Diet quality and depressive symptoms in a cohort of American Indians: The Strong Heart Family Study

Leah Neff Warner

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Amanda Fretts

Alyson Littman

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Abstract

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Leah Neff Warner

Chair of the Supervisory Committee:

Amanda Fretts

Epidemiology

Background: Higher diet quality has been shown to be associated with a lower risk of depression compared to lower diet quality, though this relationship has not been studied in American Indians (AIs). We examined the relationship of diet quality with incidence of depressive symptoms in a prospective, family-based cohort of 1,100 AIs ≥14 years of age from 12 AI communities in Arizona, Oklahoma, North Dakota, and South Dakota. **Methods:** Information on past year diet was collected using food frequency questionnaires at baseline. Diet quality was determined using the Alternative Healthy Eating Index-2010 (AHEI). Depressive symptoms were measured at follow-up 5 years later, on average, using the Center for Epidemiologic Studies Depression Scale; scores were categorized as no depressive symptoms (scores <10), mild symptoms (scores 10-15), moderate symptoms (scores 16-24), and severe

symptoms (scores >24). The primary outcome was report of moderate/severe depressive symptoms or taking antidepressants. We used GEE-based multivariate logistic regression to estimate odds ratios (OR) of depression onset associated with each 10-point increase in AHEI score, adjusted for relevant demographics, health status and psychosocial factors. **Results:** We did not find evidence of a prospective relationship between diet quality and onset of depressive symptoms; a 10-point increase in AHEI score was associated with 16% higher odds of developing depressive symptoms or antidepressant use (OR 1.16, 95% CI 0.96, 1.39). **Conclusion:** Our results are discordant with findings in other populations. Additional prospective studies that include more robust measures of diet and depression over multiple time points are needed to better understand this relationship.

INTRODUCTION

Diet quality is a well-documented determinant of cardiometabolic diseases.[1,2] American Indians (AI) face disproportionately high rates of cardiometabolic disease relative to other populations in the United States.[3–8] Within nearly one generation, diets of most AI communities transitioned from traditional to Western diets characterized by highly processed, energy-dense and nutrient-poor foods as a result of sudden loss of land, subsequent food insecurity, and government-subsidized commodity food distribution programs.[9–12] In tandem with increased incidence of cardiometabolic diseases, many AI communities experience high rates of depression[13–15] and related outcomes including suicide and substance use disorders.[15–18] While depression is attributable to many interacting biological, environmental and social factors,[15] evidence from other populations suggests that healthy diet quality may be protective against development of depression. Recent meta-analyses found that the Mediterranean diet, variations of the Healthy Eating Index, and other dietary patterns characterized by high consumption of anti-inflammatory foods like fruits, vegetables, whole grains and healthy fats were associated with reduced risk of depression.[19–23] Additionally, unhealthy dietary patterns that include high consumption of ultra-processed foods and red and processed meat may increase risk of depression.[24,25] However, study quality, study design and heterogeneity across populations have contributed to mixed findings on this topic[19,23,26,27] and no prior studies have focused on AI populations. Diets of AI populations living on reservations and in rural areas differ substantially from previously studied populations and vary across different AI communities.[8]

Because diet is a potentially modifiable risk factor, it is critical to understand how it might relate to depression risk to inform efforts that promote reclamation of mental and physical wellbeing in AI communities and the broader population. In other populations, self-reported depressive symptoms are known to vary by age and sex.[28–32] Thus, diet-depression associations by age and sex should be explored to assess whether they differ by these characteristics and to identify priority groups and life-course stages that may benefit from targeted programming and policy. The purpose of this study was to examine the prospective association between diet quality at baseline and incidence of probable depression among AIs from 12 communities in Arizona, Oklahoma, North Dakota, and South Dakota, overall and by age and sex.

METHODS

Study Design

The Strong Heart Family Study (SHFS) is a prospective, family-based cohort study designed to identify risk factors and related outcomes of cardiovascular disease among AIs ages 14 years and older from 12 primarily rural communities in the United States. Details on the original cohort design and methods have been described previously.[33,34] The SHFS consisted of two study exams: a baseline exam in 2001-2003 and follow up exam in 2007-2009. Both assessments included a detailed personal interview, physical examination and one-week pedometer log. After the study examinations in 2009, surveillance for major cardiometabolic outcomes continued for all SHFS participants through December 2017 using a single phone interview and medical record review. An additional follow-up assessment with physical exams and interviews is in the planning stages for 2022-2024. Our analysis uses the most recent available data on dietary and psychosocial measures in the SHFS cohort.

Population

The SHFS population represents 12 tribal communities in Arizona, Oklahoma, North Dakota, and South Dakota. Data collection and study management occurred at three field centers in Arizona, Oklahoma, and South Dakota. The SHFS population comprises 2,399 AI individuals from 94 large families who completed the baseline and follow up assessments. Participants were excluded from this analysis if they had reported moderate, severe, or missing depressive symptoms at baseline, were taking antidepressant medications at baseline, failed to answer more than 10% of items on the Food Frequency Questionnaire (FFQ), reported daily calorie consumption outside the bounds of 600-6,000 for females or 600-8,000 for males, or were pregnant during or within 12 months of the baseline assessment.

