Trends in Self-reported Multiple Cardiovascular Disease Risk Factors Among Adults in the United States, 1991-1999

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**Background:** There are few national- and state-level data on multiple cardiovascular disease (CVD) risk factor status and trends over time. We examined the prevalence of self-reported multiple CVD risk factors from 1991 through 1999.

**Methods:** The Behavioral Risk Factor Surveillance System is a state-based telephone survey of adults 18 years or older. Surveys in 1991, 1993, 1995, 1997, and 1999 ascertained reported high blood pressure, high blood cholesterol level, diabetes, obesity, and current smoking status. Trends in the prevalence of persons with each risk factor and of having 2 or more risk factors were calculated. Data were age standardized to the 2000 US population.

**Results:** From 1991 to 1999, the prevalence of reported high blood pressure increased from 23.8% to 25.4%, high cholesterol levels increased from 24.9% to 27.7%, diabetes increased from 5.5% to 7.1%, obesity increased from 13.5% to 20.3%, and smoking remained at approximately 21%. The prevalence of adults with 2 or more risk factors increased from 23.6% in 1991 to 27.9% in 1999 and significantly increased for both men and women and for all race or ethnic, age, and education groups. Among states, the prevalence of multiple risk factors ranged from 15.0% to 29.9% in 1991 and from 18.7% to 37.1% in 1999. From 1991 to 1999, the prevalence of multiple risk factors increased by 10% or more in 36 states.

**Conclusions:** The substantial proportion of persons with known multiple risk factors (25% of the population) suggests that increased CVD prevention and risk factor reduction efforts should focus on comprehensive risk reduction strategies.

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Current estimates suggest that almost 50 million of all Americans have high blood pressure, 42 million have high blood cholesterol levels, 47 million smoke, 44 million are obese, and almost 11 million have diabetes. Many millions more have blood pressure, cholesterol, weight, and glucose levels that are considered above optimal. Rates of heart disease and stroke mortality have been shown to vary geographically in the United States and studies have also shown geographic differences in levels of obesity and diabetes in the United States. There are also variations by state in the percentage of persons who report high blood cholesterol levels and high blood pressure.

Several studies suggest that cardiovascular disease (CVD) risk factors tend to cluster in individuals. Having multiple CVD risk factors is related to greater mortality, whereas having a beneficial CVD risk factor profile is related to lower mortality and lower Medicare costs in later years.

The major risk factors (hypertension, high cholesterol levels, and smoking) have independent effects on CVD risk, but the risk of CVD events also increases with particular combinations of risk factors and the total number of risk factors. Recommendations by the National Cholesterol Education Program and others include assessment of 10-year CVD risk in patients by means of multiple risk factor assessment. Guidelines for treating high blood pressure also call for assessment of other risk factors. Furthermore, recent attention on the metabolic syndrome—the clustering of hypertension, glucose intolerance, and dyslipidemia (high triglycerides and low high-density lipoprotein cholesterol levels) through insulin resistance—suggests the importance of assessing multiple risk factor profiles for chronic diseases, such as heart diseases and diabetes.

Despite these studies and recommendations that suggest the importance of multiple risk factors for CVD risk, there are few national data on multiple risk factor
status and trends over time. Furthermore, to our knowledge, there are no published studies using recent national data based on directly measured risk factors, and such data have not been available at the state level. The Behavioral Risk Factor Surveillance System (BRFSS), conducted in all 50 states and the District of Columbia, collects self-reported health data, including CVD risk factors. We analyzed the BRFSS to examine changes in multiple risk factor status from 1991 through 1999 among US adults.

