SPECIAL ARTICLE

Projected U.S. State-Level Prevalence of Adult Obesity and Severe Obesity

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ABSTRACT

BACKGROUND

Although the national obesity epidemic has been well documented, less is known about obesity at the U.S. state level. Current estimates are based on body measures reported by persons themselves that underestimate the prevalence of obesity, especially severe obesity.

METHODS

We developed methods to correct for self-reporting bias and to estimate state-specific and demographic subgroup–specific trends and projections of the prevalence of categories of body-mass index (BMI). BMI data reported by 6,264,226 adults (18 years of age or older) who participated in the Behavioral Risk Factor Surveillance System Survey (1993–1994 and 1999–2016) were obtained and corrected for quantile-specific self-reporting bias with the use of measured data from 57,131 adults who participated in the National Health and Nutrition Examination Survey. We fitted multinomial regressions for each state and subgroup to estimate the prevalence of four BMI categories from 1990 through 2030: underweight or normal weight (BMI [the weight in kilograms divided by the square of the height in meters], <25), overweight (25 to <30), moderate obesity (30 to <35), and severe obesity (≥35). We evaluated the accuracy of our approach using data from 1990 through 2010 to predict 2016 outcomes.

RESULTS

The findings from our approach suggest with high predictive accuracy that by 2030 nearly 1 in 2 adults will have obesity (48.9%; 95% confidence interval [CI], 47.7 to 50.1), and the prevalence will be higher than 50% in 29 states and not below 35% in any state. Nearly 1 in 4 adults is projected to have severe obesity by 2030 (24.2%; 95% CI, 22.9 to 25.5), and the prevalence will be higher than 25% in 25 states. We predict that, nationally, severe obesity is likely to become the most common BMI category among women (27.6%; 95% CI, 26.1 to 29.2), non-Hispanic black adults (31.7%; 95% CI, 29.9 to 33.4), and low-income adults (31.7%; 95% CI, 30.2 to 33.2).

CONCLUSIONS

Our analysis indicates that the prevalence of adult obesity and severe obesity will continue to increase nationwide, with large disparities across states and demographic subgroups. (Funded by the JPB Foundation.)

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Although the growing obesity epidemic in the United States has been well documented,[1-4] less is known about long-term trends and the future of obesity prevalence. Although national projections of obesity have been made previously,[5-7] state-specific analyses are limited. State-specific projections of the burden of obesity are important for policymakers, given the considerable variation in the prevalence of obesity across states,[8] the substantial state-level financial implications,[9] and the opportunity for obesity-prevention interventions to be implemented at a local level.[10-13]

However, a barrier to accurate state-level projections is the paucity of objectively measured body-mass index (BMI) data according to state. The Behavioral Risk Factor Surveillance System (BRFSS), a nationally representative telephone survey of more than 400,000 adults each year,[14] provides participants' estimates of height and weight according to state. These data have been used to track obesity prevalence and are the basis of maps that have illustrated the growth of the obesity epidemic.[1] Although the BRFSS provides valuable state-level estimates over time, the reliance on subjective body measures reported by participants substantially underestimates the prevalence of obesity owing to the well-documented self-reporting bias.[8,15,16] We developed a method of bias correction to adjust the entire distribution of BMI in the BRFSS surveys from 1993 through 2016 and estimated state-level historical trends and projections of the prevalence of BMI categories from 1990 through 2030 according to demographic subgroup.

METHODS

OVERVIEW

We adjusted reported BMI data from the BRFSS to align the data with objectively measured BMI distributions from the National Health and Nutrition Examination Survey (NHANES), a nationally representative survey in which measured data on height and weight are collected with the use of standardized examination procedures.[17] We estimated trends in the prevalence of BMI categories according to subgroup in each state and made projections through 2030. The first author designed the study, gathered and analyzed the data, and vouches for the accuracy and completeness of the data. All the authors critically revised the manuscript and made the decision to submit the manuscript for publication.

DATA

We obtained BRFSS data from 1993 through 1994 and 1999 through 2016, periods during which annual data were collected for all 50 states and Washington, D.C. (except for Wyoming in 1993, Rhode Island in 1994, and Hawaii in 2004). We obtained nationally representative NHANES data from 1991 through 1994 (phase 2 of NHANES III) and from 1999 through 2016 (continuous NHANES). Data from pre-1999 BRFSS surveys were restricted to 1993 and 1994 to coincide with phase 2 of NHANES III. (Before 1993, not all states were included in the BRFSS.) We cleaned each data set to ensure that the variables of interest were not missing and ensured that reported height and weight in the BRFSS were biologically plausible. Our final BRFSS data set included 6,264,226 adults (18 years of age or older), and our NHANES data set included 57,131 adults. (Exclusion criteria and respondent characteristics are provided in Section 1 in the Supplementary Appendix, available with the full text of this article at NEJM.org.)

ADJUSTMENT FOR SELF-REPORTING BIAS

We adjusted reported BMI data from the BRFSS so that the distribution was similar to measured BMI from NHANES. Because both the BRFSS and NHANES are designed to be nationally representative surveys, data from NHANES can be used to adjust participant-reported body measures in the BRFSS. By adjusting the entire distribution of reported BMI to be consistent with measured BMI in NHANES, we adjusted for self-reporting bias while preserving the relative position of each person's BMI.[8] Specifically, we estimated the difference between participant-reported BMI and measured BMI according to quantile and then fit cubic splines to smoothly estimate self-reporting bias across the entire BMI distribution. Each person's BMI was then adjusted for this bias given his or her BMI quantile. We adjusted BMI distributions separately according to sex and time period (1993–1994, 1999–2004, 2005–2010, and 2011–2016) to control for potential time trends in self-reporting bias and composition of demographic subgroups. (Additional details are provided in Section 2 in the Supplementary Appendix.)

