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RESEARCH ARTICLE

Group Randomized Trial of Healthy Eating and Gardening Intervention in Navajo Elementary Schools (Yéego!)

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Introduction: Few healthy eating, school-based interventions have been rigorously evaluated in American Indian communities. Gardening and healthy eating are priorities in the Navajo Nation. Collaborations between researchers and local partners supported the design and implementation of this project.

Design: The Yéego! Healthy Eating and Gardening Study was a group-randomized controlled trial to evaluate a school-based healthy eating and gardening intervention in 6 schools in the Navajo Nation. Schools were randomized 1:2 to intervention or comparison.

Setting/participants: The Shiprock and Tsaile/Chinle areas in the Navajo Nation were selected. Elementary schools were screened for eligibility. All students in third and fourth grades were invited to participate in the assessments.

Intervention: Delivered during 1 school year in the intervention schools, the intervention included a culturally relevant nutrition and gardening curriculum and a school garden.

Main outcome measures: Student self-efficacy for eating fruits and vegetables, student self-efficacy for gardening, and student healthy foods score from a modified Alternative Healthy Eating Index were assessed in third and fourth graders at the beginning and end of a school year affected by the COVID-19 pandemic. Primary analyses used repeated measures linear mixed models accounting for students nested within schools to estimate the intervention effect and 95% CIs.

Results: Students in the intervention schools had self-efficacy scores for eating fruits and vegetables that were 0.22 points greater (95% CI=0.04, 0.41) than those in the comparison schools, although the student healthy foods score increased in the intervention schools by 2.0 (95% CI=0.4, 3.6); the differential change was modest at 1.7 (95% CI=−0.3, 3.7). The self-efficacy to grow fruits and vegetables in the school garden increased among those in the intervention schools (OR=1.92;

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95% CI=1.02, 3.63) but not significantly more than it increased in the comparison schools (OR=1.29; 95% CI=0.60, 2.81).

Conclusions: The intervention was efficacious in improving self-efficacy for eating fruits and vegetables among third- and fourth-grade students over a school year. The findings warrant further evaluation of the intervention in larger-group randomized trials with schools in Navajo communities.

Trial registration: This study is registered at clinicaltrials.gov NCT03778021.

INTRODUCTION

School-based interventions to promote healthy eating choices and other health behaviors have been implemented across the U.S., but too few have been rigorously evaluated for their efficacy,[1−3] particularly in American Indian communities.[4,5] National guidelines define and promote healthy eating practices,[6] yet the gap between guidelines and behavior change in the population remains large. Just as important as the rigorously derived scientific evidence that dietary choices impact health, rigorous evaluations of interventions are needed so that guidelines can be put into practice.

Nowhere are the consequences of low rates of healthy eating behaviors more obvious than among the Navajo, where the rates of adolescent obesity and adult diabetes have been above the national average for decades.[5,7,8] The Navajo Nation is a sovereign nation of the Diné people. It is located on land in 4 states: Arizona, New Mexico, Utah, and Colorado. The research team has been collaborating with the Navajo Nation for more than a decade to address gardening and healthy eating priorities, recognized as important parts of a broad effort to reduce obesity and diabetes.[9,10] The presence and missions of Diné College and the New Mexico State University Agricultural Science Center at Farmington in the Navajo Nation have facilitated successful collaborations.[11−14] Specifically, leaders in the Navajo Nation reached out for technical assistance in establishing gardens equipped to withstand semiarid conditions. The role of researchers in environmental monitoring during the 2015 Gold King Mine emergency at the invitation of the Navajo Nation Environmental Protection Agency[15] and Shiprock chapter leaders provides an example of the trust the team has built.[15−18]

Multilevel interventions targeting individuals and communities, workplaces, or schools can increase the reach and impact of interventions on population health.[19−21] To help fill the gap between guidelines and healthy behaviors, a multilevel intervention was designed to address the health concerns of the Navajo Nation.[22] Some studies[23−32] but not all[33] have shown that school-based garden interventions are effective in improving healthy eating among children and their families. An even broader literature points to the potential impact of nutrition education on healthy eating intentions and behaviors, especially fruit and vegetable behaviors, among elementary school children.[4,27,30,34−38] Using previous research and community input, a pilot study in 2018 was conducted implementing the curriculum and school garden intervention among Navajo children.[22] The findings were used to further revise the curriculum to address input that was received from students, adults, and teachers in preparation for this study. In particular, lessons were aligned to seasons; addressed Diné education standards; and included more group discussions, snack preparation, and learning through games.[22]

In partnership with the Navajo Nation, a small-group randomized trial in elementary schools in 2 areas of the Navajo Nation was conducted. The objective of the study was to evaluate the impact of a healthy eating and gardening intervention during 1 school year on students' healthy eating and gardening behaviors.

METHODS

The Yéego! Healthy Eating and Gardening Study (Yéego!) was a stratified group-RCT with allocation to intervention or comparison in the ratio of 1:2 within each stratum. The strata were 2 areas in the Navajo Nation, namely Tsaile in Arizona and Shiprock in New Mexico, and the groups were elementary schools identified within these areas from lists of Public and Bureau of Indian Affairs elementary schools. Among the schools that met the eligibility criteria (described below), 3 from each community were randomly selected and invited to participate in the trial. After a year-long run-in period to gauge commitment and readiness, the

