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A Cluster-Randomized Evaluation of the SuperShelf Intervention in Choice-Based Food Pantries

Caitlin E. Caspi, ScD[1,2] · Maria F. Gombi-Vaca, PhD[2] · Christina Bliss Barsness, MPH, RD[3] · Nora Gordon, MPH[3] · Marna Canterbury, MPH, RD[4] · Hikaru Hanawa Peterson, PhD[5] · Julian Wolfson, PhD[6] · Rebekah Pratt, PhD[3]

[1]University of Connecticut, Department of Allied Health Sciences, Storrs, CT, USA
[2]University of Connecticut, Rudd Center for Food Policy and Health, Hartford, CT, USA
[3]University of Minnesota, Department of Family Medicine and Community Health, Minneapolis, MN, USA
[4]HealthPartners, Bloomington, MN, USA
[5]University of Minnesota, Department of Applied Economics, St. Paul, MN, USA
[6]University of Minnesota, Division of Biostatistics, Minneapolis, MN, USA

Caitlin E. Caspi
caitlin.caspi@uconn.edu

Abstract

Background Interventions in food pantry settings have the potential to improve health among clients at risk of diet-related disease.

Purpose This study evaluates whether a cluster-randomized, behavioral intervention in food pantries resulted in improved client outcomes.

Methods Sixteen Minnesota food pantries were randomized to an intervention (n = 8) or control condition (n = 8). The intervention offered pantries technical assistance to improve healthy food supply and implement behavioral economics strategies to promote healthy food selection. A convenience sample of adult clients were enrolled (paired sample, 158 intervention, 159 control) and followed for 1 year. Additional clients were enrolled at follow-up to assess food selection (follow-up sample, 85 intervention, 102 control). Analysis was limited to data from 11 pantries (5 intervention, 6 control) due to COVID-19. Outcome measures included Healthy Eating Index-2015 (HEI-2015) total and subcomponent scores for 24-hr dietary recalls and client cart selections, and Life's Simple 7 (LS7) total and subcomponent scores. Multilevel mixed-effects models tested whether client outcomes differed by intervention condition.

Results In adjusted models, there were no statistically significant differences by intervention condition in HEI-2015 or LS7 scores. Clients in intervention food pantries had improved Refined Grain subcomponent scores (p = .004); clients in control pantries had worsened Saturated Fat subcomponents scores (p = .019) and improved physical activity scores (p = .007).

Conclusions The intervention did not result in improved diet quality or cardiovascular health as measured by HEI-2015 or LS7. Coordinated efforts across settings are needed to address health risks facing this population.

Lay summary

Food pantries are an optimal setting to address health and diet quality among clients experiencing food insecurity. This study tests whether a food pantry intervention resulted in improved dietary and cardiovascular outcomes among clients. Sixteen Minnesota food pantries were randomized to either receive an intervention or a delayed intervention. The intervention offered food pantries technical assistance to improve healthy food supply and "nudge" clients toward healthy choices. Due to the COVID-19 pandemic, measures were completed 11 pantries (5 intervention, 6 control). Outcome measures included diet quality of food selected by clients, diet quality of food consumed by clients, and Life's Simple 7 measure of cardiovascular health. The intervention did not result in improved diet quality or cardiovascular health. Coordinated efforts across community settings are needed to address health risks facing this population.

Keywords Food pantries · Intervention · Behavioral economics · Healthy Eating Index

Introduction

Food insecurity is a household-level condition of limited or uncertain access to adequate food [1]. In the USA, approximately 10% of households experienced food insecurity in 2021, although rates surpassed 15% for single adult-headed households, Black and Hispanic households, and lower-income households [1]. Food insecurity is often a result of economic and structural barriers to accessing healthy and affordable food [2]. This can result in suboptimal dietary patterns [3–5]. Given the increased risk of diet-related chronic diseases associated with food insecurity [6–8], interventions are needed to increase access to healthy and affordable food in this population.

Traditionally, food pantries primarily address acute food needs of households facing food insecurity [9], but do not address the root causes of food insecurity. At the same time, clients who rely on food pantries tend to obtain a significant portion of their total food from the pantry and rely

on them for long periods of time [10–12]. This reality has prompted many food pantries to consider their role in supporting healthy dietary patterns among households at a high risk of diet-related disease. U.S. food pantries have increasingly engaged in efforts to promote healthy dietary behaviors among their clients [9, 13, 14]. Conventional intervention approaches in food pantries have been focused at the individual level, such as nutrition education for clients [15, 16]. More recent approaches that may be appropriate for resource-stretched food pantries have included organizational support and technical assistance for providing healthier food [17–19] and using behavioral economics to promote behavior change [10, 20, 21]. Pairing organizational-level technical assistance with behavioral economics may be particularly important to address issues of both healthy food supply and client demand for healthy food in the food pantry [10]. Technical support may be essential because volunteers are often responsible for the day-to-day operations at food pantries [9] and intervention implementation barriers in this setting are high [10, 22, 23]. Meanwhile, behavioral economics strategies, which use "nudges" to change behavior through deliberate choice architecture [24, 25], have the advantage of placing relatively little burden on clients [10] and may also be less burdensome than educational interventions for staff and volunteers implementing them. While various efforts to measure and increase healthy food options have been growing [26], the charitable food system is a historically fragmented and under-resourced setting, and most efforts have not been systematically evaluated.

SuperShelf is a community-led initiative that began in 2013 in choice-based food pantries in Minnesota and its central-eastern border. SuperShelf food pantries undergo a "transformation" process, working with a trained consultant, often a SNAP-Ed educator, who provides technical assistance to improve the supply of healthy food. They then implement behavioral economics strategies to make the healthy choice the easiest choice by organizing the food pantry by food group, ensuring that fruits and vegetables are displayed appealingly, and de-emphasizing lower nutritional quality foods. In a 2017 pilot evaluation in which two food pantries implemented SuperShelf, both pantries demonstrated improvements in the nutritional quality of food inventory at follow-up compared with baseline [10]. In the pantry with better implementation, the average nutritional quality of food selected by clients improved by 11.8 points on the Healthy Eating Index [10], with no improvements seen in the pantry with poorer implementation.

