The Cardiometabolic Risk Profile of Young Adults With Diabetes in the U.S.

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OBJECTIVE

We examined young adults with and young adults without diabetes by using demographic data and cardiometabolic risk profiles and compared the risk profiles of younger versus older (aged ≥45 years) adults with diabetes.

RESEARCH DESIGN AND METHODS

Data were obtained from the National Health and Nutrition Examination Survey (NHANES) 2007–2016. Diabetes was defined by self-report of health care provider diagnosis or by A1C levels of 6.5% or higher among those without a self-reported diagnosis. The cardiometabolic risk profile included adiposity, blood pressure, serum lipids, healthy eating, physical activity (PA), and exposure to tobacco smoke. Adjusted difference in difference was calculated as the difference among younger adults with and younger adults without diabetes minus the difference among older adults with and older adults without diabetes.

RESULTS

Adults with diabetes in both age-groups had higher levels of adiposity, hypertension, and cholesterol and lower levels of healthy eating and leisure-time PA. However, the differences in high cholesterol and adiposity by diabetes status were greater among young adults compared with older adults after adjustment for demographics and health insurance status. Elevated lipids were 9.6 percentage points higher (95% CI 4.6, 14.5) and obesity was 37.3 percentage points higher (95% CI 31.8, 42.7) among young adults with diabetes compared with those without diabetes than among older adults with diabetes compared with those without diabetes.

CONCLUSIONS

Young adults with diabetes have high rates of cardiometabolic risk factors, which can lead to an increased disease prevalence and mortality rate among these individuals as they age.

Amid well-documented increases in diabetes prevalence in the U.S. (1), the relative increases among youth aged 10–20 years have been the largest and most alarming (2,3). As of 2015, 4.6 million young adults aged 18–44 years had diabetes (1.6 million of whom were undiagnosed) (4), reflecting an annual percentage increase in prevalence of 4.3% since 1988–1994 (5). This increase in diabetes prevalence has resulted in a new cohort of young adults with potentially higher rates of morbidity (and subsequent use of health care) in early adulthood than ever before in the U.S.

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The large population of young adults with diabetes is of concern for several reasons. First, the presence of diabetes among youth and young adults increases their exposure to chronic hyperglycemia and accompanying cardiometabolic risk factors early in life, which increase the risk of cardiovascular disease (6), kidney failure (7), and lifetime diabetes complications (8) in middle age and can contribute to the reduced life expectancy of young adults with diabetes (9). Second, compared with older adults, young adults may be less likely to be aware of type 2 diabetes or cardiometabolic risk factors (10), which may lead to delayed (or nonexistent) risk factor management among this population. For example, declines in mortality rates among people with diabetes have been seen during the past two decades in every age-group except young adults aged 20–44 years (11), suggesting suboptimal medical care and lagging risk factor management among this group.

There is increasing evidence that the pathophysiology of diabetes, particularly type 2 diabetes, diagnosed during adolescence or young adulthood presents a more rapid onset of disease (12) as evidenced by more rapid β-cell decline among adolescents compared with older adults diagnosed with diabetes (12). Despite relatively short duration of diabetes, diabetes and cardiovascular disease complications were observed among adolescents and young adults with diabetes (2).

Despite the growing concern about diabetes among youth, the young adult population with diabetes has rarely been characterized using nationally representative U.S. data. By using data from the National Health and Nutrition Examination Survey (NHANES), we assessed the distribution of demographics and the clinical and behavioral cardiometabolic risk factors among young adults aged 18–44 years and older adults aged 45 years or older with and without diabetes. We also compared the absolute and relative differences in cardiometabolic risk factors among young and older adults with diabetes to understand whether, and the extent to which, the risk factors and disease prevalence may differ among the young adult population.

RESEARCH DESIGN AND METHODS

Data Sources

We used data from NHANES 2007–2016 (the latest data available at the time of analysis), a continuous (nonoverlapping) cross-sectional survey of the noninstitutionalized civilian U.S. population conducted in 2-year cycles. NHANES collects data from participants via physical examination, laboratory tests, and questionnaires on health-related topics. Response rates for participation in the interview and physical examination ranged from 75.4% in 2007–2008 to 58.7% in 2015–2016. NHANES methods and protocols (including participant consent) for the questionnaires, laboratory tests, and examination have been described extensively (13).

There were 30,724 participants aged 18 years or older in NHANES with physical and examination data from 2007 to 2016. We excluded women who were pregnant at the time of the exam, as well as participants missing information on cardiometabolic risk factors, dietary information, or income. This yielded a final analytic sample of 23,798 adults (including 10,898 younger adults aged 18–44 years and 12,900 older adults aged 45 years or older) available for the analysis, representing >216 million adults.

