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Recent Trends in Diabetes Knowledge, Perceptions, and Behaviors: Implications for National Diabetes Education

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Abstract

Objectives. Examine trends in diabetes-related knowledge, perceptions, and behavior among U.S. adults with and without a diagnosis of diabetes and among subpopulations at risk. Discuss implications for national diabetes education and for the National Diabetes Education Program (NDEP) in particular. *Methods*. Three population-based NDEP National Diabetes Surveys (2006, 2008, and 2011) collected information on diabetes knowledge, education, and self-management; perceived and actual risk of diabetes; and lifestyle changes. *Results*. Since 2006, U.S. adults significantly advanced their knowledge and awareness of diabetes and prediabetes. Perceived personal risk did not increase among people with prediabetes (PWP) or people at risk. Family history as a risk factor dropped in reported importance, especially among PWP and Hispanics. Diabetes self-management rose modestly, although checking blood sugar significantly declined. Trends in understanding the diabetes and cardiovascular disease link, A1C testing, and adjusted logistic regression results for perceived risk are discussed. *Discussion and Implications*. Although diabetes-related knowledge has reached high levels, stagnant perceived risk suggests people at risk are not applying this knowledge to themselves. Future surveys are planned to include additional, specific questions to capture people's movement toward behavior change and to identify where strategic efforts and educational interventions can help promote improved behaviors.

Keywords

cardiovascular disease, chronic disease management, diabetes, evaluation, health behavior, health protective behavior

The National Diabetes Education Program (NDEP) conducts the NDEP National Diabetes Survey (NNDS), a periodic population-based probability survey of U.S. adults to obtain timely information about diabetes-related knowledge, perceptions, and behavior. Since 2006, the NNDS results have guided the NDEP's messages (Griffey, Piccinino, Gallivan, Lotenberg, & Tuncer, 2014). The NDEP has targeted campaigns and resources on diabetes and heart health (*The ABCs of Diabetes*), helped people understand how to make sustainable lifestyle changes to stay healthy (*Diabetes HealthSense*) and manage their diabetes (*Managing Diabetes. It's Not Easy, But It's Worth It.*), and encouraged families to share information about their family health history of type 2 diabetes (*Family History*). Key NNDS results are presented here, and implications are discussed for the NDEP and other health education and behavior change programs.

Diabetes and its complications are of global concern. Though diabetes rates apparently are leveling off in the United States, diabetes prevention/delay is not practiced widely—rates for subgroups such as minorities and the poorly educated are rising (Fradkin, Roberts, & Rodgers, 2012; Fradkin & Rodgers, 2013; Geiss et al., 2014). The NDEP was launched in 1997 to improve diabetes management and to reduce morbidity and mortality from diabetes and its complications. The NDEP, sponsored by the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) of the National Institutes of Health (NIH) and the Division of Diabetes Translation of the Centers for Disease Control and Prevention (CDC), is a multifaceted information and education program that works closely with more than 200 public and private sector organizations. Through research and evaluation studies like those supported by NIH/NIDDK, factors influencing

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diabetes prevention, delay, and management can be identified and addressed by diabetes education programs.

Knowledge and Awareness

Recent peer-reviewed literature showed suboptimal gains in achieving some important diabetes goals, such as awareness of prediabetes among those with the condition and achievement of diabetes ABCs (A1C, blood pressure, and cholesterol) and care goals among people with diabetes (PWD; Ali et al., 2013; Casagrande, Fradkin, Saydah, Rust, & Cowie, 2013; Li, Geiss, Burrows, Rolka, & Albright, 2013). The National Health and Nutrition Examination Survey (NHANES) results showed that for 2005 to 2010, less than 14% of adults ages 20 and older with prediabetes were aware of their condition and that efforts were needed to increase awareness of their prediabetes and risk for developing type 2 diabetes (Li et al., 2013). These findings indicate more needs to be done to address awareness of risk factors related to diabetes and prediabetes.

Perceived Risk

Learning what factors are associated with perceptions of diabetes risk could provide clues to helping people acknowledge their risk. Unfortunately, there is limited research on this topic. Gallivan, Brown, Greenberg, and Clark (2009) posited that increased awareness of diabetes risk factors and perceived risk may make those at risk more receptive to efforts to help them reduce their actual risk. Others have found no significant relationship between college students' perceptions of developing diabetes and their own behaviors leading to that risk (Dickerson, Smith, Sosa, McKyer, & Ory, 2012). Hivert, Warner, Shrader, Grant, and Meigs (2009) showed that high perceived risk, even when associated with high actual risk, did not necessarily translate into intentions to adopt healthier lifestyles, suggesting that changing behavior is a complex challenge.

Perceived risk is a core factor in multiple theories about health behavior. However, care must be taken when drawing conclusions about the magnitude and causal direction of risk perceptions and behavior change from cross-sectional survey evidence. Behavior motivation hypothesis studies have found perceptions can modify behavior; conversely, behavior can influence people to reassess their risk perceptions (Brewer, Weinstein, Cuite, & Herrington, 2004; Brewer, Cuite, Herrington, & Weinstein, 2007; Rogers, 1975; Rosenstock, 1974).

Family History

Historically, individuals have not consistently mentioned having a family history of diabetes as a risk factor, although studies have indicated a strong association between having a family history and being at future risk of diabetes (Shaw, Purdie, Neil, Levy, & Turner, 1999; Valdez, 2009). Other studies have shown that individuals, when told of their family history, were more likely to be aware of diabetes, increase their feelings of personal control over preventing the disease, or make lifestyle changes (Pijl et al., 2009; Qureshi & Kai, 2008). An African American study population showed those with a family history of diabetes were more likely than those without to engage in certain health behaviors and be more aware of diabetes risk factors (Baptiste-Roberts et al., 2007). In another study, college students identified having a high number of family members with diabetes as a significant factor associated with their perceived risk of diabetes (Dickerson et al., 2012).