A randomized study of SuperShelf was launched in 2018 to further evaluate client and food pantry outcomes. A cluster-randomized design was selected because the intervention was implemented at the pantry level. Early findings from that evaluation showed that food pantries were successful at implementing SuperShelf intervention changes to the physical environment [27]. The intervention resulted in measurable changes in aesthetics and layout, promotion of healthy foods, and de-emphasis of less healthy foods compared with control food pantries. The nutritional quality of food available to clients improved by some measures (inventory Food Assortment Scoring Tool score), but not others (inventory Healthy Eating Index-2015 [HEI-2015] score) [27]. The current study reports the results of the client-level outcomes. We hypothesized that clients who obtain food from pantries randomized to the SuperShelf intervention would demonstrate positive changes in diet quality and cardiovascular health outcomes compared with clients in the control condition.

Methods

Study Overview

Study methods and results are reported following Consolidated Standards of Reporting Trials (CONSORT) guidelines [28] with the extension for cluster trial designs [29]. The study randomized food pantries in Minnesota to an intervention (n = 8) or control (n = 8) condition [30]. The evaluation tested whether the intervention condition resulted in more favorable outcomes for the following client health measures: diet quality as measured by the HEI-2015 [31] (primary outcome), food selection as measured by HEI-2015 (secondary outcome), and cardiovascular health as measured by Life's Simple 7 [32] (LS7, secondary outcome). The target sample size of 17 participants per food pantry at baseline was calculated based on 16 clusters, an intracluster correlation of 0.05, an expected difference in change in the primary outcome of 7.5 HEI points between arms with a standard deviation of 14.4 points, and an attrition rate of up to 30% [33].

Baseline data were collected over two waves of eight pantries (February–May 2018 and February–June 2019) with follow-up data collection planned for 1 year after baseline at each food pantry. In March 2020, food pantries in Minnesota closed indefinitely for indoor visits due to the COVID-19 pandemic. At that time, 11 food pantries (5 intervention, 6 control) had completed the planned intervention activities and evaluation measures that required in-person data collection. In-person intervention and evaluation activities at the remaining five food pantries were terminated early. The current analysis reports data from the 11 completed food pantries. An intent-to-treat sensitivity analysis also includes the available data (i.e., no in-person measures) from the three intervention and two control food pantries disrupted by COVID-19.

Site Selection

Food pantries in Minnesota were invited to participate through an online application process that drew applications from 63 unique pantries over two waves in 2018 and 2019. Ten food pantries applied in both waves, for a total of 73 applications considered. The application and site selection process have been previously described [4]. Participating pantries were required to have "full client-choice," in which clients could physically select their food from all food groups, and also required to have a worker who could devote 4–6 hr per month to implementing intervention activities. Food pantries submitted applications that were reviewed by at least two members of SuperShelf's founding partners to assess whether they were qualified, meaning that they met eligibility criteria, were likely to have the capacity to successfully implement the intervention, and the data collection activities were feasible at the site [34]. The Consort Table (Fig. 1) shows the selection process outcome of each unique applicant.

Seventeen qualified pantries were selected for a site visit; one food pantry was designated unqualified after the site visit. Sixteen selected pantries were randomized to the intervention or control condition. The manager of each pantry signed a Memorandum of Understanding (MOU); food pantries in the control group were asked not to make SuperShelf-related changes until study data collection had concluded.

