Diabetes and Food Insecurity in North Carolina: The Effect on Diabetes Management and Diabetes-related Complications

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Background

For persons with diabetes, a healthy diet that includes a variety of fruit, vegetables, whole grains and lean meat, is one of the keys of regulating blood sugar levels on a daily basis.[1] For diabetics who are food insecure, access to a healthy diet is disrupted. Food insecurity involves a range of conditions including persistent stress about food budgets being inadequate, running out of food, cutting the size of meals or skipping meals, and, in extreme cases, going without food for an entire day.[2] By definition food insecurity results from insufficient household resources. Food insecurity therefore exists primarily in low income households but not exclusively, i.e., being unemployed is also a risk factor.[3]

For diabetics from low-income households who suffer from food insecurity, the prospect of managing their disease becomes very difficult. Food-insecure diabetics find themselves caught between competing priorities, such as buying food or medications and testing supplies, while managing other household expenses; the confluence of these factors can worsen the course of the disease.[4] When food-insecure diabetics are forced to rely on low-cost foods that are energy-dense foods, high in carbohydrates and added sugars, their blood sugar levels can become critically high (hyperglycemic), or become critically low (hypoglycemia) when food is limited.[5]

In the medical literature on diabetes and food insecurity, poor glycemic control is often the focus of investigation. The National Center for Health Statistics defines poor glycemic control as hemoglobin A1c (HbA1c) levels greater than 9 percent.[6] (The HbA1c test serves as a marker for average blood glucose concentrations over the previous 2–3 months.[7]) In a study of patients with type 2 diabetes, receiving medical care in federally-funded clinics, researchers found that food insecurity was an independent predictor of poor glycemic control (HbA1c >/= 8.5%), after controlling for income, tobacco use, medication adherence and other risk factors.[8] In a study of low-income diabetes patients, researchers found that food-insecure participants (compared to food secure) were more likely to have poor diabetes self-management, such as daily blood glucose monitoring; more likely to put off paying for testing supplies and diabetes medications in order to pay for food and more likely to have a higher rate of hypoglycemia-related emergency department visits.[9]

Food insecurity and poor glycemic control have also been shown to play a major role in the development and progression of diabetes-related complications. In a large-scale National Health and Nutrition Examination Survey (NHANES) study of low-income participants, researchers found that food insecurity was associated with chronic disease including hypertension and diabetes.[10] In a retrospective study of patients with type 2 diabetes, researchers found that poor glycemic control predicted the onset and progression of diabetic retinopathy.[11] Depression is also known to be common among persons with diabetes. A meta-analysis of 24 studies found that depression was strongly correlated with poor glycemic control and hyperglycemia.[12]

North Carolina has one of the highest food-insecurity rates in the country. In 2013, North Carolina had the fifth highest rate (17.3%) of food insecurity in the United States; the four states with higher rates included Tennessee (17.4%), Texas (18.0%), Mississippi (21.1%) and Arkansas (21.2%)[13] In conjunction with high food insecurity, North Carolina is known to have a comparatively high rate of diabetes. In 2010, North Carolina had the 12th highest rate of adult diabetes in the United States.[14]

This study examines the association between food insecurity and diabetes among North Carolina adults. The purpose of this study is to compare diabetes management (both self-care and clinical care), diabetes risk factors and diabetes-related complications among Behavioral Risk Factor Surveillance System (BRFSS) survey respondents with diabetes, classified as either with or without food insecurity.

Methods

Data were derived from the 2011 and 2012 North Carolina BRFSS surveys. The BRFSS is an annual statewide telephone survey that assesses the health characteristics of non-institutionalized adults ages 18 and older. For both survey years, the samples included landline and cell phone respondents. The BRFSS is administered by all 50 states and several U.S. territories. The survey is sponsored in part by the Centers for Disease Control and Prevention (CDC) in Atlanta.

