Prediabetes Awareness is not Associated with Lower Consumption of Self-Reported Added Sugar in U.S. Adults

Nadia Markie Sneed, PhD, APRN, FNP-BC[a], **Andres Azuero, PhD, MBA**[b], **Shannon A Morrison, PhD, CRNP, FNP-BC**[c]

[a]Center for Research Development and Scholarship, School of Nursing, Vanderbilt University, 406 Godchaux Hall, 21st Avenue South, Nashville, TN 37240, USA.

[b]Office of Research and Scholarship, University of Alabama Birmingham, School of Nursing, University Boulevard, 1720 2nd Avenue South, NB 485H, Birmingham, AL 35294-1210, USA.

[c]Department of Family, Community Health, and Systems, University of Alabama Birmingham, School of Nursing, University Boulevard, 1720 2nd Avenue South, NB 573-J, Birmingham, AL 35294-1210, USA.

Introduction

Approximately 96 million adults in the United States (U.S.) have prediabetes;[1,2] a condition of glucose intolerance and insulin resistance.[3] About 15% of individuals with prediabetes are unaware of their condition.[2] Non-Hispanic Black and Hispanic groups are disproportionally impacted by prediabetes and are at increased risk for developing T2D[4] in comparison to non-Hispanic Whites, contributing to chronic disease disparities[5] and all-cause mortality.[6] Clinical trials have demonstrated that progression from prediabetes to T2D can be delayed or prevented with dietary lifestyle modifications,[7,8] including reduced intake of total dietary sugars.[9] Added sugars, in particular, have been linked to an increased risk for insulin resistance and T2D[10–13] and are overconsumed in the U.S. by an average of 270 calories per day (current recommendations are 200 calories per day for 2,000 calorie diet).[14] Adults aware of their prediabetes condition have been shown to engage in dietary risk-reduction behavior changes.[15,16] However, to our knowledge, no studies have assessed if being aware of one's prediabetes condition influences self-reported consumption of added sugar. The aim of this study is to examine if U.S. adults 20 years with prediabetes who are aware of their condition, self-report consuming lower quantities of added sugar compared to unaware adults and if differences are observed by age, sex, and race/Hispanic origin.

Corresponding author: Nadia M. Sneed, Tel +1 615.421.8563, nadia.sneed@vanderbilt.edu.
Nadia Markie Sneed* is a Nursing Post-doctoral Research Fellow at Vanderbilt University USA; Andres Azuero, PhD, MBA is a Professor in the Office of Research and Scholarship at the University of Alabama at Birmingham, Birmingham, Alabama, USA; Shannon A. Morrison, PhD, CRNP, FNP-BC, was an Associate Professor, School of Nursing, Department of Family, Community Health, and Systems, University of Alabama at Birmingham, Birmingham, Alabama, USA.

Materials and Methods

A cross-sectional, descriptive study was conducted using 2013–2018 National Health and Nutrition Examination Survey (NHANES) data. A total of 3,314 non-pregnant, non-lactating adults 20 years with prediabetes (hemoglobin A1c [HbA1c] between 5.7% to 6.4%) [1] who reported whether they had been told by a healthcare provider about their prediabetes condition (yes/no), and had at least 1 day of dietary recall information that contained a value for added sugar were included in the final analyses. NHANES respondents dietary information was collected via 24-hour dietary recalls using the U.S. Department of Agriculture's Automated Multiple-Pass Method.[17] The National Cancer Institute (NCI) method was used to estimate usual intakes for added sugar (g) and total calories (kcals).[18,19] Regression analyses include the following predictors of added sugar consumption: age, sex, race/Hispanic origin, education level, annual household income, marital status, and body mass index (BMI).

All analyses were performed using SAS Studio version 3.8, Enterprise Edition[20] and appropriate NHANES analytic guidelines[21] were followed using SAS SURVEY procedures[22] necessary to perform complex survey designs. Survey weighted ordinary least squares (OLS) regression was used to examine demographic differences by prediabetes awareness status for HbA1c, total energy (kcal/day), and added sugar (g/day) and for added sugar by age category, sex, race/Hispanic origin, and sociodemographic and BMI categories. Lastly, survey weighted OLS regression was used to test whether prediabetes awareness was associated with usual intake of added sugar (g/day) using the NCI Method by age, sex, and race/Hispanic origin after controlling for sociodemographic covariates.

