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Impact of a school-based intervention and the COVID-19 pandemic on healthy eating in Navajo families: Results from the Yéego! Healthy eating and gardening intervention trial

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ABSTRACT

Objectives: As part of a group randomized trial of a school-based intervention promoting gardening and healthy eating, health behaviors of adult family members were evaluated. The COVID-19 pandemic hit the Navajo Nation in March 2020 and the ongoing Yéego! collaborative study allowed description of adult response to COVID as an ancillary objective.

Methods: Six elementary schools on the Navajo Nation in Arizona or New Mexico had been randomized to intervention or comparison group. One adult family member for each 3rd and 4th grade student completed surveys at baseline, nine-month and 21-month follow-up. Adult outcomes were fruit and vegetable (F&V) intake, obesogenic dietary index and gardening frequency. COVID-related measures were collected at 21-month follow-up. Differential changes and interactions were examined using repeated measures linear mixed models.

Results: Adult F&V intake increased significantly more in the intervention group than in the comparison group at nine months by 2.26 servings/day (95% CI: 0.45, 4.06). No other changes were associated with the intervention at nine or 21 months. At 21 months, in the subgroup with COVID concerns, the differential change in F&V intake was 2.02 (95% CI: 0.21, 3.84) servings/day. In cross-sectional analyses, only healthy eating measures varied by levels of COVID concerns, stress and resilience.

Conclusions: The child focused school-based intervention had some impact on adult family members, particularly their F&V intake, suggesting the reach of the intervention extended to students' families. The impact on adult F&V intake persisted among those reporting COVID concerns. Findings have important implications for augmenting healthy eating interventions.

1. Introduction

Rates of obesity and diabetes are high on the Navajo Nation (Dabelea et al., 2014; Guenther et al., 2006; Nava et al., 2015; Will et al., 1997). Access to affordable, healthy food is limited (Kumar et al., 2016), food insecurity is common (Pardilla et al., 2014) and regular F&V[1] intake is low among both children and adults (Ballew et al., 1997; Ornelas et al., 2018; Sharma et al., 2009). One strategy for increasing healthy food intake is to increase F&V familiarity (Caldwell et al., 2009; Devereaux, 2010; Lombard et al., 2006) through school-based gardens. Studies show school-based interventions incorporating nutrition education and gardening increase healthy eating behaviors (Beresford et al., 2022; Black et al., 2017; Davis et al., 2021; Gortmaker et al., 1999; Himes et al., 2003). Increasing gardening opportunities has also been a priority

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[1] F&V Fruit and Vegetable AHEI Alternative Healthy Eating Index FFQ Food Frequency Questionnaire.

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of Navajo Nation leadership (Navajo Nation, 2016).

Building on several years of collaboration, the Yéego! team launched a three-year group randomized trial of a healthy eating and gardening school-based intervention in two areas of the Navajo Nation in the United States. The intervention comprised a school garden and an educational curriculum focused on healthy eating and gardening skills delivered to elementary school children in third and fourth grades (Ornelas et al., 2021a). The study was in its second year when the COVID-19 pandemic began.

In May 2020, reported rates of COVID in the Navajo Nation were 2,449 per 100,000, among the highest per capita in the United States (Power et al., 2020). COVID-19 affected daily life, including increased food insecurity and reduced access to water (Newton, 2020). These adverse effects might increase stress, resiliency and lead to changes in eating behavior. COVID-19 may also have increased gardening behaviors, as people were home more and sought alternative food sources (San Fratello et al., 2022; Reinhart, 2021).

The Yéego! study offered an opportunity to examine adults' response to COVID-19 (COVID concerns, food worries, stress and resilience) as well as to the intervention. Adult eating and gardening behaviors were prespecified secondary outcomes of the trial.

1.1. Purpose

Although the primary focus of the school-based intervention was on the students, we also hypothesized the intervention effects might extend to their families. We examined this hypothesis using study surveys provided by the adult caregiver.

The hypothesized direct and interaction effects are shown in Fig. 1, which uses The Health Equity Framework (Peterson et al., 2021) to illustrate factors at multiple levels interacting to influence individual health behavior. In this study, the community level factor is COVID-19. We posited that COVID impact factors interacted with possible effects of the school level Yéego! healthy eating and gardening intervention to influence health behaviors at the adult level. Higher levels of concerns about COVID, food worries, and stress were hypothesized to be associated with poorer health, less healthy behaviors, and smaller intervention effects; higher levels of resilience would be associated with better health and health behaviors and larger intervention effects.

This paper aimed to 1) estimate the effect of the school intervention on adult eating and gardening behaviors at nine-month and 21-month follow-up; 2) describe associations between COVID impact factors and dietary and gardening behaviors in adult family members; and 3) evaluate the differential change in eating behaviors between intervention and follow-up in subgroups defined by levels of COVID impact factors.