Study Groups

The study population consisted of respondents with doctor-diagnosed diabetes who answered the CDC Social Context Module question (asked in 2011 and 2012) on stress about food insufficiency, "How often in the past 12 months would you say you were worried or stressed about having enough money to buy nutritious meals?" A total of 2,964 diabetic respondents answered one of the five possible responses to the question. Those who responded "always" or "usually" or "sometimes" were assigned to the *food-insecure* group (n=906; 33.9%); those who responded "rarely" or "never" comprised the food secure group (n=2,058; 66.1%). This same definition and question has been used previously in a multi-state 2009 BRFSS study on hypertension and food insecurity.[15]

Study Outcomes/Dependent Variables

Study outcomes were broken into three domains: 1) health risk factors associated with adversely affecting diabetes and treatment of the disease, 2) self-care and clinical practices for diabetes management and 3) diabetes-related complications. Health risk factors included current smoking, obesity, physical inactivity, depression, no health insurance, diabetes onset before age 30, insulin dependent and lack of diabetes medicines or testing supplies in the past year due to cost.

Self-care of diabetes included three measures: 1) checking feet daily, 2) checking blood sugar at least twice daily and 3) ever had a class in diabetes management. The first and second of these measures were defined to represent recommended or usual self-care practices for diabetes management.[16] Clinical or physician care for diabetes management consisted of three measures: 1) had at least one annual foot exam, 2) had hemoglobin A1c blood sugar levels tested at least twice in the past year and 3) had an annual eye exam. All three of these measures are consistent

Table 1.
Key Demographic Differences for Diabetic Respondents by Food Security Status: 2011 and 2012 N.C. BRFSS Survey

Characteristics	Food Insecure		Food Secure	
	N	%	N	%
Females	632	58.4	1,126	45.8
Age 65+	300	20.7	1,180	45.7
Household income <$15,000	307	34.1	227	10.9
Married	337	47.0	1,073	61.3
Children (1+) in household	194	31.7	197	15.1

with clinical guidelines for diabetes patients meeting glucose control targets.[17]

Complications related to diabetes were defined from questions in the CDC Chronic Conditions and Diabetes modules. These indicators included respondents who reported being told by a doctor that they ever had kidney disease, or diabetes had affected their eyes (diabetic retinopathy) or had been hospitalized in the past year due to diabetes.

Analysis

For all diabetes study indicators, the crude prevalence and corresponding rate ratio (relative risk) was calculated, comparing the food-insecure group to the food secure group. The chi-square statistic was used to test the hypothesis of no association between food security status and the study outcomes. All calculations were conducted in SAS-callable SUDAAN software (SUDAAN Release 11.0.1). All percentages shown in this report are weighted.

Results

Table 1 presents results for five characteristics that most distinguish the two study groups with regard to demographic differences. Diabetic respondents with food insecurity were approximately three times more likely than food secure diabetics to report household incomes below $15,000, about two times more likely to have one or more children living in the home and more likely to be female. By contrast, the food-insecure group was less than half as likely to be age 65 or older and less likely to be married.

Table 2 shows the results for selected risk factors by food security status. For all risk factors, the risk prevalence was statistically significantly higher for diabetics with food insecurity, compared to the corresponding risk among their counterparts. Most notably, the risk of not having medicines or testing supplies due to cost was almost five times higher for the food-insecure group. This was followed by a three-fold risk of not having health insurance. Further, the risks associated with smoking, depression

Table 2.
Prevalence and Rate Ratios for Selected Diabetes Risk Factors by Food Security Status: N.C. BRFSS 2011 and 2012 Surveys

Risk Factors	Food Insecure	Food Secure	Rate Ratios (RR)	Chi-square
	%	%	(95% C.I.)	P value
Current smoking	24.8	13.4	RR=1.85 (1.44, 2.38)	<0.0001
Obese	64.6	51.9	RR=1.25 (1.13, 1.37)	<0.0001
Physical inactivity	48.5	35.2	RR=1.38 (1.21, 1.57)	<0.0001
Doctor-diagnosed depression	45.2	19.6	RR=2.30 (1.95, 2.72)	<0.0001
No health insurance	26.2	7.8	RR=3.35 (2.46, 4.56)	<0.0001
Early onset of diabetes (< age 30)	15.8	8.2	RR=1.92 (1.36, 2.71)	<0.0001
Insulin dependent	39.3	26.2	RR=1.50 (1.28, 1.76)	<0.001
Lack testing supplies or diabetes medicine past year due to cost	36.9	7.7	RR=4.82 (3.58, 6.48)	<0.0001

