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The gradual decline in stroke mortality rates observed in the United States since 1900 accelerated markedly around 1973 for whites and around 1968 for blacks. During the next decade stroke mortality rates decreased by almost 50% so that the United States now experiences one of the lowest stroke mortality rates in the world. Beginning in 1979, however, the annual rate of decline in stroke mortality began to slow considerably. Comparing the period 1979–1986 with the previous decade, a 57% slowing in the absolute rate of decline (as estimated by the slope of the linear portion of the mortality curve) was observed for white men; the corresponding slowdowns in the rate of decline were 58% for white women, 44% for black men, and 62% for black women. If the decline during the 1980s had continued at the rate observed for the period 1968/73–1978, there would have been 131,000 fewer stroke deaths during the period 1979–1986, 28,000 fewer in 1986 alone. This slowdown in the rate of decline in stroke mortality is occurring while mortality rates for both coronary heart disease and all causes are leveling off. The reasons for this change in the mortality trend remain unknown, and corresponding trends in the treatment and control of hypertension do not provide an entirely satisfactory explanation. (Stroke 1990;21:1274-1279)

A gradual decline in the stroke mortality rate has been recorded in the United States since national vital statistics became available.1 The decline in the stroke mortality rate from 1920 through the mid-1960s was sizable among whites, roughly 1%/yr, and resulted in a halving of the annual mortality rate.1 However, the decline among nonwhites during this period was much less pronounced, particularly for nonwhite men.1 In the early 1970s for whites and the late 1960s for blacks the stroke mortality curve turned sharply downward, and a period of accelerated decline occurred for the next 8–10 years.2-6 This decline in the stroke mortality rate has been accompanied by decreases in stroke morbidity and incidence,6-11 although the consistency of the incidence data has been questioned.10 Based on data recently presented by Uemura and Pisa,12 during the period 1970–1980 the United States experienced the largest percentage decline in stroke mortality rate of 27 countries, with the exception of Japan, and ended the decade with among the lowest rates in the world. Given the powerful influence of hypertension on the occurrence of stroke, much of this accelerated decline has been attributed to better detection, treatment, and control of hypertension.2,13,14

As is well known, parallel declines in the mortality rates for both coronary heart disease (CHD) and all causes were also observed during the 1970s.13-16 We recently demonstrated a leveling off of the CHD mortality rate, as well as divergence of the trends for the four major sex-race groups,17 and were prompted to examine trends in the stroke mortality rate for clues about the cause of these changing trends. We analyzed the rates of change in stroke mortality in the United States from 1960 through 1986 and confirm the finding noted for CHD of a slowdown in the rate of decline during the last several years.

Subjects and Methods

Mortality data were obtained from annual reports of national vital statistics published by the National Center for Health Statistics (NCHS). Mortality rates for the race categories black and white are published for the years 1968–1986; however, for the years 1960–1967 only the number of deaths among blacks is published. Furthermore, because of the absence of race-specific data from the state of New Jersey for the years 1962 and 1963,18 no data for blacks are published by NCHS for those 2 years. We generated...
age-specific stroke mortality rates among blacks for the years 1960, 1961, and 1964–67 by calculating age-specific mortality rates based on published numbers of deaths and the resident US population, age-adjusted to the 1940 US population. Age-specific stroke mortality rates for 1962 and 1963 among blacks were estimated by linear interpolation. Both age-specific and age-adjusted rates among whites for all years were obtained directly from published NCHS sources. Comparability of death certification for stroke has changed very little over the three revisions of the International Classification of Disease (ICD) covered by this study. ICD codes 330–334 were in force for the seventh revision, whereas ICD codes 430–438 were used for the eighth and ninth revisions.

Mortality data were entered into a computer file and analyzed using SAS. The mortality curves were divided into three periods by visual inspection: Period I is an initial period of slow decline, 1960–1972 for whites and 1960–1967 for blacks; Period II is a middle period of rapid decline, 1973–1978 for whites and 1968–1978 for blacks; and Period III is a final period of more gradual decline, 1979–1986 for both races. Linear regression equations were generated for each sex-race group in each period by taking the yearly age-specific and age-adjusted rates as individual data points, and the average annual absolute change in stroke mortality rate was calculated as the slope change in the mortality rate/100,000 population/yr. A log-linear model, which assumes a constant proportional or relative change, was used to calculate the average annual percentage change for each group by period. To monitor for any directional change in mortality trends (i.e., increase or decrease in the slope) a two-tailed t test was used to compare slopes from Periods II and III. The level of significance was 0.05, with a critical t value (df = 15) of 2.131.

Percentage changes in age-adjusted stroke mortality rates were projected for Period III and for 1986 alone using the race-sex-specific regression equations for period II. Excess stroke mortality for 1986 associated with slowing of the rate of decline for Period III was estimated by first subtracting the average annual percentage change in the rate during Period III from that during Period II. The resulting figure was multiplied by the number of calendar years that had intervened since the end of Period II as an estimate of the percentage difference between observed and predicted mortality for a given year. Excess stroke mortality was then calculated by multiplying the yearly percentage difference by the observed number of stroke deaths in each year from 1979 to 1986.

Results

As shown in Figure 1, the age-adjusted stroke mortality rate began to decline rapidly in the late 1960s and early 1970s. Although sizable year-to-year fluctuations are apparent, the period of consistent rapid decline among black men and black women began in 1968. For both white men and white women, however, the accelerated decline did not begin until 3 years later, in 1973 (Table 1).

