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Original Research Article

Improvements in dietary intake, behaviors, and psychosocial measures in a community-randomized cardiovascular disease risk reduction intervention: Strong Hearts, Healthy Communities 2.0

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ABSTRACT

Background: Cardiovascular disease (CVD) prevalence has disproportionately risen among midlife and older female adults of rural communities, partly due to poor diet and diet-related behaviors and psychosocial factors that impede healthy eating.

Objectives: This study aimed to evaluate the impact of Strong Hearts Healthy Communities 2.0 (SHHC-2.0) on secondary diet-related outcomes between intervention and control participants that align with the dietary goal and behavioral aims of the SHHC-2.0, a CVD risk reduction program.

Methods: A community-randomized controlled trial was conducted in rural, medically underserved communities. Participants were female adults ≥40 y who were classified as obese *or* both overweight and sedentary. Communities were randomized to SHHC-2.0 intervention (n = 5 communities; n = 87 participants) or control (with delayed intervention) (n = 6 communities; n = 95 participants). SHHC-2.0 consisted of 24 wk of twice-weekly experiential nutrition education and group-based physical activity classes led by local health educators. Changes between baseline and end point (24 wk) in dietary intake (24-h recalls), dietary behaviors (e.g., Rapid Eating Assessment for Participants-Short Version [REAP-S] scores) and diet-related psychosocial measures (e.g., Three Factor Eating questionnaire) between groups were analyzed using linear mixed-effects multilevel models.

Results: At 24 wk, participants from the 5 intervention communities, compared with controls, consumed fewer calories (mean difference [MD]= −211 kcal, 95% CI: −412, −110, P = 0.039), improved overall dietary patterns measured by REAP-S scores (MD: 3.9; 95% CI: 2.26, 5.6; P < 0.001), and improved psychosocial measures (healthy eating attitudes, uncontrolled eating, cognitive restraint, and emotional eating).

Conclusions: SHHC-2.0 has strong potential to improve diet patterns and diet-related psychosocial wellbeing consistent with improved cardiovascular health.

This trial was registered at www.clinicaltrials.gov as NCT03059472.

Keywords: diet, rural, female adults, community-based, randomized controlled trial, cardiovascular disease

Introduction

Cardiovascular disease (CVD) is the leading cause of diet-related deaths globally and the leading cause of death for female adults in the United States [1,2]. Following a nutrient-dense dietary pattern high in fruits, vegetables, and whole grains, limited in added sugar, saturated fat, and sodium, and within recommended caloric ranges [3] is associated with fewer CVD risk factors and reduced risk of CVD mortality among older adults [4–7]. Since 2009, premature deaths attributed to CVD have markedly risen for female adults aged 45 to 64 y in rural areas, compared with the decline in urban communities [8,9]. Urban–rural differences in CVD morbidity and mortality are partly due to poor diet quality. For example, fruit and vegetable intake is lower

Abbreviations: ASA24, automated self-administered 24-hour dietary recall; cRCT, cluster randomized controlled trial; CVD, cardiovascular disease; FMI, fraction of missing information; HEAS, Healthy Eating Attitudes Scale; HEI, Healthy Eating Index-2015; MD, mean difference; MI, multiple imputation; REAP-S, Rapid Eating Assessment for Participants-Short Version; RUCA, Rural Urban Commuting Area; SHHC-2.0, Strong Hearts Healthy Communities 2.0; SMART, Specific; Measurable, Achievable; Relevant, and Time-bound; TFEQ, Three Factor Eating Questionnaire.

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among residents of rural areas compared with urban [10,11]; only 25% of individuals in rural communities meet the daily recommended intake for fruits and vegetables of ≥5 servings, compared with 40% of the general population [11].

Poor diet quality is caused by multiple factors including psychosocial, social, and environmental that are specific to rural communities. Psychosocial factors, like self-efficacy and perceived barriers, impact healthy eating habits among female adults in rural areas [12–14]. Social networks are often close-knit in rural areas, resulting in family and friends playing a key role influencing healthy eating habits with their attitudes, actions, and support or lack of support [14–17]. For example, female adults in rural communities find it difficult to reconcile healthful eating habits with family members' and friends' preferences for less healthful traditional diets, such as "meat and potatoes" [15]. Finally, environmental factors—like perceptions that high-quality, healthy foods are more expensive [18,19] and less available [20–22] in rural areas compared to urban areas—result in fewer healthy food purchases [23]. Taken together, these barriers highlight that interventions for female adults in rural areas that account for psychosocial wellbeing, social support, and environmental factors are likely effective in improving diet and diet-related behaviors [24–26]. However, to date, very few CVD-prevention interventions for female adults in rural areas have incorporated behavioral strategies to specifically address these factors in supporting health-promoting dietary behavior change [27–34].

Strong Hearts, Healthy Communities 2.0 (SHHC-2.0) is a multilevel, experiential learning intervention informed by the socio-ecological framework [35] and social cognitive theory [36] that incorporates diet-related social and environmental support strategies, as well as individual-level behavior change, through class activities and civic engagement. In addition to diet, SHHC-2.0 targets other key behaviors related to CVD prevention such as physical activity behavior change and social and environmental support strategies. SHHC-2.0 is a refined version of the original Strong Hearts, Healthy Communities 1.0 that was modified based on outcome and process evaluation data from participants and community-based educators [37]. The primary outcome of the SHHC-2.0 intervention was to evaluate the impact of SHHC-2.0 on body weight. Previously published reports of SHHC-2.0 have demonstrated improvements in body weight [38] as well as other clinical measures (e.g., total cholesterol, blood pressure, and blood glucose) [38].

The objective of the present study was to evaluate the impact of SHHC-2.0 between intervention and control participants on secondary, diet-related outcomes that align with the goal and behavioral aims of the SHHC-2.0 program. The diet-related outcomes were selected a priori to capture diet (e.g., nutrient intake and dietary patterns) and diet-related psychosocial and social support measures. We hypothesized that intervention participants would experience greater improvements in these diet-related outcomes than control participants following the SHHC-2.0 intervention.

Methods

SHHC-2.0 was a community-based, cluster randomized controlled trial (cRCT) that took place in 11 rural, medically underserved communities [39] in upstate New York. The study enrolled female adults aged 40 and older. The definition of a rural community was based on a Rural Urban Commuting Area (RUCA) code of 4 or higher (micropolitan or rural area) [40]. The RUCA codes classify US census tracts based on population density, urbanization, and daily commuting patterns. Following a stratified randomization procedure, communities were matched into pairs, based on population size and RUCA code, and randomized following baseline data collection to intervention or control condition. Randomization was conducted by a blinded statistician unaffiliated with the study using JMP software. A full description of the study design has been published previously [41]. Change in body weight was the predeclared primary outcome of SHHC-2.0, with multiple secondary outcomes that included dietary recall and dietary patterns and attitudes [41]. The protocol and details of measures relevant to the current analysis are described below. The study protocol was approved by the Cornell University (#1402004505) and Bassett Healthcare Network (#2022) Institutional Review Boards. Participants provided written, informed consent prior to completing baseline assessments.

Intervention

Recruitment for the SHHC-2.0 intervention began in January 2017. The program consisted of twice-weekly classes for 24 wk. The start date was the same within paired sites (intervention and control) but varied between pairs, and the start date ranged from April to June 2017 and concluded between September and November 2017. Classes, led by local health educators (e.g., Cooperative Extension agents or educators), included nutrition and physical activity education and related topics as well as group-based exercise. SHHC-2.0 is a refined version of the original Strong Hearts, Healthy Communities 1.0 that was modified based on outcome and process evaluation data [37]. Examples of diet-related modifications to intervention program curriculum included moving nutrition topics to earlier in the program's class sequence, having participants use a health journal to record diet-related goals and progress, provision of additional details and guidance on recommended dietary patterns, and more frequent goal-setting reminders.

