



Food Stress and Diabetes-Related Psychosocial Outcomes in American Indian Communities: A Mixed Methods Approach

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ABSTRACT

Objective: Explore the relationship between diabetes-related psychosocial outcomes and food stress in American Indian communities.

Design: Convergence model of a mixed methods triangulation study.

Setting: Five American Indian reservation communities in the Midwest.

Participants: One-hundred ninety-two participants were randomly selected from tribal health centers using clinic patient records and were surveyed about diabetes distress, empowerment, and food stress across 4 different time points. Seventeen focus group discussions were conducted and transcribed, and a mix of purposive and convenience sampling was used.

Phenomenon of Interest: Psychosocial outcomes associated with (or related to) diabetes and food stress.

Analysis: Quantitative: Multiple linear regression was performed to explore relationships between food stress and diabetes distress and empowerment. Qualitative: Open coding of data identified portions of the transcripts related to food followed by a deductive approach on the basis of the components of quantitative food stress.

Results: Food stress in the forms of (1) not having enough money for food and not having enough time for cooking or shopping ($P = 0.08$) and (2) inadequate food access and being on a special diet ($P = 0.032$) were associated with increased diabetes distress. Lower diabetes empowerment was associated with not having enough money for food and being on a special diet ($P = 0.030$). Our qualitative data mirrored quantitative findings that experiencing multiple forms of food stress negatively impacted diabetes psychosocial outcomes and illuminated the cyclical role mental health can play in relationships to food.

Conclusions and Implications: Our findings highlight that experiencing food stress negatively affects diabetes empowerment and diabetes distress. These findings emphasize the importance of improving community food environments and addressing individual food access for diabetes management and prevention initiatives in American Indian communities.

Key Words: mixed methods, American Indian, diabetes, food security, stress (*J Nutr Educ Behav.* 2022;54:1051–1065.)

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INTRODUCTION

Within American Indian and Alaska Native (AI/AN) communities in the US, the burden of food insecurity

and type 2 diabetes (T2D) are disproportionately high. From 2000 to 2010, 25% of AI/ANs were classified as food insecure and were 20% more likely to be food insecure than White

Americans.¹ From 2017–2018, the prevalence of T2D among AI/AN adults in the US was 15%, nearly twice the diabetes prevalence of non-Hispanic White adults.² In addition, AI/AN adults living with T2D experience significant inequities in the prevalence of diabetes-related complications (eg, liver disease, limb amputations, renal failure, etc).^{2,3} Among those living with T2D, food insecurity is associated with psychological distress⁴ and poor glycemic control,^{1,5,6} both of which are risk factors for T2D complications (eg, amputation).^{2,7} Type 2 diabetes and comorbid conditions like obesity, heart disease, and stroke can be

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partially addressed through lifestyle interventions that focus on factors such as exercise, diet, and stress management; however, addressing social inequities related to food systems is key to preventing the development of chronic diseases.^{8–11}

Context of Food Insecurity and Food Stress

Rooted in a history of settler colonialism, food insecurity in AI/AN communities is one of many social determinants of health that affect the risk of T2D and its complications.⁸ The arrival of Europeans in what is now known as the Americas triggered a cascade of events that deeply affected AI/AN health and wellness. Since time immemorial, AI/AN peoples have honored their connections to the land and used their place-based knowledge to hunt, fish, gather, and cultivate foods that contribute to a healthy diet.^{12,13} However, colonization greatly disrupted this traditional subsistence and dietary patterns.^{12–15} An era of attempted systematic genocide and forced migration fueled by the Indian Removal Act of 1830 moved many AI peoples from their traditional homelands to reservations with unfamiliar landscapes that were often unable to support the traditional food systems of the relocated AI peoples.^{16–18} Furthermore, late in the 1800s, the US government began a policy of forced placement of AI children into federally run boarding schools.^{19–22} In the same period, changes were made to waterways and ecosystems to satisfy the needs of non-Indigenous settlements, agricultural initiatives, and economic endeavors. These sudden and radical changes to landscapes and traditional ways of being compromised the ecological integrity of food systems and the food security of AI/AN peoples.¹²

In the 1970s, federal food assistance programs began distributing food on AI/AN reservations through the *Commodity Supplemental Food Program* (CSFP or commodity foods) and the *Food Distribution Program on Indian Reservations* (FDPIR).^{8,23,24} These foods were often calorically dense, highly processed, and high in fat and salt.²³ The CSFP and the

FDPIR distribution continues in many AI/AN communities today, although changes have been made to programs to increase the healthfulness of available foods.^{8,24–26} Despite the efforts of these and many other community and federal food programs, many rural reservation communities have limited access to healthy foods and have been designated by the US Department of Agriculture as food deserts.^{12,27,28} Despite these challenges, many AI communities have reinvigorated their traditional food systems through food sovereignty movements, which center spiritual relationships with land, animals, and food while providing locally-based solutions to mitigate the effects of health inequities and food insecurity.^{29,30}

Food Stress and Diabetes Psychosocial Functioning

Stress has been associated with increased odds of diabetes in AI communities.³¹ This aligns with stress process models, which propose that exposure to stressors leads to distress in the form of poor health outcomes.^{32–34} Unfortunately, diabetes diagnosis and diabetes management come with their own set of stressors, including modifying dietary habits to manage blood glucose levels, new physical limitations, learning to manage chronic pain, new medication costs, and increased vulnerability to other diseases, all of which may cause or exacerbate mental health conditions.³⁵ Diabetes-related stress has been significantly associated with higher hemoglobin A1c (HbA1c), inadequate diet quality, and medication adherence issues among adults living with T2D.³²

One such stressor is food insecurity. Food insecurity is a “household-level economic and social condition of limited or uncertain access to adequate food.”³⁶ Food insecurity has been associated with increased odds of the presence of T2D and poor glycemic control, a condition that may put those with T2D at risk of diabetes-related complications.^{1,5,6,37}

Several potential mechanisms have been proposed to explain the impact of food insecurity on increased diabetes risk and complications.^{37,38} Food

insecure households may be likely to consume lower quality diets that promote the development of obesity and diabetes because of the comparatively low prices of highly processed, energy-dense food products.³⁷ Stress resulting from food insecurity may also affect metabolic function directly, potentially leading to weight gain and insulin resistance.³⁷

Diabetes distress has been correlated with low adherence to diabetes management behaviors (ie, physical activity and eating diets high in fruits and vegetables), which are crucial for decreasing an individual’s risk of diabetes-related complications and comorbidities.³⁹ Diabetes empowerment is a measure of diabetes-related psychosocial self-efficacy as it relates to a person’s openness to and ability to implement healthy behaviors, including healthy food purchasing.^{40,41} Diabetes distress and empowerment may be important predictors of diabetes management practices that could reduce mortality risk or diabetes-related complications. As such, the potential impact of food stress on diabetes distress and empowerment may influence the effectiveness of interventions to promote diabetes management and individuals’ efforts to manage diabetes.