2. Methods

2.1. Study design and population

The Yéego! Healthy Eating and Gardening Study (Yéego!) was conducted in six elementary schools on the Navajo Nation and has been previously described (Beresford et al., 2022). The study population included third and fourth grade students enrolled in Fall 2019, and one adult family member for each student (usually their parent, referred to in this paper as "adult"). Adults provided consent for themselves and their child, and the child provided assent. The study met the guidelines for human subjects concerning safety and privacy of both the Fred Hutchinson Cancer Center IRB and Navajo Nation Human Research Review Board. Schools were randomized to intervention versus delayed

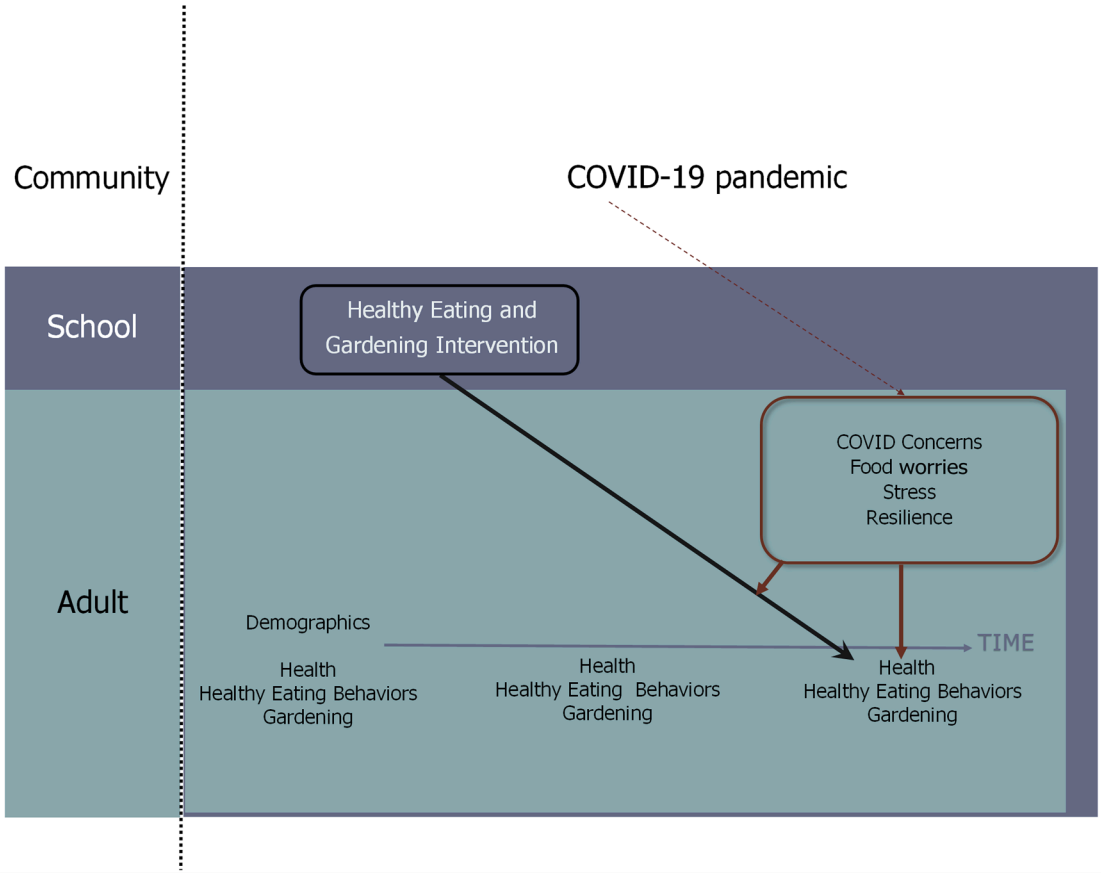

Fig. 1. Conceptual Model of Effects of Community, School and Adult Factors on Health and Health Behaviors: Navajo Nation 2019–21.
Note: Community level effects on adult COVID response factors were not directly estimated.

intervention, and surveys were administered to students and adults on three occasions: at baseline, at nine months (end of school year 2019–20), and 21 months (end of school year 2020–21).

Due to COVID-19, schools closed in mid-March 2020, switching to remote learning via paper materials, and restarting online in August 2020. Consequently, the intervention curriculum ended early, abbreviating hands-on gardening experiences for students. Follow-up surveys were administered remotely to students and adults. At 21-month follow-up, adult surveys included questions about COVID impacts.

In summer 2021, after 21-month follow-up, comparison schools received garden beds, garden sheds and tools to honor project deliverables. The full delayed intervention was postponed until the schools reopened in late 2021: the intervention's curriculum was provided to the comparison school champions in printed and electronic form.

Analyses at the nine-month follow-up preserved the randomized trial design (Aim 1). The 21-month follow-up data provided a conservative estimate of the long-term intervention effect, by using differential change estimates, given the limited exposure to any intervention in the second school year (Aim 3). For Aim 2, understanding COVID response in relation to healthy behaviors, analyses were cross-sectional.

2.2. Data collection

Baseline interviews were conducted in-person by trained interviewers from the Navajo community. Participants were recontacted at nine-month follow-up to complete the survey online, by mail, or by phone interview. For the 21-month follow-up, we attempted to reach all adults who initially consented, regardless of whether they completed baseline assessments. A different adult family member could respond to either follow-up survey if the original baseline responder was not available. Information on their relationship to the child participant was collected. The 21-month survey took 30 min to complete by phone. Adults unwilling to do the entire survey were offered an eight-question version (F&V daily servings, obesogenic dietary index, gardening frequency, food worries and stress).

