Original Report:
Diabetes

Explaining Racial/Ethnic Dietary Patterns in Relation to Type 2 Diabetes: An Analysis of NHANES 2007-2012

Sarah Y. Nowlin, PhD, MS[1]; Charles M. Cleland, PhD[1];
Maya Vadiveloo, PhD, RD, CDN[2]; Gail D'Eramo Melkus, EdD, C-NP[1];
Niyati Parekh, PhD, RD[3]; Holly Hagan, PhD[1]

Objective: The purpose of this article is to examine sociodemographic and health behavior factors associated with dietary intake as measured by the healthy eating index (HEI-2010) for persons with and without diabetes (T2D).

Design: A secondary data analysis of three NHANES data cycles spanning 2007-2012. Multiple linear regression assessed racial/ethnic differences in HEI-2010 scores in those without T2D, with T2D, and with undiagnosed T2D.

Participants: The sample included non-pregnant adults aged ≥20 years who had two days of reliable dietary recall data.

Outcome Measures: Total scores for the HEI-2010.

Results: For those without T2D, there was a significant association between race/ethnicity and HEI score, with non-Hispanic Blacks achieving significantly lower scores than their non-Hispanic White counterparts. Differences in HEI-2010 score were also associated with age, sex, smoking status and time spent in the United States. Racial/ethnic differences in dietary patterns were present, but not significant in those with undiagnosed or diagnosed T2D.

Conclusions: Racial/ethnic disparities in dietary patterns are present in individuals without T2D, but differences are not statistically significant in those with undiagnosed or diagnosed T2D. Non-Hispanic Blacks without T2D received significantly lower HEI-2010 scores than non-Hispanic Whites. Further research is necessary to determine whether or not similarities in dietary intake across racial/ethnic groups with T2D will be reflected in diabetes-related health outcomes in this population. *Ethn Dis*. 2016;26(4):529-536; doi:10.18865/ed.26.4.529.

Keywords: Type 2 Diabetes; Diet; Dietary Pattern; Racial Disparities; Race; Ethnicity; Nutrition

Introduction

The incidence of type 2 diabetes (T2D) is increasing, with nearly 1.7 million new cases of diabetes diagnosed among adults ≥ 20 years of age in 2012 in the United States.[1] The rise in prevalence of T2D nationally and internationally has been accompanied by increases in out-of-pocket health care costs related to disease management and treatments for complications for individuals, as well as increases in health care costs for the nation.[2] The Centers for Disease Control and Prevention (CDC) report that while 7.6% of non-Hispanic Whites have diabetes (NHW), ethnic minority groups have significantly higher rates, as 12.8% of Hispanic Americans and 13.2% of non-Hispanic Blacks (NHB) have the disease.[2] Given that a healthy diet is associated with a 20% reduced risk of development of T2D, differences in dietary patterns may partially explain the racial disparities in T2D prevalence.[3] Previous research shows that NHB have poorer diet quality than their NHW and Hispanic counterparts.[4] However, the diet quality of all Americans continues to fall short of the recommendations from the US Department of Agriculture (USDA).[5,6]

Dietary recommendations from the USDA for the general population and medical nutrition therapy (MNT) from the American Diabetes Association are very similar.[7] MNT is recommended for all persons with diabetes and pre-diabetes, and includes methods for adapting a healthier diet and instructions to increase physical activity.[7] Research suggests these dietary guidelines have led to reduced all-cause, CVD-, and cancer-related deaths.[8,9]

While lifestyle modifications are

[1]New York University, College of Nursing: syn216@nyu.edu
[2]University of Rhode Island, Department of Nutrition and Food Studies
[3]New York University, Department of Nutrition, Food Studies, and Public Health

Address correspondence to Sarah Nowlin, PhD, MS: New York University, College of Nursing; 433 First Avenue, NY, NY 10010; 212.992.9403; syn216@nyu.edu.

a cornerstone of treatment for T2D and abnormal glucose metabolism, reports on the diet patterns of persons with T2D, as compared with those without the disease, have produced conflicting results. The CDC's *Morbidity and Mortality Weekly Report* stated that only 24% of National Health Interview Survey participants with pre-diabetes who received instructions to make lifestyle changes were actively engaging in those behaviors.[10] However, another study using participants from National Health and Nutrition Examination Survey (NHANES) with pre-diabetes found that of those who had been told to make healthier lifestyle choices 70%- 82.5% were engaging in healthier behaviors.[11] Finally, Nelson et al found that most adults aged <65 years with T2D had diets high in saturated fat (>10% of total caloric intake), and low in fruits and vegetables.[12] None of these studies stratified by race/ethnicity in their analyses.

