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Trends in Cardiovascular Disease Risk Factors by Obesity Level in Adults in the United States, NHANES 1999-2010

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Abstract

Objective—To assess whether trends in cardiovascular disease (CVD) risk factors by among overweight and obese US adults have improved.

Methods—The study included 10,568 adults 18 years and older who participated in National Health and Nutrition Examination Survey 1999-2010. CVD risk factors included diabetes (self-reported diagnosis, glycated hemoglobin $\geq 6.5\%$, or fasting plasma glucose $\geq 126\text{mg/dl}$), hypertension (treatment or blood pressure $\geq 140/90\text{ mmHg}$), dyslipidemia (treatment or non-HDL cholesterol $\geq 160\text{ mg/dl}$), and smoking (self-report or cotinine levels $\geq 10\text{ ng/ml}$). The prevalence and temporal trends of CVD risk factors for each BMI group were estimated.

Results—In 2007-2010, the prevalence of diabetes, hypertension, and dyslipidemia was highest among obese (18.5%, 35.7%, 49.7%, respectively) followed by overweight (8.2%, 26.4%, 44.2%, respectively) and normal weight adults (5.4%, 19.8%, 28.6%, respectively). Smoking exposure was highest among normal weight (29.8%) followed by overweight (24.8%) and obese adults (24.6%). From 1999-2002 to 2007-2010, untreated hypertension decreased among obese and overweight adults and untreated dyslipidemia decreased for all weight groups. There were no significant temporal changes in smoking across BMI groups.

Conclusions—Despite decreases in untreated risk factors, it is important to improve the CVD risk profile of overweight and obese US adults.

Introduction

In 2008-2010, over 35% of adults 18 years and older in the United States were obese (1) and there is evidence that overweight and obesity among adults is associated with increased risk of cardiovascular disease (CVD) (2,3) and an increased risk of diabetes (4). Although there

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appears to be a leveling off of obesity levels in the United States (1), it is unknown whether the health burdens associated with higher weight may be continuing to increase (5).

Using data from national health surveys from 1960 to 2000, Gregg and colleagues (6) reported a significant decline in major cardiovascular risk factors, except diabetes, across all BMI levels. However, over this time period, the prevalence of undiagnosed diabetes decreased, particularly among the highest weight group (7). Whether these trends have continued in the past decade is unknown. Therefore, we analyzed data from the National Health and Nutrition Examination Survey (NHANES) from 1999 through 2010 to examine trends in the prevalence and diagnosis or treatment of cardiovascular risk factors by weight status among adults in the United States.

Methods

The NHANES is a cross-sectional survey of the health and nutritional status of the US civilian, noninstitutionalized population conducted by the National Center for Health Statistics (NCHS), Centers for Disease Control and Prevention (CDC) (8). Participants were randomly selected through a complex, multistage cluster sampling probability design. The NHANES collects data through interviews in participants' homes and conducts medical examinations and laboratory assessments in the Mobile Examination Center. For this report, we analyzed 1999-2010 NHANES data on participants who were 18 years or older and had complete measurements of CVD risk factors and anthropometry ($n = 33,560$). NHANES is conducted in independent, 2-year cycles. Response rates for participation in both the interview and physical examination were similar across cycles and ranged from 75 to 80% (9). The survey protocol was approved by the NCHS institutional review board. Written informed consent was obtained from all participants aged 18 years. NHANES methods and protocols for the questionnaires, laboratory, and examination have been described extensively (8).

Demographics included age, sex, and race/ethnicity. Race/ethnicity was based on self-report and categorized as non-Hispanic white, non-Hispanic black, Mexican American, or Hispanic and non-Hispanic other. Family income was included as a percentage of the established poverty income ratio (PIR), calculated as the family's income divided by the federal poverty level (defined as 100% in the categories below). PIR was categorized as <1.50, 1.50 to 3.50, and 3.50. Participants were considered to have health insurance if they reported to be covered by a health insurance plan at the time of the survey.

BMI groups

Participants were categorized based on BMI group as 18 to <25 kg/m² (normal weight), BMI 25 to <30 kg/m² (overweight), and BMI 30 kg/m² (obese). Participants with BMI 35 kg/m² (morbidly obese) are included in the obese category and presented separately. Underweight participants (BMI < 18.5 kg/m²) were excluded ($n = 606$).

Cardiovascular disease risk factors

Information regarding presence of cardiovascular risk factors was obtained during the NHANES interview and examination. Four CVD risk factors were included in the analysis: diabetes, hypertension, dyslipidemia, and smoking.

Blood pressure (BP) was measured during the NHANES physical examination in the mobile examination center. Up to three BP measurements were taken by a physician after a 5-minute rest following the NHANES standard protocol and the average of the measurements was used for the analysis. Non-HDL cholesterol was used for serum lipid levels and was calculated as total cholesterol minus HDL cholesterol.

Hypertension was defined as self-report of use of antihypertensive medications or systolic BP ≥ 140 mmHg or diastolic BP ≥ 90 mmHg. Among those without self-report of antihypertensive medication use, untreated hypertension was defined as systolic BP ≥ 140 mmHg or diastolic BP ≥ 90 mmHg (10).

Total dyslipidemia was defined as self-report of use of medications to lower cholesterol or non-HDL cholesterol ≥ 160 mg/dl. Among adults with no self-report of cholesterol-lowering medications, untreated dyslipidemia was defined as non-HDL cholesterol ≥ 160 mg/dl (11,12).

Among participants 20 years and older, self-reported smoking was defined as having smoked at least 100 cigarettes in a lifetime and report of current smoking. Among participants 18 and 19 years old, self-reported smoking was defined as report of use of nicotine or tobacco products in the last 5 days. Moderate to heavy smoking exposure was defined based on cotinine levels ≥ 10 ng/ml, regardless of self-reported smoking.

