

# Socioeconomic Status and Trends in Disparities in 4 Major Risk Factors for Cardiovascular Disease Among US Adults, 1971-2002

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**Background:** It is unknown whether the previously recognized disparities in cardiovascular disease (CVD) risk factors related to annual income and educational level have diminished, persisted, or worsened in recent decades. The objective of this study was to examine 31-year trends in CVD risk factors by annual income and educational levels among US adults.

**Methods:** Four cross-sectional national surveys were used: National Health and Nutrition Examination Survey I (1971-1974), II (1976-1980), III (1988-1994), and 1999-2002. The main outcome measure was prevalence of high cholesterol ( $\geq 240$  mg/dL [ $\geq 6.2$  mmol/L]), high blood pressure (140/90 mm Hg), smoking, and diabetes mellitus.

**Results:** Between 1971 and 2002, the prevalence of all CVD risk factors, except diabetes, decreased in all income and education groups, but there has been little reduction in income- and education-related disparities in CVD risk factors and few improvements during the past 10 years. The prevalence of high blood pressure declined by about half in all income and education groups, ranging from 30.3% to 40.6% in 1971-1974 and 16.4% in 1999-2002, with the greatest reduction among those in the lowest income quartile and those with less than a

high school education (18.0 and 15.9 percentage points, respectively). High cholesterol prevalence also declined in all groups and ranged from 28.8% to 32.4% in 1971-1974 and 15.3% to 22.0% in 1999-2002, with the largest decline (15.9 percentage points) among people with the highest incomes. Education- and income-related disparities in smoking widened considerably, because there were large declines in smoking prevalence among people with high incomes and education (from about 33% in 1971-1974 to about 14%-17% in 1999-2002) but only marginal reductions among those with low incomes and education (about 6–percentage point decline). Diabetes prevalence increased most among persons with low incomes and education.

**Conclusions:** Despite the general success in reducing CVD risk factors in the US population, not all segments of society are benefiting equally and improvements may have slowed. Education- and income-related disparities have worsened for smoking, and increases in diabetes prevalence have occurred primarily among persons with a lower socioeconomic status. Diabetes prevention and smoking prevention and cessation programs need to specifically target persons of lower income and education.

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**S**OCIOECONOMIC STATUS (SES) is consistently among the most fundamental determinants of health status.<sup>1,2</sup> Much of this SES relationship can be attributed to cardiovascular disease (CVD)<sup>2-4</sup> and the combined effects of disparities in health-related behaviors, environmental conditions, social structures, and the contact and delivery of health care.<sup>2,5</sup> Because these factors are modifiable, reducing disparities by 2010 is a priority of US public health efforts.<sup>6</sup>

During the past 30 years, the United States experienced large reductions in the prevalence of several CVD risk factors, including hyperlipidemia, blood pressure, and smoking,<sup>7-11</sup> along with improved

medical management of people with established CVD and large reductions in CVD-related mortality.<sup>12</sup> These health improvements were accompanied by substantial gains in annual income, wealth, and educational attainment,<sup>13</sup> but, at the same time, a widening gap in the socioeconomic circumstances in the United States.<sup>13</sup> Thus, whether the increased overall wealth resulted in improved health status across all segments of society remains unanswered and a fundamental test of the success of public health programs. However, to our knowledge, previous studies have not examined trends in CVD risk factors for the total US population in the 1990s. Therefore, the principal aim of this study was to determine whether secular

trends in 4 major CVD risk factors (high cholesterol, high blood pressure, smoking, and diabetes mellitus) affected all socioeconomic segments of the total US population in the same way.

## METHODS

We used data from 4 consecutive National Health and Nutrition Examination Surveys (NHANES) conducted from 1971 through 2002 (NHANES I, 1971-1974; NHANES II, 1976-1980; NHANES III, 1988-1994; and NHANES 1999-2002). Detailed methods are reported elsewhere.<sup>14-17</sup> The NHANES are a set of nationally representative cross-sectional surveys of the noninstitutionalized civilian US population that includes physical measurements and laboratory tests. Overall response rates (ie, attended the interview and physical examination) for the 4 surveys ranged from 60% to 77%. To maintain comparability across all 4 surveys, we limited our analyses to respondents aged 25 through 74 years who had complete data on race or ethnicity, education, income, and the 4 major CVD risk factors: NHANES I, 10 900; NHANES II, 12 939; NHANES III, 12 870; and NHANES 1999-2002, 6997.