Research comparing dietary intake patterns of persons with and without T2D across racial and ethnic groups is lacking in the United States, and may provide insight into the "diet-related disparities" in health outcomes observed in ethnic minority populations.[13]

Research comparing dietary intake patterns of persons with and without T2D across racial and ethnic groups is lacking in the United States, and may provide insight into the "diet-related disparities" in health outcomes observed in ethnic minority populations.[13] Therefore, the aim of our current study was to examine dietary patterns across racial/ethnic groups among people who self-reported with and without T2D and among those with undiagnosed diabetes. Data from NHANES were used to describe and compare the dietary patterns of NHW, Hispanic, and NHB persons with and without self-report T2D in reference to the suggested guidelines set by the USDA, as measured by the HEI-2010.

Methods

The design and methods of NHANES are well-documented.[14] Briefly, NHANES is a national survey conducted every two years using a complex multi-stage sampling strategy of randomly selected homes in 15 neighborhoods in the United States. Since 2007, NHANES began oversampling for NHB and all Hispanic subgroups, which, combined with appropriate survey weights, can produce estimates that are generalizable to the non-institutionalized US population >2 years of age.[15] Eligible participants are asked to complete an in-home interview, a physical exam at the Mobile Examination Center (MEC), and two 24-hour dietary recalls (24HR). A randomly-selected subgroup of participants is also asked to provide a fasting blood sample.

Study Participants

This sample includes men and non-pregnant women ≥ 20 years of age with reliable 24HR data from three data collection cycles of the NHANES spanning years 2007-2012.[16] Diabetes status was determined by an affirmative response to the question "Other than during pregnancy, have you ever been told by a doctor or health care professional that you have diabetes or sugar diabetes?" (n=1,708), including those with type 1 and type 2 diabetes. Self-report of diabetes has been shown to be a valid and reliable measure of diabetes status.[17] Individuals who answered that they had been told they have "borderline" diabetes were also included in the diabetes group, as they should have also received MNT. Individuals were said to have undiagnosed diabetes if they responded negatively to the aforementioned question of diabetes, but had laboratory values indicative of diabetes (ie, hemoglobin A1c≥6.5%, or fasting glucose ≥126 mmol/dL) (n= 451). The final sample included 11,668 participants.

Measures

All participants who completed an in-person 24HR were contacted for a second 24HR via telephone by an NHANES staff member. The Automated Multi-Pass Method was used for both 24HR collections, which reduces the possibility of misreporting

dietary intake due to recall difficulty through the use of food models and multiple probes.[15] Data from the first and second 24HR were processed by the Food and Nutrient Database for Dietary Studies and made available for public access through the Food Pattern Equivalents Database (FPED).[18] These dietary data are in the form of measurement (cup, teaspoon, or count) equivalents, which can be designated to fit into 37 food categories that align with the MyPyramid Guidelines for Americans.

Assessment of Diet Quality

Diet quality, as measured by the HEI-2010 score, was the dependent variable in this analysis. The HEI-2010 scores dietary intake from the FPED, and is based on food densities or recommended quantities per 1,000 calories consumed, with higher scores indicating closer adherence to the recommendations.[19] The items included in this score are total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, fatty acids, refined grains, sodium, and empty calories. If reported intake is lower than the maximum recommended values in the refined grains, sodium, and empty calories groups, a higher score is attained. If the intake of total protein foods group does not meet the recommended standard, beans and peas are counted toward 'total protein foods'.[19] The maximum score for each food grouping is 10, with the exception of 20 for empty calories, and a score of 100 indicates 100% adherence to the MyPyramid guidelines. The lowest possible score is zero.