Fasting plasma glucose was measured on participants randomly selected for the morning exam who reported fasting between 8 and 24 hours (1999-2002, $n = 4328$; 2003-2006, $n = 4305$; 2007-2010, $n = 5085$). Analysis of diabetes was restricted to this subsample. Total diabetes was defined by self-report of diagnosis by health care professional or glycated hemoglobin (A1c) level $\geq 6.5\%$ or fasting plasma glucose ≥ 126 mg/dl (13). Among those without self-report of diabetes, undiagnosed diabetes was defined as an A1c level $\geq 6.5\%$ or fasting plasma glucose ≥ 126 mg/dl. We did not distinguish between type 1 and type 2 diabetes.

Statistical analysis

Sample design variables and weights were used to produce nationally representative estimates that accounted for the NHANES complex survey design, including its stratified multistage cluster sampling. We used SAS 9.3 and SUDAAN 11 software (Research Triangle Institute, Research Triangle Park, NC) for the statistical analyses.

To assess trends over time and produce reliable estimates, we grouped data into 4-year periods: 1999-2002, 2003-2006, 2007-2010 (14). The 4-year time periods were compared based on demographics and measures of obesity. Prevalence of each risk factor was calculated overall and for each BMI group. We calculated the absolute change in prevalence

over a decade as the percent estimate for 2007-2010 minus the percent estimate for 1999-2002. Among those with a risk factor, the percent undiagnosed or untreated was calculated. Among adults who fasted and completed the morning examination, the prevalence of adults with 1, 2, or 3 risk factors within each BMI group was also calculated. As there was little difference between self-reported smoking and moderate to heavy smoking exposure based on cotinine, self-reported smoking was included in the count of the number of risk factors.

Results were age standardized to the 2000 US census population using the direct method with three age groups: 18-44, 45-64, and 65 years.

Results

Participants' characteristics overall and by survey period are reported in Table 1. Overall, there was little change in the demographics from 1999-2002 to 2007-2010. However, over this period, the percent of adults 18-44 years decreased (55.2-48.9%), percent of obese adults increased (30.1-34.3%), and the percent of morbidly obese adults increased (12.4-14.7%).

The age-standardized prevalence of each cardiovascular risk factor for each survey period overall and by weight status group is presented in Table 2. In 2007-2010, among normal weight adults, the prevalence of total diabetes was 5.4% and the prevalence of total hypertension, total dyslipidemia, and total smoking exposure was 19.8%, 28.6%, and 29.8%, respectively. Among normal weight adults from 1999-2002 to 2007-2010, there was no significant change in the prevalence of total diabetes, hypertension, or smoking exposure.

Among overweight adults, the prevalence of each cardiovascular risk factor, except for smoking exposure, was higher than among normal weight adults. In this group, from 1999-2002 to 2007-2010, there was no significant change in the prevalence of total diabetes, hypertension, or smoking exposure, but dyslipidemia decreased significantly (-3.4 percentage points [ppt], 95% confidence interval [CI] -6.3, -0.5).

In general and throughout the time period, the prevalence of total diabetes, hypertension, and dyslipidemia were higher among adults who were obese than those who were overweight or normal weight, while smoking exposure (either based on self-report or cotinine levels) was lower. Among adults who were obese, there was no significant change from 1999-2002 to 2007-2010 for total diabetes, hypertension, dyslipidemia, or total smoking exposure. There was also no significant change for undiagnosed diabetes. However, there was a significant decrease for untreated hypertension (24.6 ppt, 95% CI -7.1, -2.0) and untreated dyslipidemia (-9.6 ppt, 95% CI -12.5, -6.6).

Among the obese adults, those who were morbidly obese (BMI ≥ 35 kg/m²) had an even higher prevalence of diabetes, hypertension, and dyslipidemia. In this group, there were also significant changes between 1999-2002 and 2007-2010 in risk factors for untreated hypertension (-4.6 ppt, 95% CI -8.3, -0.8) and dyslipidemia (-6.6 ppt, 95% CI -11.1, -2.1).

Figure 1 presents the proportion of adults with undiagnosed diabetes among total diabetes or untreated hypertension among total hypertension or untreated dyslipidemia among total dyslipidemia by BMI status across time periods. The proportion of undiagnosed diabetes was approximately 30% for all BMI groups and there was not a consistent pattern of increase or decrease over time. The proportion of untreated hypertension among adults with hypertension and untreated dyslipidemia among adults with dyslipidemia did not change among normal weight adults. The proportions of untreated hypertension across weight groups decreased from 51 to 39% among overweight adults, from 39.7 to 26.8% among obese adults, and from 34 to 21% among morbidly obese adults. The proportions of untreated dyslipidemia also decreased for all weight groups with the larger decreases among the obese (9.6 ppt) and morbidly obese adults (6.5 ppt).

Table 3 presents the age standardized prevalence for 1, 2, and 3 risk factors for CVD by BMI status. In 2007-2010, adults who were obese had the highest prevalence of 3 risk factors (13.5%) followed by overweight adults (5.5%) and normal weight adults (3.2%). Morbidly obese adults had a 16.5% prevalence of 3 CVD risk factors. From 1999-2002 to 2007-2010, there was no statistically significant change in the prevalence of 1, 2, or 3 risk factors for normal weight or overweight adults. For the obese and morbidly obese adults, there was a significant increase in the prevalence of 3 risk factors (3.1 ppt 95% CI 0.5, 5.6, and 5.3 ppt 95% CI 0.7, 10.0).

Discussion

The prevalence of cardiovascular risk factors remains high among all adults and increases as people become overweight or obese. In 2007-2010, over 18% of obese adults had diabetes, 36% had hypertension, and 50% had dyslipidemia. With the exception of total smoking exposure, the prevalence of cardiovascular risk factors was highest among obese adults followed by overweight and normal weight adults. The prevalence of cardiovascular risk factors among morbidly obese adults, a subgroup of obese adults, was even higher.