Nutrition-specific intervention description

The nutrition intervention components in the SHHC-2.0 curriculum were informed by the: *1*) 2015–2020 Dietary Guidelines for Americans [3], *2*) Dietary Approaches to Stop Hypertension dietary pattern [42], and *3*) the 2017 American Heart Association recommendations for following a Mediterranean dietary pattern [43]. The SHHC-2.0 intervention focused on modifying dietary eating patterns that have been shown to reduce risk factors for CVD, such as high blood pressure and high cholesterol, rather than on specific nutrients [44,45]. The specific diet-related behavioral aims for SHHC-2.0 were to: *1*) increase fruits and vegetables, *2*) increase whole grains, *3*) decrease calories, *4*) decrease desserts, *5*) decrease processed foods, *6*) decrease saturated and trans fats, *7*) decrease sodium, and *8*) decrease sugar-sweetened beverages. Other key recommendations provided were to consume: $<$10% of calories per day from added sugars; $<$10% of calories per day from saturated fats; and $<$2300 mg of sodium per day or, if ≥51 y old, ≤1500 mg of sodium per day.

The overall goal of healthy dietary patterns and dietary behavioral aims were targeted through nutrition education lessons, food demonstrations, group discussions, goal setting, and home and grocery store audits throughout the 24-wk program. The Specific, Measurable, Achievable, Relevant, and Time-bound (SMART) goal strategy was used to set specific and attainable goals. Sample group discussion topics included: Remodeling Your Home Environment; Making the Healthy Choice the Easy Choice; Healthy Eating Away from Home; Healthier Recipes; Healthy Drinking and Emotional Eating; and Heart-Healthy Grocery Shopping.

The participant materials included: *1*) a participant guide, which provided content on the background of the curriculum, information on the tools provided to participants such as Fitbits and Withings scales, and exercise DVDs, recipes, and meal planning guides; *2*) class-specific resources; and *3*) homework. In addition, participants were provided a separate health journal, which had: *1*) monthly SMART Goal Pages where participants outlined their goals and identified what challenges they may face and action steps they can take to overcome those challenges; *2*) Weekly Planning Pages for planning their food and physical activity for the week ahead; *3*) Daily Tracking Pages where they recorded the food and beverages consumed each day; *4*) Monthly Check-In and Personal Measurements pages where they tracked how their bodies were changing over time; and *5*) Daily Food Plans and the Portion Sizes by Food Group from Strong Women Stay Slim [46], which outlined and had participants track portions within food categories (dairy, protein, grains, vegetables, fruits, and extras [fats, oils, sweets]) each day, based on either a 1200 or 1600 calories per day goal. Most female adults were advised to follow the 1600-calorie food plan but switch to the 1200-calorie food plan if they were not losing weight.

Sample

Inclusion criteria for recruited and enrolled participants were as follows: *1*) female adults, *2*) age ≥40 y, and *3*) BMI 25 to 30 kg/m^2 and no more than one bout of 30 min of leisure physical activity per week on average during the past 3 mo *or* BMI ≥30. Exclusion criteria for participants were: *1*) systolic blood pressure >160 mmHg or diastolic blood pressure >100 mmHg, *2*) resting heart rate <60 or >100 bpm, *3*) cognitive impairment, as determined by a 6-item cognitive screening test [47], *4*) currently participating or planning to participate in another health behavior change program in the next 12 mo, *5*) unable to gain permission for participation from a healthcare provider, *6*) unwilling to provide informed consent, or *7*) unwilling to be randomized to either group.

Sample size

TheC SHHC-2.0 cRT was powered for the primary outcome to detect a mean change in weight from baseline to 24 wk between the intervention and control groups, as reported elsewhere [38].

Measures

Participants completed a questionnaire that collected basic demographic information at baseline. Demographic questions were derived from national surveys (e.g., US Census) [48]. The race categories from which participants were asked to self-report were: American Indian or Alaskan Native, Asian, Black, White, Native Hawaiian or other Pacific Islander, or other race, for which participants could specify. Participants were also asked to self-report whether they identify as Hispanic. The measures used to capture dietary intake were selected based on the intervention goal of healthy dietary patterns, as well as the diet-related behavioral aims described above (Table 1). Both the hypotheses and measures were determined a priori and registered as such with clinicaltrials.gov and detailed in the protocol paper [38].

Dietary recall measures

Participants were asked to complete 5 dietary recalls using an automated self-administered 24-h dietary recall (ASA24) [49] at baseline, 12 wk, and 24 wk. If a participant completed more than 5 recalls, only the first 5 were used for analysis. In SHHC-1.0, dietary recalls were identified as being particularly burdensome to participants.

TABLE 1
Strong Hearts, Healthy Communities-2.0 program overall goal and behavioral aims and associated hypothesized diet-related outcome measures and data source

	Hypothesized diet-related outcome measure (data source)
Overall goal	
Improve dietary patterns	Increase HEI[1] score (ASA24[1]) Increase HEI component scores (ASA24) Increase REAP-S[1] score (survey)
Behavioral aims	
1. Increase fruits and vegetables	Increase fruit servings (ASA24) Increase vegetable servings (ASA24)
2. Increase whole grains	Increase whole grains (ASA24) Increase fiber (ASA24)
3. Decrease calories	Decrease calories (ASA24)
4. Decrease desserts	Decrease added sugar (ASA24)
5. Decreased processed foods	Decrease added sugar (ASA24) Decrease saturated fat (ASA24) Decrease solid fat (ASA24) Increase fiber (ASA24) Decrease sodium (ASA24)
6. Decrease saturated and trans fats	Decrease saturated fat (ASA24) Decrease solid fat (ASA24)
7. Decrease sodium	Decrease sodium (ASA24)
8. Decrease sugar-sweetened beverages	Decrease added sugar (ASA24)

[1] ASA24, automated self-administered 24-h dietary recall; HEI, Healthy Eating Index-2015; REAP-S, Rapid Eating Assessment for Participants-Short Version.

To address this concern, we reduced the number of recalls at each timepoint from 7 to 5 based on our findings that showed a 0.972 correlation between 5 and 7 recalls in SHHC-1.0 [50]. Furthermore, participants were instructed to complete the dietary recalls on any day regardless of whether they were consecutive days or both weekday and weekend days because, in SHHC-1.0, we found no significant differences in dietary recalls depending on day of week in this population [49]. Based on the National Cancer Institute's recommendations [51], nutrient intake was averaged across at least 2 recalls that did not violate exclusion criteria per time point period. Exclusion criteria for recalls were as follows: *1*) marked complete and ≤100 kcals, *2*) marked incomplete and <500 kcals; and *3*) any recall that was ≥6600 kcals, which is 300% of the estimated energy requirement for 31- to 60-y-old female adults that are physically active [52]. For reference, most participants completed 5 recalls (78.5% at baseline; 60.8% at 12 wk; 58.3% at 24 wk), and most participants' recalls included 1 weekend day (baseline, 62.4%; 12 wk, 47.1%; 24 wk, 59.2%). To explore if there were meaningful differences within intervention groups across day of week (all weekday recalls compared with including at least 1 weekend) or number of recalls (<5 compared with 5 recalls), we compared mean caloric intake and HEI total score. We found no significant differences at baseline, 12 wk, or 24 wk (Supplemental Table 1).