2.3. Measures

Demographic information was collected at baseline and follow-up, if needed. Language spoken at home included Navajo only, Navajo and English, and English only. The first two categories were combined to report percent households speaking some Navajo at home. Socioeconomic variables included education level and employment.

2.3.1. Primary outcome measures

F&V intake. Daily servings of fruit, fruit juice, vegetables (including salad and potatoes but excluding fried potatoes) were summed, using a seven-question abbreviated FFQ (Thompson and Byers, 1994), used by study centers evaluating NCI 5 A Day for Better Health programs (Havas et al., 1994) and referred to as the standard fruit and vegetable screener (Thompson et al., 2000).

Obesogenic Dietary Index. This index was derived and validated in an intervention study in worksites. Frequency of eating fried potatoes or french-fries was one item of the standard fruit and vegetable screener. Frequency of fast-food meals was assessed by the item, "… how many times in a week or month do you eat breakfast, lunch, or dinner in a place such as McDonald's®, Burger King®, Wendy's®, Arby's®, Pizza Hut®, or Kentucky Fried Chicken®?" (Dave et al., 2009; Rosenheck, 2008). Response options were converted to times per week. Average weekly soft-drink intake was assessed by asking, "How often do you drink soft drinks or soda pop (regular or diet)?" (French et al., 2000). Response options were: "Never", "Less than once a week", "About once a week", "2–5 times per week", "About once a day", and "2 or more times per day." The obesogenic index is the average weekly consumption of french-fries, soft drinks, and fast-food meals (Barrington and Beresford, 2018).

2.3.2. Secondary health or health behavior outcomes

Self-rated health. We used a single question with five response options (Adams and Benson, 1991; Diehr et al., 2001) "Would you say your health in general is excellent, very good, good, fair, or poor".

Physical Activity Score. The Godin leisure-time exercise questionnaire (Godin and Shephard, 1997) distinguishes frequency of strenuous, moderate, and mild physical activity. Examples to help respondents identify intensity level included activities common among Navajo people. In our analysis, the physical activity score included only moderate and strenuous activity (with metabolic equivalents of 5 and 9) (Amireault and Godin, 2015).

Ratio of healthy foods to total foods. The picture sort tool (Beresford et al., 2022; Beresford et al., 2023) used groups of representative pictures, with the respondent recording frequency of consumption from each food grouping. The ten major food groups of the Navajo diet were included (Sharma et al., 2009). Frequencies of healthy foods, namely fruits (fresh & dried), vegetables (not salad), whole grains, beans and nuts were derived. The ratio of frequency of healthy to total foods was calculated.

AHEI F&V score. Responses to the picture sort tool were scored according to the AHEI-2020 scoring. Individual scores were interpolated between the minimum and maximum using published criteria (Chiuve et al., 2012). Values for fruits and vegetables (not salad) were summed for the AHEI F&V score.

Gardening frequency. Participants reported how many times they gardened per month. Responses were converted to frequency per week.

Gardening interest. Participants responded to three statements about where they were interested in gardening: "… at home"; "… in my child's school garden"; "… in another local garden". The fourth statement "I'm not interested in gardening in any of these places" was used to create a binary variable (yes or no).

2.3.3. COVID impact factors

COVID Concerns. Like a survey of Latina (Ornelas et al., 2021b), participants were asked "Are you concerned about any of the following due to COVID-19?". The options were: "Becoming sick with COVID-19"; "Someone I know becoming sick with COVID-19"; "Not being able to see family and friends"; "A family member that became socially isolated"; "Not being able to work"; "Being treated unfairly because I am Navajo"; "Other, please specify". Since most reported concerns were related to sickness, we focused on the first two options, grouping participants with at least one concern about sickness versus none.

Food Worries. Adapted from a screener question in the Guide to Measuring Household Food Security (Bickel et al., 2000), participants were asked "Since March 2020, how often have you been worried about running out of food and not having sufficient funds to buy more?" Response options were "several days" or "rarely or not at all".

Stress. The four-item Perceived Stress Scale (Cohen et al., 1983), has good internal consistency and external validity (Vallejo et al., 2018) but imperfect construct validity (Ingram et al., 2016). In response to: "During the last month, how often have you felt the following emotions?", the items are "Unable to control the important things in your life?"; "Confident about your ability to handle your personal problems? "; "Things were going your way?"; "Difficulties were piling up so high that you could not overcome them". Response options were modified, based on our pilot work, to a three-point scale, viz: "almost never"; "sometimes"; "often". Item scores were summed with higher scores representing greater perceived stress. In subgroup analyses, "high stress" was defined as responding "often" to any of the four items. Its counterpart was "low stress".

Resilience. A four-item scale used responses to three options, reduced from five based on pilot feedback, from "does not describe me well" to "describes me well". The original scale demonstrated good internal reliability (Sinclair and Wallston, 2004). The items were: "I look for creative ways to alter difficult situations"; "Regardless of what happens to me, I believe I can control my reaction"; "I believe I can grow

in positive ways by dealing with difficult situations"; "I actively look for ways to replace the losses I encounter in life". Responses were summed, with a higher score reflecting higher resilience. In subgroup analyses, "high resilience" was defined as responding "does not describe me well" to any of the four items. Its counterpart was "low resilience".

