessment. The project team aimed to collect up to two Automated Self-Administered 24-hour dietary recalls (ASA24s), an internet-based dietary assessment developed by the National Cancer Institute (Bethesda, MD, USA),³³ over the course of one week at baseline (due to resource constraints, the goal of the project team was for $n = 20$ veterans to complete the dietary assessment). ASA24s were completed with project staff via phone or independently online. Assessment included a weekday and weekend day at least two days apart and within one week. Participants received a \$10.00 grocery store gift card by post for each completed ASA24. The Healthy Eating Index-2010 (HEI), designed to measure adherence to the 2010 Dietary Guidelines for Americans (greater adherence indicated by higher scores),³⁴ quantifies dietary quality and was calculated from multiple days of ASA24 dietary data. The HEI provides an overall score on a 0–100-point scale, and 12 component scores that embody the major food patterns: Total Fruit, Whole Fruit, Total Vegetables, Greens and Beans, Whole Grains, Dairy, Total Protein Foods, Seafood and Plant Protein, Fatty Acids, Refined Grains, Sodium, and Empty Calories.³⁵

Statistical analysis

Pantries

Pre-test and post-test scores on factual knowledge questions from the cultural competence assessment were compared at the group level using independent *t*-tests. Pantry veteran outreach characteristics were described (number and percentage) before and after the project period, and 2 years after the project period.

Veterans

Demographic, health and dietary characteristics were presented using frequencies and percentages for categorical variables, and means and standard deviations for continuous variables. The characteristics of participants who completed the baseline assessment only were compared via Chi-square test with those retained at the follow-up time point to identify differences associated with retention.

In preliminary analysis, McNemar's test was used to determine differences in food security categories and resource use from baseline to follow-up in the paired sample of participants who completed assessments at both time points. Final results were determined using repeated measures logistic regression models, with food security status and

enrollment in resources (structured as binary categorical variables) as outcomes in separate models, and with time as the main predictor.

To help to offset the possibility of attrition bias, an additional, more conservative repeated measures logistic regression analysis was conducted, similar to an 'intent to treat' approach,³⁶ using the 'last observation carried forward' (LOCF) procedure to impute missing outcome data at follow-up (data not presented). Participants who dropped out of the study were included by simulating follow-up data, conservatively assuming their food security status and resource use did not change at 3-month follow-up. All models adjusted for pantry site, age, sex and race at baseline. Analyses were performed using Statistical Analysis Software (version 9.3, SAS Institute Inc., Cary, NC). A *P*-value <0.05 was considered statistically significant.

Results

Pantries

Ten pantries successfully implemented the RRV pilot intervention by completing cultural competence training and hosting resource fairs to bring services for veterans to pantries. Over the project period, 430 veterans (each veteran counted once) attended at least one outreach event in IN and 664 veterans in KY, for a total of 1094 veterans reached. The average number of correct answers on the cultural competence pre-test (*n* = 22) was 8.10, standard deviation (SD) = 2.1; average post-test score (*n* = 17) was 10.35, SD = 1.8, a significant difference (*t* (35) = 2.3, 95% CI 0.99–3.62, *P* = 0.001); pre-test/post-test differences were also significant

for each state. The number of RRV pantries that tracked veteran traffic, were aware of veteran service organizations in the community, and reported referring clients to veteran service organizations increased from pre- to post-RRV, and these improvements were sustained at 2-year follow up (Table 1). The number of pantries that offered monthly outreach events increased from zero to ten (100%) from pre- to post-RRV, and reduced to five pantries (50%) at the 2-year follow up.

Veterans

RRV recruited 234 participants of the 1094 veterans reached over the seven-month project period (response rate = 21%). One hundred twenty-five baseline participants (53%) also completed a follow-up assessment yielding a 47% attrition rate. A higher proportion of retained participants were receiving SNAP, unemployed, and reported being diagnosed with obesity by a health professional at baseline compared to participants who were not retained (*P* < 0.05, data not shown). These few differences support minimal attrition bias, but may also be associated with intervention effectiveness in those retained. Twenty-eight participants completed the dietary assessment.

