



Individual- and household-level factors associated with fruit, vegetable, and dietary fiber adequacy among Native American adults in 6 reservation communities

Michelle Estradé^{a,*}, Sally Yan^a, Angela C.B. Trude^b, Sheila Fleischhacker^c, Sarah Hinman^a, Tara Maudrie^a, Brittany W. Jock^d, Leslie Redmond^e, Marla Pardia^a, Joel Gittelsohn^a

^a Johns Hopkins Bloomberg School of Public Health, Department of International Health, USA

^b University of Maryland School of Medicine, Department of Pediatrics, USA

^c Georgetown University Law Center, USA

^d McGill University Centre for Indigenous Peoples' Nutrition and Environment, USA

^e University of Alaska Anchorage, College of Health, USA

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ABSTRACT

This study utilized baseline data collected in 2017 from the OPREVENT2 trial, which included 540 Native Americans in six Midwest and Southwest reservation communities. The objective was to identify correlates of fruit, vegetable, and dietary fiber adequacy among participants 18–75 years old who self-identified as the main food purchaser or preparer in their household. Mean daily servings of fruits and vegetables and grams of dietary fiber were quantified based on a 30-day semi-quantitative food frequency questionnaire.

Participants consumed an average of 0.5 (± 0.4) cup-equivalent servings of fruit, 2.5 (± 1.8) cup-equivalent servings of vegetables, and 15.5 (± 8.9) grams of fiber per day. <2% of the study population met the 2015–2020 *Dietary Guidelines for Americans* recommendations for fruit consumption, while 12 and 42% met recommendations for dietary fiber and vegetable consumption, respectively.

Females had a prevalence ratio 1.4 times greater than males for adequate intakes of vegetables ($p = 0.008$) and over 6 times greater for dietary fiber ($p < 0.001$). Participants over the age of 30 were about twice as likely to meet dietary fiber recommendations ($p = 0.031$) compared to those 30 years and younger. Participants receiving food assistance from the USDA's Food Distribution Program on Indian Reservations (FDPIR) were nearly twice as likely as non-FDPIR recipients to meet recommendations for dietary fiber ($p = 0.008$).

These findings can help guide the development of targeted interventions to improve diet quality; however, further work is needed to understand and address underlying reasons for low fruit consumption in these rural reservation communities.

1. Introduction

Adequate intake of fruits, vegetables, and dietary fiber is central to diet quality, health maintenance, and prevention of obesity and chronic disease (Bazzano et al., 2002; Boeing et al., 2012; Hung et al., 2004; Timm and Slavin, 2008; Weickert and Pfeiffer, 2018). Fruits, vegetables, and dietary fiber have been associated with lower risk of hypertension, stroke, and cardiovascular disease (Boeing et al., 2012), which is the leading cause of mortality in the U.S., including among Native Americans (Virani et al., 2020).

Historically, Native American eating patterns in the Midwest and

Southwest United States (US) were abundant in fruits and vegetables (Gurney et al., 2015; Park et al., 2016; Vernon, 2015) – excellent sources of vitamins, minerals, phytochemicals, and dietary fiber, which have protective benefits against chronic disease and obesity (Boeing et al., 2012; Dahl and Stewart, 2015; Hung et al., 2004; McRae, 2017; Timm and Slavin, 2008). However, following centuries of systematic displacement from their ancestral lands, food and water systems, and ways of life, Native American eating patterns have shifted from a predominantly natural plant-based diet towards one characterized by increased consumption of animal products and highly processed foods, which has contributed to an inequitable burden of chronic disease

* Corresponding author at: 601 N Wolfe Street, Rm. W2041, Baltimore, MD 21205, USA.

E-mail address: MEstrad7@jhu.edu (M. Estradé).