Results from the 2006 NNDS showed adults not diagnosed with diabetes were more likely to perceive their risk of developing type 2 diabetes if they reported their mother, father, brother, or sister had diabetes (Gallivan et al., 2009). This result helped validate the direction of NDEP's national education efforts and prompted additional emphasis on family history in prevention messages and engagement of target audiences.

Cardiovascular Disease and Heart-Related Issues

The link between diabetes and cardiovascular disease (CVD) is clear: CVD is a major complication of diabetes and the leading cause of death among PWD (U.S. Department of Health and Human Services' National Diabetes Education Program [HHS NDEP], 2007). The importance of including CVD awareness and prevention in management of diabetes is also well documented (American Diabetes Association, 2013). Factors prominent in programs to prevent CVD, such as lifestyle modification (e.g., smoking cessation, physical activity, and weight control), monitoring of major risk factors (e.g., blood pressure [BP]), and preventive drug interventions (e.g., aspirin), are shared by diabetes prevention and management programs. PWD are at increased risk of heart-related problems such as high BP, heart attack, and CVD (HHS NDEP, 2007). Of increasing concern to researchers and clinicians are diabetes-related cardiovascular complications. Although gradual improvements in BP for PWD occurred from 1999 to 2010, in the study using NHANES and BRFSS data, only about half (51.3%, 2007-2010) of adult survey participants with diabetes reported meeting the target BP level (<130/80 mmHg; Ali et al., 2013; N.B.: ADA's 2015 clinical standards raised the target BP level to <140/90 mmHg). Research suggests a need to communicate CVD risks to those trying to manage diabetes and to establish awareness of the strong link between diabetes and CVD (Mosca, Hammond, Mochari-Greenberger, Towfighi, & Albert, 2013; Welschen et al., 2012).

Self-Management

One way to measure diabetes self-management is through the hemoglobin A1C (glycosylated hemoglobin) test. The A1C test is an important tool for health professionals and PWD alike. The test assesses how well PWD are managing their diabetes and staving off the onset of comorbidities. Some recent

epidemiologic studies have shown a direct relationship between A1C levels and CVD and note the lack of achievement of all ABC goals to reduce diabetes risk (American Diabetes Association, 2013; Casagrande et al., 2013).

Method

The 2006, 2008, and 2011 NNDS used list-assisted random digit dialing of landline telephone numbers to reach a sample of the U.S. civilian, noninstitutionalized adult population living in households with landline telephones. In the 2006 NNDS, 1,763 adults (ages 45 years and older) completed computer-assisted telephone interviews. In 2008 ($N = 2,078$) and 2011 ($N = 2,234$), the sample age range was expanded to include younger adults (ages 35-44 years) based on research suggesting increased diabetes at younger ages (CDC, n.d.-a). Response rates were 44%, 54%, and 30% in 2006, 2008, and 2011, respectively. Responses were weighted to reflect the race/ethnicity, gender, age, education, and marital status of the U.S. population.

NNDS oversamples of African American and Hispanic households ensured sufficient sizes of these groups in analysis. The African American stratum was created using telephone exchanges where a minimum percentage of households (at least 50% in 2006 and 2008 and at least 60% in 2011) were African American. The Hispanic stratum was created in a similar manner. The third stratum contained all remaining telephone exchanges.

Measures

The NNDS participants were categorized into diabetes risk groups in analysis. Except for those reportedly diagnosed as having diabetes or prediabetes, participants did not necessarily know their diabetes status when surveyed.

- *People with diabetes (PWD):* told by a doctor/health professional they had diabetes or sugar diabetes
- *People with prediabetes (PWP):* told by a doctor/health professional they had prediabetes, impaired fasting glucose, impaired glucose tolerance, borderline diabetes, or high blood sugar
- *People at risk (PAR):* self-reported height and weight that gave them a body mass index (BMI) of 25 or greater, or told by a doctor/health professional they were at high risk for diabetes or had gestational diabetes or high blood sugar during pregnancy
- *All others:* reported no risk factors and met none of the above criteria

Whether participants had anyone in their "immediate family" with diabetes was measured by a yes/no response. "Family history" of diabetes was constructed in analysis as having a mother, father, sister, or brother with diabetes. Perceived risk was a dichotomy—participants did or did not feel at risk for diabetes or prediabetes. BMI was calculated from self-reported height and weight. "Cardiovascular disease" assessed mention of cardiovascular disease, high BP, stroke, heart condition, or heart attack as a serious health problem caused by diabetes. "A1C test" dichotomized the number of times a participant was checked by a health care provider for A1C in the 12 months prior as zero versus one or more times. "Blood test" measured a yes/no response to whether the participant ever had a blood test for diabetes or high blood sugar. Knowledge and awareness measures were assessed as yes/no items about whether participants had ever heard of prediabetes or had heard of glycosylated hemoglobin/A1C. Knowledge/awareness measures also comprised a list of statements read to participants, including "Diabetes can be prevented," asking whether they were aware or not. The construct for the most serious health problems caused by diabetes categorized open-ended question responses. Other yes/no measures included the following: were told by a doctor they were "at risk for diabetes," were told they had high blood pressure, or were told they had high cholesterol. Age, race/ethnicity, and BMI were assessed as described in Gallivan et al. (2009).