### SES MEASURES

We used education level attained and the poverty-income ratio (PIR) as indicators of SES.<sup>18</sup> Education is an important determinant of a person's type of work and economic circumstances and the likelihood of engaging in a variety of health-enhancing activities.<sup>19</sup> Because education is typically completed early in adulthood, it is a marker of early life circumstances, stable over the adult life span, and applicable to those not in the labor force.<sup>18</sup>

The PIR is an index of income assessed in relation to need,<sup>18</sup> with a score of 1 representing the official federal poverty threshold, a score of less than 1 indicating a relative level of poverty, and a score of greater than 1 representing incomes above the poverty threshold. The PIR is comparable across surveys because income thresholds are adjusted for inflation for every calendar year that data are obtained. In our analyses, we categorized persons into quartiles of PIR for each survey.

### CVD RISK FACTORS

The prevalence of high cholesterol, high blood pressure, and current smoking was assessed using common methods across all surveys, as defined in previous publications.<sup>9,20</sup> We examined risk factors irrespective of treatment because our main objective was to determine whether disparities in risk factors have diminished or increased regardless of the reason for the change.

Serum cholesterol levels in venous blood samples were analyzed according to published methods.<sup>11,21</sup> The samples were frozen at -20°C and shipped weekly on dry ice to the Centers for Disease Control and Prevention Lipid Standardization Laboratory for NHANES I or to another research laboratory that used the Centers for Disease Control and Prevention and National Heart, Lung, and Blood Institute Lipid Standardization Program for NHANES II, NHANES III, and NHANES 1999-2002. We defined high cholesterol as serum total cholesterol concentration of 240 mg/dL or more ( $\geq 6.2$  mmol/L) regardless of whether the participant used lipid-lowering medication.

To ensure comparability of blood pressure data across surveys, we used only measurements taken when participants were seated<sup>8</sup> and we adjusted for differences in cuff size protocols used among obese people using the method of Maxwell et al.<sup>22</sup> High blood pressure was defined as an adjusted systolic blood

pressure of 140 mm Hg or higher or a diastolic blood pressure of 90 mm Hg or higher, regardless of whether the participant used antihypertensive medication.

Cigarette smoking was defined as a "yes" answer to both of these questions: "Have you smoked at least 100 cigarettes in your entire life?" and "Do you smoke cigarettes now?"<sup>23</sup>

Diagnosed diabetes was defined by self-report, while undiagnosed diabetes was defined as a fasting plasma glucose level of 126 mg/dL or more ( $\geq 7.0$  mmol/L) in persons without self-reported diabetes. A plasma glucose concentration assay was conducted using the hexokinase enzymatic method.<sup>14-17</sup> Venous whole blood was collected into vacuum tubes containing the glycolytic inhibitors potassium oxalate and sodium fluoride and centrifuged immediately. Total diabetes prevalence was the sum of diagnosed and undiagnosed diabetes.<sup>9,24,25</sup> Because fasting glucose data were unavailable for NHANES I, only data from the last 3 surveys were analyzed to determine the prevalence of total diabetes.

### DATA ANALYSIS

We used logistic regression to estimate the association of income and education groups with changes in risk factors over time. The presence of the risk factor served as the dependent variable, while age, sex, survey, and 2-way interactions between survey and PIR quartile (or education category) were included in the models. Model predictions come from a single data set that pooled standardized variables and observations from each NHANES. We report predictive marginal probabilities instead of odds ratios because they provide adjusted prevalence estimates and because the high prevalence of the risk factors makes odds ratios difficult to interpret.<sup>26</sup> We tested for changes between NHANES I and NHANES 1999-2002 and between the 2 most recent surveys by calculating differences in the age-sex-standardized prevalences of each CVD risk factor in each SES stratum.<sup>27,28</sup> We examined interaction terms between SES groups and survey years from logistic models to determine if changes between the first and last survey differed by SES group. The statistical significance of changes over time and the differences between highest and lowest income and education groups were determined using *t* tests and  $P < .05$ .

As a complementary examination of whether SES-related disparities in risk factors changed over time, we calculated a slope index of inequality (SII) for each risk factor in each survey. The SII is measured by the  $\beta$  coefficient (slope) for the linear relationship between the prevalence of a CVD risk factor in a socioeconomic category and the relative rank of that category in the overall distribution of the socioeconomic indicator. The  $\beta$  coefficient is interpreted as the absolute difference in prevalence across the entire distribution of the socioeconomic indicator.<sup>29</sup> Because the SII accounts for the size of the total population and change in the distribution of the SES variable, it is particularly relevant to the United States, in which the proportion of the population "exposed" to less than a high school education has decreased significantly over the past 30 years. All analyses were performed using SAS statistical software, version 8.2 (SAS Institute Inc, Cary, NC), with survey software (SUDAAN; RTI International, Research Triangle Park, NC) to estimate standard errors and permit extrapolation of prevalence to the US noninstitutionalized population.