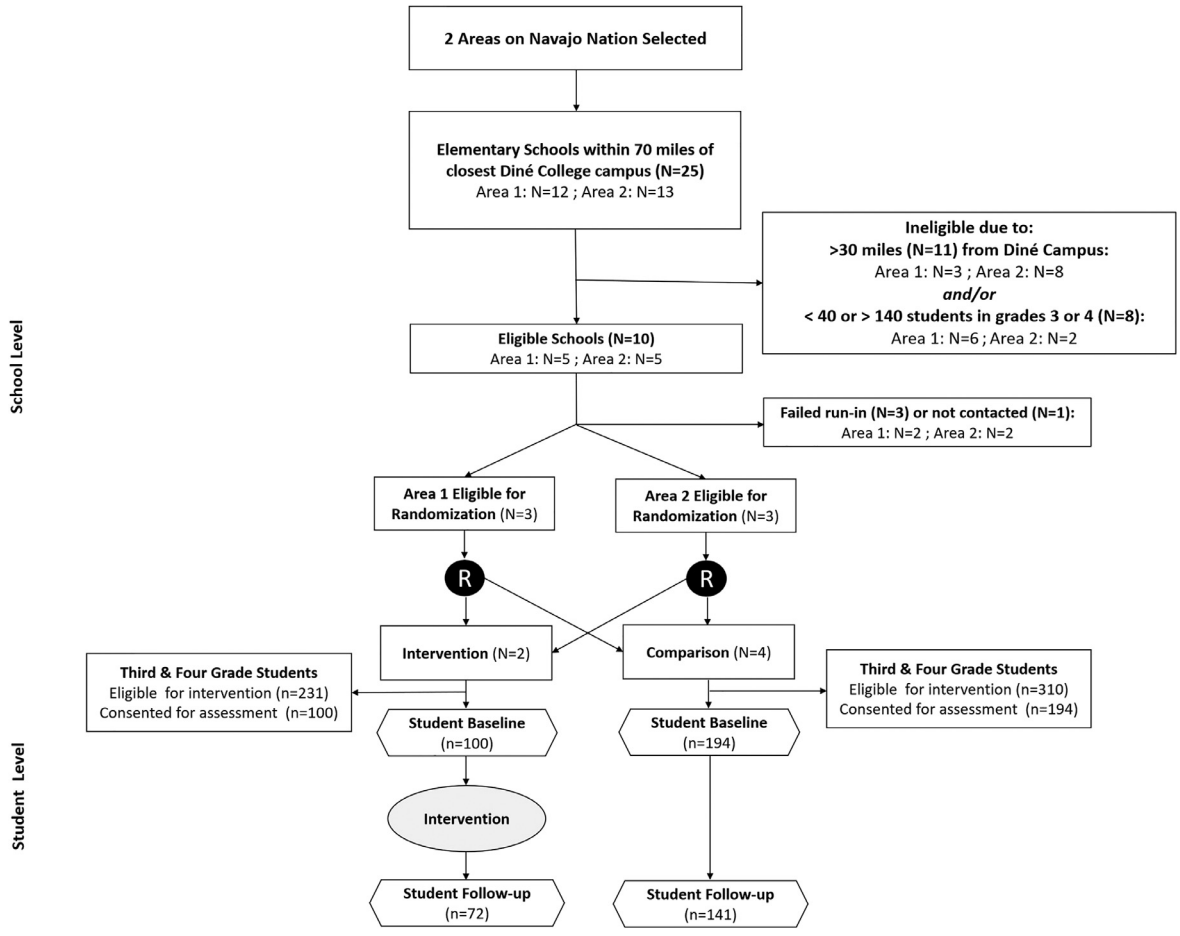

Figure 1. CONSORT diagram.

3 schools within each area were randomized, as shown in Figure 1. Third- and fourth-grade students from all the 6 schools were surveyed at the beginning and end of the 2019−2020 school year. Two schools (1 from each area) received the intervention during the 2019−2020 school year, and 4 comparison schools were scheduled to receive a delayed intervention after the follow-up to occur over the next school year.

Study Population

The Shiprock and Tsaile/Chinle areas on the Navajo Nation, with populations consisting largely of Diné (Navajo) people, were selected for the study sites on the basis of their proximity to Diné College campuses where study staff were located. Shiprock is a small town situated 30 miles from Farmington, New Mexico. Tsaile in Arizona is a rural farming community with limited access to restaurants and grocery stores, situated about 30 miles from Chinle. Stakeholders were engaged with presentations to the public school, community school, and charter school boards before approaching individual schools and as part of the application to the Navajo Nation Human Research Review Board. Concurrence with the study protocol was obtained through resolutions from the relevant school boards, chapter houses, school principals, and agency councils. The study protocol was approved by the IRBs of the collaborating institutions and the Navajo Nation Human Research Review Board.

The study was designed to recruit 6 schools, 3 in each area. A total of 25 schools were identified and screened for eligibility. Criteria included schools (1) within 30 miles of a Diné College campus, (2) in existence for at least 3 years, (3) with between 40 and 140 students in Grades 3 or 4, and (4) with a student population of at least two thirds Navajo. A total of 10 schools (5 in each area) were eligible, as shown in Figure 1. These were listed in random order and approached sequentially. Once approval was granted from each school district, the principals of the first 3 selected schools in each community were approached to (1) confirm that the school met the initial eligibility criteria, (2) confirm the principals' interest in supporting participation in the study by their school and teachers, and (3) conduct an initial Evaluation of Readiness. An initial assessment of school resources, the level of teacher willingness to participate, and the garden site informed the Evaluation of Readiness. If the school did not meet all eligibility criteria or was not interested in participating in the study, the next school on the list was approached. A minimum level of readiness to support both survey assessment and intervention delivery was required. Once the school was randomized to intervention or

Table 1. Topics in the Yéego! Healthy Eating and Gardening Curriculum

Lesson number	Healthy eating topics	Lesson number	Gardening topics
1	Introduction and kitchen safety	1	Introduction to the garden
2	Reading a recipe	2	Maintaining the garden
3	Whole foods and nutrition	3	Food preservation and seed saving
4	Eating for energy	4	Soil and compost
5	Fruits and vegetables	5	Water in the garden
6	Traditional foods and food sovereignty	6	Plant parts and life cycle
7	Healthy meals and healthy families	7	Native plants and Navajo ecology
8	Garden to table	8	Getting ready to plant in the garden
9	Garden Celebration of healthy eating and gardening		

comparison, the research staff presented the study and timeline to all third- and fourth-grade teachers. Teachers distributed a recruitment packet to their students that included information about the study, a student assent, and an adult consent. Incentives were offered to students who returned completed recruitment packets and to teachers for their facilitation.

At the beginning of the 2019–2020 school year, Yéego! study staff met with the consented students to complete the baseline surveys. Surveys were administered in English using a tablet-assisted method. Trained Navajo interviewers from the community entered student responses. A Navajo translator was available as needed. A similar interviewer-based follow-up assessment was planned for the end of the same school year (i.e., June 2020); however, owing to the coronavirus disease 2019 (COVID-19) pandemic, plans were pivoted to collect follow-up data remotely, by mail, by phone, or online. For mailed surveys, data were entered and merged with the electronically captured phone and online data in the database. Assessment staff were blinded to intervention status.