2.4. Statistical methods

Baseline demographic and health behavior characteristics were compared across intervention or comparison schools using t-tests. Characteristics were described for all adult respondents at the 21-month follow-up.

To estimate differential change in adult eating and gardening behaviors associated with the school-based intervention (first aim), repeated measures linear mixed model analyses was used, a recommended approach (Twisk et al., 2018). This method permits use of all collected responses, including those with only one time point, to estimate changes over time and the differential change, while accounting for within-school correlations. Different adults from the same family were distinguished. Mean differences and 95% confidence intervals (CI) described change in the intervention and the comparison group. The estimated intervention effect (with 95% CI) is the differential change between the two groups. Analyses were evaluated at nine-month and 21-month follow-up.

Means and standard deviations were compared for continuous health behaviors and presence of gardening interest across the COVID concerns and food worry binary variables (second aim) using t-tests and chi-square tests respectively. Simple linear regression models examined the mean difference in health behaviors associated with a one-unit increase in stress and resilience scores. Logistic regression estimated odds of having gardening interest associated with a one-unit increase in stress and resilience scores. To provide context, outcome measures at the median of stress and resilience were calculated.

To estimate differential change between intervention and comparison groups within subgroups of COVID concerns, food worries, stress (binary), and resilience (binary) at 21-month follow-up for the two pre-

Fig. 2. Consort Diagram of Study Schools and Adults, Navajo Nation 2019–21.

specified dietary behaviors (F&V intake and obesogenic dietary index), repeated measures linear mixed models was used (third aim). Because the differential change associated with the intervention was statistically significant within the subgroup reporting COVID concerns, we conducted a sensitivity analysis to examine its robustness: We re-ran the models restricted to the cohort of adults who provided values at both baseline and 21-month follow-up, allowing direct estimation of the intervention effect.

3. Results

Of 541 third and fourth grade students enrolled at six schools in Fall 2019, 55% adult family members provided consent and assent to participate. Baseline survey responses were obtained from 53% of those consenting (157/294, Fig. 2). At 21-month follow-up, thanks to additional outreach, 61% of consented families completed at least an eight-question version of the surveys. Most (68%) respondents were the same adult family member at all time points, but 62 of 178 responders at follow-up did not complete the baseline survey. At baseline and 21-month follow-up, 56% reported speaking some Navajo at home, 87% graduated from high school or received additional education, and 59% were currently employed (Table 1). Mean F&V intake at baseline were lower in intervention than comparison schools (3.1 vs. 4.3 servings/day, $p = 0.03$).

Table 2A and 2B show the three main prespecified outcome measures and estimated intervention effects (differential change) at the end of the nine-month intervention, and at 21-month follow-up, respectively. At nine-month follow-up, F&V intake improved by 1.85 servings/day in the intervention group but was reduced by 0.40 servings/day in the comparison group, for a differential change of 2.26 servings/day ($p = 0.014$). About half of this improvement was retained to 21-month follow-up in the intervention group (0.96 servings/day), although the differential change was not statistically significant. Obesogenic dietary index and gardening frequency per week were not different between the two groups at either follow-up.

Cross-sectional associations were found between health behaviors and COVID impact factors at 21-month follow-up (Table 3). Those with no COVID concerns reported 1.43 (95% CI: 0.38, 2.48) more servings/day of F&V relative to those with concerns. Health behavior measures were similar for those reporting several days of food worries compared to rarely or no days. A one-unit increase in resilience score was associated with −0.25 (95% CI: −0.45, −0.06) difference in obesogenic dietary index. Similarly, a one-unit increase in stress score was associated with −0.01 (95% CI: −0.02, −0.003) difference in ratio of healthy to total foods. No other associations between stress or resilience and gardening or other health behaviors were observed.

Figs. 3A and 3B display, within subgroups of COVID impact factors, estimated differential change between intervention and comparison groups in F&V servings/day and obesogenic dietary index, respectively. Differential change of 2.02 servings/day of F&V was significant within the subgroup of adults reporting COVID concerns. Sensitivity analysis restricted to adults with both baseline and follow-up responses showed the corresponding intervention effect for those with COVID-19 concerns was 1.93 servings/day (95% CI: –0.15, 4.01). In the subgroup with high resilience, differential change in F&V intake associated with the intervention was 1.54 servings/day (95% CI: −0.12, 3.21), while for obesogenic dietary index, it was −1.01 (95% CI: −2.10, 0.08).

4. Discussion

The potential for family structure to augment intervention efforts (Gardner et al., 2023) was realized in this study. The school-based healthy eating and gardening intervention implemented for children showed distal impact on adult family members, with larger change in F&V intake for adults in the intervention group compared to comparison group. This is consistent with the differential increase in self-efficacy to eat F&V among students in the intervention, as previously reported. (Beresford et al., 2022) Higher levels of F&V intake in adults in the intervention group persisted a year after the intervention ended, for those reporting one or more concerns about COVID.

Table 1
Descriptive characteristics of adult family members in 2019 and 2021, comparing intervention and comparison schools at baseline, Navajo Nation.