Results

A total of 3,314 adults were identified as having HbA1c defined prediabetes and reported being either aware (n=528) or unaware (n=2,786) of their condition (Table 1). Among those aware of having prediabetes, the mean intake of added sugar was 71 g/day compared to 70.1 g/day for those unaware (estimated difference= −1.36 g; p=.21). Table 1 indicates that overall added sugar consumption and added sugar consumption by age category, sex, race/Hispanic origin, and sociodemographic and BMI categories was higher among those aware of their prediabetes condition compared to those unaware, though differences in added sugar intake by each group were not statistically significant except for the 45–64 age category (estimated difference: −4.01, p=.01), the high school degree or GED category (estimated difference: −4.66, p=.04), the partner category (estimated adjusted difference: −9.17, p=.02), and the underweight BMI category (estimated difference: −11.32, p<.01). Our multivariable analysis indicated that prediabetes awareness was not significantly associated with added sugar intake (estimated adjusted difference 1.7 g; 95% CI: −.80, 4.20; p=.18). Among those with prediabetes, there were no significant differences in added sugar consumption among those aware of their condition across age, sex, or race/Hispanic origin (Type 3 test for age: p=.15, male: p=.86, Race and Hispanic origin: p=.89) (refer to Supplemental Table 2 for model estimated mean intake for added sugar for age category, sex, and race and Hispanic origin).

Discussion

Our findings indicate that adults 20 years with prediabetes, aware of their condition, do not report consuming less added sugar than unaware adults. These findings are consistent with previous studies using NHANES data[15,23] and may be the result of a lack of health care provider knowledge about added sugar's risk association with pre- and T2D and/or a lack of healthcare provider referrals to diabetes education and nutrition counseling.[24] Continued efforts are needed to not only increase prediabetes screening and improve awareness, but to ensure patients are referred for diabetes-specific nutrition counseling with a registered dietitian nutritionist.

We also found no significant differences in added sugar intake by age category, sex, and race/Hispanic origin among those aware of their prediabetes condition. Adults from our sample overconsumed added sugar by an average of 70–71 g/day (equivalent to 280–284 kcals/day). While there is strong evidence indicating that added sugar causes metabolic dysregulation of lipid and glucose, and promotes a state of insulin resistance,[13] no guidelines exist that specify added sugar limits for adults with diabetes, including prediabetes.[1] This highlights an urgent need to identify target recommendations for added sugar intake among individuals with prediabetes that can be widely disseminated for use in public health and clinical settings.

The major strengths of this study are the use of six years (2013–2018) of NHANES data, laboratory collect HbA1c measures to identify prediabetes in the sample, and use of the sophisticated NCI method to predict the usual intake of added sugar and total calories for the sample.[19,25] Limitations included: 1) the cross-sectional nature of this study in which causality, temporal associations, and behavior change could not be determined, 2) prediabetes awareness/unawareness being based on self-reported information, and 3) use of self-reported dietary intake data which is subject to recall bias due to under or over-reporting.[26]

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

References

1. American Diabetes Association. 2. Classification and diagnosis of diabetes: standards of medical care in diabetes-2020. Diabetes Care. 2020;43(Suppl 1):S14. [PubMed: 31862745]

2. Centers for Disease Control and Prevention. National diabetes statistics report. Accessed April 13, 2022. https://www.cdc.gov/diabetes/data/statistics-report/index.html

3. Tabak AG, Herder C, Rathmann W, Brunner EJ, Kivimaki M. Prediabetes: a high-risk state for diabetes development. Lancet. Jun 16 2012;379(9833):2279–90. doi:10.1016/s0140-6736(12)60283-9 [PubMed: 22683128]

4. National diabetes statistics report, 2020 (Atlanta, GA: Centers for Disease Control and Prevention, US Department of Health and Human Services) (2020).

5. Kulick ER, Moon YP, Cheung K, Willey JZ, Sacco RL, Elkind MS. Racial-ethnic disparities in the association between risk factors and diabetes: the Northern Manhattan Study. Prev Med Feb 2016;83:31–6. doi:10.1016/j.ypmed.2015.11.023 [PubMed: 26658025]

6. Huang Y, Cai X, Mai W, Li M, Hu Y. Association between prediabetes and risk of cardiovascular disease and all cause mortality: systematic review and meta-analysis. BMJ. 2016;355:i5953. [PubMed: 27881363]

7. Tuomilehto J, Lindstrom J, Eriksson JG, et al. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. N Engl J Med. May 3 2001;344(18):1343–50. doi:10.1056/NEJM200105033441801 [PubMed: 11333990]

8. Knowler WC, Barrett-Connor E, Fowler SE, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. N Engl J Med. Feb 7 2002;346(6):393–403. doi:10.1056/NEJMoa012512 [PubMed: 11832527]