METHODS

The BRFSS is a state-based telephone health survey conducted by state health departments in collaboration with the Centers for Disease Control and Prevention.31 Begun in 15 states in 1984, all states participated in the BRFSS by 1994. Surveys of randomly selected persons 18 years or older are conducted continuously throughout the year. Each state health department uses random-digit dialing to select samples of adults in households with telephones. The samples represent each state’s civilian, noninstitutionalized, adult population. States used 3-stage cluster sampling based on the Waksberg method.31 Simple random sampling, stratified random sampling, or other sampling designs. The surveys include a set of core questions that are asked of all participants every year or every other year, as well as modules on specific public health topics of interest to particular state public health programs. Data for these analyses are from the core surveys conducted in 1991, 1993, 1995, 1997, and 1999. The total sample sizes were as follows: 87846 in 1991, 102263 in 1993, 113934 in 1995, 135582 in 1997, and 159989 in 1999. Individual state sample sizes ranged from 1178 to 3417 in 1991 and from 1248 to 5340 in 1999. Median annual response rates, based on the formula of the Council of American Survey Research Organizations, which includes calculations for telephone numbers with unknown eligibility, ranged from 70.9% in 1991 to 55.2% in 1999. A review of results from numerous methodologic studies suggests that most measures included in the BRFSS are both reliable and valid.32 Recent quality control reports and further methodologic notes are available.34

Five CVD risk factors were examined. Participants reported whether they were ever told by a health professional that they had high blood pressure, high blood cholesterol levels, or diabetes. The classification of high blood pressure was based on the individual having been told on at least 2 occasions that she or he had high blood pressure. Both high blood pressure and high cholesterol levels were based on those persons who reported ever having their blood pressure and cholesterol level checked. In 1995 to 1999, diabetes survey questions ascertained information about gestational diabetes among women, whereas gestational diabetes was not discerned in 1991 or 1993. To make the data comparable with earlier years, we included women who reported gestational diabetes as having diabetes for the years 1995 to 1999. Current smoking status was defined as having smoked at least 100 cigarettes in one’s lifetime and continuing to smoke. Obesity was calculated from reported height and weight as a body mass index (calculated as weight in kilograms divided by the square of height in meters) of 30.0 or more. For these 5 risk factors, we constructed a variable that indicated the number of risk factors reported, which ranged from 0 to 5.

We examined changes in each risk factor and in the number of risk factors reported overall and by age, sex, race or ethnicity, educational level, and state. Persons were excluded from analyses if they were pregnant, never had their blood pressure or cholesterol level checked, or were missing data on 1 or more dependent variables of interest. The $\chi^2$ analyses were used to test differences in unadjusted estimates, and multiple logistic regression was used to examine differences adjusting for demographic characteristics. Trends in prevalences from 1991 to 1999 were assessed by both examination of the relative difference in prevalence between 1991 and 1999 and multiple logistic regression using all time points. Data were weighted according to state population estimates, and prevalences and SEs were calculated using statistical software to account for the complex sampling design and to calculate accurate variance estimates.33 To allow for comparisons over time and among states, the results were age adjusted to the US 2000 standard population with the direct method using 4 age groups.36 Because the age-adjusted estimates produced similar results to the analyses adjusted for demographic variables, only the age-adjusted estimates are presented. Due to large sample sizes, nearly all differences and trends were statistically significant at $P<.05$.

RESULTS

For each year examined from 1991 to 1999, approximately 99.5% of persons reported ever having their blood pressure checked. The prevalence of reported high blood pressure increased from 23.8% in 1991 to 25.4% in 1999 (Table 1). The percentage of persons who reported ever having been screened for high blood cholesterol levels increased from 65.8% in 1991 to 72.9% in 1999. Among those who ever had their cholesterol levels checked, the prevalence of high blood cholesterol levels increased from 24.9% to 27.7%. Reported diabetes increased from 5.5% to 7.1%. Obesity based on reported height and weight increased by 50%, from 13.5% to 20.3%. The prevalence of smoking remained stable at approximately 21%. The prevalence of having none of the 5 risk factors decreased slightly from 1991 to 1999, whereas the prevalence with only 1 reported risk factor remained at approximately 34.5% (Table 1). The prevalence of multiple risk factors (ie, 2 or more) increased from 23.6% in 1991 to 27.9% in 1999.

Among persons with only 1 risk factor in 1999, 19.3% had high blood pressure, 27.3% had high cholesterol levels, 3.7% had diabetes, 18.8% were obese, and 30.8% were current smokers (not presented in Table 1). The most common combination among persons with 2 risk factors was high blood pressure and high cholesterol level (23.9% in 1999). Among persons with 3 risk factors, the most common combination was high blood pressure, high cholesterol level, and obesity (32.5% in 1999). Among persons with 4 risk factors in 1999, approximately 43% had the combination of high blood pressure, high cholesterol level, obesity, and smoking, whereas another 40% had high blood pressure, high cholesterol level, obesity, and diabetes. These risk factor combinations were also the most common combinations in earlier years.