Diabetes Definition

Diabetes was defined by self-reported diagnosis by a health care provider (excluding diagnosis only during pregnancy) or by glycated hemoglobin (A1C) levels 6.5% (48 mmol/mol) or higher. Mean diabetes duration was reported for participants who self-reported diabetes diagnosis.

Demographic Variables

Demographics included age, sex, race or ethnicity, income, and health insurance. As described previously, we stratified participants into two age categories: 18–44 years old and ≥45 years old. We categorized self-reported race or ethnicity as non-Hispanic white, non-Hispanic black, Hispanic, and non-Hispanic other. Household poverty level was defined by using the established poverty-income ratio (PIR), calculated as family income divided by the federal poverty level; a PIR of 1 indicates a family income at 100% of the federal poverty level. PIR was categorized as <1.33, 1.33–3.50, and ≥3.50. A PIR of <1.33 was selected as the lower category to correspond with qualification for the federal Supplemental Nutrition Assistance Program (14). Participants were considered to have health insurance if they reported coverage by a health insurance plan at the time of interview. Participants who reported health insurance also reported insurance type as private (including Medigap), Medicare/Medicaid, other government or state sponsored (e.g., military, Indian Health Service, State Children's Health Insurance Program), or both government and private insurance. Health insurance was categorized as no insurance, private insurance alone, public insurance alone, or both. Participants also reported whether they had a place to visit for routine health care (yes/no).

Cardiometabolic Risk Factors

We included measures of adiposity, serum cholesterol, blood pressure (BP), blood glucose control, chronic kidney disease (CKD), history of cardiovascular disease, healthy eating, leisure-time physical activity (PA), and exposure to tobacco smoke. Overall, adiposity was defined by using BMI (calculated as body weight in kilograms divided by the square of height in meters), and central adiposity was defined by using waist circumference–to–height ratio (WHtR). Participants were categorized as having obesity if they had either a BMI of ≥30 kg/m^2 or a WHtR of ≥0.5 (15).

Serum total and HDL cholesterol levels were used to calculate the ratio of total to HDL cholesterol. High cholesterol levels were defined as total-to-HDL cholesterol ratio of ≥5.9 (16). Among those without self-report of cholesterol-lowering medication, uncontrolled cholesterol was defined as total-to-HDL cholesterol ratio of ≥5.9. Hypertension was defined as self-reported use of antihypertensive medications or systolic BP of ≥140 mmHg or diastolic BP of ≥90 mmHg (17). Among those who reported no antihypertensive medication use, uncontrolled hypertension was defined as systolic BP of ≥140 mmHg or diastolic BP of ≥90 mmHg. We used A1C to categorize participants with diabetes according to blood glucose control; poor blood glucose control was defined as A1C of ≥9% (75 mmol/mol).

CKD was defined as having an estimated glomerular filtration rate (eGFR) <60 mL/min/1.73 m^2 or elevated urinary albumin-to-creatinine ratio (ACR ≥30 mg/g), based on a single measurement of serum creatinine or ACR during the physical examination. eGFR was estimated

using the CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration) equation (18).

Participants were considered to have a history of cardiovascular disease if they reported ever being told they had any of the following conditions by a health care provider: congestive heart failure, coronary heart disease, angina pectoris, heart attack, or stroke. Behavioral risk factors included not meeting healthy eating or leisure-time PA recommendations and exposure to tobacco smoke. Healthy eating was measured by the Healthy Eating Index 2010 (HEI-2010), a measure of diet quality used to assess how well a set of foods aligns with key recommendations of the Dietary Guidelines for Americans (19). HEI-2010 scores range from 0 to 100; in our analysis, not meeting healthy eating recommendations was defined as HEI-2010 <75th percentile (<59.7) (20). Leisure-time PA was measured as self-reported minutes of moderate- to vigorous-intensity leisure-time PA per week. Not meeting leisure-time PA goal was defined as <150 min of moderate- to vigorous-intensity leisure-time PA per week. Tobacco smoking was assessed by serum cotinine levels. Being a current heavy smoker was defined by cotinine levels ≥10 ng/mL.