Despite the increase in the prevalence of obese adults in the US population, the prevalence of CVD risk factors has remained the same or declined over the past decade. This decline continues declines reported since the 1960s (6,15-19). More importantly, the proportion of untreated hypertension and untreated dyslipidemia among those with hypertension or dyslipidemia declined between 1999-2002 and 2007-2010. Of concern is the finding that among overweight or obese people the proportion of undiagnosed diabetes has not changed significantly in this time period and it remains similar to previous reports (7).

The decrease in prevalence with untreated hypertension and untreated dyslipidemia may be an indication that adults are getting screened and treated for these conditions, regardless of weight status. The indication that the decrease is greater among obese adults may indicate that these individuals are more likely to be screened and tested for CVD risks. Antihypertension medication use has increased in the United States in the past decade although control levels are still suboptimal (20). This supports our observation of decrease in untreated hypertension over this same time period regardless of weight status. Although the prevalence of hypertension differed by weight status, there was no change in the

prevalence of hypertension, regardless of weight status. This lack of change in prevalence has been reported previously (21). The hypertension definition includes self-report of medication use or elevated BP. These results suggest that individuals are more likely to be treated for hypertension. This observation may suggest a shift to the left in the BP distribution and decrease of BP levels in the US population. Our results with dyslipidemia and elevated non-HDL cholesterol correspond to previously reported trends that examined the mean levels of lipids among adults in the United States (22). However, obese and overweight adults are still twice as likely to have untreated dyslipidemia, highlighting an area that could benefit from increased screening and treatment.

Smoking was the one risk factor where the prevalence has not changed significantly in any BMI group from 1999-2002 to 2007-2010. For this study, we used both self-report of smoking status and serum cotinine levels to estimate smoking exposure. Serum cotinine levels are highly correlated with self-report (23). The lower levels of smoking exposure among overweight and obese adults may indicate a success of smoking prevention or treatment programs among these groups. Reverse causality may also explain this relationship as studies have found smoking to be associated with weight loss and smoking cessation to be associated with weight gain (24). It is also plausible that the self-report data are more susceptible to social desirability bias. However, inclusion of serum cotinine levels reduces this possible bias.

In the United States, over 46% of all adults have at least one uncontrolled risk factor for CVD (25). We found that over 70% of adults 18 years and older had at least one CVD risk factor, either treated or untreated. Our findings further highlight the fact that among obese adults, almost 14% have 3 or more risk factors for CVD and that this percent has increased in the past decade. Each of these CVD risk factors also contributes to increase in disability and morbidity (26). In a recent worldwide report, high BP and tobacco exposure were the top two risk factors attributable to disease and disability. High BMI and elevated glucose levels were numbers 6 and 7 and dyslipidemia was number 15 (26).

Multiple comorbidities are an increasing issue in health care especially among the over 65-year old population (27,28). Among an inpatient sample of adults in the United States, higher costs were associated with three or more chronic conditions (29). Recent commentaries have debated the best method for treatment of multiple chronic conditions (30). Our results inform the debate by further highlighting the high prevalence of multiple CVD risk factors and percent that are undiagnosed, particularly among the obese population.

In recent years, declines in CVD mortality in the United States have been documented. Many of these declines are likely due to improvements in cardiovascular risk factors in the US population (31-35). Among adults with diabetes in the United States, there were significant declines in A1c levels, BP, and low-density cholesterol from 1999 to 2008 (31). A study comparing a cohort from Minnesota to the general US population found that lower levels of CVD risk factors partially explained lower risk of cardiovascular and heart disease mortality observed in the Minnesota cohort (36). Prevention and reduction of cardiovascular risk factors has likely contributed to the decline of cardiovascular mortality in many industrialized countries (37). In the United States, it is estimated that 44% of decline in

deaths from coronary disease was due to reductions in risk factors including cholesterol, BP, and smoking (38). These findings, along with the findings reported here, may indicate that physicians and health care providers focus on controlling CVD risk factors among adults who are overweight or obese.

We chose to define untreated diabetes, hypertension, and dyslipidemia based on clinical guidelines and recent evidence of increased levels of risk (10-13). However, these guidelines and recommendations are a moving target. For example, recent guidelines from the Eighth Joint National Committee on High Blood Pressure (JNC8) recommend not starting medication for hypertension among adults over 60 years until BP \geq 150/90 mmHg (39). We did not use this new recommendation in this analysis, because at the time of the surveys the recommendation was for treatment when BP was \geq 140/90 mmHg (10). Therefore, it is possible that we have overestimated the prevalence of total hypertension and the prevalence of untreated hypertension based on this recent recommendation. Similarly, while the recommendations in the Third Report of the National Cholesterol Education Program Expert Panel on Detection, Evaluation and Treatment of High Cholesterol in Adults (ATP III) focus on total cholesterol with non-HDL cholesterol as a secondary target, recent studies have found non-HDL cholesterol to be an independent predictor of CVD risk (12,40).

The main strength of this study was the use of a nationally representative survey that assessed cardiovascular risk factors in a standardized method over time. The main limitation of this study is that this is only representative of the noninstitutionalized civilian population able to attend the in-person exam. Additionally, NHANES does not allow estimates at the subnational level.

CDC has many programs to address the reduction of cardiovascular risk factors among adults. The National Diabetes Prevention Program is designed to bring evidence-based diabetes prevention for adults at risk for diabetes to communities throughout the United States. (<http://www.cdc.gov/diabetes/prevention/about.htm>) CDC also has prevention efforts to prevent 1 million heart attacks and strokes over the next 5 years through the Million Hearts campaign (<http://www.cdc.gov/features/millionhearts/index.html>) and includes goals to reduce hypertension (<http://www.cdc.gov/bloodpressure/>), cholesterol levels (<http://www.cdc.gov/cholesterol/>) and tobacco use (<http://www.cdc.gov/tobacco/>). Despite the improvements in CVD risk factors, obese adults have a two-fold risk compared to normal weight adults for many cardiovascular risk factors. These results highlight the importance of national prevention efforts for obesity, diabetes, hypertension, lipids, and smoking and the progress to date toward these prevention efforts.

