Preventive Medicine 83 (2016) 41–45

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Household food insecurity and medication "scrimping" among US adults with diabetes

Chadwick K. Knight [a,*], Janice C. Probst [b], Angela D. Liese [c], Erica Sercy [e], Sonya J. Jones [d]

[a] South Carolina Department of Health and Environmental Control, United States
[b] Department of Health Services Policy and Management, Arnold School of Public Health, 915 Greene Street, Room 355, University of South Carolina, Columbia, SC 29208, United States
[c] Department of Epidemiology and Biostatistics, Arnold School of Public Health, 915 Greene Street, Room 461, University of South Carolina, Columbia, SC 29208, United States
[d] Department of Health Promotion, Education and Behavior, Arnold School of Public Health, 915 Greene Street, Room 435B, University of South Carolina, Columbia, SC 29208, United States
[e] Cancer Prevention and Control Program, Arnold School of Public Health, 915 Greene Street, Room 249, University of South Carolina, Columbia, SC 29208, United States

ARTICLE INFO

Available online 4 December 2015

Keywords:
Diabetes
Food insecurity
Medication restriction

ABSTRACT

Objective. Our research examined the prevalence of food insecurity among adults with self-reported diabetes and whether food insecurity was associated with cutting back ("scrimping") on prescribed medications because of financial constraints.

Methods. We conducted a cross-sectional analysis of data from the 2011 National Health Interview Survey (NHIS). Adults completing this survey were considered to have diabetes if they reported current use of insulin or "diabetic pills" (n=3,242). Food insecurity was determined with a 10-item scale; respondents were categorized as food secure (FS), marginally food secure (MFS) or food insecure (FI).

Results. Approximately one in six adults in NHIS with diabetes reported food insecurity (17.0%), and an additional 8.8% were marginally FS. An individual was considered to be scrimping on medications if he/she gave a "yes" response to at least one of four questions pertaining to reduced, delayed or avoided medication use. Overall, 18.9% of respondents with diabetes reported one or more type of medication scrimping: 11.7% of FS individuals, 27.7% of MFS individuals and 45.6% of FI individuals. In adjusted analyses, marginal food security and food insecurity remained strongly associated with scrimping.

Conclusions. One-quarter of adults with diabetes may have difficulty obtaining foods appropriate for a diabetic diet; a substantial number of these individuals also fail to obtain or take medications. Practitioners may miss either problem unless targeted questions are included in clinical encounters. Clinicians should consider referring FI and MFS diabetic patients to community food resources.

Introduction

Food insecurity (FI) is defined as individuals and/or families in a household adjusting their dietary intakes or preferences because of a lack of physical or economic resources (National Research Council, 2006; Anon., 2005, 2013a). Approximately 15% of American households were FI at some point during 2011 (Coleman-Jensen et al., 2012). Among individuals with chronic illness, the level of household food insecurity is even higher (18.8%) (Berkowitz et al., 2014). Food insecurity is linked to poverty and socioeconomic disparities in the United States (US) (Seligman and Schillinger, 2010; Siefert et al., 2001). Because of limited resources, FI households often decrease the variety of foods they consume and increase their consumption of less expensive, energy-dense groceries that contain refined grains, added sugars and saturated or trans fats (Seligman et al., 2010a). FI households typically consume fewer servings of the daily recommended levels of fruits, vegetables and dairy products compared to FS households (Seligman and Schillinger, 2010; Kendall et al., 1996; Dixon et al., 2001). Food insecurity has been linked to poorer metabolic control among persons with diabetes (Smalls et al., 2015; Heerman et al., 2015; Seligman et al., 2010b) and self-reported episodes of hypoglycemia (Berkowitz et al., 2013; Seligman et al., 2011).

Household financial strain also manifests in other ways, including failure to obtain needed medications (Berkowitz et al., 2014). Links between food insecurity and medication use have been documented for both working-age (Herman et al., 2015) and older (Afulani et al., 2015) adults. Among diabetics with limited incomes, medication costs can be a competing demand with food costs (Seligman and Schillinger, 2010; Heerman et al., 2015; Sattler et al., 2014). FI adults are less likely to purchase costly medication or adhere to recommended prescription guidelines when compared to FS peers (Bengle et al., 2010; Sattler and Lee, 2013). The need to choose between food and

Abbreviations: FS, food secure; MFS, marginally food secure; FI, food insecure; NHIS, National Health Interview Survey; BMI, body mass index.