Intervention

The Yéego! Intervention Program was school-based and aimed at increasing fruit and vegetable consumption among Navajo elementary school students. The intervention combined a school garden with a culturally relevant nutrition and gardening curriculum delivered by trained health educators and master gardeners to students in the third and fourth grades.

The creation of the school garden by intervention staff and interns involved assembling raised garden beds and small tool sheds and bringing in potting soil and plants. Garden construction in the intervention schools started in 2019. The garden space was approximately 400 square feet with 3 raised garden beds; each was 3 feet by 6 feet and constructed of redwood. The schools planted cool season crops initially (spinach, beets, radish, leafy greens, snowpeas, snap peas, and carrots), and then Three Sisters gardens (corn, beans, and squash) were started in the spring. All seeds were provided by the study. Maintenance of the garden area was the responsibility of the schools' custodial staff and teachers.

The development of the curriculum, which has been described elsewhere,[22] drew from Life Lab,[39,40] LA Sprouts,[27] and Social Cognitive theory. Lessons aimed to build confidence in gardening and healthy eating behaviors (self-efficacy), which is seen as an important determinant of health behavior change.

Table 1 shows the curriculum comprising 17 lessons (45 minutes each), delivered about twice a month over the school year. Eight lessons focused on healthy eating topics, including kitchen safety, reading a recipe, eating for nutrition and energy, and traditional foods, and 8 lessons focused on gardening, including how to plant and maintain the garden, native plants and Navajo ecology, and food preservation. The curriculum was informed by Department of Diné Education school standards, Columbia Teachers College Food Day Curriculum, Next Generation Science Standards, and New Mexico and Arizona Common Core Standards. Each lesson incorporated aspects of Diné culture, a hands-on activity in the classroom or the garden, and the healthy eating lessons included a healthy snack. The traditional snacks that were provided were blue corn mush and sumac berry mush. Bluecorn pancakes and smoothies made from spinach and leafy greens included ingredients from the garden. The students were also able to enjoy radishes and snap peas grown in the garden. Other ingredients and snacks that were prepared by the students in class were from the grocery store.

The COVID-19 pandemic led to the students being sent home toward the end of the academic year, which curtailed the harvesting from the school garden and truncated the delivery of the curriculum before the final combined healthy eating and gardening lesson (Number 9) in both intervention schools. In one of the schools, the last 2 gardening lessons (Numbers 7 and 8) also could not be taught.

Measures

Primary outcomes were 4 measures of students' healthy eating and gardening behaviors. Best practices in student dietary behavior assessment[27,41,42] were adapted for this work in collaboration with Navajo elementary schools, and pilot testing was conducted in 1 private Navajo elementary school in the Shiprock area (unpublished observations, 2021). Healthy eating was measured in 2 ways: from survey questions (student's self-efficacy to eat fruits and vegetables [F&V]) and from a picture sort method (a healthy foods score from the Alternative Healthy Eating Index [AHEI] 2010). In brief, the pilot study checked the internal consistency of the 5-item self-efficacy for eating F&V in Navajo students. Responses from the picture sort were used to estimate metrics related to the AHEI 2010. The AHEI was originally created as an alternative to the Healthy Eating Index on the basis of foods and nutrients shown to predict the risk of

chronic disease and was updated in 2012 by Chiuve and colleagues.[43] The convergent validity and test–retest reliability of the new metrics from the picture sort were evaluated in reference to self-efficacy for F&V in children and to F&V daily intake frequency (from the abbreviated Food Frequency Questionnaire) and obesogenic index in adults in the pilot testing. The metrics with acceptable validity and reliability were adopted in this study. The picture sort tool was implemented using a single pass through the pictures of groups of foods, enabling frequency choices to be recorded electronically on the tablet at baseline assessment.

The self-efficacy to eat fruits and vegetables outcome measure was a scale using 5 items used in previous studies,[42,44] each with 4-point Likert-type scale responses (*I know I can, I think I can, I'm not sure I can, and I know I can't*). Good internal consistency was shown in the pilot study, with Cronbach's α of 0.6 (unpublished observations, 2021). A mean score was calculated, with higher scores suggesting higher self-efficacy to eat fruits and vegetables.

The AHEI Healthy Foods Score was a subscale from the modified AHEI developed from pilot work described briefly earlier (unpublished observations, 2021). Data for the AHEI were derived from a picture sort frequency tool that estimated the frequencies of consumption of 10 major food groups of the Navajo diet.[45] For the Healthy Foods Score, the AHEI 2010[43] scoring was applied to reported frequencies of fruits (fresh and dried), vegetables (not salad), whole grains, beans, and nuts.

The self-efficacy to garden outcome measure used questions about student's confidence to grow F&V at home or school. These questions were adapted from LA Sprouts[27,30] using the previously described 4-point Likert scale responses. Owing to low variability, these measures were dichotomized on the basis of full self-efficacy to garden (i.e., response was *I know I can* versus *not*).

Secondary student outcomes included additional dietary behavior scores from the picture sort frequency tool. The modified AHEI total score was based on 6 components (vegetables, fruits, whole grains, nuts and legumes, sugar-sweetened beverages and fruit juices, and red and/or processed meat) that were captured from the tool out of the 11 components of the AHEI 2010.[43] The ratio of healthy-to-total servings was based on servings rather than on scores. A total of 4 items asked about participation in healthy eating activities at school, with higher scores indicating higher participation. Obesogenic dietary behaviors were based on the frequency of fast food and the frequency of soda consumption, with higher scores suggesting higher obesogenic behavior. These questions were adapted from previously published studies conducted with American Indian children[46] or dietary assessment studies by the larger research group.[47]

Demographic characteristics from surveys completed by the student were collected. Students self-reported their age; gender; race; and whether they identify as Navajo and, if so, whether they understand and speak the Navajo language. In addition to survey data, Yéego! staff also collected baseline students' heights and weights in duplicates, recording the consistent value. Sex- and age-specific BMI *Z*-scores and percentiles were calculated using Centers for Disease Control and Prevention programs and growth charts.[48] *Overweight* and *obesity* were defined as being in the 85 to <95th and ≥95th BMI percentiles, respectively. Students' height and weight measures were not collected at follow-up.