Table 2 gives the prevalence of particular combinations of risk factors. In 1991, 35.6% of persons with high blood pressure also reported having high cholesterol level; this percentage increased to 41.5% in 1999. Likewise, the percentage of persons with high blood pressure who also reported diabetes or obesity increased from 1991 to 1999, whereas the percentage who were also current smokers remained fairly stable. In 1991, 65.6% of persons who reported having high blood pressure also reported having at least 1 other risk factor; this in-
The percentage of persons with high cholesterol level and at least 1 other risk factor increased from 57.7% in 1991 to 63.6% in 1999. In all years examined, approximately three quarters of persons with diabetes, approximately two thirds of obese persons, and approximately half of all current smokers reported having at least 1 other risk factor.

In each study year from 1991 to 1999, the prevalence of multiple risk factors was higher for older vs younger groups, about the same for men and women, higher among African Americans vs other race or ethnic groups, and higher among those with less compared with more education (Table 3). From 1991 to 1999, the prevalence of multiple risk factors significantly increased for...
all age groups ($P<.01$), both sexes, all race or ethnic groups, and those of all educational levels. The relative change from 1991 to 1999 in the prevalence of multiple risk factors was greatest for those 65 years and older, men, Hispanics, and those with at least a college education.

The prevalence of and trends in multiple risk factors by state are shown graphically (Figure 1) for 1991, 1995, and 1999. State prevalences were grouped into approximate quartiles based on the distribution in 1991, with the 2 middle quartiles further grouped together. The upper quartile for 1991 corresponds to the category of 25.0% to 29.9%. We then included 30.0% or higher as an additional category. By state, the prevalence of multiple risk factors ranged from 15.0% to 29.9% in 1991 and from 18.7% to 37.1% in 1999. In 1991, the states with the highest prevalences of multiple risk factors tended to be the midwestern and southern states, states with known high heart disease and stroke rates. No state had a multiple risk factor prevalence more than 30% in 1991. Although 13 states had a multiple risk factor prevalence of 25% or more in 1991, 37 states had percentages above this level by 1999, and 11 states had a prevalence of 2 or more risk factors that was 30.0% or more. From 1991 to 1999, the prevalence of multiple risk factors increased by 10% or more in 36 states (significantly so for Alabama, Arkansas, California, Florida, Georgia, Idaho, Iowa, Kentucky, Louisiana, Minnesota, Mississippi, New Mexico, North Carolina, North Dakota, Ohio, Oregon, South Dakota, Tennessee, Virginia, Washington, and West Virginia; $P\leq.01$ for all) (Figure 2). The prevalence of multiple risk factors declined by 10% or more in Arizona and Oklahoma but was not statistically significant for either state.

Table 3. Prevalence of Multiple Cardiovascular Disease Risk Factors by Selected Characteristics, 1991-1999, Behavioral Risk Factor Surveillance System*