References

1. Flegal KM, Carroll MD, Kit BK, Ogden CL. Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999-2010. *JAMA*. 2012; 307:491-497. [PubMed: 22253363]
2. Brown CD, Higgins M, Donato KA, Rohde FC, Garrison R, Obarzanek E, et al. Body mass index and the prevalence of hypertension and dyslipidemia. *Obes Res*. 2000; 8:605-619. [PubMed: 11225709]
3. Wilson PW, D'Agostino RB, Sullivan L, Parise H, Kannel WB. Overweight and obesity as determinants of cardiovascular risk: the Framingham experience. *Arch Intern Med*. 2002; 162:1867-1872. [PubMed: 12196085]

4. Abdullah A, Peeters A, de Courten M, Stoelwinder J. The magnitude of association between overweight and obesity and the risk of diabetes: a meta-analysis of prospective cohort studies. *Diabetes Res Clin Pract.* 2010; 89:309–319. [PubMed: 20493574]
5. Peeters A, Backholer K. Is the health burden associated with obesity changing? *Am J Epidemiol.* 2012; 176:840–845. [PubMed: 23100248]
6. Gregg EW, Cheng YJ, Cadwell BL, Imperatore G, Williams DE, Flegal KM, et al. Secular trends in cardiovascular disease risk factors according to body mass index in US adults. *JAMA.* 2005; 293:1868–1874. [PubMed: 15840861]
7. Gregg EW, Cadwell BL, Cheng YJ, Cowie CC, Williams DE, Geiss L, et al. Trends in the prevalence and ratio of diagnosed to undiagnosed diabetes according to obesity levels in the U.S. *Diabet Care.* 2004; 27:2806–2812.
8. Centers for Disease Control and Prevention. National Center for Health Statistics (NCHS). Hyattsville, MD: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 1999–2010; 2012. National Health and Nutrition Examination Survey Data. Available at http://www.cdc.gov/nchs/nhanes/nhanes_questionnaires.htm [accessed April 2, 2012]
9. Centers for Disease Control and Prevention. National Center for Health Statistics. [accessed April 2, 2012] National Health and Nutrition Examination Survey Response Rates and CPS Totals, 2009–2010. 2012. A available at http://www.cdc.gov/nchs/nhanes/response_rates_CPS.htm
10. National High Blood Pressure Education Program. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7). National Heart Lung and Blood Institute, National Institutes of Health; 2004.
11. National Cholesterol Education Program. Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation and Treatment of High Cholesterol in Adults (Adult Treatment Panel III). National Health Lung and Blood Institute NIOH, ed; 2001.
12. Rana JS, Boekholdt SM, Kastelein JJ, Shah PK. The role of non-HDL cholesterol in risk stratification for coronary artery disease. *Curr Atheroscler Rep.* 2012; 14:130–134. [PubMed: 22203405]
13. American Diabetes A. Standards of medical care in diabetes–2014. *Diabet Care.* 2014; 37:S14–S80.
14. National Center for Health Statistics. Analytic note regarding 2007–2010 survey design changes and combining data across other survey cycles. Hyattsville, MD: 2012. Available at http://www.cdc.gov/nchs/data/nhanes/analyticnote_2007-2010.pdf [accessed September 19, 2013]
15. Capewell S, Ford ES, Croft JB, Critchley JA, Greenlund KJ, Labarthe DR. Cardiovascular risk factor trends and potential for reducing coronary heart disease mortality in the United States of America. *Bull World Health Organ.* 2010; 88:120–130. [PubMed: 20428369]
16. Go AS, Mozaffarian D, Roger VL, Benjamin EJ, Berry JD, Borden WB, et al. Executive summary: heart disease and stroke statistics–2013 update: a report from the American Heart Association. *Circulation.* 2013; 127:143–152. [PubMed: 23283859]
17. Go AS, Mozaffarian D, Roger VL, Benjamin EJ, Berry JD, Borden WB, et al. Heart disease and stroke statistics–2013 update: a report from the American Heart Association. *Circulation.* 2013; 127:e6–e245. [PubMed: 23239837]
18. Huffman MD, Capewell S, Ning H, Shay CM, Ford ES, Lloyd-Jones DM. Cardiovascular health behavior and health factor changes (1988–2008) and projections to 2020: results from the National Health and Nutrition Examination Surveys. *Circulation.* 2012; 125:2595–602. [PubMed: 22547667]
19. Imperatore G, Cadwell BL, Geiss L, Saadine JB, Williams DE, Ford ES, et al. Thirty-year trends in cardiovascular risk factor levels among US adults with diabetes: National Health and Nutrition Examination Surveys, 1971–2000. *Am J Epidemiol.* 2004; 160:531–539. [PubMed: 15353413]
20. Gu Q, Burt VL, Dillon CF, Yoon S. Trends in antihypertensive medication use and blood pressure control among United States adults with hypertension: the National Health And Nutrition Examination Survey, 2001 to 2010. *Circulation.* 2012; 126:2105–2114. [PubMed: 23091084]
21. Yoon, SS.; Burt, V.; Louis, T.; Carroll, MD. NCHS Data Brief. 2012. Hypertension among adults in the United States, 2009–2010; p. 1–8.