Table 3.
Prevalence and Rate Ratios for Diabetes Management and Diabetes-related Complications by Food Security Status: N.C. BRFSS 2011 and 2012 Surveys

Indicators	Food Insecure	Food Secure	Rate Ratios (RR)	Chi-square
	%	%	(95% C.I.)	P value
Diabetes self-care:				
Check feet at least once daily	74.7	73.0	RR=1.02 (0.96, 1.10)	0.51
Check blood sugar at least twice daily	49.0	34.9	RR=1.40 (1.23, 1.60)	<0.0001
Ever taken class on managing diabetes	56.0	55.4	RR=1.01 (0.91, 1.12)	0.84
Diabetes clinical care:				
Had at least one foot exam past year	76.7	78.5	RR=0.98 (0.98, 1.04)	0.48
Had HbA1c checked at least twice past year*	69.4	78.3	RR=0.89 (0.82, 0.96)	<0.01
Had eye exam past year (yes)	61.9	75.6	RR=0.82 (0.75, 0.89)	<0.0001
Complications related to diabetes:				
Ever told you had kidney disease	9.6	6.2	RR=1.55 (1.09, 2.23)	0.02
Ever told diabetes has affected eyes	27.8	16.3	RR=1.70 (1.35, 2.15)	<0.0001
Hospitalized due to diabetes past year	12.9	4.1	RR=3.12 (2.11, 4.62)	<0.0001

*Note: Those who reported "never heard of the A1c test" were excluded from the analysis.

and early onset of diabetes were all about two times higher. The excess risk of obesity and physical inactivity was also significant.

Table 3 shows the results for self-care and clinical management of diabetes, as well as complications related to diabetes. Regarding self-care, there was no difference in prevalence between study groups with respect to checking feet daily or taking a class in managing diabetes. However, there was a noticeable difference in monitoring blood glucose: the food-insecure group was 40 percent more likely to check their blood sugar at least twice daily compared to the food secure group.

The results for clinical care show a significant decrease in the utilization of clinical care for food-insecure respondents. The prevalence of having HbA1c checked at least twice in the past year was 11 percent lower, and the prevalence of having an annual eye exam was 18 percent lower—both values were statistically significant. However, there was no difference between groups with respect to having at least one foot exam in the past year.

For the three measures of diabetes-related complications, i.e., kidney disease, diabetic retinopathy and hospitalization due to diabetes, the respective risks were all statistically significantly higher for the food-insecure group, with the risk of hospitalization over three times higher.

Discussion

This study found that the crude rates for all risk factors (Table 2), potentially mediating diabetes onset or poor glycemic control, were significantly higher for respondents in the food-insecure (FI) group compared to respondents in the food secure group. In the medical research, studies have shown that smoking, obesity and physical inactivity are predictors of poor glycemic control. In a study of smokers with diabetes, the authors found a significant improvement in HbA1c levels for smokers who had

quit smoking for one year compared to those who continued to smoke.[18] In a large-scale prospective cohort study, former and current smoking was associated with a higher risk of incident (onset) type 2 diabetes compared with never smoking in men and women.[19] Obesity is also a well-known and well-established risk factor for both diabetes onset and poor glycemic control.[20–21] Physical inactivity has likewise been associated with poor glycemic control. A meta-analysis of controlled clinical trials of diabetes patients in an exercise training program found that when the post-intervention results were pooled, HbA1c was significantly lower in the exercise groups compared to the control groups (no exercise).[22] These findings imply that, if we could have measured HbA1c, we would expect to find a significantly higher rate of poor glycemic control among the FI group than the food secure group.

Barriers to diabetes care, including lack of health insurance and lack of testing supplies or diabetes medicines were both significantly higher in the FI group. Over one-fourth of the FI group had no health insurance and over one-third lacked testing supplies/ medicines in the past year due to cost.

For diabetes-related complications, the crude rates for both diabetic retinopathy and kidney disease were statistically significantly higher in the FI group. These findings may be related to the excess risk of insulin dependency and early onset of diabetes also found in the FI group. In a population-based study of 1,414 diabetics, researchers found that the prevalence of diabetic retinopathy was almost two times higher in subjects who developed diabetes before age 40 than those who developed it later.[23] Similarly, findings from the Wisconsin Epidemiological Study of Diabetic Retinopathy found that the prevalence of diabetic retinopathy was related not only to early diabetes onset (before age 30) but also use of insulin.[24] Food insecurity has also been linked to chronic kidney disease (CKD). A large-scale study using data from the National Health and Nutrition Examination Survey (NHANES) 2003–2008, found that food insecurity contributed to disparities in CKD, especially among persons with hypertension or

diabetes.[25] This study found that prevalence of kidney disease was 55 percent higher in the FI group.