Data Collection

At baseline and follow up assessments, participants underwent a physical examination and personal interview. The exam consisted of a general physical assessment for overall health, pregnancy testing if suspected, and a medication review.[35] Blood samples were collected after a 12-hour overnight fast and were stored at -80 degrees Celsius. Plasma glucose was measured using enzymatic methods.[34,35] For the medication review, participants were asked to bring all medications taken in the past two weeks to the exam and asked to report if the medications were taken as prescribed. The personal interview collected information on medical history, demographic

factors, health behaviors and psychosocial factors. Ambulatory physical activity (i.e., average steps per day over one week) was assessed using Accusplit AE120 pedometers (Yamax, Japan).[36]

The validated Block 1998 Food Frequency Questionnaire (FFQ) was used to estimate the usual dietary intake during the previous year. The FFQ food list included 110 items that reflected the most common nutrient sources and food groups in American diets based on NHANES dietary recall data.[37] Nine additional items specific to the diets of some AI communities, such as red chili stew and fry bread, were included at the end of the questionnaire. For each food item, participants reported an estimated frequency of consumption (seasonally, never, few times per year, 1x/month, 2-3x/month, 1x/week, 2x/week, 5-6x/week, or daily) and quantity (small, medium, large portion size). Using previous FFQ analysis methods with a Block Dietary Database, the average daily micronutrient and energy intakes were calculated for each participant.[37] We used the dietary information to calculate an Alternative Healthy Eating Index 2010 (AHEI) score for each participant as a measure of diet quality, the primary exposure of interest. The AHEI is a dietary index based on 11 nutrients and food groups that are associated with risk of cardiometabolic disease.[6,38,39] Absolute intake of each nutrient or food item was scored 0 (worst) to 10 (best) using standardized serving sizes and cut points known to increase or decrease disease risk as shown in Supplementary Table 1.[6,38,39] The total AHEI score ranges from 0 (least healthy) to 100 (most healthy). The score for alcohol intake (0-10) did not contribute to the total AHEI score due to reliability and sensitivity concerns about this measure in the population, so the total score was 100 instead of the usual 110. Alcohol use was included as a covariate in the analysis instead.

The primary outcome of interest was new onset of depressive symptoms or taking antidepressant medications at follow up. Depressive symptoms were assessed using the validated Center for Epidemiologic Studies of Depression Scale (CES-D) for nonclinical measures of depressive symptomology,[40] which has been used and validated in AI populations.[16,41–46] The CES-D was interviewer-administered, and participants rated twenty items on a 4-point Likert scale indicating how often in the past week they experienced symptoms associated with depression, including loneliness, sadness, poor appetite and restless sleep (rarely or none of the time, some or a little of the time, occasionally or a moderate amount of the time, or most or all of the time).[47] Each item was scored 0-3, four items were inversely scored (3-0), then scores were summed to produce an overall CES-D score (0-60) to create four categories of depressive symptoms: none <10, mild 10-15, moderate 16-24, severe >24.[40] A participant's overall CES-D score was

considered missing if they failed to respond to more than four items on the CES-D questionnaire. Use of antidepressants was determined from the medication review at the follow-up assessment. Participants with any of the following medications documented in their review were considered to be taking antidepressants: Amitriptylin, Bupropion, Buproprion SR, Celexa, Citalopram, Cymbalta, Desipramine, Effexor, Effexor XR, Elavil, Escitalopram, Fluoxetine, Fluvoxamine, Imipramine, Lexapro, Nortriptylin, Paroxetine, Paroxetine HC, Paxil, Prozac, Remeron, Sertraline, Trazodone, Venlafaxine, Wellbutrin, Wellbutrin SR, and Zoloft.

Confounding factors at baseline were determined *a priori* due to potential associations with diet quality and depressive symptoms. Participants' field center location (Arizona, Oklahoma, South Dakota), sex (male/female), years of age, and years of education were collected in the personal interview. Participants also reported their smoking status (never, former, current), smokeless tobacco use status (current/no) and alcohol use status (never, former, current). Body mass index (BMI) was calculated from height and weight measurements at the physical examination. A seven-day pedometer log was used to measure daily step counts. We calculated the average number of steps per day after removing the minimum and maximum step count observations for each participant; all observations were included if a participant was missing more than two observation days. Known diabetes was defined as ≥126 mg/dL fasting blood glucose at baseline or reported history of diabetes and any of the following: on insulin treatment, hypoglycemic agent, renal dialysis or had kidney transplantation. Impaired glucose tolerance was defined as fasting blood glucose 110-125mg/dL and no diabetes treatment, and normal glucose tolerance was <110mg/dL at baseline and no diabetes treatment. Social support questions were selected from the American Indian Service Utilization, Psychiatric Epidemiology, Risk and Protective Factors Project (AI-SUPERPFP) and included measures on perceived emotional support, social networks, tangible social support, and negative social support—all of which are thought to influence health outcomes, including depression, in AI communities.[48,49] Items were rated on a Likert scale and summed to reflect a total social support score ranging from 0-40. The Multidimensional Health Locus of Control (MHLC) Scale was used to measure the degree to which individuals believed their health is determined by internal or external factors, which helps to understand tendencies toward healthy behaviors and psychological responses to health outcomes.[48,50,51] Using a Likert scale, participants indicated their agreement with a series of statements representing the three constructs of the Health Locus of Control (internal, external:

chance, and external: powerful others). Summary scores were calculated for each construct, ranging from 0-18. Identification with tribal traditions was measured by responses to the question, "How much do you identify yourself with your own tribal tradition?", which were dichotomized as "a little" (not at all or a little) and "a lot" (some or a lot). Depressive symptoms at baseline were also assessed using the CES-D scale. Summary scores were categorized to reflect levels of depressive symptoms (none, mild, moderate, and severe) with the same methods as described for follow-up measures.