Data Analysis

Analyses were conducted using SUDAAN Release 11.0.0 to allow for complex sampling and weighting. Ages 45 years and older were compared across survey years (2008, $N = 1,639$; 2011, $N = 1,697$). Logistic regression models included categorical predictors, controlling for age and race/ethnicity, with dichotomous outcomes.

Results

Knowledge, Awareness, and Behavior

The NNDS surveyed the public's knowledge and awareness of diabetes-related topics and found levels to be high. Results for key indicators, such as whether diabetes could be prevented and whether people had heard of prediabetes or glycosylated hemoglobin/A1C, demonstrated an overall significant increase in diabetes-related knowledge and awareness among the U.S. population from 2006 to 2011 (Figure 1A).

When individual diabetes risk groups were examined, some group differences in trends appeared. PWD had no significant gains in the perception that diabetes can be prevented, although levels remained high (69%). From 2006 to 2011, the percentage of PWP (70% to 85%) and PAR (64% to 81%) who knew diabetes could be prevented rose. Percentages of PWD (37% to 54%) and PAR (47% to 56%) who had heard of prediabetes increased significantly (Figure 1B). About one third (29% to 35%) of PWP had heard of glycosylated hemoglobin/A1C, with no significant trend movement. Trends for PAR (23% to 25%) mirrored those for PWP, except at lower levels. No significant improvements in the self-management of diabetes, as measured by A1C testing, were found among PWD.

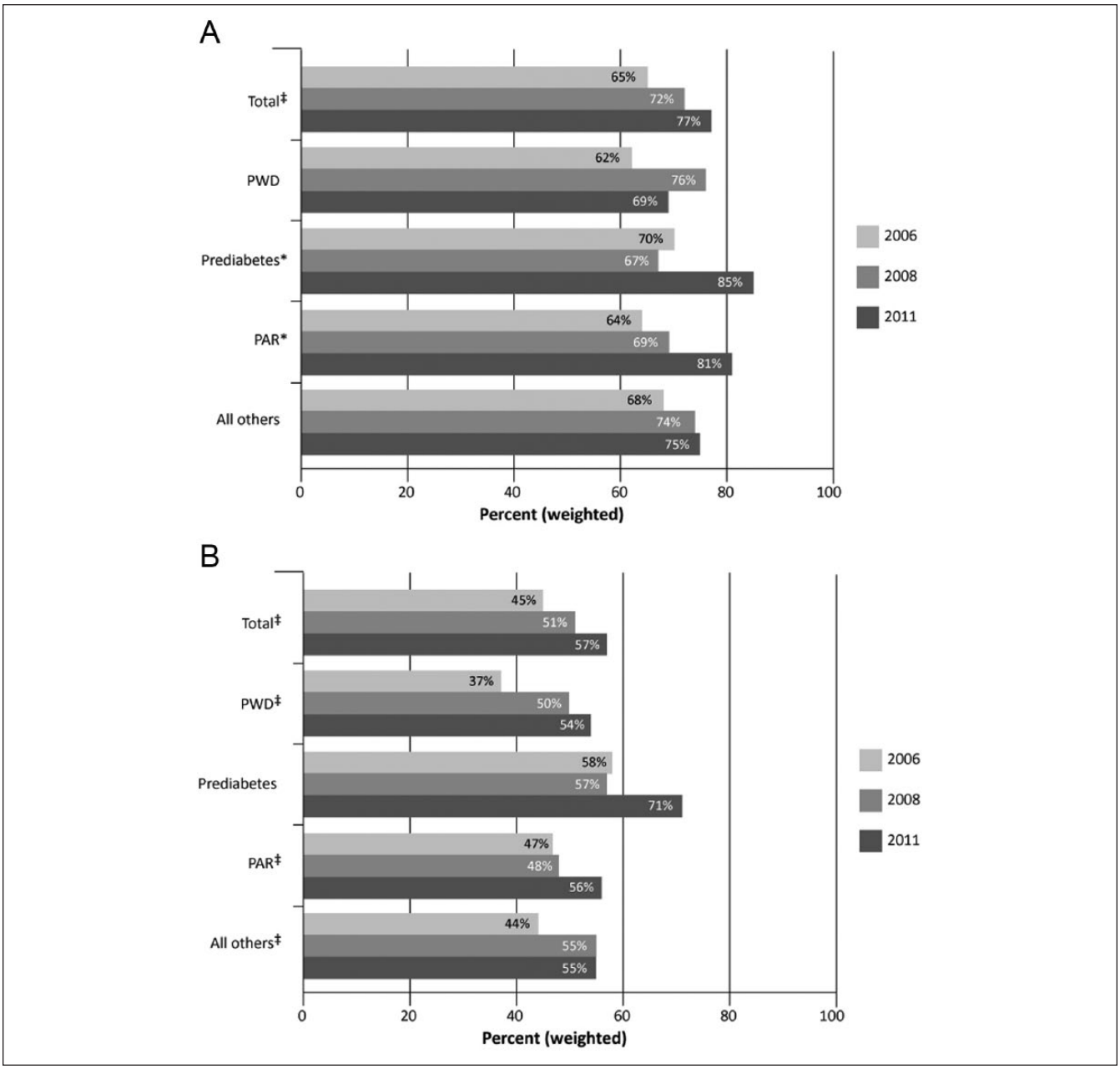

Figure 1. Trends in selected key indicators of knowledge/awareness of diabetes-related factors by risk group for adults 45+ years of age for (A) awareness that diabetes can be prevented and (B) knowledge of prediabetes: 2006, 2008, and 2011.

Note. PWD = people with diabetes; PAR = people at risk. Percentages may not add exactly due to rounding.