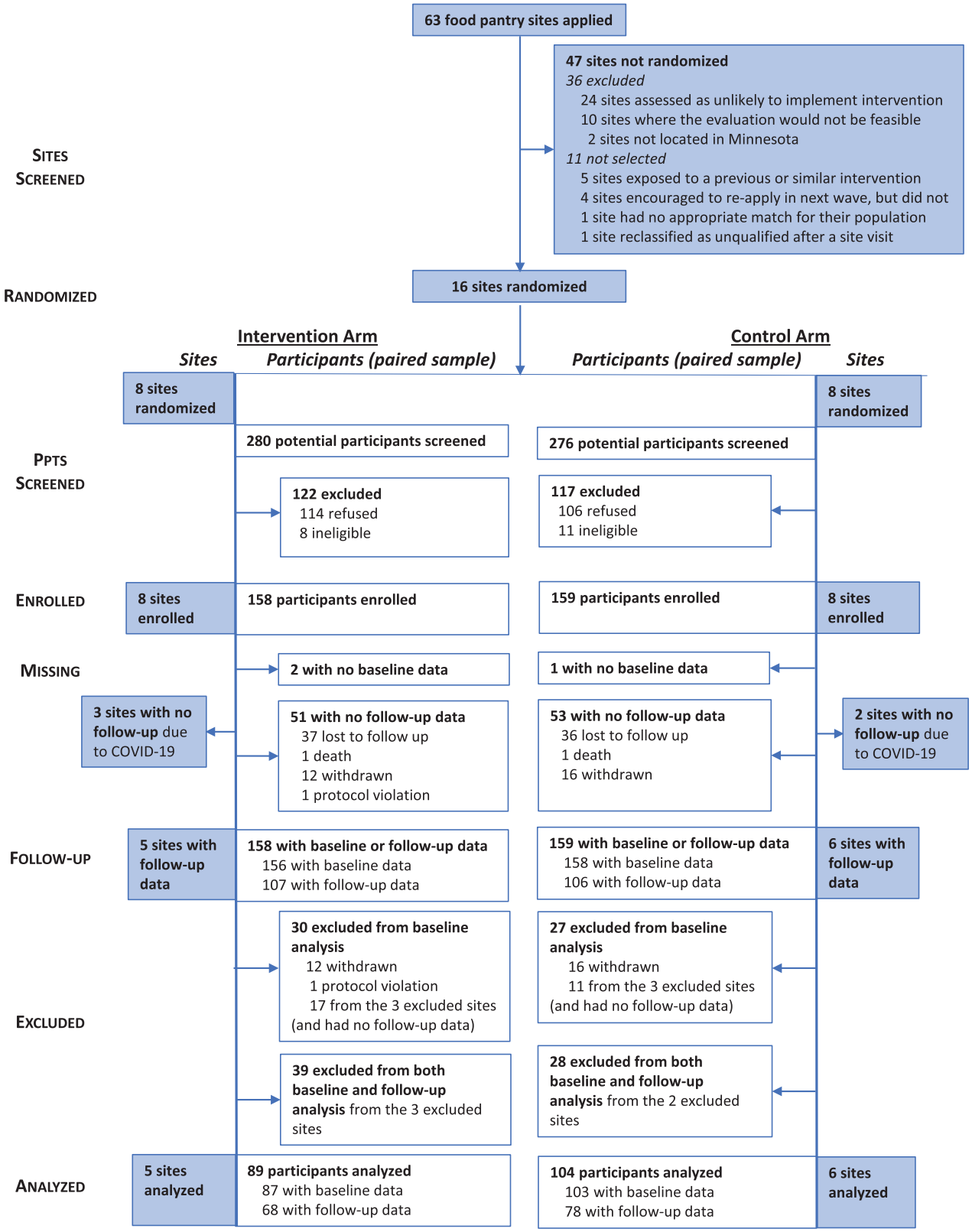

Fig. 1. CONSORT figure for screening, enrollment, follow-up and analysis of food pantry sites and participants in the longitudinal paired sample, based on the primary outcome analysis of client diet quality measured among clients with at least one 24-hr dietary recall. An additional 187 (85 intervention, 102 control) participants were recruited at 5 intervention and 6 control food pantries for the cross-sectional secondary outcome of client cart food selection, with no loss to follow-up or exclusions in the analysis.

Randomization

The randomization process has been previously described [27]. Within each wave, the selected food pantries were matched prior to randomization using Rural Urban Commuting Area (RUCA) codes [35], food bank catchment area (nonoverlapping regions determined by food banks), and interventionist (based on assigned SNAP-Ed Educator region). Randomization was conducted by the project coordinator using a virtual coinflip generator with no concealment after assignment. Control food pantries received no intervention during the study period but were provided a delayed intervention following the completion of all data collection.

Client Enrollment

The study was approved by the Institutional Review Board at University of Minnesota and University of Connecticut. The research team agreed upon a data collection start date with each food pantry; on the start date, the research team screened all clients receiving food at the food pantry until at least 17 clients were enrolled. Clients were approached and consent was obtained after they had selected their food. Participants were required to be at least 18 years old, speak English, Spanish, or Somali, be mentally capable of consent and participation, and have access to a phone.

A convenience sample of 317 clients was enrolled at baseline (paired sample, 158 intervention, 159 control). Client measures for this sample included: (i) a survey of demographics, food pantry usage, and cardiovascular health; (ii) a record of the food clients selected at their visit; and (iii) two 24-hr dietary recalls collected by telephone following the visit. After 1 year, clients were contacted again and asked to complete a follow-up survey and two additional 24-hr dietary recalls. Since these measures were remotely collected, they were obtained among clients at all 16 food pantries and are included in the intent-to-treat analysis.

It was not feasible to collect food selection data at the pantry from the same clients 1 year later because clients might not still be using the food pantry at follow-up, and measures would be biased because participants would know they were being observed. Therefore, a second sample of 187 clients (follow-up only, 85 intervention, 102 control) was enrolled during follow-up to measure client food selection. The follow-up only sample completed a shortened version of the survey. The follow-up only sample only includes clients from the 11 food pantries collected prior to the start of the COVID-19 pandemic.

Intervention

SuperShelf is a collaborative, community-led intervention developed by a core team of representatives from a food pantry, a food bank, an integrated health care system, a university research team, and the university's Extension services [36]. Detailed descriptions of the intervention have been published [4, 10]. The intervention was implemented by trained SuperShelf consultants, mostly SNAP-Ed educators at University of Minnesota who worked with each food pantry over a period of 1–2 months. The two phases of the intervention focus on improving healthy food availability in the food supply, and promoting healthy foods on the shelf using choice architecture. In the first phase, consultants analyzed food procurement practices at the pantry. They worked with pantry staff to increase the quantity and variety of healthy food, for example, by maximizing the rescue of fruits and vegetables from local produce distributors.

In the second phase, behavioral economics strategies were implemented. Consultants guided a pantry reorganization into major food groups. Food groups included fruits and vegetables, grains, proteins, and dairy (which align with USDA MyPlate [37] categories), along with a category for cooking and baking items, which are in high demand in Minnesota food pantries [38]. Highly processed foods, including mixed meals, snacks, and desserts, were placed last. New shelving, paint, displays, and signage made foods like fruits and vegetables attractive; healthy foods were bundled with other items to promote home-cooked meals. Consultants designed a new client "shopping list" organized according to the updated food categories. By necessity, food allowances at each pantry were customized to the food pantry's inventory and sourcing streams. Food allowances varied by household size and food category. For example, due to limitations in inventory, all pantries set limits on dairy items; typical food pantries might allow 1 milk item to be selected for a household of three to four people. In contrast, for fruits and vegetables, consultants strongly encouraged food pantries to offer them without limitations ("take all you can use"), recognizing that at times, sourcing constraints prevented the ability to distribute all types of fresh fruits and vegetables in this way. Consultants also guided food pantries in customizing the shopping list to minimize defaults for less healthy options [10]. For example, prior to the intervention, food pantries might offer macaroni and cheese as a default option; clients could opt *not* to take macaroni and cheese, but only at an opportunity cost. The new shopping list grouped macaroni and cheese into a broader "mixed meals" category so that it was one choice that competed among others, rather than a default. Control pantries operated in a "business as usual" manner with no redesign of their space or shopping lists. As part of the study, intervention food pantries could be reimbursed up to $4,000 to implement these environment changes by submitting receipts; the consultant also assisted managers in placing an order of up to $1,000 for SuperShelf branded signage from a printing company, designed to create an appealing environment with signage similar to retail grocers.