Statistical Analysis

All students who provided survey data at baseline were included in the analyses of the primary and secondary outcomes. In the characterization of the study population at baseline, grouping by intervention status of the school (intervention versus comparison) was made, and differences between the 2 groups were examined. Descriptive statistics for all variables were estimated. In evaluating the effectiveness of the intervention, repeated measures linear mixed model analyses, accounting for students nested within schools, were conducted for all continuous measures. This method follows the common practice in the analysis of group randomized trials by the larger research group[49] and recommendations by Twisk et al.,[50] allowing all baseline and follow-up responses from students to contribute to the effect estimates. For binary outcomes, generalized mixed models accounting for students nested within schools were used, specifying a binomial distribution, to examine the OR and 95% CIs associated with receiving the intervention. Both methods allowed least square estimation of change within group and of intervention effect accounting for potential within-school correlations. For all outcomes, 2 models were run: one that was unadjusted and one that adjusted for gender and whether the student speaks Navajo because the distributions in the intervention and comparison schools for these covariates differed at baseline. In sensitivity analyses, the analyses were repeated, (1) explicitly specifying school as a random effect and (2) excluding the smallest comparison school that had suffered dramatically reduced enrolment after randomization and before baseline assessment. Secondary analyses explored whether the effectiveness of the intervention on 1 of the primary outcomes (self-efficacy for eating F&V) may have been stronger for subgroups defined by area, grade level, or category of BMI. Stratified analyses were conducted to estimate the intervention effects on student self-efficacy to eat F&V within categories of these variables. Statistical analyses were completed using SAS statistical software, Version 9 (SAS Institute Inc, Cary, NC).

RESULTS

A total of 294 students assented and provided baseline data. Table 2 shows the baseline characteristics for the students from the 2 schools that received the intervention and the students from the 4 comparison schools. In particular, the comparison schools had a higher proportion of female students (56.2% vs 42.4%, p=0.03) and students speaking Navajo (62.9% vs 43.4%, p=0.002) than the intervention schools. The follow-up from the baseline cohort was completed by 213 students (72% of baseline).

The intervention effects estimated from the repeated measures linear mixed models are shown in Table 3. Students from the intervention schools increased their self-efficacy to eat F&V score more than the students in the comparison schools, by an average of 0.22 (95% CI=0.04, 0.41). The differential increase in AHEI Healthy Foods Score was 1.40 (95% CI=−0.67, 3.46) but not statistically significant (p=0.18). Student self-efficacy to grow F&V at home did not change significantly from

Table 2. Student Baseline Characteristics by Intervention Group Among the 6 Schools

Characteristics	Total	Intervention	Comparison (delayed intervention)	*p*-value intervention versus comparison
n (%)	294	100	194	
Female, *n* (%)	151 (51.5)	42 (42.4)	109 (56.2)	0.03
Age, years, mean (SD)	8.7 (0.8)	8.6 (0.7)	8.7 (0.9)	0.12[a]
American Indian or Alaska Native, *n* (%)	266 (96.7)	91 (93.8)	175 (98.3)	0.05
Understands Navajo, *n* (%)	168 (57.3)	49 (49.5)	119 (61.3)	0.05
Speaks Navajo, *n* (%)	165 (56.3)	43 (43.4)	122 (62.9)	0.002
Language most spoken at home, *n* (%)				
Navajo	27 (9.2)	7 (7.1)	20 (10.3)	0.16
Both English and Navajo	148 (50.5)	44 (44.4)	104 (53.6)	
English	113 (38.6)	45 (45.5)	68 (35.1)	
Other	5 (1.7)	3 (3.0)	2 (1.0)	
Height, cm, mean (SD)	135.5 (6.9)	135.4 (7.4)	135.6 (6.6)	0.76
Weight, kg, mean (SD)	36.8 (10.9)	37.6 (11.5)	36.5 (10.5)	0.42
BMI, kg/m^2, mean (SD)	19.8 (4.4)	20.2 (4.5)	19.6 (4.3)	0.25
BMI-for-age Z, mean (SD)	0.83 (1.17)	0.94 (1.23)	0.78 (1.14)	0.27
BMI-for-age percentile, mean (SD)	70.9 (30.3)	73.1 (31.2)	69.7 (29.8)	0.38
Overweight or obese, *n* (%)	133 (46.0)	50 (51.0)	83 (43.5)	0.22
Primary outcomes				
Self-efficacy to eat F&V (5 items), mean (SD)	3.3 (0.60)	3.2 (0.65)	3.4 (0.57)	0.009
AHEI Healthy Foods Score, mean (SD)	17.5 (6.2)	16.9 (5.8)	17.8 (6.4)	0.24
Full self-efficacy to grow F&V at home, *n* (%)	164 (57.5)	58 (58.0)	106 (57.3)	0.91
Full self-efficacy to grow F&V at school, *n* (%)	123 (43.2)	49 (49.0)	74 (40.0)	0.14
Secondary outcomes				
Ratio of healthy-to-total food servings, mean (SD)	0.26 (0.08)	0.26 (0.08)	0.26 (0.08)	0.46
AHEI total score, mean (SD)	18.4 (5.7)	17.9 (5.6)	18.7 (5.8)	0.25
Number of healthy eating activities at school, mean (SD)	2.0 (1.2)	1.9 (1.1)	2.0 (1.3)	0.30
Eats fast food meal everyday, *n* (%)	29 (10)	9 (9.1)	20 (10.8)	0.65
Drinks soft drinks everyday, *n* (%)	24 (8.5)	9 (9.1)	15 (8.1)	0.78

AHEI, Alternative Healthy Eating Index; F&V, fruits and vegetables.
[a]*p*-value from Satterthwaite because of unequal variances.

baseline to follow-up among the intervention and comparison groups, and the OR contrasting them was 0.62 (95% CI=0.29, 1.33). However, a higher proportion of students in both the intervention and comparison groups indicated full self-efficacy to grow F&V at school at the follow-up assessment. Students from the intervention schools had 1.92 (95% CI=1.02, 3.63) odds of full self-efficacy to grow F&V at school relative to the odds at the baseline, and those from the comparison schools had 1.48 (95% CI=0.95, 2.31) odds. However, the relative odds (intervention effect) was not significant (OR=1.29; 95% CI=0.60, 2.81). Models adjusting for gender and whether the student spoke Navajo estimated intervention effects for these primary outcomes that were similar to those in the unadjusted analyses. For example, the estimated intervention effect on self-efficacy to eat F&V, adjusted for gender and language, was 0.21 (95% CI=0.03, 0.40). The results of the sensitivity analysis excluding the school with reduced enrolment were also very similar to those of the main unadjusted analyses. The sensitivity analysis explicitly specifying school as a random effect in the unadjusted analysis of self-efficacy to eat F&V yielded identical estimates to 3 decimal places.