*Statistically significant differences between years 2008-2011 and 2006-2011, $p < .05$. †Statistically significant differences between years 2008 and 2011, $p < .05$. ‡Statistically significant differences between years 2006 and 2011, $p < .05$.

Figure 1A—Total: 2006, n = 1,740; 2008, n = 1,538; 2011, n = 1,672. PWD: 2006, n = 369; 2008, n = 353; 2011, n = 431. Prediabetes: 2006, n = 178; 2008, n = 149; 2011, n = 192. PAR: 2006, n = 720; 2008, n = 675; 2011, n = 634. All others: 2006, n = 473; 2008, n = 361; 2011, n = 415.

Figure 1B—Total: 2006, n = 1,754; 2008, n = 1,545; 2011, n = 1,687. PWD: 2006, n = 374; 2008, n = 354; 2011, n = 432. Prediabetes: 2006, n = 179; 2008, n = 150; 2011, n = 194. PAR: 2006, n = 726; 2008, n = 678; 2011, n = 642. All others: 2006, n = 475; 2008, n = 363; 2011, n = 419.

Knowledge and Awareness of Complications of Diabetes and the Cardiovascular Disease Link

Progress in awareness of complications of diabetes or serious health problems associated with the disease was less clear. The NNDS showed most participants were not aware of the link between diabetes and cardiovascular disease. The comparatively lower prevalence of some complications of diabetes (e.g., self-reported vision impairment; 23.7% [1997] to 16.7% [2010]; CDC, 2011) may partly explain a drop in awareness. Overall, people most commonly reported blindness and amputation as serious problems caused by

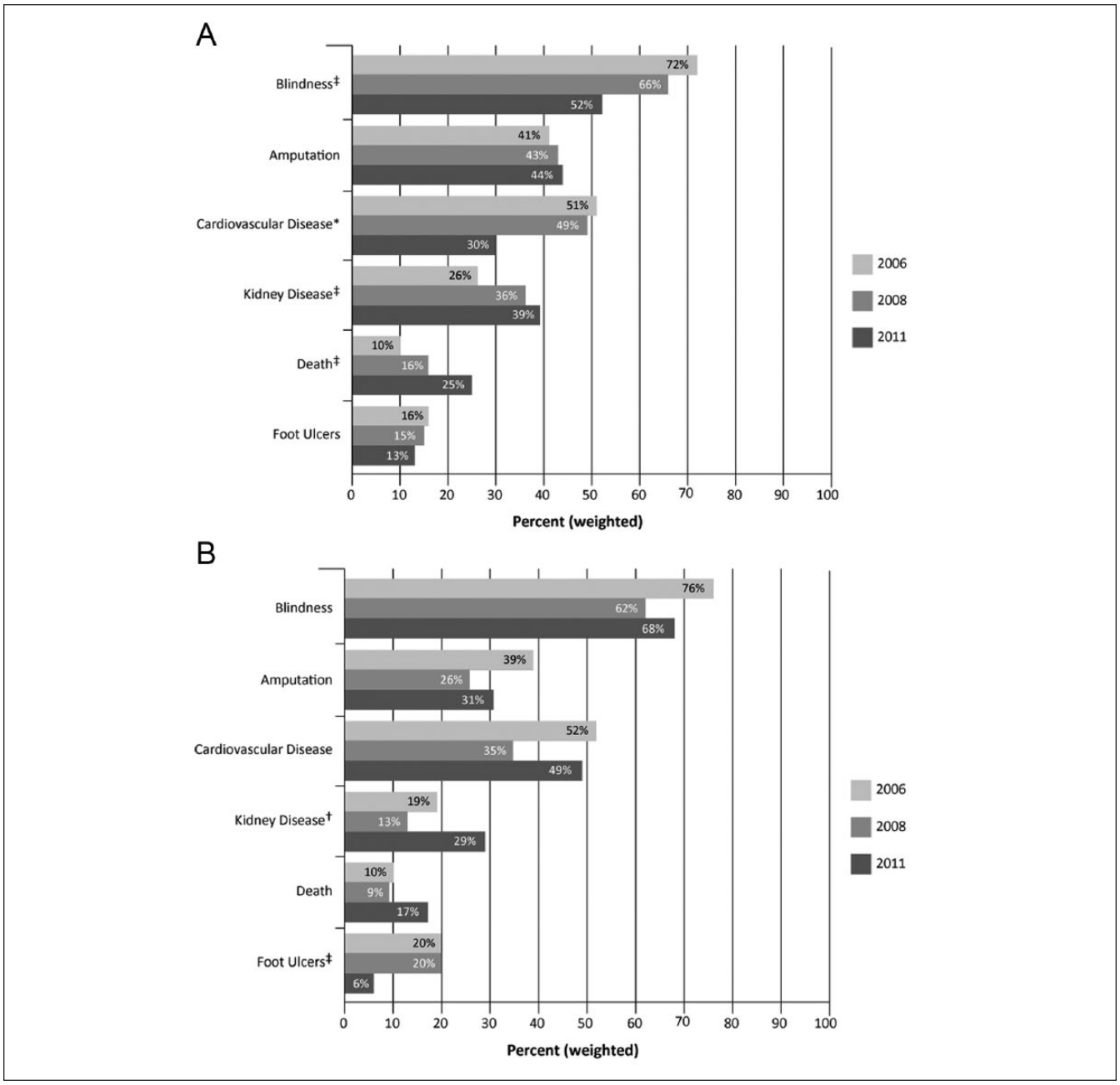

Figure 2. Awareness of serious health problems associated with diabetes among adults 45+ years of age for (A) people with diabetes (PWD) and (B) people with prediabetes (PWP): 2006, 2008, and 2011.