Regarding diabetes self-care, there were no differences in prevalence between study groups with respect to foot care or ever taking a class in diabetes management. However, the prevalence of monitoring blood glucose at least twice daily was significantly higher in the FI group. One of the reasons for this may be due to the high proportion (39.3%) of insulin-dependent respondents in the FI group, i.e., those most likely to require glucose testing at least twice daily. When we cross-tabulated this indicator with food secure diabetics, who were also insulin dependent, their 2+ daily testing rate was 70.8 percent, close to the rate of 74.5 percent for the FI group (results not shown).

In terms of diabetes clinical/physician care, the results showed no difference in prevalence between groups with respect to having an annual foot exam. However, the prevalence was significantly lower for the FI group with respect to having HbA1c checked at least twice yearly or having an annual eye exam. The latter finding is disturbing given that the risk of eye disease was elevated in the FI group.

In conclusion, this study shows that food-insecure adults with diabetes in North Carolina have an excess risk of adverse health behaviors (smoking, physical inactivity, obesity), less access to clinical care (HbA1c checked twice yearly, annual eye exam), and higher risk of diabetes-related complications (diabetic retinopathy, kidney disease, hospitalization) than food secure adults with diabetes. The extent of agreement between the study findings (diabetes risk/complications) and previously-cited research points to the validity of the use of the single BRFSS question on food security and the definition used to define food-insecure respondents. In much of the cited-research, food insecurity was assessed using standardized food security modules containing multiple questions. Where the study findings diverge from the cited-research was with respect to diabetes self-care practices. The FI group did not fare worse on these indicators compared to the food secure group.

The results of this study provide evidence that food insecurity is an important social determinant of health. Given the large number of adults in North Carolina—an estimated 3.4 million—who were affected by food insecurity in 2011 and in 2012, and given the high rate of diet-sensitive chronic diseases in the state, including heart disease and hypertension, it can be argued that there is a need for periodic, public health surveillance of food security in North Carolina. Secondly, the reader should view the results of this study as baseline data (unadjusted estimates) on the association between food insecurity and diabetes in North Carolina. Age and education, for example—both likely to confound the association between food insecurity and diabetes—were not controlled for in this study. As a consequence, the degree of significance reported across the study outcomes would likely be altered or attenuated if these factors were accounted for in the analyses.

References

1. Nelson, J. Healthy eating especially important for those who have diabetes. Mayo Clinic Health Letter 2014. http://healthletter.mayoclinic.com/editorial.cfm. Accessed Nov. 4, 2014.

2. Bickel G, Nord M, Price C, Hamilton W, Cook J. Guide to Measuring Household Food Security. United States Department of Agriculture. Measuring Food Security in the United States. Alexandria, Va.; 2000.

3. Coleman-Jensen A, Gregory C, Singh. Household Food Security in the United States in 2013: Statistical Supplement, AP-066, U.S. Department of Agriculture, Economic Research Service, September 2014.

4. Gucciardi E, Vahabi M, Norris N, Del Monte JP, Farnum C. The Intersection between Food Insecurity and Diabetes: A Review. *Current Nutrition Reports*. 2014;3(4):324–32.

5. Lopez A, Seligman HK. Clinical Management of Food-Insecure Individuals With Diabetes. American Diabetes Association. Diabetes Spectrum. February 2012; 25(1):14–18.

6. National Center for Health Statistics. Health, United States, 2013: With Special Feature on Prescription Drugs. Hyattsville, Md. 2014.

7. Mayo Clinic. Tests and Procedures, A1c Test Definition 2014. www.mayoclinic.org/tests-procedures/a1c-test/basics/definition/prc-20012585. Accessed Nov. 4, 2014.

8. Seligman HK, Jacobs EA, López A, Tschann J, Fernandez A. Food insecurity and glycemic control among low-income patients with type 2 diabetes. *Diabetes Care*. 2012;35(2):233–8.