Statistical Analysis

We compared demographic characteristics, health care access and utilization, and cardiometabolic risk factors using two-sided *t* tests among young and older adults by diabetes status. We used logistic regression to calculate predicted marginal and the absolute differences in risk factors by diabetes status adjusting for age (continuous), sex, race or ethnicity, PIR, and health insurance status among young adults. We repeated the analysis among older adults. We used the difference in differences analysis to examine whether differences in risk factors among younger adults by diabetes status were similar to the differences among older adults (21). Within each age-group, we computed adjusted odds ratios (AORs) for each risk factor to compare those with diabetes with those without diabetes. Model fit was examined by the log-likelihood ratio.

Analysis was performed by using SAS 9.3 and SUDAAN 11 software (Research Triangle Institute, Research Triangle Park, NC) to account for complex sampling design. *P* values <0.05 were considered statistically significant. Unreliable estimates (i.e., those with relative SEs >30%) were not reported.

RESULTS

Characteristics of Young Adults With Diabetes

Young adults with diabetes differed from those without diabetes on a number of demographic and health care access characteristics (Table 1). Compared with those without diabetes, young adults with diabetes were older (mean age of 36.4 years compared with 30.9 years, respectively), fewer were non-Hispanic white, and more were non-Hispanic black. Those with diabetes were more likely to have low PIR and to have only public health insurance compared with young adults without diabetes. Similar patterns were observed among adults 45 years or older (Table 1). Among older adults, those with diabetes tended to be older, were less likely to be non-Hispanic white, and had lower PIR than those without diabetes. Younger adults with diagnosed diabetes had a shorter duration of diabetes (mean 7.7 years) than older adults with diagnosed diabetes (mean 11.2 years).

Table 1—Characteristics of adults with and adults without diabetes in the U.S. among young adults (18–44 years old) compared with older adults (≥45 years old)—NHANES, 2007–2016

	18–44 years old		≥45 years old	
	No diabetes	Diabetes	No diabetes	Diabetes
Sample size	10,438	460	9,866	3,034
Age, mean, years	30.9 (30.6, 31.2)	36.4 (35.7,37.0)[a]	59.4 (59.0, 59.7)	62.7 (62.2, 63.1)[a]
Male, %	51.3 (50.3, 52.3)	49.1 (44.2, 54.0)	46.4 (45.5, 47.3)	52.0 (49.7, 54.4)[a]
Race/ethnicity, %				
H	18.5 (15.9, 21.1)	23.0 (17.0, 29.0)	8.1 (6.6, 9.6)	14.4 (11.2, 17.7)[a]
NHW	61.3 (57.8, 64.8)	47.4 (40.9, 54.0)[a]	78.2 (75.2, 80.7)	63.1 (58.7, 67.5)[a]
NHB	11.9 (10.1, 13.7)	20.2 (15.5, 24.8)[a]	8.5 (7.1, 9.8)	14.9 (12.4, 17.5)[a]
NHO	8.3 (7.3, 9.3)	9.4 (5.9, 13.0)	5.3 (4.4, 6.1)	7.6 (6.1, 9.1)[a]
PIR, %				
<1.33	28.1 (25.9, 30.4)	35.9 (30.2, 41.6)[a]	16.2 (14.4, 18.0)	25.6 (23.0, 28.1)[a]
1.33 to <3.5	35.9 (34.2, 37.5)	36.0 (31.0, 41.1)	32.5 (30.6, 34.5)	39.4 (36.9, 41.8)[a]
3.5+	36.1 (33.6, 38.5)	28.1 (21.7, 34.4)[a]	51.3 (48.4, 54.2)	35.1 (32.1, 38.1)[a]
Health insurance status, %				
No health insurance	25.7 (24.1, 30.4)	28.8 (23.6, 33.9)	11.0 (10.0, 12.0)	10.3 (8.9, 11.6)[a]
Private health insurance alone	59.3 (57.3, 61.3)	48.7 (42.1, 55.6)[a]	51.5 (49.5, 53.5)	35.4 (32.8, 38.1)[a]
Public health insurance alone	13.4 (12.3, 14.4)	21.8 (16.8, 26.9)[a]	19.7 (18.4, 21.0)	30.2 (27.5, 33.0)[a]
Both public and private health insurance	n/r	n/r	17.6 (16.4, 18.8)	23.7 (21.6, 25.8)[a]
Health care access, %				
Usual place to receive health care	57.8 (56.3, 59.4)	64.5 (55.0, 74.1)	59.8 (57.7, 61.9)	69.7 (66.1, 73.4)[a]
Duration of diabetes, mean, years[b]	n/a	7.7 (6.4, 9.0)	n/a	11.2 (10.5, 11.9)

Data are presented as mean or percentage with 95% CIs in parenthesis. Diabetes defined as self-report of diabetes diagnosis by a health care provider or A1C ≥6.5% (48 mmol/mol). H, Hispanic; n/a, not applicable; n/r, not reported, relative SE >30%; NHB, non-Hispanic black; NHO, non-Hispanic other; NHW, non-Hispanic white. [a]Diabetes significantly different from no diabetes based on two-sided *t* test with $P < 0.05$. [b]Among adults with self-report of diagnosed diabetes: 18–44 years old, $n = 252$; ≥45 years old, $n = 1,935$.