STATE-SPECIFIC TRENDS AND PROJECTIONS

BMI categories were defined according to the Centers for Disease Control and Prevention (CDC) guidelines: underweight or normal weight (BMI [the weight in kilograms divided by the square of the height in meters], <25), overweight (25 to <30), moderate obesity (30 to <35), and severe obesity (≥35).[18] We used multinomial (renormalized logistic) regressions to predict the prevalence of each BMI category as a function of time. This method ensures that the prevalence of all categories sums to 100% in each year and allows estimation of nonlinear trends in the prevalence of BMI categories. Our reduced covariate model (i.e., with year as the independent variable) implicitly accounts for trends in the composition of demographic subgroups (e.g., age distribution and composition of race or ethnic group categories) within each state, since the relative contributions of these various factors (and their potential changing effect over time) are already reflected in the prevalence estimates. Such an approach also implicitly controls for trends in other variables that may affect BMI, such as smoking or illness. Although it is important to explicitly control for these variables when estimating the effect of BMI on related health outcomes, because our outcome of interest was the prevalence of BMI categories over time, it was not necessary to control for these variables because their effect was already reflected in the observed prevalence estimates used to fit the models. (Additional details and a discussion of previous approaches are provided in Sections 3.1 and 3.2 in the Supplementary Appendix.)

Regressions were performed nationally and for each state independently, while taking the complex survey structure of the BRFSS into account. We estimated historical trends and projections of the prevalence of each BMI category from 1990 through 2030, as well as the prevalence of overall obesity (BMI, ≥30). We also made projections for demographic subgroups to examine trends and explore the effect of geography (i.e., state of residence) on obesity trends within subgroups. We estimated trends according to sex (male or female), race or ethnic group (non-Hispanic white, non-Hispanic black, Hispanic, or non-Hispanic other), annual household income (<\$20,000, \$20,000 to <\$50,000, or ≥\$50,000), education (less than high-school graduate, high-school graduate to some college, or college graduate), and age group (18 to 39, 40 to 64, or ≥65 years) (Section 3.3 in the Supplementary Appendix). Because of the small sample sizes and changing BRFSS categories of race or ethnic group over time, we combined five groups ("American Indian or Alaskan Native," "Asian," "Native Hawaiian or Pacific Islander," "other," and "multiracial") into one "non-Hispanic other" category.

In accordance with the CDC guidelines that consider BRFSS estimates unreliable if they are based on a sample of fewer than 50 people,[19] we suppressed state-level estimates from subgroups with fewer than 1000 respondents; given our data set of 20 rounds of BRFSS surveys, we suppressed estimates from subgroups with fewer than 50 respondents on average per year in a state. Thus, estimates for the following subgroups were suppressed: non-Hispanic black adults in 12 states (Alaska, Hawaii, Idaho, Maine, Montana, New Hampshire, North Dakota, Oregon, South Dakota, Utah, Vermont, and Wyoming) and Hispanic adults in 2 states (North Dakota and West Virginia).

To account for uncertainty, we bootstrapped both data sets (NHANES and BRFSS) 1000 times, considering the complex structure of each survey (Section 3.4 in the Supplementary Appendix) and repeated all analyses (i.e., adjustment for self-reporting bias and state-specific projections). We report the mean and 95% confidence interval (calculated as the 2.5 and 97.5 percentiles of the bootstrapped values) for all estimates.

ASSESSMENT OF PREDICTIVE ACCURACY AND SENSITIVITY ANALYSES

To evaluate the accuracy of our approach, we restricted our data sets (NHANES and BRFSS) to include only data from 1999 through 2010. We then repeated our analyses with this subset of data and predicted the prevalence of each BMI category in 2016 (i.e., 6 years after the last observed year in our truncated data). We compared our predictions with the observed prevalence (corrected for self-reporting bias) in 2016. This exercise allowed us to evaluate the accuracy of our approach in predicting future values and allowed us to assess the potential effect of the change in the BRFSS sample design in 2011 to include cell-phone interviews on our estimation of trends. For our predictions, we calculated the coverage probability (i.e., the percentage of observed estimates that fell within our 95% confidence intervals), the percentage of our mean predictions that fell within a certain distance (e.g., 10% relative error) of the observed estimate, and the mean absolute error.

In a sensitivity analysis, we also made projections based on self-reported body measures (i.e., no adjustment for self-reporting bias). Statistical analyses were performed with the use of R software, version 3.2.5 (R Foundation for Statistical Computing), with BRFSS bootstrapping performed in Java for computational efficiency.

RESULTS

BIAS-CORRECTED BMI DATA

After we corrected for self-reporting bias, our adjusted BMI distributions in the BRFSS data set did not differ significantly (P>0.05) from those in the NHANES data set for each sex and time period. Adjustment of the entire BMI distribution also ensured that the prevalence of each BMI category in the BRFSS data set was similar to that in the NHANES data set. BMI values for men and women were adjusted on average by 0.71 and 1.76 units, respectively, with differential (increasing) adjustment according to reported BMI. (Additional details are provided in Section 2 in the Supplementary Appendix.)