Although relationships between diet quality and various diabetes outcomes have been established, there is little understanding of how the psychosocial aspects of diet, including food-related stressors, play a role in diabetes distress and empowerment among AI populations.^{42,43} In alignment with previous findings that experiencing multiple stressors has a greater deleterious effect on health than experiencing a single stressor,³² we anticipated a dose-response relationship between the number of food stressors experienced such that the magnitude of experiencing 1 form of food stress will be amplified in the presence of other food stressors (interactive effect). This aligns with a stress proliferation/amplification argument highlighted in stress process models.³³

We used a mixed-methods approach to explore 3 research questions: (1) What was the prevalence of food stress in the study population? (2) What was the association between food stress and diabetes-related

psychosocial outcomes (diabetes empowerment and distress) among AI adults with T2D? and (3) How did food stress affect the lives of those living with T2D?

METHODS

This study used a convergence model of a mixed methods triangulation study⁴⁴ to explore the prevalence and characteristics of food stress (both as a proxy for and as an expansion of the idea of food insecurity) among AIs in the upper Midwest. We aimed to examine the relationships between food stress and diabetes-related psychosocial outcomes. Understanding the prevalence, drivers, and impact of food-related stressors on diabetes-related psychosocial factors is important for shaping effective prevention and intervention initiatives to improve T2D outcomes in AI/AN communities. In this study, we examined a constellation of food-related stressors that, while including questions adapted from the US Department of Agriculture Food Security Screener, go beyond conventional food security measures to include participation in food assistance programs, time limitations for

acquiring and preparing food, and whether participants were on a diabetes-specific diet.⁴⁵ In this study, we have termed this constellation of stressors food stress. In addition to using a mixed-methods approach to examining the prevalence and characteristics of food-specific stressors, we explored relationships between food stress and 2 diabetes-related psychosocial outcomes (distress and empowerment). Data sources for this study are visually represented in Figure 1.

Quantitative Sample

The quantitative data for this study came from Gathering for Health, a collaborative study with 5 tribal reservation communities in Minnesota and Wisconsin focused on psychosocial stress and T2D. Clinical staff at each tribal site's health center generated simple random samples for study recruitment using clinic patient records. Specifically, staff (1) created a sampling frame (list) of all patients in medical records who met initial inclusion criteria (diagnosis of T2D within 2 years of sampling date, aged ≥ 18 years, and self-identified as American Indian), (2) numbered

the list and randomly selected patients from the sampling frame using a random number generator, and (3) sent invitation letters and brochures to residences of randomly selected patients. A total of 344 patients were invited into the study across sites. Of these, 46 were not eligible for participation (eg, did not meet inclusion criteria; lived outside of the geographic boundaries of the study), and 104 declined participation. The remaining individuals were contacted by trained community interviewers, screened for study eligibility, and formally invited to participate. A total of 194 participants enrolled in the study, comprising a baseline response rate of 67%. Two participants were missing data at all time points and were dropped from the final analytic sample ($n = 192$). Participants were interviewed 4 times in 6-month intervals, and the baseline survey started in 2014-2016. The retention rate at time point 2 was 86% ($n = 167$), and 84% at time points 3 and 4 ($n = 164$). Study protocols were approved by the University of Minnesota and National Indian Health Services Institutional Review Boards (full board review).

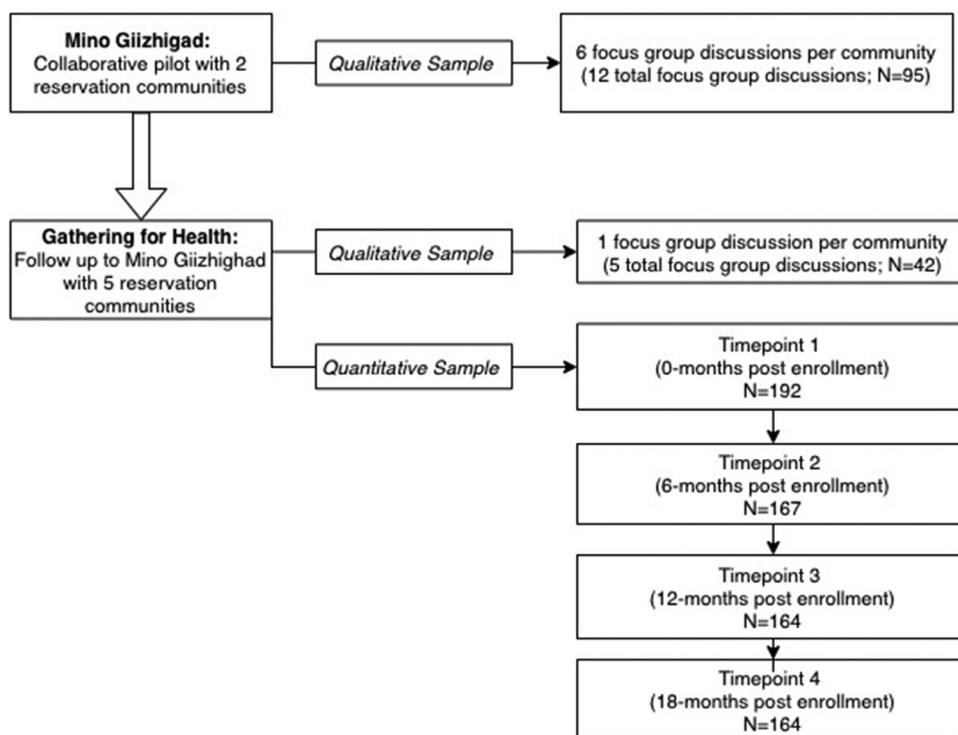


Figure 1. Summary of data sources for mixed methods analysis.