Table 2—Cardiovascular disease risk factors and complications among young adults (18–44 years old) and older adults (≥45 years old) by diabetes status—NHANES, 2007–2016

	18–44 years old		≥45 years old	
	No diabetes	Diabetes	No diabetes	Diabetes
Lipids				
Total-to-HDL cholesterol ratio, mean	3.9 (3.8, 3.9)	4.9 (4.7, 5.1)[a]	3.9 (3.9, 4.0)	4.2 (4.1, 4.3)
Total-to-HDL cholesterol ratio ≥5.9, %	8.7 (7.89, 9.5)	27.5 (22.1, 32.9)[a]	8.2 (7.4, 8.9)	12.0 (10.2, 13.9)[a]
Report of taking cholesterol medication, %	1.9 (1.5, 2.4)	20.5 (16.1, 24.9)[a]	24.1 (22.9, 25.3)	55.5 (52.8, 58.2)[a]
Uncontrolled high cholesterol, %[b]	8.5 (7.6, 9.3)	27.5 (21.2, 33.9)[a]	9.2 (8.3, 10.1)	16.1 (13.3, 18.9)[a]
BP				
SBP, mean, mmHg	115.3 (114.9, 115.7)	122.8 (121.1, 124.5)[a]	126.1 (125.4, 126.7)	130.8 (129.7, 131.1)[a]
DBP, mean, mmHg	69.5 (69.0, 70.0)	74.8 (73.5, 76.2)[a]	68.8 (68.1, 69.5)	71.8 (71.3, 72.3)[a]
SBP/DBP ≥140/90, %	5.3 (4.8, 5.8)	14.0 (10.2, 17.9)[a]	20.9 (19.6, 22.3)	28.1 (25.9, 30.3)[a]
Report of taking antihypertension medication, %	4.4 (3.8, 4.9)	29.3 (23.8, 34.8)[a]	33.2 (31.6, 34.7)	63.7 (61.1, 66.3)
Uncontrolled hypertension, %[c]	4.5 (4.0, 5.0)	11.3 (6.7, 15.8)[a]	16.4 (15.0, 17.9)	23.7 (19.8, 27.6)[a]
A1C				
A1C, mean; %, mmol/mol	5.3 (5.2, 5.3), 34 (33, 34)	7.8 (7.6, 8.1), 62 (60, 65)[a]	5.5 (5.5, 5.6), 37 (37, 38)	7.3 (7.2, 7.4), 56 (55, 57)
A1C ≥9% (≥75 mmol/mol), %	n/a	25.5 (20.7, 30.4)	n/a	12.6 (10.9, 14.2)
CKD	9.5 (8.6, 10.4)	27.2 (22.7, 31.7)[a]	19.3 (18.2, 20.3)	40.3 (37.9, 42.7)[a]
History of cardiovascular disease	1.4 (1.1, 1.7)	8.6 (5.2, 12.0)[a]	10.5 (9.8, 11.3)	26.5 (24.4, 28.5)[a]
Measures of adiposity				
BMI, mean, kg/m^2	28.0 (27.8, 28.2)	35.7 (34.7, 36.8)[a]	28.5 (28.3, 28.8)	32.8 (32.5, 33.2)[a]
BMI ≥30 kg/m^2, %	31.6 (30.2, 33.1)	74.5 (70.0, 79.0)[a]	33.5 (32.0, 35.0)	63.4 (60.7, 66.0)[a]
WHtR, mean	0.56 (0.55, 0.56)	0.68 (0.66, 0.69)[a]	0.59 (0.59, 0.60)	0.67 (0.66, 0.67)[a]
WHtR ≥0.5, %	68.6 (66.7, 70.4)	92.4 (89.3, 95.5)[a]	88.2 (87.2, 89.2)	98.2 (97.6, 98.9)[a]
Health behaviors				
HEI-2010, mean	47.8 (47.3, 48.4)	45.7 (44.0, 47.4)	52.7 (52.1, 53.4)	52.1 (51.4, 52.9)
HEI-2010 <75th percentile	78.8 (77.3, 80.4)	85.5 (81.3, 89.8)[a]	67.9 (66.1, 69.8)	70.3 (68.2, 72.4)
Leisure-time PA <150 min/week, %	57.5 (56.0, 59.1)	74.5 (69.9, 79.2)[a]	67.8 (65.9, 69.6)	79.5 (77.2, 81.9)[a]
Cotinine levels ≥10 ng/mL, %	28.8 (27.1, 30.5)	32.5 (27.3, 37.8)	21.0 (19.4, 22.6)	20.2 (18.2, 22.2)