Veterans who completed the demographic and food security assessment were predominantly male (91%), white (78%), 45–64 years (59%), and reported being retired (33%) or unable to work (25%; Table 2). Most households had children <18 years (82%). Most participants were not enrolled in federal food assistance programs, such as SNAP, WIC, and did not have children enrolled in free or reduced school lunches

Table 1 Pantry coordination with veteran services in a Reaching Rural Veterans (RRV) pilot intervention (*n* = 10)

	Pre-RRV ^a		Post-RRV ^b		Two-year follow-up	
	n	(%)	n	(%)	n	(%)
Pantry Characteristics^c						
Track veteran traffic	2	(20)	10	(100)	10	(100)
Aware of veteran service organizations in the community	8	(80)	10	(100)	10	(100)
Refer clients to veteran service organizations	5	(50)	10	(100)	10	(100)
Offer monthly outreach events where at least one veteran service organization is present	0	(0)	10	(100)	5	(50)
Total number of veterans served per month at outreach events across all pantry sites	—	—	418	—	114 ^d	—

^aPre-RRV characteristics reflect pantry characteristics during the application period of the RRV project (prior to final pantry selection and the start of the pilot intervention [October 2015]).

^bPost-RRV characteristics reflect pantry characteristics during the final month of the RRV project period (April 2016).

^cPantry characteristics were tracked and reported by RRV research staff.

^dTwo-year follow-up characteristics reflect pantry characteristics 28 months following the end of the RRV project period. At the 2-year follow up, pantries provided a range for the number of veterans currently being served at each monthly event. The average of this estimated range was used to determine the total sum of veterans served.

Table 2 Characteristics and resource use among rural Indiana and Kentucky US veteran adult participants of the Reaching Rural Veterans pilot intervention at baseline ($n = 234$)

<i>Demographic Characteristics</i>		<i>n (%)</i>
State		
Indiana		178 (76)
Kentucky		56 (24)
Age		
18–44 years		19 (8)
45–64 years		137 (59)
≥65 years		78 (33)
Sex		
Male		210 (91)
Female		20 (9)
Race		
White		175 (78)
Black or African American		46 (20)
American Indian or Alaska Native		3 (1)
Native Hawaiian or other Pacific Islander		1 (<1)
Education level		
High School/General Equivalency Diploma or less		110 (48)
College or more		113 (50)
Other		4 (2)
Employment status		
Employed		37 (17)
Out of work		31 (14)
Retired		74 (33)
Unable to work		56 (25)
Homemaker, student, or other		25 (11)
Marital status		
Married & living with spouse		89 (39)
Living together as married		11 (5)
Widowed		15 (7)
Divorced/separated		83 (36)
Never married/single		32 (14)
Household type		
With children <18 years		186 (82)
Without children <18 years		40 (18)
Household size		
One member		86 (37)
Two members		82 (35)
Three or more members		64 (28)
Household income in the last 12 months		
<\$10 000		79 (37)
\$10 001–\$15 000		48 (23)
>\$15 000		86 (40)
Housing type		
House, condo, mobile home, or apartment		220 (94)
Other		14 (6)

Continued

Table 2 Continued

<i>Demographic Characteristics</i>		<i>n (%)</i>
Transportation		
Drives him/herself		157 (70)
Other		66 (30)
Military Characteristics		
Military status		
Veteran		90 (98)
Non-active		2 (2)
Active		0 (0)
Branch of military		
Air Force		29 (13)
Army		129 (57)
Navy		44 (20)
Marine Corps		23 (10)
Guard/Reserve Service		
Yes		72 (31)
No		158 (69)
Years served [mean (SD)]		6.5 (7)
Service-related Veterans Affairs-recognized disability		
Yes		85 (38)
No		141 (62)
Service-related non-Veterans Affairs-recognized disability		
Yes		67 (30)
No		155 (70)
Health Conditions*		
Obesity		
Yes		31 (13)
No		203 (87)
Diabetes		
Yes		70 (30)
No		164 (70)
High blood pressure		
Yes		144 (62)
No		90 (38)
High cholesterol		
Yes		96 (41)
No		138 (59)
Number of different health conditions reported		
No health conditions		61 (26)
One health condition		67 (29)
Two health conditions		57 (24)
Three health conditions		36 (15)
Four health conditions		13 (6)
Healthy Eating Index (HEI) Scores (Maximum Score)		[mean (SD)]
HEI total score (100)		44.9 (14.4)
Total vegetables (5)		3.6 (1.6)
Greens and beans (5)		1.2 (2.1)
Total fruit (5)		1.5 (2.0)