	Baseline			**21-month Follow-up**
Characteristic *Mean (s.d.) unless otherwise specified*	Total Adults	Adults with children at an intervention school	Adults with children at a comparison (delayed intervention) school	Adult responders at final follow-up information
N	157	47	110	178[1]
Age in years	37.4 (8.7)	37.1 (8.0)	37.5 (9.0)	37.9 (8.4)
% Female	93.6%	95.7%	92.7%	96.2%
% American Indian/Alaska Native	97.4%	95.5%	98.2%	96.0%
% Navajo Tribal affiliation	91.7%	89.4%	92.7%	90.4%
% Speaks some Navajo at home	56.4%	63.8%	53.2%	55.8%
% currently married	51.6%	48.9%	52.7%	48.4%
% high school graduate or equivalent	86.6%	89.4%	85.5%	86.7%
% currently employed	58.6%	57.5%	59.1%	58.5%
F&V intake (servings/day)	3.90 (3.49)	3.07 (2.75)	4.26 (3.71)*	3.80 (3.04)
Obesogenic dietary index[2] (scored 0 to 14)	2.46 (1.91)	2.51 (1.80)	2.44 (1.96)	2.54 (1.93)
Self-rated health (scored 1-Excellent to 5-Poor)		DID NOT COLLECT AT BASELINE		2.90 (1.07)
Physical activity score (scored 0 to 98)[3]		DID NOT COLLECT AT BASELINE		42.3 (27.1)
Ratio of healthy foods to total foods (0 to 1)		DID NOT COLLECT AT BASELINE		0.29 (0.08)
AHEI F&V score (scored 0 to 20)[4]		DID NOT COLLECT AT BASELINE		9.18 (3.50)
Gardening frequency per week	1.22 (1.96)	1.36 (2.19)	1.16 (1.86)	1.42 (1.92)
Gardening interest, n (%)	136 (87.2)	39 (83.0)	97 (89.0)	122 (81.3)
COVID concerns, n (%)		DID NOT COLLECT AT BASELINE		93 (52.3)
Frequent Food Worries, n (%)		DID NOT COLLECT AT BASELINE		57 (36.8)
Stress Score (scored 1-low to 8-high)		DID NOT COLLECT AT BASELINE		3.18 (1.68)
Resilience Score (scored 1-low to 8-high)		DID NOT COLLECT AT BASELINE		5.51 (2.05)

*$p < 0.05$ using *t*-test comparing intervention vs. comparison groups at baseline.
s.d. standard deviation AHEI Alternative Healthy Eating Index F&V Fruit and Vegetable.
[1] Includes participants who responded to the eight-question version. Many variables had responses from 151 to 157 participants.
[2] Average weekly frequency of fast food, french-fries and soda. Higher scores represent higher obesogenic behavior.
[3] Score is sum of weekly frequency, weighted by MET equivalents, of vigorous (MET 9) and moderate (MET 5) physical activity. Higher scores denote higher physical activity.
[4] AHEI F&V score is sum of AHEI Fruit score (max 10 for 4+ servings/day fruits) and AHEI Vegetables score (max 10 for 5+ servings/day vegetables).

Table 2A
Changes in adult dietary and gardening behaviors by intervention group, Navajo Nation: baseline to nine-month follow-up.

	Intervention			Comparison			Differential change
	Baseline	Nine-month Follow-up	Change	Baseline	Nine-month Follow-up	Change	
	n = 47	n=43		n=110	**n = 90**		
Adult Outcomes	Mean (s.d.)	Mean (s.d.)	Mean Change (95% CI)	Mean (s.d.)	Mean (s.d.)	Mean Change (95% CI)	Unadjusted Mean Difference (95% CI)
F&V intake (servings/day)	3.1 (2.8)	4.9 (3.8)	1.85 (0.35, 3.36)	4.3 (3.7)	3.9 (3.6)	−0.40 (−1.40, 0.60)	2.26 (0.45, 4.06)*
Obesogenic Dietary Index	2.5 (1.8)	2.3 (2.1)	−0.27 (−1.53, 0.99)	2.4 (2.0)	2.2 (1.7)	−0.28 (−1.13, 0.56)	0.01 (−1.51, 1.53)
Gardening frequency per week	1.4 (2.2)	1.9 (2.0)	0.59 (−0.76, 1.93)	1.2 (1.9)	1.9 (2.5)	0.77 (−0.18, 1.71)	−0.18 (−1.82, 1.46)

Table 2B
Changes in adult dietary and gardening behaviors by intervention group, Navajo nation: baseline to 21-month follow-up.