## RESULTS

**Table 1** shows the demographic characteristics of the sample from each survey. Over time, the proportion of respondents from minority groups and the level of educational attainment increased notably. Across the 4 sur-

**Table 1. Characteristics of Participants by Survey**

Characteristic	NHANES*				P Value†
	I (1971-1974)	II (1976-1980)	III (1988-1994)	1999-2002	
Age, y					
25-44	47.7	50.2	56.8	50.7	<.001
45-64	40.3	37.5	31.1	38.8	
65-74	12.0	12.4	12.1	10.5	
Female sex	52.6	52.4	51.3	51.4	>.05
Ethnicity					
White‡	89.4	88.0	77.8	72.1	<.001
African American	9.7	9.7	10.5	10.7	
Hispanic	NA	NA	4.6	6.7	
Other§	0.9	2.3	7.1	10.5	
Educational level					
<High school	37.6	34.5	22.3	19.7	<.001
High school graduate	35.7	31.3	34.4	25.1	
>High school	26.8	34.6	43.3	55.2	
PIR quartile					
1 (low annual income)	<1.6	<1.7	<1.8	<1.6	NA
2	1.6 to <2.6	1.7 to <2.6	1.8 to <3.0	1.6 to <3.2	
3	2.6 to <3.9	2.6 to <3.8	3.0 to <4.5	3.2 to <5.0	
4 (high annual income)	≥3.9	≥3.8	≥4.5	≥5.0	

Abbreviations: NA, data not applicable; NHANES, National Health and Nutrition Examination Survey; PIR, poverty-income ratio.

\*Data are given as percentage of each group, unless otherwise indicated. Percentages may not total 100 because of rounding.

†P value was determined by  $\chi^2$  test.

‡Whites include Hispanics for NHANES I and II.

§Other includes Hispanics for NHANES I and II.

||Data are given as range.

veys, the lowest quartile was composed of people below the poverty level and up to an income level of 1.6 times the poverty level, whereas the highest quartile was composed of people living at 3.9 to 5.0 or more times the income of people at the poverty level.

### HIGH BLOOD PRESSURE

The prevalence of high blood pressure declined for all income groups from NHANES I to NHANES III and was followed by no change between the last 2 surveys (**Table 2**). People in the lowest PIR quartile had a steeper decrease in prevalence from the first to the fourth survey (18.0 percentage points) than those in the other income quartiles (range, 13.8-16.1 percentage points), although this difference in magnitude of change between groups was not statistically significant ( $P=.73$ ). The SII values for blood pressure are negative, indicating a lower prevalence is associated with a higher PIR. The SII trends showed that the amount of SES inequality decreased for blood pressure after the first NHANES, but increased slightly from NHANES III to NHANES 1999-2002.

Trends by education were similar to those for relative income. People with less than a high school education had a decrease in prevalence from NHANES I to NHANES 1999-2002 of 15.9 percentage points, compared with a decrease of 13.4 percentage points for those with more than a high school education. Although the difference in prevalence for people with a low level of education and those with a high level of education was lower in 1999-2002 (6.7 percentage points) than in 1971-

1974 (9.1 percentage points), these differences were not significant. However, the differences in prevalence over time were not significant, and a higher prevalence of elevated blood pressure among people with less than a high school education persisted through 1999 to 2002. The SII trends by education were similar to those of PIR.

### HIGH CHOLESTEROL

The prevalence of high cholesterol declined substantially during the past 3 decades for all PIR quartiles, from a prevalence of about 30% to about 31% in 1971 to 1974 to about 15% to 20% in 1999 to 2002 (Table 2). The magnitude of decline tended to be greater among people in the highest PIR quartile (16–percentage point decline) than among those in the lowest PIR quartile (10.5–percentage point decline), such that by 1999 to 2002, the prevalence of elevated cholesterol was 4.3 percentage points higher for the lowest PIR quartile compared with the highest PIR quartile. There was a significant survey  $\times$  income group interaction, which indicates that the amount of reduction in prevalence over time was greater for the richest quartile than for the poorest quartile ( $P=.005$ ). This is also reflected in the decreasing SII scores, indicating an increase in cholesterol level inequality across PIR groups over time. Education status was not consistently associated with prevalence of high cholesterol. The prevalence declined for all groups, with greater declines for the least educated and the most educated (about 14 percentage points) than for those with the intermediate level of education (6.8 percentage points) ( $P=.02$ ).