22. Carroll MD, Kit BK, Lacher DA, Shero ST, Mussolino ME. Trends in lipids and lipoproteins in US adults, 1988-2010. *JAMA*. 2012; 308:1545–1554. [PubMed: 23073951]
23. Jaakkola MS, Jaakkola JJ. Assessment of exposure to environmental tobacco smoke. *Eur Respir J*. 1997; 10:2384–2397. [PubMed: 9387970]
24. Audrain-McGovern J, Benowitz NL. Cigarette smoking, nicotine, and body weight. *Clin Pharmacol Ther*. 2011; 90:164–168. [PubMed: 21633341]
25. Fryar, C.; Chen, T.; Li, X. NCHS data brief, no 103. Hyattsville, MD: National Center for Health Statistics 2012; 2012. Prevalence of uncontrolled risk factors for cardiovascular disease: United States, 1999-2010.
26. Murray CJ, Lopez AD. Measuring the global burden of disease. *N Engl J Med*. 2013; 369:448–457. [PubMed: 23902484]
27. Boyd CM, Leff B, Wolff JL, Yu Q, Zhou J, Rand C, et al. Informing clinical practice guideline development and implementation: prevalence of coexisting conditions among adults with coronary heart disease. *J Am Geriatr Soc*. 2011; 59:797–805. [PubMed: 21568950]
28. Weiss CO, Boyd CM, Yu Q, Wolff JL, Leff B. Patterns of prevalent major chronic disease among older adults in the United States. *JAMA*. 2007; 298:1160–1162. [PubMed: 17848649]
29. Steiner CA, Friedman B. Hospital utilization, costs, and mortality for adults with multiple chronic conditions, Nationwide Inpatient Sample, 2009. *Prev Chronic Dis*. 2013; 10:E62. [PubMed: 23618542]
30. Tinetti ME, Fried TR, Boyd CM. Designing health care for the most common chronic condition—multimorbidity. *JAMA*. 2012; 307:2493–2494. [PubMed: 22797447]
31. Ford ES. Trends in the control of risk factors for cardiovascular disease among adults with diagnosed diabetes: findings from the National Health and Nutrition Examination Survey 1999-2008*. *J Diabet*. 2011; 3:337–347.
32. Ford ES, Giles WH. Changes in prevalence of nonfatal coronary heart disease in the United States from 1971-1994. *Ethn Dis*. 2003; 13:85–93. [PubMed: 12723017]
33. Ford ES, Li C, Zhao G, Pearson WS, Capewell S. Trends in the prevalence of low risk factor burden for cardiovascular disease among United States adults. *Circulation*. 2009; 120:1181–1188. [PubMed: 19752328]
34. Ford ES, Li C, Zhao G, Tsai J. Trends in obesity and abdominal obesity among adults in the United States from 1999-2008. *Int J Obes (Lond)*. 2011; 35:736–743. [PubMed: 20820173]
35. Lopez-Jimenez F, Batsis JA, Roger VL, Brekke L, Ting HH, Somers VK. Trends in 10-year predicted risk of cardiovascular disease in the United States, 1976 to 2004. *Circ Cardiovasc Qual Outcomes*. 2009; 2:443–450. [PubMed: 20031875]
36. Wang H, Steffen LM, Jacobs DR, Zhou X, Blackburn H, Berger AK, et al. Trends in cardiovascular risk factor levels in the Minnesota Heart Survey (1980-2002) as compared with the National Health and Nutrition Examination Survey (1976-2002): A partial explanation for Minnesota's low cardiovascular disease mortality? *Am J Epidemiol*. 2011; 173:526–538. [PubMed: 21273396]
37. Di Cesare M, Bennett J, Best N, Stevens G, Danaei GME. The contributions of risk factor trends to cardiometabolic mortality decline in 26 industrialized countries. *Int J Epidemiol*. 2013 Epub Jun 5, 2013.
38. Ford ES, Ajani UA, Croft JB, Critchley JA, Labarthe DR, Kottke TE, et al. Explaining the decrease in U.S. *deaths from coronary disease, 1980-2000*. *N Engl J Med*. 2007; 356:2388–2398. [PubMed: 17554120]
39. James PA, Oparil S, Carter BL, Cushman WC, Dennison-Himmelfarb C, Handler J, et al. 2014 Evidence-Based Guideline for the Management of High Blood Pressure in Adults: Report From the Panel Members Appointed to the Eighth Joint National Committee (JNC 8). *JAMA*. 2013
40. Sigdel M, Yadav BK, Gyawali P, Regmi P, Baral S, Regmi SR, et al. Non-high density lipoprotein cholesterol versus low density lipoprotein cholesterol as a discriminating factor for myocardial infarction. *BMC Res Notes*. 2012; 5:640. [PubMed: 23158803]

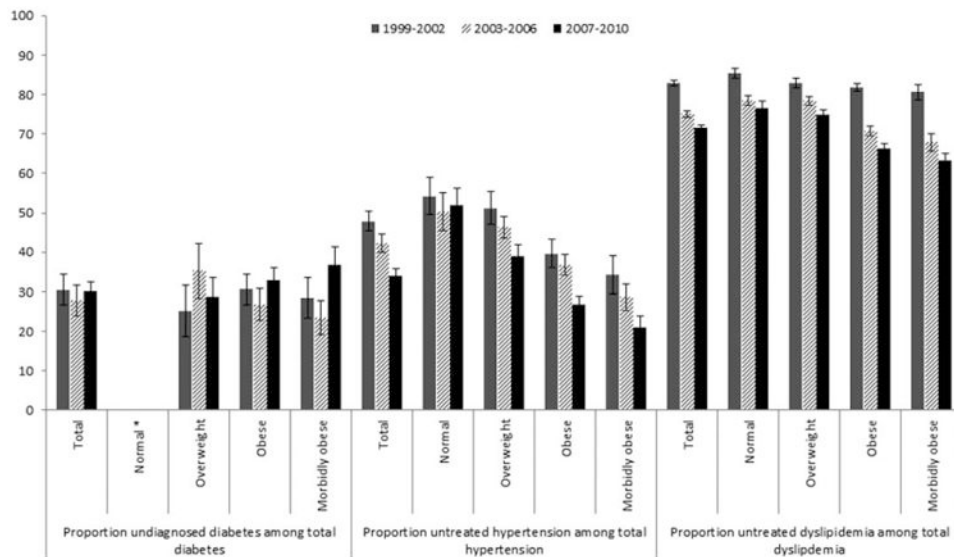


Figure 1.