PREDICTIVE ACCURACY

Our coverage probability (i.e., the percentage of time that our 95% confidence intervals contained the observed estimate) for state-level prevalence in 2016 was 94.6% across the four BMI categories. Subgroup-specific coverage probabilities were 92.5% on average (Section 4 in the Supplementary Appendix). Our mean predictions for states were within 10% (relative error) of the reported estimate 95.6% of the time, with a mean absolute error of 0.85 percentage points. Although our coverage probabilities are high, our mean predictions are less accurate for subgroups with smaller sample sizes.

TRENDS AND PROJECTIONS

Our projections show that the national prevalence of adult obesity and severe obesity will rise to 48.9% (95% confidence interval [CI], 47.7 to 50.1) and 24.2% (95% CI, 22.9 to 25.5), respectively, by 2030, with large variation across states. Maps of state-level prevalence of obesity and severe obesity over time are provided in Figure 1. Based on current trends, our projections show that the prevalence of overall obesity (BMI, ≥30) will rise above 50% in 29 states by 2030 and will not be below 35% in any state. We also project that the prevalence of severe obesity (BMI, ≥35) will rise above 25% in 25 states (Table 1). State-level trends in the prevalence of each BMI category are presented according to subgroup in Section 5 in the Supplementary Appendix. These trends show that the prevalence of overweight is declining as obesity develops in more people.

Our sensitivity analyses, which did not correct for self-reporting bias, revealed similar trends over time but with an overall projected obesity prevalence that was on average 5.3 percentage points lower than the bias-corrected obesity prevalence (relative error of approximately 10%) and similar underestimates according to subgroup (Section 6 in the Supplementary Appendix).

Our projections also revealed large disparities in obesity prevalence across subgroups. We project that by 2030 severe obesity will be the most common BMI category nationwide among women, black non-Hispanic adults, and low-income adults (i.e., household income <$50,000) (Fig. 2).

In addition, we found large geographic disparities within subgroups (Fig. 3). (State-level maps and tables are provided in Sections 7 and 8 in the Supplementary Appendix.) In general, we found a higher prevalence of obesity among non-Hispanic black and Hispanic adults than among non-Hispanic white adults, and the heterogeneity in the composition of the non-Hispanic other category of race or ethnic group across states was reflected by the variation in obesity prevalence across states for this group.

We also found a large gradient in the prevalence of obesity according to income. For example, our projections show that severe obesity will be the most common BMI category in 44 states among adults with an annual household income of less than $20,000, as compared with only 1 state among adults with an annual household income

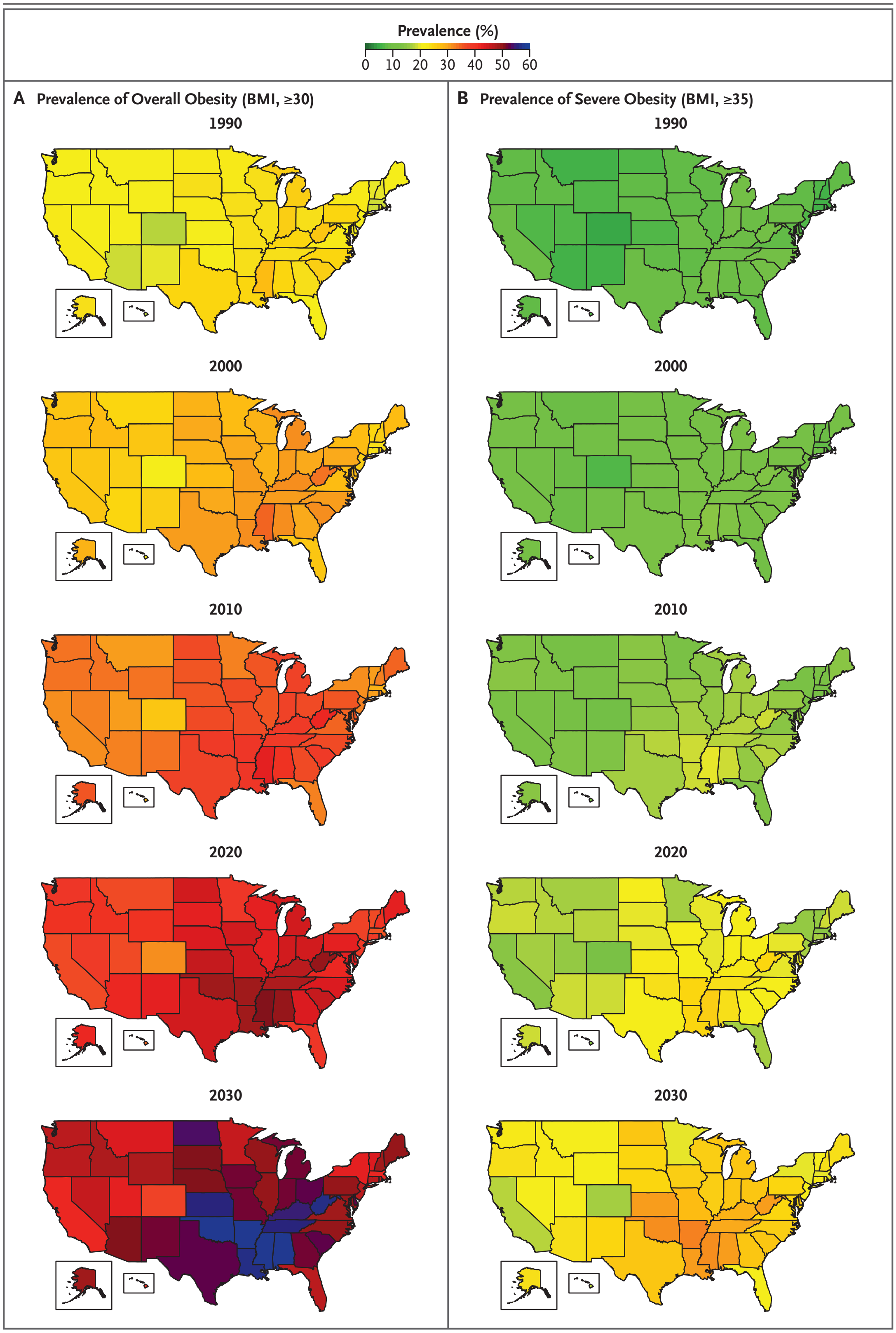
Prevalence (%)
0 10 20 30 40 50 60
A Prevalence of Overall Obesity (BMI, ≥30)
B Prevalence of Severe Obesity (BMI, ≥35)
1990
2000
2010
2020
2030