Data are presented as mean or percentage with 95% CIs in parenthesis. Hypertension defined as BP ≥140/90 mmHg or report of taking BP medication. Diabetes defined as self-report of diabetes diagnosis by a health care provider or A1C ≥6.5% (48 mmol/mol). CKD defined as eGFR <60 mL/min/1.73 m^2 or elevated urinary ACR (ACR ≥30 mg/g). History of cardiovascular disease defined as self-report of congestive heart failure, coronary heart disease, angina pectoris, heart attack, or stroke. DBP, diastolic blood pressure; n/a, not applicable; SBP, systolic blood pressure. [a]Comparison based on two-sided *t* test with $P < 0.05$. [b]Uncontrolled high cholesterol defined as total-to-HDL cholesterol ratio ≥5.9 among participants who do not report use of cholesterol-lowering medications (18–44 years old, *n* = 10,134; ≥45 years old, *n* = 8,503). [c]Uncontrolled BP defined as BP ≥140/90 mmHg among participants who do not report use of antihypertensive medications (18–44 years old, *n* = 10,336; ≥45 years old, *n* = 7,297).

Table 3—Adjusted[a] predicted marginals and differences of cardiovascular disease risk factors among young adults (18–44 years old) and older adults (≥45 years old) with and without diabetes—NHANES, 2007–2016

	18–44 years old (n = 10,898)			≥45 years old (n = 12,900)			Difference in difference (difference 18–45 years old − difference ≥45 years old), 95% CI
	Diabetes, % (95% CI)	No diabetes, % (95% CI)	Difference (diabetes − no diabetes), 95% CI	Diabetes, % (95% CI)	No diabetes, % (95% CI)	Difference (diabetes − no diabetes), 95% CI	
Total-to-HDL cholesterol ratio ≥5.9	22.8 (18.6, 27.6)	8.8 (8.1, 9.6)	**14.0 (9.4, 18.5)**	12.5 (10.7, 14.5)	8.1 (7.4, 8.8)	**4.4 (2.4, 6.4)**	**9.6 (4.6, 14.5)**
BP ≥140/90 mmHg	9.5 (7.0, 12.8)	5.4 (4.9, 4.9)	**4.2 (1.3, 7.0)**	24.3 (22.3, 24.5)	21.7 (20.4, 23.0)	**2.7 (0.6, 4.7)**	1.5 (−2.0, 5.0)
CKD	27.8 (23.3, 32.7)	9.5 (8.6, 10.4)	**18.3 (13.6, 22.9)**	34.7 (32.3, 37.0)	20.1 (19.1, 21.2)	**14.5 (12.2, 16.8)**	3.7 (−1.5, 8.9)
History of cardiovascular disease	4.8 (3.2, 7.3)	1.4 (1.1, 1.7)	**3.4 (1.4, 5.4)**	22.0 (20.1, 24.0)	11.1 (10.3, 11.9)	**10.9 (8.9, 12.9)**	**−7.5 (10.3, −4.7)**
BMI ≥30 kg/m^2	69.1 (63.4, 74.3)	31.8 (30.4, 33.3)	**37.3 (31.8, 42.7)**	64.1 (61.3, 66.9)	33.4 (32.0, 34.9)	**30.7 (28.0, 33.5)**	**6.5 (0.4, 12.6)**
WHtR ≥0.5	87.9 (82.7, 91.7)	68.9 (67.1, 70.7)	**18.9 (14.2, 23.7)**	98.0 (97.1, 98.6)	88.5 (87.5, 89.4)	**9.5 (8.4, 10.6)**	**9.5 (4.6, 14.4)**
Total healthy eating index <75th percentile	85.8 (80.9, 89.6)	78.8 (77.3, 80.3)	**7.0 (2.3, 11.4)**	70.0 (67.7, 72.3)	68.0 (66.2, 69.7)	2.1 (−0.4, 4.5)	4.9 (−0.12, 10.0)
Leisure-time PA <150 min per week	69.8 (64.3, 74.9)	57.8 (56.2, 59.3)	**12.1 (7.0, 17.2)**	77.3 (74.5, 79.8)	68.4 (66.6, 70.1)	**8.9 (6.4, 11.4)**	3.2 (−2.5, 8.9)
Cotinine levels ≥10 ng[b]	32.1 (27.1, 37.5)	28.8 (27.1, 30.5)	3.3 (−2.3, 8.8)	20.1 (18.0, 22.5)	21.0 (19.6, 22.6)	−0.09 (−3.2, 1.4)	4.2 (−1.8, 10.2)