Variables

The main exposure variables examined in this analysis are race/ethnicity and diabetes status. In NHANES, race/ethnicity, age, education status, and sex are self-reported. Race/ethnicity was coded in NHANES 2007-2010 cycles as either NHW, NHB, Hispanic, or Other or Mixed-Race. Due to the heterogeneity of ethnic background of the latter group, it was excluded from the analysis, consistent with previous NHANES research.[12] Although the 2011-2012 NHANES cycle further classified individuals into NH Asian, these participants were not included, as they could not be combined with previous cycles. Age was categorized into three groups consistent with previous NHANES research (20-39, 40-59, and ≥60). Education was dichotomized to having completed "some college" or beyond, and "high school" or less. Poverty index ratio (PIR) was categorized into three levels, the lowest of which is <1.3 (<130% above the poverty threshold). Individuals who reported smoking more than 100 cigarettes in their lifetime were further categorized into either "current" or "past" smokers; all others were considered "never" smokers. Participants were asked how long they have lived in the United States and this was recorded as a continuous variable. Time in the United States was further categorized based on examples from previous research into <1 year, 1-4.99 years, 5-9.99 years, 10-19.99 years, and 20 or more years, as compared with those born in the United States.[20]

Statistical Analysis

Descriptive statistics were used to examine demographic characteristics of the sample. Survey procedures were used to account for design effects as a result of the complex sampling method used in NHANES. Rao-Scott Chi-square tests were used to detect differences across race/ethnicity on sample characteristics. Multivariable linear regression with the Complex Samples module in SPSS version 22 was used to estimate associations between the Total HEI Score and each of the following variables: race/ethnicity, age, sex, T2D status, education, PIR, smoking status, marital status, and time in the United States. A data-based model-building approach was used to create the final multivariable regression model. Factors that changed the estimate for the key variable race/ethnicity by >10% were kept in the final model.[21] Diabetes status did not fit the criteria for model building, but the final regression model was stratified by the three levels of diabetes status to test racial/ethnic differences in HEI-2010 score by diabetes status level. Cycle of NHANES did not fit the criteria for model building when added as a covariate, and was not included in the final model. As means for both days of 24HR were used to create the total HEI Score, survey weights for the second day of dietary recall were used for all analyses, adjusted for the inclusion of three waves of NHANES. A P value of <.01 was considered significant due to the large sample size and multiple tests performed.

Results

Participants aged <20 years, who did not complete the MEC exam, or whose dietary data were deemed un-

