

Applying the Healthy Eating Index-2015 in a Sample of Choice-Based Minnesota Food Pantries to Test Associations Between Food Pantry Inventory, Client Food Selection, and Client Diet

Caitlin E. Caspi, ScD; Cynthia Davey, MS; Christina Bliss Barsness, MPH, RD; Julian Wolfson, PhD; Hikaru Peterson, PhD; Rebekah J. Pratt, PhD

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ABSTRACT

Background Food pantry clients are at a high risk for diet-related chronic disease and suboptimal diet. Relatively little research has examined diet quality measures in choice-based food pantries where clients can choose their own food.

Objective This study tested whether the diet quality scores for food at the pantry were associated with client food selection scores, and whether client food selection scores at the pantry were associated with client diet intake scores.

Design This cross-sectional regression analysis, part of a larger evaluation study (SuperShelf), used baseline data from client and food pantry surveys, food pantry inventories, assessments of client food selections (“client carts”), and single 24-hour client dietary recalls.

Participants/setting The analysis includes 316 clients who completed a survey (282 of whom completed a dietary recall measure) from one of 16 choice-based Minnesota food pantries during 2018–2019. Adult English, Spanish, or Somali-speaking clients were eligible in the case that they had selected food on the day of recruitment at their food pantry visit.

Main outcome measures A Healthy Eating Index-2015 (HEI-2015) Total score and 13 subcomponent scores were calculated for: pantry food inventories of food available on the shelf, client carts, and a 24-hour client dietary recall.

Statistical analysis Descriptive statistics were generated for client and food pantry characteristics, and for HEI-2015 Total score and subcomponent scores. Linear regression models tested the association between HEI-2015 Total score and subcomponent scores for food pantry inventory and client carts, and for client carts and dietary recalls, adjusted for covariates.

Results Food pantry inventory HEI-2015 Total score averaged 65.1, client cart Total score averaged 60.8, and dietary recall Total score averaged 50.9. The diet quality scores for inventory were not associated with client cart scores, except for Added Sugars ($P = .005$). Client cart HEI-2015 Total score was positively associated with client diet HEI-2015 Total score ($P = .002$) and associations for Total Fruits, Whole Fruits, Total Vegetables, Greens and Beans, Whole Grains, Seafood and Plant Proteins, and Added Sugars subcomponents were statistically significant.

Conclusions In choice-based Minnesota food pantries, the diet quality of food selected by clients was positively associated with client diet quality.

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FOOD PANTRIES PLAY AN IMPORTANT ROLE IN providing food for families facing food insecurity.¹ In 2014, more than 43 million clients made visits to food pantries in the United States.² The role of food banks and food pantries may be particularly critical during local or national emergencies, such as natural disasters or pandemics.^{3,4}

Most clients visiting pantries visit them frequently, for long durations, and get a substantial portion of their total food from them.⁵⁻⁸ Food pantry clients are at an especially high risk for diet-related chronic diseases^{2,9,10} and suboptimal diet.^{6,10,11}

Like most populations, the determinants of food pantry client diets are complex and influenced by factors at multiple

levels. However, food pantry clients may face unique challenges in obtaining healthy food in the hunger relief system. At the food pantry, the diet quality of food available at pantries has demonstrated shortcomings.¹²⁻¹⁴ Only recently has the system begun to adopt evidence-based healthfulness standards.¹⁵ Furthermore, many pantries offer minimal choice for clients to select food that appeals to their household.¹⁶ Several recent studies in limited-choice food pantries demonstrate that client diet quality is meaningfully lower than the diet quality of US adults overall. Specifically, using the Healthy Eating Index-2010, which reflects how well dietary patterns align with the 2010 Dietary Guidelines for Americans and has a maximum score of 100,¹⁷ scores for clients at limited-choice midwestern pantries have been found in the range of 39 to 46,^{8,18,19} compared with the US adult population average of 58.²⁰ In choice-based pantries, where clients are allowed to select their own food,¹⁶ client dietary patterns may differ from the patterns of clients at limited-choice pantries; however, in the shallow body of research on choice-based pantries, rigorous measures of client diet quality have not been reported.^{5,21}

This study uses data from 16 choice-based food pantries in Minnesota to test whether diet quality scores for food at the pantry are associated with client food selection scores, and whether client food selection scores at the pantry are associated with client diet quality. The study tested the hypotheses that Total and subcomponent Healthy Eating Index 2015 (HEI-2015) scores were positively associated for food pantry inventory and client food selection and client food selection and client diet. Testing these associations is useful for understanding how diet quality could be improved at the environment and individual levels in choice-based pantries.