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(Vernon, 2015). The federal Indian reservations to which Native Americans were relocated are typically geographically isolated, and in many cases, the land is not located on a tribe's historical land base, which has resulted in reduced ability to engage in traditional food systems and subsistence patterns (e.g. hunting, fishing, and gathering) and increased reliance on industrialized food systems (Settee and Shukla, 2020). Numerous studies have documented barriers to healthy food access, quality, and affordability on federal Indian reservations, as well as high rates of food insecurity, one of many symptoms of settler colonialism and systemic racism in contemporary food systems (Byker Shanks et al., 2019; Chodur et al., 2016; Fretts et al., 2018; Jernigan et al., 2017, 2012; Kaufman et al., 2014; Mucioki et al., 2018; Pindus and Hafford, 2019; Wetherill et al., 2018). A 2012 US Department of Agriculture (USDA) report found that 23% of Native American households were food insecure, compared to 15% of all US households (Gordon and Oddo, 2012). Subsequent regional analyses have found much higher rates among some Native American populations (Pardilla et al., 2014; Sowerwine et al., 2019).

Despite the health challenges caused by inequitable food systems, Native Americans have been historically resilient and continue to find ways to reclaim their health through the traditional wisdom of native elders, policy changes (Antone-Nez et al., 2018; Williams et al., 2019), food sovereignty initiatives (Michnik, 2018), and research partnerships (Dellinger et al., 2016; Gittelsohn et al., 2020). For example, the Native Farm Bill Coalition lead a historic effort in shaping the 2018 US Farm Bill, which included a provision to purchase locally-grown and traditional foods for the USDA Food Distribution Program on Indian Reservations (FDPIR), among other milestones for tribal food systems (Mucioki et al., 2018). Both FDPIR and the USDA Supplemental Nutrition Assistance Program (SNAP) offer nutrition education and culturally-tailored programming opportunities for many Native American communities (Finegold et al., 2009; Hersey et al., 2012). In 2007, the USDA Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) expanded its food package to allow more culturally-acceptable food substitutions among Native American communities (Gleason et al., 2014).

While policy levers are critical to improving food access among tribal communities, there have been few attempts to intervene at other levels of Bronfenbrenner's socioecological model (Bronfenbrenner, 1977). Understanding individual- and household-level correlates of fruit, vegetable, and dietary fiber consumption could help guide the development of interventions at various levels of the socioecological model. This study aims to identify individual- and household-level factors associated with adequacy of fruit, vegetable, and dietary fiber intake among a sample of Native American adults living in six rural reservation communities in the Midwest and Southwest United States by addressing the following questions:

- What proportion of Native American adults living in federal Indian reservation communities meet 2015–2020 *Dietary Guidelines for Americans* (DGA) recommendations for fruit, vegetable, and dietary fiber consumption?
- What individual-level factors are associated with adequate consumption of fruit, vegetable, and dietary fiber in this population?
- What household-level characteristics are associated with adequate consumption of fruit, vegetable, and dietary fiber in this population?

2. Methods

2.1. Study design

This is a cross-sectional analysis using baseline data from the OPREVENT2 trial. OPREVENT2 is a multi-level multi-component community-randomized trial in six rural Native American communities located on federal Indian reservations in the Midwest and Southwest regions of the U.S. After baseline assessment, three communities were

randomized to receive the intervention to improve access to healthy and indigenous foods and improve physical activity levels, and three served as comparison sites, receiving a delayed intervention. Details of the intervention design and components are described elsewhere (Gittelsohn et al., 2017).

2.2. Sampling

A sample of 100 adults per community was collected ($n = 601$) to assess baseline characteristics. In several communities, households were contacted via telephone from a master list of residents for recruitment and eligibility screening. If a master list was not available, the tribal offices were consulted to help provide research study information to community members who could contact the research team for screening. Participation was limited to one individual per household. Eligible individuals had to be 18 years or older, self-identify as the main household food getter and/or preparer, not pregnant, and have no intention to move for at least two years. A total of 859 individuals were screened for participation. Of those, 234 did not meet the inclusion criteria, and 24 were eligible but declined participation.

2.3. Data collection

Data collectors attended a one-week training on data collection methods, confidentiality and consenting, and best practices, including in-depth instruction and practice using each data collection instrument. Most data collectors spoke the local tribal language and could translate interview questions if requested by participants. Approximately 15% of the interviews were conducted in a tribal language, and a further 15% were conducted in a mix of English and tribal language. Written consent was obtained prior to each interview.