Analyses

Descriptive analyses involved examining baseline characteristics grouped by AHEI quartiles as well as average intake of AHEI dietary components stratified by the primary outcome. We examined the distribution of baseline AHEI scores by primary outcome and by categories of CES-D scores at follow up using boxplots and histograms. Covariates that were missing for some individuals were assumed to be missing at random and were imputed using multiple imputation by chained equations.[52,53] We evaluated convergence and appropriateness of imputations by plotting distributions of means and standard deviations separately for each imputed variable and comparing tabulations of imputed versus observed mean values.

For the primary analysis, we fit a logistic regression model using generalized estimating equations (GEE) with an independence working correlation and robust standard errors to estimate the crude and multivariate-adjusted population odds ratios for developing depressive symptoms at follow up associated with a higher baseline AHEI score. The GEE accounted for clustered data at the family level across families. AHEI scores at baseline were modeled continuously and presented for 10-point differences since this was considered to be a meaningful difference in diet quality. Onset of depressive symptoms was defined as reporting moderate or severe depressive symptoms (CES-D score ≥16), which indicates risk for clinical depression,[40,41,54] or taking antidepressants at follow-up (yes/no). Participants with no or mild depressive symptoms and who were not taking antidepressants were considered to not have the outcome of interest. The following covariates were included in the model: field center (Arizona, Oklahoma, South Dakota), sex (male/female), age (years), education (years), smoking status (current, former, never), alcohol use status (current, former, never), smokeless tobacco use (current/no), body mass index (kg/m^2), average steps per day, diabetes status (known diabetes, impaired glucose tolerance, normal glucose tolerance), social support (numeric scale 0-40), internal locus of control score (numeric score 0-18; scores for the

chance and powerful others constructs were omitted due to slight correlations with the internal construct[50,51] and to avoid overfitting the model), and identification with own tribal traditions (a little/a lot).

In sensitivity analyses, we considered a stricter definition of the outcome (CES-D scores >24 or taking antidepressants) to evaluate the association between diet quality and development of severe depressive symptoms. We also restricted the baseline population to those who reported CES-D scores <10 (rather than <16) to assess the relationship among individuals with less than mild depressive symptoms.

Exploratory analyses independently evaluated whether the relationship between diet and depressive symptoms differed by age and sex. Due to statistical power limitations, we qualitatively examined the age and AHEI interaction term and 95% confidence interval for deviance from zero. We stratified the exponentiated regression coefficients from the multivariate model by sex and qualitatively evaluated the odds ratios for a meaningful difference. All analyses were performed using Stata 15 (2017, College Station, TX: StataCorp LLC).

This study was reviewed and approved by participating tribal review boards and the Strong Heart Study procedural committee. The study did not require further review by the University of Washington IRB as determined by the researchers because all data were deidentified and researchers had no access to identifiable information.

RESULTS

Of the 2,786 individuals who completed the baseline assessment, 2,399 (86%) participated in the follow-up assessment after an average of 5.3 years (SD 1.1). The prevalence of moderate and severe depressive symptoms was nearly 25% at baseline (n=690). After excluding those who, at baseline, had moderate/severe depressive symptoms or met other exclusion criteria (n=1,302), and those who were missing CES-D scores at follow up (n=384), 1,100 individuals comprised our study population (Figure 1). Individuals with missing CES-D scores at follow up were more likely to be male (54% vs. 43%), older (13% 66-90 years old vs. 7%), have less than a high school education (28% vs. 23%), and have known diabetes (21% vs. 15%) compared to the analytic sample. Baseline AHEI scores were slightly higher among those missing CES-D scores at follow up compared to those without missing CES-D scores, with 29%

and 26% in the third and fourth quartiles compared to 24% and 25%, respectively (Supplementary Table 2).

Baseline characteristics of the study population by quartiles of AHEI score are presented in Table 1. Overall, AHEI scores ranged from 19.6 to 74.0 and the median score was 39.6 (Inter-quartile range [IQR] 34.2-46.1). Compared to individuals in the highest AHEI score quartile, individuals with scores in the lowest quartile were more likely to be male (55% vs 34%), younger (85% <45 years vs. 52%), have less than a high school education (31% vs. 17%), be current smokers (43% vs. 28%), smokeless tobacco users (11% vs. 5%), and current alcohol users (69% vs. 51%), and have normal BMI (25% vs. 14%). Additionally, a larger proportion of those in the lowest quartile reported mild depressive symptoms compared to those in the three higher quartiles (33% vs. 27-29%). Fewer individuals in the lowest quartile were sedentary (38% <5,000 steps/day vs. 48%), had known diabetes (8% vs. 21%), and identified with their own tribal traditions (67% vs. 75%). Individuals had similar social support scores and health locus of control scores regardless of AHEI score.

At follow-up, 10% of individuals reported moderate depressive symptoms and 5% reported severe depressive symptoms, amounting to a cumulative incidence of 15% for depressive symptoms at levels of probable clinical importance in the population.[40,41,54] Five percent of the population had initiated use of antidepressant medications. Table 2 presents baseline dietary intake measures stratified by the primary outcome. Overall, diet quality was similar between those who did and did not develop moderate or severe depressive symptoms or begin taking antidepressants: both groups reported low consumption of fruits (0.9 and 1.0 servings/day), vegetables (2.6 and 2.7 servings/day), and nuts and legumes (0.7 and 0.8 servings/day). Additionally, both groups reported high intake of red and processed meat (1.4 servings/day), sugar-sweetened beverages (2.9 and 3.0 servings/day), and sodium (3114 and 3230 mg/day). The median AHEI score was similar for those who reported moderate or severe depressive symptoms or took antidepressants and those who did not [39.6 (IQR 33.4-46.8) vs. 39.7 (IQR 34.3-45.8)]. Box and whisker plots of AHEI scores by primary outcome are shown in Figure 2. Scores among those who reported moderate or severe depressive symptoms or took antidepressants had a wider range above the median than below, while scores among those who had no or mild depressive symptoms were normally distributed with a broader range overall and a greater number of observations more than 1.5 times the IQR (indicated in circles in Figure 2).