* Corresponding author at: 331 Clermont Lakes Drive, Lexington, SC 29073, United States. Fax: +1 803 777 1836.
E-mail address: chadwick159@hotmail.com (C.K. Knight).

http://dx.doi.org/10.1016/j.ypmed.2015.11.031
0091-7435/

medication can exacerbate disease symptoms and cause either acute or chronic health problems if an individual gets an insufficient supply of one or the other, resulting in increased utilization of healthcare or more frequent trips to the emergency room or hospital, as well as poorer metabolic control in persons with diabetes (Biros et al., 2005). In low-income populations—but not others—hospital admissions for hypoglycemia are the highest during the last week of the month, suggesting strained financial resources for food and medication (Seligman et al., 2014).

Recent work (Berkowitz et al., 2014) has documented a relationship between food insecurity and failure to obtain or use medications among persons with chronic disease (Berkowitz et al., 2014), including diabetes (Sattler et al., 2014; Moreno et al., 2015; Silverman et al., 2015). Our work expands on this prior study by focusing on persons with diabetes, providing more detail about the types of medication restriction, or scrimping, seen among this population. This issue is particularly important in diabetic patients because of the role food has in this disease; a healthy diet can help in successful diabetes management and the control of blood sugar levels, and diabetic patients must use a combination of medication (e.g., insulin) and diet to manage their condition (American Diabetes Association, 2010). Insufficient supply of either of these two factors can lead to adverse health effects among diabetic individuals in particular. Our paper addresses two questions: (1) what is the prevalence of food insecurity in a national sample of adults with diabetes; and (2) what is the prevalence of medication scrimping, defined as failing to obtain and/or use all prescribed medications for financial reasons, among persons with diabetes?

Methods

Study design and population

We conducted a cross-sectional analysis using data from the 2011 National Health Interview Survey (NHIS). The NHIS, a cross-sectional, nationally representative survey of the non-institutionalized US population, has been a principal source of information on the health status of adults and children in the US since its initiation in 1957 (King, 2011). The sampling frame is stratified by state and within state into smaller geographic units; non-white populations are oversampled to ensure adequate numbers of observations. Final observations are weighted to reflect the US population (Parsons et al., 2014). The NHIS is designed by the National Center for Health Statistics of the US Centers for Disease Control and Prevention and is conducted in the household by trained interviewers from the Census Bureau (Anon., 2013b).

Approximately 35,000 households comprising 87,500 individuals completed the survey. Adults were considered to have diabetes if they responded that they are "now taking insulin" and/or "now taking diabetic pills;" these respondents with diabetes were the principal study population ($n = 3240$). Research linking Medicare claims to the NHIS found a high degree of concordance between self-reported and documented diabetes (93%), with under-reporting being more common than over-reporting. Thus, our sample may underrepresent the US adult population with diabetes, particularly persons who are younger and in self-perceived good health (Day and Parker, 2013). This research was approved by the Institutional Review Board at [name suppressed for blinding].

Dependent variable

The dependent variable in our study model is medication non-adherence because of financial constraints, for which we have chosen the label scrimping. NHIS respondents were asked whether they "couldn't afford prescription medicine," "skipped medication doses to save money," "took less medicine to save money" or "delayed filling a prescription to save money." A positive response to any of these questions was categorized as medication scrimping.

Independent variables

Food insecurity

Ten questions on the 2011 NHIS questionnaire address adult food insecurity (Table 1). These questions were sponsored by the US Department of Agriculture (USDA) (Economic Research Service, U.S. Department of Agriculture) and were drawn from the 30-Day Food Security scale (Nord, 2002), a measure of family food security (Frongillo, 1999). Using USDA cut points, the National Center for Health Statistics categorized households as high food security (no items affirmed), marginal food security (1–2 items affirmed), low food security (3–5 items affirmed) or very low food security (6–10 items affirmed). For the present analysis, respondents were considered to be FI if they fell into either the low food security or very low food security category.