2.4. Measures

2.4.1. Dietary intake

Usual dietary intake was assessed with a semi-quantitative Block Food Frequency Questionnaire (FFQ), based on one used in the Strong Heart Study, which included foods considered culturally-relevant in several Native American populations (Lee et al., 1990). During the extensive formative phase of the project, the FFQ was modified to include additional foods common in the specific study communities, for example venison, mutton and piñon nuts (Setiono et al., 2019). The FFQ instrument collected data on food and drink consumption patterns over the past 30 days. Completed questionnaires were sent to NutritionQuest (Berkley, California) for calculation of nutrient and food group intakes. Outputs used in the current analysis included daily servings of fruit including juice (cup equivalents), daily servings of vegetables (cup equivalents), and daily grams of dietary fiber.

2.4.2. Individual-level factors

An interviewer-administered questionnaire collected information on sex, age, education level (elementary, some high school, diploma/GED, technical school, some college, undergraduate degree, graduate degree), employment status (full time, part time, seasonal/temporary, unemployed, student, retired, disabled), smoking status (current smoker or not), and self-reported comorbidities (hypertension, heart disease, diabetes, cancer). Participants' height and weight were directly measured to calculate body mass index (BMI). Participants were instructed to remove shoes and jackets, and two repeated measurements were taken for each participant's height and weight; if the measurements varied by more than 0.5 in. or 0.5 lb, a third measurement was taken. Each participant's BMI was calculated dividing weight (kg) by height (m^2) and classified normal weight ($BMI < 25 \text{ kg}/m^2$), overweight (BMI from $25 \text{ kg}/m^2$ to $<30 \text{ kg}/m^2$), or those who have obesity ($BMI \geq 30 \text{ kg}/m^2$ or greater).

2.4.3. Household-level factors

The interview-administered questionnaire collected information on household size and participation in nutrition assistance programs (WIC, SNAP, FDIPIR, senior meals, food banks, church assistance, summer food service, local farm surplus). A series of 18 questions asked about the number and types of material items that belonged to the household, for example “How many televisions in working order do you have in your home?” and “How many computers/laptops/tablets in working order do you have in your home?”. The sum of all material items in the household were combined to create a Material Style of Life (MSL) score, an additive scale used as a proxy for socioeconomic status, which has been used in a previous study (Gittelsohn et al., 2006). Reliability, or internal consistency, of the scale was confirmed by computing Cronbach’s alpha (alpha = 0.84). MSL scores ranged from 1 to 48, with a mean of 17 ± 8.

2.5. Data analysis

All analyses were conducted using Stata 15 (StataCorp, College Station, TX). Individuals who reported consuming ≤ 500 kcal per day (n = 7), or ≥ 7000 kcal per day (n = 14) were excluded from the analysis (Estradé et al., 2021). Also excluded were those who reported more than 10 servings of vegetables per day (n = 3), or had missing data for height (n = 20) or weight (n = 16). The final analytical sample included 540 individuals.

Daily fruit, vegetable, and dietary fiber consumption were transformed into binary variables indicating whether an individual met the age- and sex-specific DGA recommendations (Health.gov, 2018) for each category. The adequacy cutoffs for dietary fiber in males were 33 g/day for those under 30 years old, 30 g/day from 30 to 50 years old, and 28 g/day for those over 50. For females, dietary fiber adequacy was defined as at least 28 g/day for those under 30 years old, 25 g/day from 30 to 50 years, and 22 g/day for those over 50. Vegetable adequacy among males was defined as 2.5 servings per day for those over age 50, and 3 servings/day for those 50 and younger. Vegetable adequacy among females was defined as 2 servings per day for those over age 50, and 2.5 servings per day for those 50 and younger. Fruit adequacy was defined as 2 or more servings per day for females under age 30 and all males, and 1.5 servings per day for females age 30 and over. Because adequate fruit consumption was a rare outcome in our sample (n = 9 meeting fruit recommendations), another variable was created to indicate whether an individual consumed at least one cup-equivalent of fruit per day. This one-cup-equivalent variable replaced the fruit adequacy variable in the analysis. Fruit, vegetable, and dietary fiber adequacy were then regressed on individual- and household-level sociodemographic factors using Poisson regression with robust error variance (Barros and Hirakata, 2003). Analyses of individual-level factors were controlled for total daily caloric intake and seasonality. Analyses of household-level factors were controlled for sex, age, smoking status, season of data collection, and total daily caloric intake. Given the cross-sectional nature of the data, results are expressed as prevalence ratios (PrR), which is analogous to relative risk.