Missing covariate observations, which amounted to less than 7% across all covariates, were imputed prior to statistical analysis. We found no evidence of an association between baseline AHEI score and developing moderate or severe depressive symptoms or taking antidepressants at follow up (Table 3). Each 10-point increase in the AHEI score was associated with 4% higher odds of developing moderate or severe depressive symptoms or taking antidepressants in the population [95% confidence interval (CI) 0.88, 1.23]. After adjusting for pre-specified confounders, a 10-point increase in the AHEI score was associated with 16% higher odds of developing the outcome in the population (95% CI 0.96, 1.39). The adjusted association was similar after restricting the outcome to only severe depressive symptoms or taking antidepressants, with an estimated odds ratio of 1.12 (95% CI 0.86, 1.46). The association appeared stronger, though still non-significant, when estimated among those who reported no depressive symptoms at baseline (as opposed to none or mild symptoms), with an odds ratio of 1.23 (95% CI 0.96, 1.59). We did not find evidence of interaction between AHEI score and age in the primary model; the interaction term for a 10-point increase in AHEI and a one-year higher age was 1.00 (95% CI 0.99, 1.01). Associations between AHEI score and depression onset were similar among males (OR for a 10-point higher AHEI score: 1.04, 95% CI 0.78, 1.37) and females (1.22, 95% CI 0.94, 1.56).

DISCUSSION

Our results do not provide evidence of a prospective association between diet quality and onset of depressive symptoms or antidepressant use in a large, family-based cohort of AIs. The interpretation did not change after adjusting for potential confounders, restricting the outcome or baseline population to those with extreme values, or stratifying on age and sex.

Meta-analyses have concluded generally that diet quality appears to be a determinant of depression, though findings have been mixed across study populations and study designs.[19–21,23,27] Cross-sectional studies have shown the strongest evidence of an association, while results from prospective studies have been suggestive of a relationship, yet more variable.[21,23] Two prospective studies not included in the meta-analyses, the Whitehall II Study[55] and Japan Public Health Center-based Prospective Study, also found no association between diet quality and depressive outcomes. Potential reasons for discordant findings in the literature include the limited number of studies with pre-specified measures of diet quality and appropriate confounder

control,[19,20] different measurement instruments for diet and depression,[19,23] and heterogeneity in study populations.

Our results do not support our hypothesis that diet quality is inversely associated with incidence of depressive symptoms. Further analyses in the SHFS cohort and other communities are warranted to understand the circumstances of our null findings and whether an association truly exists. We offer several potential reasons for our observed results. The first is that the AHEI may have inadequately captured elements of the diet that are associated with onset of depressive symptoms. The AHEI was designed to measure diet components that increase the risk of metabolic conditions, including diabetes and cardiovascular disease.[38] Such components may not fully represent the factors hypothesized to influence depression, such as inflammation and added sugars; antioxidants, vitamins, and minerals; and fiber and prebiotics that promote a healthy gut microbiome.[56] Additionally, as with many food frequency questionnaires, there are internal validity concerns about whether food items are understood and reported accurately by participants. Mixed dishes and prepared, frozen meals are common foods that are easily misclassified in terms of sodium and fat content and servings of fruits and vegetables. Lack of variety and heterogeneity in the population's diet may also explain the null findings. Most of the SHFS participants live in rural communities with limited access to healthy foods and limited selections in general, resulting in simple and similar diet patterns across SHFS communities.[57–59] Finally, missing CES-D scores at follow up must also be considered. Participants with a missing score at follow up were more likely to report having no depressive symptoms (CES-D score <10) at baseline and had a slighter higher mean AHEI score than those with complete data. Loss-to-follow-up may have induced a positive, non-significant association between diet quality and reporting depressive symptoms.

Our study has several limitations. First, the primary outcome was the presence of self-reported depressive symptoms instead of a clinical diagnosis, which has fueled some concern about overestimating associations with diet quality in other populations.[19] However, the CES-D scale has been used in other AI populations as a valid measure of depressive symptoms.[42–46] It is possible that under-ascertainment of depressive symptoms may be of greater concern in this cohort. Due to the sensitive nature of the CES-D questionnaire and its administration by an interviewer in small, close-knit communities, participants may have underreported their symptoms associated with depression. Further analysis is needed to understand if this was

differential by AHEI score and contributed to the null findings. Diet quality was also self-reported and subject to misclassification due to potentially vague food item categories on the FFQ. Still, the FFQ has been used previously in the SHFS to estimate associations between diet quality and cardiometabolic outcomes consistent with other populations.[5–7] Second, the study is limited by two assessments periods, necessitating our assumption that AHEI scores derived from the FFQ were representative of the usual diet before and after the baseline assessment. Even so, diets of the Strong Heart Family Study population are known to be relatively consistent over time.[6] Additionally, while the single follow-up assessment prevents us from estimating time of onset of depressive symptoms and time-varying confounding, our prospective assessment of this relationship is the first of its kind among AI populations. A third limitation is that we were unable to exclude participants with possible post-partum depression because we did not have pregnancy information at follow-up. It is unlikely this influenced our results due to the average age of the cohort and because few pregnancies were observed at baseline.