**Table 2. Prevalence and SII of High Blood Pressure and High Cholesterol Among Adults Aged 25 to 74 Years, Between 1971 and 2002, by Annual Income and Education\***

Variable	NHANES				Difference	
	I (1971-1974)	II (1976-1980)	III (1988-1994)	1999-2002	NHANES I vs 1999-2002	NHANES III vs 1999-2002
<b>High Blood Pressure</b>						
PIR quartile						
1 (low)	40.6 (38.1 to 43.1)	29.9 (26.8 to 33.0)	19.4 (17.6 to 21.2)	22.6 (19.5 to 25.7)	-18.0 (-21.9 to -14.1)†	3.2 (0.0 to 6.6)
2	33.2 (30.8 to 35.6)	27.1 (24.5 to 29.7)	15.8 (13.6 to 18.0)	18.8 (16.3 to 21.3)	-14.4 (-17.7 to -11.1)†	3.0 (-0.1 to 6.1)
3	32.3 (29.4 to 35.2)	25.7 (22.4 to 29.0)	15.4 (13.8 to 17.0)	18.5 (15.6 to 21.4)	-13.8 (-17.9 to -9.7)†	3.1 (0.0 to 6.2)
4 (high)	32.5 (30.0 to 35.0)	26.7 (23.0 to 30.4)	15.4 (13.6 to 17.2)	16.4 (13.7 to 19.1)	-16.1 (-19.6 to -12.6)†	1.0 (-2.1 to 4.1)
Difference between high and low	-8.1 (-11.6 to -4.6)‡	-3.2 (-7.1 to 0.7)	-4.0 (-6.6 to -1.4)‡	-6.2 (-9.9 to -2.5)‡	NA	NA
SII†	-9.9 (-14.6 to -5.2)	-4.4 (-9.9 to 1.1)	-5.0 (-8.3 to -1.7)	-7.7 (-12.4 to -3.0)	NA	NA
Education group						
<High school	39.5 (37.1 to 41.9)	29.9 (27.0 to 32.8)	18.6 (17.0 to 20.2)	23.6 (21.8 to 25.4)	-15.9 (-18.8 to -13.0)†	5.0 (2.6 to 7.4)†
High school graduate	32.8 (30.6 to 35.0)	27.1 (24.0 to 30.2)	16.7 (14.9 to 18.5)	20.0 (17.8 to 22.2)	-12.8 (-15.6 to -9.8)†	3.3 (0.7 to 6.1)†
>High school	30.3 (27.8 to 32.8)	25.3 (21.6 to 29.0)	15.3 (13.9 to 16.7)	16.9 (14.7 to 19.1)	-13.4 (-16.7 to -10.1)†	1.6 (-0.8 to 4.0)
Difference between >high school and <high school	-9.2 (-12.8 to -5.4)‡	-4.6 (-7.9 to -1.3)‡	-3.3 (-4.9 to -1.7)‡	-6.7 (-9.2 to -4.2)‡	NA	NA
SII	-13.9 (-18.8 to -9.0)	-7.0 (-13.6 to -0.4)	-4.7 (-7.9 to -1.5)	-10.0 (-14.1 to -5.9)	NA	NA
<b>High Cholesterol</b>						
PIR quartile						
1 (low)	30.1 (28.1 to 32.1)	27.0 (24.6 to 29.4)	21.0 (19.0 to 23.0)	19.6 (16.5 to 22.7)	-10.5 (-13.8 to -7.2)†	-1.4 (-4.8 to 2.2)
2	29.6 (27.1 to 32.1)	30.3 (27.9 to 32.7)	22.1 (19.9 to 24.3)	20.0 (17.5 to 22.5)	-9.6 (-13.1 to -6.1)†	-2.1 (-5.1 to 1.1)
3	30.8 (28.1 to 33.5)	29.5 (26.9 to 32.1)	21.1 (18.5 to 23.7)	18.7 (16.5 to 20.9)	-12.1 (-15.6 to -8.6)†	-2.4 (-6.0 to 1.0)
4 (high)	31.2 (28.7 to 33.7)	32.0 (29.8 to 34.2)	20.0 (17.8 to 22.2)	15.3 (13.1 to 17.5)	-15.9 (-19.3 to -12.7)†	-4.7 (-7.6 to -1.8)†
Difference between high and low	1.1 (-1.6 to 3.8)	5.0 (1.8 to 8.0)‡	-1.0 (-3.8 to 1.8)	-4.3 (-7.8 to -0.8)‡	NA	NA
SII	1.8 (-2.6 to 6.2)	5.7 (1.5 to 9.9)	-1.6 (-5.6 to 2.4)	-6.0 (-10.3 to -1.7)	NA	NA
Education group						
<High school	32.4 (30.6 to 34.2)	28.9 (26.9 to 30.9)	23.2 (20.8 to 25.6)	18.0 (15.5 to 20.5)	-14.4 (-17.1 to -11.7)†	-5.2 (-8.5 to -1.9)†
High school graduate	28.8 (26.8 to 30.8)	31.5 (29.5 to 33.5)	21.9 (19.7 to 24.1)	22.0 (18.9 to 25.1)	-6.8 (-10.3 to -3.3)†	0.1 (-3.4 to 3.6)
>High school	30.8 (28.1 to 33.5)	29.4 (26.8 to 32.0)	19.7 (17.9 to 21.5)	16.8 (15.4 to 18.2)	-14.0 (-17.0 to -10.8)†	-2.9 (-5.2 to -0.4)
Difference between >high school and <high school	-1.6 (-4.5 to 1.3)	0.5 (-2.1 to 3.1)	-3.5 (-6.7 to -0.3)‡	-1.2 (-3.4 to 1.0)	NA	NA
SII	-3.0 (-7.5 to 1.5)	0.7 (-4.0 to 5.4)	-5.4 (-9.7 to -1.1)	-4.7 (-9.4 to 0.0)	NA	NA