Socioeconomic and other variables

Several demographic and socioeconomic variables that were potentially associated with food insecurity and/or medication adherence were selected. Demographic variables included sex, age (years), race/ethnicity and BMI. Race/ethnicity was self-reported and was categorized as non-Hispanic white, non-Hispanic black, Hispanic or other. We included race because this characteristic may have implications on the interactions between specific respondents and healthcare workers. Age was self-reported and verified during the NHIS interview. Using BMI, respondents were characterized as underweight (BMI less than 18.49), normal weight (BMI 18.50–24.99), overweight (BMI 25.00–29.99) or obese (BMI 30.00 or higher). Other socioeconomic factors included were education, working status, occupation, income, region of residence and health insurance.

Statistical analysis

Data were weighted to reflect the unequal probability of selection and clustering within strata of the NHIS design (Adams et al., 2011). Statistical analysis was conducted utilizing SAS 9.3 software (version 9.3; SAS Institute Inc., Cary, North Carolina). Bivariate analyses (chi-square) test associations between food insecurity and the dependent variable (non-adherence to recommended prescription guidelines because of financial constraints, or medication scrimping). Multivariate logistic regression models assess the relationship between food insecurity and medication scrimping while adjusting for demographic and socioeconomic characteristics of each individual.

Results

Demographic characteristics of adults with diabetes

Respondents with diabetes were divided evenly by gender (49.8% female), principally white (63.3%) and mostly 45 years of age and older (86.9%; Table 1). Slightly more than one-third of respondents with diabetes (34.0%) had household incomes below 200% of the federal poverty level. More than one-half of respondents with diabetes reported having public health insurance (55.9%). Obesity (54.9%) and overweight status (30.0%) were common. Table 1 shows detailed characteristics of the adult respondents included in the study.

Prevalence of food insecurity among adults with diabetes

Approximately one in six respondents with diabetes reported food insecurity (17.0%), with an additional 8.8% being classified as MFS. Females were more likely to report food insecurity than males (Table 1). Black and Hispanic adults with diabetes were more likely to report food insecurity than whites (28.7% and 26.5%, respectively, versus 12.1% among whites); these two groups were similarly more likely to report marginal food security (Table 1). Younger adults (18–44 years of age) with diabetes were more apt to report food insecurity (30.7%) and marginal food security (13.4%) compared to older respondents. About one-half of adults with diabetes who reported food insecurity had a high school education or less (46.4%); 22.3% of MFS respondents had a high school education or less. Slightly more than two-thirds of diabetic respondents who reported food insecurity (67.8%), and 24.1% of those with marginal food security, had household incomes below 200% of the federal poverty level. Most adults with diabetes reported having either private (34.2%) or public (55.9%) health insurance, which is relevant to their ability to afford medications. However, FI and MFS diabetic adults were more likely to be uninsured than their FS peers. FI and MFS adults with diabetes were also more likely to be

Table 1
Characteristics of adults with diabetes by food security status, 2011 National Health Interview Survey.