Continued

Table 2 Continued

Demographic Characteristics	n (%)
Whole fruit (5)	1.1 (1.9)
Whole grains (10)	2.5 (3.7)
Total dairy (10)	4.9 (2.9)
Total protein (5)	4.7 (0.6)
Seafood and plant proteins (5)	1.3 (2.1)
Fatty acids (10)	4.7 (3.5)
Sodium (10)	2.3 (2.4)
Refined grains (10)	6.7 (3.5)
Empty calories (20)	10.4 (5.9)
Resource Use	
Disability payments	
Yes	118 (5.2)
No	111 (4.8)
Veteran's disability benefits ^a	
Yes	58 (5.0)
No	58 (5.0)
SNAP participation	
Yes	76 (3.3)
No	156 (6.7)
WIC ^b participation	
Yes	8 (3)
No	222 (9.7)
Meals on Wheels participation	
Yes	9 (4)
No	223 (9.6)
TANF/SSI/GA/ATT ^c participation	
Yes	23 (1.0)
No	205 (9.0)

^aHealth conditions were reported by participants as being diagnosed by a doctor or other health professional.

^bThe survey question regarding enrollment in 'veterans disability benefits' was asked only to participants who answered affirmatively to receiving 'disability payments' in the preceding survey question ($n = 118$).

^cSNAP: Supplemental Nutrition Assistance Program.

^dWIC: Special Supplemental Nutrition Programs for Women, Infants and Children.

^eTANF/SSI/GA/ATT: Temporary Assistance for Needy Families, Supplemental Security Income, General Assistance, or Assistance from the Township Trustee. These programs were grouped into one survey question (see Methods section of manuscript).

at baseline. The majority served in the Army, and the mean years served for all branches of the military was 6.5. Roughly half received disability payments at baseline, however only half of those were receiving veterans disability benefits. This is not surprising as nearly the same proportion of participants who reported having a service-related VA-recognized disability reported having a service-related disability not

recognized by the VA. Mean overall dietary quality measured by the total HEI score was 44.9 at baseline.

The proportion of food secure households increased from 30% to 38% ($P = 0.03$), and adults from 35% to 44% ($P = 0.01$, Table 3). The proportion of participants receiving SNAP benefits and the proportion of participants enrolled in ≥ 1 of the following programs: TANF, SSI, GA or ATT also increased at follow-up compared to baseline, and changes were statistically significant ($P = 0.02$ and $P = 0.005$, respectively).

The odds of household and adults within a household being food secure both increased by 10% ($P = 0.009$ and $P = 0.01$, respectively), and the odds of being enrolled in TANF/SSI/GA/ATT increased by 11% ($P = 0.005$), at follow-up compared to baseline after controlling for pantry site, age, sex and race (Table 4). The odds of being enrolled in SNAP at follow-up compared to baseline was considered a trend ($P = 0.06$). The LOCF analysis confirmed these results, showing statistically significant odds ratios for household food security, adult food security, and TANF/SSI/GA/ATT enrollment (results not shown) indicating meaningful results despite attrition.