Visits were scheduled at a location of participants' choosing, at which time interviewers obtained signed informed consent and Health Insurance Portability and Act authorization forms. Interviewers were members of their tribal community and were provided a 2-day training by the investigative team, which consisted of human subjects' safety, interviewing protocols, and multiple practice sessions. Data for this manuscript include responses from all 4-time points of the study, for which participants received a \$50 incentive and a small, culturally relevant gift each visit.

Quantitative Measures

The content of the survey instrument for this study was primarily informed by focus group discussions (see Qualitative Methods section for more details) conducted at each of the 5 participating tribal sites across 2 separate research projects. Measures were reviewed by Community Research Councils and adapted for community and cultural relevance. The investigative team piloted the survey instrument for consistency, length, flow, and relevance for individuals living with T2D.

Diabetes distress. Diabetes distress was measured with the Diabetes Distress Scale-2.³⁹ Respondents were asked how bothered they were in the past month with 2 potential problems that people living with T2D may experience (feeling overwhelmed by the demands of living with diabetes and feeling that I am often failing with my diabetes regimen). Response options ranged from not at all bothersome (0) to very bothersome (5). At each time-point, items were summed together to create a composite diabetes distress score (r = correlation coefficient; time point 1: $r=0.48$; time point 2: $r=0.55$; time point 3: $r=0.72$; time point 4: $r=0.64$).

Diabetes empowerment. Diabetes empowerment was assessed using an adapted Diabetes Empowerment Scale-Short Form.⁴⁰ In this study, the original 13-item scale was reduced to 8 questions on the basis of Community

Research Council feedback and asked participants how strongly they agree or disagree with specific questions (eg, in general, I believe that I know the positive ways I cope with diabetes-related stress). For each item, response options range from (0) strongly disagree to (3) strongly agree. Principle axis factor analysis models showed that 1 item of the scale loaded poorly with the rest of the items (ie, know what parts of taking care of my diabetes I am dissatisfied with) and was dropped from the scale. At each study time point, the 7 remaining items were summed together to create a scale of diabetes empowerment, and Cronbach's α was used to assess internal consistency⁴⁶ (time point 1: $\alpha=0.83$; time point 2: $\alpha=0.84$; time point 3: $\alpha=0.88$; time point 4: $\alpha=0.74$).

Food stress. Five items adapted from the 6-item US Department of Agriculture Food Security Module were examined.⁴⁷ These items were adapted by Community Research Councils to better fit the community context. At each of the 4-time points, respondents were asked in the past 6 months whether there was not enough money for food (money), the kinds of food they wanted were not available (available), there was not enough time for shopping or cooking (time), it was hard to get to the store (access), and if they were on a special diet (special diet). Response options were no (0) and yes (1). Although these 5 questions fall under the same conceptual framework, they were not intended to be used as a unidimensional construct. Across each of the 4-time points, internal consistency was poor (Kuder-Richardson-20: -0.45 to 0.65).⁴⁸ As such, each item was examined individually.

Food assistance. Respondents were asked in the past 6 months whether they have started receiving government assistance such as food stamps, social security disability, unemployment, or something else. Response options were no (0) and yes (1).

Demographics. Age was determined by using the respondent's date of birth and date of the survey to create

age at baseline (continuous), gender was assessed by asking participants if their gender was male or female (0 = male; 1 = female), residing on vs off-reservation land (0 = off-reservation land; 1 = on-reservation land) was assessed by asking participants whether they currently lived on reservation land, the highest level of education completed was assessed through 1 question with the response options less than high school diploma (0), high school diploma (1), some college (2), college degree (3), per capita family income (total income sources from all household members, divided by the number of people in the household—divided by 1,000 for analytic purposes), and the number of years living with T2D since diagnosis (continuous) was included as demographic correlates and controls.

Qualitative Sample

Qualitative data for the current study derived from 2 different projects. The first project (*Mino Giizhigad: A New Day*) was a collaborative pilot study with 2 reservation communities in Minnesota and Wisconsin, and the university-based researchers focused on mental health and T2D. In the winter and spring of 2011, each community held 6 focus group discussions: 2 groups of informal service providers, including family members and other supportive community members, who care for someone living with T2D; 2 groups consisting of formal service providers, including clinicians, nurses, and other community-based service providers; and 2 groups of AI adult community members living with T2D. A total of 12 focus groups were conducted with 95 participants (62 females, 33 males), which ranged from 25–84 minutes in length. The second project (*Maawaji' Idi-Oog Mino-Ayaawin: Gathering For Health*) was a follow-up to the pilot project and was partially described in the quantitative methods. In the spring of 2013, 1 focus group was conducted in each of the 5 communities and consisted of AI adults living with T2D. Across the 5 focus group discussions, 42 individuals participated (24 female, 18

male), and discussions ranged from 99–130 minutes in length.

In each community, facilitators were selected by the Community Research Councils and were members of their respective communities. Facilitators were provided a 2-day training session by the investigative team on human subject safety, focus group facilitation, participant recruitment, and practice sessions. In both projects, a mix of purposive and convenience sampling was used to generate samples for qualitative inquiry. Facilitators, with guidance from Community Research Councils (described previously in Elm and Handeland),⁴⁹ were responsible for locating a convenient and available space in which focus group discussions could take place (eg, private meeting space, restaurant, conference room). Participants were provided a meal and a monetary incentive (\$25 for the pilot study, \$30 for the *Gathering for Health Study*). Before each focus group, participants provided signed informed consent and were notified that discussions would be recorded and transcribed. The questioning route used in focus group discussions has been provided as [Supplementary Material](#). The final protocol for both qualitative studies was reviewed and approved by tribal partners, the University of Minnesota Institutional Review Board (full board review), and National Indian Health Services Institutional Review Board.

Data Analysis

As previously described, the qualitative and quantitative data were collected at different points, but the quantitative and qualitative data were analyzed concurrently using the convergence model of a mixed methods triangulation study design.⁴⁴ In a convergence triangulation mixed-methods study design, the qualitative and quantitative data are collected separately and merged during interpretation by comparing and contrasting findings between qualitative and quantitative data.⁴⁴ Our study demonstrates the mixing of methods at the levels of data collection (focus group discussions informed quantitative surveys), analysis through

deductive coding, and interpretation through comparing qualitative and quantitative findings. The convergence mixed-methods triangulation study design is useful for holistic understanding and well-evidenced interpretations of a phenomenon and aided us in our pursuit of understanding the complex relationships between food stress, diabetes empowerment, and diabetes distress.⁵⁰

Quantitative analyses. For the quantitative analyses, generalized estimating equations were used to account for the nested structure of the data (ie, observations at each of the 4 time points nested within an individual).^{51,52} For the models predicting diabetes distress and empowerment, a normal distribution with an identity link function was used with an unstructured correlation structure. We examined the bivariate associations (unadjusted) of each food stressor on diabetes-related psychosocial outcomes and an adjusted model with all food stress, demographic, and time variables included (model 1). We also examined the interaction effects of all food stress variables on 1 another in separate models.