Figure 1 (facing page). Estimated Prevalence of Overall Obesity and Severe Obesity in Each State, from 1990 through 2030.

Shown is the estimated prevalence of overall obesity (Panel A) and severe obesity (Panel B) among adults in each U.S. state from 1990 through 2030. Overall obesity includes the BMI (body-mass index) categories of moderate obesity (BMI, 30 to <35) and severe obesity (BMI, ≥35).

of greater than $50,000 (Fig. 3). State-specific analyses according to subgroup are provided in Sections 7 through 9 in the Supplementary Appendix, including the results for education and age subgroups, as well as suppressed estimates for race or ethnic groups.

Discussion

In this study, we used more than 20 years of data from more than 6 million adults and applied an analytical approach that provided more accurate state-level estimates of BMI trends, corrected for self-reporting bias. Our method differentially adjusted the entire BMI distribution, an approach that preserves heterogeneity, in contrast to regression-based approaches that adjust mean values.[6,15] Adjustment of the entire BMI distribution has been shown to better capture the tails of the BMI distribution, resulting in more accurate estimates of obesity prevalence, especially for severe obesity.[8]

Although analyses of trends in adult obesity in the United States have been performed previously,[1-6,15,20-23] a strength of our analysis is that we provided both national and state-level, subgroup-specific estimates (i.e., 832 demographic subgroups) based on bias-corrected data from more than 6 million adults over many years. Although previous criticisms of obesity projections — often based on small samples over short periods — argue that changes in obesity prevalence have not followed a predictable pattern,[24] we observed remarkably stable and predictable trends across a wide range of states and demographic subgroups. Moreover, we provided empirical evidence of the predictive validity of our approach, showing that our model has a high degree of accuracy. Our coverage probabilities of approximately 95% indicate that our 95% confidence intervals appropriately reflect the uncertainty around our estimates.

Our sensitivity analyses, which did not adjust for self-reporting bias, revealed similar trends to those in our main analysis but with a lower prevalence, as expected. For example, our unadjusted projections of the prevalence of obesity among women in 2030 were on average 13% (6.4 percentage points) lower than our bias-corrected projections, a finding that highlights the importance of correcting for self-reporting bias to obtain accurate prevalence estimates.

We found that nearly 1 in 2 adults nationwide will probably have obesity by 2030, with large disparities across states and demographic subgroups. Using our model, we projected that by 2030 the majority of adults in 29 states will have obesity and that the prevalence of obesity will approach 60% in some states and not be below 35% in any state. These results are similar to previous estimates showing that 57% of children 2 to 19 years of age in 2016 are projected to have obesity by the age of 35 years.[7]

We noted that as more adults cross the threshold to obesity, the prevalence of overweight is declining, a finding that highlights the importance of assessing changes in weight across the entire BMI distribution rather than focusing on only one category. Especially worrisome is the projected rise in the prevalence of severe obesity, which is associated with even higher mortality and morbidity[25] and health care costs.[9] Using our model, we projected that by 2030 nearly 1 in 4 U.S. adults will have severe obesity, and the prevalence will be higher than 25% in 25 states. Severe obesity is thus poised to become as prevalent as overall obesity was in the 1990s. Indeed, our projections suggest that severe obesity may become the most common BMI category among adults in 10 states by 2030 and even more common in some subgroups, especially among women, non-Hispanic black adults, and low-income adults; these findings highlight persistent disparities according to sex, race or ethnic group, and income. The high projected prevalence of severe obesity among low-income adults and the high medical costs of severe obesity have substantial implications for future health care costs,[9] especially as states expand access to obesity-related services for adult Medicaid beneficiaries.[26]

Although severe obesity was once a rare con-

Table 1. Projected State-Specific Prevalence of Adult Obesity and Severe Obesity in 2030.