Discussion

Main findings of this study

The RRV pilot study was successful in implementing all intervention components in 10 faith-based food pantries over the project period; however, participant response rates were low. Food pantry awareness of veterans using their services and additional community resources, veteran referrals and hosting monthly veteran outreach events improved from the beginning to the end of the project period and were mostly sustained at 2-year follow-up. Food security and resource use among RRV participants also increased at 3-month follow-up compared to baseline. Improvement in resource use suggests that an intervention that brings services directed toward veterans to rural food pantries may successfully connect veterans with the resources they need to enroll in assistance programs. Only TANF/SSI/GA/ATT enrollment improved at follow-up, suggesting that the service organizations present at outreach events (Supplemental Table 1) may have assisted with enrollment in these programs. Of the government benefits programs reported, SNAP had the highest percentage of participants enrolled prior to the intervention and this preliminary analysis shows promise for an improvement in SNAP enrollment after a longer follow-up period or in a larger and more representative future intervention. Lack of increases in program enrollment, especially WIC and free or reduced school meals that may benefit the high

Table 3 Food security status and enrollment in resources at baseline and follow-up in rural Indiana and Kentucky veteran adult participants of the Reaching Rural Veterans pilot intervention ($n = 125$)^a

Food Security/Resource Status Variables:	Baseline n (%)	Follow-up n (%)	McNemar's test (P)
Household Food Security			0.03*
Food Secure	29 (30)	36 (38)	
Food Insecure	66 (70)	59 (62)	
Adult Food Security			0.01*
Food Secure	37 (35)	47 (44)	
Food Insecure	69 (65)	59 (56)	
SNAP ^b			0.02*
Enrolled	46 (38)	53 (44)	
Not Enrolled	75 (62)	68 (56)	
TANF/SSI/GA/ATT ^c			0.005*
Enrolled	10 (9)	23 (20)	
Not Enrolled	105 (91)	92 (80)	
WIC ^d			0.16
Enrolled	3 (3)	1 (1)	
Not Enrolled	116 (97)	118 (99)	
School Meals			0.08
Enrolled	9 (22)	6 (15)	
Not Enrolled	32 (78)	35 (85)	
Meals on Wheels			0.56
Enrolled	3 (3)	4 (3)	
Not Enrolled	116 (97)	115 (97)	
Disability Payments			0.71
Enrolled	63 (53)	64 (53)	
Not Enrolled	57 (47)	56 (47)	
Veterans Disability Benefits ^e			0.32
Enrolled	27 (57)	28 (60)	
Not Enrolled	20 (43)	19 (40)	

^aThis table includes participants who reported their status for any food security or resource variable at both baseline and follow-up.

^bSNAP: Supplemental Nutrition Assistance Program.

^cTANF/SSI/GA/ATT: Temporary Assistance for Needy Families, Supplemental Security Income, General Assistance, or Assistance from the Township Trustee. These programs were grouped into one survey question (see Methods section of manuscript).

^dWIC: Special Supplemental Nutrition Program for Women, Infants and Children.

^eThe survey question regarding enrollment in 'Veterans Disability Benefits' was asked only to participants who answered affirmatively to receiving 'Disability Payments' in the preceding survey question.

*Statistical significance $P < 0.05$. McNemar's test used.

proportion of households with children <18 years represented in the study population, suggests opportunities for a future intervention. Barriers to participation may include

Table 4 Odds ratios for repeated measures logistic regression analysis of time (follow-up compared to baseline) on food security status and enrollment in resources in rural Indiana and Kentucky veteran adult participants of the Reaching Rural Veterans pilot intervention ($n = 125$)

Resource	Odds Ratio ^a	Standard error	P
Household Food Security			
(Food Insecure)	1.00	—	—
Food Secure	1.10	0.04	0.009*
Adult Food Security			
(Food Insecure)	1.00	—	—
Food Secure	1.10	0.04	0.01*
SNAP^b			
(Not Enrolled)	1.00	—	—
Enrolled	1.05	0.02	0.06
TANF/SSI/GA/ATT^c			
(Not Enrolled)	1.00	—	—
Enrolled	1.11	0.04	0.005*
WIC^d			
(Not Enrolled)	1.00	—	—
Enrolled	0.99	0.01	0.23
School Meals			
(Not Enrolled)	1.00	—	—
Enrolled	0.96	0.04	0.24
Meals on Wheels			
(Not Enrolled)	1.00	—	—
Enrolled	0.99	0.01	0.84
Disability Payments			
(Not Enrolled)	1.00	—	—
Enrolled	0.99	0.02	0.85
Veterans Disability Benefits^e			
(Not Enrolled)	1.00	—	—
Enrolled	0.99	3.5×10^{-5}	0.99

^aBy design, the reference category, shown in (parentheses), odds ratio is 1. This table includes participants who completed the assessment at both baseline and follow-up. All models adjusted for pantry site, age, sex and race at baseline.