Abbreviations: NA, data not applicable; NHANES, National Health and Nutrition Examination Survey; PIR, poverty-income ratio; SII, slope index of inequality.

\*Data are given as percentage (95% confidence interval).

† $P < .05$  for comparison between the first and last survey (column 5) and between the third and last survey (column 6) within annual income and education groups.

‡ $P < .05$  for test of comparison between high and low group within survey year.

## SMOKING

The prevalence of smoking declined substantially (19.6 and 17.1 percentage points) for the highest 2 income quartiles and moderately (13.1 percentage points) for the second quartile, but only modestly (6.6 percentage points) for the lowest income quartile (**Table 3**). The survey  $\times$  income group interaction term was significant ( $P < .001$ ), indicating that reductions over time were greater for people in a high PIR quartile than for those in a low PIR quartile. Furthermore, only the top 2 PIR quartiles had significant decreases in smoking from NHANES III to NHANES 1999-2002. For NHANES I, those in the lowest income quartile had a 10.5–percentage point higher prevalence than those in the highest income quartile; this difference more than doubled (to 23.5 percentage points) by NHANES 1999-2002. Similar associations existed for trends by education. People with at least some college had a significantly greater de-

cline (16.4 percentage points) than those with a high school education or less (6.5 and 7.6 percentage points, respectively) ( $P < .001$ ). The increasing inequality gap for PIR and education was mirrored by an increasing SII across the surveys.

## DIABETES MELLITUS

All surveys found that the prevalence of diagnosed diabetes was higher for people in the lowest income quartiles. The prevalence increased from 1971 to 1974 to 1999 to 2002 for all groups except those with the highest relative income (Table 3). The increase in prevalence tended to be greater for those in the lowest 2 relative income quartiles (about 5 percentage points) than for those in the upper income quartile (about 1-2 percentage points). Although not statistically significant, these changes tripled the disparity in diabetes prevalence between the high and low income quartiles (from

**Table 3. Prevalence and SII of Smoking and Diagnosed Diabetes Mellitus Among Adults Aged 25 to 74 Years, Between 1971 and 2002, by Annual Income and Education\***