None of the students' secondary outcomes, including the ratio of healthy-to-total food servings from the card-sort tool, AHEI total score, obesogenic dietary behaviors, and participation in healthy eating activities

Table 3. Student's Dietary and Gardening Behaviors by Intervention Group

Outcomes	Intervention, *n* = 100 baseline, 72 at follow-up			Comparison, *n* = 194, at baseline, 141 at follow-up			Intervention effect
Primary outcomes (continuous)	**Baseline mean (SD)**		**Mean change (SE)**	**Baseline mean (SD)**		**Mean change (SE)**	**Mean difference (95% CI)**
Self-efficacy to eat FV	3.2 (0.65)		**0.47 (0.08)*** **	3.4 (0.60)		**0.24 (0.05)*** **	**0.22 (0.04, 0.41)**
AHEI Healthy foods score	16.9 (5.8)		**2.0 (0.82)**	17.8 (6.4)		0.28 (0.58)	1.40 (−0.67, 3.46)
Secondary outcomes							
Ratio of healthy-to-total foods	0.26 (0.08)		**0.03 (0.01)** **	0.26 (0.08)		**0.03 (0.01)*** **	0.006 (−0.02, 0.03)
AHEI total score	17.7 (5.5)		**1.7 (0.9)**	18.7 (5.8)		0.6 (0.6)	1.1 (−1.0, 3.2)
Number of healthy eating activities at school	1.9 (1.1)		**0.6 (0.2)*** **	2.0 (1.3)		**0.4 (0.1)** **	0.2 (−0.2, 0.6)
Primary outcomes (percentages)	Baseline %	Follow-up %	OR follow-up to baseline	Baseline %	Follow-up %	OR follow-up to baseline	OR intervention to comparison (95% CI)
Full self-efficacy to grow F&V at home	57	55	0.88	58	67	1.43	0.62 (0.29, 1.33)
Full self-efficacy to grow F&V at school	51	65	**1.92***	42	50	1.48	1.29 (0.60, 2.81)
Secondary outcomes (percentages)							
Eats fast food meal every day	9.7	1.4	0.15	11	2.3	0.31*	0.46 (0.04, 4.75)
Drinks soft drinks every day	9.7	4.3	0.44	11%	5.4	0.63	0.71 (0.14, 3.69)

Note: Boldface indicates statistical significance (*p<0.05, **p<0.01, ***p<0.001).

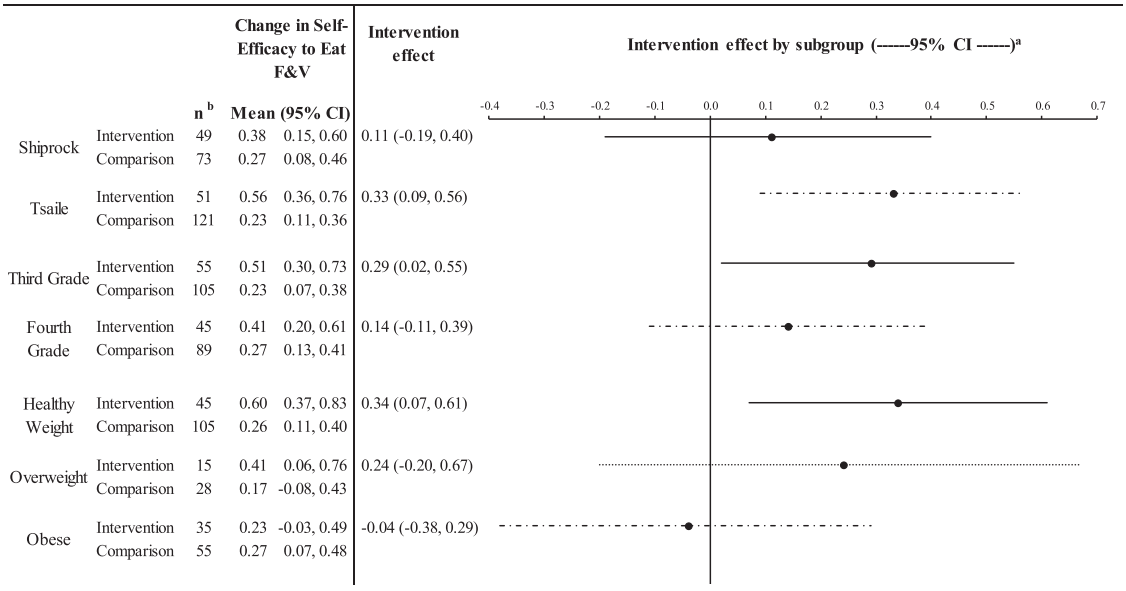

Figure 2. Change in students' self-efficacy to eat fruits and vegetables by area, grade, and BMI.
[a]Repeated measures linear mixed model accounting for students nested within schools.
[b]n at baseline CI.

at school, showed differential change between the intervention and comparison groups. Within subgroups of students defined by baseline factors of area, grade level, and BMI category, the estimated intervention effects on student self-efficacy for eating F&V are shown in Figure 2. The intervention appeared to be more effective in the Tsaile area, in the third grade, and in the healthy weight subgroups, although the tests for multiplicative interactions were not statistically significant.