MATERIALS AND METHODS

Study Design and Recruitment

This study used baseline data from an intervention evaluation (SuperShelf, NCT03421106) in 16 food pantries in Minnesota.²² Participating pantries were selected in two waves among 62 unique pantries that applied. An open call to food pantries in Minnesota was advertised through the SuperShelf Leadership Team, a network that included food banks across the state and the state's partner administrator of The Emergency Food Assistance Program during a 6-week period in early fall 2017 and another in early fall 2018. Interested pantries submitted an online application with questions pertaining to pantry organizational operations, food distribution procedures, commitment to implementing intervention changes, and a set of open-ended questions assessing reasons for applying. The application required a letter of support from the Board of Directors and photographs of the pantry. Pantries were required to have already in place a full client-choice distribution model similar to a grocery shopping experience, with food displayed on the shelf and clients able to physically select or decline food from all different food groups. They were also required to have a worker who could devote 4 to 6 hours per month to intervention activities. The intervention required the pantry to commit to significant changes in food sourcing and pantry layout to promote client-centeredness and nutrition (eg, behavioral economic strategies). To select the 16 sites, each application was evaluated by at least two reviewers from SuperShelf's founding

RESEARCH SNAPSHOT

Research Question: Applying the Healthy Eating Index-2015 in choice-based food pantries, is the diet quality of food pantry inventory associated with the quality of client food selection, and is the quality of client food selection associated with the quality of client dietary intake?

Key Findings: In this cross-sectional analysis of 16 Minnesota food pantries using the Healthy Eating Index-2015, the diet quality scores of food pantry inventory were not associated with scores of the food selected by clients, except for Added Sugars. Scores of the food selected by clients was positively associated with client dietary intake Total score and Total Fruits, Whole Fruits, Total Vegetables, Greens and Beans, Whole Grains, Seafood and Plant Proteins, and Added Sugars subcomponent scores.

partners,²³ who gave an initial ranking of high, medium, or low potential to each applicant, with consideration given to the following: whether the pantry was likely to succeed in implementing the intervention (eg, open-ended responses reflected organizational priorities that aligned with the intervention), whether data collection and study timeline goals were feasible at the site (eg, enough clients were likely to be recruited in 1 week given the pantry's hours of operation and location), and whether the pantry could be matched and randomized with another to create intervention and delayed intervention conditions for the larger evaluation that were balanced in terms of urban/rural location, food bank region, and client populations served (eg, a college food pantry did not have a good match). Reviewers met in person to reach consensus on selecting pantries. Top applicants received a site visit before selection to verify responses of the written application. Notably, whereas all pantries were full client choice, all had some guidelines on the amount of food that clients could select, although not the specific type of food. For example, signs noted "pick up to four cans of vegetables" or "one container of milk limit." Baseline data were collected in two waves of eight pantries (February to June 2018 and February to July 2019).

A convenience sample of clients were enrolled at the food pantry after selecting their food. All clients visiting the food pantry on data collection days were approached and eligible to participate in the case that they were at least age 18 years; had received food at the pantry that day; had reliable access to a telephone; and spoke English, Spanish, or Somali. Data collectors visited each pantry on at least two consecutive open days to recruit at least 17 participants per pantry. After completing informed consent, clients completed a survey while research staff recorded the food that clients selected. Following their visit, clients were contacted by the Nutrition Coordinating Center (NCC) at the University of Minnesota to obtain up to two 24-hour dietary recalls. Only the first recall was used in the current analysis because it was more likely to represent consumption of food provided at the pantry. Participants received \$45 for completing all baseline measures. The study was approved by the University of Minnesota Institutional Review Board.