	Intervention			Comparison			Differential change
	Baseline	21-month Follow-up	Change	Baseline	21-month Follow-up	Change	
	n=47	n=64		**n = 110**	**n = 114**		
Adult Outcomes	Mean (s.d.)	Mean (s.d.)	Mean Change (95% CI)	Mean (s.d.)	Mean (s.d.)	Mean Change (95% CI)	Unadjusted Mean Difference (95% CI)
F&V intake (servings/day)	3.1 (2.8)	4.0 (3.3)	0.96 (−0.41, 2.32)	4.3 (3.7)	4.0 (3.9)	−0.23 (−1.20, 0.74)	1.19 (−0.49, 2.86)
Obesogenic Dietary Index	2.5 (1.8)	2.2 (2.0)	−0.21 (−1.09, 0.67)	2.4 (1.9)	2.9 (2.4)	0.49 (−0.12, 1.10)	−0.70 (−1.78, 0.37)
Gardening frequency per week	1.4 (2.2)	1.2 (1.7)	−0.12 (−0.94, 0.69)	1.2 (1.9)	1.5 (2.0)	0.37 (−0.19, 0.93)	−0.50 (−1.49, 0.50)

*$p < 0.05$ using repeated measures linear mixed model analyses.
s.d. standard deviation CI Confidence Interval F&V Fruit and Vegetable.

The intervention incorporated three of five strategies reported as effective in a systematic review in American Indian/Alaskan Native youth (Andreo and Andrade, 2020). The differential change in adult F&V intake indicating an impact of the intervention beyond the children is consistent with qualitative results from Feast for the Future suggesting community members made healthier food choices because of the classroom and school garden intervention (Cueva et al., 2020).

Two other studies included parental components in school-based interventions in collaboration with indigenous peoples. The Pathways study reported low family participation but did not discuss adult eating behaviors (Caballero et al., 2003; Gittelsohn et al., 2003). The FRESH study was a farm-to-school intervention in rural, tribally owned early childhood education programs, showing a small, but not statistically significant differential increase in adult F&V intake at six months (Taniguchi et al., 2022). On the other hand, a family randomized study in American Indian families demonstrated increased F&V intake in adults at one year (Tomayko et al., 2019).

Our study found multiple factors associated with adult healthy eating behaviors. At the individual level, having COVID concerns was associated cross-sectionally with lower F&V intake, and higher resilience was associated with lower obesogenic dietary index scores. In other words, healthier eating was associated with no concern and more resilience.

The overall prevalence of concerns about COVID were similar in this study (53%) to a social media-based study reporting 50% of Native Americans being concerned about COVID infection from people they know. (Stockman et al., 2021) Frequent food worries were reported by 37% participants in this study. This compares with a weighted prevalence of food insecurity (46%) (Nikolaus et al., 2022) and findings from the Native American Agricultural Fund (NAAF) Food Access Survey, reporting 37% adults in their household skipped meals or reduced meal size because of limited money for food, at least one month in the pandemic (Stanger-McLaughlin et al., 2022). The NAAF study reported 49% experienced food insecurity overall, but the prevalence was 56% for households with children under age 18 years. This disparity in food insecurity among households with children was also reported in a U.S. multisite study of the pandemic (Niles et al., 2021).

This study found a weak positive association between ratio of healthy to total food consumed and frequent food worries. In contrast, the NAAF study (Stanger-McLaughlin et al., 2022) found higher food insecurity was associated with poorer self-reported health; those with fair or poor health reported twice as much food insecurity as those with good, very good, or excellent health (64% cf. 36.5%).

A systematic review of the COVID-19 effects (focusing on social distancing measures including lockdown) on obesity and its risk factors (Daniels et al., 2022) suggested COVID exacerbated poor health behaviors, including poor diet and low physical activity. This study supported these findings; lower resilience was associated with higher obesity risk. Opportunities for greater reliance on local agricultural infrastructure and greater food sovereignty have been suggested as ways to build community resilience to future health crises and food insecurity challenges (Chan and Anderson, 2021; Oaster, 2022). Following the study, consistent with recommendations for comprehensive school-based intervention for indigenous children (Gillies et al., 2020), we made a series of YouTube videos on healthy eating and gardening skills available to the whole community in each area, as part of community outreach (NMSU, 2021).

4.1. Limitations

The proportion of consenting families was lower than we hoped. Time for consenting and obtaining baseline surveys from parents and children was limited since these tasks had to precede the intervention start. Adult response rates were higher at 21-month follow-up than at baseline, due to more time allotted and increased effort to reach as many consented adults as possible. Nevertheless, the trial results may not have been fully representative of all parents eligible. Although intervention

Table 3
Health and Health Behaviors at 21-month follow-up associated with COVID-19 concerns, Food Worries, Stress and Resilience, Navajo Nation.