State	Overall Obesity (BMI, ≥30)*			Severe Obesity (BMI, ≥35)		
	Overall	Men	Women	Overall	Men	Women
	percentage (95% confidence interval)					
U.S. overall	48.9 (47.7–50.1)	48.2 (46.8–49.6)	49.9 (48.5–51.4)	24.2 (22.9–25.5)	21.1 (19.6–22.6)	27.6 (26.1–29.2)
Alabama	58.2 (56.2–60.2)	56.7 (53.8–59.4)	59.7 (57.3–62.3)	30.6 (28.5–32.8)	25.6 (22.6–28.5)	35.7 (33.2–38.3)
Alaska	49.3 (46.3–52.2)	48.9 (45.0–53.1)	50.0 (46.1–54.1)	24.2 (21.4–26.8)	21.7 (17.5–25.7)	27.6 (24.1–31.4)
Arizona	51.4 (48.9–53.9)	49.3 (45.7–53.0)	53.6 (50.5–56.6)	24.4 (22.1–26.7)	20.8 (17.5–24.2)	28.3 (25.3–31.2)
Arkansas	58.2 (55.7–60.4)	56.7 (53.2–59.9)	59.9 (57.0–62.8)	32.6 (30.1–35.1)	29.6 (26.2–33.1)	36.1 (33.0–39.1)
California	41.5 (39.9–43.3)	41.1 (39.0–43.4)	42.1 (40.0–44.3)	18.3 (16.8–19.8)	16.1 (14.1–18.1)	20.9 (19.0–22.8)
Colorado	38.2 (36.3–40.3)	37.5 (34.8–40.0)	39.2 (36.7–42.0)	16.8 (15.2–18.6)	14.3 (12.1–16.6)	19.8 (17.6–22.2)
Connecticut	46.6 (44.4–48.9)	46.5 (43.5–49.4)	46.9 (44.3–49.6)	22.5 (20.6–24.6)	19.8 (17.2–22.7)	25.3 (22.9–27.9)
Delaware	53.2 (51.0–55.7)	51.4 (48.2–55.0)	55.0 (51.9–58.1)	27.1 (24.8–29.6)	22.2 (19.0–25.6)	31.7 (28.7–34.8)
District of Columbia	35.3 (33.0–37.8)	32.3 (29.1–36.3)	39.0 (35.9–42.2)	17.3 (15.2–19.3)	11.3 (8.9–13.9)	23.1 (20.3–26.1)
Florida	47.0 (45.0–48.9)	47.9 (45.5–50.2)	46.3 (43.9–48.8)	21.3 (19.7–23.1)	19.0 (16.7–21.1)	24.0 (22.0–26.3)
Georgia	51.9 (49.9–54.2)	49.6 (46.6–52.7)	54.5 (51.8–57.2)	26.6 (24.3–28.8)	21.2 (18.3–24.2)	32.1 (29.6–34.7)
Hawaii	41.3 (39.2–43.4)	43.3 (40.3–46.1)	39.1 (36.4–41.9)	18.2 (16.4–20.2)	17.5 (14.9–20.1)	19.1 (17.0–21.7)
Idaho	47.7 (45.4–50.0)	48.0 (44.5–51.3)	47.7 (44.6–50.6)	23.0 (20.8–25.2)	20.8 (17.9–23.8)	26.0 (23.3–28.7)
Illinois	50.0 (47.8–52.1)	48.6 (45.3–51.3)	51.6 (48.9–54.5)	25.5 (23.5–27.7)	20.7 (17.8–23.5)	30.4 (27.5–33.0)
Indiana	51.6 (49.7–53.6)	50.7 (48.1–53.5)	52.9 (50.3–55.4)	26.9 (24.8–29.0)	24.1 (21.2–26.9)	30.3 (27.8–32.8)
Iowa	52.0 (50.0–54.0)	52.6 (49.8–55.2)	51.9 (49.2–54.4)	26.4 (24.4–28.5)	24.8 (22.0–27.7)	28.8 (26.1–31.5)
Kansas	55.6 (53.8–57.5)	54.3 (51.8–56.9)	57.0 (54.7–59.5)	30.6 (28.7–32.5)	26.7 (24.3–29.3)	34.8 (32.6–37.2)
Kentucky	54.8 (52.9–56.8)	54.5 (51.8–57.2)	55.4 (53.0–57.9)	29.4 (27.4–31.4)	26.0 (23.3–28.8)	33.1 (30.5–35.7)
Louisiana	57.2 (55.1–59.2)	56.3 (53.2–59.3)	58.3 (55.6–61.0)	31.2 (28.9–33.5)	26.8 (23.5–29.9)	36.0 (33.2–38.9)
Maine	50.3 (48.1–52.6)	49.4 (46.3–52.5)	51.3 (48.5–54.0)	24.2 (22.1–26.4)	20.9 (18.2–23.7)	27.7 (25.0–30.3)
Maryland	50.0 (48.1–52.0)	48.0 (45.4–50.8)	52.1 (49.7–54.5)	24.6 (22.8–26.6)	19.7 (17.5–22.1)	29.4 (27.0–31.9)
Massachusetts	42.3 (40.2–44.3)	43.1 (40.4–45.7)	41.7 (39.1–44.2)	20.0 (18.2–22.1)	18.7 (16.3–21.4)	21.5 (19.3–24.0)
Michigan	51.9 (50.2–53.7)	51.2 (48.8–53.6)	53.0 (50.8–55.2)	27.2 (25.5–29.1)	24.4 (21.9–26.9)	30.7 (28.3–33.1)
Minnesota	46.1 (44.3–48.0)	48.2 (46.0–50.4)	44.3 (41.9–46.6)	20.4 (18.7–22.2)	20.0 (17.7–22.3)	21.6 (19.5–23.6)
Mississippi	58.2 (56.0–60.2)	54.3 (51.1–57.2)	62.0 (59.3–64.6)	31.7 (29.5–33.9)	24.6 (21.4–28.0)	38.6 (35.9–41.2)
Missouri	52.4 (50.2–54.6)	51.0 (47.8–54.1)	53.9 (51.0–56.5)	28.3 (26.1–30.5)	24.4 (21.5–27.5)	32.4 (29.6–35.1)
Montana	44.2 (41.8–46.6)	44.5 (41.4–47.6)	44.3 (41.3–47.5)	21.4 (19.3–23.5)	19.6 (16.7–22.6)	23.9 (21.2–26.8)
Nebraska	51.3 (49.3–53.3)	51.0 (48.3–53.7)	51.7 (49.2–54.1)	25.4 (23.4–27.4)	21.5 (18.9–24.1)	29.6 (27.0–32.2)
Nevada	45.5 (42.7–48.3)	45.3 (41.5–49.0)	45.8 (42.1–49.6)	20.6 (18.1–23.4)	18.1 (14.7–22.1)	23.4 (20.0–26.8)
New Hampshire	48.8 (46.6–51.1)	50.5 (47.3–53.5)	47.1 (44.1–50.0)	24.1 (21.9–26.5)	21.9 (18.8–25.2)	26.6 (23.7–29.6)
New Jersey	46.6 (44.4–48.6)	48.6 (45.6–51.6)	44.8 (42.0–47.4)	21.7 (19.8–23.5)	19.9 (17.2–22.7)	23.8 (21.4–26.2)
New Mexico	51.8 (49.5–54.1)	49.5 (46.0–52.6)	54.6 (51.8–57.3)	24.8 (22.6–27.0)	22.7 (19.6–26.0)	27.5 (24.9–30.3)
New York	42.8 (41.0–44.8)	42.0 (39.5–44.7)	43.9 (41.4–46.3)	19.8 (18.2–21.6)	17.5 (15.2–19.9)	22.5 (20.4–24.8)
North Carolina	50.3 (48.3–52.2)	47.3 (44.8–49.9)	53.4 (50.8–55.7)	25.7 (23.6–27.5)	21.0 (18.3–23.6)	30.6 (28.0–33.0)
North Dakota	53.9 (51.6–56.1)	56.5 (53.4–59.4)	51.3 (48.5–54.0)	26.9 (24.7–29.0)	26.6 (23.4–29.6)	27.9 (24.9–30.7)
Ohio	53.2 (51.0–55.3)	52.4 (49.5–55.3)	54.1 (51.3–56.9)	26.8 (24.8–28.8)	23.8 (21.1–26.6)	30.0 (27.2–32.7)
Oklahoma	58.4 (56.4–60.2)	59.5 (56.9–61.9)	57.5 (54.9–59.8)	31.7 (29.7–33.9)	29.0 (26.1–32.0)	34.9 (32.6–37.6)
Oregon	47.5 (45.5–49.5)	47.9 (45.1–50.8)	47.3 (44.7–49.8)	24.1 (22.0–26.1)	21.6 (18.7–24.5)	27.1 (24.5–29.7)
Pennsylvania	50.2 (48.2–52.1)	50.8 (48.1–53.2)	50.0 (47.7–52.5)	24.8 (22.7–26.8)	23.3 (20.7–25.8)	27.0 (24.5–29.6)