Of 537 clients approached, 59% participated. The most common reason for declining participation was not having time

(66% of those who gave a reason for declining). The final baseline sample consisted of 317 clients. Of those, 316 had their food selections recorded (“client cart” data), whereas one had already taken the food from the pantry home and come back to the pantry to enroll, so cart measures could not be recorded. Of those who enrolled, 283 completed the first dietary recall. One participant was fasting at the time of their first recall and was, therefore, excluded from that sample ($n = 282$). The study’s baseline sample size (a minimum of 272) was based on the larger intervention evaluation’s aim of detecting a change in HEI-2015 Total diet scores (the primary outcome) among participants followed for 1 year; 187 additional participants were enrolled at the larger study’s follow-up time point for a secondary outcome, but are not included in this baseline analysis.

Food Pantry Measures

Pantry Characteristics. Pantry manager surveys assessed pantry characteristics, including monthly households served, monthly pounds of food distributed, number of full-time employees, and number of freezers and coolers. One food pantry did not report the number of monthly households served or monthly pounds of food distributed on their baseline manager survey, so these data were drawn from their SuperShelf application. Food pantry urban/rural status was assigned based on Rural-Urban Commuting Area code classifications.²⁴

Pantry Inventory. Food pantry inventory was assessed by research data collectors in a single snapshot measure that included food available for clients to choose at their visit, and thus excluded back-stock. Inventory was conducted when the pantry was closed to clients, but stocked as it typically would be for clients. Inventory was collected in the same week as the client cart data collection. Data collectors recorded the details for each product, including the item name, brand, net product weight, exact count of the product, and special nutrition-related notes on the label (eg, reduced sodium or reduced fat) into an Excel database.²⁵ For prepackaged items, data were obtained from package labels. Nonpackaged items like produce were weighed with the container weight (eg, bin or cart) subtracted.

After the food pantry visit, data were entered into Nutrition Data System for Research (NDSR) version 2019,²⁶ a computer-based software application developed at the NCC. The NCC Food and Nutrient Database²⁷ includes more than 18,000 foods and more than 160,000 food variants. Values for 174 nutrient, nutrient ratios, and other food components are generated from the database, used by NDSR. NDSR is primarily used to capture dietary recall data, but has been used to capture inventory and food purchase data with slight modifications.^{5,28-30} NDSR is designed to minimize data entry errors by providing a user interface that facilitates the selection of the appropriate foods. NDSR includes a large number of brand name items and is able to account for different preparation methods. In the current study, foods were searched in NDSR by their exact profile (eg, brand and preparation form), with a generic version or a substitute with similar nutrient profile selected in the case that an exact match could not be found. For processed or prepared foods, in the case that an acceptable substitute could not be found, the food product would be assembled as a recipe of

individual ingredients using the Nutrition Facts label and ingredients list. One hundred percent of foods from the pantry were coded in NDSR. Data entry team members were trained on NDSR by the NCC. Quality assurance included regular consultation with the registered dietitian or NCC staff regarding food items not found in the database used by NDSR, as well as a line-by-line review of records entered into NDSR by a second NCC-trained study team member.

Client Measures

Client Demographic Characteristics. The client survey assessed participant characteristics, including age, gender, race/ethnicity, education, household size, and the frequency clients visited the food pantry in the last 12 months. The client survey was self-administered, filled out either online through a REDCap version 10.0.28³¹ platform or on a paper copy and entered into REDCap by the data collection team.

Client Carts. After clients had selected their food at the pantry, staff photographed it with a study-specific iPod touch device. Prepackaged item photographs captured the product name, brand, size, quantity, special nutrition-related notes on the label (eg, reduced sodium or reduced fat). Nonpackaged items like produce were photographed on a scale with the weight displayed. Following the pantry visit, photograph data were entered into an Excel database and then entered into NDSR using the same protocol as for inventory.

24-Hour Dietary Recalls. Client 24-hour dietary recalls were collected from the clients using NDSR using a multiple-pass interview³² during unannounced telephone calls conducted by trained NCC staff. The goal was to complete both 24-hour dietary recalls within 3 weeks of the food pantry visit. Participants were given a food amount booklet to assist in estimating portions for the dietary recalls. The quality assurance process by the NCC included an initial review by the interviewer for accuracy, a set of quality assurance reports run on 100% of records to resolve any data outliers, notes, or foods flagged by the interviewer, and having 10% of records reviewed line-by-line.