Despite these limitations, our study used standardized, *a priori* measures of diet quality and depressive symptoms to test for a prospective association in AI communities—a population unique to the literature on this topic, yet known to experience diet-related and mental health disparities relative to other populations. The SHFS is a large, multi-tribal study of risk factors for cardiovascular disease in an underserved and rural population of AIs. Because of the comprehensive data collected on demographic, behavioral, psychosocial and health factors, we were able to control for potential confounders, explore effect modifiers, and impute missing values. Studies with more robust and sensitive measures of diet and depressive outcomes, and with measures collected over multiple time points, are needed to better understand the extent of this relationship in AI populations. Studies should also investigate possible associations with other measures of mental wellbeing that are most relevant to the needs and interests of AI communities.

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TABLES AND FIGURES

Table 1. Study population baseline characteristics by quartiles of AHEI diet quality score

	AHEI Score Quartiles				
	Q1 (19.6–34.2)	**Q2 (34.3-39.6)**	**Q3 (39.7-46.1)**	**Q4 (46.1-74.0)**	**Total n=1100**
	n (column %) or mean (SD)				
Male %	152 (55)	118 (43)	105 (38)	94 (34)	469 (43)
Age, years					
15-25	104 (38)	72 (26)	44 (16)	32 (12)	252 (23)
26-45	129 (47)	116 (42)	120 (44)	111 (40)	476 (43)
46-65	35 (13)	70 (25)	89 (32)	96 (35)	290 (26)
66-90	7 (3)	17 (6)	22 (8)	36 (13)	82 (7)
Education, years					
0-11	84 (31)	65 (24)	62 (23)	47 (17)	258 (23)
12-15	168 (61)	176 (64)	172 (63)	185 (67)	701 (64)
16-20	23 (8)	33 (12)	40 (15)	41 (15)	137 (12)
Missing	0	1 (<1)	1 (<1)	2 (1)	4 (<1)
Smoking status					
Never	112 (41)	112 (41)	130 (47)	120 (43)	474 (43)
Former	44 (16)	72 (26)	55 (20)	79 (29)	250 (23)
Current	119 (43)	91 (33)	90 (33)	76 (28)	376 (34)
Smokeless tobacco use, current	31 (11)	20 (7)	15 (5)	14 (5)	80 (7)
Missing	0	2 (1)	5 (2)	5 (2)	12 (1)
Alcohol use status					
Never	30 (11)	38 (14)	36 (13)	32 (12)	136 (12)
Former	55 (20)	87 (32)	81 (29)	102 (37)	325 (30)
Current	190 (69)	150 (55)	157 (57)	141 (51)	638 (58)
Missing	0	0	1 (<1)	0	1 (<1)
BMI Category*					
Underweight	4 (1)	6 (2)	1 (1)	1 (<1)	13 (1)
Normal	68 (25)	44 (16)	46 (17)	39 (14)	197 (18)
Overweight	75 (27)	76 (28)	79 (29)	95 (35)	325 (30)
Obese	126 (46)	148 (54)	146 (53)	140 (51)	560 (51)
Missing	2 (1)	1 (<1)	2 (1)	0	5 (<1)
Pedometer average steps/day					
<5,000	105 (38)	100 (36)	124 (45)	133 (48)	462 (42)
5,000-9,999	115 (42)	119 (43)	102 (37)	99 (36)	435 (40)
≥10,000	40 (15)	38 (14)	31 (11)	32 (12)	141 (13)
Missing	15 (5)	18 (7)	18 (7)	11 (4)	62 (6)
Type 2 Diabetes‡					
Known diabetes	22 (8)	38 (14)	53 (19)	57 (21)	170 (15)
Impaired glucose tolerance	53 (19)	53 (19)	69 (25)	66 (24)	241 (22)
Normal glucose tolerance	199 (72)	183 (67)	151 (55)	152 (55)	685 (62)
Missing	1 (<1)	1 (<1)	2 (1)	0	4 (<1)
Social support score (0-49)	40.0 (5.7)	40.6 (5.1)	41.6 (4.8)	41.4 (4.9)	40.9 (5.2)
Health Locus of Control scores					
Internal (0-18)	12.6 (2.2)	12.7 (2.4)	12.4 (2.4)	12.8 (2.4)	12.6 (2.4)
External: Chance (0-18)	8.2 (2.5)	7.6 (2.5)	7.7 (2.3)	7.2 (2.8)	7.7 (2.5)
External: Powerful others (0-18)	8.4 (2.5)	8.2 (2.9)	8.5 (2.8)	8.4 (3.0)	8.4 (2.8)
Identify with tribal traditions (some/a lot)	184 (67)	197 (72)	194 (71)	207 (75)	782 (71)
Missing	0	8 (3)	12 (4)	5 (2)	25 (2)
Depressive symptoms (CES-D)					
None	183 (67)	198 (72)	202 (73)	196 (71)	779 (71)
Mild	92 (33)	77 (28)	73 (27)	79 (29)	321 (29)

Data are pooled across three field centers in Arizona, Oklahoma and South Dakota.

*Body mass index (BMI): underweight <18.5 kg/m^2; normal 18.5-24.9 kg/m^2; overweight 25-29.9 kg/m^2; obese ≥30 kg/m^2.