Proportion (age standardized to the 2000 US population using the following age groups: 18-44, 45-64, and 65 years) of undiagnosed or untreated among total cardiovascular disease risk group overall and by body mass index group among adults 18 years and older, National Health and Nutrition Examination Surveys 1999 to 2010. *Estimates for normal weight participants not presented due to small sample size (<150) and relative standard error <35%. Normal weight = BMI 18.5 to <25 kg/m²; overweight = BMI 25 to <30 kg/m²; obese = BMI 30 kg/m²; morbidly obese = BMI 35 kg/m². Proportion of undiagnosed diabetes among adults with total diabetes fasting in morning exam. Proportion of untreated hypertension among adults with total hypertension. Proportion of untreated dyslipidemia among adults with total dyslipidemia. Total diabetes = self-report of diagnosis by health care professional or A1c level 6.5% or fasting plasma glucose 126 mg/dl. Undiagnosed diabetes = no self-report and A1c level 6.5% or fasting plasma glucose 126 mg/dl. Total hypertension = self-report of antihypertensive medications or blood pressure 140/90 mmHg; Untreated hypertension = no self-report of antihypertensive medications and blood pressure 140/90 mmHg. Total dyslipidemia = self-report of medications to lower cholesterol or non-HDL cholesterol 160 mg/dl; Untreated dyslipidemia = no report of cholesterol lowering medications and non-HDL cholesterol 160 mg/dl.

Table 1
Characteristics of US adults aged 18 years and older, National Health and Nutrition Examination Surveys 1999 through 2010

	Total	1999-2002	2003-2006	2007-2010
Sample size	33,560	10,568	10,637	12,355
Age, mean years (SE)	45.1 (0.22)	44.2 (0.32)	45.4 (0.47)	45.9 (0.33)
Age group, % (SE)				
18-44 years	51.6 (0.62)	55.2 (0.94)	51.1 (1.29)	48.9 (0.89)
45-64 years	32.3 (0.47)	29.9 (0.84)	32.4 (0.91)	34.5 (0.64)
65 years and older	16.1 (0.37)	14.9 (0.50)	16.6 (0.82)	16.6 (0.53)
Male, % (SE)	48.2 (0.25)	48.0 (0.46)	48.1 (0.43)	48.3 (0.40)
Race/ethnicity, % (SE)				
Mexican American or Hispanic	13.0 (0.99)	14.0 (2.02)	11.5 (1.32)	13.6 (1.74)
Non-Hispanic black	11.3 (0.70)	10.9 (1.21)	11.5 (1.35)	11.5 (1.05)
Non-Hispanic other	5.6 (0.36)	4.7 (0.65)	5.4 (0.46)	6.5 (0.75)
Non-Hispanic white	70.1 (1.28)	70.4 (1.82)	71.6 (2.20)	68.4 (2.48)
Poverty Income Ratio category, % (SE) ^a				
<1.50	25.5 (0.75)	26.8 (1.54)	23.2 (1.20)	26.4 (1.16)
1.50 to <3.50	32.4 (0.58)	31.7 (1.05)	34.4 (1.08)	30.9 (0.89)
3.50	42.2 (0.93)	41.5 (1.84)	42.3 (1.56)	42.6 (1.42)
Have Health Insurance, % (SE)	80.9 (0.51)	81.6 (0.89)	81.4 (1.02)	79.7 (0.74)
BMI, mean kg/m ² (SE)	28.3 (0.07)	27.9 (0.13)	28.3 (0.14)	28.5 (0.10)
BMI group, % (SE)				
18.5 to <25 kg/m ²	32.0 (0.46)	33.9 (0.83)	32.0 (0.82)	30.3 (0.75)
25 to <30 kg/m ²	33.5 (0.40)	34.0 (0.79)	33.0 (0.68)	33.6 (0.60)
30 kg/m ²	32.6 (0.49)	30.1 (0.89)	33.1 (0.92)	34.3 (0.71)
35 kg/m ²	13.6 (0.33)	12.4 (0.66)	13.5 (0.62)	14.7 (0.45)

SE, standard error.

^aPIR missing for participants 2,880 (8% of total NHANES sample).

Table 2
Age standardized^a prevalence (95% CI) of cardiovascular disease risk factors^b overall and by BMI group among adults 18 years and older, National Health and Nutrition Examination Surveys 1999 through 2010

