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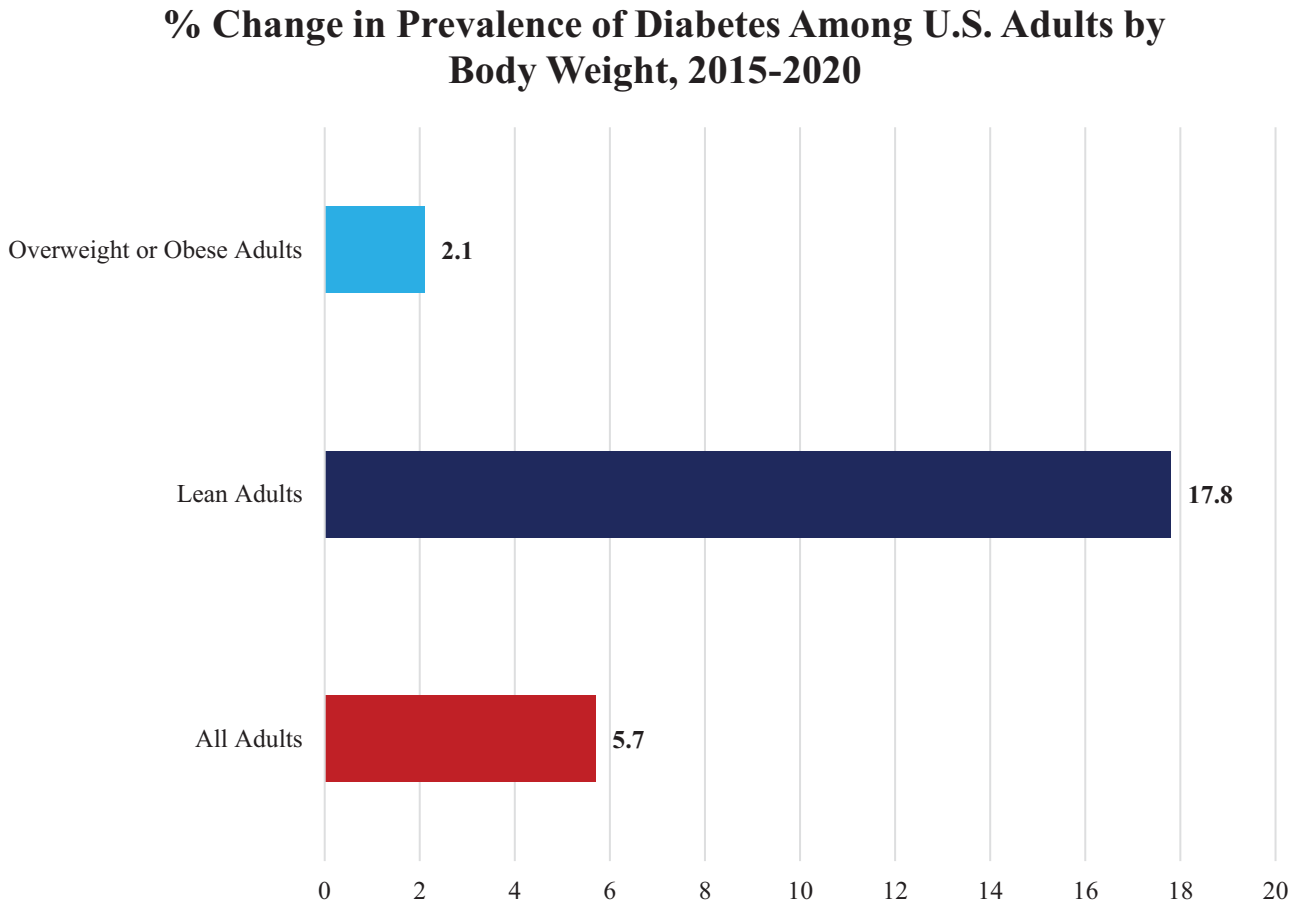

ARTICLE HIGHLIGHTS

- The prevalence of lean diabetes increased significantly among U.S. adults from 2015 to 2020.
- Black and Hispanic adult populations experienced larger increases in lean diabetes compared with other race/ethnic categories.
- Among overweight and obese adults, diabetes prevalence did not increase significantly from 2015 to 2020.
- Lean diabetes contributes to the increase in overall diabetes prevalence in the U.S.