‡Known diabetes (DM) defined as ≥126 mg/dL fasting blood glucose, or reported history of DM and any of the following: on insulin treatment, hypoglycemic agent, renal dialysis or had kidney transplantation. Impaired glucose tolerance: fasting blood glucose 110-125mg/dL and no DM treatment. Normal glucose tolerance: fasting blood glucose <110mg/dL and no DM treatment.

**Alternative Healthy Eating Index (AHEI) is a dietary index based on absolute intake of 10 nutrients and foods each scored 0-10 using standardized serving sizes (excluding alcohol). Total AHEI score ranges from 0 (least healthy) to 100 (most healthy).

Center for Epidemiologic Studies of Depression Scale (CES-D) scores: none <10; mild 10-15; moderate 16-24; severe >24.

Table 2. Diet quality components of the AHEI at baseline stratified by primary outcome

	CES-D <16 at follow up n=893	**CES-D ≥ 16 or antidepressants at follow up n=207**
	Mean (SD)	
Fruits (serv/day)	0.9 (1.0)	1.0 (1.3)
Vegetables (serv/day)	2.6 (2.1)	2.7 (2.2)
Whole grains (g/day)	19.9 (25.7)	19.1 (23.7)
Sugar-sweetened beverages and fruit juice (serv/day)	2.9 (2.6)	3.0 (2.9)
Nuts and legumes (serv/day)	0.7 (1.0)	0.8 (1.1)
Red/processed meat (serv/day)	1.4 (1.1)	1.4 (1.1)
Trans fat (% of energy)	1.6 (0.5)	1.6 (0.6)
Long-chain n-3 fatty acids (EPA and DHA) (mg/d)	67.7 (113.6)	65.0 (104.0)
Polyunsaturated fatty acids (% of energy)	8.6 (2.6)	8.8 (2.7)
Sodium (mg/d)	3114 (1891)	3230 (1892)
Total calories*	2322 (1254)	2436 (1327)
AHEI score	40.5 (9.0)	40.8 (9.4)

Alternative Healthy Eating Index (AHEI) is a dietary index based on absolute intake of 10 nutrients and foods each scored 0-10 using standardized serving sizes and cut points associated with increased or decreased chronic disease risk (Supplemental Table 1). Alcohol use was excluded from the AHEI score calculations and was included as a separate covariate in analyses. Center for Epidemiologic Studies of Depression Scale (CES-D) scores: none <10; mild 10-15; moderate 16-24; severe >24.
*Total calories are not included in AHEI score calculation; shown for descriptive purposes only.

Table 3. Population odds ratios for reporting depressive symptoms or taking antidepressants at follow up associated with a 10-point higher AHEI score at baseline.

Outcomes	Crude OR (95% CI)	Adjusted OR (95% CI)*
Moderate or severe depressive symptoms or antidepressants[1] (n=1100)	1.04 (0.88, 1.23)	1.16 (0.96, 1.39)
Severe depressive symptoms or antidepressants[2] (n=1100)	1.04 (0.82, 1.33)	1.12 (0.86, 1.46)
Moderate or severe depressive symptoms or antidepressants[3] (n=779)	1.18 (0.94, 1.48)	1.23 (0.96, 1.59)

*Adjusted models included baseline measures of study site, sex, age, education, smoking status, smokeless tobacco use, alcohol use, body mass index, physical activity, diabetes diagnosis, social support score, internal health locus of control score, and self-identification with tribal traditions.

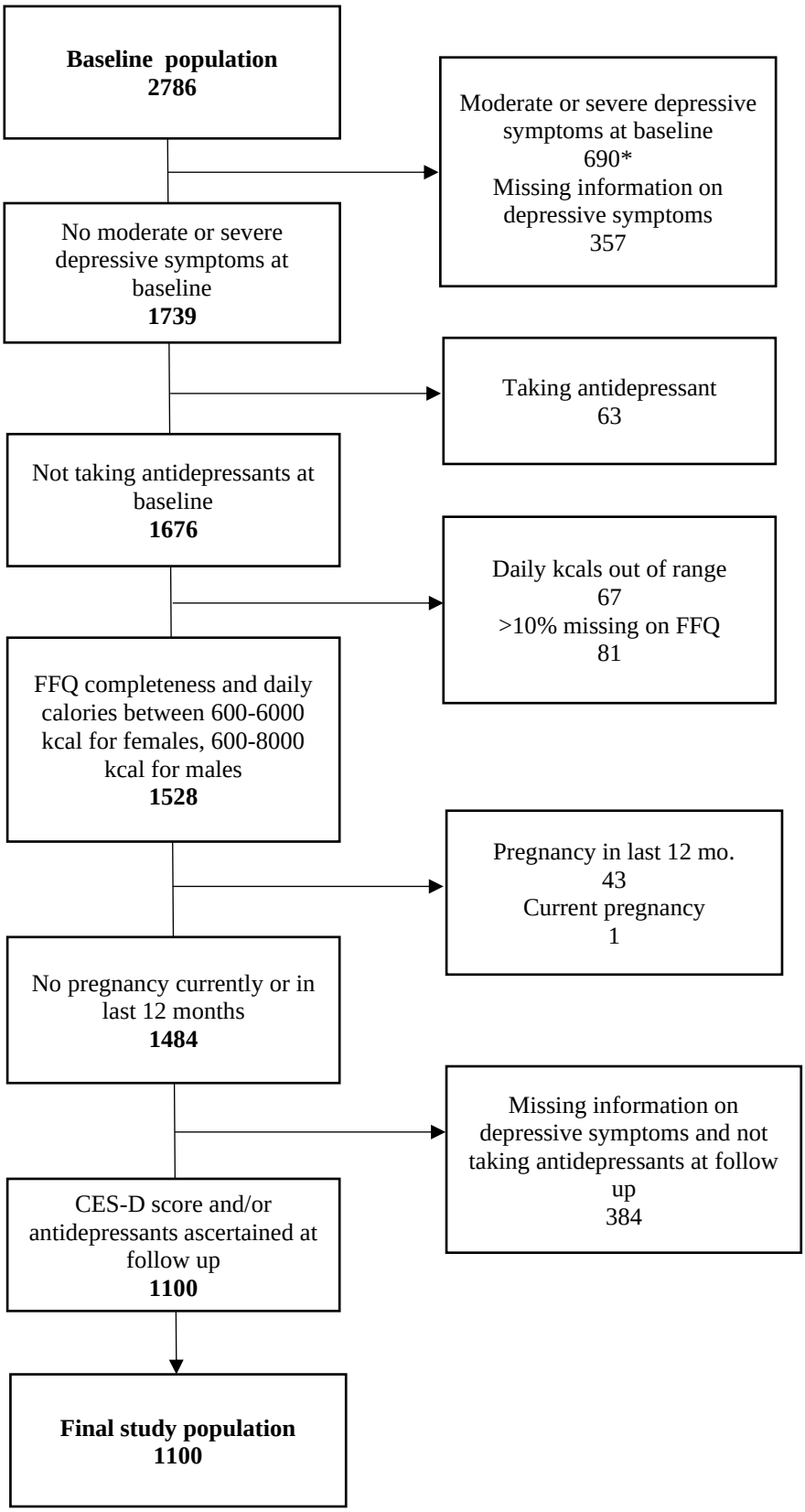
[1]Primary analysis; among those with baseline depressive scores of mild or none (CES-D <16)