Table 1. (Continued.)

State	Overall Obesity (BMI, ≥30)*			Severe Obesity (BMI, ≥35)		
	Overall	Men	Women	Overall	Men	Women
	percentage (95% confidence interval)					
Rhode Island	47.3 (45.0–49.9)	48.8 (45.3–52.3)	46.3 (42.8–49.7)	22.9 (20.6–25.4)	21.9 (18.7–25.3)	24.5 (21.6–27.6)
South Carolina	52.8 (51.0–54.6)	49.6 (47.0–52.3)	56.0 (53.6–58.3)	27.2 (25.3–29.1)	21.2 (18.8–23.8)	33.0 (30.7–35.4)
South Dakota	50.6 (48.1–52.9)	53.0 (49.6–56.1)	48.2 (45.1–51.4)	25.2 (22.9–27.7)	24.1 (20.8–27.3)	26.9 (24.1–29.9)
Tennessee	55.8 (53.9–57.8)	55.0 (52.1–57.8)	56.9 (54.4–59.5)	29.9 (27.8–32.1)	26.5 (23.5–29.7)	33.7 (31.2–36.5)
Texas	52.9 (50.9–54.7)	50.1 (47.3–52.5)	55.9 (53.5–58.5)	26.6 (24.6–28.5)	22.5 (20.0–25.2)	31.1 (28.5–33.8)
Utah	43.2 (41.3–45.1)	43.9 (41.5–46.3)	42.7 (40.2–45.2)	20.6 (18.9–22.6)	18.8 (16.7–21.3)	23.0 (20.6–25.5)
Vermont	43.6 (41.5–45.8)	43.1 (40.2–46.1)	44.2 (41.7–47.0)	20.7 (18.9–22.7)	17.8 (15.4–20.2)	23.9 (21.5–26.4)
Virginia	48.9 (46.7–50.9)	46.0 (43.0–48.9)	51.8 (48.9–54.7)	25.3 (23.3–27.5)	20.7 (18.0–23.4)	30.0 (27.4–32.4)
Washington	47.4 (45.6–49.2)	48.0 (45.7–50.3)	47.2 (44.9–49.5)	22.6 (20.9–24.4)	20.9 (18.6–23.2)	25.0 (23.0–27.2)
West Virginia	57.5 (55.6–59.4)	57.0 (54.2–59.6)	58.3 (55.8–61.0)	30.8 (28.7–32.8)	27.0 (24.1–29.9)	35.2 (32.5–37.9)
Wisconsin	50.3 (48.0–52.7)	50.3 (47.0–53.2)	50.7 (47.6–53.7)	25.5 (23.4–27.8)	23.1 (20.2–26.1)	28.6 (25.7–31.7)
Wyoming	48.2 (45.6–50.9)	45.5 (41.6–49.3)	51.3 (47.7–54.8)	22.4 (19.8–25.0)	19.2 (16.0–22.4)	26.1 (22.7–29.8)

* "Overall obesity" includes the body-mass index (BMI) categories of moderate obesity (BMI, 30 to <35) and severe obesity (BMI, ≥35).