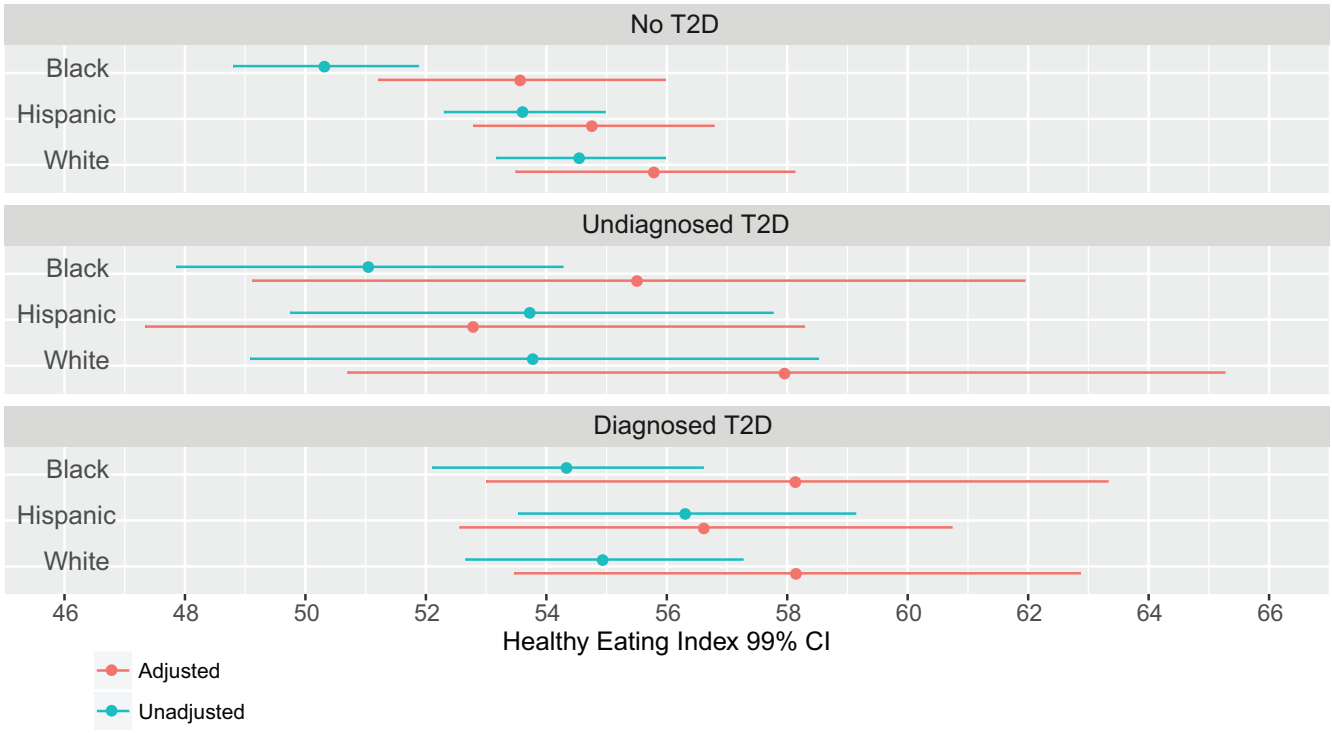

Figure 1. Unadjusted and adjusted mean HEI-2010 scores, and 99% CI, for three levels of diabetes status, stratified by race/ethnicity, accounting for complex survey design weights for three waves of NHANES.
HEI scores range from 0-100, with higher scores indicating greater adherence to dietary recommendations from the USDA. Means adjusted for the following covariates, stratified by T2D status: Race/ethnicity, age, sex, education, PIR, smoking status, marital status, and time in the United States.

reliable by NHANES staff, were excluded (n=14,993; 49%). Consistent with existing literature, we further excluded extreme total caloric intake values (those below 400 or above 7,000) from this analysis (n=2,631; 17%).[22]

The mean age in years for this sample of adults was 44.7 for NHB participants, 49.0 for NHW participants, and 40.8 for Hispanic participants. Table 1 displays age and other demographic characteristics as percentage of total by category. All demographic characteristics differed significantly by race/ethnicity.

The full adjusted model included age, sex, marital status, education, PIR, smoking status, and time in the U.S. Using the data-based model building mentioned above, when the variable for time spent in the United States. was added to the model, the association between race/ethnicity and HEI-2010 score was attenuated. Figure 1 presents mean unadjusted and adjusted total HEI-2010 scores stratified by race/ethnicity and diabetes status. In the full, adjusted model, NHW participants without T2D scored significantly higher than their NHB counterparts. Overall, people with T2D scored higher than those without, although the significance of this difference was not tested in this analysis. The mean HEI score for individuals with T2D was 57.7, and descriptive analysis of the individual HEI components revealed deficits in most categories, except total protein (data not shown).

Table 2 displays the results of the multivariable regression model for each T2D status group to demonstrate the differences across predictors of HEI 2010 score by the three groups. For participants with undiagnosed T2D, the full, adjusted model explained 30.3% of the variance in HEI score (data not shown), but only 9.2% and 15.8% of the variance for participants with and without a diagnosis of T2D, respectively.

In participants with undiagnosed T2D, HEI-2010 scores were nearly 4 points higher among females, those aged ≥60 years (as compared with aged 20-39 years), and those living in

Table 1. Sample characteristics by race/ethnicity, %

	All	NHW	NHB	Hispanic	P
	N=11,668	n=6,048	n=2,658	n=2,962	
Age years					
20-39	35.8	32.0	40.5	52.6	<.001
40-59	38.9	39.7	39.8	34.3	
≥60	25.2	28.3	19.7	13.1	
Sex					
Male	47.8	47.9	43.1	51.0	<.001
Female	52.2	52.1	56.9	49.0	
Marital status					
Married	62.5	65.6	41.5	64.6	<.001
Single/Other	37.5	34.5	58.5	35.4	
Education					
HS or below	40.3	35.2	47.9	61.9	<.001
≥Some college	59.7	64.8	52.1	38.1	
Poverty index ratio					
≤1.29	22.4	16.5	35.0	43.7	<.001
1.3-3.49	34.2	32.8	40.0	36.9	
≥3.5	43.4	50.7	25.0	19.3	
Diabetes status					
No diabetes	86.9	88.2	81.1	84.9	<.001
Undiagnosed	2.7	2.3	3.8	4.3	
T2D	10.3	9.5	15.2	10.8	
HEI Total Score, mean (SD)	54.1 (.37)	54.6 (.49)	51.0 (.55)	54.0 (.43)	<.001
Smoking status					
Not at all	79.4	79.6	74.5	82.5	<.001
Some days	3.4	2.7	5.0	5.9	
Every day	17.2	17.7	20.6	11.6	
Years in US					<.001
<5	1.5	.7	1.1	5.8	
5 - 19.9	5.4	1.1	3.9	30.5	
≥20	5.4	2.6	3.6	22.1	
Born in US	87.7	95.6	91.3	41.6	