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<td></td>
<td>Percentage ± 95% Confidence Interval</td>
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<td>Age group, y</td>
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<tr>
<td>18-34</td>
<td>11.7 ± 0.82</td>
<td>12.1 ± 0.78</td>
<td>13.3 ± 0.92</td>
<td>13.2 ± 0.73</td>
<td>14.1 ± 0.77</td>
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<td>35-49</td>
<td>22.7 ± 0.98</td>
<td>22.7 ± 0.82</td>
<td>23.3 ± 1.00</td>
<td>24.1 ± 0.75</td>
<td>26.0 ± 0.77</td>
<td>+15</td>
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<tr>
<td>50-64</td>
<td>35.1 ± 1.31</td>
<td>35.9 ± 1.14</td>
<td>38.4 ± 1.37</td>
<td>38.3 ± 1.02</td>
<td>40.4 ± 0.98</td>
<td>+15</td>
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<td>≥65</td>
<td>33.2 ± 1.23</td>
<td>35.5 ± 1.08</td>
<td>37.2 ± 1.16</td>
<td>38.3 ± 0.98</td>
<td>41.8 ± 1.02</td>
<td>+26</td>
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<tr>
<td>Sex</td>
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<tr>
<td>Men</td>
<td>23.3 ± 0.80</td>
<td>24.5 ± 0.73</td>
<td>25.6 ± 0.83</td>
<td>26.2 ± 0.65</td>
<td>28.2 ± 0.65</td>
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<td>Women</td>
<td>23.7 ± 0.69</td>
<td>23.8 ± 0.59</td>
<td>25.5 ± 0.71</td>
<td>25.6 ± 0.53</td>
<td>27.5 ± 0.57</td>
<td>+16</td>
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<td>Race/ethnicity</td>
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<td>White, non-Hispanic</td>
<td>22.8 ± 0.55</td>
<td>23.5 ± 0.51</td>
<td>24.9 ± 0.57</td>
<td>25.1 ± 0.45</td>
<td>26.7 ± 0.47</td>
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<tr>
<td>African American, non-Hispanic</td>
<td>32.3 ± 1.96</td>
<td>32.3 ± 1.65</td>
<td>34.1 ± 1.96</td>
<td>34.6 ± 1.55</td>
<td>37.8 ± 1.53</td>
<td>+17</td>
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<tr>
<td>Hispanic</td>
<td>23.5 ± 2.74</td>
<td>26.4 ± 2.33</td>
<td>25.0 ± 2.80</td>
<td>29.6 ± 1.76</td>
<td>29.8 ± 1.78</td>
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<tr>
<td>Other</td>
<td>21.4 ± 3.68</td>
<td>24.1 ± 2.92</td>
<td>21.8 ± 2.70</td>
<td>21.3 ± 2.18</td>
<td>26.7 ± 2.29</td>
<td>+25</td>
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<tr>
<td>Education</td>
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<td>&lt;12 y</td>
<td>35.0 ± 2.04</td>
<td>35.6 ± 1.80</td>
<td>34.9 ± 1.84</td>
<td>38.6 ± 1.76</td>
<td>40.4 ± 1.88</td>
<td>+15</td>
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<tr>
<td>12 y</td>
<td>26.2 ± 0.96</td>
<td>27.8 ± 0.90</td>
<td>29.2 ± 0.92</td>
<td>29.4 ± 0.90</td>
<td>31.5 ± 0.82</td>
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<tr>
<td>Some college</td>
<td>23.8 ± 1.06</td>
<td>23.8 ± 0.90</td>
<td>26.2 ± 1.08</td>
<td>26.3 ± 0.90</td>
<td>27.6 ± 0.90</td>
<td>+16</td>
</tr>
<tr>
<td>College or more</td>
<td>16.2 ± 0.88</td>
<td>17.0 ± 0.78</td>
<td>18.5 ± 1.04</td>
<td>18.2 ± 0.67</td>
<td>20.8 ± 0.69</td>
<td>+28</td>
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*Percentages are weighted to state population estimates. Percentages by sex, race/ethnicity, and education are also age adjusted to the 2000 US standard population. Relative percent change from 1991 to 1999 is statistically significant for all groups at $P<.001$, except “other” ethnic group ($P=.02$).

Previous studies have demonstrated that a beneficial cardiovascular risk factor profile is related to lower cardiovascular and noncardiovascular mortality and longer life expectancy, and lower Medicare costs in later years. However, these studies also observed that the prevalence of adults with no risk factors was very low. Similarly, the percentage of persons engaging in healthy lifestyles appears to be very low. Chang et al observed that most heart disease mortality attributable to individual risk factors is caused by those risk factors in combination with other risk factors, not to risk factors in isolation. In the present study, we observed that the prevalence of persons who reported having multiple CVD risk factors increased slightly in the 1990s and that a substantial proportion of US adults (more than 25% of the population) have multiple risk factors for heart disease and stroke. The prevalence of 4 risk factors studied (hypertension, high cholesterol level, diabetes, obesity) increased, whereas the prevalence of current smoking remained about the same throughout the decade.

