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A Food Store–Based Environmental Intervention Is Associated with Reduced BMI and Improved Psychosocial Factors and Food-Related Behaviors on the Navajo Nation[1–3]

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Abstract

The prevalence of obesity is significantly higher among American Indians (AIs) and is associated with increased rates of diabetes, hypertension, and cardiovascular disease. We implemented a 14-mo intervention trial (Navajo Healthy Stores) on the Navajo Nation that sought to increase availability of healthier foods in local food stores and to promote these foods at the point of purchase and through community media. We divided the Navajo Nation into 10 store regions, half of which were randomized to intervention and half to comparison. We evaluated the program by using a pre-post sample of systematically sampled adult Navajo consumers (baseline, n = 276; postintervention, n = 145). Intervention impact was examined by analyzing pre-post differences by intervention group and by intervention exposure level. When intervention and comparison groups were compared, only body mass index (BMI) showed a trend toward impact of the intervention (P = 0.06). However, greater exposure to the intervention was associated with significantly reduced BMI ($P \leq 0.05$) and improved healthy food intentions ($P \leq 0.01$), healthy cooking methods ($P \leq 0.05$), and healthy food getting ($P \leq 0.01$). With increasing exposure, the odds of improving overweight or obese status was 5.02 (95% CI: 1.48, 16.99; $P \leq 0.01$) times the odds of maintaining or worsening overweight or obese status. In summary, a food store intervention was associated with reduced overweight/obesity and improved obesity-related psychosocial and behavioral factors among those persons most exposed to the intervention on an AI reservation. J. Nutr. 143: 1494–1500, 2013.

Introduction

In the US, 66% of adults are currently classified as overweight or obese and 16% of children and adolescents are overweight, whereas 34% are at risk of becoming overweight (1). Obesity prevalence is significantly higher among low-income ethnic minority groups (2–4). American Indians (AIs),[4] in particular, are at an increased risk of obesity (5,6). According to the U.S. Department of Health and Human Services, AIs are 1.6 times as likely to be obese compared with non-Hispanic whites (7).

The high rates of obesity in AI populations are associated with increased rates of diabetes, hypertension, heart disease, and cardiovascular disease (4,6,8). Two out of the top 5 leading causes of death for all ages among AIs are diseases of the heart and diabetes (9). The age-adjusted death rate due to diabetes is 2.9 times the rate of other U.S. races and 3.2 times the rate of U.S. whites (9). Diabetes contributes to cardiovascular disease as the leading cause of death among AIs (9). Among AIs, the consumption of foods high in fat and low in dietary fiber is associated with increased risk of diabetes and the consumption of foods low in fat and high in fiber appears to have a protective effect (5).

The past decade has produced a number of studies that have indicated that racial health disparity may be attributable in part to disadvantages at the community level (10,11). Closer proximity to a supermarket is positively associated with healthier diets, increased fruit and vegetable consumption, and lower rates of obesity (11–13). Supermarkets generally have better availability and selection, superior quality, and lower prices (14). However, supermarkets are less accessible in low-income neighborhoods and even among stores of the same type, those located in economically disadvantaged neighborhoods have less availability, more limited selection, and higher prices of foods (15–17).

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[3] Supplemental Tables 1 and 2 are available from the ''Online Supporting Material'' link in the online posting of the article and from the same link in the online table of contents at http://jn.nutrition.org.
[4] Abbreviations used: AI, American Indian; AIQ, Adult Impact Questionnaire; IEQ, Impact Exposure Questionnaire; MSL, material style of life; NHS, Navajo Healthy Stores; NSDP, Navajo Special Diabetes Project.
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In AI settings, the food environment plays a key role in limiting food access and choice (18,19). Pareo-Tubbeh et al. (20) showed that many geographical areas on the Navajo Nation were limited in terms of healthy food options, with fresh fruits and vegetables in poor condition and dramatically varying prices among stores. Environmental factors such as access to and availability of healthy foods are influenced by types of retail stores and by the selection available at these stores (21). Changing the food environment in AI communities may be a feasible way to affect diet quality and reduce obesity and chronic disease risk (18,22). A few trials have been conducted to improve the food environment in AI communities. The Zhiwaapenewin Akino'Maagewin (23,24) and Apache Healthy Stores (25,26) programs both sought to improve the local food environment by working with food stores. These interventions showed positive changes in individual psychosocial measures, characterized by increased knowledge, and demonstrated indirect improvements in diet as measured by the frequency of healthy food acquisition. Despite these positive findings, to our knowledge, no food store–based trial in AI populations has been successful in reducing BMI among adults. In fact, no such program has demonstrated impact on BMI in any population, despite multiple trials in several countries (22). In addition, few studies of the sustainability of diet and food-related interventions have been conducted, and none have been conducted for environmental interventions.