NOTE: All results account for the complex sample design of NHANES using survey weights from the second day of 24HR recall.
No significant differences were present in sample characteristics between waves of NHANES data cycles (P=.973).

the United States >5 years since immigration (P<.01). Of note are the large coefficients comparing HEI scores of those born in the United States with those who had immigrated to the United States 5 to 19.9 years, and >20 years from the time they were questioned, who have an average HEI 2010 score that is 9.6 and 14.5 points higher than those born in the United States. Race/ethnicity was not a significant predictor of HEI Score for those with undiagnosed T2D.

Significant predictors of higher HEI score in those with T2D include a moderate amount of time since immigration (5 to >20 years), as compared with being born in the United States, never smoking, and aged ≥60 years. No other significant predictors of HEI-2010 score were present in those with T2D.

Significant predictors of higher HEI-2010 score in those without T2D include aged ≥60 years, being female, NHW race/ethnicity as compared with NHB, completion of some college or advanced degrees, a PIR of >3.5, never smoking, and immigration to the United States >1 year ago as compared with US born citizens.

Discussion

This analysis of three waves of NHANES data collected over 2007-2012 examined racial/ethnic differences in HEI-2010 score of adults by diabetes status. Prevalence of diabetes in this sample was 10.3% (n=1,708), slightly lower than the estimated US

prevalence reported by the CDC for 2012, which was 12.3% for adults.[2] The main findings of our secondary data analysis suggest that diet quality in people with diabetes and undiagnosed diabetes may not differ significantly across racial/ethnic groups; however, racial/ethnic disparities in diet quality are present in those without diabetes. Previous research indicates that although Americans would rate their diet quality as "good," the diet quality of Americans is poor, suggesting that there is a need for further investigation into the reasons behind this lack of concordance between healthy diet and perceived healthy diet.[23] The mean HEI score for adults with diabetes was <60% of the maximum possible score. While there are many paths to such a low score, it indicates deficits in healthy food groups. This low mean total score could also indicate that adults are consuming sodium, saturated fats, and empty calories in excess. Further analysis of the component scores of the HEI-2010 is warranted, but is beyond the scope of this article. Nutrition education by primary care providers and public health outreach programs, as well as improvements in food policy (by labeling sodium intake in restaurants, etc.) could impact the dietary patterns of the general population, and thus prevent the development of chronic disease.

Previous research addressing dietary patterns of Americans using the HEI-2010 scoring system suggest that higher income and NHW race are associated with greater adherence to the USDA dietary guidelines.[24] Compared with NHW, ethnic minority groups have lower total HEI scores overall; however, in this study, when further stratifying by diabetes status, differences between NHW and NHB were significant only in those without diabetes. Results should be interpreted with caution, as a lack of significant racial/ethnic differences in HEI scores in those with undiagnosed and diagnosed T2D could be due to insufficient power. However, these results are consistent with previous research examining racial/ethnic disparities in persons with chronic disease.[25]

Indicators of socioeconomic status (education and PIR) were also significantly associated with HEI 2010 scores in those without diabetes. Although socioeconomic and demographic characteristics have been shown to correlate highly with race/ethnicity, this study showed that race/ethnicity is uniquely contributing to disparities in HEI-2010 score over

Table 2. Multivariable linear regression coefficients and SE of factors predicting total HEI 2010 scores stratified by three levels of T2D status