Un-weighted observations (*n*)	Total 3240	Food secure 2278	Marginally food secure 297	Food insecure 665	
Variable	% (SE)[a]	% (SE)[a]	% (SE)[a]	% (SE)[a]	P value
Total, all adults	100.0 (0)	74.2 (0.92)	8.8 (0.59)	17.0 (0.73)	
Medication-restriction behavior					
Couldn't afford prescription medicine[b]	15.0 (0.72)	7.6 (0.70)	21.3 (2.98)	43.8 (2.26)	<0.0001
Skipped medication doses to save money[b]	13.1 (0.70)	7.1 (0.67)	19.9 (2.74)	35.2 (2.26)	<0.0001
Took less medicine to save money[b]	13.8 (0.71)	8.0 (0.70)	17.6 (2.76)	36.5 (2.30)	<0.0001
Delayed filling a prescription to save money[b]	16.4 (0.75)	9.4 (0.74)	22.8 (2.92)	43.7 (2.38)	<0.0001
Total, any medication scrimping[c]	18.9 (0.83)	11.7 (0.85)	27.7 (3.16)	45.6 (2.37)	<0.0001
Other characteristics					
Gender					<0.0001
Male	50.2 (1.04)	78.7 (1.19)	7.5 (0.82)	13.9 (0.96)	
Female	49.8 (1.04)	69.7 (1.31)	10.2 (0.84)	20.1 (1.09)	
Race					<0.0001
Non-Hispanic white	63.3 (1.01)	81.5 (1.08)	6.4 (0.70)	12.1 (0.83)	
Non-Hispanic black	15.3 (0.72)	58.2 (2.18)	13.0 (1.64)	28.7 (1.97)	
Hispanic	14.8 (0.69)	58.8 (2.55)	14.7 (1.80)	26.5 (2.08)	
Other	6.6 (0.54)	76.1 (3.28)	9.2 (2.21)	14.8 (2.78)	
Age					<0.0001
18–44	13.2 (0.76)	55.8 (2.73)	13.4 (2.02)	30.8 (2.52)	
45–64	47.1 (1.09)	71.2 (1.38)	9.6 (0.88)	19.3 (1.17)	
65+	39.7 (1.01)	83.9 (1.14)	6.5 (0.73)	9.60 (0.90)	
Education					<0.0001
Less than high school education	13.1 (0.62)	59.8 (2.51)	12.4 (1.70)	27.7 (2.11)	
High school graduate/G.E.D.	25.9 (0.95)	71.5 (1.93)	9.8 (1.28)	18.7 (1.54)	
Some college credits or above	61.0 (1.05)	78.5 (1.12)	7.6 (0.76)	13.9 (0.90)	
Income (% of federal poverty level)					<0.0001
<100%	14.7 (0.69)	48.2 (2.16)	13.6 (1.49)	38.2 (2.29)	
≥100%, <200%	19.3 (0.76)	60.0 (2.12)	10.5 (1.44)	29.6 (1.92)	
≥200%, <300%	22.0 (0.90)	82.0 (1.93)	7.6 (1.29)	10.4 (1.46)	
≥300%	34.1 (0.99)	88.8 (1.17)	6.5 (0.98)	4.6 (0.74)	
Missing[d]	9.9 (0.64)	73.0 (2.83)	9.3 (1.97)	17.7 (2.47)	
Region					0.0009
Northeast	16.2 (0.8)	78.4 (2.2)	8.6 (1.5)	13.0 (1.6)	
Midwest	22.3 (0.9)	80.0 (1.8)	6.4 (1.2)	13.6 (1.4)	
South	40.5 (1.1)	71.0 (1.5)	10.0 (1.0)	19.0 (1.2)	
West	21.0 (0.9)	71.0 (2.0)	9.4 (1.2)	19.6 (1.8)	
Health insurance					<0.0001
Private (private or Medi-gap)	34.2 (1.08)	82.3 (1.44)	6.4 (0.89)	11.3 (1.18)	
Public	55.9 (1.15)	72.9 (1.24)	9.4 (0.80)	17.8 (0.99)	
None	9.9 (0.58)	54.0 (3.07)	14.2 (2.52)	31.8 (2.82)	
Body mass index					0.0474
Underweight or normal (≤24.99)	15.1 (0.71)	78.8 (2.31)	6.9 (1.38)	14.4 (1.85)	
Overweight (25.00–29.99)	30.0 (0.94)	76.1 (1.53)	8.5 (0.99)	15.4 (1.20)	
Obese (30.00+)	54.9 (1.04)	71.9 (1.26)	9.5 (0.81)	18.5 (1.02)	

Values shown are US national estimates. All statistical analyses were performed with chi-square tests.
[a] SE, standard error.
[b] Percentage (SE) shown answering "yes" to the medication-restriction question.
[c] Percentage (SE) shown answering "yes" to at least one medication-restriction question.
[d] Missing data retained to keep observations; income is the only variable containing missing data.

overweight (15.4% and 8.5%, respectively) or obese (18.5% and 9.5%, respectively).