To address these gaps, investigators from the Johns Hopkins Center for Human Nutrition collaborated with the Navajo Special Diabetes Project (NSDP). The overall goal of the program was to improve dietary patterns on the Navajo Nation and to reduce risk of obesity by increasing the availability, purchase, and consumption of healthy foods. The Navajo Healthy Stores (NHS) program was developed through extensive formative research and a community engagement process involving a combination of 1–2-d workshops and 12 d of community workshops. The workshop discussions generated a series of key foods and behaviors for promotion using a brainstorming and a prioritizing process (27). A series of messages and ideas were developed to promote healthy food choices, preparation, and consumption. The overall approach was a locally implemented and sustained intervention that was carried out by the NSDP staff with training, materials, and support by the Johns Hopkins team.

During the planning stage, community members and members of the NSDP worked together to identify small towns and divided the Navajo Nation into 10 regions on the basis of the presence of a supermarket. The Navajo Nation is the largest federally recognized AI tribe in the US, spanning 43,452 km^2 across New Mexico, Arizona, and Utah, with an estimated on reservation population of >250,000 individuals (28). On the reservation, individuals live in scattered small towns or rural, isolated homesteads of several related households. These areas are usually surrounded by dry land with no running water or electricity. A few of the towns on the reservation have supermarkets, but the majority of them have a trading post or convenience store. Thus, the NHS program planned to use the available environmental resources by conducting interventions in supermarkets, trading posts, and convenience stores.

The 10 store regions identified span the entire Navajo Nation, covering the majority of the reservation with the exception of the most remote areas with no food stores and few households, and some satellite communities that are not attached to the main reservation. The 10 store regions on the Navajo Nation were randomized into comparison or intervention regions. In round 1 of the intervention, 5 store regions served as the intervention regions and the other 5 served as the comparison regions. Due to random assignment of regions to treatment status, comparison and intervention regions were frequently contiguous. Round 2 was a delayed intervention implemented postintervention in the 5 comparison store regions. Thus, all regions on the Navajo Nation received the NHS intervention by the end of the trial. Baseline data consisting of respondent sociodemographic information, anthropometric characteristics, and food-related attitudes, knowledge, and behavior were collected before the beginning of the first round. Postintervention evaluation assessments took place between rounds 1 and 2, with the same information collected. Additional questions about exposure to the NHS intervention were asked postintervention. This article presents the data collected before (baseline) and after (postintervention) round 1 was implemented.

During each round, 6 intervention phases were conducted, with each phase lasting 6–10 wk (**Supplemental Table 1**). The intervention was carried out by local NSDP nutritionists/health workers who were fluent in both English and Navajo with basic nutrition knowledge and experience in delivering nutrition interventions in the Navajo Nation. Johns Hopkins University provided periodic additional training and oversight. In each region, the main grocery store and a few smaller stores housed the intervention. Each interventionist was assigned 1–2 stores and conducted a 1–2-h interactive session at each store 2–4 times per month. The interactive sessions included demonstrating healthier cooking methods, taste-testing healthy foods, giving away promotional items, and responding to questions from store customers. The interventionists' additional duties were to create and maintain relationships with food stores, work with stores to stock key promoted healthier foods, and set up media materials such as educational displays, posters, and shelf labels. Additionally, radio announcements of key messages were recorded and played regularly in both Navajo and English.

This purpose of this article is to examine the impact of the NHS program on Navajo community members by measuring changes in psychosocial variables, food-related behavior, and BMI. Previous work supported the idea that combined environmental and educational approaches would lead to behavioral and health outcome improvements (18,22,23).