HEI-2015 Scores

The HEI is an assessment tool developed and evaluated by the National Cancer Institute and the US Department of Agriculture.^{33,34} The HEI, including its most recent version based on the 2015-2020 Dietary Guidelines for Americans,³⁵ the HEI-2015, can be applied at multiple levels of the food system to assess how well a set of foods aligns with the corresponding Dietary Guidelines for Americans.³³

Scores are computed by deriving ratios of dietary constituents to energy (or, in the case of fatty acids, the ratio of poly- and monounsaturated fatty acids to saturated fatty acids), and then scoring each of the 13 subcomponents according to minimum and maximum standards.³³ HEI-2015 contains nine adequacy components (Total Fruits, Whole Fruits, Total Vegetables, Greens and Beans, Whole Grains, Dairy, Total Protein Foods, Seafood and Plant Proteins, and Fatty Acids) and four moderation components (Refined Grains, Sodium, Added Sugars, and Saturated Fats); for all components, higher scores represent higher diet quality. In the current study, NDSR data were used to create three sets of HEI-2015 scores:

RESEARCH

pantry inventory ($n = 16$), client carts ($n = 316$), and client diet recalls ($n = 282$).

Analysis

In this study, HEI-2015 Total and subcomponent scores from food pantry inventory, client food selection, and client diet were created and examined using radar plot³³ to visualize subcomponent scores at different levels. NDSR Intake Properties Totals (file 04) and Serving Count Totals (file 09) output files were used along with the publicly available NCC SAS code and guide for the National Cancer Institute's "simple HEI scoring algorithm" with 1 day of intake^{36,37} to calculate HEI-2015 total and component scores for pantry inventory, client carts, and client dietary recalls. Descriptive statistics included frequencies and percents for categorical variables, means and standard deviation for continuous variables, and median and range for food pantry number of employees. Average number of households and pounds of food distributed were used for pantries that reported ranges instead of single values. The number of coolers and freezers were summed to a single variable because they were highly correlated. To display subcomponents across measures, an HEI-2015 radar plot³⁸ was created representing the percent of the maximum subcomponent score. Regression models tested the association between food pantry inventory (independent variable) and client cart HEI-2015 total and subcomponents scores (dependent variable) for 316 clients with client cart data, and the association between client cart (independent variable) and client dietary intake (dependent variable) HEI-2015 total and subcomponent scores, limited to 282 clients with both client cart and dietary intake data and adjusted for client-level covariates (ie, age, gender, race/ethnicity category, education level, household size, and frequency of food pantry visits), and food pantry covariates, including urban or rural location, average pounds of food served per month, and number of freezers and coolers. Models included a random intercept for food pantry to account for clustering of clients within food pantries. SAS software version 9.4³⁹ was used for HEI-2015 score calculations, descriptive statistics, and regression analyses. Statistical significance was set at $P < 0.05$.

RESULTS

Client and pantry characteristics are presented in Table 1. The analytic sample of 316 participants was approximately two-thirds women (63.9%) with 43.3% aged 18 to 44 years. Participants mostly identified as non-Hispanic White (57.3%) with 15.8% identifying as non-Hispanic Black, 6.3% identifying as Native American/Alaskan Native, 10.4% identifying as Hispanic/Latinx, and 10.1% identifying as other, more than one race, or missing race/ethnicity. About half (50.5%) had greater than a high-school degree. Most (78.9%) visited a pantry at least once a month during the past year. The average household size was 3.1 people. Ten food pantries were urban; six were rural. On average, pantries served 566 households and distributed 41,259 pounds of food per month. Pantries had a median of one full-time employee and a median of six total coolers and fridges.

The first dietary recalls were obtained, on average, 5.1 days after the pantry visit; 78% of first diet recalls were completed within 1 week of pantry visit, 92% were completed within 2

weeks, 99% were completed within 3 weeks; 4 outliers were at 26, 27, 31, and 84 days after cart selection. Seventy-one percent of recalls were collected during the week, Monday through Thursday, whereas 29% were collected on the weekend, Friday through Sunday (not shown in Table 1).

The Figure presents a radar plot of HEI-2015 subcomponent scores across levels according to the percent of the maximum subcomponent score achieved. The radar plot displays visually (without statistical testing) that for eight of the 13 subcomponents, HEI-2015 subcomponent scores decreased from pantry inventory to client carts to client diet.