General estimating equations models account for missing data completely at random.⁵³ As age at baseline increases, the odds of missing data at a subsequent time point decrease. Females had lower odds of attrition compared with males. Participants living with T2D longer had higher odds of dropping out. To account for missing data, multiple imputations by chained equations were used in Stata software (version 15, StataCorp, 2017).^{52,54} For continuous variables with missing data (ie, diabetes distress, diabetes empowerment, per capita income, and the number of years with T2D), imputed data were handled with linear regression, and for binary variables with missing data (ie, 5 food stress items and food assistance) imputed data were handled with logistic regression. A total of 50 imputed data replicates were created. Data were imputed in a wide format (eg, each participant is represented as a single row in the dataset and repeated responses across study timepoints represented in separate columns), which

increases the amount of known information used in the imputation model compared with imputed in long format.⁵⁵ To analyze the generalized estimating equation models, the imputed data were reshaped into a long format (eg, each row is a 1-time point per participant, and repeated responses across study time points are represented in a single column).

Qualitative analyses. Qualitative data coding was conducted using a deductive approach on the basis of the quantitative findings.⁵⁶ First, 1 author open-coded transcripts to detect any portions of focus group discussions related to food-related concepts, including food stress.⁵⁷ This process resulted in 14 distinct codes that were further condensed into similar topics and used to establish principal themes, of which 4 related directly to the quantitative themes. Second, 2 authors coded the food-related data independently and met with a third author to reach a consensus on final codes and themes relating to the following questions about food stress: What are the food-related stressors that participants experience? What are barriers to food access in these communities? Data were then organized in a table by themes to highlight qualitative findings.

RESULTS

Our quantitative analyses included 192 self-identified American Indian adults, who, on average, were diagnosed with T2D 1.59 years before the start of time point 1. Most participants were female (56%) with an average age of 46.3 years. The majority of participants reported living on a tribal reservation (79%). A small proportion (1.01%) of participants reported college graduation, with 40% reporting some college, 33% reporting graduating high school or achieving a GED, and 13.02% receiving less than high school education. An average participant reported per capita family income was \$9,780.

Prevalence of Food Stress

Table 1 shows the prevalence of each food-related stressor at the 4-time

Table 1. Demographic Characteristics, Food Stress Prevalence, and Diabetes-Related Psychosocial Outcomes (n = 192)

Variables	Wave 1	Wave 2	Wave 3	Wave 4	Any Wave
Demographics					
Age, mean ± SD	46.3 ± 12.18				
Female, proportion	0.6				
Resides on reservation, proportion	0.8				
Education					
Less than high school, %	13.02				
High school diploma or GED, %	33.33				
Some college, %	40.10				
College graduate, %	1.01				
Per capita income, ^b \$	9,780 ± 8,950				
Years with T2D, mean ± SD	1.6 ± 1.55				
Food stress					
Money, %	30.0	21.3	26.3	24.8	51.7
Available, %	34.7	37.4	30.0	27.3	67.2
Time, %	37.3	38.4	36.3	34.8	68.0
Access, %	19.5	25.6	21.9	23.0	44.4
Special diet, %	15.3	8.6	8.8	9.4	28.7
Food assistance, %	24.6	12.8	16.3	16.8	40.1
Any food stressor, %	73.8	67.0	62.6	61.5	92.2
Diabetes outcomes					
Distress, mean ± SD	3.1 ± 2.77	2.8 ± 2.99	3.2 ± 3.49	3.0 ± 2.98	
Empowerment, mean ± SD	14.1 ± 2.66	14.1 ± 3.04	14.1 ± 3.15	13.8 ± 2.13	

GED indicates General Educational Development; T2D, type 2 diabetes.

^aMean education level is used in regression analyses. Levels of education are presented for additional context; ^bFor the regression analyses, per capita family income, is divided by 1,000.

points and the cumulative prevalence across the 4-time points. Across each timepoint, between 21% to 30% of participants reported not having enough money for food, 27% to 37% reported lacking availability of wanted types of foods, 35% to 38% reported not having enough time for shopping or cooking, 19% to 26% reported difficulty getting to the store, 9% to 15% reported being on a special diet, and 13% to 25% reported receiving food assistance. Across the 2 years of data collection, the overall prevalence of each food stressor nearly doubled compared with any single assessment at individual time points. Two-thirds of respondents reported a lack of availability of wanted types of food or not having enough time for shopping or cooking (68% and 67%, respectively). Around half of the participants reported not having enough money for food, having difficulty getting to a grocery store, or receiving food assistance (52%, 44%, and 40%, respectively). One-

third of participants reported being on a special diet (29%). A small proportion of participants consistently experienced each type of food stressor across all 4-time points of data (not having enough money for food [5%], lacking availability of wanted types of food [5%], not having enough time for shopping or cooking [11%], difficulty getting to the grocery store [7%], special diet [1%], and food assistance [1%]).

Models Predicting Diabetes Distress

Table 2 presents the generalized estimating equation models predicting diabetes distress. In the unadjusted model, 3 out of the 6 food stressors were significantly associated with diabetes distress ($P < 0.05$). Not having enough money for food, being on a special diet, and receiving food assistance increased diabetes distress. In the model adjusting for covariates (model 1), not having enough money for food and being on a special diet increased diabetes distress. Females

had higher levels of diabetes distress, whereas increases in educational attainment decreased diabetes distress.

All possible food stressor × food stressor interactions were tested. Of the 15 interactions tested, 2 were significant ($P < 0.05$), which is more than would occur by chance alone. In model 2, there was a significant interaction between not having enough money for food and not having enough time for shopping or cooking. In model 3, there was a significant interaction between lack of access to desired food and being on a special diet. The results of these interaction terms (ie, predicted values of diabetes distress across levels of both types of food stressors) are visually displayed in Figure 2. The link between insufficient time for cooking or shopping and higher diabetes distress was stronger among those who reported not having enough money for food. Similarly, the effect of lack of access to desired types of food on diabetes distress is stronger for participants on a special diet.