	No T2D	Undiagnosed T2D	Has T2D
	n= 9,509	n= 451	n= 1,708
Intercept	63.21 (.8) [a]	57.59 (2.6) [a]	59.41 (1.7) [a]
Age years			
20-39	-6.05 (.5) [a]	-12.24 (3.0) [a]	-7.77 (1.9) [a]
40-59	-3.20 (.6) [a]	-2.66 (1.8)	-4.45 (1.5) [a]
≥60	Ref	Ref	Ref
Sex			
Male	-2.63 (.4) [a]	-4.27 (1.5)	-.95 (.84)
Female	Ref	Ref	Ref
Marital status			
Married	Ref	Ref	Ref
Single/other	-.30 (.5)	-.08 (2.1)	-.08 (1.0)
Education			
HS or below	-4.34 (.5) [a]	-2.19 (1.8)	-2.73 (1.1)
Beyond	Ref	Ref	Ref
PIR			
≤1.29	-3.15 (.6) [a]	-1.47 (2.0)	-.96 (1.4)
1.3-3.49	-2.47 (.6) [a]	4.68 (2.1)	1.00 (1.4)
≥3.5	Ref	Ref	Ref
Race/ethnicity			
Hispanic	-1.00 (.7)	-4.98 (2.6)	-1.52 (1.2)
NHB	-2.22 (.6) [a]	-2.46 (1.6)	-.004 (1.1)
NHW	Ref	Ref	Ref
Smoking status			
Current	-7.25 (.5) [a]	-2.96 (1.7)	-4.43 (1.3)
Past	-3.07 (1.2)	5.10 (3.8)	-.51 (1.9)
Never	Ref	Ref	Ref
Years in US			
<5	5.54 (1.4)	9.53 (5.8)	6.44 (2.9)
5 – 19.99	6.62 (.7) [a]	9.57 (3.3) [a]	11.14 (2.1) [a]
≥20	4.83 (.7) [a]	14.49 (2.8) [a]	5.32 (1.2) [a]
US Born	Ref	Ref	Ref

[a] $P<.01$.
Adjustment for NHANES cycle did not significantly change the associations in the full regression model. Aggregated NHANES sample weight from the second day of recall for all three waves (2007-2012) were applied to account for day of the week of the 24HR, non-response, and unequal probability of selection.
PIR, Poverty index ratio; Ref, reference group.

and above the impact of socioeconomic and demographic factors.[24]

Results from this analysis suggest that racial/ethnic disparities in diet quality, if present, are not captured by the factors assessed in this study in people with undiagnosed and diagnosed T2D. Other factors that were not assessed in this analysis that are associated both with race/ethnicity and diet quality include body mass index, proximity to healthy foods, and geographic region. Given the importance of diet quality in managing T2D, these findings indicate that awareness of a diagnosis of T2D may contribute to a reduction in racial/ethnic disparities in dietary quality.

Limitations

There are some limitations of the present analysis that must be noted. Self-reported dietary information from 24-hour recalls is often misreported depending on a person's BMI, which was not included in this analysis. 24HR also may not be the best measure of "usual dietary intake", as it does not capture normal variations in diet from day to day.[26] Research has shown that 4-6 24HR are superior to one or two, as in NHANES, to capture normal variations in dietary intake.[27] Additionally, the HEI-2010 score may not capture the essence of the specific changes a person with T2D might make in his or her diet after receiving nutritional counseling for a diabetes diagnosis, such as a decreases in cholesterol and total caloric intake.

Finally, our research assumes all persons with T2D or with impaired glucose metabolism, as diagnosed by a health care provider, have received at least some nutritional counseling. NHANES provides limited access to geographic data of participants, which is important because neighborhood factors such as access to healthy foods has been shown to impact diabetes self-care activities, including dietary pattern.[28] Other factors affecting diet quality that were not measured, including psychosocial factors, could have impacted results.

The main findings of our secondary data analysis suggest that diet quality in people with diabetes and undiagnosed diabetes may not differ significantly across racial/ethnic groups; however, racial/ethnic disparities in diet quality are present in those without diabetes.

Despite these limitations, the strengths of this analysis must also be noted. NHANES provides access to a nationally representative sample of individuals. The ability to combine waves of NHANES increases power to find associations that may otherwise be difficult when stratifying by race/ethnicity and diabetes status, due to limitations of sample size. Additionally, NHANES oversamples for Hispanic and NHB populations, increasing the generalizability of these findings to those racial/ethnic minority groups.

Conclusions

Results of this secondary data analysis found that HEI-2010 scores differ by race/ethnicity only among persons without diabetes, with NHB having significantly lower total scores than their NHW counterparts. This racial/ethnic disparity in HEI-2010 score was not detected in those with T2D or undiagnosed T2D, however lack of sufficient power due to smaller sample sizes may have prevented significant findings. Future research on this topic should include larger sample sizes in these groups, perhaps by including more cycles of NHANES in the analyses. As racial/ethnic minority groups achieve poorer diabetes-related health outcomes than their NHW counterparts, further research is necessary to assess whether or not the absence of racial/ethnic disparities in diet quality in persons with T2D is reflected in diabetes-related health outcomes in this population.

Conflict of Interest

No conflicts of interest to report.