2.6. Ethical approval and tribal approvals

Prior to writing the grant that would fund this study, over 20 tribes in the Midwest and Southwest were contacted, and six responded with strong interest in forming a collaborative relationship with the research team, providing tribal resolutions and memoranda of understanding. In order to address population-level privacy concerns raised by participating communities as a result of difficult past research study experiences, the study team agreed not to name the individual tribes in any public dissemination of the study findings. After securing tribal approvals from each participating community, this study was also approved by the Johns Hopkins University Institutional Review Board (IRB), Indian Health Service (IHS) IRB, and the Navajo Nation Human Research Review Board.

3. Results

3.1. Proportion of participants meeting 2015–2020 DGA recommendations for fruit, vegetables, and dietary fiber

On average, participants consumed 0.5 (±SD 0.4) cup-equivalent servings of fruit, 2.5 (±SD 1.8) cup-equivalent servings of vegetables, and 15.5 (±SD 8.9) grams of fiber per day (Table 1). In this sample, 42.2% met the DGA recommendation for daily vegetable consumption, and 11.5% met the current recommendation for daily fiber consumption. Only 1.7% of the study population met the current recommendation for fruit intake. Over 88% of participants reported consuming less than one serving of fruit per day, and the maximum number reported by any participant in the study was 2.6 servings per day. Relatively few participants (17%) reported consuming less than one serving of vegetables per day. The most common sources of vegetable servings came from corn, potatoes, green salad, and tomatoes.

3.2. Individual- and household-level factors associated with adequate consumption of fruit, vegetable, and dietary fiber

Females had a prevalence ratio 1.40 times greater than males for adequate intakes of vegetables (PrR 1.40, p = 0.008) and over six times greater for dietary fiber (PrR 6.68, p < 0.001) (Table 2). Those in older age categories (31–50 and >50) were more likely to meet dietary fiber recommendations (PrR 1.88, p = 0.031 and PrR 3.20, p < 0.001, respectively) than those 30 years and younger. Fruit, vegetable, and dietary fiber consumption did not differ by region (Midwest vs Southwest), nor by presence of self-reported comorbidities (i.e., those who reported no comorbidities compared to those who reported being diagnosed with one or more of the following conditions: diabetes, hypertension, heart disease or cancer).

Table 1
Individual and Household Characteristics of Native American Adults in the OPREVENT2 Trial^a (n = 540).

Individual characteristics	% or Mean (SD) ^b
Age (years) 18–45 years (%) ≥ 46 years (%)	45.6 (15.0) 47.5 (2.5)
Female (%)	74.8
BMI (kg/m ²) ^c < 25 (%) 25–29.9 (%) 30–34.9 (%) ≥ 35 (%)	15.6 25.3 32.8 26.3
Dietary Intake ^d	
Daily kilocalorie consumption	2186.4 (1153.7)
Daily servings of fruit (cup equivalent)	0.5 (0.4)
Daily servings of vegetables (cup equivalent)	2.5 (1.8)
Daily grams of dietary fiber	15.5 (8.9)
Education Level	
Less than high school (%)	17.8
High school (%)	29.8
More than high school (%)	53.4
Current smoker (%)	27.2
Employed (%)	56.3
Household characteristics	
Household size	3.7 (1.9)
WIC participant (%)	15.0
SNAP participant (%)	40.8
FDPIR participant (%)	14.5

^a Baseline data. Collected in 2017 in six rural Midwest and Southwest reservation communities.

^b unless otherwise specified.

^c BMI was calculated according to WHO standards, based on measured height and weight.

^d Based on FFQ data Abbreviations: SD (standard deviation), BMI (Body Mass Index), WIC (Special Supplemental Nutrition Program for Women, Infants, and Children), SNAP (Supplemental Nutrition Assistance Program), FDPIR (Food Distribution Program on Indian Reservations).