Table 2 presents HEI-2015 Total and subcomponent scores at each level, and regression results for the association between inventory and client cart scores, and between client cart scores and dietary recall scores. Mean \pm standard deviation HEI-2015 Total score was 65.1 ± 5.1 for pantry inventory, 60.8 ± 11.0 for client carts, and 50.9 ± 15.7 for diet recall. Inventory HEI-2015 scores were positively and statistically significantly associated with cart selection HEI-2015 scores only for the Added Sugars subcomponent ($P = 0.005$), adjusted for all covariates. All but one food pantry had the maximum achievable score for the inventory Total Protein Foods subcomponent, so the regression coefficient is not precise, and all food pantries had the maximum achievable score for the inventory Seafood and Plant Proteins subcomponent, so the regression coefficient is not estimable. Client cart HEI-2015 Total score was positively and statistically significantly associated with client diet HEI-2015 Total score ($P = 0.002$). On average, a 1-point difference in client cart HEI-2015 Total score was positively associated with a 0.27 point difference in client diet Total score. Seven of the 13 HEI-2015 subcomponents for client carts were positively and statistically significantly associated with client diet subcomponents (Total Fruits, Whole Fruits, Total Vegetables, Greens and Beans, Whole Grains, Seafood and Plant Proteins, and Added Sugars), adjusted for all covariates.

DISCUSSION

In this study of 16 choice-based Minnesota food pantries, the Total HEI-2015 inventory score averaged 65.1, client food selection score averaged 60.8, and dietary recall score averaged 50.9. Descriptively, HEI-2015 scores decreased from the level of inventory to client carts to client diet for the majority of subcomponents, although statistical significance was not tested. Contrary to the first hypotheses, inventory HEI-2015 scores were not associated with client cart scores, with the exception of the Added Sugars subcomponent. However, consistent with the second hypothesis, client cart HEI-2015 Total score was positively associated with client diet Total score, along with more than half of the HEI-2015 subcomponent scores.

Although studies using HEI-2015 in the hunger relief system are just emerging,⁴⁰ there is a relative abundance of studies that have used HEI-2010 in the hunger relief system.^{5,6,8,12,14,18,41-43} Whereas some caution is needed in comparing scores across HEI versions, HEI-2010 and HEI-2015 totals have scored within 1 point of each other in an analysis using the same sample,³⁴ and comparison with similar studies using HEI-2010 in food pantries may be useful for contextualizing the current study's results. Most relevant is a recent study of midwestern food pantries by Wright and

Table 1. Unadjusted characteristics of adult food pantry user participants completing baseline measures in the SuperShelf study, and characteristics of the 16 Minnesota food pantries from which clients were recruited during 2018-2019

	Client Cart Sample (n = 316) ^a	Client Diet Sample (n = 282) ^a	Food Pantry Sample (n = 16)
	←————— <i>n (%)</i> —————→		
Age group (y)			
18-44	136 (43.3)	124 (44.0)	
45-64	134 (42.7)	116 (41.1)	
65+	44 (14.0)	42 (14.9)	
Gender			
Female	202 (63.9)	188 (66.7)	
Male	110 (34.8)	91 (32.3)	
Transgender	1 (0.3)	1 (0.35)	
Prefer not to answer	3 (0.9)	2 (0.7)	
Race/ethnicity			
Non-Hispanic White	181 (57.3)	159 (56.4)	
Non-Hispanic Black	50 (15.8)	47 (16.7)	
Non-Hispanic Native American/Alaskan Native	20 (6.3)	16 (5.7)	
Hispanic/Latinx	33 (10.4)	31 (11.0)	
Other, more than 1 race, or missing ^b	32 (10.1)	29 (10.3)	
Highest education level			
Less than high school	38 (12.3)	29 (10.5)	
High school or graduate equivalency degree	115 (37.2)	104 (37.6)	
Some college/associates/vocational-technical degree	122 (39.5)	111 (40.1)	
Four-year college degree or higher	34 (11.0)	33 (11.9)	
Food pantry visit frequency			
Once a month or more	246 (78.9)	218 (78.4)	
Less than once a month	66 (21.1)	60 (21.6)	
	←————— <i>mean (SD)^c</i> —————→		
Household size	3.1 (2.1)	3.1 (2.1)	
Pantry number of freezers + coolers			
More than 6			8 (50)
6 or fewer			8 (50)
Pantry location^d			
Urban			10 (63)
Rural			6 (37)
Pantry households served per month^e			566 (538)
Pantry pounds of food served per month^e			41,295 (41,707)
	←————— <i>Median (range)</i> —————→		
Full time employees			1 (0-6)

^aCategory counts do not sum to total for characteristics with missing data; percentages are calculated based on nonmissing data total.