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OBJECTIVE

To examine trends and prevalence of lean diabetes among adults in the U.S. from 2015 to 2020, overall and stratified by age, sex, and race/ethnicity.

RESEARCH DESIGN AND METHODS

An exploratory study design evaluated the prevalence and trends of lean diabetes among 2,630,463 (unweighted) adults aged ≥18 years who responded to the Behavioral Risk Factor Surveillance System (BRFSS), years 2015 to 2020.

RESULTS

Diabetes increased significantly among lean adults with BMI of <25 kg/m^2 from 4.5% (95% CI 4.3–4.7) in 2015 to 5.3% (95% CI 5.0–5.7) in 2020, representing a 17.8% increase (odds ratio 1.21; 95% CI 1.12–1.31), with no significant change among overweight/obese adults. Increases in diabetes prevalence among lean adults varied by subgroup with Black, Hispanic, and female populations seeing the largest growth.

CONCLUSIONS

The prevalence of lean diabetes among the U.S. adult population is increasing, with larger increases among women and populations of color.

Diabetes is an important public health challenge as it impacts >10% of the U.S. population (1). The prevalence of diabetes in the U.S. has increased over time, rising by 26% from 9.5% in 1999–2002 to 12% in 2013–2016 but reducing to 10.5% in 2018 (1). A prominent risk factor for diabetes is excessive body weight (2). Approximately 89% of adults with diabetes are overweight or obese (1). Beyond increasing the risk of developing diabetes, obesity also complicates diabetes care and management (3). Although diabetes prevalence increased over time, whether this trend was similar for individuals of different body weight categories is unclear.

Despite the well-known relationship between obesity and diabetes, diabetes can also occur among populations that are lean (i.e., BMI <25 kg/m^2) (4,5). Such "lean diabetes" (4) is characterized by reduced insulin secretion and less insulin resistance compared with diabetes among the obese population (6), and lean diabetes may be a result of different underlying factors, such as malnutrition (4). While diabetes among nonobese adults and among obese adults may present different clinically and have different potential etiologies, both groups share an increased risk for mortality, cardiovascular disease complications, and other adverse outcomes relative to their counterparts without diabetes (6). Furthermore, nonobese adults

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with diabetes may face a slightly increased risk for adverse outcomes relative to their obese counterparts who have diabetes (6). While 11% of adults with diabetes in the U.S. are not overweight or obese (1), there is little understanding regarding trends in lean diabetes in the U.S. Information on the contribution of lean diabetes to the overall diabetes prevalence is useful for surveillance and better diabetes management in lean individuals. We contribute to the literature by evaluating trends in the prevalence of diabetes among lean populations in the U.S. overall and by race/ethnicity, age, and sex.

RESEARCH DESIGN AND METHODS

This study used data from 2015 to 2020 of the Behavioral Risk Factor Surveillance System (BRFSS), a telephone survey that collects information on health risk behaviors, chronic health conditions, and preventive health care use among adults (≥18 years). The primary outcome of the study was having indicated self-reported diabetes by answering "yes" to the question "Has a doctor, nurse, or other health professional ever told you that you [had] . . . diabetes?," with women who indicated diabetes only during pregnancy not being considered as having diabetes for this study. The University of Arkansas for Medical Sciences Institutional Review Board determined the study as nonhuman subject research.

We evaluated prevalence and trends of diabetes by body weight category, with "lean" defined as BMI <25.0 kg/m^2 and "overweight/obese" defined as BMI ≥25.0 kg/m^2 according to the BRFSS-calculated BMI variable. To assess differences in trends among various subgroups, analyses were stratified by race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, and other race/ethnicity), sex (male and female), and age (<45 years and ≥45 years). Analyses accounted for the complex survey design of the BRFSS (7), which allows results to be generalizable to adults with diabetes in the U.S. We evaluated trends in diabetes in two ways. First, we used logistic regression models with a linear time trend to regress diabetes status on to survey year (8). Second, we conducted logistic regressions with categorical year variables, with 2015 as the reference to be able to compare 2020 to 2015. These models were conducted separately for BMI categories and by race/ethnicity, sex, and age. We conducted a sensitivity analysis that excluded year 2020 from the data due to the general disruption in the health care system related to the coronavirus disease 2019 pandemic. Statistical significance was assumed at $P < 0.05$.