Table 2

Individual factors associated with proportion of Native American adults who meet Dietary Guideline recommendations for daily vegetable and fiber intake, and at least 1 serving of fruit per day.^a

	Vegetable PrR (95% CI)	Fruit PrR (95% CI)	Dietary Fiber PrR (95%CI)
Age category			
18–30	Ref	Ref	Ref
31–50	1.07 (0.84 – 1.38)	0.90 (0.54 – 1.50)	1.88 (1.06 – 3.33)
51 and older	1.41 (1.09 – 1.81)	0.72 (0.41 – 1.26)	3.20 (1.78 – 5.76)
Sex			
Males	Ref	Ref	Ref
Females	1.40 (1.12 – 1.76)	0.83 (0.54 – 1.29)	6.68 (2.86 – 15.61)
BMI category			
Normal Weight(BMI < 25 kg/m2)	Ref	Ref	Ref
Overweight(BMI ≥ 25 & <30 kg/m2)	1.14 (0.82 – 1.60)	1.25 (0.64 – 2.48)	1.48 (0.75 – 2.95)
Obesity (BMI ≥ 30 kg/m2)	1.28 (0.96 – 1.71)	1.14 (0.63 – 2.08)	1.40 (0.79 – 2.46)
Education Level			
Less than high school	Ref	Ref	Ref
High school	0.96 (0.73 – 1.27)	1.32 (0.73 – 2.39)	1.08 (0.57 – 2.03)
More than high school	0.99 (0.78 – 1.27)	1.24 (0.70 – 2.20)	1.24 (0.68 – 2.24)
Smoking status			
Non-smoker	Ref	Ref	Ref
Current Smoker	0.96 (0.79 – 1.18)	0.93 (0.58 – 1.49)	0.73 (0.44 – 1.20)
Employment			
Not employed	Ref	Ref	Ref
Employed	0.87 (0.73 – 1.01)	0.87 (0.57 – 1.32)	0.68 (0.45 – 1.03)

^a Baseline data. Collected in 2017 in six rural Midwest and Southwest reservation communities Abbreviations PrR (prevalence ratio, BMI (Body Mass Index)Adjusted for daily caloric intake and season of data collection.

Participants who reported receiving food assistance from FDPIR were almost twice as likely as non-FDPIR recipients to meet intake recommendations for dietary fiber (PrR 1.80, $p = 0.008$), after controlling for sex, age, smoking status, season of data collection, and daily calorie intake (Table 3).

4. Discussion

This is one of the first studies to explore correlates of adequacy of fruit, vegetables, and dietary fiber intake at multiple levels of the socioecological model in rural Native American reservation communities. Our findings fill an important gap, as national- and state-level diet monitoring systems and surveys largely exclude reservation communities or have significant barriers to participation (e.g., random-digit telephone dialing, and conducted in English or Spanish only). This is also one of the first studies to report on dietary characteristics and correlates of the main food shoppers and preparers of the household, who act as key gatekeepers of diet quality, among rural Native American families.

The average intake of fruit reported in this study was lower than the U.S. population average (0.5 vs 1.1 cup equivalents per day), with <2% of participants meeting DGA recommendations, compared to 12% of adults nationally (Lee-Kwan et al., 2017). However, the average number of vegetable servings was higher than the national average (2.5 vs 1.5 cup equivalents), and over 42% of participants met DGA recommendations, compared to just 9% of adults nationally (Lee-Kwan et al., 2017). The relatively high rate of vegetable adequacy is a noteworthy dietary strength in this population, especially given that more than 40% of participants reported receiving SNAP benefits, which has been

Table 3

Household factors associated with proportion of Native American adults who meet Dietary Guideline recommendations for daily vegetable and fiber intake and at least 1 serving of fruit per day.^a