*Statistically significant differences between years 2008-2011 and 2006-2011, $p < .05$. †Statistically significant differences between years 2008 and 2011, $p < .05$. ‡Statistically significant differences between years 2006 and 2011, $p < .05$.

Figure 2A (PWD)—Blindness: 2006, *n* = 241; 2008, *n* = 204; 2011, *n* = 196. Amputation: 2006, *n* = 148; 2008, *n* = 117; 2011, *n* = 431. Cardiovascular disease: 2006, *n* = 207; 2008, *n* = 174; 2011, *n* = 130. Kidney disease: 2006, *n* = 102; 2008, *n* = 118; 2011, *n* = 147. Death: 2006, *n* = 27; 2008, *n* = 35; 2011, *n* = 42. Foot ulcers: 2006, *n* = 58; 2008, *n* = 43; 2011, *n* = 52.

Figure 2B (PWP)—Blindness: 2006, *n* = 112; 2008, *n* = 87; 2011, *n* = 93. Amputation: 2006, *n* = 64; 2008, *n* = 54; 2011, *n* = 60. Cardiovascular disease: 2006, *n* = 87; 2008, *n* = 51; 2011, *n* = 65. Kidney disease: 2006, *n* = 40; 2008, *n* = 21; 2011, *n* = 44. Death: 2006, *n* = 17; 2008, *n* = 13; 2011, *n* = 23. Foot ulcers: 2006, *n* = 25; 2008, *n* = 12; 2011, *n* = 11.

diabetes. However, mentions of blindness had significantly declined since 2006 (70% to 53%), while mentions of amputation stayed level. Mentions of kidney disease as a related health problem increased significantly (18% to 28%) among participants. For PAR, mentions of associated kidney disease increased significantly (17% to 27%), and of blindness (71% to 48%) significantly decreased. Similar trends were found for PWD (Figure 2A). For PWP, no significant

changes were observed for mentions of blindness or amputation (Figure 2B).

Heart-related issues—cardiovascular disease, high BP, stroke, heart condition, or heart attack—were seldom mentioned as problems caused by diabetes. Except for stroke, mentioned significantly less often, the proportion reporting each heart-related issue as a serious health problem caused by diabetes has remained relatively low and unchanged since 2006. When grouped in analysis as "Cardiovascular Disease," these heart-related issues became the third-highest problem mentioned for people overall, PWD, PWP, and PAR. However, mentions declined significantly overall (42% to 35%) and for PWD (51% to 30%). Recognition of cardiovascular complications was low in 2011 and had not significantly improved among vulnerable groups (PWP and PAR).

Perceptions of Risk

Stagnant and Low. Participant knowledge and awareness of diabetes and related topics stayed high, but perceived risk has remained stagnant and low in spite of educational programs to promote improvement. The NNDS measured personal risk perceptions by asking whether participants felt at risk for diabetes or prediabetes and, if so, why they felt at risk, and what they could do to reduce their risk. Results showed no significant trends from 2006 to 2011 for the overall population or risk groups (Figure 3). Levels of perceived risk were low, except among PWP, and were relatively unchanged over the 5 years. Among PWP, almost two thirds felt at risk (62% to 60% from 2006 to 2011). Only about one fourth of PAR (26% to 27%) felt at risk for developing the disease.

Family History of Diabetes. Participants in 2011 who felt at risk for diabetes/prediabetes and were undiagnosed with diabetes most often named having a history of diabetes in their family as a reason for feeling at risk, but the change since 2006 was not statistically significant (61% to 51%). Over that period, there were significant declines in family history of the disease as a reason cited for perceived risk among PWP (58% to 36%) and Hispanics (57% to 39%).

Effects of Multiple Factors. Researchers previously used 2006 NNDS data to identify factors associated with perceived personal risk of diabetes/prediabetes among people undiagnosed with diabetes (Gallivan et al., 2009). We updated the researchers' logistic regression model with more recent data to identify strong predictors of personal risk perception (see Table 1 and Supplement Table 1 [available online at heb.sagepub.com/supplemental]).

Common to each survey, we found three significant predictors of feeling personally at risk of diabetes: being obese (BMI ≥ 30), having a "family history" of diabetes, and having been told by a health care professional they had prediabetes or one of several associated risk factors. In 2011, those whose BMI levels were 30 kg/m^2 or higher were four times more likely than those at the lowest level (BMI < 25 kg/m^2) to feel at risk; those with a family history were four times more likely to feel at risk than those without. PWP were almost six times (odds ratio [OR] = 5.74, 95% confidence interval [CI] = 2.35-14.05) more likely to perceive themselves at risk of diabetes than those not identified as having prediabetes.

The 2006 model included post hoc constructed family history and diabetes status variables. To identify specific and modifiable factors, we created new models—this time using disaggregated family history and diabetes status information—and added CVD and behavior/self-efficacy variables (see Table 2 and Supplement Table 1 [available online at heb.sagepub.com/supplemental]).

Results from the new models showed that having immediate family with diabetes, regardless of relationship, was a significant factor over the three surveys in people's perceived risk. Being told by a health professional they were at risk of diabetes also was significant over time (OR = 5.92 [2006], 95% CI = 2.43-14.38; OR = 5.04 [2008], 95% CI = 1.58-16.01; OR = 6.84 [2011], 95% CI = 1.75-26.69), net of other factors. Among the model's knowledge and awareness variables, mentions of high BP/hypertension being caused by diabetes were significant. Those mentioning high BP/hypertension were less likely in 2006 (OR = 0.19, 95% CI = 0.06-0.62) and in 2011 (OR = 0.11, 95% CI = 0.02-0.54) to feel at risk compared with those not mentioning it. Mentions of heart attack among those who felt at risk were about one fourth (OR = 0.28, 95% CI = 0.08-0.98) the levels of those who did not mention this. The two measures of behavior/self-efficacy had no significant effects in the full model.