RESULTS

The study included 2,630,463 (unweighted) respondents. Table 1 provides the prevalence of diabetes by year overall and stratified by BMI category and by demographic characteristics. The right-most columns of the table indicate the change in prevalence from 2015 to 2020, the unadjusted odds ratio (OR) associated with 2020 vs. 2015 in logistic regressions, and the unadjusted OR associated with a continuous year variable in logistic regressions. Please refer to Table 1 for CIs.

Overall, the prevalence of diabetes increased significantly from 10.5% in 2015 to 11.1% in 2020, representing an increase of 5.7% (OR 1.07; 95% CI 1.04–1.10; $P < 0.001$). Among lean adults, there was a significant increase in the prevalence of diabetes from 4.5% in 2015 to 5.3% in 2020, representing a 17.8% (OR 1.21; 95% CI 1.12–1.31; $P < 0.001$) increase, but there was no significant increase among overweight/obese adults.

When stratifying by race, we found that the prevalence of diabetes among lean adults increased significantly by 41.5% (OR 1.44; 95% CI 1.16–1.78) among Black adults and by 30.9% (OR 1.32; 95% CI 1.04–1.67) among Hispanic adults, with a 15.8% (OR 1.15; 95% CI 1.05–1.25) increase among White adults.

When evaluating trends by sex, we found a 6.9% (OR 1.08; 95% CI 1.00–1.17) significant increase in diabetes prevalence among women in the entire study sample, with no such increases among men. We also found a 43.2% (OR 1.45; 95% CI 1.19–1.78) increase in diabetes among lean women but no such significant increases among lean men.

When assessing differences in the prevalence of diabetes among different age-groups, we found a significant increase in diabetes prevalence of 14.3% (OR 1.15; 95% CI 1.05–1.25) among adults <45 years old and an increase of 4.1% (OR 1.05; 95% CI 1.01–1.08) among adults >45 years. There was a significant increase of 17.9% (OR 1.19; 95% CI: 1.09–1.29) in adults >45 years of age among lean individuals and a significant increase of 10.0% (OR 1.11; 95% CI 1.00–1.23) in adults <45 years in the overweight/obese category.

CONCLUSIONS

This nationally representative study from 2015 to 2020 found significant increases in the prevalence of diabetes among lean adults of all races except for Asian and the "other" race/ethnicity, among those aged ≥45 years, and among women, with no increases in diabetes prevalence among overweight/obese populations overall. While the higher prevalence of diabetes among adult populations of color is well established (1), our study finds an increasing trend in the percentage of diabetes in lean populations of color.

The U.S. Preventive Services Task Force (USPSTF) recommends that overweight or obese adults aged 35 to 70 years be screened for prediabetes and type 2 diabetes (9). Our study found that lean populations had approximately nine-times higher growth in the prevalence of diabetes in the last 5 years compared with overweight/obese populations. In addition to screening overweight and obese adults for diabetes, it may be beneficial to consider increasing screening efforts to populations that are not overweight or obese, particularly women, populations aged ≥45, and non-White adults. Previous studies in other countries have found relationships between malnutrition and diabetes among lean populations (4). Another study found a high prevalence of alcoholism and smoking in lean adults with diabetes (10). More studies should consider exploring other socioeconomic factors that may predispose lean populations to diabetes. Given the substantially higher trends of diabetes prevalence among lean adult populations of color, a better understanding of how to prevent and treat diabetes among lean adults will be critical for ensuring health equity.

Health care providers and public health professionals should be aware of the increasing manifestation of diabetes in individuals who are not overweight or obese. Therefore, early diabetes screening and preventive programs should include lean individuals, with increased focus on adults aged ≥45, women, and adult populations of color.