	COVID concerns			Food Worries			Stress score		Resilience Score	
	Yes Mean (s.d.)	No Mean (s.d.)	Mean difference (95% CI)	Several days Mean (s.d.)	Rarely or not at all Mean (s.d.)	Mean difference (95% CI)	Estimated value at median	Mean change associated with 1-unit increase (95% CI)	Estimated value at median	Mean change associated with 1-unit increase (95% CI)
F&V intake (servings/day)	3.22 (2.31)	4.65 (3.73)	1.43 (0.38, 2.48)ˆ	4.45 (3.46)	3.46 (2.75)	−1.00 (−2.07, 0.08)ˆ	3.8	−0.02 (−0.34, 0.31)	3.79	−0.04 (−0.28, 0.20)
Obesogenic dietary index	2.38 (1.82)	2.76 (2.08)	0.38 (−0.24, 1.01)	2.74 (1.92)	2.44 (1.94)	−0.30 (−0.94, 0.33)	2.52	−0.03 (−0.24, 0.17)	2.45	−0.21 (−0.36, −0.06)
Self-rated health (1-Excellent to 5-Poor)	2.89 (1.07)	2.91 (1.08)	0.01 (−0.33, 0.36)	2.86 (1.25)	2.91 (0.96)	0.05 (−0.33, 0.43)ˆ	2.99	0.14 (0.03, 0.25)	2.89	−0.004 (−0.09, 0.08)
Physical activity score	39.2 (26.6)	47.1 (27.3)	7.9 (−1.0, 16.7)	38.5 (26.0)	44.5 (27.5)	5.9 (−3.1, 14.9)	42.8	0.77 (−2.08, 3.62)	41.1	0.72 (−1.43, 2.86)
Ratio of healthy foods to total foods	0.29 (0.05)	0.29 (0.11)	−0.002 (−0.032, 0.028)ˆ	0.28 (0.05)	0.30 (0.09)	0.02 (−0.0004, 0.04)ˆ	0.28	−0.01 (−0.02, −0.003)	0.29	0.002 (−0.004, 0.008)
AHEI F&V score	9.19 (3.35)	9.18 (3.73)	−0.008 (−1.14, 1.12)	9.11 (3.34)	9.22 (3.62)	0.11 (−1.05, 1.27)	9.09	−0.11 (−0.48, 0.26)	9.25	0.16 (−0.11, 0.44)
Gardening frequency	1.52 (1.86)	1.32 (2.00)	−0.20 (−0.77, 0.37)	1.18 (1.64)	1.48 (1.90)	0.30 (−0.29, 0.90)	1.43	0.01 (−0.16, 0.18)	1.4	0.06 (−0.08, 0.20)
	Yes n (%)	No n (%)	p-value	Several days n (%)	Rarely or not at all n (%)	p-value	Odds at median	Odds Ratio associated with 1-unit increase (95% CI)	Odds at median	Odds Ratio associated with 1-unit increase (95% CI)
Gardening interest	77 (85.6)	45 (75.0)	0.10	41 (75.9)	80 (85.1)	0.16	2.29	1.23 (0.94, 1.61)	0.47	0.88 (0.71, 1.10)

NOTE: Total sample = 178, of which n = 19 completed the eight-question version
Analyses used t-tests for COVID concerns and Food Worries except for gardening interest which used chi-square tests.
Analyses used simple linear regression in Stress and Resilience except for gardening interest which used logistic regression.
ˆSatterthwaite for unequal variances.
s.d. standard deviation CI Confidence Interval AHEI Alternative Healthy Eating Index F&V Fruit and Vegetable.

		Change Mean	(95% CI)	Intervention effect[a] (95% CI)
COVID-19 Concerns				
Yes	Intervention	1.07	(-0.41, 2.56)	2.02 (0.21, 3.84)
	Comparison	1.35	(-0.73, 3.42)	
No	Intervention	-0.46	(-1.67, 0.76)	0.64 (-1.99, 3.27)
	Comparison	0.71	(-0.91, 2.32)	
Food Worries				
Several Days	Intervention	2.08	(-0.19, 4.35)	1.80 (-1.03, 4.64)
	Comparison	0.27	(-1.42, 1.97)	
Rarely or not at all	Intervention	0.71	(-0.82, 2.25)	1.17 (-0.73, 3.07)
	Comparison	-0.46	(-1.58, 0.66)	
Stress				
Low	Intervention	0.79	(-0.70, 2.29)	0.87 (-1.03, 2.76)
	Comparison	-0.07	(-1.23, 1.09)	
High	Intervention	1.87	(-0.47, 4.21)	2.45 (-0,35, 5.25)
	Comparison	-0.58	(-2.12, 0.95)	
Resilience				
Low	Intervention	1.85	(-1.54, 5.23)	1.16 (-3.06, 5.38)
	Comparison	0.69	(-1.83, 3.21)	
High	Intervention	1.06	(-0.28, 2.41)	1.54 (-0.12, 3.21)
	Comparison	-0.48	(-1.46, 0.50)	

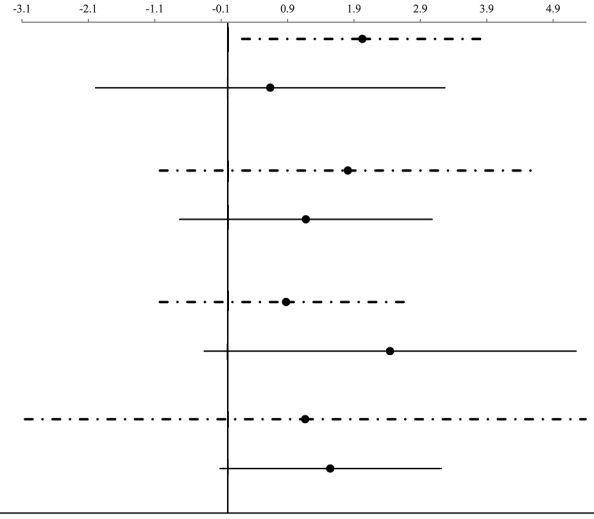

Fig. 3A. Estimated Change in Fruit & Vegetable Intake at 21 months attributable to the intervention by subgroup of COVID-impact factors, Navajo Nation.
[a] *Repeated measures linear mixed model accounting for students nested within schools CI Confidence Interval.*