Table 2. GEE Models Predicting Diabetes Distress: Unstandardized Coefficients (n = 192)

Variables	Unadjusted ^a		Model 1 ^b		Model 2 ^c		Model 3 ^d	
	<i>b</i>	<i>P</i>	<i>b</i>	<i>P</i>	<i>b</i>	<i>P</i>	<i>b</i>	<i>P</i>
Food Stress								
Money	0.84**	0.001	0.48*	0.039	0.52*	0.026	0.49*	0.035
Availability	0.19	0.396	-0.13	0.543	-0.11	0.603	-0.09	0.678
Time	0.41 [†]	0.060	0.37 [†]	0.094	0.17	0.461	0.36	0.104
Access	0.42	0.109	0.10	0.698	0.10	0.690	-0.09	0.741
Special Diet	0.83*	0.013	0.76*	0.013	-0.14	0.751	0.30	0.416
Food Assistance	0.51*	0.035	0.41 [†]	0.089	0.36	0.135	0.40 [†]	0.098
Demographics								
Age			-0.01	0.481	-0.01	0.445	-0.01	0.358
Female			0.84**	0.003	0.89**	0.002	0.83**	0.004
On Reservation			0.33	0.342	0.34	0.330	0.32	0.352
Education			-0.45**	0.007	-0.48**	0.004	-0.43**	0.009
Income			-0.02	0.318	-0.02	0.290	-0.02	0.347
Years with T2D			0.04	0.714	0.02	0.833	0.01	0.857
Wave								
Wave 1 (ref)								
Wave 2			-0.22	0.366	-0.24	0.319	-0.22	0.350
Wave 3			0.04	0.845	0.00	0.981	0.03	0.877
Wave 4			-0.11	0.616	-0.16	0.478	-0.08	0.727
Diet x Time					1.57**	0.008		
Access x Diet							1.37*	0.032
Intercept			13.18***	0.000	3.26**	0.000	3.24***	0.000

GEE indicates generalized estimating equation; T2D indicates type 2 diabetes.

^aBivariate/Unadjusted estimates (*b* _ unstandardized regression coefficients); ^bFull regression model with all food stress, demographic, and time predictors included (*b* _ unstandardized regression coefficients); ^cFull regression model with significant interaction (*b* _ unstandardized regression coefficients); ^dFull regression model with significant interaction (*b* _ unstandardized regression coefficients).

[†]*P* < 0.10; **P* < 0.05; ***P* < 0.01; ****P* < 0.001

Models Predicting Diabetes Empowerment

Table 3 presents the generalized estimating equation models predicting diabetes empowerment. In the unadjusted model, not having enough money for food, not having enough time for shopping or cooking, and lack of access to wanted types of food significantly decreased diabetes empowerment. In the model adjusting for demographic covariates (model 1), only not having time for shopping or cooking decreased diabetes empowerment. Residing on reservation land and income increased diabetes empowerment. Of the 15 interactions tested, only 1 was significant, slightly above chance alone. In model 2, there was a significant interaction between insufficient money for food and a special diet. Predicted values of diabetes empowerment were plotted across levels of both

types of food stressors; these interaction terms are presented visually in Figure 1. As expected, the effect of not having enough money for food was stronger for those on a special diet.

Qualitative Results

Table 4 displays themes relating to food stress and the experiences of those living with T2D.

Food accessibility. Perceptions regarding food stress tended to emphasize barriers to adequate food access and achieving the diet quality recommended by health care providers. One female participant stated,

You go to the nutritionist, and she tells you what you're supposed to eat, and especially up in [home community], we can't have those foods all the time. We go to

[nearby city] to buy our groceries, and we might buy our fruits and vegetables, but they don't last for two weeks—you know? Until the next payday. We can't follow the right diet, because we can't get the right foods.

Perceptions of food stress were often expressed in relation to diet quality, with participants citing various forms of food stress as the reason they were unable to achieve the diet quality desired by their health care providers.

Financial constraints. Participant perspectives illustrate the negative impacts of financial hardships on food purchasing and diet quality. A female participant said, "I think for me, it's a money thing. I can't buy the food I'm supposed to eat. So I have to buy the food that I'd like to

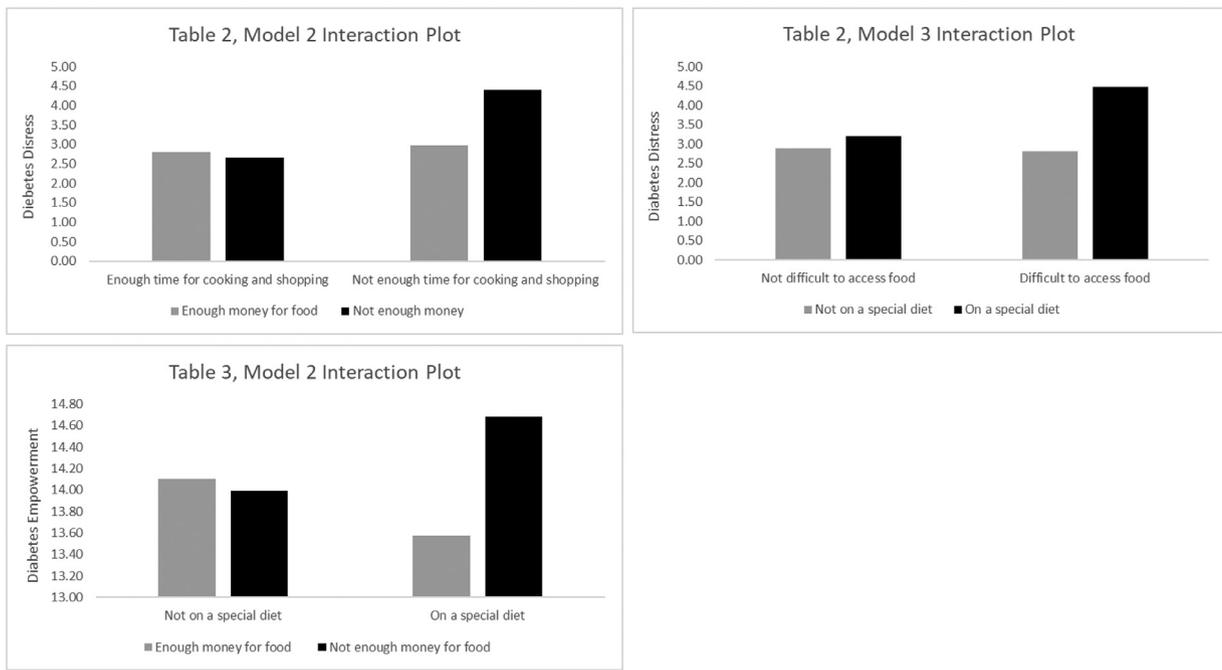


Figure 2. Predicted values of diabetes distress (top) and diabetes empowerment (bottom) for significant interaction effects.

eat. So, I just buy whatever I need instead of buying like fresh vegetables all the time and stuff.” This perspective aligns with quantitative

findings that not having enough money for food decreased diabetes empowerment and increased diabetes distress.