Our study had several limitations. First, BRFSS is self-reported data that are subject

Table 1—Prevalence[a] of diabetes among overweight and nonoverweight adults aged ≥18 years in the U.S., overall and by race/ethnicity, sex, and age: BRFSS 2015–2020

	Respondents (*n*)	2015	2016	2017	2018	2019	2020	% Change 2015–2020	2020 vs. 2015[b] OR (95% CI)	*P* value of 2020 vs. 2015[b]	Test for linear trend[c] OR (95% CI)	*P* value for test of linear trend[c]
All	2,630,463[d]	10.5 (10.3–10.7)	10.8 (10.7–11.0)	10.9 (10.7–11.1)	11.4 (11.2–11.6)	11.1 (10.9–11.3)	11.1 (10.9–11.4)	5.7	1.07 (1.04–1.10)	<0.001	1.01 (1.01–1.02)	<0.001
By race/ethnicity												
White	1,970,177	9.8 (9.7–1.0)	10.3 (10.1–10.5)	10.1 (9.9–10.3)	10.7 (10.5–10.9)	10.3 (10.1–10.5)	10.5 (10.3–10.7)	7.1	1.08 (1.04–1.11)	<0.001	1.01 (1.01–1.02)	<0.001
Black	206,697	14.3 (13.7–15.0)	14.2 (13.6–14.8)	14.3 (13.6–15.0)	14.9 (14.2–15.6)	14.9 (14.2–15.5)	15.5 (14.7–16.3)	8.4	1.10 (1.01–1.18)	0.022	1.02 (1.01–1.03)	0.004
Hispanic	222,128	10.7 (10.2–11.2)	10.9 (10.3–11.4)	11.7 (11.1–12.4)	11.6 (10.9–12.3)	12.0 (11.4–12.6)	11.9 (11.1–12.7)	11.2	1.13 (1.03–1.24)	0.012	1.03 (1.01–1.04)	0.001
Asian	59,127	8.8 (7.6–10.2)	8.8 (7.7–10.1)	8.4 (7.2–9.8)	9.2 (8.0–10.5)	7.8 (6.7–8.9)	6.8 (5.9–7.8)	−22.7	0.75 (0.60–0.94)	0.011	0.95 (0.92–0.99)	0.007
Other	121,831	11.5 (10.6–12.3)	11.8 (11.1–12.7)	12.9 (12.0–13.9)	13.9 (12.9–15.0)	13.4 (12.5–14.3)	11.5 (10.6–12.4)	0	1.00 (0.89–1.13)	0.998	1.01 (0.99–1.03)	0.156
By sex												
Female	1,107,162	10.1 (9.9–10.3)	10.5 (10.3–10.8)	10.6 (10.3–10.8)	11.1 (10.8–11.4)	10.5 (9.9–11.1)	10.8 (10.1–11.5)	6.9	1.08 (1.00–1.17)	0.048	1.02 (1.01–1.03	<0.001
Male	868,724	10.9 (10.7–11.2)	11.1 (10.9–11.4)	11.2 (10.9–11.5)	11.7 (11.5–12.0)	10.9 (10.3–11.5)	11.5 (10.7–12.2)	5.5	1.05 (0.97–1.14)	0.199	1.01 (1.00–1.03	0.006
By age												
<45	737,653	2.8 (2.6–2.9)	2.8 (2.7–3.0)	2.9 (2.7–3.1)	3.1 (3.0–3.3)	2.9 (2.8–3.1)	3.2 (3.0–3.4)	14.3	1.15 (1.05–1.25)	0.002	1.03 (1.01–1.04)	0.001
≥45	1,892,810	17.2 (17.0–17.5)	17.7 (17.5–18.0)	17.7 (17.4–18.1)	18.5 (18.1–18.8)	18.1 (17.8–18.3)	17.9 (17.5–18.2)	4.1	1.05 (1.01–1.08)	0.005	1.01 (1.00–1.01)	<0.001
Lean population												
All	791,445	4.5 (4.3–4.7)	4.8 (4.6–5.0)	4.6 (4.4–4.9)	5.1 (4.9–5.4)	5.0 (4.8–5.3)	5.3 (5.0–5.7)	17.8	1.21 (1.12–1.31)	<0.001	1.03 (1.02–1.05)	<0.001
By race/ethnicity												
White	615,208	3.8 (3.7–4.0)	4.2 (4.0–4.4)	4.0 (3.8–4.3)	4.5 (4.3–4.8)	4.2 (4.0–4.4)	4.4 (4.1–4.7)	15.8	1.15 (1.05–1.25)	0.002	1.02 (1.01–1.04)	0.001
Black	45,200	6.5 (5.8–7.4)	7.0 (6.2–7.9)	6.8 (5.9–7.9)	6.9 (6.0–7.9)	8.3 (7.2–9.6)	9.2 (7.8–10.6)	41.5	1.44 (1.16–1.78)	0.001	1.07 (1.03–1.11)	<0.001
Hispanic	55,878	5.5 (4.8–6.3)	5.5 (4.7–6.4)	6.0 (5.2–6.9)	5.9 (5.0–6.8)	6.8 (5.9–7.7)	7.2 (6.0–8.5)	30.9	1.32 (1.04–1.67)	0.024	1.06 (1.02–1.10	0.005
Asian	28,890	4.9 (3.8–6.4)	5.2 (4.1–6.5)	4.3 (3.5–5.4)	6.2 (4.8–8.0)	4.3 (3.3–5.7)	4.7 (3.6–6.0)	−4.1	0.95 (0.65–1.40)	0.809	0.99 (0.93–1.05)	0.728
Other	33,436	5.3 (4.2–6.7)	4.9 (4.1–5.9)	5.8 (4.6–7.1)	6.8 (5.4–8.7)	6.1 (5.0–7.5)	5.4 (4.5–6.5)	1.9	1.02 (0.75–1.38)	0.918	1.03 (0.98–1.08)	0.276