9. Pan XR, Li GW, Hu YH, et al. Effects of diet and exercise in preventing NIDDM in people with impaired glucose tolerance. the Da Qing IGT and Diabetes Study. Diabetes Care. Apr 1997;20(4):537–44. [PubMed: 9096977]

10. Rodriguez LA, Madsen KA, Cotterman C, Lustig RH. Added sugar intake and metabolic syndrome in US adolescents: cross-sectional analysis of the National Health and Nutrition Examination Survey 2005–2012. Public Health Nutr. Sep 2016;19(13):2424–34. doi:10.1017/s1368980016000057 [PubMed: 26932353]

11. de Koning L, Malik VS, Rimm EB, Willett WC, Hu FB. Sugar-sweetened and artificially sweetened beverage consumption and risk of type 2 diabetes in men. Am J Clin Nutr. Jun 2011;93(6):1321–7. doi:10.3945/ajcn.110.007922 [PubMed: 21430119]

12. Montonen J, Järvinen R, Knekt P, Heliövaara M, Reunanen A. Consumption of sweetened beverages and intakes of fructose and glucose predict type 2 diabetes occurrence. Article. J Nutr. 2007;137(6):1447–1454. [PubMed: 17513405]

13. Stanhope KL. Sugar consumption, metabolic disease and obesity: The state of the controversy. Crit Rev Clin Lab Sci. 2016;53(1):52–67. doi:10.3109/10408363.2015.1084990 [PubMed: 26376619]

14. U.S. Department of Agriculture and U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2020–2025. Accessed January, 2021. DietaryGuidelines.gov

15. Bardenheier BH, Cogswell ME, Gregg EW, Williams DE, Zhang Z, Geiss LS. Does knowing one's elevated glycemic status make a difference in macronutrient intake? Diabetes Care. Dec 2014;37(12):3143–9. doi:10.2337/dc14-1342 [PubMed: 25205140]

16. Owei I, Umekwe N, Ceesay F, Dagogo-Jack S. Awareness of prediabetes status and subsequent health behavior, body weight, and blood glucose levels. J Am Board Fam Med. Jan-Feb 2019;32(1):20–27. doi:10.3122/jabfm.2019.01.180242 [PubMed: 30610138]

17. Zipf G, Chiappa M, Porter KS, Ostchega Y, Lewis BG, Dostal J. National Health and Nutrition Examination Survey plan and operations, 1999–2010. Vital and Health Statistics. 2013;1(56)

18. National Cancer Institute. Usual dietary intakes: The NCI method. Updated July 24. Accessed February 22, 2021. https://epi.grants.cancer.gov/diet/usualintakes/method.html

19. Herrick KA, Rossen LM, Parsons R, Dodd KW. Estimating usual dietary intake from National Health and Nutrition Examination Survey data using the National Cancer Institute method. 2018. Vital and Health Statistics.

20. SAS Studio. Version 3.8 Enterprise Edition. Cary, NC, USA: SAS Institute Inc; 2021;

21. Centers for Disease Control and Prevention. National Center for Health Statistics. National Health and Nutrition Examination Survey (NHANES): Analytic guidelines, 2011–2016. Centers for Disease Control and Prevention. Accessed February 22, 2019. https://wwwn.cdc.gov/nchs/nhanes/analyticguidelines.aspx#analytic-guidelines

22. SAS Institute. SAS/STAT Software Survey Analysis. Accessed February 23, 2022. https://support.sas.com/rnd/app/stat/procedures/SurveyAnalysis.html

23. Siegel KR, Bullard KM, Imperatore G, et al. Prevalence of major behavioral risk factors for type 2 diabetes. Diabetes Care. Mar 2 2018;doi:10.2337/dc17-1775

24. Tseng E, Greer RC, O'Rourke P, et al. National survey of primary care physicians' knowledge, practices, and perceptions of prediabetes. J Gen Intern Med. 2019;34(11):2475–2481. [PubMed: 31502095]

25. Tooze JA. Estimating usual intakes from dietary surveys: methodologic challenges, analysis approaches, and recommendations for low-and middle-income countries. 2020. Accessed June 1, 2020. https://www.intake.org/resource/estimating-usual-intakes-dietary-surveys-methodologic-challenges-analysis-approaches-and

26. Naska A, Lagiou A, Lagiou P. Dietary assessment methods in epidemiological research: current state of the art and future prospects. F1000Research. 2017;6:926–926. doi:10.12688/f1000research.10703.1 [PubMed: 28690835]

Table 1.