Diet Quality Measure (Primary Outcome, Paired Sample)

Overall diet quality was measured by up to two 24-hr dietary recalls at both baseline and follow-up, collected during unannounced phone calls by study staff at University of Minnesota Nutrition Coordinating Center (NCC). This outcome was intended to measure typical food consumption, not only in the days after a food pantry visit. Staff aimed to collect the first recall at baseline within 1 week of the food pantry visit and the second recall within 3 weeks of the food pantry visit. Because assessments could not be timed around food pantry visits at the 1-year follow-up, capturing dietary intake in this way was the most appropriate comparison between baseline and follow-up. Recalls relied on direct data entry into Nutrition Data Systems for Research (NDSR) nutrient calculation software [39]. Using a multiple-pass interview technique and a food amount booklet to assist in estimating portions, participants were prompted for complete food recall and descriptions of foods consumed from midnight to midnight the previous day [40]. The NCC Food and Nutrient Database [41] includes over 18,000 foods and over 160,000

food variants. It generates values for 174 nutrient, nutrient ratios, and other food components.

An HEI score was computed for each participant at each time point by averaging the two 24-hr recall scores or using the single recall available. HEI is an assessment tool developed and evaluated by the National Cancer Institute (NCI) and the U.S. Department of Agriculture (USDA) [31, 42]. The HEI-2015 replaced the planned HEI-2010 measure when the 2015 version, which aligned with 2015–2020 Dietary Guidelines for Americans (DGA) [43], was released after the start of the study. 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) that are reverse scored. Scores are computed by deriving ratios of dietary constituents to energy for each subcomponent except Fatty Acids, which is computed as the ratio of poly- and mono-unsaturated fatty acids to saturated fatty acids. Subcomponents are scored according to minimum and maximum standards. For all subcomponents, higher scores represent better alignment with the DGA [31].

Client Food Selection Measure (Secondary Outcome, Both Samples at First Contact Only)

At baseline in the paired sample and in the follow-up only sample, research staff photographed each food in a client's cart with an iPod Touch. Photographs of prepackaged foods including the product name, brand, size, quantity, and special nutritional notes on the label (e.g., reduced fat). Photographs of non-packaged items were taken with the item placed on a scale. Foods were entered into an Excel database and then NDSR by entering each item's exact profile (brand, preparation form, etc.). A generic version or a substitute with similar nutrient profile using the nutrition facts label was selected if no exact match was found, or the food product would be entered as an assembled food or recipe using the ingredients list.

Cardiovascular Health Measure (Secondary Outcome, Paired Sample)

Cardiovascular health was measured by LS7 [32] captured through self-report at baseline and follow-up. LS7 is a summary of seven modifiable subcomponents, including smoking, healthy diet, physical activity, body mass index, blood pressure, total cholesterol, and fasting glucose [44, 45]. LS7 total scores were based on a scale of 0–7 representing the sum of scores for each of the subcomponents. The LS7 subcomponents levels and scores defined are described in Supplementary Table S1.

Food Pantry Characteristic Measures

Pantry characteristics were assessed by an online form through REDCap (Research Electronic Data Capture, Version 10.0.28) [46]. Managers completed a survey at baseline and follow-up in 11 food pantries.

Client Characteristic Measures (Both Samples)

Surveys assessed self-reported individual and household demographics and food pantry usage. A customized question on the paired sample follow-up survey asked if they had visited the food pantry since the month that the intervention was completed (for participants at intervention sites) and the same month for participants at each matched control site. The survey was self-administered through REDCap or on a paper copy.

Analytic Sample

The analytic sample for client diet quality and cardiovascular health included all participants from the paired sample from the 11 food pantries with at least one dietary recall at baseline or follow-up (n = 89 baseline, n = 104 follow-up). Clients who had not visited the pantry since the intervention transformation (n = 8 intervention, n = 11 control) were included in the analysis. The analytical sample for food selected by clients included all participants in the follow-up only sample (n = 187) at 11 food pantries.

Analysis

The analysis was conducted in 2021–2022. Linear mixed models examined change from baseline to follow-up in client diet quality (HEI-2015 total and subcomponents scores) and cardiovascular health (LS7 total and subcomponents scores) by intervention arm using clients with data at baseline or follow-up. Models included a random intercept for food pantry to account for clustering of clients within pantries and a random intercept for client nested within pantries to account for within-client correlation over time. Model estimates were adjusted for client gender, age, race/ethnicity, education, household size, frequency of food pantry visit, and amount of all food from food pantry in past 6 months. Household size, frequency of food pantry visits, and amount of food from food pantry in past 6 months were included as time-varying covariates. Food pantry-level covariates included location (urban or rural), pounds of food served per month, and number of freezer/coolers. The estimates for HEI-2015 total score and subcomponents scores were rescaled by dividing the estimated value by the corresponding averaged pre-intervention HEI-2015 scores, yielding measures of proportional change relative to baseline scores. This approach was used because HEI-2015 subcomponents have different maximum scores; rescaling yields a consistent interpretation of coefficients across subcomponents. Intracluster correlation coefficients (ICCs) were estimated for each outcome. Finally, for the primary outcome we ran an intent-to-treat mixed-model analysis that included data from clients at all 16 food pantries in the study. We also ran a mixed model analysis excluding the 19 clients who reported not visiting the food pantry since its transformation.