Continued on p. 888

Table 1—Continued

	Respondents (*n*)	2015	2016	2017	2018	2019	2020	% Change 2015–2020	2020 vs. 2015[b] OR (95% CI)	*P* value of 2020 vs. 2015[b]	Test for linear trend[c] OR (95% CI)	*P* value for test of linear trend[c]
By sex												
Female	380,848	3.7 (3.5–3.9)	4.3 (4.0–4.5)	4.3 (4.0–4.6)	4.5 (4.1–4.8)	4.3 (3.7–5.1)	5.3 (4.4–6.3)	43.2	1.45 (1.19–1.78)	<0.001	1.06 (1.03–1.09)	<0.001
Male	221,938	5.5 (5.1–5.9)	5.5 (5.2–5.9)	5.1 (4.8–5.5)	6.0 (5.6–6.5)	4.7 (4.1–5.5)	5.9 (5.0–6.9)	7.3	1.08 (0.90–1.29)	0.434	1.01 (0.99–1.04)	0.289
By age												
<45	257,338	1.1 (0.9–1.2)	1.1 (1.0–1.3)	1.2 (1.0–1.3)	1.3 (1.1–1.5)	1.1 (1.0–1.3)	1.3 (1.1–1.6)	18.2	1.20 (0.94–1.52)	0.146	1.03 (0.99–1.07)	0.159
≥45	534,107	8.4 (8.1–8.8)	9.1 (8.7–9.5)	8.7 (8.3–9.1)	9.5 (9.0–10.0)	9.6 (9.1–10.0)	9.9 (9.3–10.5)	17.9	1.19 (1.09–1.29)	<0.001	1.03 (1.02–1.05)	<0.001
Overweight-obese population												
All	1,615,241	14.0 (13.8–14.3)	14.2 (14.0–14.5)	14.4 (14.1–14.7)	14.8 (14.5–15.0)	14.3 (14.1–14.6)	14.3 (14.0–14.6)	2.1	1.02 (0.99–1.06)	0.159	1.00 (1.00–1.01)	0.075
By race/ethnicity												
White	1,209,468	13.3 (13.0–13.5)	13.7 (13.4–13.9)	13.5 (13.2–13.8)	14.1 (13.8–14.4)	13.5 (13.2–13.8)	13.7 (13.3–14.0)	3.0	1.03 (0.99–1.07)	0.061	1.00 (1.00–1.01)	0.099
Black	141,806	17.9 (17.1–18.8)	17.3 (16.5–18.2)	17.6 (16.7–18.6)	18.2 (17.3–19.1)	17.7 (16.9–18.5)	17.9 (16.9–18.9)	0.0	1.00 (0.91–1.09)	0.942	1.00 (0.99–1.02)	0.735
Hispanic	136,139	13.3 (12.6–14.1)	13.7 (12.9–14.5)	14.7 (13.8–15.6)	14.0 (13.1–14.9)	14.7 (13.8–15.6)	14.5 (13.4–15.7)	9.0	1.11 (0.99–1.24)	0.076	1.02 (1.00–1.04)	0.038
Asian	24,134	15.0 (12.6–17.9)	14.1 (11.7–16.8)	14.6 (12.1–17.6)	14.7 (12.4–17.3)	12.8 (10.9–15.1)	10.5 (8.7–12.6)	−30.0	0.66 (0.49–0.89)	0.006	0.94 (0.89–0.98)	0.007
Other	78,596	14.9 (13.8–16.1)	15.5 (14.4–16.7)	16.6 (15.4–18.0)	17.8 (16.4–19.3)	17.0 (15.7–18.3)	15.1 (13.7–16.5)	1.3	1.01 (0.88–1.17)	0.17	1.01 (0.99–1.04)	0.261
By sex												
Female	602,624	14.8 (14.4–15.1)	14.9 (14.5–15.3)	14.9 (14.5–15.3)	15.2 (14.8–15.6)	14.8 (13.9–15.8)	14.7 (13.6–15.8)	−0.7	0.99 (0.91–1.09)	0.902	1.00 (0.99–1.02)	0.572
Male	608,497	13.4 (13.1–13.7)	13.7 (13.3–14.0)	13.9 (13.5–14.3)	14.3 (13.9–14.7)	13.6 (12.8–14.4)	13.8 (12.8–14.9)	3.0	1.04 (0.95–1.13)	0.447	1.01 (1.00–1.03)	0.023
By age												