Diabetes defined by self-report of diagnosis or A1C ≥6.5% (48 mmol/mol). Differences statistically different from zero are shown in boldface type. CKD defined as eGFR <60 mL/min/1.73 m^2 or elevated urinary ACR (ACR ≥30 mg/g). History of cardiovascular disease defined as self-report of congestive heart failure, coronary heart disease, angina pectoris, heart attack, or stroke. [a]Adjusted for age (continuous), sex, race/ethnicity, health insurance status, and PIR. [b]Cotinine levels only available for 2007–2014 (18–44 years old, n = 8,448; ≥45 years old, n = 10,009).

Cardiometabolic Risk Factors

Young adults with diabetes had a less favorable cardiometabolic risk profile compared with young adults without diabetes (Table 2). Compared with those without diabetes, young adults with diabetes were more likely to have a high total-to-HDL cholesterol ratio, elevated BP levels or hypertension, uncontrolled high cholesterol, CKD, and self-reported history of cardiovascular disease. The percentage of young adults with diabetes who were obese, measured by BMI or WHtR, was twice as high compared with young adults without diabetes. Young adults with diabetes were more likely to have lower HEI-2010 scores and to engage in less leisure-time PA than their counterparts without diabetes. There were no significant differences in cotinine levels between the groups; approximately one-third of young adults had cotinine levels indicating current smoking (with ≥10 ng/mL). Similar patterns in cardiometabolic risk factors were observed among older adults with diabetes compared with those without diabetes (Table 2), with the exception of HEI-2010 scores, which were not significantly different.

Young and older adults with diabetes differed by a number of treatment and control measures (Table 2). Young adults with diabetes were less likely than older adults with diabetes to report medication for high cholesterol (20.5% and 55.5%, respectively) and antihypertension medication (29.3% and 63.7%, respectively). Among those with diabetes, 25.5% of young adults and 12.6% of older adults had A1C levels >9% (75 mmol/mol).

After adjustment for age, sex, race or ethnicity, PIR, and health insurance status, the difference between young adults with diabetes and those without diabetes was significantly different from zero for every risk factor except cotinine levels (Table 3). Young adults with diabetes were 14.0 percentage points (95% CI 9.4, 18.5) more likely to have elevated cholesterol levels and 4.2 percentage points (95% CI 1.3, 7.0) more likely to have elevated BP compared with those without diabetes. Young adults with diabetes were also less likely to report consuming a healthy diet or engaging in leisure-time PA compared with those without diabetes (7.0 percentage points [95% CI 2.3, 11.4] and 12.1 percentage points [95% CI 7.0, 17.2], respectively).