^bThe sample of 316 includes Asian (n = 1), Native Hawaiian/Pacific Islander (n = 1), Other specified race (n = 3), Prefer not to answer (n = 6), and More than 1 race (n = 21). More than 1 race includes Native American/Alaskan Native and White, Black, or both (n = 15); Other specified race and White, Asian, or Native American (n = 4), White and Black or Native Hawaiian/Pacific Islander (n = 2).

^cSD = standard deviation.

^dUrban food pantries have Rural Urban Commuting Area codes 1 through 3, rural food pantries have Rural Urban Commuting Area codes 4 through 10.

^eData from the manager survey for 15 pantries and from the initial site application for 1 pantry.

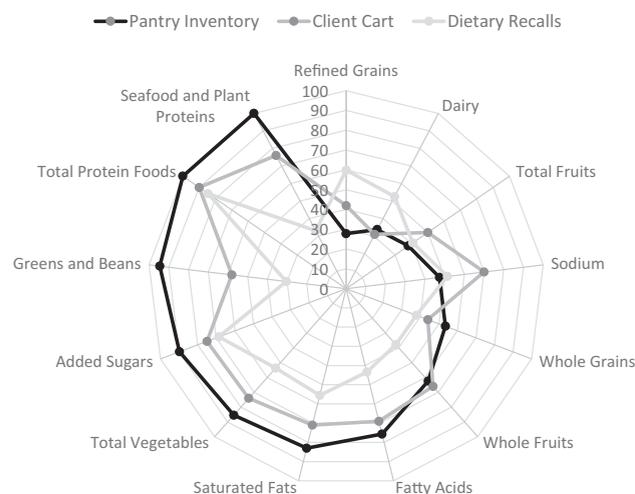


Figure. Radar plot depicting the percent of the maximum possible score for each Healthy Eating Index-2015 subcomponent for food pantry inventory scores, pantry client cart scores, and client dietary recall scores in a sample of Minnesota food pantries in the SuperShelf study during 2018 and 2019.

colleagues,⁴¹ which tested the association between the quality of client food bags and client diet in mostly limited-choice pantries. In that study, the HEI-2010 Total score of food bags was not associated with client diet Total score; three subcomponent scores were statistically significant, but with substantially smaller effect estimates than in the current study. Moreover, Wright and colleagues⁴¹ observed an average client diet HEI-2010 total score of 42.9, compared with an average HEI-2015 Total score of 50.9 in the current study, although the diet quality of food clients received at the pantry was similar in the two studies. A possible explanation for these differences is that the association between the food received at the pantry and client dietary intake is stronger and client diet quality is higher when clients have more choice to select their own food at the pantry. Alternately, differences in the results between the two studies might not be explained by pantry distribution method, and might be explained instead by methodological differences, such as the lag time between when the food pantry visit occurred and when dietary recalls were collected. Future research is warranted to directly compare measures of diet quality in limited-choice and full-choice pantries to better understand whether and how client choice models contribute to a healthier diet.

Descriptive findings from the current study suggest that food received at the pantry is generally healthier than foods from all sources consumed by clients. One likely reason for differences between client cart measures and client diet measures is that food obtained from the pantry food is intended for household consumption. With an average household size of 3.1, foods from the pantry are likely to be frequently shared across household members, which would weaken the association between client cart and client diet measures. Our findings are, however, consistent with other studies in mostly limited-choice pantries suggesting that the diet quality of client diets may have been even lower without the food provided at the pantry.^{7,8,18}