Prevalence of medication scrimping among adults with diabetes

Nearly one in five respondents with diabetes reported some form of medication scrimping (18.9%; Table 1). The most common form of medication restriction was delaying filling prescriptions to save money (16.4%), followed by inability to afford medications at all (15.0%), taking less medication (13.8%) or skipping doses (13.1%). The prevalence of all scrimping behaviors was higher among FI and MFS adults compared to FS adults. Over one-third of FI adults with diabetes reported skipping doses (35.2%), taking less medication (36.5%) or delaying filling medications to save money (43.7%), with 45.6% of respondents affirming at least one of the scrimping questions. In contrast, the prevalence of these behaviors ranged from 7.6% to 11.7% among FS persons with diabetes (Table 1).

Adjusted relationship between food insecurity and medication scrimping

Multivariate adjusted analyses confirmed that food insecurity was positively and strongly associated with scrimping ($P < 0.0001$), independent of a large number of covariates (Table 2). Specifically, FI respondents with diabetes had approximately six-fold higher odds of medication scrimping (odds ratio (OR) 5.89, 95% confidence interval (CI) 4.22, 8.23), and MFS respondents had approximately two and one-half higher odds of medication scrimping (OR 2.66, 95% CI 1.78, 3.98), compared to FS respondents, adjusting for age, gender, race, education, occupation, income, region, health insurance, body mass index, consultation with a health professional on diet and frequency of health care provider visits.

Discussion

An estimated 17.0% of US adults with diabetes live in FI households, and an additional 8.8% live in MFS households. Thus, approximately 3.4

Table 2
Adjusted odds for medication scrimping among adults with diabetes, 2010 National Health Interview Survey.

Characteristic	Odds ratio	95% confidence interval		P value
Food security				<0.0001
Food security	1.00			
Marginal food security	2.66	1.78	3.98	
Food insecurity	5.89	4.22	8.23	
Gender				0.0594
Female	1.30	0.99	1.70	
Race				0.0426
Non-Hispanic white (referent)	1.00			
Non-Hispanic black	0.74	0.55	1.00	
Hispanic	0.65	0.45	0.92	
Other	0.94	0.55	1.59	
Age (years)				0.0002
18–44	1.73	1.14	2.63	
45–64	2.00	1.44	2.77	
65 and older (referent)	0.00			
Education				0.0067
Less than high school education	0.55	0.38	0.80	
High school graduate/G.E.D.	0.87	0.65	1.18	
Some college credits, associate, bachelor, masters, doctorate or professional degree (referent)	1.00			
Income (percentage of federal poverty level)				0.0003
Income <100%	1.08	0.66	1.76	
Income between 100% and 200%	2.01	1.37	2.94	
Income between 200% and 300%	1.80	1.25	2.57	
Income greater than 300% (referent)	1.00			
Missing (retained to keep observations)	1.27	0.73	2.21	
Region				0.0395
Northeast (referent)	1.00			
Midwest	1.48	0.91	2.42	
South	1.87	1.19	2.92	
West	1.50	0.91	2.48	
Health insurance				<0.0001
Private (private or Medi-gap; referent)	1.00			
Public	0.75	0.54	1.04	
None	3.06	2.03	4.62	
Body mass index				0.0004
Underweight or normal (≤24.99; referent)	1.00			
Overweight (25.00–29.99)	1.34	0.87	2.07	
Obese (30.00 or higher)	1.99	1.35	2.93	

Statistical analyses were conducted using multivariate logistic regression based on a single independent variable, and P values for medication scrimping were based on a single independent variable in the model (assuming linearity). Included in the model but not shown: occupation (not significant), doctor/other discussed diet and number of visits in past 12 months.

million persons, or about one-quarter of all adults with diabetes, may have difficulty securing the types of foods most appropriate for their diet. Given the role of diet in diabetes control, diabetic adults who live in FI households are at higher risk of adverse clinical outcomes, such as hypoglycemia (Smalls et al., 2015; Heerman et al., 2015; Seligman et al., 2010b).

In addition, adults with diabetes who experience food insecurity may be limited in the amount of money available to spend on medications. Diabetics who were FI were more likely to affirm each of the possible indications of medication scrimping, a relationship that persisted even after adjusting for other financial constraints, such as income level and insurance status. These findings are consistent with those of previous studies of adults with diabetes carried out in California (Billimek and Sorkin, 2012) and with the finding from the more recent work by Berkowitz et al. (2014) that food insecurity is linked to medication use across persons with a range of chronic diseases.