Healthy Eating Index-2015 Total Score

The Healthy Eating Index-2015 (HEI) scores were computed from the ASA24 using the National Cancer Institute's SAS program and macro for the simple HEI scoring algorithm [53]. The program used the available 2 to 5 recalls to approximate usual intake and was run at each time point (baseline, 12 wk, and 24 wk). The HEI total and component scores were averaged for each participant at each time point. Scores could range from 0 to 100 for HEI total score and 0 to 5 or 0 to 10 for HEI component scores, with a higher score indicating closer alignment with Dietary Guidelines for Americans [54]. Additional details of the HEI scoring standards can be found on the National Cancer Institute's website [55].

Nutrient intake

Averages per time point period were used to estimate participants' total caloric intake, total protein and total carbohydrate intake, and diet components specifically targeted by the intervention (e.g., sugar, added sugar, sodium, fruits, vegetables, whole grains, fiber, solid fats, and saturated fats).

Survey measures: diet patterns and psychosocial and social support measures

Participants were also asked to complete an online survey via Qualtrics for the dietary eating patterns and psychosocial dietary measures (described below) at 3 time points: just prior to randomization (baseline), 12 wk (midpoint), and 24 wk (endpoint).

Rapid Eating Assessment for Participants-Short Version (REAP-S)

The REAP-S is a self-report 16-item scale with demonstrated validity for assessing dietary quality and evaluates typical weekly consumption of whole grains, fruits and vegetables, calcium, fat, saturated fat, cholesterol, sugary beverages, sodium, and diet-related behaviors (e.g., breakfast consumption, cooking at home) [56]. Online survey responses are scored on a scale of 1 to 3 (1 = usually/always, 2 = sometimes, and 3 = rarely/never). Responses are summed to create a total score (range 13–39) with higher REAP scores reflecting better eating habits.

Three Factor Eating Questionnaire (TFEQ)

The TFEQ is a validated 18-item measure of eating behavior that evaluates cognitive restraint, uncontrolled eating, and emotional eating on a 4-point Likert scale, with higher values indicating higher salience of those eating behaviors [57].

Healthy Eating Attitudes Scale (HEAS)

The HEAS consists of 7 items, scored on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree) [58]. Mean scores for the 7 items were calculated, with higher scores indicating more positive attitudes toward healthy eating.

Self-Efficacy for Diet Behaviors

The Sallis Self-Efficacy for Diet Behaviors measure contains 16 items, scored on a 5-point Likert scale with higher scores indicating more self-efficacy, and has demonstrated reliability and validity [59].

Social Support for Diet Behaviors

The Sallis Social Support for Diet Behaviors, a valid and reliable tool, consists of 10 items scored on a 5-point Likert scale with higher scores indicating more perceived social support received [60].

Adverse events

Study participants were instructed to report any adverse events to leaders and/or the research team at any time. Survey questions about adverse events were also included at 12 and 24 wk.

Statistical analyses

For the primary analysis, difference in change from 0 to 24 wk between groups was analyzed using linear mixed-effects multilevel models. Additionally, differences in change from 0 to 12 wk (midpoint) were analyzed in the same manner. Models included random cluster (community) effects to account for the community-level randomization and correlation between participants in the same community as well as a priori covariates of age (in years) and educational attainment (high school or less; some college/technical or vocational school; college graduate; postgrad/professional). Complete case analysis was done using restricted maximum likelihood to incorporate all available data, and intention-to-treat analyses included all participants as randomized.

To determine the sensitivity of the analysis to statistical outliers, we ran the same analyses with the eliminated dietary recall outliers removed (1.5 interquartile range above the third quartile or below the first quartile). An additional sensitivity analysis for total energy consumption was performed on nutrient and food group components from ASA24 variables. We modeled the effect of SHHC 2.0 on nutrients as a percent of total energy consumption for the following: total fat, saturated fat, solid fat, carbohydrates, protein, sugar, added sugar, and fiber. For food groups (whole grains, fruit, and vegetable consumption), we tested additional models with total energy consumption as a covariate.

Missing data

Data were missing in the following proportions at each time period for the ASA24 dietary recalls (less than 2 valid recalls): 18% at baseline, 44% at 12 wk, and 43% at 24 wk and the survey: 5% at baseline, 29% at 12 wk, and 37% at 24 wk. Missingness by variable and time point is available in Supplemental Table 2. To explore the potential that data may not be missing at random, baseline characteristics of respondents and nonrespondents were compared at 24 wk for each data collection tool (survey and ASA24). No significant differences were observed for age, income, education, race, BMI, weight, meeting physical activity guidelines, or self-reported perceived overall health for those missing the ASA24 compared with those who completed the ASA24. For the survey, nonrespondents tended to have a higher BMI compared with respondents, and therefore, BMI was used as an auxiliary variable for multiple imputation.

Multiple imputation

Multiple imputation (MI) was used to estimate missing data points and standard errors. Imputations followed standardized, rigorous procedures, including auxiliary variables (random assignment group, community site, age, education, and BMI) and employed hierarchical approaches. Fraction of missing information (FMI) was used to measure the level of uncertainty about the values imputed for missing values [median FMI for outcomes was 0.292 (range: 0.02–0.629)]. We used 70 imputations, which satisfies the recommendations to have the number of imputations (at least) equal the highest FMI percentage [61]. Sensitivity, "tipping point," analyses were conducted to identify the point at which adjusting imputed values reversed the main findings and determine the plausibility of erroneous conclusions based on data not missing at random and MI modeling [62]. All statistical analyses were conducted using SAS, version 9.4. As principal investigator, Dr Seguin-Fowler had full access to all study data and takes responsibility for its integrity and the data analysis.

Results

Over a 6-mo period, 316 participants were screened, and 182 were enrolled into the study (Table 2). Five communities were randomized to the intervention group (n = 87 participants) and 6 communities to the delayed intervention/control group (n = 95 participants) (Figure 1). Class sizes ranged from 7 to 17 female adults. Class attendance