Food pantry inventory HEI-2015 scores were mostly not associated with client cart HEI-2015 scores, with the exception of the Added Sugars subcomponent. With the inventory Added Sugars HEI-2015 subcomponent score averaging 90% of the maximum score, it could be that most pantries presented few opportunities for clients to select many items high in added sugars. One explanation for the lack of other statistically significant associations is that inventory HEI-2015 scores were perhaps not variable enough across pantries to detect an association with client carts. The standard deviation for the inventory HEI-2015 Total score was small at 5.1,^{41,44} and for two subcomponents the score demonstrated almost no variability across pantries at all. Other pantry and clients factors likely also contributed to the null findings. For example, behavioral economic theory^{45,46} and evidence from previous studies^{5,47} supports the notion that pantry layout and aesthetics might influence client food selection beyond the availability of foods. Moreover, even excluding back stock, inventory measures may have an overabundance of certain food categories, and may not have aligned well with client demand due to space constraints, incidental stocking practices by volunteers, or other unknown pantry practices. The pantries in this study also set some guidelines for the amount of food in certain categories that clients could select that may have weakened the association between inventory and food selected. All of these pantry and client factors could explain why inventory and client cart scores were mostly not associated. With the development of more refined pantry environment assessment tools, future research might examine these influences in the pantry further, much in the way that food retail environment researchers continue to explore the influence of store marketing and food affordability on the healthfulness of customer grocery purchases.^{27,48,49} Finally, client food selections may incorporate an array of client preferences, including those related to food skills, cultural background, and health conditions.⁵⁰⁻⁵²

Limitations

This study presents associations of HEI-2015 scores at three levels of the hunger relief system, but the cross-sectional study design does not support causal claims about the effects of food pantry environment on client behavior. Future analyses in this group-randomized study will look at the potential causal effect of pre/post changes in inventory and changes in client food selection on client diet as a result of the intervention. The study was also limited to a specific geographic region and limited to choice-based pantries that had opted in to an intervention study. Participating pantries may have had healthier food than other pantries in the United States because they were selected because they were choice-based and had a high capacity. Thus, the range of pantries and pantry clients included in the study is unlikely to be generalizable to the full range of pantries and client populations in the United States. Whereas 24-hour dietary recalls have some strengths for assessing dietary behavior relative to other measures,^{53,54} recalls can result in under- or overreporting of nutrients^{53,54}; moreover, different dietary patterns have been observed on weekends vs weekdays,⁵⁵ and the known day-to-day variability may be particularly relevant in a study that relies on a single dietary recall.

In addition, this study does not include factors such as pantry layout, which may have influenced associations, and

Table 2. Healthy Eating Index-2015 (HEI-2015) scores and the association between food pantry inventory HEI-2015 scores (independent variable) and food pantry client cart HEI-2015 scores (dependent variable) and the association between food pantry client cart HEI-2015 scores (independent variable) and food pantry client diet HEI-2015 scores (dependent variable) in a sample of Minnesota food pantries and their clients participating in the SuperShelf study in 2018-2019

HEI-2015 component (maximum score)	Food pantry inventory (n = 16)	Food pantry client carts (n = 316)	Inventory-cart HEI-2015 score association ^a (n = 303)		Food pantry client diet (n = 282)	Cart-diet HEI-2015 score association ^a (n = 271)	
	Mean (SD) ^b	Mean (SD) ^b	β (SE) ^c	P value ^d	Mean (SD) ^b	β (SE) ^c	P value ^d
Total score (100)	65.1 (5.1)	60.8 (11.0)	0.27 (0.22)	0.224	50.9 (15.7)	0.27 (0.08)	0.002
Total Fruits (5)	1.9 (0.7)	2.5 (1.4)	0.17 (0.19)	0.359	2.0 (2.2)	0.33 (0.09)	< 0.001
Whole Fruits (5)	3.1 (1.1)	3.3 (1.6)	0.12 (0.11)	0.291	1.9 (2.2)	0.28 (0.09)	0.002
Total Vegetables (5)	4.3 (1.0)	3.7 (1.3)	0.09 (0.09)	0.334	2.7 (1.8)	0.20 (0.09)	0.019
Greens and Beans (5)	4.7 (0.7)	2.9 (1.9)	0.17 (0.20)	0.386	1.5 (2.2)	0.21 (0.07)	0.005
Whole Grains (10)	5.4 (2.2)	4.4 (3.2)	0.06 (0.16)	0.686	3.8 (4.2)	0.24 (0.08)	0.003
Dairy (10)	3.4 (2.2)	3.1 (2.2)	0.15 (0.14)	0.261	5.3 (3.8)	0.14 (0.11)	0.217
Total Protein Foods (5) ^e	5 (0)	4.5 (0.9)	Unstable estimate	Unstable estimate	4.2 (1.3)	0.02 (0.09)	0.817
Seafood and Plant Proteins (5) ^f	5 (0)	3.8 (1.7)	Unstable estimate	Unstable estimate	1.7 (2.2)	0.16 (0.08)	0.046
Fatty Acids (10)	7.6 (2.5)	6.9 (3.2)	0.004 (0.13)	0.977	4.3 (3.7)	0.09 (0.07)	0.242
Refined Grains (10)	2.8 (2.9)	4.2 (3.6)	-0.05 (0.13)	0.699	6.0 (4.0)	0.06 (0.07)	0.381
Sodium (10)	4.7 (2.9)	7.0 (3.4)	0.16 (0.11)	0.159	5.1 (3.9)	0.03 (0.07)	0.710
Added Sugars (10)	9.0 (1.0)	7.5 (2.6)	0.90 (0.32)	0.005	6.9 (3.4)	0.22 (0.08)	0.008
Saturated Fats (10)	8.3 (2.7)	7.1 (2.9)	-0.14 (0.15)	0.358	5.6 (3.6)	0.06 (0.08)	0.454