DISCUSSION

This study showed that the curriculum and school garden intervention improved student self-efficacy for healthy eating as measured by self-efficacy for F&V among Navajo. These results are consistent with those of other school-based interventions in indigenous and underserved communities.[23,27,28,30]

Other healthy eating intervention studies in American Indian schools include Feast for the Future, Pathways, and Tribal Turning Point. The Pathways study was a group randomized controlled intervention trial of 41 schools in 3 areas, which found a significant reduction in percent energy from fat after a 3-year multicomponent intervention, including a nutrition education curriculum.[5,31] Feast for the Future, a multicomponent program in American Indian communities,[28,29] included school curricula also based on LifeLab.[28,39] Qualitative findings reaffirmed cultural identity and successful promotion of healthy eating according to key stakeholders.[28] By contrast, the Tribal Turning Point study was a small individually randomized trial of participants aged 7−10 years with overweight or obesity. It used extracurricular active learning classes for youth and parents as part of its intervention and found intervention effects in BMI and physical activity but not in dietary self-efficacy.[51] The LA Sprouts study[30] and the TX Sprouts study[23] shared many elements with this Yéego! study, including the grades of students participating, curricula based in part on LifeLab,[40] and the use of repeated measures linear mixed models to evaluate the intervention effects. The LA Sprouts intervention was associated with a decrease in BMI *Z*-score and an increase in estimated daily vegetable servings,[30] and the TX Sprouts intervention was associated only with increased vegetable intake.[23]

As summarized in a recent systematic review,[1] other school-based obesity-prevention studies have focused not only on healthy eating behaviors but also on increasing physical activity or a generally healthy lifestyle program. Some of the studies include explicit parental involvement.[1] Including other family members in intervention studies might be expected to increase the intervention effect, as has been shown in at least 1 adult work-site–based study.[52]

Few previous evaluations of school-based garden interventions have included measures of gardening self-efficacy.[26,53,54] This study found no differential increase in student self-efficacy to garden associated with the intervention, which is consistent with the findings of

other studies in Hispanic/Latino youth.[26,54] As a caveat, the single question used in this study may not have captured the underlying construct adequately, namely confidence in being able to garden if a garden were available.[53] The significant increase in gardening self-efficacy among students in the intervention schools over the school year supported change over time, but responses from students in the comparison schools (where there was no school garden of any type in 3 of the 4 comparison schools) were also weakly indicative of change. It is possible that the measure that was used was subject to social desirability bias. By contrast, there was no evidence of change in student self-efficacy for gardening at home.

Limitations

The study had some limitations. The group randomized trial was small because only 6 schools were enrolled and randomized. Not all the adult caregivers of the third and fourth graders agreed for their child to participate in the survey, and the retention rate in the cohort of third and fourth graders from baseline to follow-up was 73%, so the results may not have been fully representative. Dietary behaviors were assessed using self-efficacy for F&V and metrics on the basis of the frequency of intake from the picture sort tool. None of these measures is considered as reliable as the 24-hour recall method. The 2 AHEI-based metrics may have been limited by the fact that only 6 of the 11 standard components of AHEI could be estimated from the picture sort tool used. Although other studies have included explicit home or family components of the intervention, this study included only implicit engagement with the home environment through what students took home with them from class. Long-term sustainability of improved self-efficacy for F&V was not evaluated within this study, although other multilevel interventions targeting F&V in adults have shown evidence of long-term changes.[55]

The strengths of the study include its group randomized design and analysis. This work also provided a more accurate and culturally appropriate dietary intake assessment with demonstrated convergent validity and test–retest reliability (unpublished observations, 2021).

CONCLUSIONS

This study showed that the curriculum and school garden intervention was efficacious in improving healthy eating behavior in Navajo elementary school students. Several other school-based interventions in indigenous or other underserved communities support this conclusion. Given the need for multilevel approaches to addressing obesity and diabetes disparities, the intervention warrants further evaluation among Navajo elementary schools in a larger group randomized trial involving more schools in a greater number of communities.

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REFERENCES

1. Verrotti A, Penta L, Zenzeri L, Agostinelli S, De Feo P. Childhood obesity: prevention and strategies of intervention. A systematic review of school-based interventions in primary schools. *J Endocrinol Invest.* 2014;37(12):1155–1164. https://doi.org/10.1007/s40618-014-0153-y.
2. Ohly H, Gentry S, Wigglesworth R, Bethel A, Lovell R, Garside R. A systematic review of the health and well-being impacts of school gardening: synthesis of quantitative and qualitative evidence. *BMC Public Health.* 2016;16:286. https://doi.org/10.1186/s12889-016-2941-0.
3. Savoie-Roskos MR, Wengreen H, Durward C. Increasing fruit and vegetable intake among children and youth through gardening-based interventions: a systematic review. *J Acad Nutr Diet.* 2017;117(2):240–250. https://doi.org/10.1016/j.jand.2016.10.014.