We found that uninsured adults were particularly at risk for medication scrimping (adjusted OR 3.06, 95% CI 2.03, 4.62). The 2011 NHIS preceded implementation of the Affordable Care Act. During the past 2 years, reduction in the number of uninsured persons generally may have led to improved medication compliance among adults with diabetes. However, states that have not participated in Medicaid expansion are disproportionately located in the South and West, areas that are associated with a higher prevalence of food insecurity. Low-income adults who experience food insecurity in these states may experience the same risks for medication scrimping found in 2011.

Our study could not assess whether the relationships between food insecurity and medication scrimping differ between urban and rural areas, as residence information is not available in NHIS public use files. However, annual reports from the USDA suggest that food insecurity, paradoxically, is higher in rural America (17%) than in urban (16%) or suburban (12%) communities (Coleman-Jensen et al., 2015). Adults with diabetes in rural areas may also have fewer resources to assist with medication costs. Free clinics, which might provide help for low-income and uninsured patients, are located principally in urban counties (Martin et al., submitted for publication).

Our research is subject to the limitations typically associated with survey research, such as recall bias. The causality between food insecurity and scrimping also cannot be determined because of the cross-sectional nature of the analysis. In addition, as noted previously by Berkowitz et al., food security is a household-level variable, whereas disease control (diabetes) is measured at the individual level (Berkowitz et al., 2013). On a related note, although we have data on whether a household as a whole lacked food, we do not know whether each individual respondent was affected. Similarly, we do not know which medications the respondent chose to restrict or whether this restriction extended to other diagnostic provisions that generally accompany medications for adults with diabetes (i.e., glucose testing strips, syringes, etc.). In addition, our analyses are based on persons who self-identify as having diabetes. Prior research suggests that under-reporting occurs among this population and is more common among healthier, younger respondents (Day and Parker, 2013) Nonetheless, our findings are consistent with other research on food insecurity in adults with diabetes. A strength of this study is that it is one of the first to use the US NHIS data to evaluate associations between food insecurity and medication adherence among persons with diabetes, rather than across all persons with chronic disease (e.g., Berkowitz et al., 2014) or the total population (e.g., Herman et al., 2015; Afulani et al., 2015). Our findings parallel similar work at the national level conducted in Canada (Gucciardi et al., 2009).

Conclusions

Food security screening during physician office visits can assist primary care providers in two ways: identifying patients who need food assistance referrals, and identifying patients unable to comply with certain prescribed treatments (Holben, 2004). Study findings have suggested that healthcare processes for adults with diabetes should include a food-oriented referral when needed.

Most medical providers are familiar with medication programs for low-income persons. Our findings suggest that it would also be prudent for providers to become familiar with supplemental food programs for the treatment of individuals with diabetes. A physician and/or staff member can guide the patient to community resources that will aid in improving his/her food security. In addition, clinicians can refer patients towards federal- and state-funded programs (i.e., Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), Supplemental Nutrition Assistance Program (SNAP, previously referred to as food stamps), Meals on Wheels, etc.) or to local food pantries and banks (Holben, 2004).

Other possible implications of this study include the expansion of diet counseling for adult patients with diabetes to include financial as well as nutritional guidance, particularly for individuals with a higher risk for food insecurity. FI patients may benefit from tips on stretching their budgets, planning healthy low-cost meals and/or nearby locations to purchase quality foods at lower prices. The Massachusetts General Hospital, for example, runs the Food for Families Program, which

actively connects FI patients to federal, state and local resources to ensure that they have ample access to healthy food (Anon., 2014).

Food insecurity is both prevalent in the population of adults with diabetes and highly associated with medication adherence, particularly among young, poor and uninsured persons. Even in an age of increasing healthcare reform, innovative community-based programs are needed to address these twin needs and secure the best possible outcomes for patients.

Conflict of interest statement

The authors declare that there are no conflicts of interests.

Acknowledgments

C.K. and J.P. researched data, wrote and edited the manuscript and contributed to the discussion. A.L. and S.J. reviewed/edited the manuscript and contributed to the discussion. E.S. provided editorial assistance and contributed to preparing the manuscript for publication. C.K. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. No funding was received for this work.