Variable	NHANES				Difference	
	I (1971-1974)	II (1976-1980)	III (1988-1994)	1999-2002	NHANES I vs 1999-2002	NHANES III vs 1999-2002
<b>Current Smoker</b>						
PIR quartile						
1 (low)	44.0 (40.3 to 47.7)	43.3 (41.1 to 45.5)	40.0 (37.6 to 42.4)	37.4 (34.1 to 40.7)	-6.6 (-11.5 to -1.7)†	-2.6 (-6.6 to 1.2)
2	43.1 (39.0 to 47.2)	36.8 (34.2 to 39.4)	31.7 (28.3 to 35.1)	30.0 (26.5 to 33.5)	-13.1 (-18.4 to -7.8)†	-1.7 (-6.4 to 3.0)
3	37.6 (33.5 to 41.7)	35.8 (33.4 to 38.2)	26.4 (23.6 to 29.2)	20.5 (17.2 to 23.8)	-17.1 (-22.3 to -12.1)†	-5.9 (-10.0 to -1.8)†
4 (high)	33.5 (29.2 to 37.8)	35.9 (34.1 to 37.7)	20.3 (17.5 to 23.1)	13.9 (11.0 to 16.8)	-19.6 (-24.7 to -14.5)†	-6.4 (-12.5 to -0.3)†
Difference between high and low	-10.5 (-16.6 to -4.4)‡	-7.4 (-10.5 to -4.3)‡	-19.7 (-23.1 to -16.3)‡	-23.5 (-27.6 to -19.4)‡	NA	NA
SII‡	-14.8 (-22.1 to -7.5)	-9.3 (-13.3 to -5.3)	-25.8 (-30.8 to -20.8)	-32.6 (-38.1 to -27.1)	NA	NA
Education group						
<High school	45.1 (42.0 to 48.2)	42.0 (40.6 to 43.4)	41.1 (38.7 to 43.5)	38.6 (35.3 to 41.9)	-6.5 (-11.0 to -2.0)†	-2.5 (-6.4 to 1.4)
High school graduate	39.9 (36.2 to 43.6)	40.7 (38.9 to 42.5)	34.7 (32.3 to 37.1)	32.3 (29.4 to 35.2)	-7.6 (-12.2 to -2.8)†	-2.4 (-5.8 to 1.2)
>High school	33.5 (29.8 to 37.2)	31.4 (29.6 to 33.2)	19.2 (17.0 to 21.4)	17.1 (15.1 to 19.1)	-16.4 (-20.7 to -12.1)†	-2.1 (-5.0 to 0.8)
Difference between >high school and <high school	-11.6 (-16.8 to -6.6)‡	-10.6 (-12.6 to -8.6)‡	-21.9 (-24.9 to -18.9)‡	-21.5 (-25.4 to -17.6)‡	NA	NA
SII	-16.6 (-23.9 to -9.3)	-16.1 (-19.6 to -12.6)	-34.3 (-39.0 to -29.6)	-35.4 (-40.8 to -30.0)	NA	NA
<b>Diagnosed Diabetes Mellitus</b>						
PIR quartile						
1 (low)	4.9 (3.9 to 5.9)	4.8 (4.2 to 5.4)	8.0 (6.8 to 9.2)	9.7 (8.1 to 11.3)	4.8 (3.0 to 6.6)†	1.7 (-0.1 to 3.5)
2	3.5 (2.5 to 4.5)	3.8 (3.2 to 4.4)	5.2 (4.0 to 6.4)	8.0 (6.4 to 9.6)	4.5 (2.7 to 6.3)†	2.8 (0.8 to 4.8)†
3	2.9 (2.1 to 3.7)	3.3 (2.7 to 3.9)	4.4 (3.4 to 5.4)	4.9 (3.7 to 6.1)	2.0 (0.6 to 3.4)†	0.5 (-1.0 to 2.2)
4 (high)	2.6 (2.0 to 3.2)	2.9 (2.1 to 3.7)	4.0 (3.0 to 5.0)	3.5 (2.5 to 4.5)	0.9 (-0.3 to 2.1)	-0.5 (-1.8 to 1.0)
Difference between high and low	-2.3 (-3.4 to -1.0)‡	-1.9 (-2.9 to -0.9)‡	-4.0 (-5.4 to -2.6)‡	-6.2 (-8.2 to -4.2)‡	NA	NA
SII	-3.0 (-4.5 to -1.5)	-2.5 (-3.6 to -1.4)	-5.1 (-7.0 to -3.2)	-8.8 (-11.2 to -6.4)	NA	NA
Education group						
<High school	4.4 (3.8 to 5.0)	4.4 (4.0 to 4.8)	7.9 (7.1 to 8.7)	9.9 (8.3 to 11.5)	5.5 (3.9 to 7.1)†	2.0 (0.2 to 3.8)†
High school graduate	3.3 (2.3 to 4.3)	3.7 (2.9 to 4.5)	5.1 (4.1 to 6.1)	6.5 (5.3 to 7.7)	3.2 (1.6 to 4.8)†	1.4 (-0.2 to 3.0)
>High school	2.2 (1.4 to 3.0)	2.8 (2.2 to 3.4)	3.7 (2.9 to 4.5)	5.1 (4.1 to 6.1)	2.9 (1.7 to 4.1)†	1.4 (0.2 to 2.6)†
Difference between >high school and <high school	-2.2 (-3.4 to -1.0)‡	-1.6 (-2.2 to -1.0)‡	-4.3 (-5.3 to -2.9)‡	-4.8 (-6.6 to -3.0)‡	NA	NA
SII	-3.2 (-4.9 to -1.5)	-2.4 (-3.7 to -1.1)	-5.9 (-7.6 to -4.2)	-6.7 (-9.3 to -4.1)	NA	NA

Abbreviations: See Table 2.

\*Data are given as percentage (95% confidence interval).

† $P < .05$  for test of comparison between the first and last survey (column 5) and between the third and last survey (column 6) within annual income and education groups.