[2]Sensitivity analysis; among those with baseline depressive scores of mild or none (CES-D <16)

[3]Sensitivity analysis; among those with baseline depressive scores of none (CES-D <10)

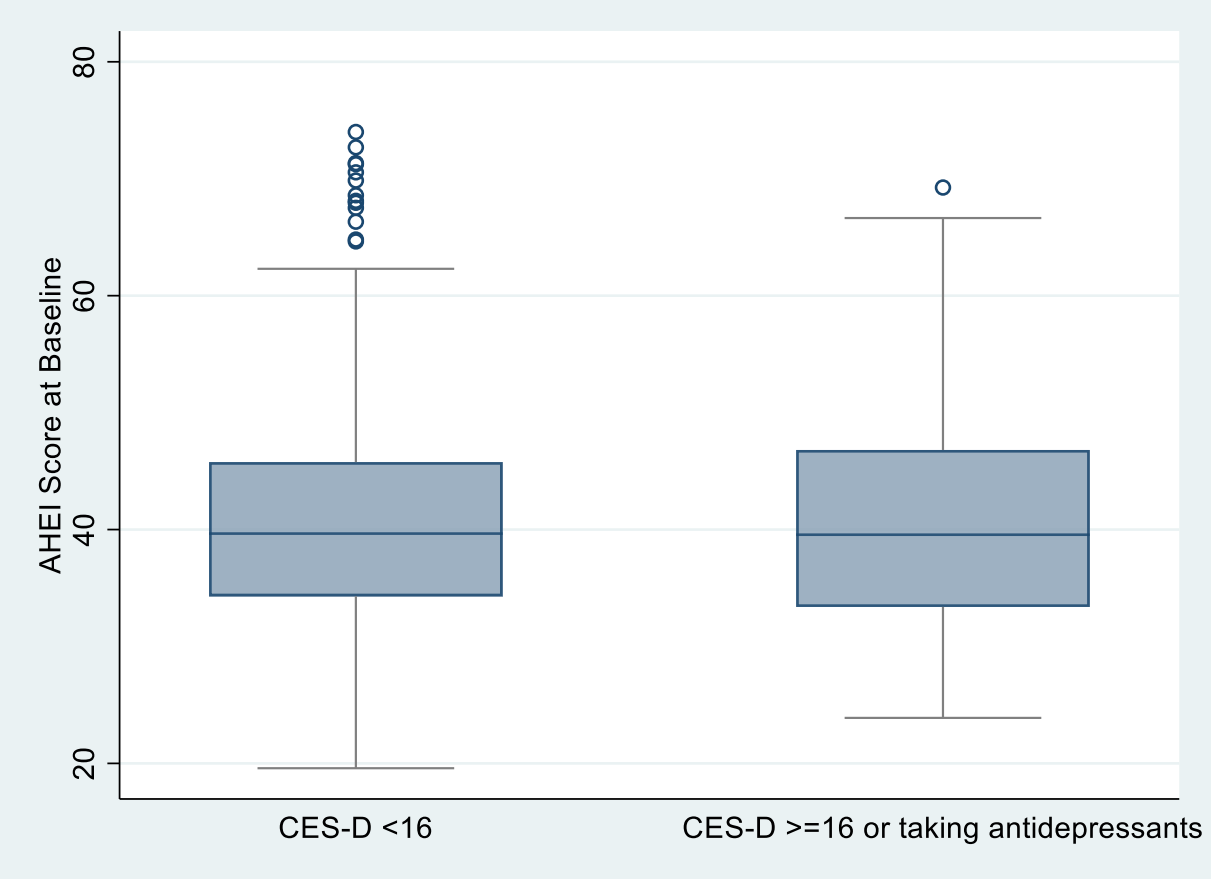
Alternative Healthy Eating Index (AHEI) is a dietary index based on absolute intake of 10 nutrients and foods; the total AHEI score ranges from 0 (least healthy) to 100 (most healthy). Center for Epidemiologic Studies of Depression Scale (CES-D) scores: none <10; mild 10-15; moderate 16-24; severe >24.