<45	408,996	4.0 (3.8–4.3)	4.1 (3.8–4.3)	4.1 (3.8–4.4)	4.4 (4.1–4.7)	4.2 (3.9–4.5)	4.4 (4.1–4.8)	10.0	1.11 (1.00–1.23)	0.040	1.02 (1.00–1.04)	0.02
≥45	1,206,245	21.1 (20.7–21.5)	21.4 (21.1–21.8)	21.6 (21.1–22.0)	22.1 (21.7–22.5)	21.5 (21.1–21.9)	21.4 (20.9–21.8)	1.4	1.02 (0.98–1.05)	0.400	1.00 (1.00–1.01)	0.267

[a]Percentages are weighted to reflect the complex survey design of the BRFSS, years 2015-2020. [b]Percentage change calculated as relative change from 2015 to 2020. ORs and *P* values were calculated using unadjusted logistic regression with year as a categorical variable to compare each year to 2015 as the reference. [c]ORs and *P* values were calculated using unadjusted logistic regression with year as a continuous variable. [d]Summation of *n* values of subgroups may not equal the total sample *N* due to missing information for subgroup variables.

to social desirability bias and which may underrepresent diabetes and obesity in this study. Second, the question regarding diabetes does not distinguish between type 1 and type 2 diabetes. However, given the low prevalence of type 1 diabetes, estimated at 6% of all diagnosed diabetes (11), and the increasing prevalence of diabetes among lean adults >45 years, we believe that type 1 diabetes is unlikely to be the sole cause of the increasing prevalence of lean diabetes in the U.S. Finally, our study was unable to disaggregate racial/ethnic subgroups within the larger racial/ethnic categories, such as disaggregated Asian subgroups (e.g., Chinese) within the broader Asian category. Future studies with the ability to distinguish between type 1 and type 2 diabetes are needed. Additionally, future studies that consider changes in screening across populations may help elucidate whether the change in lean diabetes noted in this study is due to better recognition or increased prevalence.

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

Author Contributions. T.P.A. conceptualized the study and was responsible for data curation. T.P.A. wrote the first draft. T.P.A. and C.C.B. contributed to the methodology and formal analysis. Both authors edited, reviewed, and approved the final version of the manuscript. T.P.A. 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.

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