	1999-2002	2003-2006	2007-2010	Percentage point change from 1999-2002 to 2007-2010, % (95% CI)
Total population ^c				
Sample size	10,132	10,436	12,175	
Fasting sample size ^d	4,426	4,406	5,188	
Total diabetes ^d	9.4 (8.2, 10.7)	10.2 (9.0, 11.4)	11.0 (9.9, 12.2)	1.6 (0.01, 3.2)
Undiagnosed diabetes ^d	3.4 (2.8, 4.0)	3.2 (2.5, 4.0)	3.7 (3.1, 4.3)	0.3 (-0.5, 1.1)
Total hypertension	27.8 (26.2, 29.4)	28.7 (27.3, 30.1)	28.6 (27.6, 29.6)	0.8 (-1.1, 2.7)
Untreated hypertension	10.9 (9.7, 12.1)	9.3 (8.3, 10.3)	7.3 (6.7, 7.8)	-3.6 (-4.9, -2.3)
Total dyslipidemia	41.1 (39.7, 42.5)	39.8 (38.5, 41.2)	40.4 (39.2, 41.7)	-0.7 (-2.5, 1.1)
Untreated dyslipidemia	32.5 (31.1, 33.9)	27.5 (26.3, 28.7)	26.0 (24.9, 27.0)	-6.5 (-8.2, -4.8)
Self-reported smoking	27.8 (25.8, 29.8)	30.2 (28.2, 32.1)	27.1 (25.4, 28.7)	-0.7 (-3.2, 1.8)
Moderate to heavy smoking exposure	28.6 (26.3, 30.8)	29.0 (26.8, 31.1)	26.0 (24.1, 28.0)	-2.6 (-5.5, 0.3)
Normal weight				
Sample size	3,325	3,282	3,385	
Fasting sample size ^d	1,486	1,362	1,441	
Total diabetes ^d	5.1 (3.5, 6.8)	5.1 (3.4, 6.8)	5.4 (3.8, 6.9)	0.3 (-2.0, 2.5)
Undiagnosed diabetes ^d	1.3 (0.7, 1.9)	1.5 (0.8, 2.2)	1.6 (0.8, 2.4)	0.3 (-0.8, 1.3)
Total hypertension	18.7 (17.0, 20.4)	20.2 (8.6, 21.7)	19.8 (18.1, 21.6)	1.12 (-1.3, 3.5)
Untreated hypertension	8.7 (7.5, 9.8)	8.0 (6.7, 9.3)	7.4 (6.4, 8.3)	-1.3 (-2.8, 0.2)
Total dyslipidemia	29.4 (27.8, 31.0)	26.8 (24.7, 29.0)	28.6 (27.2, 30.0)	-0.8 (-9, 1.3)
Untreated dyslipidemia	23.5 (21.7, 25.2)	18.7 (16.8, 20.6)	19.0 (17.3, 20.7)	-4.5 (-6.9, 22.1)
Self-reported smoking	31.5 (28.0, 35.1)	33.6 (31.1, 36.3)	29.5 (26.7, 32.2)	-2.1 (-6.5, 2.4)
Moderate to heavy smoking exposure	32.4 (28.6, 36.2)	32.3 (29.6, 35.0)	28.8 (25.9, 31.6)	-2.0 (-5.3, 1.2)
Overweight				
Sample size	3,525	3,494	4,102	
Fasting sample size ^d	1,548	1,451	1,768	
Total diabetes ^d	8.2 (6.3, 10.0)	7.6 (6.2, 9.0)	8.2 (6.5, 9.9)	0.01 (-2.5, 2.5)
Undiagnosed diabetes ^d	2.9 (2.1, 3.7)	2.6 (1.7, 3.6)	3.1 (2.3, 3.9)	0.2 (-0.9, 1.4)
Total hypertension	26.7 (24.4, 29.1)	27.3 (25.2, 29.4)	26.4 (24.7, 28.0)	-0.4 (-3.2, 2.5)
Untreated hypertension	11.4 (9.4, 13.4)	9.7 (8.1, 11.3)	7.2 (6.2, 8.2)	-4.2 (-6.5, 21.9)
Total dyslipidemia	47.6 (45.6, 49.7)	45.8 (43.2, 48.3)	44.2 (42.5, 46.0)	-3.4 (-6.3, 20.5)
Untreated dyslipidemia	38.1 (35.5, 40.7)	33.6 (31.5, 35.8)	30.6 (29.0, 32.3)	-7.5 (-10.5, 24.5)
Self-reported smoking	28.0 (26.0, 30.1)	29.2 (26.7, 31.6)	27.4 (25.1, 29.8)	-0.3 (-3.4, 2.8)
Moderate to heavy smoking exposure	27.7 (25.4, 29.9)	27.8 (25.0, 30.5)	26.0 (23.7, 28.3)	-1.7 (-4.9, 1.6)
Obese				

	1999-2002	2003-2006	2007-2010	Percentage point change from 1999-2002 to 2007-2010, % (95% CI)
Sample size	3,083	3,465	4,476	
Fasting sample size ^d	1,294	1,492	1,876	
Total diabetes ^d	16.0 (13.01, 18.8)	17.4 (14.8, 20.0)	18.5 (16.6, 20.4)	2.5 (-0.9, 5.9)
Undiagnosed diabetes ^d	6.2 (4.8, 7.7)	5.8 (4.1, 7.4)	6.6 (5.2, 8.0)	0.4 (-1.6, 2.4)
Total hypertension	37.5 (35.1, 39.9)	38.4 (36.2, 40.6)	35.66 (37.3, 40.1)	-1.9 -4.6, 0.9)
Untreated hypertension	12.5 (10.2, 14.9)	10.4 (9.1, 11.8)	7.96 (6.9, 9.0)	-4.6 (-7.1, 22.0)
Total dyslipidemia	50.7 (48.4, 53.0)	48.7 (46.2, 51.2)	49.74 (47.4, 52.0)	0.9 (-4.1, 2.3)
Untreated dyslipidemia	40.2 (37.8, 42.6)	32.1 (29.8, 34.9)	30.55 (28.5, 32.6)	-9.6 (-12.5, 26.6)
Self-reported smoking	24.8 (22.1, 27.4)	27.5 (25.0, 30.0)	24.5 (22.9, 26.1)	-0.3 (-3.4, 2.8)
Moderate to heavy smoking exposure	25.1 (22.5, 27.9)	26.6 (24.1, 29.0)	23.1 (21.3, 25.0)	-2.0 (-5.3, 1.2)
Morbidly obese				
Sample size	1,257	1,422	1,939	
Fasting sample size ^d	530	632	797	
Total diabetes ^d	21.6 (16.7, 26.6)	23.5 (18.9, 28.1)	23.2 (19.9, 26.5)	1.6 (-4.3, 7.4)
Undiagnosed diabetes ^d	7.6 (5.1, 10.2)	8.5 (5.1, 12.0)	9.3 (6.6, 12.0)	1.7 (-2.0, 5.4)
Total hypertension	42.4 (28.5, 46.3)	44.5 (41.6, 47.4)	44.4 (42.1, 46.7)	1.98 (-2.5, 6.4)
Untreated hypertension	12.0 (8.7, 15.3)	9.9 (8.2, 11.7)	7.4 (5.5, 9.0)	-2.6 (8.3, 20.8)
Total dyslipidemia	46.6 (43.4, 49.8)	47.3 (44.3, 50.3)	47.7 (44.6, 50.9)	1.1 (-3.3, 5.6)
Untreated dyslipidemia	36.3 (33.0, 39.7)	29.7 (26.7, 32.8)	27.7 (25.0, 30.4)	-6.6 (-11.1, -2.1)
Self-reported smoking	22.4 (19.3, 25.6)	24.6 (21.0, 28.2)	23.0 (20.6, 25.3)	0.5 (-3.3, 4.4)
Moderate to heavy smoking exposure	22.6 (18.7, 26.5)	24.1 (20.5, 27.6)	21.4 (19.0, 23.8)	-1.2 (-5.8, 3.3)

^aEstimates among fasting participants in morning examination only, age standardized to the 2000 U.S. population using the following age groups: 18-44, 45-64, and 65 years.