TABLE 2

Strong Hearts, Healthy Communities-2.0 participant characteristics at baseline

	All participants		Control		Intervention	
	n		*n*		*n*	
Participants, %	182	100	95	52.2	87	47.8
Age (y), mean±SD	182	57.2 ± 9.0	95	55.9 ± 8.5	87	58.5 ± 9.3
Race, *n* (%)	168		86		82	
White, non-Hispanic		164 (97.6)		84 (97.7)		80 (97.6)
Non-white or Hispanic		4 (2.4)		2 (2.3)		2 (2.4)
Annual income, *n* (%)	162		85		77	
<$25,000		29 (17.9)		17 (20.0)		12 (15.6)
$25,000–50,000		37 (22.8)		15 (17.6)		22 (28.6)
>$50,000		96 (59.3)		53 (62.4)		43 (55.8)
Relationship status, *n* (%)	171		87		84	
In a relationship		116 (67.8)		62 (71.3)		54 (64.3)
Not in a relationship		55 (32.2)		25 (28.7)		30 (35.7)
Educational attainment, *n* (%)	172		87		85	
High school or less		26 (15.1)		14 (16.1)		12 (14.1)
Some college/technical or vocational school		35 (20.3)		17 (19.5)		18 (21.2)
College graduate		63 (36.6)		33 (37.9)		30 (35.3)
Postgrad/professional		48 (27.9)		23 (26.4)		25 (29.4)
Smoking status, *n* (%)	171		87		84	
Never		100 (58.5)		49 (56.3)		51 (60.7)
Former		69 (40.4)		37 (42.5)		32 (38.1)
Current		2 (1.2)		1 (1.2)		1 (1.2)
Self-report overall health, *n* (%)	175		89		86	
Excellent/very good		46 (26.3)		20 (22.5)		26 (30.3)
Good		99 (56.6)		50 (56.2)		49 (57.0)
Fair/poor		30 (17.1)		19 (21.3)		11 (12.7)
Body mass index, mean kg/m^2±SD	182	36.7 ± 7.8	95	37.9 ± 8.5	87	35.4 ± 6.8
Self-report condition/disease, *n* (%)	170		86		84	
High blood cholesterol		71 (41.8)		33 (38.4)		38 (45.2)
Hypertension		71 (41.8)		41 (47.7)		30 (35.7)
Arthritis		70 (41.2)		39 (44.8)		31 (37.3)
High blood sugar		37 (21.8)		16 (19.3)		21 (24.1)
Diabetes		25 (14.7)		17 (19.5)		8 (9.6)
Cancer		12 (7.1)		5 (5.7)		7 (8.4)
Heart disease		10 (5.9)		5 (5.7)		5 (6.0)
Kidney disease		3 (1.8)		1 (1.1)		2 (2.4)
Overall dietary patterns (ASA24), mean ± SD	149		77		72	
HEI 2015 Total Score (100 points)		58.7 ± 12.0		57.6 ± 11.0		59.9 ± 12.9
HEI Component - Total Fruits (5 pts)		2.9 ± 1.8		2.8 ± 1.8		2.9 ± 1.8
HEI Component - Whole Fruits (5 pts)		3.3 ± 1.9		3.3 ± 1.9		3.4 ± 1.8
HEI Component - Total Vegetables (5 pts)		4.0 ± 1.2		4.1 ± 1.2		4.0 ± 1.2
HEI Component - Greens and Beans (5 pts)		3.5 ± 1.9		3.7 ± 1.7		3.4 ± 2.0
HEI Component - Whole Grains (10 pts)		3.2 ± 2.8		3.4 ± 3.2		3.0 ± 2.4
HEI Component - Dairy (10 pts)		6.6 ± 2.5		6.8 ± 2.6		6.5 ± 2.5
HEI Component - Total Protein Foods (5 pts)		4.7 ± 0.8		4.7 ± 0.8		4.7 ± 0.8
HEI Component - Seafood and Plant Proteins (5 pts)		3.7 ± 1.8		3.8 ± 1.7		3.6 ± 1.9
HEI Component - Fatty Acids (10 pts)		4.4 ± 2.9		4.4 ± 2.8		4.3 ± 3.0
HEI Component - Refined Grains (10 pts)		7.3 ± 2.8		7.6 ± 2.5		7.0 ± 3.0
HEI Component - Sodium (10 pts)		3.0 ± 2.6		3.5 ± 2.7		2.5 ± 2.5
HEI Component - Added Sugar (10 pts)		7.9 ± 2.4		7.8 ± 2.2		7.9 ± 2.5
HEI Component - Saturated Fat (10 pts)		4.4 ± 3.1		4.1 ± 3.0		4.6 ± 3.3
Food groups (ASA24), mean ± SD	149		77		72	
Whole grains (ounce equivalents)		0.8 ± 0.7		0.7 ± 0.6		0.9 ± 0.8
Fruit (cup equivalents)		1.0 ± 0.8		1.0 ± 0.8		1.0 ± 0.8
Vegetables (cup equivalents)		1.7 ± 0.8		1.7 ± 0.8		1.8 ± 0.8
Nutrient intake (ASA24), mean ± SD	149		77		72	
Calories (kcal)		1763 ± 561		1715 ± 607		1815 ± 506
Protein (g)		75.8 ± 22.5		74.3 ± 23.6		77.4 ± 21.3
Total fat (g)		74.5 ± 29.1		71.7 ± 30.2		77.5 ± 27.8
Solid fat (g)		34.2 ± 17.6		33.3 ± 17.9		35.2 ± 17.3
Saturated fat (g)		25.2 ± 11.0		24.3 ± 11.1		26.2 ± 10.8
Carbohydrates (g)		196.2 ± 73.0		191.6 ± 82.6		201.2 ± 61.3
Sugar (g)		87.9 ± 45.5		85.0 ± 49.8		90.9 ± 40.4
Added sugar (g)		11.6 ± 7.8		11.2 ± 8.3		12.0 ± 7.2
Fiber (g)		16.4 ± 6.1		15.9 ± 6.0		16.9 ± 6.2
Sodium (mg)		3114 ± 999		3109 ± 1048		3118 ± 951

(*continued on next page*)

TABLE 2 (*continued*)

	All participants		Control		Intervention	
	n		*n*		*n*	
Overall Dietary Pattern (survey), mean ± SD	172		87		85	
Rapid Eating Assessment for Participants-Short (scale 13–39)		28.9 ± 4.1		28.9 ± 4.4		28.9 ± 3.9
Diet Psychosocial (survey), mean ± SD	172		87		85	
Healthy Eating Attitudes (scale 1–10)		3.6 ± 0.5		3.6 ± 0.5		3.6 ± 0.5
Uncontrolled eating score (scale 6–24)		20.3 ± 4.9		20.9 ± 5.1		19.8 ± 4.8
Cognitive restraint score (scale 6–24)		15.0 ± 2.9		15.2 ± 3.0		14.8 ± 2.8
Emotional eating score (scale 6–24)		7.9 ± 2.6		8.2 ± 2.6		7.6 ± 2.6
Confidence in ability to stick to low-saturated fat, low salt foods (scale 1–5)		3.2 ± 1.0		3.3 ± 1.0		3.0 ± 1.0
Confidence in ability to eat smaller portions (scale 1–5)		3.5 ± 1.0		3.6 ± 1.0		3.5 ± 0.9
Confidence in ability to avoid adding salt at the table (scale 1–5)		3.8 ± 1.4		4.0 ± 1.3		3.6 ± 1.4
Confidence in ability to choose low-saturated-fat foods (scale 1–5)		3.9 ± 0.9		4.0 ± 0.8		3.9 ± 1.0
Diet Social Support (survey)[3], mean ± SD						
Family encouraged healthy eating habits (scale 5–25)	128	10.6 ± 4.6	69	10.6 ± 4.4	59	10.6 ± 4.8
Family discouraged healthy eating habits (scale 5–25)	123	12.5 ± 5.0	69	13.1 ± 5.2	54	11.7 ± 4.8
Friends encouraged healthy eating habits (scale 5–25)	142	9.2 ± 4.3	73	9.9 ± 4.7	69	8.5 ± 3.7
Friends discouraged healthy eating habits (scale 5–25)	123	8.6 ± 3.8	69	9.1 ± 4.3	54	7.8 ± 2.9

[1] ASA24, automated self-administered 24-h dietary recall; HEI, Healthy Eating Index.
[2] Note: Sample sizes for individual participant characteristics that are smaller than the total enrolled sample ($n = 182$) are due to missing data.
[3] The number of responses was lower ($n = 123$–142) for the Sallis Social Support Scale for Diet questions because those living alone were asked to skip the family columns; this led to additional missed responses because respondents skipped all or some questions in this section.