^bSNAP: Supplemental Nutrition Assistance Program.

^cTANF/SSI/GA/ATT: Temporary Assistance for Needy Families, Supplemental Security Income, General Assistance, or Assistance from the Township Trustee. These programs were grouped into one survey question (see Methods section of manuscript).

^dWIC: Special Supplemental Nutrition Program for Women, Infants and Children.

^eThe survey question regarding enrollment in 'Veterans Disability Benefits' was asked only to participants who answered affirmatively to receiving 'Disability Payments' in the preceding survey question ($n = 69$).

*Statistical significance $P < 0.05$.

participant ineligibility due to lack of a residential address, which is a common problem among transient populations, or difficulties with the application process. Additional support

to connect veterans with these resources, including enrollment guidance at venues where SNAP, a program with the highest enrollment, is commonly offered, may allow these programs to capitalize on reaching rural veterans by further collaboration.

Gains in resource use are likely related to food security improvement and are promising for implementing future interventions to promote food security among this unique and underserved population. A higher proportion of food secure households and adults at follow-up compared to baseline may be due to the emergency food provided through the pantry and receipt of other resources allowing more secure access to food. Dietary quality indicated the sample of rural veterans scored 15 points lower compared with US adults.³⁷ Such a low dietary quality is linked with a high risk of diet-related chronic health outcomes.³⁷ Further interventions are needed to support improvement of dietary intake. HEI component scores indicated poor adherence to sodium recommendations, which may explain the high prevalence of high blood pressure reported and supports pantry interventions offering low-sodium foods.

What is already known on this topic?

A national study that compared US veterans who were denied VA disability compensation to those who were awarded compensation found that denied applicants were more likely to have poorer overall health, greater limitations in activities of daily living, and decreased knowledge and use of VA benefits.³⁸ Evidence that more than one-third of the RRV pilot study population reported a service-related disability not recognized by the VA may explain why rural veteran pantry clients may have additional functional and knowledge barriers to receiving services for which they are eligible. Physical and cognitive difficulties navigating the application process for resource enrollment may compound barriers due to rurality, such as lack of transportation. Denied applicants may need additional support through programs like RRV to connect to resources. Measuring eligibility and application status (approval or denial) for resources may help to explain characteristics of resource use in future studies.

Elevated food insecurity among veterans and low-income groups living in rural areas compared to the national average^{12,39} may also be indicative of less prevalent use of food and other government assistance programs. The prevalence of food insecurity in this rural veteran food pantry-user sample was consistent with other studies that have evaluated food security in emergency food system clients,⁴⁰⁻⁴³ but much higher compared to studies of veterans outside of the emergency food system population, as expected.^{12,44} In the homeless veteran population, Austin *et al.* found that 59% of subjects reported going without food for ≥1 days per

week, suggesting severe food insecurity in the majority of the homeless veteran study population, and supporting the findings of this study.⁴⁵ Interestingly, compared to a recent study of patients who were enrolled in care at one of six VA clinics for the homeless where food insecurity prevalence was 49%, prevalence of food insecurity in the present study was much higher.⁴⁶ Lower estimates of food insecurity in a patient setting supports the idea that food insecurity is significantly associated with difficulty accessing health care,⁴⁷ and emphasizes the importance of delivering interventions in populations where veterans may not necessarily be enrolled as patients, and face a higher burden of food insecurity as an associated consequence compared to patient settings.

Limitations of this study

Limitations of this pilot study were lack of a control group and quantification of the 'dose' of the intervention (i.e. how many resources each participant connected with at outreach events, how many outreach events participants attended before participating in the study and between the baseline and follow-up assessment). Using a mail-in approach to collect assessments likely contributed to the low response rate. Results of this study likely include bias due to the convenience sample, non-response, and high attrition, which reduces generalizability of results. However, the conservative LOCF analysis confirmed the results and offers support to the study findings. These limitations may be addressed in future studies by recruiting a larger, more representative sample, monitoring contact information and implementing real-time data collection techniques to reduce attrition. A randomized comparison group would strengthen evidence of causal improvement.