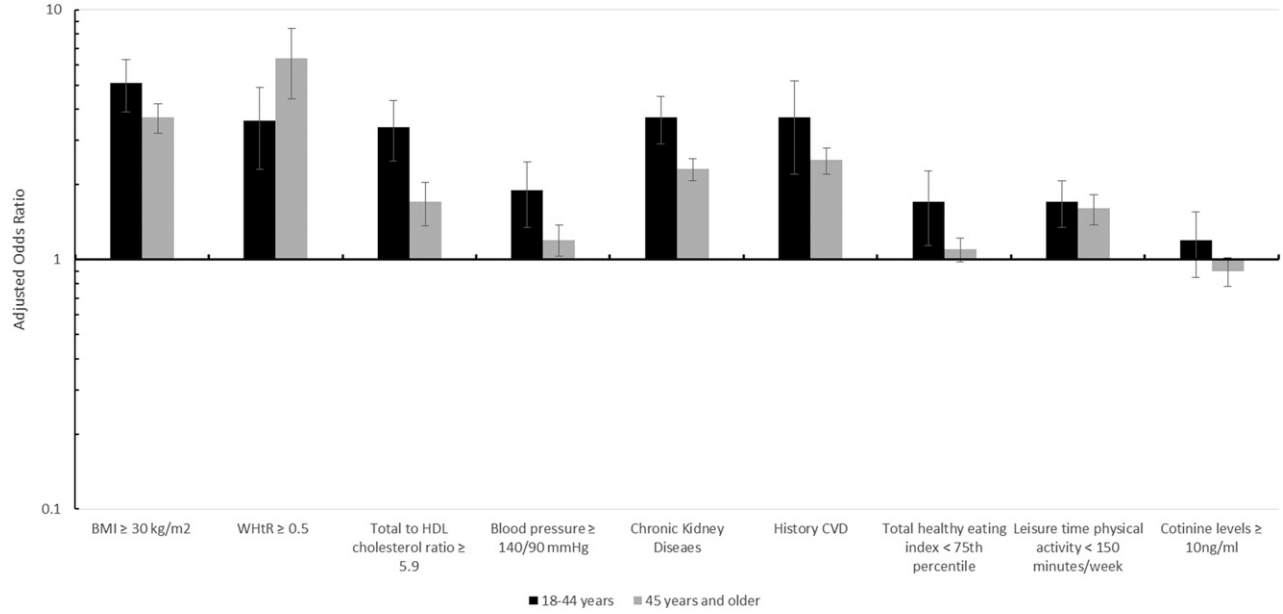

Figure 1—AORs of cardiovascular disease risk factors for adults with diabetes compared with those without diabetes, 18–44 years old and ≥45 years old (NHANES, 2007–2016). Adults 18–44 years old modeled separately from adults ≥45 years old, and each risk factor or complication modeled separately. Reference group for each participant without diabetes. Sample size: 18–44 years old, *n* = 10,898, and ≥45 years old, *n* = 12,900. Odds ratios adjusted for age (continuous), sex, race/ethnicity, PIR, and health insurance status.

Observed differences in cardiometabolic risk factors across diabetes status were similar among younger compared with older adults, and we found that the percentage differences for hypertension, leisure-time PA, HEI-2010, and cotinine levels were not significantly different from zero. Although we observed differences by diabetes status in both groups, the magnitude of these differences was too small to be statistically significant. However, differences in differences greater than zero were observed for high cholesterol (9.6 [95% CI 4.6, 14.5]) and measures of adiposity (BMI 6.5 [95% CI 0.4, 12.6] and WHtR 9.5 [95% CI 4.6, 14.4]).

Young adults with diabetes also had greater relative differences, as measured by AOR, for cardiometabolic risk factors compared with those without diabetes (Fig. 1), with larger relative differences for obesity measures and lipids. Among young adults with diabetes, the AOR for a BMI of ≥30 kg/m^2 was 5.1 (95% CI 3.9, 6.6), for WHtR the AOR was 3.6 (95% CI 2.3, 5.7), and for high cholesterol the AOR was 3.4 (95% CI 2.5, 4.6) compared with those without diabetes. In addition, older adults with diabetes had greater relative differences, as measured by AOR, for cardiometabolic risk factors compared with those without diabetes.

CONCLUSIONS

Young adults with diabetes have a worse cardiometabolic risk profile than young adults without diabetes, being almost twice as likely to have obesity, elevated lipids, or hypertension and less likely to report being physically active or consuming a healthy diet. We found that differences in severe obesity and lipid levels were much larger between young adults with and without diabetes compared with older adults with and without diabetes. We also found among participants with diabetes that young adults were more likely to have poor blood glucose control (A1C ≥9% [75 mmol/mol]) compared with older adults.

These findings are a public health concern because diabetes beginning in youth or young adulthood presents a future population health burden affecting morbidity and mortality rates, loss of quality of life, and a burden on the health care system (2,7,8,22,23). Among the population, it is estimated that an individual diagnosed with diabetes at age 40 years will lose 6–7 years of life (24) and 19 quality-adjusted life years compared with an individual without diabetes (25). Recently, the SEARCH for Diabetes in Youth study found that some individuals diagnosed with diabetes in childhood had already presented subclinical cardiovascular diseases within a few years of diagnosis (2). Diagnosis of diabetes by 10 years of age corresponds to a 1.2 times increased risk of all-cause mortality and a 1.6 times increased risk of cardiovascular disease mortality (8). Regardless of diabetes status, elevated risk factors, such as A1C levels and obesity, increase the risk of death before age 55 years (26).