‡ $P < .05$  for test of comparison between high and low group within survey year.

a 2.3–percentage point difference in 1971-1974 to a 6.2–percentage point difference in 1999-2002). The SII became more negative with time, indicating a higher prevalence among the poor and that the gap between the higher and lower strata has been increasing over the past 25 years. Trends by education were similar to those for relative income, because those with less than a high school education had the largest increase in prevalence between NHANES I and NHANES 1999-2002 (5.5 percentage points) ( $P < .05$ ).

When we examined trends in total diabetes (ie, diagnosed and undiagnosed diabetes) based on the surveys for which relevant data were available (NHANES II, NHANES III, and NHANES 1999-2000), we found similar associations with SES as those found for diagnosed diabetes (Table 4). The prevalence of total diabetes increased by about 7 percentage points for the lowest PIR quartile, compared with more modest increases in the middle quartiles (about 2 and 5 percentage points) and a less than 1% increase in diabetes prevalence for the highest quartile. Similar patterns existed for education: those with less than a high school education had about an 8–per-

centage point increase over 25 years compared with approximately 3% for people with a high school education or more. The SII trend for total diabetes was similar to the trend for diagnosed diabetes but was of greater magnitude.

#### COMMENT

In this series of national surveys over 30 years, we found that reductions in blood pressure and cholesterol levels generally benefited the full spectrum of income and education, albeit with cholesterol level improving most among the rich and educated and blood pressure improving most among the poor and less educated. However, disparities in smoking and diabetes worsened, because there was a doubling of the difference in prevalence between people who are rich or well educated and those who are poor or not well educated. The widening of the income- and education-related disparity was most ominous for smoking: among people with the highest income and most education, prevalence decreased by 50% to 59% from 1971

**Table 4. Prevalence and SII of Total Diabetes Mellitus (Diagnosed and Undiagnosed Combined) Among Adults Aged 25 to 74 Years, Between 1976 and 2002, According to Annual Income and Education\***

Variable	NHANES			Difference	
	II	III	1999-2002	NHANES	NHANES
	(1976-1980)	(1988-1994)		II vs 1999-2002	III vs 1999-2002
PIR quartile					
1 (low)	7.0 (5.5 to 8.5)	10.3 (8.6 to 12.1)	13.6 (11.4 to 15.8)	6.6 (4.0 to 9.2)†	3.3 (0.5 to 6.0)†
2	5.7 (4.0 to 7.3)	7.3 (5.5 to 9.2)	10.1 (7.7 to 12.5)	4.4 (1.6 to 7.3)†	2.8 (-0.1 to 5.7)
3	3.9 (2.9 to 4.9)	5.6 (4.4 to 6.8)	6.4 (4.8 to 7.9)	2.5 (0.6 to 4.2)†	0.8 (-1.2 to 2.6)
4 (high)	4.1 (2.8 to 5.3)	5.6 (4.1 to 7.1)	4.7 (3.3 to 6.0)	0.6 (-1.1 to 2.3)	-1.0 (-2.9 to 1.0)
Difference between high and low	-2.9 (-4.9 to -1.0)‡	-4.7 (-7.1 to -2.4)‡	-8.9 (-11.6 to -6.3)‡	NA	NA
SII	-4.2 (-6.6 to -1.8)	-6.3 (-9.1 to -3.5)	-12.3 (-15.6 to -9.0)	NA	NA
Education group					
<High school	6.0 (4.7 to 7.3)	10.7 (9.2 to 12.3)	13.6 (11.4 to 15.8)	7.6 (5.1 to 10.0)†	2.9 (0.2 to 5.4)†
High school graduate	5.6 (4.4 to 6.8)	7.2 (5.8 to 8.7)	8.7 (7.0 to 10.3)	3.1 (1.1 to 5.0)†	1.5 (-0.7 to 3.6)
>High school	3.5 (2.8 to 4.3)	4.9 (3.9 to 6.0)	6.1 (4.9 to 7.3)	2.6 (1.2 to 4.0)†	1.2 (-0.4 to 2.7)
Difference between >high school and <high school	-2.5 (-4.0 to -1.0)‡	-5.8 (-7.7 to -3.9)‡	-7.5 (-10.0 to -5.0)‡	NA	NA
SII	-3.8 (-6.1 to -1.5)	-8.2 (-10.9 to -5.5)	-10.6 (-14.0 to -7.2)	NA	NA

Abbreviations: See Table 2.

\*Data are given as percentage (95% confidence interval).

† $P < .05$  for test of comparison between the second and last survey (column 4) and between the third and last survey (column 5) within annual income and education groups.

‡ $P < .05$  for test of comparison between high and low group within survey year.

through 2002 compared with only 15% relative reductions in prevalence for people with the lowest levels of education and income. These findings suggest that the general success in reducing high blood pressure and high cholesterol across segments of society is countered by a widening disparity in smoking and diabetes. Furthermore, the improvements that did occur may have slowed since 1994.