Participants and Methods

Design and participants. The NHS was a store-region randomized controlled community-based intervention, with a systematic sample of adult respondents divided into intervention and comparison groups. Every fifth respondent encountered was sampled in each store region at various community locations. At baseline, a total of 276 participants were recruited from participating stores, senior centers, and community centers. Eligibility criteria included being the main food preparer/shopper for the household, age ≥18 y, Navajo tribal member, having lived in the community for at least 1 mo, not pregnant, and no plans to move off the reservation in the next year. Baseline measures were taken at study initiation, and postintervention measures were taken 15–20 mo later. The study was approved by the Navajo Nations Human Research Review Board and the Johns Hopkins Institutional Review Board. Signed consent was obtained from all participants.

Measures. The measures used were adapted from materials developed from formative research findings, our previous studies in AI settings (22,31–33), and contributions of project stakeholders in AI settings (26).

The Adult Impact Questionnaire (AIQ) was used to assess the level of food-related attitudes, knowledge, and behaviors in the population. The

AIQ included sociodemographic information, including age, sex, household size, marital status, educational level, employment status, material style of life (MSL), personal/family history of chronic disease, and food-assistance program participation. Trained data collectors measured participant height and weight. When measurement was refused, participant-reported height (52.41%) and weight (59.31%) were used. BMI was calculated by using the standard equation, weight (kg)/height (m^2).

The Intervention Exposure Questionnaire (IEQ) was administered postintervention to measure exposure to specific components of the NHS program. Participant exposures to educational materials/sessions (store shelf labels, posters, logos, educational displays, fliers, and receipt of promotional items) and media (radio, newspaper, etc.) were collected. Questions were asked about participation in the store food demonstrations and the use of intervention stores in the past 30 d. Four "red herring" questions were included to identify potential response bias.

A quantitative FFQ was developed for the study and will be presented in a follow-up article.

Construct scores. Constructs were developed on the basis of Social Cognitive Theory (29) and the Theory of Planned Behavior (30) to evaluate food-related behaviors and psychosocial predictors. Cronbach's α was used to determine the internal consistency of questions pertaining to an underlying construct in order to assess the reliability of the scales that were created. For each construct, higher numbers indicate healthier (positive) scores (**Supplemental Table 2**).

Healthy food knowledge is calculated from 9 questions asking participants about their general knowledge of healthy foods and healthy food behaviors. For example, they were asked, "Which cereal has the most fiber?" Responses were given scores ranging from 0–2 and summed to create the scale score (baseline α = 0.67; postintervention α = 0.66).

Healthy food self-efficacy is the sum of scores for 19 multiple-choice questions. Respondents were asked questions on how easy or difficult it would be to perform certain food-related behaviors [e.g., use cooking spray, like Pam (ConAgra Foods, Inc.)]. These questions were scored on a 4-point Likert-type scale with answers given scores between 1 and 4. For example, *1*) would be impossible for you to do regularly, *2*) would be very hard for you to do regularly, *3*) would be kind of hard for you to do regularly, *4*) would be very easy for you to do (baseline α = 0.88; postintervention α = 0.88).

Healthy food intentions is based on 15 multiple-choice questions asking participants which foods they would actually buy, eat, and cook if they were presented with specific choices (e.g., If you buy milk, which would you buy?). Responses were given scores ranging from 0 to 2 and added to form the scale score (baseline α = 0.74; postintervention α = 0.78).

Nutrition label reading is the sum of 8 questions pertaining to reading nutrition labels. Participants were asked questions about serving size, grams of fat, and percentage of daily value, and each correct answer was scored as 1 point. For example, "How many servings are in the entire bar?" (baseline α = 0.82; postintervention α = 0.82).

Healthy cooking methods is based on reported main cooking methods for 9 foods: ground beef, chicken, pork, fish, mutton, potato, eggs, bread, and fresh vegetables. Each cooking method was assigned a score between −2 and 1, with higher numbers indicating healthier cooking methods. Examples of cooking methods include deep-fried, pan-fried, cooking spray, etc. Participants were asked to choose their primary and secondary methods of cooking each food. If the primary method was used to cook the food, it was weighed by a factor of 0.6, and if the secondary method was used, it was weighed by a factor of 0.4. These scores were summed to form the scale score (baseline α = 0.65; postintervention α = 0.71).

Healthy food getting is an additive scale score based on 41 healthy food items. Healthy food items were defined as products lower in fat and sugar, or higher in fiber, than commonly consumed alternatives (e.g., whole-wheat bread). Participants were asked about foods and the number of times they were gotten in the past 30 d (baseline α = 0.93; postintervention α = 0.93).