^bCVD risk factors included: total diabetes (self-report of diagnosis by health care professional or A1c level $\geq 6.5\%$ or fasting plasma glucose ≥ 126 mg/dL); undiagnosed diabetes (no self report of diabetes and A1c level $\geq 6.5\%$ or fasting plasma glucose ≥ 126 mg/dL); total hypertension (self-report of anti-hypertensive medications or blood pressure $\geq 140/90$ mmHg); untreated hypertension (no self-report of anti-hypertensive medications and blood pressure $\geq 140/90$ mmHg); total dyslipidemia (self-report of medications to lower cholesterol or non-HDL cholesterol ≥ 160 mg/dL); untreated dyslipidemia (no self-report of medications to lower cholesterol and non-HDL cholesterol ≥ 160 mg/dL); self-reported smoking (18-19 years report of tobacco or nicotine use in past 5 days, 20 years and older report of smoking at least 100 cigarettes and currently smoking) and moderate to heavy smoking exposure (cotinine levels ≥ 10 ng/mL).

^cTotal population includes participants with BMI < 18.5 kg/m².

^dTotal and undiagnosed diabetes estimates only among fasting participants in morning exam.

Normal weight = BMI 18.5 to < 25 kg/m²; overweight = BMI 25 to < 30 kg/m²; obese = BMI ≥ 30 kg/m²; morbidly obese = BMI ≥ 35 kg/m².

Table 3
Age standardized prevalence^a (95% CI) of number of cardiovascular disease (CVD) risk factors^b by BMI group among adults 18 years and older, National Health and Nutrition Examination Surveys 1999 through 2010

	1999-2002	2003-2006	2007-2010	Percentage point change from 1999-2002 to 2007-2010, % (95% CI)
Total^c				
Sample size	4,426	4,406	5,188	
1 CVD risk factor	38.4 (36.3, 40.6)	37.8 (36.0, 39.6)	37.8 (35.6, 39.9)	-0.6 (-3.6, 2.4)
2 CVD risk factors	25.0 (23.0, 27.1)	22.3 (20.6, 24.0)	21.1 (19.5, 22.7)	-3.9 (-6.5, 21.3)
3 CVD risk factors	6.6 (5.6, 7.6)	8.3 (7.1, 9.4)	7.7 (6.9, 8.6)	-1.1 (-0.2, 2.4)
Normal weight				
Sample size	1,484	1,361	1,441	
1 CVD risk factor	38.1 (35.6, 40.6)	39.0 (36.4, 41.5)	36.2 (32.6, 39.9)	-1.8 (-6.3, 2.6)
2 CVD risk factors	18.8 (16.0, 21.6)	18.7 (16.5, 21.0)	16.7 (13.9, 19.4)	-2.2 (-6.0, 1.7)
3 CVD risk factors	3.5 (1.9, 5.1)	3.5 (2.1, 4.9)	3.2 (2.4, 4.0)	-0.3 (-2.1, 1.4)
Overweight				
Sample size	1,548	1,450	1,766	
1 CVD risk factor	40.7 (37.2, 44.2)	39.9 (37.2, 42.6)	41.8 (38.5, 45.0)	1.1 (-3.7, 5.8)
2 CVD risk factors	27.4 (24.3, 30.5)	21.3 (18.8, 23.9)	22.3 (19.8, 24.8)	-5.1 (-9.1, -1.2)
3 CVD risk factors	6.0 (4.8, 7.2)	7.0 (5.3, 8.7)	5.5 (4.6, 6.5)	-0.4 (-1.9, 1.1)
Obese				
Sample size	1,294	1,492	1,876	
1 CVD risk factor	37.1 (33.5, 40.7)	34.9 (31.1, 38.7)	36.0 (33.5, 38.5)	-1.1 (-5.5, 3.2)
2 CVD risk factors	31.0 (27.3, 34.6)	27.1 (23.2, 30.9)	25.1 (22.4, 27.7)	-5.9 (-10.4, -1.5)
3 CVD risk factors	10.4 (8.4, 12.4)	14.0 (12.3, 16.3)	13.5 (11.9, 15.1)	3.1 (0.5, 5.6)
Morbidly obese				
Sample size	530	632	797	
1 CVD risk factor	35.7 (30.6, 40.9)	35.3 (29.1, 41.5)	30.3 (26.3, 34.4)	-5.4 (-11.9, 1.1)
2 CVD risk factors	31.3 (26.5, 36.1)	27.7 (20.7, 34.8)	26.7 (22.6, 30.7)	-4.6 (-10.8, 1.7)
3 CVD risk factors	11.2 (7.4, 15.1)	16.5 (12.8, 20.2)	16.5 (13.9, 19.2)	5.3 (0.7, 10.0)

^aEstimates among fasting participants in morning examination only, age standardized to the 2000 U.S. population using the following age groups: 18-44, 45-64, and ≥ 65 years.

^bCVD risk factors included: total diabetes (self-report of diagnosis by health care professional or A1c level ≥ 6.5% or fasting plasma glucose ≥ 126 mg/dl); total hypertension (self-report of antihypertensive medications or blood pressure ≥ 140/90 mmHg); total dyslipidemia (self-report of medications to lower cholesterol or non-HDL cholesterol ≥ 160 mg/dl); and self-reported smoking.

^cTotal population includes participants with BMI < 18.5 kg/m² (fasting participants with BMI < 18.5 kg/m² in morning exam: 1999-2002, n = 98; 2003-2006, n = 101; 2007-2010, n = 103).

Normal weight = BMI 18.5 to < 25 kg/m²; overweight = BMI 25 to < 30 kg/m²; obese = BMI ≥ 30 kg/m²; morbidly obese = BMI ≥ 35 kg/m².