Figure 1. Study population inclusion and exclusion criteria



*321 individuals were additionally excluded in the sensitivity analysis with a baseline population restricted to those with a CES-D score <10 (no depressive symptoms).

Figure 2. Baseline AHEI scores comparing those with and without the primary outcome of moderate or severe depressive symptoms or taking antidepressants at follow up



Alternative Healthy Eating Index (AHEI) is a dietary index based on absolute intake of 10 nutrients and foods each scored 0-10 using standardized serving sizes (excluding alcohol). Total AHEI score ranges from 0 (least healthy) to 100 (most healthy). Center for Epidemiologic Studies of Depression Scale (CES-D) scores: none <10; mild 10-15; moderate 16-24; severe ≥25.
Note: Points outside of the box and whiskers are values greater than 1.5 * interquartile range + upper value of the interquartile range.

Supplementary Table 1. The Alternative Health Eating Index-2010 (AHEI) scoring method

Component	**Criteria for Min. Score (0)**	**Criteria for Max. Score (10)**
Fruit (serv/day)	0	≥4
Vegetables (serv/day)	0	≥5
Whole grains (grams/day) Males Females	 0 0	 90 75
Sugar-sweetened beverages and fruit juice (serv/day)	≥1	0
Nuts and legumes (serv/day)	0	≥1
Red/processed meat (serv/day)	≥1.5	0
Trans fat (% of energy)	≥4	≤0.5
Long-chain (n-3) fats (mg/d)	0	250
Polyunsaturated fatty acids (% of energy)	≤2	≥10
Sodium (mg/d)	Highest decile	Lowest decile
Total	0	100

Alcohol use was excluded from the AHEI score calculations and was instead included as a separate covariate in analyses. Therefore, the maximum score possible was 100, not 110.

Supplementary Table 2. Characteristics of included individuals vs. those missing follow up CES-D or antidepressant data

	Included n=1100	**Missing CES-D score and not taking antidepressants at follow-up* n=384**
	n (%) or mean (SD)	
Males	469 (43)	206 (54)
Age, years		
15-25	252 (23)	96 (25)
26-45	476 (43)	138 (36)
46-65	290 (26)	100 (26)
66-90	82 (7)	49 (13)
Missing	0	1 (<1)
Education, years		
0-11	258 (23)	108 (28)
12-15	701 (64)	235 (61)
16-20	137 (12)	39 (10)
Missing	4 (<1)	2 (1)
Smoking status		
Never	474 (43)	141 (37)
Former	250 (23)	110 (29)
Current	376 (34)	133 (35)
Smokeless tobacco use	80 (7)	28 (7)
Missing	12 (1)	5 (1)
Alcohol use status		
Never	136 (12)	41 (11)
Former	325 (30)	124 (32)
Current	638 (58)	219 (57)
Missing	1 (<1)	0
BMI Category*		
Underweight	13 (1)	4 (1)
Normal	197 (17)	73 (19)
Overweight	325 (30)	118 (31)
Obese	560 (50)	186 (48)
Missing	5 (<1)	3 (1)
Pedometer average steps/day		
<5,000	462 (42)	173 (45)
5,000-9,999	435 (40)	129 (34)
≥10,000	141 (13)	50 (13)
Missing	62 (6)	32 (8)
Diabetes diagnosis‡		
Known diabetes	170 (15)	79 (21)
Impaired glucose tolerance	241 (22)	84 (22)
Normal glucose tolerance	685 (62)	215 (56)
Missing	4 (<1)	6 (2)
Social support score (0-49)	40.9 (5.2)	38.1 (6.8)
Identify with own Tribal traditions (yes)	782 (71)	260 (68)
Missing	25 (2)	7 (2)
Locus of control score		
Internal (0-18)	12.6 (2.4)	12.8 (2.3)
External: Chance (0-18)	7.7 (2.5)	8.0 (2.5)
External: Powerful others (0-18)	8.4 (2.8)	8.9 (2.9)
AHEI score (no alcohol), quartiles		
1	275 (25)	96 (25)
2	291 (26)	80 (21)
3	261 (24)	110 (29)
4	273 (25)	98 (26)
Depressive symptoms (CES-D) (baseline)		
None	779 (71)	279 (73)
Mild	321 (29)	105 (27)

Data are pooled across three field centers in Arizona, Oklahoma and South Dakota.

‡Known diabetes (DM) defined as ≥126 mg/dL fasting blood glucose, or reported history of DM and any of the following: on insulin treatment, hypoglycemic agent, renal dialysis or had kidney transplantation. Impaired glucose tolerance: fasting blood glucose 110-125mg/dL and no DM treatment. Normal glucose tolerance: fasting blood glucose <110mg/dL and no DM treatment.

*Individuals who did not answer any questions on the CES-D questionnaire: n=262; individuals who skipped >4 questions on the CES-D questionnaire: n=122. Individuals with missing CES-D scores, but who were taking antidepressants at follow up are included in the study population (n=13). Individuals not shown in this table are those who, at baseline, had current or recent (≤12 months) pregnancies, CES-D scores ≥16 or missing CES-D scores, or reported taking antidepressants.