Unhealthy food getting is an additive scale score based on 12 unhealthy foods. Unhealthy food items were defined as products higher in fat and sugar than commonly consumed alternatives [e.g., regular Coke (Coca-Cola Company)]. Participants were asked about foods and the number of times they were gotten in the past 30 d (baseline α = 0.77; postintervention α = 0.83).

Perceptions of healthy food is the sum of 8 questions that asked participants how strongly they agreed or disagreed with statements about healthy foods (e.g., "Healthy foods are expensive") (baseline α = 0.87; postintervention α = 0.84).

Shelf label–driven healthy food purchasing 1 is based on a question that asked about the frequency of purchasing a food due to an NHS label. The question asked was "Have you ever purchased a food because you saw one of the Healthy Stores shelf labels under it?" Answers to this question were reverse coded and summed.

Shelf label–driven healthy food purchasing 2 is the sum of answers to a question asking which foods were bought in the past year due to an NHS label. The question asked was "Which of the following foods did you ever buy in the last year because you saw a Healthy Stores shelf label like the one I just showed you?" (postintervention α = 0.92).

Data management and analysis. Intervention impacts were assessed by analyzing pre-post differences in store regions randomized to intervention versus comparison and by examining different levels of intervention exposure.

The paper version of the AIQ and IEQ were administered by trained data collectors, then entered into MS Access (Microsoft Corporation). Ten percent of the entries were double-entered for quality control. All data were transferred into SAS software, version 9.2, of the SAS System for Management and Analysis (SAS Institute).

Descriptive analyses using *t* tests for continuous variables and chi-square tests for categorical variables were conducted for baseline data (**Table 1**). Characteristics of those who were lost to follow-up and those who stayed in the study were also compared. Changes from baseline to postintervention were compared between intervention and comparison groups by using Student's *t* test.

The overall exposure score was calculated by summing the exposure scores of the various components of the NHS intervention. Missing values were imputed by using the highest frequency (mode) answer for

TABLE 1 Sociodemographic characteristics of the Navajo Healthy Stores evaluation sample[1]

Characteristics	Intervention (*n* = 98)	Comparison (*n* = 47)
Female, %	72.5	78.7
Age, *y*	48.2 ± 16.2	45.8 ± 18.5
Years of schooling	10.9 ± 3.6*	9.3 ± 4.9
Married, %	35.7	40.4
Household size, *n*	4.6 ± 2.6	3.7 ± 2.3
Personal or family history of chronic diseases, %	70.4	74.5
Not employed or retired, %	43.9	40.4
Food assistance, %		
WIC	21.4	14.9
SNAP	20.4	25.5
Commodity foods	20.4	12.8
Eat at senior center	26.5	27.7
Food bank/Navajo Way	5.10	4.26
MSL[2]	15.0 ± 13.8	11.6 ± 7.2
BMI, *kg/m²*	30.6 ± 6.0	30.2 ± 5.9
Overweight or obese, %	87.5	87.0
Obese, %	47.9	43.5

[1] Values are means ± SDs or percentages. *Significantly different from comparison group, $P \leq 0.05$. MSL, material style of life; SNAP, Supplemental Nutrition Assistance Program; WIC, Special Supplemental Nutrition Program for Women, Infants, and Children.
[2] MSL was constructed on the basis of questions in the Adult Impact Questionnaire. Each point indicates ownership of 1 item on the scale. A higher MSL reflects greater ownership of a number of different household items (cars, televisions, etc.), which is an indicator of household economic status.

that question, because the IEQ included ordinal answers (31). The components of the intervention were standardized to a 0–1 scale and consisted of a logo score, a shelf label score, a taste-test score, a poster score, an educational display score, a flyer/pamphlet score, a promotional item score, a newspaper article score, and a radio announcement score. Exposure to newspaper articles and radio announcements were considered to be equally accessible by all participants and thus not included in the final exposure score. Exposure scores ranged from 0 to 7. Therefore, a 1-unit change in exposure score represents a considerable difference in the participant's exposure level to our intervention activities. No respondents reported positively to >2 of the 4 red-herring questions, so the entire postevaluation sample was used.

Exposure scores were further categorized into quartiles. Differences in outcomes based on exposure levels were assessed by using ANOVA.