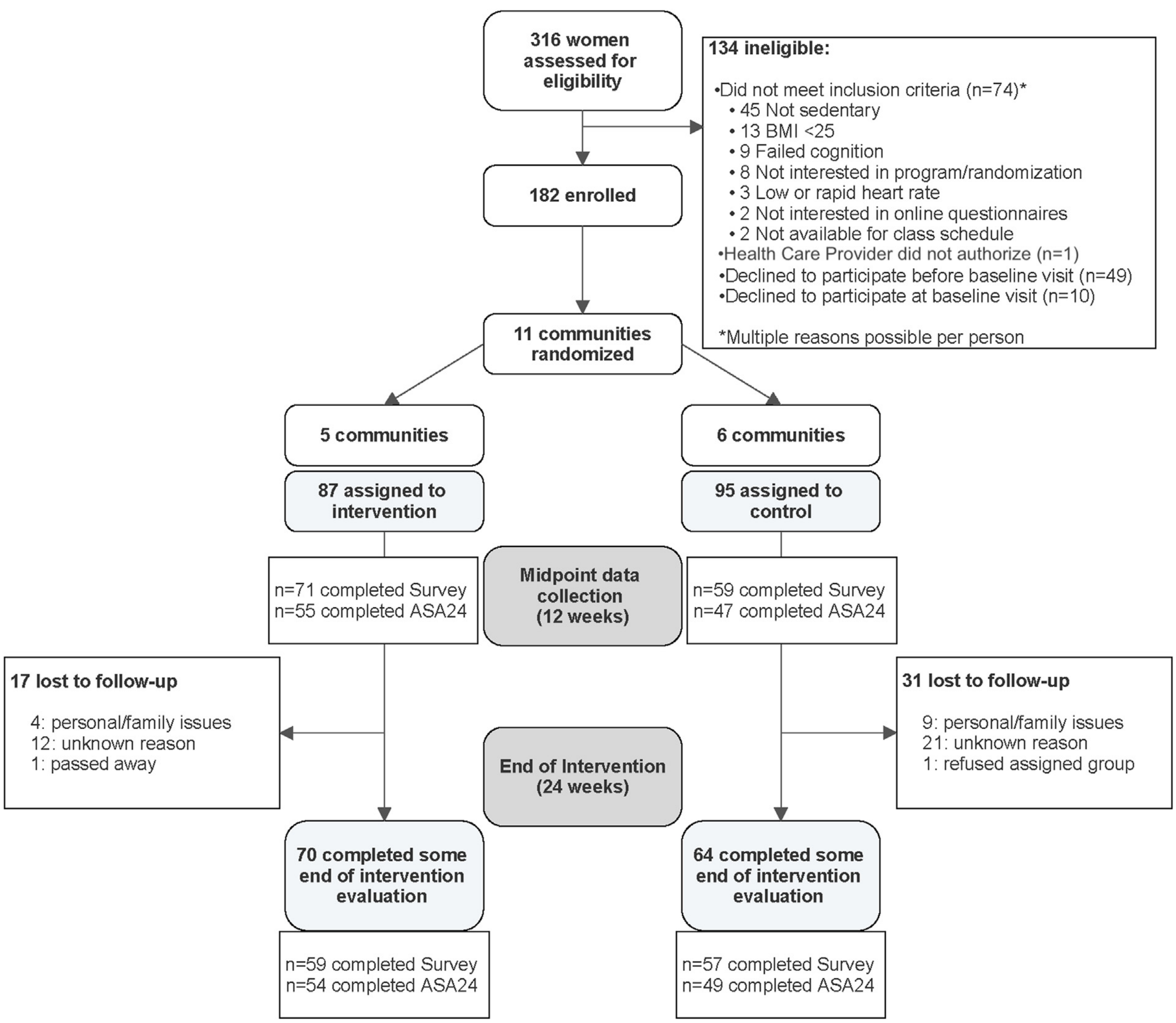

FIGURE 1. CONSORT flow diagram of progress through phases of *Strong Hearts, Healthy Communities-2.0* cluster randomized controlled trial. ASA24, automated self-administered 24-h dietary assessment tool.

averaged 59% of participants across all 24 wk (66% in weeks 1–12; 54% in weeks 13–24). The complete and MI estimates within-group and between-group changes at 24 wk in diet intake are reported in Table 3, and the behaviors and psychosocial changes are reported in Table 4. Below, we report the MI estimates, since all but one significant finding from the MI analysis were also present in the complete case models. Additionally, the sensitivity analysis to remove outliers 1.5 interquartile range above the third quartile or below the first quartile did not significantly differ from the reported findings (Supplemental Table 3 [0–24 wk]).

At 24 wk, there was a larger decline in mean caloric intake (mean difference [MD]: −211; 95% CI: −412, −110; P = 0.039) for the intervention participants compared with control participants (Table 3). Other dietary intake measures that were not significant but had a P value <0.10 were: HEI total score (MD: 4.9; 95% CI: 0.0, 9.7; P = 0.050), HEI component score – total vegetables (MD: 0.5; 95% CI: −0.1, 1.0; P = 0.095), total fat (g) (MD: −10.9; 95% CI: −22.8, 0.9; P = 0.070), saturated fat (g) (MD: −4.2; 95% CI: −8.6, 0.3; P = 0.068), carbohydrates (g) (MD: −20.7; 95% CI: −44.9, 3.6; P = 0.095), sugar (g) (MD: −11.7; 95% CI: −25.0, 1.6; P = 0.085), and added sugar (g) (MD: −2.8; 95% CI: −5.7, 0.1; P = 0.061). Results did not differ in a sensitivity analysis that adjusted for energy intake (Supplemental Table 4).

Intervention participants improved in terms of overall dietary patterns measured by REAP-S score (MD: 3.9; 95% CI: 2.3, 5.6; P < 0.001), healthy eating attitudes (MD: 0.4; 95% CI: 0.2, 0.6; P < 0.001), uncontrolled eating (MD: −2.3; 95% CI: −3.9, −0.6; P = 0.009), and cognitive restraint (MD: 2.1; 95% CI: 0.7, 3.4; P = 0.003), compared with control participants (Table 4). Higher improvements in emotional eating scores in intervention participants compared with control participants was significant in the multiple imputation model (MD: −1.3, 95% CI: −2.1, −0.4, P = 0.004) but was not significant in the complete case model (P = 0.059) (Table 4). Using the MI model, changes in diet-related social support did not significantly differ between the intervention and control participants (Table 4).

Descriptively, participants began the study with low or below average compliance with dietary recommendations; however, intervention participants on average increased their total HEI (Figure 2A) and REAP-S (Figure 2B) scores between baseline and end of

TABLE 3

Within-group change and between-group change in dietary measures derived from ASA-24[1] from baseline to intervention end point (24 wk) among *Strong Hearts, Healthy Communities-2.0* intervention and control participants