What this study adds

To our knowledge, this is the first study to evaluate resource use and food security in the difficult-to-reach rural veteran pantry-user population. This study is one of few recent studies to evaluate food security among veterans.^{1,2,44} Other studies that investigated food security among veterans used less standard measures and only included veterans that had accessed VA health care,¹² or used nationally representative data.⁴⁴ This study is also more current than the most recent investigation of veterans in low-resource populations.⁴⁵ Another strength is implementation of a practical, multi-pronged intervention using a cultural competence model and building on existing community infrastructures, paired with a scientific evaluation, among this underserved population. This multi-pronged approach supports the strategic goal of the Department of Veterans Affairs to 'empower veterans to improve their well-being by connecting them with organizations'.⁴⁸

The RRV intervention shows promise as a new mechanism that may be cost-effective and sustainable for institutions to implement. Social ecological perspectives urge greater attention to the community context of vulnerable populations. Consistent with this view, RRV was designed to use food pantries as a delivery platform. Food pantries are an existing community system, well positioned to make contact with hard-to-reach, low-resource populations. Training pantry staff on military culture and needs of low-resource veterans increased their knowledge, contributing to greater cultural sensitivity. Working with pantries was cost-effective because they already have physical locations and staff, allowing RRV activities to operate on a 'pop up' basis at each pantry. In addition, Cooperative Extension Specialists in many states deliver nutrition education at food pantries, providing a ready-made and sustainable mechanism for delivering training to food pantry staff and veterans themselves.

This study found enrollment gaps in government programs, such as TANF/SSI/GA/ATT, among rural veterans using food pantries that improved after the 3-month follow-up. Findings also highlighted a high prevalence of food insecurity, which improved over the project period. These preliminary results serve as a foundation for understanding discrepancies in resource use in this population. Future interventions directed at improving these outcomes may include partnerships with existing community infrastructures to successfully reach low-density populations. Findings may be used to inform future efforts to help ensure that rural veteran families will receive measurable support and assistance from community and government organizations to improve food insecurity, and ultimately health, among this population.

Supplementary data

Supplementary data are available at the *Journal of Public Health* online.

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References

1. Wilome R, Jensen A, Bangert A *et al*. Food insecurity among Veterans of the US wars in Iraq and Afghanistan. *Public Health Nutr* 2018;18:844–9.
2. Wang EA, McGinnis KA, Goulet J *et al*. Food insecurity and health data from the Veterans Aging Cohort Study. *Public Health Reports* 2015;130:261–8. (Washington, DC: 1974).
3. Andersen SA. Core indicators of nutritional state for difficult-to-sample populations. *J Nutr* 1990;120(Suppl 11):1559–600.
4. Coleman-Jensen A, Rabbit MP, Gregory CA *et al*. Household Food Security in the United States in 2015. Economic Research Report Number 215. (2016). <https://www.ers.usda.gov/webdocs/publications/79761/ers-215.pdf?v=0>. Accessed August 2016.
5. O'Toole TP, Johnson EE, Aiello R *et al*. Tailoring care to vulnerable populations by incorporating social determinants of health: the Veterans Health Administration's 'Homeless Patient Aligned Care Team' Program. *Prog Chronic Dis* 2016;13:B44.
6. Purcell KM, Gershoff ET, Lawrence Aber J. Low Income Families' Utilization of the Federal 'Safety Net': individual and state-level predictors of TANF and food stamp receipt. *Child Youth Serv Rev* 2012; 34(4):713–24.
7. Mabli J, Ohk J. Supplemental Nutrition Assistance Program participation is associated with an increase in household food security in a national evaluation. *J Nutr* 2015;145:344–51.
8. Schmidt L, Shore-Sheppard L, Watson T. The Effect of Safety Net Programs on Food Insecurity. NBER Working Paper No. 19558 (2013). <http://www.nber.org/papers/w19558.pdf>. Accessed August 2018.
9. Department of Veterans Affairs Office of Rural Health. Health Day Fact Sheet. http://www.ruralhealth.va.gov/docs/ORH_FactSheet_Nut_Rural_Health_Day_Nov2011.pdf (2011) Accessed August 2016.
10. Montgomery S. *Characteristics of Rural Veterans: 2010—Data from the American Community Survey*. Washington, DC: National Center for Veterans Analysis and Statistics, 2012. http://www.va.gov/verdau/docs/SpecialReports/Rural_Veteran_ACS2010_FINAL.pdf. Accessed August 2016.
11. Wax SG, Stankorb SM. Prevalence of food insecurity among military households with children 5 years of age and younger. *Public Health Nutr* 2016;13:2458–66.
12. Brucker DL. Food security among young adults with disabilities in the United States: findings from the National Health Interview Survey. *Disability and Health Journal* 2016;9:298–305.
13. U.S. Department of Veterans Affairs Office of Rural Health. <https://www.ruralhealth.va.gov/aboutus/ruralvets.asp>. Accessed August 2018.
14. Ohls J, Saleem-Ismail F, Cohen R *et al*. The Emergency Food Assistance System- Findings From the Provider Survey: United States Department of Agriculture, Economic Research Service.