Linear regressions were used to assess psychosocial and behavioral outcomes by intervention group and exposure levels. Logistic regressions were used to assess the impact on individual weight status. All linear regression models were adjusted for the baseline value of the outcome variable, sex, age, educational level, household size, and MSL. All logistic regression models were adjusted for sex, age, educational level, household size, and MSL. A dummy variable to account for self-reported versus measured BMI was included as an adjustment (1 = measured, 0 = self-reported). The coding of outcome variables in logistic regression was as follows: For the variable "overweight or obese"—1 = overweight or obese at baseline and not overweight or obese at postintervention; 0 = 1 of the following conditions: *1*) overweight or obese at baseline and same weight status at postintervention, *2*) normal weight at baseline and postintervention, or *3*) normal weight at baseline and overweight or obese at postintervention. For the variable "obese," the same coding rule was applied only for those who were obese at baseline.

Results

Sample description. A total of 145 participants completed both baseline and postintervention assessments, a retention rate of 56.5% (Table 1). The sample was predominantly female (74.5%), and the mean (±SD) age of participants was 46.0 ± 16.1 y. The intervention group reported more years of schooling than the comparison group ($P \leq 0.05$). All other sociodemographic characteristics between the 2 groups were not significantly different. There were no differences found between participants who were lost to follow-up (n = 118) and participants who completed the study (n = 145).

Intervention effects. In bivariate analyses, we found no significant differences in any of the study outcomes between the intervention group and the comparison group (**Table 2**). The intervention group showed a marginal decrease in BMI score (P = 0.06).

Exposure to intervention. We compared differences in exposure to intervention components between the intervention and comparison respondents (**Table 3**). Significant differences in shelf label score ($P \leq 0.01$), taste-test score ($P \leq 0.01$), and overall exposure score ($P \leq 0.05$) were found. Whereas the intervention group was significantly more exposed to the intervention than the comparison group, exposure to most intervention components was found among comparison respondents.

Intervention effects by exposure category. Significant differences in change scores were observed between quartiles of exposure when outcomes were compared between very low, low, medium, and high exposure levels (**Table 4**). It was observed that consumers who visited participating stores more frequently had significantly higher exposure scores. Increased exposure was associated with significant increases in healthy food intention scores ($P \leq 0.05$) and shelf label–driven healthy food purchasing scores 1 and 2 ($P \leq 0.01$) and with significant decreases in BMI ($P \leq 0.01$). The strongest effects were observed in the most highly exposed group of respondents. We found a significant positive association between exposure to the intervention and frequency of getting of healthier foods (data not shown).

Linear and logistic regressions were conducted by using the overall exposure score as a continuous variable (**Table 5**). In the linear regression models, higher exposure to the intervention was associated with significantly improved healthy food intentions ($P \leq 0.01$), healthy cooking methods ($P \leq 0.05$), and healthy food getting frequency ($P \leq 0.01$). At the highest levels of exposure, there was a significant decrease in BMI from baseline to postintervention ($P \leq 0.01$). In the logistic regression models, there was a significant association between increased exposure and improved overweight/obese status from baseline to postintervention (OR: 5.02; 95% CI: 1.48, 17.0).

Discussion

This article reports on the results of a successful environmental intervention to reduce obesity and obesity-related psychosocial and behavioral factors on an AI reservation by working with food stores. To our knowledge, this is one of the first such community-based trials to show an impact on weight status among adult AIs. The fact that we saw an impact on psychosocial and behavioral factors provides additional support for the validity of our associations. We have conducted food store–centered trials in other settings with indigenous peoples that have shown positive impacts on psychosocial factors and food-related behaviors (23–26).

It is important to emphasize that the positive findings were in association with the reported level of exposure to the intervention and not based on treatment group assignment. We divided the Navajo Nation into distinct regions on the basis of communities and clusters of food stores. However, Navajo community members shop at multiple venues, including off reservation. Therefore, we found that our comparison group respondents were also exposed to intervention components. It is likely that intervention respondents also shopped in comparison area stores or in stores that were not part of the intervention, further reducing opportunities to detect differences between the 2 groups in terms of original treatment group assignment. This is one of the challenges in conducting community-based trials. It is difficult to avoid contamination without working in many communities, an expensive alternative.

We found an association between exposure and combined overweight/obese status at baseline but not between exposure and those who were obese at baseline. This difference may be due to sample size. Close to 90% of our sample were either overweight or obese at baseline, nearly twice as were obese only. The larger overweight/obese sample may have had greater power to detect change.