4. Wahi G, de Souza RJ, Hartmann K, Giglia L, Jack SM, Anand SS. Effectiveness of programs aimed at obesity prevention among Indigenous children: a systematic review. *Prev Med Rep.* 2021;22:101347. https://doi.org/10.1016/j.pmedr.2021.101347.
5. Caballero B, Clay T, Davis SM, et al. Pathways: a school-based, randomized controlled trial for the prevention of obesity in American Indian schoolchildren. *Am J Clin Nutr.* 2003;78(5):1030–1038. https://doi.org/10.1093/ajcn/78.5.1030.
6. U.S. Department of Agriculture and HHS. Dietary Guidelines for Americans, 2020−2025. 9th Edition. December 2020. https://DietaryGuidelines.gov. Accessed June 28, 2022.
7. Centers for Disease Control and Prevention. National Diabetes Statistics Report, 2020. Atlanta, GA: Centers for Disease Control and Prevention, HHS; 2020. https://www.cdc.gov/diabetes/pdfs/data/statistics/national-diabetes-statistics-report.pdf. Accessed July 6, 2022.
8. Freedman DS, Serdula MK, Percy CA, Ballew C, White L. Obesity, levels of lipids and glucose, and smoking among Navajo adolescents. *J Nutr.* 1997;127(10 suppl):2120S–2127S. https://doi.org/10.1093/jn/127.10.2120S.
9. Diné Policy Institute. Diné Food Sovereignty. Tsaile, AZ: Diné College. https://www.dinecollege.edu/wp-content/uploads/2018/04/dpi-food-sovereignty-report.pdf. Published April 2014. Accessed May 7, 2018.
10. Navajo Nation Council. Healthy Diné Nation Act of 2014. Window Rock, AZ: Navajo Nation Council. https://nec.navajo-nsn.gov/Portals/0/Projects%20Webpage/HDNA%20Webpage/HDNAbooklet.v7b.Oct8.2019.PRINTQUALITY%20(002).pdf. Published 2014. Accessed January 2, 2018.
11. Lombard KA, Beresford SAA, Ornelas IJ, Jim J, Bauer M, Nez F. Where health and horticulture intersect: a Navajo wellness collaboration. *Hortscience.* 2015;50(9):S360. https://doi.org/10.21273/HORTSCI.50.9S.S1.
12. Lombard KA, Beresford SAA, Ornelas IJ, et al. Healthy gardens/healthy lives: Navajo perceptions of growing food locally to prevent diabetes and cancer. *Health Promot Pract.* 2014;15(2):223–231. https://doi.org/10.1177/1524839913492328.
13. Lombard KA, Forster-Cox S, Smeal D, O'Neill MK. Diabetes on the Navajo nation: what role can gardening and agriculture extension play to reduce it? *Rural Remote Health.* 2006;6(4):640. https://doi.org/10.22605/RRH640.
14. Navajo Gardening, Nutrition, and Community Wellness Survey Project. U.S. Department of Agriculture. https://reeis.usda.gov/web/crisprojectpages/0226007-navajo-gardening-nutrition-and-community-wellness.html. Published February 28, 2014. Accessed December 12, 2017.
15. Weindorf DC, Lombard KA. *Rapid Assessment of Soil Metal Concentrations Along the Animas River, New Mexico*. Paper presented at: Environmental Conditions of the Animas and San Juan Watersheds with Emphasis on Gold King Mine and Other Mine Waste Issues; San Juan College; Farmington, NM; 2016.
16. Moorman J. NMSU gathering baseline soil data after Gold King Mine river contamination. *High Plains Journal.* October 10, 2015. https://www.hpj.com/ag_news/nmsu-gathering-baseline-soil-data-after-gold-king-mine-river-contamination/article_f83831b3-32f7-569c-a695-48548559fe3e.html. Accessed August 22, 2022.
17. Lombard KA, Ulery A, Francis B, Weindorf DC, Duda B. *Rapid Assessment of Soil Metal Concentrations Along the Animas River, New Mexico. Environmental Conditions of the Animas and San Juan Watersheds With Emphasis on Gold King Mine and Other Mine Waste Issues.* NMSU2016 page 2. available at. https://animas.nmwrri.nmsu.edu/wp-content/uploads/poster_presentations.pdf. Accessed May 2, 2022.
18. Smith NL. NMED wants to hear about Gold King Mine spill effect on Navajo Nation farms. *Farmington Daily Times.* February 29, 2020. https://www.daily-times.com/story/news/local/navajo-nation/2020/02/29/nmed-wants-comments-navajo-farmers-gold-king-mine-spill/4908341002/. Accessed April 18, 2021.
19. Stokols D. Translating social ecological theory into guidelines for community health promotion. *Am J Health Promot.* 1996;10(4):282–298. https://doi.org/10.4278/0890-1171-10.4.282.
20. Paskett E, Thompson B, Ammerman AS, Ortega AN, Marsteller J, Richardson D. Multilevel interventions to address health disparities show promise in improving population health. *Health Aff (Millwood).* 2016;35(8):1429–1434. https://doi.org/10.1377/hlthaff.2015.1360.
21. Weiner BJ, Lewis MA, Clauser SB, Stitzenberg KB. In search of synergy: strategies for combining interventions at multiple levels. *J Natl Cancer Inst Monogr.* 2012;2012(44):34–41. https://doi.org/10.1093/jncimonographs/lgs001.
22. Ornelas IJ, Rudd K, Bishop S, et al. Engaging school and family in Navajo gardening for health: development of the yéego intervention to promote healthy eating among Navajo children. *Health Behav Policy Rev.* 2021;8(3):212–222. https://doi.org/10.14485/HBPR.8.3.3.
23. Davis JN, Pérez A, Asigbee FM, et al. School-based gardening, cooking and nutrition intervention increased vegetable intake but did not reduce BMI: Texas sprouts - a cluster randomized controlled trial. *Int J Behav Nutr Phys Act.* 2021;18(1):18. https://doi.org/10.1186/s12966-021-01087-x.
24. Duncan MJ, Eyre E, Bryant E, et al. The impact of a school-based gardening intervention on intentions and behaviour related to fruit and vegetable consumption in children. *J Health Psychol.* 2015;20(6):765–773. https://doi.org/10.1177/1359105315573445.
25. Landry MJ, van den Berg AE, Hoelscher DM, et al. Impact of a school-based gardening, cooking, nutrition intervention on diet intake and quality: the TX sprouts randomized controlled trial. *Nutrients.* 2021;13(9):3081. https://doi.org/10.3390/nu13093081.
26. Landry MJ, Markowitz AK, Asigbee FM, Gatto NM, Spruijt-Metz D, Davis JN. Cooking and gardening behaviors and improvements in dietary intake in Hispanic/Latino youth. *Child Obes.* 2019;15(4):262–270. https://doi.org/10.1089/chi.2018.0110.
27. Martinez LC, Gatto NM, Spruijt-Metz D, Davis JN. Design and methodology of the LA Sprouts nutrition, cooking and gardening program for Latino youth: a randomized controlled intervention. *Contemp Clin Trials.* 2015;42:219–227. https://doi.org/10.1016/j.cct.2015.04.008.
28. Cueva K, Lovato V, Carroll D, et al. A qualitative evaluation of a community based, culturally relevant intervention to promote healthy food access in American Indian communities. *J Community Health.* 2020;45(3):458–464. https://doi.org/10.1007/s10900-019-00760-4.
29. Cueva K, Speakman K, Neault N, et al. Cultural connectedness as obesity prevention: indigenous youth perspectives on Feast for the future. *J Nutr Educ Behav.* 2020;52(6):632–639. https://doi.org/10.1016/j.jneb.2019.11.009.
30. Gatto NM, Martinez LC, Spruijt-Metz D, Davis JN. LA sprouts randomized controlled nutrition, cooking and gardening programme reduces obesity and metabolic risk in Hispanic/Latino youth. *Pediatr Obes.* 2017;12(1):28–37. https://doi.org/10.1111/ijpo.12102.
31. Davis SM, Going SB, Helitzer DL, et al. Pathways: a culturally appropriate obesity-prevention program for American Indian schoolchildren. *Am J Clin Nutr.* 1999;69(4 suppl):796S–802S. https://doi.org/10.1093/ajcn/69.4.796S.
32. Johnson-Jennings M, Paul K, Olson D, LaBeau M, Jennings D, Oi G. Ode'imin Giizis: Proposing and piloting gardening as an indigenous childhood health intervention. *J Health Care Poor Underserved.* 2020;31(2):871–888. https://doi.org/10.1353/hpu.2020.0066.
33. Christian MS, Evans CEL, Cade JE. *Does the Royal Horticultural Society Campaign for School Gardening increase intake of fruit and vegetables in children? Results from two randomised controlled trials. Public Health Research.* 2014;2(4). Southampton (UK): NIHR Journals Library. https://doi.org/10.3310/phr02040.