	Complete case models				Multiple imputation models[3]			
	Control participants (n = 47)	Intervention participants (n = 50)	Difference between groups		Control participants	Intervention participants	Difference between groups	
	Mean change	Mean change	Estimate (95% CI)[2]	P value	Mean change ± SD	Mean change ± SD	Estimate (95% CI)[2]	P value
HEI-2015[1]								
Total score (100 pts)	-0.7 ± 10.7	3.6 ± 12.4	4.4(-0.3,9.1)	0.072	-1.3 ± 1.8	3.6 ± 1.8	4.9 (0.00,9.7)	0.050
HEI-2015 Components								
Total Fruits (5 pts)	0.2 ± 1.6	0.4 ± 2	0.2 (-0.5,0.9)	0.531	0.4 ± 2.0	0.8 ± 2.1	0.3 (-0.4,1.0)	0.371
Whole Fruits (5 pts)	-0.1 ± 2	0.1 ± 2	0.2 (-0.6,1.0)	0.642	0.2 ± 2.1	0.4 ± 2.1	0.2 (-0.5,0.9)	0.602
Total Vegetables (5 pts)	-0.1 ± 1.4	0.3 ± 1.2	0.4 (-0.2,0.9)	0.167	-0.1 ± 1.5	0.3 ± 1.3	0.5 (-0.1,1.0)	0.095
Greens and Beans (5 pts)	-0.4 ± 2.3	0.2 ± 2.1	0.6 (-0.3,1.5)	0.184	-0.1 ± 2.4	0.2 ± 2.1	0.3 (-0.5,1.1)	0.424
Whole Grains (10 pts)	0.3 ± 3.1	1.6 ± 3.6	1.3 (0.0,2.7)	0.053	0.1 ± 4.5	1.2 ± 4.7	1.1 (-0.7,3.0)	0.223
Dairy (10 pts)	0.2 ± 2.7	0.5 ± 2.9	0.3 (-0.8,1.4)	0.600	0.6 ± 3.4	0.5 ± 3.3	-0.2 (-1.4,1.1)	0.817
Total Protein Foods (5 pts)	0 ± 0.8	-0.1 ± 0.7	-0.1 (-0.4,0.2)	0.701	-0.1 ± 1.0	-0.1 ± 0.9	-0.1 (-0.4,0.3)	0.710
Seafood and Plant Proteins (5 pts)	-0.7 ± 2.8	0.0 ± 2.1	0.7 (-0.3,1.7)	0.166	-0.5 ± 2.6	0.0 ± 2.3	0.5 (-0.3,1.3)	0.226
Fatty Acids (10 pts)	-0.9 ± 3.4	-0.6 ± 3.6	0.3 (-1.1,1.8)	0.647	-0.5 ± 4.7	-0.4 ± 4.4	0.1 (-1.7,1.9)	0.913
Refined Grains (10 pts)	0.7 ± 3.2	0.7 ± 3.0	0.0 (-1.2,1.3)	0.974	1.0 ± 5.3	-0.2 ± 4.5	0.0 (-1.2,1.2)	0.992
Sodium (10 pts)	0.3 ± 2.5	-0.9 ± 2.6	-1.1 (-2.2,-0.1)*	0.034*	0.7 ± 3.5	0.7 ± 3.2	-1.2 (-3.5,1.1)	0.295
Added Sugar (10 pts)	0.1 ± 1.6	0.9 ± 2.0	0.8 (0.1,1.5)*	0.035*	-0.5 ± 4.0	0.3 ± 4.1	0.7 (-0.2,1.6)	0.147
Saturated Fat (10 pts)	-0.2 ± 2.7	0.4 ± 3.4	0.6 (-0.6,1.9)	0.322	0.2 ± 2.4	0.9 ± 2.4	0.9 (-0.9,2.6)	0.335
Food groups								
Whole grains (oz)	0.1 ± 0.8	0.3 ± 1.0	0.2 (-0.1,0.6)	0.234	0.1 ± 0.3	0.3 ± 0.3	0.2 (-0.6,1.0)	0.617
Fruit (cup)	0.1 ± 0.8	0.2 ± 1.0	0.1 (-0.3,0.5)	0.661	-2.3 ± 30.4	0.2 ± 0.4	2.5 (-56.0,61.0)	0.934
Vegetables (cup)	0.1 ± 0.8	0.1 ± 0.9	0.0 (-0.3,0.4)	0.868	0.0 ± 0.2	0.2 ± 0.2	0.1 (-0.3,0.6)	0.593
Nutrient intake								
Calories	1 ± 438	-228 ± 471	-229 (-414,-44)*	0.017*	-14 ± 76	-225 ± 75	-211 (-412,-110)*	0.039*
Protein (g)	2.6 ± 26.4	-5.4 ± 23.7	-8.1 (-18.0,1.8)	0.114	0.6 ± 4.4	-6.1 ± 4.0	-6.7 (-18.0,4.6)	0.245
Total fat (g)	0.1 ± 0.8	0.2 ± 1.0	-10.6 (-20.5,-0.7)*	0.039*	-0.8 ± 4.4	-11.7 ± 4.2	-10.9 (-22.8,0.9)	0.070
Solid fat (g)	0.5 ± 17.5	-3.7 ± 16.7	-4.2 (-11.1,2.8)	0.246	1.6 ± 2.8	-3.8 ± 2.6	-5.4 (-12.9,2.0)	0.153
Saturated fat (g)	0.3 ± 9.4	-3.5 ± 10.1	-3.9 (-7.9,0.1)	0.059	0.7 ± 1.7	-3.5 ± 1.6	-4.2 (-8.6,0.3)	0.068
Carbohydrates (g)	-0.7 ± 54.7	-22.5 ± 57.7	-21.8 (-44.6,1.0)	0.064	-4.0 ± 9.6	-24.6 ± 9.1	-20.7 (-44.9,3.6)	0.095
Sugar (g)	1.1 ± 27.3	-13.2 ± 36.7	-14.3 (-27.2,-1.3)*	0.034*	-1.8 ± 5.1	-13.5 ± 5.0	-11.7 (-25.0,1.6)	0.085
Added sugar (g)	-0.4 ± 6	-3.5 ± 6.3	-3.2 (-5.7,-0.7)*	0.015*	-0.5 ± 1.2	-3.3 ± 1.0	-2.8 (-5.7,0.1)	0.061
Fiber (g)	-0.6 ± 4	0.7 ± 6.5	1.3 (-0.9,3.5)	0.237	-0.8 ± 0.9	0.4 ± 1.0	1.2 (-1.2,3.6)	0.331
Sodium (mg)	-87 ± 951	-253 ± 731	-166 (-510,178)	0.347	-130 ± 143	-264 ± 131	-135 (-502,232)	0.471

* P value < 0.05.

[1] ASA-24, automated self-administered 24-h dietary recall; HEI, Healthy Eating Index.

[2] All estimates adjusted for random cluster (community) effects, random assignment group, age, and education.

[3] Multiple imputation model based on available sample of control participants (n = 47) and intervention participants (n = 50).

TABLE 4

Within-group change and between-group change in survey measures from baseline to intervention end point (24 wk) among *Strong Hearts, Healthy Communities-2.0* intervention and control participants