For each 1-point increase in exposure score, the participants' odds of changing to a healthy weight group increased by 5 times (see categorization of weight-change groups in the footnote of Table 5). In fact, an exposure score increase of 1 point is a very large change in our study—our mean exposure score for the intervention group was 2.28 and for the comparison group was 1.69. Only a few participants actually changed from overweight/obese to a healthy BMI.

TABLE 2 Psychosocial, behavioral, and anthropometric changes in the Navajo Healthy Stores evaluation sample[1]

	Intervention (n = 98)			Comparison (n = 47)		
	Baseline	Postintervention	Change from baseline to postintervention[2]	Baseline	Postintervention	Change from baseline to postintervention[2]
Health food knowledge score	9.1 ± 2.7	6.9 ± 2.7	2.3 ± 2.5	9.1 ± 2.7	6.9 ± 2.1	2.2 ± 2.3
Healthy food self-efficacy score	60.7 ± 10.0	66.2 ± 7.8	5.3 ± 10.8	60.5 ± 10.7	65.6 ± 7.69	5.6 ± 11.2
Healthy food intentions score	13.8 ± 4.3	16.3 ± 4.1	2.47 ± 4.5	14.6 ± 4.47	16.1 ± 4.55	1.3 ± 5.4
Nutrition label reading score	1.5 ± 1.9	1.8 ± 2.1	0.2 ± 2.1	1.8 ± 2.1	2.5 ± 2.5	0.6 ± 2.3
Healthy cooking methods score	0.1 ± 2.8	1.2 ± 3.0	1.1 ± 3.5	0.3 ± 2.6	2.1 ± 2.6	1.8 ± 3.2
Healthy food getting score	76.5 ± 46.1	70.5 ± 37.7	−5.7 ± 47.8	78.6 ± 51.9	67.1 ± 34.7	−12.1 ± 51.6
Unhealthy food getting score	25.3 ± 17.7	15.7 ± 12.7	−9.7 ± 18.8	26.8 ± 25.4	15.9 ± 13.9	−11.9 ± 25.8
Perceptions of healthy food score	25.0 ± 6.3	26.6 ± 6.1	1.5 ± 7.1	26.9 ± 7.0	26.8 ± 5.9	−0.4 ± 6.6
Shelf label–driven healthy food purchasing 1 score[3]	—	2.4 ± 1.2	—	—	2.1 ± 1.2	—
Shelf label–driven healthy food purchasing score 2[3]	—	5.08 ± 5.06	—	—	4.55 ± 5.50	—
BMI, *kg/m²*	30.6 ± 6.0	30.0 ± 5.7	−0.6 ± 3.3	30.2 ± 5.9	30.8 ± 6.5	0.6 ± 3.1
Overweight or obese, *%*	87.5	85.1	−2.4	87.0	84.8	−2.2
Obese, *%*	47.9	40.4	−7.5	43.4	47.8	4.4

[1] Values are means ± SDs or percentages and reflect changes from baseline to postintervention. No significant differences in change in scores were detected between intervention and comparison groups ($P \leq 0.05$).
[2] Change time is the period from baseline to postintervention measurement, 15–20 mo.
[3] Assessed postintervention only.

In addition, we found a consistent impact of the intervention on shelf label–driven healthy food purchasing. Those respondents who were part of the intervention group or more exposed to the intervention were much more likely to purchase shelf label–promoted healthy foods. This finding is in line with much of our previous research on the utility and effectiveness of shelf labels as means of promoting healthier foods in retail food stores (23–25).

The research reported in this article has several limitations. The demographic characteristics of our sample limit the overall generalizability of our results. Although the design of the study made it possible to randomize at the regional level, it was very difficult to randomize at the individual level due to limited funds and time. We required that the main food preparer or shopper be the respondent. In many instances, this person was the female head of the household, accounting for our sample of mostly female consumers. Thus, our evaluation sample was not representative of the general adult Navajo population (51.0% female; median age, 24 y). Importantly, we controlled for factors such as sex, education, and age in our impact analyses to limit the impact of differences of these factors on study findings.