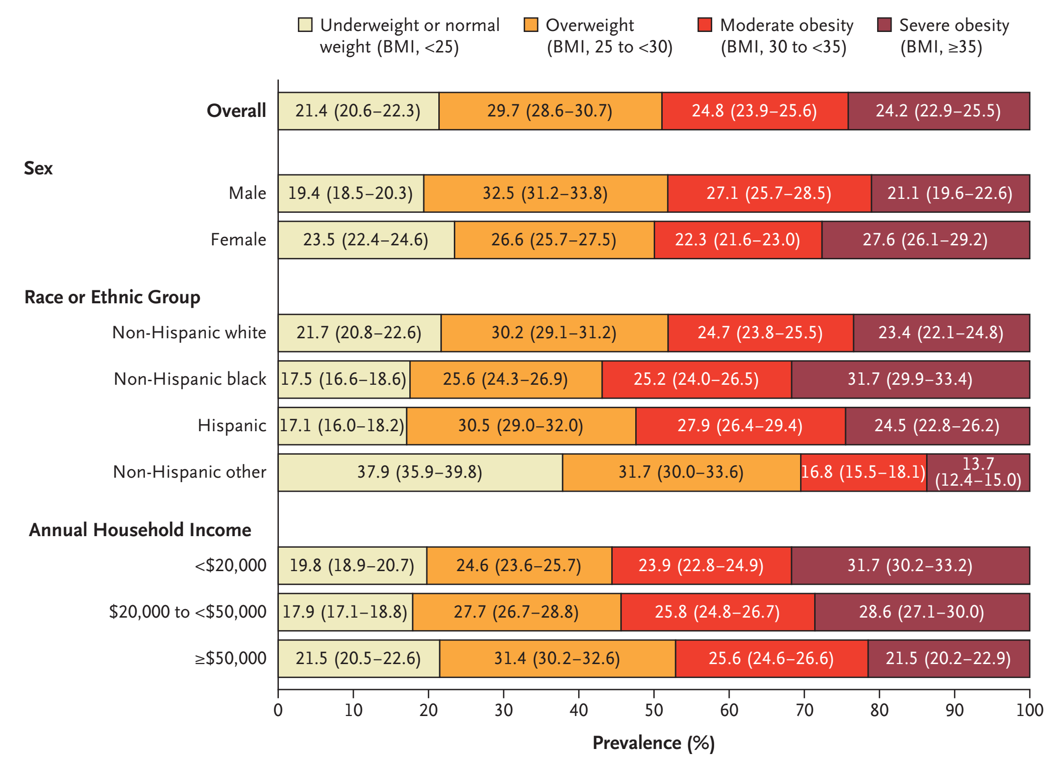

Figure 2. Projected National Prevalence of BMI Categories in 2030, According to Demographic Subgroup.

Shown is the projected national prevalence of BMI categories in 2030, according to sex, race or ethnic group, and annual household income.

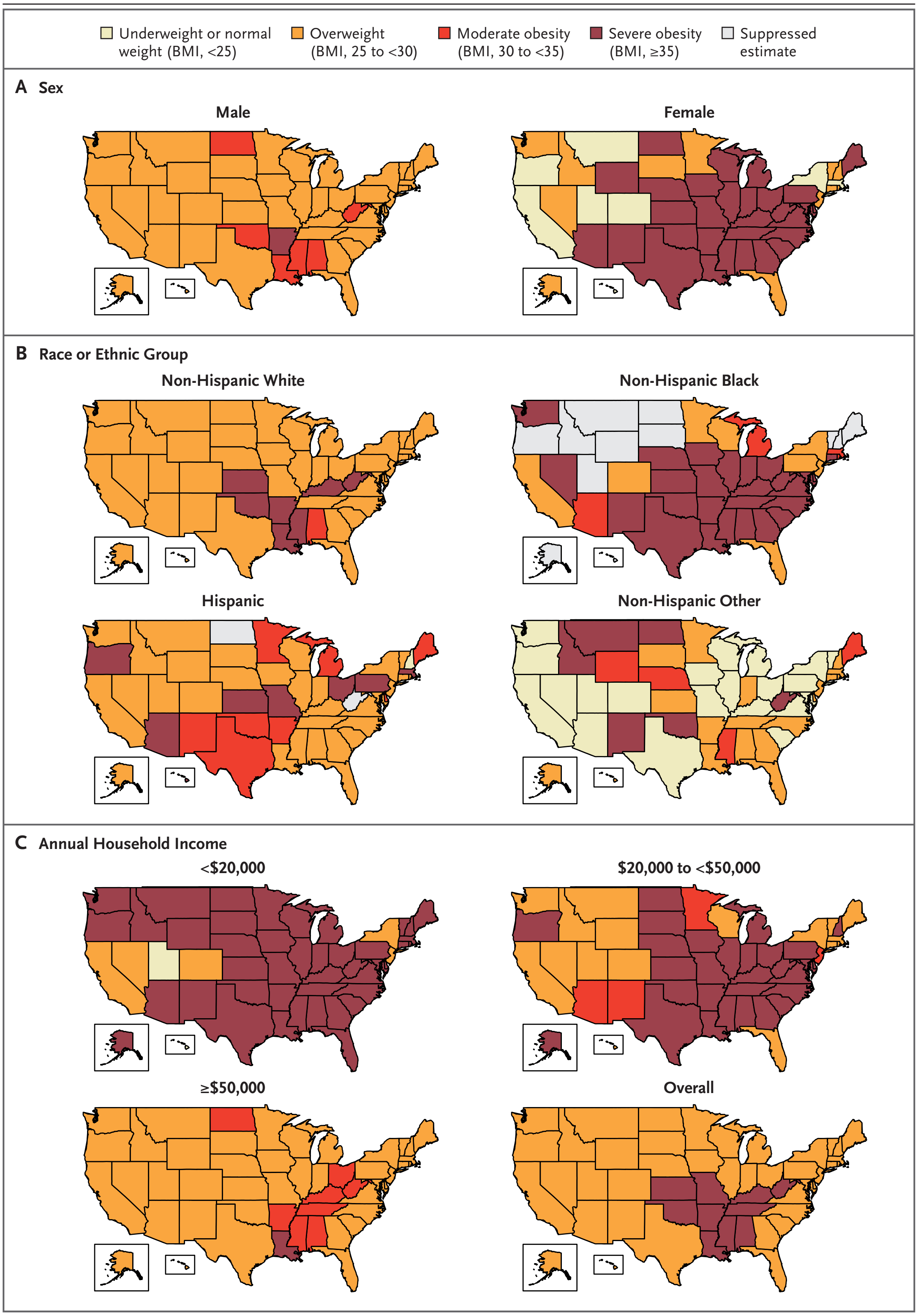
Underweight or normal weight (BMI, <25)
Overweight (BMI, 25 to <30)
Moderate obesity (BMI, 30 to <35)
Severe obesity (BMI, ≥35)
Suppressed estimate
A Sex
Male
Female
B Race or Ethnic Group
Non-Hispanic White
Non-Hispanic Black
Hispanic
Non-Hispanic Other
C Annual Household Income
<$20,000
$20,000 to <$50,000
≥$50,000
Overall