For the outcome of food selected by clients (HEI-2015 total and subcomponent scores), linear mixed models examined differences between follow-up only clients in intervention and control pantries, including a random intercept for food pantry to account for clustering of clients within food pantry. Models were adjusted for the average baseline pantry-level HEI-2015 scores for food selected by clients. This number was derived by averaging food selection HEI-2015 scores at each pantry from the paired sample at baseline. Models were also adjusted for the same individual- and pantry-level covariates as in the model for the primary outcome described above.

Results

There were no notable harms or unintended effects noted in either group. Characteristics of participating food pantry

clients and food pantries are presented in Table 1. In both analytical samples (paired and follow-up only), most participants were female, with about half between 45 and 64 years old. About half of participants obtained half or more of all food in the last 6 months from a food pantry, and visited a food pantry once a month or more in the last 12 months.

Results of the mixed models for the client diet quality HEI-2015 score in the paired sample are presented in Table 2. Mean baseline HEI-2015 total scores were 50.3 in the intervention arm and 49.6 in the control arm. At baseline, first recalls were obtained a median of 3 days after the pantry visit and second recalls were obtained a median of 13 days after the pantry visit. The ICC was 0.047. In adjusted models, there were no statistically significant differences in changes in client diet HEI-2015 total or subcomponent scores between intervention arms (p = .512). Within the intervention arm, there was a 27% increase in the Refined Grains subcomponent score (p = .004) and in the control arm, there was a 17% decrease in the Saturated Fat subcomponent score (p = .019). The results from the intent-to-treat sample of clients from

Table 1 Characteristics of Food Pantries and Food Pantry Clients Participating in the SuperShelf Intervention at Baseline

Food pantry characteristics	**Intervention (n = 5)**		**Control (n = 6)**	
Pantry number of freezers/coolers, n (%)				
More than 6	3	(60)	2	(33.3)
6 or fewer	2	(40)	4	(66.7)
Pantry location, n (%)				
Urban	3	(60)	3	(50)
Rural	2	(40)	3	(50)
Pantry pounds of food served per month, mean (*SD*)	31,488	(29,734)	29,388	(13,902)

Food pantry client characteristics	**Paired sample**				**Follow-up only sample**			
	Intervention (n = 89)		**Control (n = 104)**		**Intervention (n = 85)**		**Control (n = 102)**	
Gender, n (%)								
Female	57	(64.0)	65	(63.1)	49	(58.3)	63	(61.8)
Male	32	(36.0)	37	(35.9)	34	(40.5)	39	(38.2)
Non-binary	0	(0.0)	1	(1.0)	1	(1.2)	0	(0.0)
Age group, n (%)								
18–44 years old	37	(41.6)	39	(37.5)	36	(42.9)	44	(44.0)
45–64 years old	37	(41.6)	52	(50.0)	42	(50.0)	44	(44.0)
≥65 years old	15	(16.9)	13	(12.5)	6	(7.1)	12	(12.0)
Race/ethnicity[a], n (%)								
Hispanic-Latino/a	10	(11.2)	9	(8.7)	13	(15.7)	10	(10.3)
Non-Hispanic White	60	(67.4)	58	(55.8)	46	(55.4)	53	(54.6)
Non-Hispanic Black	9	(10.1)	28	(26.9)	10	(12.1)	17	(17.5)
Non-Hispanic Native American	4	(4.5)	3	2.9)	4	(4.8)	4	(4.1)
More than one race or Other	6	(6.7)	6	(5.8)	10	(12.1)	13	(13.4)
Education, n (%)								
Less than high school	8	(9.1)	14	(13.9)	8	(9.6)	6	(6.2)
High school or graduate equivalency degree	31	(35.2)	43	(42.6)	33	(39.8)	36	(37.1)
Some college/associates/vocational-technical degree	32	(36.4)	37	(36.6)	33	(39.8)	46	(47.4)
Four-year college degree or higher	17	(19.3)	7	(6.9)	9	(10.8)	9	(9.3)
Frequency of food pantry visit, n (%)								
Once a month or more	61	(70.9)	71	(69.6)	60	(72.3)	75	(73.5)
Less than once a month	25	(29.1)	31	(30.4)	23	(27.7)	27	(26.5)
Amount of all food from food pantry in past 6 months, n (%)								
Half or more of all food	48	(53.9)	50	(48.1)	43	(51.8)	53	(52.5)
Less than half of all food	41	(46.1)	54	(51.9)	40	(48.2)	48	(47.5)
Household size, mean (*SD*)	2.8	(1.6)	2.5	(1.7)	3.1	(2.0)	2.7	(1.9)

[a]Participants self-reported racial background as "Native American," "Alaska Native," "Asian, including Southeast Asian," "Native Hawaiian or Pacific Islander," "Black, African American," "African (e.g., Somali, Ethiopian, Liberian, Eritrean)," "White or Caucasian," "I identify as…(please specify)," or prefer not to answer; and self-reported ethnicity as "Hispanic or Latino/a," "Non-Hispanic or Latino/a," or prefer not to answer. Race and ethnicity were combined into one variable. Participants of all races who self-classified as Hispanic or Latino/a formed a category. Those who self-classified as "Non-Hispanic or Latino/a" were classified as Non-Hispanic and their race, with "White or Caucasian" renamed Non-Hispanic White, "Black, African American" or "African" renamed Non-Hispanic Black, and Native American" renamed Non-Hispanic Native American.