Another limitation is that our retention rate for the evaluation sample was only 56.5%. The population living on the reservation is very large and scattered, and weather and road conditions made it very difficult to locate people for follow-up interviews. Another contributing factor may have been the effect of the harsh economy on the Navajo Nation, with unemployment at ~70% during the time data were collected. Many of our baseline participants had moved off the reservation to find employment. The staff made numerous attempts through letters, phone calls, and postcards. However, due to address and phone number changes, it was difficult to locate many of the original participants.

TABLE 3 Exposure to Navajo Healthy Stores intervention components by intervention group[1]

Score	Intervention (n = 98)	Comparison (n = 47)
Logo score	0.6 ± 0.3	0.5 ± 0.3
Shelf label score	0.2 ± 0.2**	0.1 ± 0.1
Taste-test score	0.3 ± 0.3**	0.1 ± 0.2
Poster score	0.4 ± 0.4	0.3 ± 0.3
Educational display score	0.4 ± 0.4	0.3 ± 0.4
Flyer/pamphlet score	0.3 ± 0.3	0.2 ± 0.3
Promotional item score	0.2 ± 0.3	0.1 ± 0.2
Exposure score	2.3 ± 1.6*	1.7 ± 1.5

[1] Values are means ± SDs. *,**Significantly different from the comparison group: *$P < 0.05$, **$P \leq 0.01$.

Our results are based largely on self-report. The inclusion of red-herring questions in our exposure questionnaires was intended to minimize participant bias. Additionally, anthropometric measurements were objectively collected by trained data collectors when possible, but some participants refused to be measured, and we relied on participants' knowledge of their current weight and height in our calculations of BMI and weight status in some cases. We adjusted for self-report versus direct measurement in our analyses. In future studies, extra consideration of privacy in taking measurements in AI settings should be planned and objective measures of change collected.

A final limitation is that our program was not able to work with all of the food stores in an area. In each region, we worked with the major supermarket plus a few smaller food stores in the vicinity that were willing to work with us. In particular, a chain of convenience stores was unwilling to participate. Had we been able to implement our program in every store, a larger group of consumers would have been reached. Future studies involving store interventions should consider ways to include all stores in an area by using incentives, rapport-building, and building on connections with local community members (22,32).

A strength of our program is that it was implemented by the NSDP and supported by Navajo tribal members from the areas in which they were working. The success of the NHS intervention was primarily due to their hard work and strong rapport with community members and store owners. A strong community engagement process was central to the planning and implementation of the intervention. The formative research and community workshops allowed the development of a program that was locally and culturally tailored. This community-based

TABLE 4 Individual psychosocial, behavioral, and anthropometric changes by quartile of exposure to the Navajo Healthy Stores program[1]

	Very low	Low	Medium	High
n	36	36	37	36
Exposure score	0.2 ± 0.2**	1.2 ± 0.4**	2.7 ± 0.5**	4.3 ± 0.5**
Number of intervention store visits[2]	3.7 ± 6.6**	6.5 ± 8.0**	9.4 ± 6.5**	11.9 ± 6.0**
Healthy food knowledge score	2.6 ± 2.2	2.7 ± 2.0	2.0 ± 2.7	1.7 ± 2.8
Healthy food self-efficacy score	2.1 ± 9.6	5.5 ± 7.5	8.3 ± 13.3	5.7 ± 12.0
Healthy food intentions score	0.1 ± 4.7*	1.4 ± 3.5*	3.4 ± 5.7*	3.3 ± 4.7*
Nutrition label reading score	0.5 ± 2.1	0.3 ± 2.2	0.2 ± 2.4	0.3 ± 1.9
Healthy cooking methods score	1.1 ± 3.4	0.8 ± 2.9	1.7 ± 3.8	1.6 ± 3.4
Healthy food getting score	−13.7 ± 43.9	−19.3 ± 42.9	1.7 ± 50.1	−0.9 ± 56.8
Unhealthy food getting score	−7.2 ± 19.6	−13.3 ± 29.8	−13.9 ± 17.3	−6.8 ± 15.1
Perceptions of healthy food score	0.6 ± 6.5	1.3 ± 5.1	−0.2 ± 7.9	1.9 ± 7.9
Shelf label–driven healthy food purchasing score 1	1.1 ± 0.3**	1.7 ± 1.0**	2.9 ± 0.8**	3.3 ± 0.7**
Shelf label–driven healthy food purchasing score 2	0.2 ± 1.0**	2.1 ± 2.9**	7.0 ± 3.8**	10.3 ± 4.6**
BMI	−0.1 ± 2.3**	1.0 ± 2.8**	−0.0 ± 3.4**	−1.8 ± 3.8**

[1] Values are mean differences ± SDs in change from pre- to postintervention and are presented by quartile of exposure. *,**Significant change: *$P \leq 0.05$, **$P \leq 0.01$.
[2] Number of visits in the last 30 d.

approach also enhances the long-term sustainability of NHS. Currently, some components of the intervention are still being sustained on the reservation. The NSDP nutrition interventionists continue to conduct healthy food store demonstrations and continue to use materials and concepts from the NHS to educate community members.