^aModels for association between HEI-2015 scores (Inventory and cart, cart and diet) are adjusted for client level covariates: age, gender, race/ethnicity category, education level, household size, and frequency of food pantry visits, and food pantry level covariates: urban or rural location, average pounds of food served per month, number of freezers and coolers (> median or ≤ median); models include a random intercept for food pantry to account for clustering of clients within food pantries.

^bSD = standard deviation.

^cSE = standard error.

^dStatistical significance was determined at $P < 0.05$.

^eCoefficient for inventory Total Protein Foods HEI-2015 is unstable because all but one food pantry had a score of 5 for this subcomponent.

^fCoefficient for inventory Seafood and Plant Protein HEI-2015 is unstable because all 16 food pantries had a score of 5 for this subcomponent.

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should be explored in future studies. Moreover, all pantries had some guidelines on how much food clients could select that were not easily accounted for. In the pantry setting, these guidelines might be considered roughly analogous—although not perfectly similar—to price constraints at a grocery store, which affects how much food is taken among those shopping on a budget.

CONCLUSIONS

In this study of 16 choice-based Minnesota food pantries, the diet quality of food pantry inventory was mostly not associated with the diet quality of the food selected by clients. The HEI-2015 score of food selected by clients was positively and statistically significantly associated with client diet HEI-2015 Total score and with a number of subcomponents. Results suggest that food pantries are an important source of healthy food for clients, including fruits, vegetables, whole grains, and other nutrient sources. Additional studies are needed to test whether improvements in the food pantry environment, particularly changes that support healthier client food selection, might be causally related to improvements in client dietary behaviors.

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AUTHOR INFORMATION

C. E. Caspi is director of food security initiatives, Rudd Center for Food Policy and Obesity, University of Connecticut, Hartford; an associate professor, Department of Allied Health Sciences, University of Connecticut, Storrs; and an assistant/associate professor, Program in Health Disparities Research, Department of Family Medicine and Community Health, University of Minnesota, Minneapolis. C. Davey is a data analyst with the Biostatistical Design and Analysis Center, Clinical and Translational Science Institute, University of Minnesota, Minneapolis. C. B. Barsness is a project manager, Program in Health Disparities Research, Department of Family Medicine and Community Health, University of Minnesota, Minneapolis. J. Wolfson is an associate professor, Division of Biostatistics, School of Public Health, University of Minnesota, Minneapolis. H. Peterson is a professor, Department of Applied Economics, University of Minnesota, St Paul. R. Pratt is an assistant professor, Program in Health Disparities Research, Department of Family Medicine and Community Health, University of Minnesota, Minneapolis.

Address correspondence to Caitlin E. Caspi, ScD, Rudd Center for Food Policy and Obesity, University of Connecticut, 1 Constitution Plaza, Hartford, CT 06103. E-mail: caitlin.caspi@uconn.edu

STATEMENT OF POTENTIAL CONFLICT OF INTEREST

No potential conflict of interest was reported by the authors.

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C. B. Barsness was responsible for data management and C. Davey conducted the data analysis on consultation with J. Wolfson. C. E. Caspi wrote the first draft with contributions from H. Peterson and R. Pratt. All authors reviewed and commented on subsequent drafts of the manuscript.