34. Lofton S, Julion WA, McNaughton DB, Bergren MD, Keim KS. A systematic review of literature on culturally adapted obesity prevention interventions for African American youth. *J Sch Nurs.* 2016;32(1):32–46. https://doi.org/10.1177/1059840515605508.
35. Dudley DA, Cotton WG, Peralta LR. Teaching approaches and strategies that promote healthy eating in primary school children: a systematic review and meta-analysis. *Int J Behav Nutr Phys Act.* 2015;12:28. https://doi.org/10.1186/s12966-015-0182-8.
36. Jarpe-Ratner E, Folkens S, Sharma S, Daro D, Edens NK. An experiential cooking and nutrition Education Program increases cooking self-efficacy and vegetable consumption in children in Grades 3−8. *J Nutr Educ Behav.* 2016;48(10):697–705.e1. https://doi.org/10.1016/j.jneb.2016.07.021.
37. Poelman AAM, Cochet-Broch M, Wiggins B, et al. Effect of experiential vegetable education program on mediating factors of vegetable consumption in Australian primary school students: a cluster-randomized controlled trial. *Nutrients.* 2020;12(8):2343. https://doi.org/10.3390/nu12082343.
38. Magarey AM, Pettman TL, Wilson A, Mastersson N. Changes in primary school children's behaviour, knowledge, attitudes, and environments related to nutrition and physical activity. *ISRN Obes.* 2013;2013:752081. https://doi.org/10.1155/2013/752081.
39. Getting Started - A Guide for Creating School Gardens as Outdoor Classrooms. Third ed. Life Lab; 2007. Available from https://lifelab.org/free-downloads/. Accessed July 28, 2016.
40. Professional development opportunities. LifeLab, https://lifelab.org/for-educators/professional-development/. Updated 2016. Accessed July 21, 2016.
41. Baranowski T, Davis M, Resnicow K, et al. Gimme 5 fruit, juice, and vegetables for fun and health: outcome evaluation. *Health Educ Behav.* 2000;27(1):96–111. https://doi.org/10.1177/109019810002700109.
42. Watson K, Baranowski T, Thompson D. Item response modeling: an evaluation of the children's fruit and vegetable self-efficacy questionnaire. *Health Educ Res.* 2006;21(suppl 1):i47–i57. https://doi.org/10.1093/her/cyl136.
43. Chiuve SE, Fung TT, Rimm EB, et al. Alternative dietary indices both strongly predict risk of chronic disease. *J Nutr.* 2012;142(6):1009–1018. https://doi.org/10.3945/jn.111.157222.
44. Domel SB, Baranowski T, Davis HC, Thompson WO, Leonard SB, Baranowski J. A measure of stages of change in fruit and vegetable consumption among fourth- and fifth-grade school children: reliability and validity. *J Am Coll Nutr.* 1996;15(1):56–64. https://doi.org/10.1080/07315724.1996.10718565.
45. Sharma S, Yacavone M, Cao X, Pardilla M, Qi M, Gittelsohn J. Dietary intake and development of a quantitative FFQ for a nutritional intervention to reduce the risk of chronic disease in the Navajo Nation. *Public Health Nutr.* 2010;13(3):350–359. https://doi.org/10.1017/S1368980009005266.
46. Stevens J, Cornell CE, Story M, et al. Development of a questionnaire to assess knowledge, attitudes, and behaviors in American Indian children. *Am J Clin Nutr.* 1999;69(4 suppl):773S–781S. https://doi.org/10.1093/ajcn/69.4.773S.
47. Barrington WE, Beresford SAA. Applying multiple statistical methods to derive an index of dietary behaviors most related to obesity. *Am J Epidemiol.* 2018;187(7):1559–1569. https://doi.org/10.1093/aje/kwx370.
48. A SAS program for the 2000 CDC growth charts (ages 0 to <20 years). Centers for Disease Control and Prevention. (2009). https://www.cdc.gov/nccdphp/dnpao/growthcharts/resources/sas.htm. Updated 2016. Accessed July 12, 2021.
49. Beresford SA, Thompson B, Feng Z, Christianson A, McLerran D, Patrick DL. Seattle 5 a Day worksite program to increase fruit and vegetable consumption. *Prev Med.* 2001;32(3):230–238. https://doi.org/10.1006/pmed.2000.0806.
50. Twisk J, Bosman L, Hoekstra T, Rijnhart J, Welten M, Heymans M. Different ways to estimate treatment effects in randomised controlled trials. *Contemp Clin Trials Commun.* 2018;10:80–85. https://doi.org/10.1016/j.conctc.2018.03.008.
51. Sauder KA, Dabelea D, Bailey-Callahan R, et al. Targeting risk factors for type 2 diabetes in American Indian youth: the Tribal Turning Point pilot study. *Pediatr Obes.* 2018;13(5):321–329. https://doi.org/10.1111/ijpo.12223.
52. Sorensen G, Stoddard A, Peterson K, et al. Increasing fruit and vegetable consumption through worksites and families in the treatwell 5-a-day study. *Am J Public Health.* 1999;89(1):54–60. https://doi.org/10.2105/ajph.89.1.54.
53. Geller KS, Melbye MJ, Rosenkranz RR, Shoemaker C, Dzewaltowski DA. Measuring elementary-aged children's self-efficacy and proxy efficacy for gardening and related health behaviors. *Horttechnology.* 2015;25(6):731–741. https://doi.org/10.21273/HORTTECH.25.6.731.
54. Bell BM, Martinez L, Gotsis M, et al. Virtual sprouts: a virtual gardening pilot intervention increases self-efficacy to cook and eat fruits and vegetables in minority youth. *Games Health J.* 2018;7(2):127–135. https://doi.org/10.1089/g4h.2017.0102.
55. Beresford SA, Thompson B, Bishop S, Macintyre J, McLerran D, Yasui Y. Long-term fruit and vegetable change in worksites: Seattle 5 a Day follow-up. *Am J Health Behav.* 2010;34(6):707–720. https://doi.org/10.5555/ajhb.2010.34.6.707.