Food assistance. Participants cited the inaccessibility of healthy foods as a food stressor and an important barrier to eating a healthy diet. Several

Table 3. GEE Models Predicting Diabetes Empowerment: Unstandardized Coefficients (n = 192)

Predictors	Unadjusted ^a		Model 1 ^b		Model 2 ^c	
	b	P	b	P	b	P
Food Stress						
Money	-0.54*	0.015	-0.34	0.131	-0.53*	0.027
Availability	-0.20	0.338	0.04	0.851	0.06	0.759
Time	-0.48*	0.019	-0.44*	0.037	-0.41*	0.048
Access	-0.60*	0.013	-0.42†	0.078	-0.41†	0.085
Special Diet	0.11	0.709	0.34	0.239	-0.11	0.745
Food Assistance	-0.28	0.221	-0.16	0.496	-0.15	0.517
Demographics						
Age			0.01	0.513	0.01	0.549
Female			-0.11	0.664	-0.09	0.709
On Reservation			0.71*	0.221	0.68*	0.025
Education			0.17	0.031	0.19	0.194
Income			0.03*	0.031	0.03*	0.028
Years with T2D			-0.12	0.157	-0.13	0.130
Wave						
Wave 1 (ref)						
Wave 2			0.01	0.974	0.01	0.976
Wave 3			-0.02	0.907	-0.04	0.827
Wave 4			-0.30	0.204	-0.31	0.191
Money x Diet					1.22*	0.030
Intercept			13.18***	0.000	13.25***	0.000

GEE indicates generalized estimating equation.

^aBivariate/Unadjusted estimates (b _ unstandardized regression coefficients); ^bFull regression model with all food stress, demographic, and time predictors included (b _ unstandardize regression coefficients); ^cFull regression model with significant interaction (b _ unstandardized regression coefficients).

†P < 0.10; *P < 0.05**P < 0.01; ***P < 0.001

Table 4. Summary of Themes Related to Focus Group Participants' Recognition of Food Stressors and Experiences of Living With Diabetes

Theme	Participants' Views	Representative Transcript Excerpts
Lack of food access negatively affects diet quality	Inadequate access to food presents difficulties for eating a diabetic-friendly diet	<p>"You go to the nutritionist, and she tells you what you're supposed to eat, and especially up in [home community], we can't have those foods all the time. We go to [nearby city] to buy our groceries, and we might buy our fruits and vegetables, but they don't last for two weeks—you know? Until the next payday. We can't follow the right diet, because we can't get the right foods." (Female)</p> <p>"I know for a lot of years, a large part of our community has used commodities and a lot of the starch foods come in commodities, the macaroni, the flour, rice, potatoes, for a while there was butter and lard and, you know. That stuff was developed for times of famine, you know, when people needed extra body fat, but since our economy has changed and gotten better that, that diet that was developed for commodities is doing more harm than good now... A lot of them [community members] are diabetic, you know, depend on commodities for staples and, you know, and sometimes when that is the only food they have access to, that is what they have to eat" (Female)</p> <p>"I know when I go to the Trading Post up here, I like bananas, I like oranges. When you go there, there isn't nothing there on the shelves." (Female)</p>
Nutrition support programs affect diet quality	Nutrition support programs are used to access foods. Foods offered in these programs and gaps between benefit cycles were cited as stressors	<p>"I know they have WIC that has healthy stuff, but you run out of WIC during parts of the month when there is no choice, I am going to get whole milk because that is all I can afford. If it was cheaper, people wouldn't have to pick affordable over healthy" (Female)</p> <p>"I think a big part of it, the changing your eating style is hard, but when you have a lot of patients that may be getting commodities, there is nothing there really that is good for a diabetic." (Male)</p>
Financial restrictions affect diet quality	Financial stress contributes to unhealthy food choices	<p>"I think for me, it's a money thing. I can't buy the food I'm supposed to eat. So I have to buy the food that I'd like to eat. So, I just buy whatever I need instead of buying like fresh vegetables all the time and stuff." (Female)</p> <p>"It's hard to shop and eat healthy too, when there's more processed, processed foods are cheaper than fresh foods." (Male)</p> <p>"Like when you go to the store, or the supermarket... look at the prices on fruit and vegetables and say boy, it really costs a lot to try and stay healthy, because everything is so high priced. And then you think, well, I won't get that, I'll get something else that's a little cheaper, and that makes you eat a lot of macaroni." (Male)</p>
A diabetic diet causes stress	The adjustment from a 'normal' eating pattern to a diabetic one is a difficult adjustment for many patients with diabetes	<p>"And another stressor too, the whole eating thing. I was never, ever told what I could and what I couldn't eat and it kills me everyday when I walk by and I see somethin' that I know I can't have it. And it's torture... The whole food part is a stressor because you gotta count the calories and the sugars and all that. Just, I don't have time for it but now I gotta make time for it. Before I never had to look at the labels... It sucks" (Female)</p> <p>"That's stressful because when you look at the meter and see numbers you don't want, you wonder, how am I going to get the numbers I want. That's stressful, trying to learn how to eat differently" (Female).</p> <p>"And I completely changed our whole way of eating, and we could only have white meat. We ate red meat once a week. Wheat, water. But in doing that, I think I was almost starving him [diabetic husband], because there was days I'd come home from work and he'd have cookies made, and he'd be passed out on the couch, just like he overloaded on sugar and just passed out... He was binge eating... One day I had to laugh because we had a big vegetable tray I had taken to work that day, and I brought the leftovers home, and that next morning I got up and I went some place and I came back, and he was laying on the floor there with that big plate of vegetables, and just sitting and eating. I said, 'What are you doing?' He</p>