To test more parsimonious models, we reanalyzed *only* the significant variables from the disaggregated model for each survey. After controlling for other factors, three significant (in the positive direction) covariates of perceived risk were common to all three survey periods: having immediate family with diabetes, being obese (BMI ≥ 30.0), and being told they were at risk for diabetes. Being told they had impaired glucose tolerance was also significant in 2008. In 2011, being overweight (BMI = 27.0-29.9) and "Other" (American Indian/Alaska Native, Asian, native Hawaiian/other Pacific Islander, or other not specified) race also were significant (see Supplement Figure 1 [available online at heb.sagepub.com/supplemental]). People who reported having immediate family with diabetes were at least three times more likely to perceive themselves at risk than those who did not have relatives with diabetes. This finding was consistent with studies that found relationships between awareness of a family history of the disease and having a heightened sense of personal risk (Baptiste-Roberts et al., 2007; Dickerson et al., 2012; Pijl et al., 2009; Qureshi & Kai, 2008).

Discussion

The NNDS showed gains in knowledge have outstripped advances in personal risk perceptions and behavior, with significant improvements in knowing diabetes can be prevented among those most at risk of the disease (PWP and

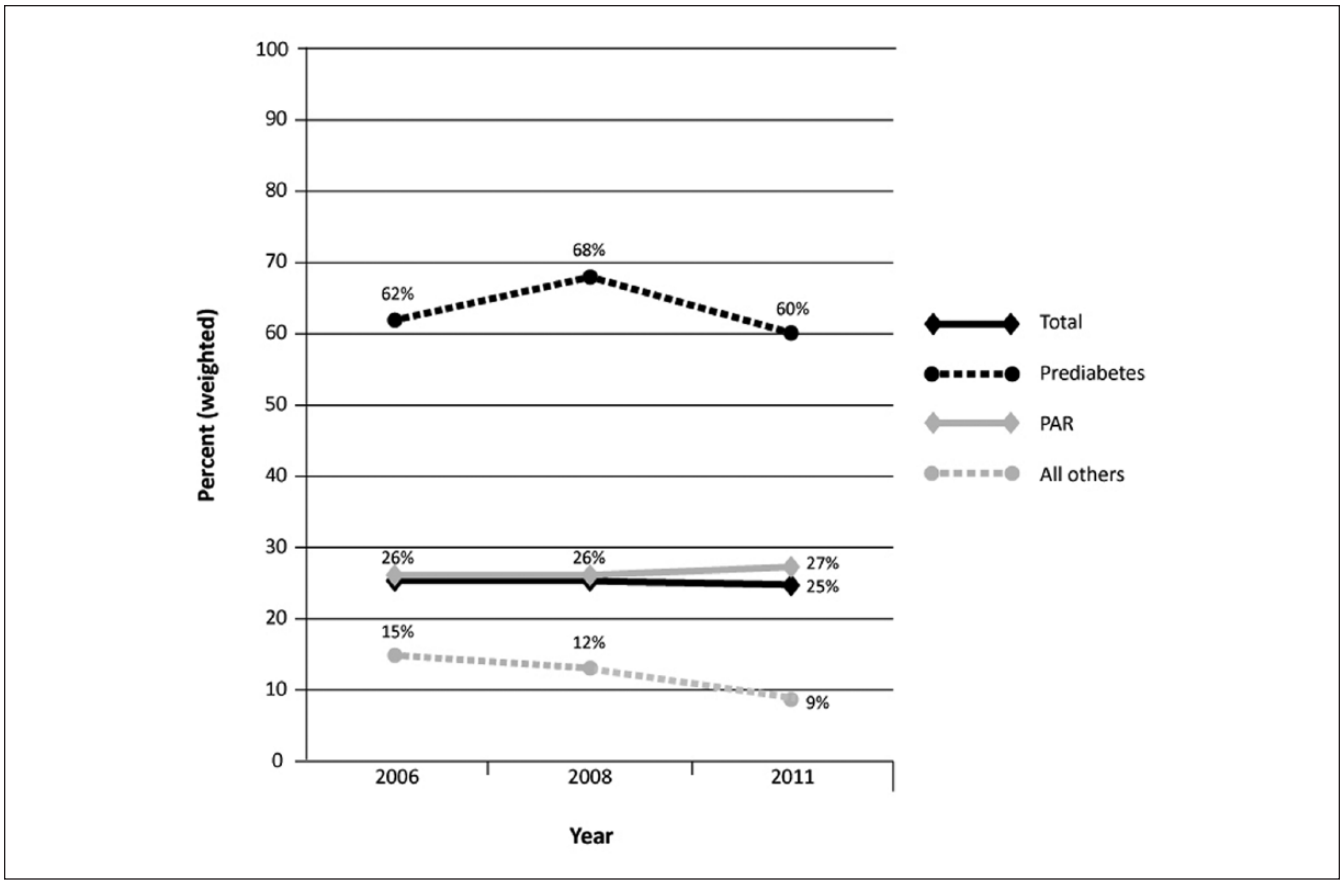

Figure 3. Perceived personal risk, by risk group, among adults 45+ years of age reported not diagnosed with diabetes: 2006, 2008, and 2011.
Note. PAR = people at risk.
Total: 2006, *n* = 313; 2008, *n* = 326; 2011, *n* = 345. Prediabetes: 2006, *n* = 104; 2008, *n* = 88; 2011, *n* = 103. PAR: 2006, *n* = 164; 2008, *n* = 195; 2011, *n* = 177. All others: 2006, *n* = 45; 2008, *n* = 43; 2011, *n* = 65.