Table 2 Changes in Healthy Eating Index-2015 (HEI-2015) Score and Life's Simple 7 (LS7) Score in the Paired Sample[a]

HEI-2015 component (max. score)	Diet quality							
	Intervention (five sites)			Control (six sites)			Between-arm changes[b,c]	
	Baseline (n = 87)	Follow-up (n = 68)	Within-arm changes	Baseline (n = 103)	Follow-up (n = 78)	Within-arm changes		
	Mean (*SD*)		p value	Mean (*SD*)		p value	Estimate (*SE*)	p value
Total score (100)	50.3 (15.2)	50.9 (12.8)	.491	49.6 (15.1)	48.7 (10.8)	.821	0.03 (0.1)	.512
Total Vegetables (5)	2.6 (1.6)	3.0 (1.5)	.415	2.8 (1.6)	2.6 (1.6)	.500	0.12 (0.1)	.290
Greens and Beans (5)	1.6 (2.1)	1.5 (2.1)	.396	1.4 (2.0)	1.3 (1.9)	.508	−0.05 (0.3)	.870
Total Fruits (5)	2.0 (2.0)	1.8 (1.9)	.339	2.1 (2.0)	1.9 (2.0)	.890	−0.10 (0.2)	.531
Whole Fruits (5)	2.0 (2.1)	1.5 (1.9)	.054	1.9 (2.1)	1.7 (2.0)	.920	−0.27 (0.2)	.142
Whole Grains (5)	3.6 (3.9)	3.9 (3.7)	.234	4.7 (4.0)	3.8 (3.6)	.397	0.25 (0.2)	.148
Dairy (10)	6.2 (3.3)	5.7 (3.6)	.545	5.1 (3.4)	5.4 (3.1)	.636	−0.08 (0.1)	.443
Total Protein Foods (5)	4.2 (1.3)	4.4 (1.0)	.364	4.5 (1.0)	4.7 (0.7)	.089	−0.03 (0.2)	.608
Seafood and Plant Proteins (5)	1.9 (2.2)	2.1 (2.2)	.699	1.5 (1.9)	2.1 (2.1)	.140	−0.20 (0.3)	.463
Fatty Acids (10)	3.7 (3.1)	3.7 (3.5)	.821	3.7 (3.1)	4.1 (3.2)	.316	−0.09 (0.2)	.598
Sodium (10)	5.5 (3.4)	5.2 (3.5)	.838	4.2 (3.5)	3.8 (3.4)	.458	0.05 (0.1)	.717
Refined Grains (10)	5.4 (3.6)	6.6 (3.3)	.004	5.9 (3.7)	6.1 (3.4)	.339	0.18 (0.1)	.157
Added Sugars (10)	6.5 (3.4)	6.5 (3.2)	.904	6.3 (3.5)	6.4 (3.5)	.665	−0.04 (0.1)	.698
Saturated Fats (10)	5.1 (3.2)	4.8 (3.5)	.586	5.6 (3.2)	4.7 (3.2)	.019	0.15 (0.1)	.220
LS7 components (max. score)	**Cardiovascular health**							
	Mean (*SD*)		p value	Mean (*SD*)		p value	Estimate (*SE*)	p value
Total score (7)	4.2 (1.2)	4.0 (1.2)	.378	3.8 (1.3)	3.9 (1.3)	.581	−0.17 (0.2)	.307
Smoking status (1)	0.7 (0.5)	0.7 (0.5)	.580	0.5 (0.5)	0.6 (0.5)	.897	−0.02 (0.1)	.625
Healthy diet score (1)	0.2 (0.4)	0.2 (0.3)	.865	0.2 (0.3)	0.1 (0.3)	.211	0.05 (0.1)	.320
Physical activity (1)	0.7 (0.3)	0.7 (0.3)	.589	0.7 (0.3)	0.8 (0.3)	.007	−0.09 (0.1)	.142
BMI (1)	0.4 (0.4)	0.4 (0.4)	.331	0.4 (0.4)	0.3 (0.4)	.147	0.02 (0.1)	.780
Blood pressure (1)	0.6 (0.5)	0.4 (0.5)	.365	0.5 (0.5)	0.5 (0.5)	.956	−0.05 (0.1)	.487
Total cholesterol (1)	0.8 (0.4)	0.7 (0.5)	.083	0.8 (0.4)	0.8 (0.4)	.903	−0.08 (0.1)	.243
Fasting glucose (1)	0.8 (0.4)	0.8 (0.4)	.206	0.8 (0.4)	0.7 (0.4)	.979	0.05 (0.1)	.370

BMI body mass index.
[a]Mixed-effect models were based on all available data from baseline and follow-up in 11 food pantries sites; exclusions are detailed in Fig. 1's Consort Table.
[b]Models were adjusted by for client gender, age group, race/ethnicity, education, household size, frequency of food pantry visit, and amount of all food from food pantry in past 6 months, pantry location, pantry pounds of food served per month, and pantry number of freezer/coolers.
[c]In the between arms adjusted models had a sample size of n = 185 for HEI-2015 total and subcomponent scores, LS7 total score, and the LS7 subcomponents healthy diet score, blood pressure, total cholesterol, and fasting glucose, due to missing data in the following covariates: gender (one participant), education (four participants), frequency of food pantry visit (five participants), and household size (one participant). For the LS7 subcomponent smoking status, n = 184 due to missing data on smoking status for one participant. For LS7 subcomponents physical activity and BMI, n = 181 due to missing data for four participants for these two variables.

all 16 pantries did not differ substantially from the reported analysis with the 11 food pantries completed prior to the COVID-19 pandemic, nor were the results from the analysis excluding participants who had not visited the pantry since prior to its transformation.

Changes in cardiovascular health LS7 scores are presented in the bottom panel of Table 2. Mean baseline LS7 scores were 4.2 in the intervention arm and 3.9 in the control arm. The ICC was 0.047. In adjusted models, there were no statistically significant differences in changes in total LS7 score between intervention arms, but the control group had a statistically significant increase of 0.11 in physical activity subcomponent from the baseline to follow-up (p = .007).

Results of the mixed models for the client food selection HEI-2015 score are presented in Table 3. Mean follow-up only HEI-2015 score for the food selected by clients was 60.6 in the intervention condition and 64.0 in the control condition. The ICC was 0.204. In adjusted models controlling for mean baseline HEI-2015 scores of food selected by clients, there were no statistically significant differences in client cart HEI-2015 total or subcomponent scores between intervention arms (p = .081).