Usual intakes of total energy, added sugar[a], and added sugar by age category, sex, Race/Hispanic origin, and sociodemographic and BMI categories for adults ≥ 20 years[b] with HbA1c defined prediabetes who are aware or unaware of their prediabetes condition, the NHANES[c] 2013– 2018.

	Aware of prediabetes (SE[d])	Unaware of prediabetes (SE)	Estimated difference	p-value*
Total energy	**N=528 (19%)**	**N=2,786 (81%)**		
(kcals[e]/day)	2076 (12.72)	2059 (6.01)	−17.26	.28
Added sugar	**N=528 (19%)**	**N=2,786 (81%)**		
(g[f]/day)	71.4 (.99)	70.1 (.39)	−1.36	.21
Age category	**N=528 (19%)**	**N=2,786 (81%)**		
20–44 years	73.6 (2.21)	70.7 (.69)	−2.87	.25
45–64 years	73.5 (1.35)	69.5 (.54)	−4.01	**.01**
65 years	68.2 (1.49)	70.2 (.82)	2.09	.22
Sex	**N=528 (19%)**	**N=2,786 (81%)**		
Female	71.1 (1.57)	70.9 (.56)	−0.18	.92
Male	71.5 (1.49)	69.1 (.50)	−2.66	.06
Race/Hispanic origin	**N=528 (19%)**	**N=2,786 (81%)**		
Non-Hispanic White	71.5 (1.41)	69.7 (.62)	−1.79	.24
Non-Hispanic Black	71.6 (1.70)	69.7 (.48)	−1.82	.26
Hispanic (including Mexican American and Latino)	71.7 (1.54)	71.1 (.92)	−.60	.75
Other Race including Multi-Racial	70.4 (2.18)	71 (9.3)	.56	.81
Education level[g]	**N=528 (19%)**	**N=2,783 (81%)**		
<High school degree	70.1 (2.48)	69.9 (.79)	−.16	.95
High school degree or GED	73.8 (2.09)	69.2 (.69)	−4.66	**.04**
Some college or college graduate	70.6 (1.21)	70.5 (.58)	−.13	.93
Marital status	**N=528 (19%)**	**N=2,785 (81%)**		
Married	70.6 (1.03)	69.7 (.58)	−.90	.45
Widowed	68.7 (2.82)	71.4 (1.11)	2.70	.37
Divorced	74.2 (3.49)	69.3 (1.43)	−4.92	.21
Separated	77.1 (7.15)	68.9 (2.32)	−8.17	.28

	Aware of prediabetes (SE[d])	Unaware of prediabetes (SE)	Estimated difference	p-value*
Partner	80.2 (3.77)	71 (1.11)	−9.17	**.02**
Never married	70.4 (2.10)	71.3 (.85)	.91	.70
Annual household income [h]	**N = 466 (19%)**	**N = 2,450 (81%)**		
<$20,000	73.2 (2.28)	70.3 (.67)	−2.97	.20
$20,000–$99,999	70.3 (1.27)	69.3 (.48)	−1.04	.47
$100,000	72.9 (2.21)	70.8 (.94)	−2.18	.38
BMI category [i]	**N =524 (19%)**	**N = 2,767 (81%)**		
Underweight 18.49 kg/m^2	86.1 (0)	74.7 (3.97)	−11.32	**<.01**
Normal 18.5–24.99 kg/m^2	71.9 (3.06)	69.8 (.94)	−2.12	.50
Overweight 25–29.99 kg/m^2	68.4 (1.66)	69.3 (.74)	.94	.61
Obese 30 kg/m^2	73.3 (1.26)	70.5 (.57)	−2.79	.07

[a] Usual intake was estimated using the National Cancer Institute Method for total calories and total added sugar and was based on at least 1 day of dietary recall information that contained a value for added sugar.

[b] Sample includes non-pregnant, non-lactating adults 20 years with prediabetes not taking insulin or diabetic medications who also had dietary recall information (Day 1) that contained a value for added sugar.

[c] NHANES = National Health and Nutrition Examination Survey

[d] SE = standard error

[e] Kcals = kilocalories

[f] g = grams

[g] Education level was based on self-reported data asking participants their highest grade or level of school completed/received. < High school includes less than high school degree or no high school diploma. High school includes being a graduate or having a GED or equivalent. Some college or college degree includes some college/ associate degree or greater.

[h] Annual household income includes incomes $20,000 up to $100,000. NHANES does not specify income levels above $100,000

[i] BMI category= body mass index and was based on standard weight status categories using CDC criteria for underweight, normal weight, overweight, obese.

* Bolded p-values indicate statistical significance. All tests were two-sided and p values < .05 were considered statistically significant.

Note: Numbers differ by characteristics due to missing data for the variable.