Table 1. Relationship Between Selected Characteristics and Whether Feel at Risk for Diabetes Among Adults 45+ Years of Age Reported Not Diagnosed With Diabetes: 2006, 2008, and 2011.

Characteristics	2006 (Model *n* = 1,123), OR (95% CI)	2008 (Model *n* = 1,095), OR (95% CI)	2011 (Model *n* = 1, 110), OR (95% CI)
Younger vs. older age	2.08* (1.28-3.39)	1.07 (0.61-1.90)	1.75 (0.91-3.37)
Hispanic vs. non-Hispanic White	0.48* (0.25-0.91)	0.47* (0.24-0.93)	0.60 (0.25-1.45)
African American vs. non-Hispanic White	0.89 (0.53-1.50)	1.56 (0.63-3.87)	0.51 (0.21-1.25)
Other race vs. non-Hispanic White	1.57 (0.76-3.23)	1.22 (0.49-3.00)	0.58 (0.14-2.49)
BMI 25.0-26.9 vs. BMI <25.0	1.06 (0.58-1.96)	1.77 (0.74-4.21)	1.01 (0.41-2.49)
BMI 27.0-29.9 vs. BMI <25.0	1.32 (0.69-2.52)	2.00 (0.91-4.43)	2.02 (0.82-4.97)
BMI ≥30 vs. BMI <25.0	3.67* (2.13-6.31)	3.79* (1.72-8.37)	4.21* (2.01-8.82)
Family history of diabetes[a]	6.48* (4.07-10.31)	4.16* (2.30-7.51)	4.38* (2.41-7.97)
Told have prediabetes[b]	6.53* (3.57-11.97)	9.47* (3.61-24.86)	5.74* (2.35-14.05)
Told have high blood pressure	1.28 (0.81-2.02)	1.01 (0.55-1.85)	0.87 (0.46-1.66)
Told have high blood cholesterol	1.28 (0.83-1.96)	1.40 (0.77-2.55)	1.21 (0.66-2.21)

Note. OR = odds ratio; CI = confidence interval; BMI = body mass index. Model variables based on Gallivan et al. (2009). "Model *n*" denotes number of participants with nonmissing values on model variables.
[a]Post-coded "family history": If a participant reported they had an immediate family member with diabetes, and it was their mother, father, brother, or sister, they were considered to have a family history of the disease. [b]Post-coded diabetes status "prediabetes": If the participant had been told by a doctor or other health professional that they had prediabetes, impaired fasting glucose, impaired glucose tolerance, borderline diabetes, or high blood sugar.
*$p < .05$.

Table 2. Expanded Models of Predictors of Feeling at Risk for Diabetes Among Adults 45+ Years of Age Reported Not Diagnosed With Diabetes: 2006, 2008, and 2011.

Variable group	Characteristics	2006 (Model *n* = 723), OR (95% CI)	2008 (Model *n* = 738), OR (95% CI)	2011 (Model *n* = 632), OR (95% CI)
Biological/clinical/demographic				
Age	Younger vs. older age	1.72 (0.91-3.25)	0.98 (0.47-2.01)	1.65 (0.67-4.10)
Race/ethnicity	Hispanic vs. non-Hispanic White	0.54 (0.25-1.17)	0.65 (0.24-1.76)	0.76 (0.21-2.71)
	African American vs. non-Hispanic White	1.61 (0.80-3.24)	1.10 (0.38-3.24)	0.88 (0.28-2.73)
	Other race vs. non-Hispanic White	2.06 (0.81-5.21)	2.99 (0.64-14.00)	8.24* (2.25-30.19)
Body mass index (BMI)	BMI 25.0-26.9 vs. BMI <25.0	0.94 (0.45-1.95)	1.50 (0.51-4.36)	1.38 (0.48-3.96)
	BMI 27.0-29.9 vs. BMI <25.0	1.23 (0.54-2.77)	2.18 (0.79-5.98)	7.69* (2.08-28.44)
	BMI ≥30 vs. BMI <25.0	2.77* (1.41-5.47)	3.80* (1.53-9.45)	7.38* (2.51-21.72)
Immediate family	Anyone in immediate family has diabetes	5.94* (3.32-10.64)	4.35* (2.18-8.67)	3.26* (1.43-7.46)
Prediabetes	Told by doctor have prediabetes	0.41 (0.06-3.02)	1.22 (0.10-15.19)	0.57 (0.03-10.14)
	Told by doctor have impaired fasting glucose	1.17 (0.17-8.32)	1.33 (0.08-20.85)	4.04 (0.49-33.55)
	Told by doctor have impaired glucose tolerance	1.26 (0.23-6.80)	21.77* (1.34-353.11)	0.27 (0.02-3.27)
	Told by doctor have borderline diabetes	2.97 (0.42-20.88)	3.31 (0.71-15.51)	9.75 (0.34-276.02)
	Told by doctor have high blood sugar	4.59* (1.38-15.24)	8.45* (2.01-35.50)	1.23 (0.14-11.14)
At risk[a]	Told by doctor at risk for diabetes	5.92* (2.43-14.38)	5.04* (1.58-16.01)	6.84* (1.75-26.69)
Blood pressure	Told have high blood pressure	1.06 (0.60-1.87)	0.88 (0.42-1.85)	0.64 (0.27-1.52)
Cholesterol	Told have high blood cholesterol	1.32 (0.76-2.28)	0.98 (0.47-2.04)	0.88 (0.40-1.92)
Knowledge/awareness				
Prediabetes	Ever heard of prediabetes	1.46 (0.84-2.54)	1.56 (0.78-3.12)	2.46 (0.91-6.66)
A1C	Heard of glycosylated hemoglobin/A1C	1.07 (0.60-1.92)	0.81 (0.34-1.94)	0.52 (0.20-1.37)
Cardiovascular disease	Heart condition caused by diabetes	0.94 (0.50-1.79)	2.14 (0.88-5.22)	1.95 (0.78-4.90)
	Stroke caused by diabetes	1.29 (0.57-2.95)	0.64 (0.21-1.96)	1.31 (0.36-4.78)
	Heart attack caused by diabetes	0.56 (0.22-1.43)	0.28* (0.08-0.98)	1.21 (0.39-3.75)
	Cardiovascular disease caused by diabetes	1.49 (0.69-3.25)	1.00 (0.32-3.18)	0.92 (0.22-3.85)
	High blood pressure/ hypertension caused by diabetes	0.19* (0.06-0.62)	1.98 (0.48-8.26)	0.11* (0.02-0.54)
Behavior/self-efficacy				
Blood test	Ever had blood test for diabetes	1.22 (0.63-2.34)	1.84 (0.76-4.47)	1.75 (0.56-5.45)
A1C test	Checked for A1C in last year 1+ times	0.84 (0.45-1.58)	0.53 (0.21-1.33)	1.30 (0.52-3.23)