Discussion

Results of this group-randomized evaluation of the SuperShelf intervention found no statistically significant differences between intervention arms in client-level health outcomes. While intervention pantries implemented environmental changes with a high degree of fidelity [27], these changes

Table 3 Differences in Food Selected by Clients Healthy Eating Index (HEI-2015) Scores in the Follow-up Only Sample

HEI-2015 component (maximum score)	Food selected by clients					
	Paired sample at baseline[a]		Follow-up only sample		Adjusted model[b]	
	Intervention (n = 5)	Control (n = 6)	Intervention (n = 85)	Control (n = 102)	(n = 165)[c]	
	Mean (*SD*)				Estimate (*SE*)	p value
Total score (100)	60.9 (11.0)	59.7 (11.0)	60.6 (11.8)	64.0 (10.0)	−0.06 (0.1)	.081
Total Vegetables (5)	3.6 (1.3)	3.6 (1.4)	3.5 (1.3)	3.7 (1.2)	−0.03 (0.1)	.689
Greens and Beans (5)	2.8 (1.8)	2.8 (1.9)	2.9 (2.1)	3.2 (1.9)	−0.12 (0.1)	.304
Total Fruits (5)	2.4 (1.3)	2.2 (1.4)	2.5 (1.3)	2.6 (1.5)	−0.20 (0.2)	.263
Whole Fruits (5)	3.5 (1.5)	3.0 (1.6)	3.4 (1.5)	3.3 (1.6)	−0.21 (0.1)	.113
Whole Grains (5)	4.1 (3.0)	4.8 (3.3)	4.8 (3.5)	5.0 (3.6)	0.04 (0.2)	.867
Dairy (10)	3.4 (2.5)	2.8 (2.3)	4.0 (2.7)	3.2 (2.2)	0.09 (0.2)	.683
Total Protein Foods (5)	4.7 (0.7)	4.2 (1.0)	4.8 (0.7)	4.6 (0.8)	0.04 (0.1)	.600
Seafood and Plant Proteins (5)	3.8 (1.6)	3.8 (1.7)	4.3 (1.4)	4.3 (1.5)	−0.04 (0.1)	.697
Fatty Acids (10)	6.9 (3.4)	7.0 (3.3)	5.9 (3.2)	7.4 (2.9)	−0.18 (0.1)	.209
Sodium (10)	6.5 (3.4)	7.3 (3.2)	5.2 (4.2)	7.1 (3.4)	−0.10 (0.1)	.459
Refined Grains (10)	5.1 (3.4)	3.5 (3.5)	5.2 (3.5)	4.7 (3.6)	0.06 (0.3)	.858
Added Sugars (10)	8.1 (1.8)	7.2 (3.0)	8.0 (2.4)	7.4 (2.6)	−0.05 (0.1)	.734
Saturated Fats (10)	6.0 (3.2)	7.5 (2.8)	6.2 (3.4)	7.6 (2.7)	−0.01 (0.2)	.960

[a]Average food pantry-level HEI-2015 scores derived from the measures obtained from the paired sample at baseline.
[b]Models were adjusted for average baseline food pantry-level HEI-2015 scores, gender, age group, race/ethnicity, education, household size, frequency of food pantry visit, and amount of all food from food pantry in past 6 months, pantry location, pantry pounds of food served per month, and pantry number of freezer/coolers.
[c]Sample size in the adjusted models is n = 165 due to missing data in the following covariates: gender (one participant), age group (three participants), race/ethnicity (seven participants), education (seven participants), household size (nine participants), frequency of food pantry visit (two participants), amount of all food from food pantry in past 6 months (three participants).

did not appear to translate into healthier food selection or better client diet quality measured by HEI-2015, or improved overall cardiovascular health measured by LS7.

There are several possible explanations for these findings. First, client diet quality scores are based on all food sources for clients, including those outside of food pantry. Moreover, not all clients continued to rely on the food pantry throughout the duration of the study. Even though food obtained from the pantry tends to have high nutritional quality relative to other sources [3, 11, 12], measurably improving overall client diet quality may require changes in more than one food source. Next, even in full-choice pantries, clients still had some limits on most food categories due to persistent sourcing constraints at the food pantry. This could have limited the potential of the intervention to meaningfully change healthy food selections. Finally, it is worth noting that at baseline, all food pantries in the study were already well positioned to offer clients healthy food, with the average HEI-2015 score of food pantry inventory surpassing that of the U.S. food supply [47]. High baseline scores limited the opportunity to observe what happens when a below-average pantry improves its inventory. It may be that there is a threshold after which improving the food supply yields minimal effect on behavior.

Measurement considerations are also important to the interpretation of findings. The outcome measure of HEI-2015 may not have been optimal for detecting diet-related behavior change in the SuperShelf intervention. The HEI-2015 is a measure of alignment with DGA based on the nutrient density of 13 dietary subcomponents [31]. The SuperShelf approach, by contrast, did not focus on any specific nutrients, or require food pantry staff to look at nutrition facts panels. Instead, it broadly emphasized healthy food groups like fruits and vegetables and de-emphasized less healthy categories like snacks and desserts. Unique aspects of the food pantry setting likely made modifying certain HEI-2015 subcomponents more difficult. For instance, food pantries face well-recognized challenges in sourcing perishable foods [22, 48], and dairy supply consistently falls short of demand [49]. Finally, the evaluation was designed to compare changes in typical dietary intake from the baseline to the follow-up period and did not limit assessments only to the few days after a food pantry visit. This approach made it more difficult to observe changes, since measurements likely include many foods from non-pantry sources. From an evaluation perspective, other outcome measures developed specifically for the charitable food system could be better-suited targets for change [50–52].