Author Contributions

Research concept and design: Nowlin, Vadiveloo, D'Eramo Melkus, Parekh, Hagan Acquisition of data: Nowlin; Data analysis and interpretation: Nowlin, Cleland, Vadiveloo, D'Eramo Melkus, Parekh, Hagan; Manuscript draft: Nowlin, Cleland, Vadiveloo, Parekh, Hagan; Statistical expertise: Nowlin, Cleland, Vadiveloo, Parekh, Hagan; Acquisition of funding: Nowlin, Hagan; Supervision: Cleland, Vadiveloo, D'Eramo Melkus, Parekh, Hagan

References

1. Centers for Disease Control and Prevention. *National diabetes fact sheet: national estimates and general information on diabetes and prediabetes in the United States.* Atlanta, GA: Department of Health and Human Services, Centers for Disease Control and Prevention; 2011.
2. Centers for Disease Control and Prevention. National Diabetes Statistics Report: Estimates of Diabetes and It's Burden in the United States. In: *Department of Health and Human Services.* Atlanta, GA: Centers for Disease Control and Prevention; 2014.
3. Esposito K, Chiodini P, Maiorino MI, Bellastella G, Panagiotakos D, Giugliano D. Which diet for prevention of type 2 diabetes? A meta-analysis of prospective studies. *Endocrine*. 2014;47(1):107-116. http://dx.doi.org/10.1007/s12020-014-0264-4. PMID:24744219.
4. Vitolins MZ, Anderson AM, Delahanty L, et al; Look AHEAD Research Group. Action for Health in Diabetes (Look AHEAD) trial: baseline evaluation of selected nutrients and food group intake. *J Am Diet Assoc*. 2009;109(8):1367-1375. http://dx.doi.org/10.1016/j.jada.2009.05.016. PMID:19631042.
5. Hiza HA, Casavale KO, Guenther PM, Davis CA. Diet quality of Americans differs by age, sex, race/ethnicity, income, and education level. *J Acad Nutr Diet*. 2013;113(2):297-306. http://dx.doi.org/10.1016/j.jand.2012.08.011. PMID:23168270.
6. Ervin RB. Healthy Eating Index--2005 total and component scores for adults aged 20 and over: National Health and Nutrition Examination Survey, 2003-2004. *Natl Health Stat Report*. 2011;(44):1-9. PMID:22432250.
7. Bantle JP, Wylie-Rosett J, Albright AL, et al; American Diabetes Association. Nutrition recommendations and interventions for diabetes: a position statement of the American Diabetes Association. *Diabetes Care*. 2008;31(suppl 1):S61-S78. http://dx.doi.org/10.2337/dc08-S061. PMID:18165339.
8. Liese AD, Krebs-Smith SM, Subar AF, et al. The Dietary Patterns Methods Project: synthesis of findings across cohorts and relevance to dietary guidance. *J Nutr*. 2015;145(3):393-402. http://dx.doi.org/10.3945/jn.114.205336. PMID:25733454.
9. George SM, Ballard-Barbash R, Manson JE, et al. Comparing indices of diet quality with chronic disease mortality risk in postmenopausal women in the Women's Health Initiative Observational Study: evidence to inform national dietary guidance. *Am J Epidemiol*. 2014;180(6):616-625. http://dx.doi.org/10.1093/aje/kwu173. PMID:25035143.
10. Centers for Disease Control and Prevention (CDC). Self-reported prediabetes and risk-reduction activities--United States, 2006. *MMWR Morb Mortal Wkly Rep*. 2008;57(44):1203-1205. PMID:18987616.
11. Yang K, Lee YS, Chasens ER. Outcomes of health care providers' recommendations for healthy lifestyle among U.S. adults with prediabetes. *Metab Syndr Relat Disord*. 2011;9(3):231-237. http://dx.doi.org/10.1089/met.2010.0112. PMID:21361822.
12. Nelson KM, Reiber G, Boyko EJ; NHANES III. Diet and exercise among adults with type 2 diabetes: findings from the third national health and nutrition examination survey (NHANES III). *Diabetes Care*. 2002;25(10):1722-1728. http://dx.doi.org/10.2337/diacare.25.10.1722. PMID:12351468.
13. Satia JA. Diet-related disparities: understanding the problem and accelerating solutions. *J Am Diet Assoc*. 2009;109(4):610-615. http://dx.doi.org/10.1016/j.jada.2008.12.019. PMID:19328255.