Our findings were consistent with CVD risk factor reductions observed among all education groups during the 1980s in selected populations from the Minnesota Heart Survey<sup>30</sup> and the control conditions of the Stanford Five-City Project<sup>31</sup> and the Stanford Three Community Study.<sup>32</sup> Those community surveys also found no appreciable reduction in the differences between people with the highest and lowest education. Our findings of growing differences in smoking by SES are consistent with results of the National Health Interview Survey, which showed widening differences in smoking prevalence by education level, income level, and occupational category (eg, blue collar vs white collar jobs).<sup>33-35</sup> Our study extends these previous studies in that we examined 31-year trends for the overall US population through the 1990s, a period of considerable increased wealth in the United States.

Several factors could explain the encouraging reductions in blood pressure and cholesterol levels at all socioeconomic levels. Lower serum cholesterol levels may be because of populationwide reductions in intake of saturated fats and more consumption of fruit, vegetables, and whole grains.<sup>36-38</sup> Reductions in blood pressure levels since the 1970s have been attributed to better awareness, use of antihypertensive medications, improved management, and possibly reduced sodium intake.<sup>8,39</sup> Large-scale public health promotion efforts, such as the National Blood Pressure Education Program and the National

Cholesterol Education Program, launched in the 1970s, are credited with stimulating and helping to maintain many of these positive trends.<sup>11</sup> The National Blood Pressure Education Program and the National Cholesterol Education Program include programs specifically targeted to minority populations and to people with low incomes and education. More recently, aggressive lipid control through increased use of lipid-lowering medications has probably influenced cholesterol levels,<sup>40</sup> at least among people with high annual incomes.

Reductions in smoking prevalence are attributed to public health policy and health promotion efforts, especially comprehensive tobacco prevention and control programs.<sup>41</sup> Specific effective interventions include public education campaigns, increases in tobacco excise taxes, paid mass media counteradvertising, clean indoor air policies, and increased availability of proved cessation methods.<sup>41-43</sup> Although these efforts have been broad based, they may be less effective among people with low education and annual income levels than among the more affluent, perhaps because of competing efforts of the cigarette industry, whose marketing tactics target minority populations and middle- to low-income neighborhoods.<sup>44</sup>

Diabetes is the one risk factor that did not decrease during recent decades. Prevalence increased most among the lowest 2 income groups and among those with less than a high school education. National surveillance data suggest that among non-Hispanic whites, the prevalence of obesity increased most among the poorest segments, whereas among non-Hispanic blacks, the greatest increases occurred among people with middle and high annual incomes.<sup>45</sup> Similarly, the difference in physical activity levels between people with and people without a college education may have widened in the past decade.<sup>46,47</sup> Of the 4 risk factors examined, large-scale pub-

lic health prevention efforts occurred at least 2 decades later for diabetes than for hypertension, hypercholesterolemia, and smoking. Therefore, it is important to evaluate whether recent public health programs to reduce diabetes risk factors are effective for people at all income and education levels.

Our analyses have several limitations. First, our study was based on consecutive cross-sectional samples and, thus, not designed to assess the cause and effect between income, education, and CVD risk factors. Education and income can play a role in the cause of CVD risk factors and conditions, but could also be affected by prevalent CVD. Our main goal was not to assess cause, but to determine the population burden of CVD risk factors by education and income levels and to determine whether the disparity in burden has changed. Second, the utility of education and income as indicators of social class may be limited by the fact that their relationships with social class may have changed over time. Because of this limitation, our findings related to risk factor changes should be interpreted as changes according to relative income level as opposed to absolute income level, and according to absolute (as opposed to relative) education level. Despite this discrepancy, it is reassuring that similar conclusions are derived from a relative measure of social class (PIR), an absolute measure (education), and a validated index of inequality (SII). Third, changes in the questionnaires from one NHANES to the next prevented truly consistent categorization across surveys. Finally, our assessments of diabetes and smoking depended on self-report. Self-reported diabetes and smoking, however, result in minimal underestimates compared with their biochemical gold standards.<sup>48,49</sup> We found no evidence that such underestimation changed considerably according to SES and year over time.

The improvement in CVD risk factors and the concomitant decrease in CVD mortality among adults is a chronic disease success story in the United States. These analyses produced some good news: at least with regard to trends in blood pressure and cholesterol, people with low annual incomes and low education levels are not left behind. However, the lack of progress in reducing disparities in these 2 risk factors, combined with worsening disparities in smoking and diabetes across the US population, underscores the need for public health efforts to find ways to reach people with lower and intermediate levels of annual income and education.

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