References

Adams, P.F., Martinez, M.E., Vickerie, J.L., Kirzinger, W.K., 2011. Summary health statistics for the U.S. population: National Health Interview Survey, 2010. Vital Health Stat 10(251). National Center for Health Statistics.

Afulani, P., Herman, D., Coleman-Jensen, A., Harrison, G.G., 2015. Food insecurity and health outcomes among older adults: the role of cost-related medication underuse. J. Nutr. Gerontol. Geriatr. 34 (3), 319–342 (Jul-Sep).

American Diabetes Association, 2010. Standards of medical care in diabetes—2010. Diabetes Care 33 (Suppl. 1), S11–S61 (Jan).

Anon., 2005. A comparison of surveys for food insecurity and hunger measurement (article online)Available from http://www.nationalacademies/CNSTAT/ (Accessed 7 June 2013).

Anon., 2013a. Trade, foreign policy, diplomacy and health (article online)Available from http://www.who.int/trade/glossary/story028/en/ (Accessed 19 June 2013).

Anon., 2013b. About the National Health Interview Survey (article online)Available from http://www.cdc.gov/nchs/nhis/about_nhis.htm (Accessed 12 May 2013).

Anon., 2014. Food for families. (article online)Available from http://www.massgeneral.org/cchi/services/treatmentprograms.aspx?id=1502 (Accessed 24 January 2014).

Bengle, R., Sinnett, S., Johnson, T., et al., 2010. Food insecurity is associated with cost-related medication non-adherence in community-dwelling, low-income older adults in Georgia. J. Nutr. Elder. 29 (2), 170–191 (Apr).

Berkowitz, S.A., Baggett, T.P., Wexler, D.J., et al., 2013. Food insecurity and metabolic control among U.S. adults with diabetes. Diabetes Care 36 (10), 3093–3099 (Oct).

Berkowitz, S.A., Lman, H.K., Choudhry, N.K., 2014. Treat or eat: food insecurity, cost-related medication underuse, and unmet needs. Am. J. Med. 127 (4), 303–310 (Apr).

Billimek, J., Sorkin, D.H., 2012. Food insecurity, processes of care and self-reported medication underuse in patients with type 2 diabetes: results from the California Health Interview Survey. Health Serv. Res. 47 (6), 2159–2168 (Dec).

Biros, M.H., Hoffman, P.L., Resch, K., 2005. The prevalence and perceived health consequences of hunger in emergency department patient populations. Acad. Emerg. Med. 12 (4), 310–317 (Apr).

Coleman-Jensen, A., Nord, M., Andrews, M., et al., 2012. Household Food Security in the United States in 2011. U.S. Department of Agriculture, Economic Research Service (ERR-141, September).

Coleman-Jensen, A., Rabbitt, M., Gregory, C., Singh, A., 2015. Household Food Security in the United States in 2014, ERR-194. U.S. Department of Agriculture, Economic Research Service (September).

Day, H.R., Parker, J.D., 2013. Self-report of diabetes and claims-based identification of diabetes among Medicare beneficiaries. Natl. Health Stat. Rep. (69), 1–14 (Nov 1).

Dixon, L.B., Winkleby, M.A., Radimer, K.L., 2001. Dietary intakes and serum nutrients differ between adults from food-insufficient and food-sufficient families: third national health and nutrition examination survey, 1988–1994. J. Nutr. 131 (4), 123–1246 (Apr).

Economic Research Service, U.S. Department of Agriculture, d. Food security in the USAvailable at http://www.ers.usda.gov/data-products/food-security-in-the-united-states/documentation.aspx#NHIS (Accessed October 22, 015).

Frongillo Jr., E.A., 1999. Validation of measures of food insecurity and hunger. J. Nutr. 129 (2S Suppl.), 506S–509S (Feb).

Gucciardi, E., Vogt, J.A., DeMelo, M., et al., 2009. Exploration of the relationship between household food insecurity and diabetes in Canada. Diabetes Care 32 (12), 2218–2224 (Dec).

Heerman, W., Wallston, K.A., Osborn, C.Y., et al., 2015. Food insecurity is associated with diabetes self-care behaviours and glycaemic control. Diabet. Med. (Aug 28, Epub ahead of print), http://dx.doi.org//10.1111/dme.12896.