Secular changes in the broader charitable food sector could not be ruled out and may have affected study results. Changes such as improved food bank food distribution practices or expanded federal commodity food programming would have affected both study arms and potentially diminished observed post-intervention differences between the groups. As a separate issue, contamination between study arms must be considered in this cluster-randomized study. SuperShelf became well known to pantries throughout the state during the study period. Controls were not prevented from making operational changes in the food pantry that reflected changing norms in the sector. Yet, implementing most SuperShelf changes without technical assistance was unlikely; the intervention was time and resource intensive, and relied on branded materials. Implementation scores demonstrated that SuperShelf was put into practice at intervention pantries

while control pantries did not make substantial changes [27]. There was also little evidence of an improvement in outcomes in either arm. Taken together, it is unlikely that the lack of differences between groups in the current study can be explained by contamination.

These findings contrast with another randomized study in Midwestern food pantries, which observed improvements in HEI-2010 total scores for client diet from baseline to follow-up in both intervention arms [19]. In that study, food pantries did not have a choice-based distribution model at baseline, but they implemented one during the intervention along with other pantry changes. Another intervention, Freshplace, implemented a choice-based food pantry and offered motivational interviewing and service referrals for clients. Compared with clients receiving traditional food bags, those at Freshplace had greater fruit and vegetable consumption as measured by a screener [53]. An intervention package that introduces client choice in a pantry may yield larger environmental changes or behavioral gains than the SuperShelf intervention.

To date, over 40 food pantries have completed SuperShelf transformations with additional transformations underway [36]. Feedback from managers and clients suggested that the technical assistance provided and the investments in the physical space may have served as a conduit for more extensive organizational change. Feedback also suggests that the intervention's focus on client dignity and attention to aesthetic displays appealed to clients. The SuperShelf intervention aligns well with other interventions aimed at improving nutrition in the food pantry setting [18–20, 54] and could be paired with components of these other efforts. To strengthen the impact of interventions on client health, SuperShelf might be implemented in conjunction with more specific nutrition-related messages, nutrition education, or more nutrition-focused food pantry practices. At the same time, it is important to look beyond nutrition education. Approximately half of the sample had attained some college or higher; other studies of Minnesota food pantry clients have demonstrated moderate to high levels of nutrition knowledge [38, 55]. More effective interventions for clients will likely require coordination across food sources (e.g., community food retail, federal food assistance policies). Furthermore, LS7 subcomponents scores suggest that health risks for food pantry clients extend beyond nutrition-related behaviors. This underscores the need for interventions to address the social determinants of health and other chronic disease risks in this population.

Limitations

Inclusion criteria for food pantries were narrow, representing only choice-based pantries that had opted-in to an intervention study and located in a small geographic region, which may limit generalizability across U.S. food pantries. The primary outcome assessment, 24-hr dietary recalls, did not ensure representation of both weekdays and weekend days. The timing of the assessment was not limited to the days after a pantry visit, which made it more difficult to observe an effect. Only changes in HEI-2015 scores were assessed, rather than intake of other nutrients or traditional food groups. For the secondary outcome of food selection, the study team could not realistically follow the same clients over time, so the analysis is based on a post-intervention comparison. Finally, because this cluster-randomized study was terminated early due to the COVID-19 pandemic, the study team could not observe measures in five planned study sites; inclusion of these five pantries could have changed the results.

Conclusion

Results of this group-randomized study of the SuperShelf intervention found no statistically significant differences between intervention arms in client diet or cardiovascular outcomes. Interest in SuperShelf remains high among food pantries. The SuperShelf intervention is well suited to be paired with other interventions aimed at improving nutrition in the food pantry setting.

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Compliance with Ethical Standards

Authors' Statement of Conflict of Interest and Adherence to Ethical Standards Dr. Wolfson is a co-founder of and holds an equity interest in Daynamica, Inc., a University of Minnesota-backed startup company that creates app-based solutions for measuring human behavior. Dr. Wolfson is a paid consultant for MediKarma, Inc. Caitlin E. Caspi, Maria F. Gombi-Vaca, Christina Bliss Barsness, Nora Gordon, Marna Canterbury, Hikaru Hanawa Peterson, and Rebekah Pratt declare that they have no conflict of interest.

Authors' Contributions Caitlin Caspi (Conceptualization [equal], Funding acquisition [lead], Investigation [equal], Supervision [lead], Writing – original draft [lead]), Maria Gombi-Vaca (Formal analysis [lead], Visualization [lead], Writing – original draft [supporting], Writing – review & editing [supporting]), Christina Bliss Barsness (Data curation [supporting], Formal analysis [supporting], Project administration [lead], Supervision [supporting], Writing – review & editing [supporting]), Nora Gordon (Project administration [supporting], Resources [lead], Writing – review & editing [supporting]), Marna Canterbury (Conceptualization [equal], Investigation [supporting], Validation [supporting], Writing – review & editing [supporting]), Hikaru Hanawa Peterson (Conceptualization [supporting], Investigation [supporting], Writing – review & editing [supporting]), Julian Wolfson (Conceptualization [supporting], Formal analysis [supporting], Funding acquisition [supporting], Investigation [supporting], Methodology [lead], Writing – review & editing [supporting]), and Rebekah Pratt (Conceptualization [supporting], Funding acquisition [supporting], Investigation [equal], Writing – review & editing [supporting])

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Transparency Statements (i) *Study registration*: The study was preregistered at ClinicalTrials.gov Identifier NCT03421106. (ii) *Analytic plan preregistration*: The analysis plan was not formally preregistered. (iii) *Analytic code availability*: Analytic code used to conduct the analyses is not available in a public archive, but may be available by emailing the corresponding author. (iv) *Materials availability*: The study protocol and data analysis plan available at ClinicalTrials.gov Identifier NCT03421106. Additional information is available at https://www.supershelfmn.org.

Data Availability

Deidentified data from this study are not available in a public archive, but will be made available by emailing the corresponding author.

Supplementary Material

Supplementary material is available at *Annals of Behavioral Medicine* online.

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