Our data highlight the state variation and increase in the percentage of persons with multiple risk factors for heart disease and stroke. A previous study suggested that self-reports of several CVD risk factors at the state level correlated strongly with state-level mortality rates. Although national trends are important, most preventive health care activities, policies, and other efforts occur at the state or community level, and important trends may exist at the state level that are obscured by national data. State differences in the percentage of the...
population with adverse risk factors may be related to differences in the ethnic makeup of the population and to differences in lifestyles, socioeconomic status and related variables (eg, employment status, income level, and insurance status), state and local programs and policies, clinical standards of care, and the presence of consumers who are informed about prevention.

Recent national data based on directly measured risk factor measurement are not currently available, and no such state-level data are available to examine geo-
graphic differences. Data from the National Health and Nutrition Examination Surveys (NHANES) based on directly measured blood pressure suggest that the age-adjusted (2000 population standard) prevalence of high blood pressure declined from 39.8% in 1971-1974 to 23.9% in 1988-1991 among persons 20 to 74 years old. The 1991 BRFSS estimate of self-reported high blood pressure (23.8%) is comparable to the 1988-1991 NHANES III estimate and was comparable when similar age ranges and age adjustments were used. Although mean blood pressures have declined, awareness of hypertension status (those who reported having high blood pressure compared with measured blood pressure) increased to more than 80% among those with blood pressures of 160/95 mm Hg or higher and to more than 65% among those with blood pressures of 140/90 mm Hg or higher for black and white men and women in the NHANES. These results from the NHANES suggest that self-reported high blood pressure status is in general agreement with clinical definitions of hypertension and may be adequate for public health surveillance purposes. Furthermore, the sensitivity and specificity of self-reported high blood pressure compared with measured blood pressure and/or use of medications were reported to be relatively high among both African American and white men and women. On the other hand, data on obesity are underreported in the BRFSS compared with directly measured height and weight in the NHANES in 1988-1994, but the increase in obesity observed in the BRFSS is consistent with the trends observed in NHANES. The BRFSS estimate of 24.9% of persons reporting high cholesterol levels is somewhat higher than the 19.7% estimated from directly measured cholesterol values in the NHANES III for persons aged 20 to 74 years but are generally consistent across demographic variables (age, sex, race, or ethnicity) with those in the NHANES III. A recent study observed that 65% of persons in NHANES III reported having had their cholesterol level checked and that 35% of these persons were told that they had high cholesterol levels. The mean blood cholesterol levels from laboratory measurement were higher for persons who were told they had high cholesterol levels compared with those not told (234 vs 198 mg/dL [6.05 vs 5.12 mmol/L]), suggesting some validity to self-reports of high cholesterol levels. Smoking status is usually assessed by questionnaire, and estimates from the BRFSS are comparable to those produced from other surveys, such as the NHANES and the National Health Interview Survey.

Self-reported health data are dependent on several factors, including screening and awareness, reporting of conditions to patients by physicians, respondent recall, social desirability of responses, and other factors. The BRFSS data probably also include persons reporting high-normal levels of risk factors, such as blood pressure and cholesterol level. Furthermore, it is unknown whether the observed trends are due to actual changes in risk factor status or to greater detection and reporting of risk factors. Actual increases in the prevalences of hypertension, high cholesterol level, and diabetes are possible, for example, in association with observed increases in the prevalence of overweight and obesity. On the other hand, it is also possible that the increase in these conditions is due to the greater detection and reporting of conditions to patients by their health care practitioners such as through greater counseling from and interaction with health care professionals who have discussed results of tests with patients. For example, given an increase in cholesterol screening rates, it is possible that the observed trends are the result of people’s greater awareness of their condition rather than an actual increase in the prevalence of high cholesterol levels. Current data based on directly measured risk factor status are needed to verify self-reported data.

Although our data suggest that the prevalence of multiple risk factors increased in the 1990s, mortality rates declined in the same period. An increase in awareness and reporting of risk factors rather than actual increases in risk factor prevalence may partly explain this discrepancy. On the other hand, a report from a recent national conference also noted that the rate of decline in cardiovascular mortality slowed in the 1990s and that trends in risk factor appeared to correspond with the slowing of the decline in mortality. Furthermore, it is unclear whether total (both fatal and nonfatal) cardiovascular events have increased. The total number of hospital discharges from 1979 to 1999, for example, increased by nearly 30%. Furthermore, our data assessed the presence of risk factors and did not assess risk factor levels, such as actual blood pressure or cholesterol level or the number of cigarettes smoked, which may affect risk level. Mean cholesterol levels and blood pressures as observed in the NHANES, for example, have declined from the 1970s to the early 1990s.