Note. OR = odds ratio; CI = confidence interval. "Model *n*" denotes number of participants with nonmissing values on model variables.
[a]Told by a doctor they were at risk for diabetes. The diabetes status "PAR" recode included women who were told by a health care professional that they had gestational diabetes or high blood sugar during pregnancy; however, these two elements of post-coded diabetes status were dropped from the models because these only pertained to women, and because of the small sample size for those affected.
*$p < .05$; significance refers to within each model year, not across years.

PAR). General knowledge and awareness of diabetes has stayed high since the 2006 NNDS. By 2011, we saw evidence of progress in more focused knowledge and awareness. Among PWD, despite increases in A1C knowledge, findings did not show significant improvements in A1C testing behavior. This helps underscore recent literature (Casagrande et al., 2013) stating suboptimal achievement of ABC goals.

Low recognition of CVD complications associated with diabetes (2011 NNDS) had not significantly improved among vulnerable groups (PWP and PAR), and declined further for PWD. This finding may reflect a perception that diabetes does not raise one's risk for CVD. Nevertheless, CVD death rates among adults diagnosed with diabetes are nearly double the rates for those not diagnosed (CDC, 2014). The results suggest a need for increased educational efforts to communicate the strong diabetes–CVD link and related risks to those trying to prevent, delay, and manage diabetes.

In recent years the NDEP expanded its messaging about weight as a diabetes risk factor to include being overweight as well as obese. The logistic regression modeling results revealed two additional factors in 2011 influencing perceptions of personal diabetes risk beyond the three identified in the 2006 and 2008 surveys (see Supplement Figure 1 [available online at heb.sagepub.com/supplemental]). Being of an ethnicity/race not Hispanic, African American, or White was one factor; the other was being overweight—not just being obese. Though not all participants may have known their BMI classification, this is an example of how NDEP messaging may have led to the emergence of being overweight (BMI = 27.0-29.9) as a factor in increased perceived risk in 2011.

Limitations

The extent to which participants' information may have differed from people in excluded households and other nonrespondents is unknown. Any error introduced through sampling methods, question wording, or practical difficulties in administering the surveys may have led to error or bias in the findings. In addition, data were limited to self-reports and available variables. Prediabetes may have been underreported, as it often goes undiagnosed (Geiss et al., 2010). Perceived risk measured as a dichotomous response may have missed grey areas in, and the degree of, participants' perceptions of their risk. Despite these limitations, repeated administration of the NNDS has enabled the NDEP to track trends in diabetes-related knowledge and behaviors in national probability-based samples.

Future Directions

The NNDS results continue to provide the NDEP with valuable information for targeting future educational messaging. These results also contribute evidence for achievement of the HHS' Healthy People 2020 diabetes-related objectives of reducing new cases of diabetes and increasing prevention behaviors in people at high risk for diabetes or with prediabetes, among other national health goals (CDC, n.d.-b). PAR who did not perceive themselves to be at risk, but reported characteristics that put them at risk for diabetes/prediabetes, are of special concern. Although more research is needed to identify factors leading to positive behavioral and lifestyle changes for those at risk, the NNDS results point to gains the NDEP and other programs appear to be making in educating the U.S. population.

Fortunately, the periodicity of the three NNDS has allowed researchers to examine trends and draw conclusions from more than one set of cross-sectional survey results. The NNDS results will continue to play a critical role in providing sound evidence for diabetes education efforts and in setting the direction of strategic planning for the NDEP.

Declaration of Conflicting Interests

The authors declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Gallivan and Tuncer are the director and deputy director, respectively, for the National Diabetes Education Program (NDEP), National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), National Institutes of Health (NIH). Together they manage the funding under which this work was conducted. They also participated in interpretation of the data and in the preparation and review of the manuscript. Social & Scientific Systems, Inc. (Piccinino, Griffey) and Hager Sharp (Doner Lotenberg) received funding from the NDEP and from NIH for the work that is discussed in the article. All three authors had major roles in the design and conduct of the study; in the collection, analysis, and interpretation of the data; and in the preparation and review of the manuscript.

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Supplemental Material

Additional supporting information is available at heb.sagepub.com/supplemental.

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