Although young adults with diabetes had lower BP levels compared with older adults with diabetes, young adults had higher cholesterol levels. High cholesterol levels are a major risk factor for cardiovascular disease (27). Because total cholesterol levels tend to increase with age (28), it was unexpected to find higher elevated total cholesterol-to-HDL ratio among young adults versus older adults with diabetes. This finding may be more attributable to the difference in HDL cholesterol levels than total cholesterol levels because HDL cholesterol levels tend to be higher among older than younger adults (29). We also found that older adults were more than twice as likely to report use of cholesterol-lowering medication. Current clinical guidelines by the American Diabetes Association recommend treatment of elevated cholesterol levels regardless of age (17). Regardless, diabetes and high cholesterol are independent major risk factors for cardiovascular disease, and with the

combined presence of both, cardiovascular risk is further increased (30). Furthermore, the risk of ischemic heart disease mortality can be lowered to a larger extent among young adults compared with older adults when cholesterol levels are similarly reduced (31).

We found that more than one-quarter of young adults with diabetes already have CKD, increasing their risk of kidney failure and cardiovascular disease (32). While this high prevalence is concerning, it is important to note that the difference in the prevalence of CKD by diabetes status among young adults is not significantly different than the difference observed among older adults. However, the prevalence of CKD increases with age (33) and whether this difference in CKD prevalence will widen as the young adult population with diabetes ages is unknown.

Eating a healthy diet and engaging in leisure-time PA are associated with lower morbidity and mortality rates (34) and are recommended for cardiovascular disease prevention (35). Although there were no significant differences in these healthy behaviors between younger and older adults, young adults with diabetes were significantly less likely to report consuming a healthy diet or participating in PA compared with their counterparts without diabetes. Promoting healthy eating and increased PA among young adults may reduce cardiometabolic risk in this group.

Although there was no significant difference in smoking status for young adults with and without diabetes, young adults have higher levels of smoking compared with the older adult population. This is a particular concern because smoking in combination with diabetes dramatically increases the risk of cardiovascular disease (36). Our findings of a high prevalence of smoking among the young adult population are supported by a recent article that found that young adults aged 18–25 years had the highest levels of smoking initiation (37).

Possible reasons and causes for the observed differences by diabetes status and age are likely complex. Health care access and utilization might contribute to these differences. While report of having a usual place to receive health care was similar across groups, we found that young adults were almost twice as likely to have no health insurance compared with older adults. The lack of health insurance may influence health care decisions and access by young adults to treatments for diabetes or elevated cholesterol.

There are five main limitations to our analysis. First, we did not distinguish between type 1 and 2 diabetes in this analysis. Previously, the prevalence of type 1 diabetes in NHANES, which is based on use of insulin alone and age of diagnosis $<$30 or 40 years, was 0.34–0.42% among those aged 20–40 years (38). Recent studies of diabetes complications among adolescents and young adults found the prevalence higher among those with type 2 diabetes but common for both type 1 and type 2 diabetes (2). The disease pathophysiology of type 2 diabetes may differ by age of diagnosis; individuals diagnosed at younger ages are at increased risk of developing earlier complications caused by more rapid decline of β-cell function and development of complications (12). Whether there are differences in the disease process for type 1 diabetes depending on age of diagnosis is unknown because most studies of type 1 diabetes and its complications have focused on individuals diagnosed in childhood (39).

Second, because of the relatively small number of young adult NHANES participants with diabetes, we had to combine multiple survey cycles to characterize the population more fully. This prevented a full exploration of trends in the prevalence of risk factors among young adults with diabetes. The results presented are the time-averaged mean from 2007 to 2016; therefore, it is unknown whether there is a secular trend. Third, we defined diabetes by self-report or A1C levels because of the smaller number of participants with measured fasting plasma glucose. There is a possibility that participants with diabetes based on fasting plasma glucose levels were misclassified. Fourth, self-report of income level and health insurance is potentially subject to social desirability bias. Lastly, NHANES is a cross-sectional survey, which means we cannot determine causality. We also do not have follow-up information on outcomes, such as cardiovascular disease complications, for the participants.

Strengths of this study are as follows: the results are nationally representative of the noninstitutionalized civilian U.S. population; cardiometabolic risk factors are obtained through standardized measurement and laboratory procedures; and we examined and compared characteristics of the young adult and older adult diabetes populations.

The overall burden of diabetes among young adults is expected to more than double to $>$5 million in the U.S. by 2030 (40). Although lower mortality rates among adults with diabetes in the U.S. have been seen during the past two decades, the age-group that did not see improvements was the young adult population (11). In addition, even though this study did not examine associations between cardiometabolic risk factors among young adults and mortality, previous studies suggest that these risk factors may lead to early mortality among this group (26). A better understanding of the modifiable differences between the young and older populations with diabetes can illuminate how best to improve the cardiometabolic risk profile of this younger population, which can be an important contribution to reducing future diabetes-related morbidity and mortality rates.

Duality of Interest. No potential conflicts of interest relevant to this article were reported.
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