(continued)

Table 4. (Continued)

Theme	Participants' Views	Representative Transcript Excerpts
The lack of diabetic-friendly options for shared meals causes stress	Shared meals can cause stress for diabetic individuals who may not be able to eat the same foods as others	said, 'I'm depressed.' (Laughing) But the only thing I had was the vegetables so that's the only thing he could binge eat on." (Female) "Here's some stress. Sit down and watch everybody eat when I can't eat nothing." (Male) [Replying to male] "That's right! Feeling like you can't even enjoy the meal with anybody... I see a lot of people talking about fry bread. And we can't eat that fry bread like they talk about." (Female) "As far as going to potlucks and not being able to find your perfect food is going to potlucks and have people looking at you and saying, 'I am sorry, we don't have anything for you to eat.'...because I got diabetes doesn't mean that I haven't got [to eat] food. (Female) "Here, in our community we have a lot of feasts, you know, and that's, a lot of ways, you know, a lot of traditions ways are that way, you know, everybody brings a dish to pass, it's a feast, and it's a celebration. Maybe we don't all bring the right foods, you know." (Female) "They [my family] don't know what it's like, or what I'm going through with my diabetes, and you know, they look at me like I'm an oddball, or I'm not from this planet, cause of the stuff that I have to eat and drink, and I can't drink, and cause that's what I tell them when they try to give me something. I say, I can't eat that. And they're like, looking at me like, you know, why can't you eat it, it's good... I just tell them, I can't eat it, there's like too much sugar in there...But they still look at me like I'm from mars or some place" (Female)
Lack of nutrition knowledge causes stress	Lack of nutrition knowledge for individuals with diabetes and their family members causes stress	"When I was diagnosed as a diabetic, I didn't know what to eat. Even though my older siblings were diabetic. It took me two months before I actually seen a dietician. What the hell am I going to eat, y'know?" (Male) "I think what they should have up here is like somebody to educate the families, even the ones that aren't diabetic." (Female) "We went grocery shopping and we bought a bag of cherries and I figured, well, it's not sugar. So my husband and I just pigged out on those cherries. I got up off the couch... I felt just drunk... Then I took my sugar and it was 550. Then he [uncle] called the clinic and they said, "bring her in right away!" (Female)
Mental health affects food choices and eating behaviors	Eating and certain types of foods used as coping strategies to manage a variety of mental health concerns from stress to depression	"I know just from personal experience; depression can also lead to type 2 diabetes. I was depressed for many years and overate, and overate, and overate all the sugar, greasy, flour, you know, everything, and worked myself into being diabetic. And I attribute it to being stressed and depressed and... not having enough income and, you know, you buy what's cheap at the store and it just so happens that the doughnuts are cheaper." (Female) "For me, I'm a comfort eater, and also a diabetic, so, [when I'm] stressed out, [I] eat a plate of cookies." (Male) "And I was really depressed when I found out... I could still like, 'Oh I could eat this donut.' I just have to shoot myself up with this [insulin]. . . I've seen a lot of people do that — 'I could eat this whole plate of food and I'll shoot this up and I'll be OK.' I don't want to go that route." (Female)

WIC indicates *Special Supplemental Nutrition Program for Women Infants and Children*.

participants discussed difficulties related to specific nutrition support programs, including the healthfulness of foods offered in the commodity food program and other nutrition supports (eg, *Special Supplemental Nutrition Program for Women, Infants,*

and Children [WIC]). A female participant stated, "I know they have WIC that has healthy stuff, but you run out of WIC during parts of the month when there is no choice, I am going to get whole milk because that is all I can afford. If it was cheaper,

people wouldn't have to pick affordable over healthy." A male participant pointed out that the commodity food program, on which many tribal members rely for food, is not always compatible with a diabetic-friendly diet, "I think a big part

of it, the changing your eating style is hard, but when you have a lot of patients that may be getting commodities, there is nothing there really that is good for a diabetic."

Adhering to a diabetic-friendly diet. Many participants cited the change from a normal diet to a diabetic one as stress-inducing. One participant stated, "That's stressful because when you look at the meter and see numbers you don't want, you wonder, how am I going to get the numbers I want. That's stressful. Trying to learn how to eat differently" (Female).

Shared meals. Participants expressed that sharing meals with family or community can be stressful while maintaining a diabetic-friendly diet. When asked about stressors specific to diabetes, one male participant stated, "Here's some stress. Sit down and watch everybody eat when I can't eat nothing." A female participant replied to him, "That's right! Feeling like you can't even enjoy the meal with anybody... I see a lot of people talking about fry bread. And we can't eat that fry bread like they talk about." This theme emphasizes that adhering to a diabetic-friendly diet is not just an individual endeavor but requires the support of the community and family, who may be unaware of the dietary needs of their relatives living with diabetes.

Nutrition knowledge. An additional form of stress for participants was the lack of nutrition education for those living with diabetes and their family members. One male participant explained, "When I was diagnosed as a diabetic, I didn't know what to eat. Even though my older siblings were diabetic. It took me two months before I actually seen a dietician. What the hell am I going to eat, y'know?" Another participant suggested that education is not only needed for people living with diabetes but also their families.

Mental health. A theme emerged regarding the potential cyclic role mental health plays in eating behaviors and food choices. A female participant shared,

I know just from personal experience; depression can also lead to type 2 diabetes. I was depressed for many years and overate, and overate, and overate all the sugar, greasy, flour, you know, everything, and worked myself into being diabetic. And I attribute it to being stressed and depressed and... not having enough income and, you know, you buy what's cheap at the store and it just so happens that the doughnuts are cheaper.

Furthermore, a male participant described eating unhealthy foods as a coping mechanism for stress, "For me, I'm a comfort eater, and also a diabetic, so, [when I'm] stressed out, [I] eat a plate of cookies." As participants described, mental health and eating behaviors are interrelated and can create a potential harmful cycle for the physical and mental health of those living with diabetes.

Our qualitative findings are consistent with our quantitative findings that lack of access to wanted kinds of food, being on a special (eg, diabetic) diet, financial restrictions, and receiving food assistance are common forms of food stress among study participants. Qualitative analysis revealed that types of food stress are not necessarily discrete concepts in participants' experiences. Participants' descriptions of food stressors emphasized that experiencing > 1 type of food stress (eg, diabetic diet and food accessibility) amplified the effects of stress on mental health. In addition, the qualitative findings included 3 forms of food stress not assessed in quantitative analyses: lack of nutrition knowledge, shared meals, and mental health impact on eating behaviors. Finally, our qualitative findings are consistent with our quantitative results that food stress is inversely associated with diabetes empowerment.