		Change Mean	(95% CI)	Intervention effect[a] (95% CI)
COVID-19 Concerns				
Yes	Intervention	-0.66	(-1.71, 0.38)	-0.64 (-1.91, 0.64)
	Comparison	-0.03	(-0.76, 0.70)	
No	Intervention	-0.46	(-1.67, 0.76)	-1.04 (-2.58, 0.50)
	Comparison	0.58	(-0.36, 1.52)	
Food Worries				
Several Days	Intervention	-0.71	(-2.08, 0.67)	-0.78 (-2.49, 0.93)
	Comparison	0.07	(-0.95, 1.08)	
Rarely or not at all	Intervention	-0.51	(-1.50, 0.47)	-0.82 (-2.04, 0.40)
	Comparison	0.31	(-0.41, 1.03)	
Stress				
Low	Intervention	-0.53	(1.47, 0.40)	-0.79 (-2.49, 0.93)
	Comparison	0.26	(-0.47, 0.98)	
High	Intervention	-0.65	(-2.08, 0.79)	-0.75 (-2.46, 0.97)
	Comparison	0.10	(-0.84, 1.04)	
Resilience				
Low	Intervention	0.57	(-1.31, 2.45)	-0.12 (-2.46, 2.22)
	Comparison	0.69	(-0.71, 2.09)	
High	Intervention	-0.94	(-1.82, -0.05)	-1.01 (-2.10, 0.08)
	Comparison	-0.07	(-0.57, 0.71)	

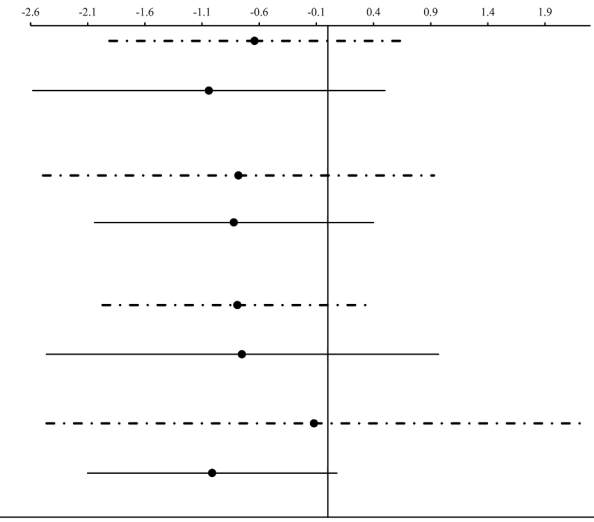

Fig. 3B. Estimated Change in obesogenic dietary index at 21 months attributable to the intervention by subgroup of COVID-impact factors, Navajo Nation.
[a] *Repeated measures linear mixed model accounting for students nested within schools CI Confidence Interval.*

effects on obesogenic index and gardening frequency were evaluated, lack of intervention focus on fast foods, french-fries, soda and access to gardens may explain why no changes were found. The study was not originally designed to evaluate community level factors affecting the health of the participants, and only cross-sectional associations could be reported for those COVID impact analyses. The distal differential changes associated with the intervention within subgroups of adults stratified by COVID impact factors were examined post-hoc, and so should be interpreted with caution.

5. Conclusions

The beneficial effects of a school level intervention were demonstrated in adult family members, although no outreach to the families of the students was formally part of the intervention. A differential change of two servings/day in the F&V intake of the adult family member is substantial, suggesting that behavioral changes in a child may also impact the broader family. Cross-sectionally, the study demonstrated that factors potentially exacerbated by COVID-19, such as stress and low resilience, were associated cross-sectionally with obesity risk. In addition, the beneficial effects of the school level intervention were experienced differently by strata of COVID impact factors, especially COVID concerns. Future intervention iterations could include adding family outreach to the school curriculum and evaluating the modified intervention in more elementary schools. In disseminating results of the intervention study to participating communities, acknowledgement of COVID-19 is critically important to maintaining trust, showing respect, and maintaining collaboration. The land and vegetation are sacred to

the Diné people and our strategies around school gardens demonstrated one salient approach with potential to improve diet and reduce obesity risk.

CRediT authorship contribution statement

Shirley A.A. Beresford: Writing – review & editing, Writing – original draft, Methodology, Funding acquisition, Formal analysis, Conceptualization. **India J. Ornelas:** Writing – review & editing, Methodology, Conceptualization. **Geraldine Garrity:** Writing – review & editing, Resources. **Mark C. Bauer:** Writing – review & editing, Resources. **Sonia K. Bishop:** Writing – review & editing, Investigation, Data curation. **Annie Vreeke:** Writing – review & editing, Conceptualization. **Linda Garcia:** Supervision, Conceptualization. **Brandon Francis:** Investigation. **Eileen Rillamas-Sun:** Writing – review & editing, Validation, Software, Formal analysis. **Kevin A. Lombard:** Writing – review & editing, Supervision, Resources, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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The authors have no conflicts of interest to declare. All co-authors have seen and agree with the contents of the manuscript and there is no financial interest to report. We certify that the submission is original work and is not under review at any other publication.

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