9. Seligman HK1, Davis TC, Schillinger D, Wolf MS. Food insecurity is associated with hypoglycemia and poor diabetes self-management in a low-income sample with diabetes. *Journal of Health Care for the Poor and Underserved*. 2010;21(4):1227–33.

10. Seligman HK, Laraia BA, Kushel MB. Food insecurity is associated with chronic disease among low-income NHANES participants. *The Journal of Nutrition*. 2010;140(2):304–10.

11. Pan J, Li Q, Zhang L, Jia L, Tang J, Bao Y, Jia W. Serum glycated albumin predicts the progression of diabetic retinopathy-a five year retrospective longitudinal study. *Journal of Diabetes and Its Complications*. 2014;28(6):772–8.

12. Lustman PJ, Anderson RJ, Freedland KE, de Groot M, Carney RM, Clouse RE. Depression and poor glycemic control: a meta-analytic review of the literature. *Diabetes Care*. 2000;23(7):934–42.

13. Coleman-Jensen A, Gregory C, Singh A. Household Food Security in the United States in 2013, ERR-173, U.S. Department of Agriculture, Economic Research Service, September 2014.

14. Centers for Disease Control and Prevention. *Diabetes Report Card 2012*. Atlanta: Centers for Disease Control and Prevention, U.S. Department of Health and Human Services; 2012.

15. Irving SM, Njai RS, Siegel PZ. Food Insecurity and Self-Reported Hypertension Among Hispanic, Black, and White Adults in 12 States, Behavioral Risk Factor Surveillance System, 2009. *Preventing Chronic Disease* 2014;11:140190. DOI: http://dx.doi.org/10.5888/pcd11.140190.

16. Centers for Disease Control and Prevention. Take Charge of Your Diabetes . 4th edition. Atlanta: U.S. Department of Health and Human Services, 2007.

17. American Diabetes Association. Standards of Medical Care in Diabetes--2014. *Diabetes Care*. January 2014;(37) Supplement 1:514–580.

18. Gunton JE, Davies L, Wilmshurst E, Fulcher G, McElduff A. Cigarette smoking affects glycemic control in diabetes. *Diabetes Care*. 2002;25(4):796–7.

19. The InterAct Consortium, Spijkerman AM, van der A DL, Nilsson PM, Ardanaz E, Gavrila D), et al. Smoking and Long-Term Risk of Type 2 Diabetes: The EPIC-InterAct Study in European Populations. *Diabetes Care*. 2014;37(12):3164–71.

20. Hillier TA1, Pedula KL. Characteristics of an adult population with newly diagnosed type 2 diabetes: the relation of obesity and age of onset. *Diabetes Care*. 2001;24(9):1522–7.

21. Kushiyama A, Yoshida Y, Kikuchi T, Suzawa N, Yamamoto M, Tanaka K, Okayasu M, et al. Twenty-year trend of increasing obesity in young patients with poorly controlled type 2 diabetes at first diagnosis in urban Japan. *Journal of Diabetes Investigation*. 2013;4(6):540–5

22. Boulé NG, Haddad E, Kenny GP, Wells GA, Sigal RJ. Effects of exercise on glycemic control and body mass in type 2 diabetes mellitus: a meta-analysis of controlled clinical trials. *Journal of the American Medical Association*. 2001;286(10):1218–27.

23. Raman R, Vaitheeswaran K, Vinita K, Sharma T. Is Prevalence of Retinopathy Related to the Age of Onset of Diabetes? Sankara Nethralaya Diabetic Retinopathy Epidemiology and Molecular Genetic Report No. 5. *Ophthalmic Research*. 2011;45:36–41.

24. Klein R, Davis MD, Moss SE, Klein BE, DeMets DL. The Wisconsin Epidemiologic Study of Diabetic Retinopathy. A comparison of retinopathy in younger and older onset diabetic persons. *Advances in Experimental Medicine and Biology.* 1985;189:321–35.

25. Crews DC, Kuczmarski MF, Grubbs V, Hedgeman E, Shahinian VB, Evans MK, et al. Effect of food insecurity on chronic kidney disease in lower-income Americans. *American Journal of Nephrology*. 2014;39(1):27–35.

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