	Complete case				Multiple imputation			
	Control participants (n = 56)	Intervention participants (n = 59)	Difference between groups		Control participants	Intervention participants	Difference between groups	
	Mean change ± SD	Mean change ± SD	Estimate[2] (95% CI)	*P* value	Mean hange ± SD	Mean change ± SD	Estimate[2] (95%CI)	*P* value
Overall Dietary Patterns								
REAP-S[1] score (scale 13 to 39) (Survey)	-0.2 ± 3.7	3.3 ± 4.1	3.5 (2.1,5.0)*	<0.001*	-0.5 ± 0.7	3.4 ± 0.5	3.9 (2.3,5.6)*	<0.001*
Diet Psychosocial								
Healthy Eating Attitudes (scale 1–10)	0.0 ± 0.5	0.3 ± 0.6	0.3 (0.1,0.5)*	0.012*	-0.1 ± 0.1	0.3 ± 0.1	0.4 (0.2,0.6)*	<0.001*
Uncontrolled eating score (scale 6–24)	0.2 ± 3.2	-2.1 ± 4.0	-2.4 (-3.7,-1.0)*	0.001*	0.5 ± 0.6	-1.8 ± 0.6	-2.3 (-3.9,-0.6)*	0.009*
Cognitive restraint score (scale 6–24)	-0.2 ± 2.6	1.9 ± 3.6	2.1 (1.0,3.2)*	<0.001*	-0.3 ± 0.5	1.7 ± 0.5	2.1 (0.7,3.4)*	0.003*
Emotional eating score (scale 6–24)	-0.3 ± 2.3	-1.1 ± 2.0	-0.8 (-1.5,0.0)	0.059	0.0 ± 0.3	-1.2 ± 0.3	-1.3 (-2.1,-0.4)*	0.004*
Confidence in ability to stick to low-saturated fat, low salt foods (scale 1–5)	0.0 ± 0.9	0.1 ± 1.4	0.1 (-0.3,0.6)	0.546	-0.2 ± 0.2	0.2 ± 0.2	0.3 (-0.2,0.8)	0.218
Confidence in ability to eat smaller portions (scale 1–5)	-0.1 ± 1.0	-0.3 ± 1.1	-0.2 (-0.6,0.2)	0.336	-0.1 ± 0.2	-0.2 ± 0.2	-0.1 (-0.6,0.3)	0.581
Confidence in ability to avoid adding salt at the table (scale 1–5)	0.2 ± 1.2	0.0 ± 1.2	-0.2 (-0.6,0.3)	0.441	0.2 ± 0.2	0.2 ± 0.2	0.0 (-0.5,0.5)	0.977
Confidence in ability to choose low-saturated-fat foods (scale 1–5)	-0.2 ± 0.8	-0.1 ± 0.9	0.1 (-0.2,0.4)	0.523	-0.3 ± 0.1	-0.1 ± 0.1	0.2 (-0.2,0.5)	0.421
Diet-related Social Support[4]								
Family encouraged healthy eating habits (scale 5–25)[5]	0.3 ± 5.4	0.9 ± 4.2	0.5 (-1.6,2.7)	0.626	-0.3 ± 1.1	0.7 ± 0.9	1.1 (-1.6,3.8)	0.432
Family discouraged healthy eating habits (scale 5–25)[6]	-0.2 ± 4.2	-0.7 ± 3.5	-0.5 (-2.2,1.3)	0.588	-1.1 ± 1.1	-0.5 ± 0.9	0.7 (-2.2,3.6)	0.654
Friends encouraged healthy eating habits (scale 5–25)[7]	-1.0 ± 5.0	1.4 ± 4.6	2.4 (0.3,4.6)*	0.032*	-0.9 ± 1.4	1.8 ± 1.6	2.7 (-1.7,7.0)	0.224
Friends discouraged healthy eating habits (scale 5–25)[8]	-0.5 ± 4.2	-0.3 ± 2.3	0.2 (-1.7,2.1)	0.840	-0.0 ± 5.4	-0.2 ± 4.6	0.17 (-1.65, 1.99)	0.854

* P value < 0.05.
[1] REAP-S, Rapid Eating Assessment for Participants-Short Version.
[2] All estimates adjusted for random cluster (community) effects, random assignment group, age, and education.
[4] The number of responses was lower for the Sallis Social Support Scale for Diet questions (see footnotes below) because those living alone were asked to skip the family columns; this led to additional missed responses because some respondents skipped all or some questions in this section.
[5] $n = 41$ control, $n = 36$ intervention
[6] $n = 38$ control, $n = 36$ intervention
[7] $n = 40$ control, $n = 38$ intervention
[8] $n = 33$ control, $n = 24$ intervention

intervention above US averages for each measure, whereas control arm participants did not.

All statistically significant improvements for intervention participants at endpoint were significant at midpoint compared with controls and were similar across complete case and outlier analyses (Supplemental Table 5). Total fat, saturated fat, solid fat, vegetable, and fiber consumption and HEI score were also improved at midpoint for intervention compared with controls. To determine if participant attendance impacted outcomes that were statistically significant at 12 wk, but not 24 wk, we conducted a dose response analysis that used 0 to 12-wk and 12 to 24-wk attendance as both a continuous and a categorical (75% or more) variable; however, this analysis did not significantly alter findings (data not shown).

Discussion

The objective of the present study was to evaluate the impact of SHHC-2.0 between intervention and control participants on secondary, dietary intake, diet behaviors, and related psychosocial outcomes as they pertain to the goal and behavioral aims of the intervention. For this population of female adults with overweight or obesity living in medically underserved rural areas, there was a critical need for a dietary intervention as their diet quality was below the national average at baseline (e.g., REAP-S was 29 at baseline for the participants and the national average for omnivores is 32) [63] and additionally, with only 10% or less meeting recommendations for fruit and 15% or less meeting recommendations for vegetable intake. These findings are consistent with the current trend in dietary intake among adults in the United States that show lower diet quality among individuals from rural areas compared to urban areas [3,64,65] and the general population (25% in rural communities compared to 40% in general population) [11]; this further underscores the need to prioritize female adults in underserved rural populations in CVD-prevention efforts [66].

Reduction in total caloric intake was seen for participants from the 5 intervention communities at 24 wk compared to communities in the control intervention. Reduced caloric intake can contribute to weight loss and is associated with improvement in cardiovascular health [67]. Guidelines for the management of obesity often recommend deficits of 500 to 750 calories to achieve weight loss [68]. However, reduction in total caloric intake (average daily dietary deficit of 225 ± 75 kcals in the intervention group), along with other activities that contribute to weight loss in SHHC-2.0, like increased physical activity, supports

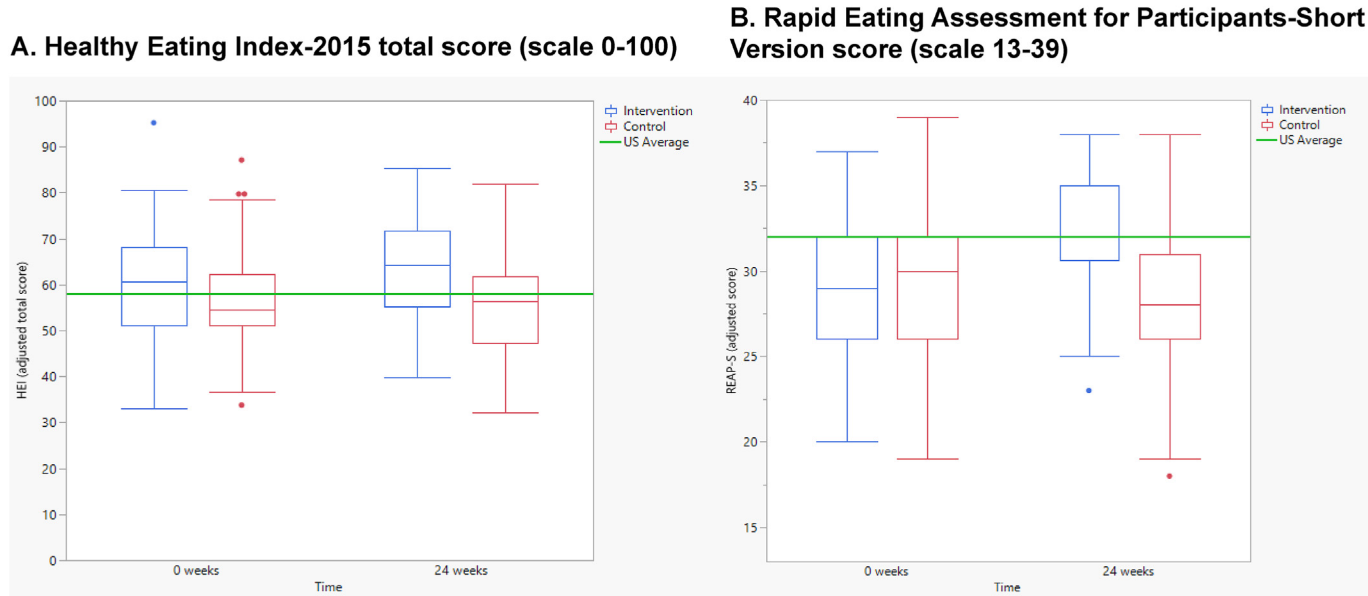

FIGURE 2. Distribution of dietary intake with interquartile range at baseline and intervention end point (24 wk) by intervention group. The middle of the box plot represents the median Healthy Eating Index-2015 (HEI) score (A) and Rapid Eating Assessment for Participants-short version (REAP-S) score (B), with each side representing the interquartile range (25th to 75th percentile of the data) and whiskers representing 1.5 times the interquartile range below the 25th percentile and above the 75th percentile. Each dot in the figure represents HEI score (A) and REAP-S score (B) for each intervention group (in blue) and control group (in red) participant.
The United States national average for HEI is 58: United States Department of Agriculture Center for Nutrition Policy and Promotion. HEI Scores for Americans. https://www.fns.usda.gov/hei-scores-americans. Accessed 21 July 2022.
The mean REAP-S score for U.S. adults consuming a typical omnivorous diet is 32: Johnston, C.S., Bliss, C., Knurick, J.R. *et al.* Rapid Eating Assessment for Participants [shortened version] scores are associated with Healthy Eating Index-2010 scores and other indices of diet quality in healthy adult omnivores and vegetarians. *Nutr J* **17,** 89 (2018). https://doi.org/10.1186/s12937-018-0399-x.