- (2002). https://www.ers.usda.gov/webdocs/publications/46497_52144_fnrr16-2.pdf?v=42082. Accessed March 2018.
- 15 Verpy H, Smith C, Reicks M. Attitudes and behaviors of food donors and perceived needs and wants of food shelf clients. *J Nutr Educ Behav* 2003;35:6–15.
 - 16 Tobin T, Downer S, Prendergast K *et al*. Food Banks as Partners in Health Promotion: Creating Connections for Client & Community Health. FeedingAmerica.org. https://hungerandhealth.feedingamerica.org/wp-content/uploads/legacy/mp/files/tool_and_resources/files/food-banks-as-partners-in-health-promotion-creating-connections-for-client-community-health.pdf (2015) Accessed March 2018.
 - 17 Werber L, Derose KP, Rudnick M *et al*. Path-based organizations and veteran reintegration: enriching the web of support. *Rand Health Q* 2015;5(2):15.
 - 18 Ricketts TC. *Rural Health in the United States*. New York: Oxford University Press, 1999.
 - 19 Substance Abuse and Mental Health Services Administration. Cultural Competence. <https://www.samhsa.gov/capt/applying-strategic-prevention/cultural-competence>. Accessed July 2018.
 - 20 Centers for Disease Control and Prevention. The Social-Ecological Model: A Framework for Prevention. <https://www.cdc.gov/violenceprevention/intro/social-ecologicalmodel.html> Accessed July 2018.
 - 21 Kaiser M. Food security: an ecological-social analysis to promote social development. *Journal of Community Psychol* 2011;19(1):62–79.
 - 22 Tanielian T, Parris C, Banks C *et al*. *Ready to Serve: Community-Based Provider Capacity to Deliver Culturally Competent, Quality Mental Health Care to Veterans and Their Families*. Santa Monica, CA: RAND Corporation, 2014. https://www.rand.org/pubs/research_reports/RR806.html. Also available in print form. Accessed July 2018.
 - 23 Atuel HR, Castro CA. Military cultural competence. *Clin Soc Work J* 2018;46:74–82.
 - 24 Convoy S, Westphal RJ. The importance of developing military cultural competence. *J Emerg Nurs* 2013;39(6):591–4.
 - 25 Englebretson J, Mahoney J, Carlson ED. Cultural competence in the era of evidence-based practice. *J Prof Nurs* 2008;24(3):172–8.
 - 26 Department of Veterans Affairs TN and KY State Summaries. http://www.va.gov/verdata/docs/SpecialReports/State_Summaries_Kentucky.pdf http://www.va.gov/verdata/docs/SpecialReports/State_Summaries_Indiana.pdf. (2014) Accessed August 2016.
 - 27 Arain M, Campbell MJ, Cooper CL *et al*. What is a pilot or feasibility study? A review of current practice and editorial policy. *BMC Med Res Methodol* 2010;10:67.
 - 28 USDA Economic Research Service: Rural-Urban Commuting Area Codes. <https://www.ers.usda.gov/data-products/rural-urban-commuting-area-codes/>. Accessed May 2017.
 - 29 Centers for Disease Control National Center for Health Statistics. National Health and Nutrition Examination Survey. <https://www.cdc.gov/nchs/nhanes/continuous-nhanes/questionnaires.aspx?BeginYear=2013>. Accessed August 2018.