	Vegetable PrR (95% CI)	Fruit PrR (95% CI)	Dietary Fiber PrR (95% CI)
Household Size			
1	Ref	Ref	Ref
Each additional member	1.14 (1.02 – 1.28)	0.93 (0.71 – 1.20)	1.22 (0.95 – 1.57)
Nutrition assistance			
WIC (vs no WIC)	1.17 (0.91 – 1.49)	1.24 (0.71 – 2.19)	0.77 (0.39 – 1.52)
SNAP (vs no SNAP)	0.87 (0.72 – 1.05)	1.04 (0.67 – 1.60)	1.13 (0.73 – 1.73)
FDPIR (vs no FDPIR)	0.97 (0.75 – 1.25)	0.92 (0.51 – 1.66)	1.80 (1.16 – 2.77)
Region			
Southwest	Ref	Ref	Ref
Midwest	0.91 (0.73 – 1.13)	1.06 (0.65 – 1.75)	0.81 (0.46 – 1.41)

^a Baseline data. Collected in 2017 in six rural Midwest and Southwest reservation communities Abbreviations: PrR (Prevalence Ratio), SD (standard deviation), BMI (Body Mass Index), WIC (Special Supplemental Nutrition Program for Women, Infants, and Children), SNAP(Supplemental Nutrition Assistance Program), FDPIR (Food Distribution Program on Indian Reservations) Adjusted for sex, age, smoking status, season of data collection, and daily calorie intake.

associated with low fruit and vegetable consumption in past studies (Andreyeva et al., 2015). Further exploration of this finding could be an important next step in developing assets-based approaches that support and reinforce current dietary strengths. One potential explanation for high vegetable adequacy in this population might be due to gardening or engagement in other food-sovereignty initiatives. For example, a survey conducted among several Navajo communities in the Southwest found that over half of the study population engaged in gardening, and that gardening was associated with total (combined) fruit and vegetable consumption (Ornelas et al., 2018).

Dietary fiber intakes our the study population were similar to the US average (15.5 vs 16.2 g per day) (McGill et al., 2015), but FDPIR recipients were far more likely to have adequate dietary fiber intakes, which is a new finding that should be explored further in future studies. It is possible that recent efforts to improve fresh fruit and vegetable offerings and culturally relevant foods in FDPIR (Mucioki et al., 2018) might increase dietary fiber intake among recipients. It should also be noted that FDPIR offers nutrition education through partnerships, grants, and direct programming that includes gardening, cooking classes, youth engagement, and a variety of other activities aimed at addressing a range of diet- and health behaviors (Pindus and Hafford, 2019), which could also impact dietary fiber consumption.

5. Limitations

These findings should be interpreted in light of several limitations. Only the primary household food shopper or preparer was eligible to participate in the study, and the sample is therefore over-represented by females and older participants (Flagg et al., 2014). The results of this study may also have limited generalizability because Native Americans are not a homogenous group; cultures, customs, food environments, and dietary habits vary widely between regions, tribes, and communities (Gurney et al., 2015; Trude et al., 2015). In addition, FFQs are prone to recall bias and systematic error, and although the Block FFQ has been validated to assess individual and group dietary intakes (Baer et al., 2005; Block et al., 1992), its validity has not been thoroughly studied in rural Native American populations (Walls et al., 2019). Food access and food insecurity, which can both impact diet quality, were not assessed in this study.

6. Conclusions

Our study highlights the need for further work to understand and address the underlying reasons for low fruit consumption in rural reservation communities in the Midwest and Southwest. Understanding individual correlates of fruit, vegetable, and dietary fiber intake can help guide interventions at various levels of the socioecological model, and our findings represent a first step toward identifying these factors. Although individual and household level approaches are important, they have limited ability to impact food access and food security issues. The current efforts of federal nutrition assistance programs to promote indigenous foods, which include a variety of fruits, vegetables, and other foods high in dietary fiber, are important but understudied approaches to improve diet quality in these populations. Community based participatory research approaches may be an important next step to understanding the intersection between food sovereignty, food security, and diet quality in Native American communities.

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CRedit authorship contribution statement

Michelle Estradé: Formal analysis, Writing - original draft. **Sally Yan:** Formal analysis. **Angela C.B. Trude:** Formal analysis. **Sheila Fleischhacker:** . **Sarah Hinman:** . **Tara Maudrie:** . **Brittany W. Jock:** Investigation. **Leslie Redmond:** . **Marla Pardiella:** Investigation. **Joel Gittelsohn:** Conceptualization, Methodology, Funding acquisition.

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.

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