previously published findings on SHHC-2.0 that demonstrated higher weight loss among SHHC-2.0 participants compared with the control group [38]. This is a promising result, as other CVD-prevention interventions for female adults from rural areas showed no significant difference or even reported an increase in energy intake when comparing program participants to a control group [27,28]. Only the Strong Women-Healthy Hearts study—the curriculum from which SHHC-2.0 originated—demonstrated decreased energy intake in the intervention compared with control group [33], adding evidence to the effectiveness of the present program.

Although overall reduced calorie intake was evident at 12 and 24 wk, other nutrient-specific intakes that improved at midpoint (12 wk)—including total fat, saturated fat, solid fat, vegetable servings, fiber, and HEI total score—were not sustained to 24 wk. Several nonsignificant findings ($0.05 < P < 0.10$) are worth noting at the 24-wk time point as they are tied to specific behavioral aims of the study and suggest improvements in overall diet (HEI total score) and improved eating habits related to processed foods (total fat, total carbohydrate, saturated fat, sugar, and added sugar). These findings could highlight the need for increased statistical power to detect these dietary intake changes or the challenges of long-term adherence to dietary health behaviors with the need to focus on additional strategies and support to sustain changes [69].

Additionally, we measured overall diet quality using the REAP-S, a 16-question scale that captures diet quality and diet-related behaviors and takes less than 10 min to complete. REAP-S scores have been shown to correlate with HEI-2010 scores in a healthy adult population consuming both plant and animal-based diets [70]. REAP-S also correlates well with 4 indicators of diet quality: potential renal acid load, urine pH, plasma vitamin C, and nutrient density of the diet, as well as intake of various nutrients including saturated fat [70]. Furthermore, REAP-S includes additional direct self-reported measures of types of foods and diet-related behaviors that impact CVD risk (e.g., intake of fried food and processed meat, breakfast consumption) [71–73] not directly captured by HEI. These results, in combination with ease of use and low cost, suggest that the REAP-S measure is a useful tool for rapid assessment of diet quality. In this study, we found that intervention participants saw greater improvements in REAP-S at both 12 and 24 wk compared with controls. Furthermore, the average REAP-S score for participants at 24 wk surpassed the average score for American adults of 32, whereas the control group remained below this average [70]. These findings provide new evidence regarding the ability of multilevel community-based interventions to improve dietary patterns among female adults in rural areas. Previous CVD-prevention interventions for female adults in rural communities have reported improvements in dietary components (e.g., fruits and vegetables, dairy, saturated fat, fried foods) but, to the authors' knowledge, none have reported a comprehensive measure of overall dietary patterns, like in the present study [27,28,30,31,33].

Intervention participants experienced greater improvements than control participants in a variety of psychosocial measures including healthy eating attitudes, uncontrolled eating, cognitive restraint, and emotional eating. Diet-related psychosocial outcomes have not been previously reported in CVD-prevention interventions for female adults in rural areas, adding to the uniqueness of this study [34]. The HEAS was created to capture motivation toward healthy eating behaviors and is an important precursor to actual behavior change, whereas the TFEQ [74] serves as an indicator for the adoption of strategies to improve dietary intake through cognitive restraint and disinhibited eating. Improvements in psychosocial factors, as seen in the present study, highlight the multifaceted impact of the intervention and likely contributed to the improved dietary outcomes experienced by intervention participants.

Higher mean changes in diet-related social support from friends or family were not evident in the intervention group compared with the control group. Social support has been shown to play an important role in healthy eating behaviors across a variety of settings [75–78]. Although the measures selected for the present study captured support from friends or family, it may not have reflected support from other important sources, such as other SHHC-2.0 participants or program leaders that could have contributed to the improved diet-related outcomes seen among intervention participants. Nonetheless, incorporating more strategies for garnering and maintaining friend and familial social support in SHHC-2.0 curriculum may be warranted.

This study was not without limitations. Most of the participants were older female adults who identified as White, and although this is reflective of many rural communities, future programs should include a more diverse sample of female adults from rural areas. Future studies should also collect information on menopause status of participants, since critical cardiometabolic health changes occur over the menopausal transition, contributing to CVD risk [7]. Additionally, as with all self-reported data, there is a possibility of bias resulting from recall or social desirability. This was a particular concern with dietary intake that may have issues with measurement error due to self-report or been misreported or underestimated in the intervention group due to social desirability (i.e., desire to show to the investigators that the intervention was effective for them). Also, the study was not powered to detect nonprimary outcomes of diet intake and behaviors and diet-related psychosocial measures; given the number of outcomes we explored in this analysis, there is an increased risk of type 1 error (false positives). The participant dropout rate was 12.3% higher than was estimated in the protocol. The plausibility of erroneous conclusions based on data not missing at random and MI modeling was conducted. The "tipping point" sensitivity analysis found that those lost to follow-up in the intervention group would have to increase their daily caloric intake by 115 kcals more than the control group during the 24-wk intervention period to reverse the findings. Therefore, future studies should include strategies to minimize participant attrition. As noted, some of the improvements seen at 12 wk were not sustained at 24 wk. Participants attended, on average, 59% of classes, equivalent to 28.4 contact hours across 6 mo. Attending twice weekly in-person classes over 6 mo, including the winter season, was likely a challenge for participants. Given this, condensing the program to 3 mo with postprogram maintenance support is a favorable option for future SHHC-2.0 iterations and may improve session attendance.

In conclusion, this study provides evidence that this community-based multilevel CVD-prevention intervention can improve dietary patterns and diet-related psychosocial factors. The improvements in diet-related psychosocial factors, coupled with improved dietary patterns, highlight the critical importance of using multilevel theories to design effective, evidence-based health promotion programs. Based on the findings, future health promotion programs for midlife and older female adults from rural areas would benefit from implementing SHHC-2.0 to promote dietary patterns and diet-related behaviors that help prevent CVD.

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Author contributions

The authors' responsibilities were as follows—RASF, SCF, DS, MEN: designed research; RASF, MLG: conducted research; MD: analyzed data; ALMU, MD, MLG, JS, CDR, PG: wrote the paper; RLB, DS, JND: provided critical scientific input, review, and revisions; ALMU; RASF had primary responsibility for final content; and all authors read and approved the final manuscript.

Conflict of interest

RASF and MEN are co-founders of strongpeopleprogram.org. All other authors report no conflicts of interest.

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Data availability

Data described in the manuscript, code book, and analytic code will be made available upon request pending application and approval.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ajcnut.2023.09.003.

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