A key finding was that exposure matters. Those individuals who had the highest level of exposure to the intervention showed improvements in many of the psychosocial, behavioral, and BMI-related outcomes we assessed. These findings suggest that exceeding some threshold of exposure to all intervention components is needed. Exposure appears to be especially important in environmental interventions in which the approach is one of altering choice, and passively allowing consumers to modify their behaviors (33).

Another aspect of the program success had to do with improvements in several psychosocial and behavioral factors through multiple intervention approaches, including both environmental changes and behavioral education. The intervention was designed so that the different components would reinforce each other and lead to enhanced potential for behavioral change. When we made healthier choices available, coupled with increased knowledge and skills, and nudges through signage that identified and "pushed" labeled healthier items at the point of purchase, consumers chose to make healthier choices. Future planned analyses will assess the impact of the intervention on diet and the consumption of specific promoted foods.

In summary, we were able to demonstrate that a combined environmental and educational intervention in food stores was associated with positive impacts on food-related psychosocial factors, behaviors, and weight status in a large AI reservation. A major asset to the program was our Navajo-speaking partners who delivered the intervention and our Navajo project staff. These findings add to the growing literature of successful intervention trials seeking improvements to the food environment as a means of addressing the obesity epidemic (34,35). Future efforts should consider working in multiple institutions, such as schools, worksites, and food stores, as a means of enhancing intervention exposure and leading to sustained change. Furthermore, policy initiatives initiated by AI leadership may be an additional means of sustaining these crucial initiatives.

TABLE 5 Impact of exposure to Navajo Healthy Stores program on outcome variables: results of linear and logistic regression analyses[1]

	Healthy food intentions	Healthy cooking methods	Healthy food getting	Shelf label–driven healthy food purchasing 1	Shelf label–driven healthy food purchasing 2	BMI[2]	OR of improving overweight or obese status (95% CI)[3]	OR of improving obese status (95% CI)[4]
Exposure[5]	0.6 ± 0.2**	0.4 ± 0.2*	10.2 ± 2.1**	0.5 ± 0.1**	2.5 ± 0.2**	−0.6 ± 0.2**	5.0 (1.5, 17.0)**	1.5 (1.0, 2.5)
R-squared[6]	0.4 (0.1)	0.3 (0.0)	0.6 (0.0)	0.6 (0.6)	0.6 (0.6)	0.1 (0.1)	—	—

[1] Values are regression coefficients ± SEs and adjusted R^2 for linear regressions or ORs (95% CIs) for logistic regressions. All linear models were adjusted for baseline value, sex, age, educational level, household size, material style of life, and a dummy variable to account for self-reported versus measured BMI (1 = measured, 0 = self-reported). All logistic regression models were adjusted for the same covariates except for baseline value. $n = 145$. Dependent variables healthy food intentions, healthy cooking methods, healthy food getting and BMI are calculated as change from pre to post intervention. The timeframe from pre to post is 15–20 mo. *$P \leq 0.05$; **$P \leq 0.01$.
[2] $n = 138$ due to missing values in weight and/or height.
[3] Coding of outcomes in logistic regression—1 = overweight or obese at baseline and not overweight or obese at postintervention; 0 = 1 of the following conditions: *1*) overweight or obese at baseline and same weight status at postintervention, *2*) normal weight at baseline and postintervention, or *3*) normal weight at baseline and overweight or obese at postintervention.
[4] Coding of outcomes in logistic regression: please refer to footnote 3. Outcome is obese in this model.
[5] Continuous exposure score.
[6] Total R^2 values are presented. Partial R^2 contributed by the variable ''exposure'' are (in same order): 0.06, 0.01, 0.02, 0.60, 0.62, and 0.06.

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