Figure 3 (facing page). Projected Most Common BMI Category in 2030 in Each State, According to Demographic Subgroup.
Shown is the projected most common BMI category (underweight or normal weight, overweight, moderate obesity, or severe obesity) in 2030 in each U.S. state, according to sex (Panel A), race or ethnic group (Panel B), and annual household income (Panel C). In accordance with the Centers for Disease Control and Prevention guidelines that consider Behavioral Risk Factor Surveillance System (BRFSS) survey estimates unreliable if they are based on a sample of fewer than 50 respondents,[19] we suppressed state-level estimates from subgroups with fewer than 1000 respondents; given our data set of 20 rounds of BRFSS surveys, we suppressed estimates from subgroups with fewer than 50 respondents on average per year in a state.

dition, our findings suggest that it will soon be the most common BMI category in the patient populations of many health care providers. Given that health professionals are often poorly prepared to treat obesity,[27] this impending burden of severe obesity and associated medical complications has implications for medical practice and education. In addition to the profound health effects, such as increased rates of chronic disease and negative consequences on life expectancy,[25,28] the effect of weight stigma[29] may have far-reaching implications for socioeconomic disparities as severe obesity becomes the most common BMI category among low-income adults in nearly every state.

Given the difficulty in achieving and maintaining meaningful weight loss,[30,31] these findings highlight the importance of prevention efforts. Although some cost-effective prevention interventions have been identified,[10] a range of sustained approaches to maintain a healthy weight over the life course, including policy and environmental interventions at the community level that address upstream social and cultural determinants of obesity,[32] will probably be needed to prevent further weight gain across the BMI distribution.

Our analysis has certain limitations. Although we found that our model predictions are accurate for states overall, our point estimates (i.e., mean predictions) may be less accurate for subgroups with smaller sample sizes. However, our high coverage probabilities for all subgroups indicate that we appropriately accounted for the uncertainty around our estimates, which highlights the importance of considering the 95% confidence intervals of our projections as well. In addition, our assessment of predictive accuracy reveals that our projections are robust to the change in the BRFSS sample design in 2011 to include cell-phone interviews. Although our predictive validity checks from 2010 through 2016 help build confidence in our approach, projections through 2030 involve a much longer period, so the uncertainty around our projections may be larger than estimated because we assumed that current trends will continue.

Because of data limitations, we could not explore trends in obesity according to all race or ethnic groups included in our “non-Hispanic other” category. We found large differences in the prevalence of obesity across states for this category, a finding that is consistent with the well-known differences in obesity prevalence among Native American, Native Hawaiian, and Asian populations that are included in this heterogeneous category, which differs in composition from state to state. Also, because the BRFSS reports categories of annual household income (as opposed to actual dollar values), we were unable to adjust the household income of respondents for inflation over time.

Finally, because of the small sample size, we combined underweight (BMI, <18.5) and normal weight into one category. (Underweight comprises only 2% of respondents in our NHANES data set.) Although this grouping may be problematic when used as the reference category for estimating BMI-related health risks, it should not present any problems for estimating the prevalence of BMI categories.

We project that given current trends, nearly 1 in 2 U.S. adults will have obesity by 2030, and the prevalence will be higher than 50% in 29 states and not below 35% in any state — a level currently considered high. Furthermore, our projections show that severe obesity will affect nearly 1 in 4 adults by 2030 and become the most common BMI category among women, black non-Hispanic adults, and low-income adults.

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