 - 30 2014 Status of Forces Survey of Reserve Component Members. Defense Research, Surveys, and Statistics Center (RSSC). www.dmdc.osd.mil/app/dsdp/dsdp_surveys.jsp. Accessed September 2018.
 - 31 Bickel G, Nord M, Price C *et al*. Guide to Measuring Household Food Security: Revised 2000. (2000)
 - 32 USDA Economic Research Service. U.S. Household Food Security Survey Module: Three-Stage Design, With Screens. (2012)
 - 33 Sular AF, Kirkpatrick SI, Miri B *et al*. The automated self-administered 24-hour dietary recall (ASA24): a resource for researchers, clinicians, and educators from the National Cancer Institute. *J Am Nutr Diet* 2012;112(8):1134–7.
 - 34 Miller PE, Mitchell DC, Harala PL *et al*. Development and evaluation of a method for calculating the Healthy Eating Index-2005 using the Nutrition Data System for Research. *Publ Health Nutr* 2011;14:306–13.
 - 35 Guenther PM, Casavale KO, Reedy J *et al*. Update of the Healthy Eating Index: HEI-2010. *J Am Nutr Diet* 2013;113:569–80.
 - 36 Gupta SK. Intention-to-treat concept: a review. *Progr Clin Res* 2011;2(3):10–12.
 - 37 USDA Center for Nutrition Policy and Promotion. Healthy Eating Index. <https://www.cnpp.usda.gov/healthyeatingindex>. Accessed September 2018.
 - 38 Fried DA, Passannante M, Helmer D *et al*. The health and social isolation of American Veterans Denied Veterans Affairs Disability Compensation. *Health Soc Work* 2017;42(1):7–14.
 - 39 USDA: Hunger Rising in Indiana. <http://www.indystar.com/story/news/2015/09/10/usda-hunger-rising-indiana/71964762/>. (2015) Accessed August 2016.
 - 40 Duffy P, Zizza C, Jacoby J *et al*. Diet quality is low among female food pantry clients in Eastern Alabama. *J Nutr Educ Behav* 2009;41:414–9.
 - 41 Marin K, Shuckerow M, O'Rourke C *et al*. Changing the conversation about hunger: the process of developing Freshplace. *Prog Community Health Partnersh* 2012;6:429–34.
 - 42 Marin KS, Wu R, Wolf M *et al*. A novel food pantry program: food security, self-sufficiency, and diet-quality outcomes. *Amer J Prev Med* 2013;45:569–75.
 - 43 Robins KA, Marin KS. Food insecurity, poor diet quality, and obesity among food pantry participants in Hartford, CT. *J Nutr Educ Behav* 2013;45:159–64.
 - 44 Miller DP, Larson MJ, Byrne T *et al*. Food insecurity in Veteran households: findings from nationally representative data. *Publ Health Nutr* 2016;19:1731–40.
 - 45 Austin CK, Goodman CE, Van Halderen LL. Absence of malnutrition in a population of homeless Veterans. *J Am Diet Assoc* 1996;96:1283–5.
 - 46 O'Toole TP, Roberts CB, Johnson EE. Screening for food insecurity in six Veterans Administration Clinics for the homeless, June–December 2015. *Prev Chronic Dis* 2017;14:E04.
 - 47 Kushel MB, Gupta R, Gee L *et al*. Housing instability and food insecurity as barriers to health care among low-income Americans. *J Gen Intern Med* 2006;21(1):71–7.
 - 48 Department of Veterans Affairs FY 2014–2020 Strategic Plan. http://www.vets.gov/Portals/36/Documents/Doctrine/Interorganizational_Documents/va_sp_fy14-20.pdf. Accessed August 2016.