DISCUSSION

This mixed-methods study examined the relationship between food stress and diabetes-related distress and empowerment and contextualized these findings using qualitative perspectives elicited through focus

group discussions. Given high rates of food insecurity and T2D among AI/AN people, understanding the 2 in concert with one another is vital for driving evidence-based community solutions.^{1,10,58} The qualitative and quantitative findings from this study converged on several points. For example, qualitative themes intersected with a high prevalence of corresponding forms of food stress. Nearly half of survey participants (40%) reported receiving food assistance at least 1-time point during the study, and focus group participants shared that gaps in benefit cycles, and the quality of foods offered through these programs, are sources of stress. Being on a special diet was reported by 29% of participants at least 1-time point of the study. Our qualitative findings support that following a diabetic-friendly diet was a source of stress for participants. In addition, the overall prevalence of food stress across 2 years was nearly double that of any given time. Few participants consistently experienced each type of food stress at all 4 study time points, which is consistent with the idea put forth by other researchers that food insecurity is more often a transient state than a persistent one.^{59,60} Our qualitative data supports this idea as participants cited gaps between benefit cycles of the Supplemental Nutrition Assistance Program, WIC, and FDIPIR to be stressful.

There were also notable divergences between our qualitative and quantitative findings. Not having time for shopping or cooking, the type of food stress most prevalent in the quantitative finding, did not emerge as a theme in the qualitative analysis. This may have to do with the nature of the focus group questions, which were not specifically about food stress. Several unique food stressors not measured quantitatively emerged in our qualitative analysis, including lack of nutrition knowledge, shared meals, and literacy for diabetic-friendly diets. Participants discussed their lack of nutrition knowledge and their family members without diabetes as stressful, particularly for events like family dinners or feasts. This finding emphasizes the importance of diabetes education at the family and

community level to create healthy and safe food environments for those with diabetes and food insecurity.⁶¹ In addition, the bidirectional relationship between mental health and eating behaviors emerged as an additional form of food stress. This is consistent with other racially diverse studies showing that food insecurity strongly affects mental health, including feelings of stress, shame, and sadness.^{62,63}

Quantitative results revealed several key findings, including evidence that diabetes distress is associated with not having enough money for food and being on a special diet. Similarly, income increases are found to increase diabetes empowerment. This is similar to prior research, which found that diabetes distress is common among patients making lifestyle changes, but focusing on small manageable changes can reduce diabetes distress.⁶⁴ In a quantitative model adjusted for demographic covariates, food stress from not having enough time for shopping or cooking decreased diabetes empowerment.

Quantitative and qualitative data revealed that a single type of food stress (ie, lack of food access; we can't have those foods all the time) could affect the presence of additional food stressors (ie, ability to follow a special diet; we can't follow the right diet, because we can't get the right foods). This finding aligns with stress process model concepts of stress proliferation, in which an initial stressor can lead to the onset of secondary stressors, further impacting health outcomes.⁶⁵ Our results reveal that food stress is a multifaceted concept that incorporates social and economic problems, individual mental health, community food access, and affects diabetes distress and empowerment. Our mixed-methods approach also demonstrates how food stress, a concept that could easily be attributed to individual perceptions and health, relates to the collective community well-being and the food environments of AI/ANs. In summary, food stress represents a social determinant of health modifiable by policy change to improve food access, availability, and affordability.

Although this manuscript offers novel contributions, it is not without limitations. The questioning route used in focus group discussions did not specifically ask about food-related stressors, which limited the information on food stressors from our qualitative findings to those brought up organically by participants. Therefore, our qualitative findings may be a more naturalistic view of what community members deem food stressors. We also did not ask focus group participants to discuss what they perceive to be community stressors related to diabetes; instead, they were only asked for their perspectives. Although our food stress measure was intended to explore food-related stress and expand on previous conceptions of food security, it is not a validated measure to detect food insecurity. The data presented in this manuscript are almost 10 years old and therefore may not reflect current circumstances.

Furthermore, our analyses did not include the study site as a predictor; the relationship between food stress, diabetes distress, and diabetes empowerment may be impacted by the study site. Finally, the data was collected from one American Indian cultural group and may not be generalizable to other American Indian or Alaska Native cultural groups. The data were also collected from American Indians who lived on or near reservations meaning the findings may not be generalizable to urban American Indian populations.

IMPLICATIONS FOR RESEARCH AND PRACTICE

The policy implications of this study can be situated within a food sovereignty framework. Collective efforts to promote health and wellness by targeting priority issues, like T2D and food insecurity, demonstrate resiliency and survivance in action.⁶⁶ Many AI/AN communities throughout the US are working to improve the food security and health of their people through diverse food sovereignty initiatives that orient traditional foods as the focal point of health promotion and ecological sustainability.^{67,68} Local

Indigenous food sovereignty movements embody this survivance and resilience by using traditional ecological knowledge to reclaim, redefine, and use food systems to promote community health and prevent chronic diseases, such as T2D.¹² Food sovereignty initiatives, such as the *Feast for the Future* program, Ziibimijwang Farms, and many others, have the opportunity to address multiple types of foods stress by strengthening local food economies, fostering opportunities for sharing of traditional nutritional knowledge, and increasing access to affordable, healthy food.^{68,69} Beyond this, local food sovereignty movements can potentially decrease reliance on federal nutrition supports (ie, FDIPIR and CSFP) that participants in this study cited as being sources of food stress. Our data support that future diabetes intervention and prevention trials consider improving healthy food access through collaboration with food sovereignty movements. Local food sovereignty initiatives address barriers to food access, thus providing an alternative to individual nutrition education and food security interventions that may not effectively address the root causes of health inequities.¹² Taking steps to optimize and exercise food sovereignty may decrease food stress levels of individuals, contributing to better diabetes control and reduced burden of T2D in communities.

This mixed-methods analysis shows that specific food-related stressors of American Indians living with diabetes are associated with diabetes distress and empowerment. Although food stress and diabetes-related psychosocial outcomes are often individual attributes, they are intimately tied to the food environment and require community-level solutions. Food sovereignty encompasses the Indigenous relational view of health and has the potential to provide a meaningful way to improve community food security.

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SUPPLEMENTARY DATA

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