14. National Health and Nutrition Examination Survey: Plan and operations, 1999–2010 [Internet]. National Center for Health Statistics. 2013 [cited 3/10/2016]. Available from: http://www.cdc.gov/nchs/data/series/sr_01/sr01_056.pdf.
15. Ahluwalia N, Dwyer J, Terry A, Moshfegh A, Johnson C. Update on NHANES Dietary Data: Focus on Collection, Release, Analytical Considerations, and Uses to Inform Public Policy. *Adv Nutr*. 2016;7(1):121-134. http://dx.doi.org/10.3945/an.115.009258. PMID:26773020.
16. Centers for Disease Control and Prevention, *National Health and Nutrition Examination Survey Questionnaire*, National Center for Health Statistics, Editor. Hyattsville, MD: U.S., Department of Health and Human Services, Centers for Disease Control and Prevention; 2007
17. Margolis DJ, Hoffstad O, Strom BL. Association between serious ischemic cardiac outcomes and medications used to treat diabetes. *Pharmacoepidemiol Drug Saf*. 2008;17(8):753-759. http://dx.doi.org/10.1002/pds.1630. PMID:18613215.
18. Bowman SA CJ, Friday JE, Thoerig RC, Shimizu M, Barrows BR. *Food Patterns Equivalents Database 2007-08: Methodology and User Guide* [Online]. In: Food Surveys Research Group ARS, U.S. Department of Agriculture, editor. Beltsville, MD: Beltsville Human Nutrition Research Center; 2013.
19. Guenther PM, Casavale KO, Reedy J, et al. Update of the Healthy Eating Index: HEI-2010. *J Acad Nutr Diet*. 2013;113(4):569-580. http://dx.doi.org/10.1016/j.jand.2012.12.016. PMID:23415502.
20. Hahn N. Diabetes Among Hispanic Immigrants: The Impact of Age at Migration [Dissertation]. UMI Dissertations Publishing: Walden University; 2015.
21. David W. *Hosmer, S.L., Applied Logistic Regression.* Hoboken, NJ: John Wiley & Sons, Inc; 2000:91-142.
22. Vadiveloo M, Parekh N, Mattei J. Greater healthful food variety as measured by the US Healthy Food Diversity index is associated with lower odds of metabolic syndrome and its components in US adults. *J Nutr*. 2015;145(3):564-571. http://dx.doi.org/10.3945/jn.114.199125. PMID:25733473.
23. Powell-Wiley TM, Miller PE, Agyemang P, Agurs-Collins T, Reedy J. Perceived and objective diet quality in US adults: a cross-sectional analysis of the National Health and Nutrition Examination Survey (NHANES). *Public Health Nutr*. 2014;17(12):2641-2649. http://dx.doi.org/10.1017/S1368980014000196. PMID:24636343.
24. Kirkpatrick SI, Dodd KW, Reedy J, Krebs-Smith SM. Income and race/ethnicity are associated with adherence to food-based dietary guidance among US adults and children. *J Acad Nutr Diet*. 2012;112(5):624-635.e6. http://dx.doi.org/10.1016/j.jand.2011.11.012. PMID:22709767.
25. Chen X, Cheskin LJ, Shi L, Wang Y. Americans with diet-related chronic diseases report higher diet quality than those without these diseases. *J Nutr*. 2011;141(8):1543-1551. http://dx.doi.org/10.3945/jn.111.140038. PMID:21697303.
26. Freedman LS, Commins JM, Moler JE, et al. Pooled results from 5 validation studies of dietary self-report instruments using recovery biomarkers for energy and protein intake. *Am J Epidemiol*. 2014;180(2):172-188. http://dx.doi.org/10.1093/aje/kwu116. PMID:24918187.
27. Carroll RJ, Midthune D, Subar AF, et al. Taking advantage of the strengths of 2 different dietary assessment instruments to improve intake estimates for nutritional epidemiology. *Am J Epidemiol*. 2012;175(4):340-347. http://dx.doi.org/10.1093/aje/kwr317. PMID:22273536.
28. Smalls BL, Gregory CM, Zoller JS, Egede LE. Effect of neighborhood factors on diabetes self-care behaviors in adults with type 2 diabetes. *Diabetes Res Clin Pract*. 2014;106(3):435-442. http://dx.doi.org/10.1016/j.diabres.2014.09.029. PMID:25451904.