Several methodologic issues should be noted. First, we restricted analyses to persons who reported ever having their blood pressure and cholesterol level checked. Although nearly all persons ever had their blood pressure checked, only approximately 66% of persons in 1991 and 73% of persons in 1999 had ever had their cholesterol level checked, thereby excluding 27% to 34% of the sample. However, when we analyzed the data for all persons (including persons who never had their cholesterol level checked as not having been told that they had high cholesterol levels), overall trends were the same as those reported.

Second, we included persons who reported gestational diabetes as a risk factor, since this was not discerned in earlier years of the survey period. This would tend to slightly overestimate the percentage of women who reported having diabetes in terms of CVD risk. For each survey in 1995-1999, approximately 1.7% of women reported having gestational diabetes.

Finally, the observed declining response rate, which has been attributed to telemarketing and increased cellular telephone use, may bias the results if those who refused to participate were more likely to be aware of symptoms than were those who participated. Because persons of lower socioeconomic status and ethnic minorities are less likely to be included in telephone surveys due to lack of telephone coverage, our results may underestimate prevalences and trends for such groups. These results also are not applicable to persons living in private institutions for health or other reasons.

Nonetheless, the substantial proportion of persons with known multiple risk factors suggests that in-
increased efforts at risk factor reduction and disease prevention should focus on comprehensive risk reduction strategies. In the BRFSS, the prevalence of multiple risk factors increased for all demographic groups from 1991 to 1999. The observation that those with the highest education had the greatest relative increase suggests that formal education alone may be insufficient for improving risk factor status. The increase in the prevalence of multiple risk factors among those 18 to 34 years of age is also of concern. Furthermore, although the prevalence of smoking appears not to have changed substantially, our observation that approximately half of all current smokers reported at least 1 other risk factor suggests that greater efforts at smoking cessation and further risk reduction are required. Several studies have suggested that even brief health care practitioner counseling can result in improved health behavior change. The National Cholesterol Education Program now recommends assessing 10-year CVD risk based on risk factor status, family history, and prior disease when assessing cholesterol treatment. Such assessments may be useful in the clinical setting for highlighting individual patients’ risk levels, particularly for those with multiple risk factors.

In addition to a focus on persons at high risk or persons with clinically high-risk factors, these results, particularly the observed geographic differences, stress the importance of the population approach to reducing the burden of heart disease and stroke in the United States. This approach focuses on reducing risk factor levels in the entire population and preventing adverse risk factor development in the first place. In addition to promoting healthy lifestyle changes, public health programs aimed at populations should also focus on social, policy, and environmental factors that either promote healthy lifestyles or directly influence risk factors or their effective treatment (such as access to care). Both population-wide and clinical efforts have had an impact on declines in risk factor levels up to the early 1990s. An analysis of mean blood pressures by birth cohort among persons from several national health examination surveys from 1960 to 1994 observed lower systolic and diastolic blood pressures with each decade of birth year and at the low, middle, and upper ends of the blood pressure distribution. Similar results were observed for blood cholesterol concentrations, which were lower for successive birth cohorts at all levels of the cholesterol distribution, although the decline was greater among those at the upper end. The results suggest that both blood pressure and cholesterol levels declined for the entire population due to both population-wide approaches among all persons and risk reduction efforts among high-risk individuals.

Our results also demonstrate persistent disparities between blacks and whites, Hispanics and non-Hispanic whites, and those with low vs higher educational attainment in the percentage of persons with multiple risk factors. An overarching goal of Healthy People 2010, the nation’s health objectives, is to eliminate health disparities. If this goal is to be achieved for CVD, then interventions and prevention programs must also focus on reducing disparities in risk factors. These observations suggest that population-wide and individual high-risk approaches to prevention and risk reduction efforts must continue to reduce the burden of heart disease and stroke in the United States.

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