Herman, D., Afulani, P., Coleman-Jensen, A., Harrison, G.G., 2015. Food insecurity and cost-related medication underuse among nonelderly adults in a nationally representative sample. Am. J. Public Health 105 (10), e48–e59 (Oct).

Holben, D.H., 2004. Food insecurity in the United States: its effect on our patients. Am. Fam. Physician 69 (5), 1058–1064 (Mar).

Kendall, A., Olson, C.M., Frongillo, E.A., 1996. Relationship of hunger and food insecurity to food availability and consumption. J. Am. Diet. Assoc. 96 (10), 1019–1026 (Oct).

King, M.L., 2011. A half century of health data for the U.S. population: The Integrated Health Interview Series. Hist. Methods 44 (2), 87–93 (Jun 8).

Martin, A.B., Bhavsar, G.P., Workman, L., Probst, J.C., 2015. Free Clinics in the Rural Safety Net, 2014. (Prepared under Grant Award No 1 UIC RH 03711 with the Federal Office of Rural Health Policy, Health Resources and Services Administration, submitted for publication, August, Available at http://rhr.sph.sc.edu/).

Moreno, G., Morales, L.S., Isiordia, M., et al., 2015. Latinos with diabetes and food insecurity in an agricultural community. Med. Care 53 (5), 423–429 (May).

National Research Council, 2006. Food Insecurity and Hunger in the United States: An Assessment of the Measure. The National Academies Press, Washington, DC.

Nord, M., 2002. A 30-day food security scale for Current Population Survey food security supplement data. E-FAN;02(015) pp. 1–23.

Parsons, V.L., Moriarity, C., Jonas, K., et al., 2014. Design and estimation for the National Health Interview Survey, 2006–2015. Vital Health Stat 2(165). National Center for Health Statistics.

Sattler, E.L., Lee, J.S., 2013. Persistent food insecurity is associated with higher levels of cost-related medication nonadherence in low-income older adults. J. Nutr. Gerontol. Geriatr. 32 (1), 41–58.

Sattler, E.L., Lee, J.S., Bhargava, V., 2014. Food insecurity and medication adherence in low-income older Medicare beneficiaries with type 2 diabetes. J. Nutr. Gerontol. Geriatr. 33 (4), 401–417.

Seligman, H.K., Schillinger, D., 2010. Hunger and socioeconomic disparities in chronic disease. N. Engl. J. Med. 363 (1), 6–9 (Jul).

Seligman, H.K., Laraia, B.A., Kushel, M.B., 2010a. Food insecurity is associated with chronic disease among low-income NHANES participants. J. Nutr. Dis. 140 (2), 304–310 (Feb).

Seligman, H.K., Davis, T.C., Schillinger, D., Wolf, M.S., 2010b. Food insecurity is associated with hypoglycemia and poor diabetes self-management in a low-income sample with diabetes. J. Health Care Poor Underserved 21 (4), 1227–1233 (Nov).

Seligman, H.K., Jacobs, E.A., Lopez, A., et al., 2011. A food insecurity and hypoglycemia among safety net patients with diabetes. Arch. Intern. Med. 171 (13), 1204–1206 (Jul).

Seligman, H.K., Bolger, A.F., Guzman, D., et al., 2014. Exhaustion of food budgets at month's end and hospital admissions for hypoglycemia. Health Aff. 33 (1), 116–123 (Jan).

Siefert, K., Heflin, C.M., Corcoran, M.E., et al., 2001. Food insufficiency and the physical and mental health of low-income women. Women Health 32 (1-2), 159–177.

Silverman, J., Krieger, J., Kiefer, M., Hebert, P., Robinson, J., Nelson, K., 2015. The relationship between food insecurity and depression, diabetes distress and medication adherence among low-income patients with poorly-controlled diabetes. J. Gen. Intern. Med. 30 (10), 1476–1480 (Oct).

Smalls, B.L., Gregory, C.M., Zoller, J.S., Egede, L.E., 2015. Assessing the relationship between neighborhood factors and diabetes related health outcomes and self-care behaviors. BMC Health Serv. Res. 15 (1), 445 (Oct 1).