For each race-sex group, the slope of the regression equation (the average annual absolute change in stroke mortality rate) was significantly steeper for Period II than for Period I (p < 0.01, Table 2). Similarly, the slopes were significantly steeper for Period II than for Period III (p < 0.01, Table 2). As seen in Table 2, for all groups the decline in stroke mortality decelerated significantly in Period III relative to that in Period II (p < 0.01). Average annual percentage changes in the stroke mortality rates were also consistent, but smaller, for all groups and were significant for all groups except black men (Table 2).

The rate of decline for blacks was considerably steeper than that for whites (Table 2), particularly during Period II. During Period II, the absolute decline for blacks was approximately 1.5 times that for whites, while the percentage fall was three-quarters that for whites. Over all three periods, white men gained relative to white women and the sex gap had narrowed considerably by 1986 (Figure 1). The narrowing of the sex gap was less pronounced among blacks. The average or smoothed trends for the three periods, as represented by the regression lines, are plotted in Figure 2.

Because of their different rates of change, the absolute gap between the races narrowed considerably over these three periods; however, the relative difference between the races remained essentially constant. Thus, in 1960 the age-adjusted stroke mortality rate among black men exceeded that among white men by 61 deaths/100,000 persons, while for black and white women the gap was 70 deaths/100,000 persons. In 1986 this gap had narrowed to 28 and 21 deaths/100,000 persons for men and women, respectively. The ratio of the black:white stroke mortality rates, on the other hand, was 1.8 for men and 2.0 for women in 1960 and 1.9 for men and 1.8 for women in 1986. Over the three periods age-adjusted rates fell somewhat more for white men...
TABLE 1. Age-Adjusted Stroke Mortality Rates in United States by Sex-Race Group, 1960–1986

<table>
<thead>
<tr>
<th>Year</th>
<th>White Men</th>
<th>White Women</th>
<th>Black Men</th>
<th>Black Women</th>
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<tbody>
<tr>
<td>1960</td>
<td>80.3</td>
<td>68.7</td>
<td>141.0</td>
<td>139.3</td>
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<tr>
<td>1961</td>
<td>77.5</td>
<td>66.1</td>
<td>132.9</td>
<td>133.5</td>
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<tr>
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<td>77.6</td>
<td>66.2</td>
<td>134.0*</td>
<td>131.4*</td>
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<tr>
<td>1963</td>
<td>77.9</td>
<td>65.5</td>
<td>135.1*</td>
<td>129.2*</td>
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<tr>
<td>1964</td>
<td>74.9</td>
<td>62.7</td>
<td>136.2</td>
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<td>74.2</td>
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<tr>
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<td>74.2</td>
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<td>72.1</td>
<td>59.2</td>
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<td>114.0</td>
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<td>73.6</td>
<td>60.2</td>
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<td>70.9</td>
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<td>68.8</td>
<td>56.2</td>
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<tr>
<td>1986</td>
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<td>27.1</td>
<td>58.9</td>
<td>47.6</td>
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</table>

Rate per 100,000.
*Rates for blacks not available for 1962 and 1963; data derived by linear interpolation.


than for white women, while the declines were more similar for black men and black women. Finally, the slowdown in Period III relative to Period II is least pronounced among black men and greatest among black women.

Because of the deceleration in the rate of decline in stroke mortality in Period III relative to Period II, 27,968 excess stroke deaths were observed in 1986 in the United States; of these deaths 9,791 occurred among white men, 15,992 among white women, 406 among black men, and 1,778 among black women. For Period III, 131,112 excess stroke deaths occurred.

Age-specific stroke mortality rates rise by a factor of 10 with every two decades' increase in age after the age of 35 years, and two thirds of all deaths due to stroke occur among persons aged ≥75 years. However, age-specific trends have consistently paralleled the age-adjusted patterns. As expected, the absolute...
Average annual percentage change
Age (yr)  Men  White  Women  Black
35-44 -0.6  -0.6  -2.7  -3.1
45-54 -1.9  -1.6  -6.4  -6.7
55-64 -7.3  -7.8  -16.7  -15.5
65-74 -26.4  -17.0  -33.9  -34.4
75-84 -78.9  -68.7  -55.0  -51.6
85+ -167.8  -176.0  -53.3  -56.2

Average annual absolute change
35-44 -6.5  -6.1  -6.0  -3.1
45-54 -6.9  -6.0  -5.2  -6.8
55-64 -7.8  -6.4  -5.7  -6.9
65-74 -7.7  -7.2  -4.9  -6.0
75-84 -6.9  -6.9  -4.4  -4.4
85+ -5.8  -5.9  -2.3  -2.4


Deeleration (i.e., the change in the number of deaths/100,000/yr) was largest in the oldest age groups. Among whites, the younger and older age groups experienced similar percentage changes (Table 3). However, among blacks the percentage change was smaller among older than among younger persons.

Discussion
This analysis of the secular trends in stroke mortality rate identifies three distinct periods between 1960 and 1986. During the 1960s a very gradual decline in the stroke mortality rate was observed, but the rate of decline accelerated markedly around 1970. This second period appears to have come to an end in the late 1970s, and the trajectory for the change in stroke mortality rate subsequently leveled off. This deceleration in the rate of decline occurred simultaneously with a reduction in the rate of decline in CHD mortality and virtually no change in the all-cause mortality rates over the last 4 years. An end to the period of decline in the incidence of acute stroke has recently been reported from the population-based registry in Rochester, Minn., with increases in stroke incidence observed during the most recent period.

Although the United States has made remarkable progress in the control of stroke, the recent slowdown in the rate of decline is cause for considerable concern. While it might be argued that the rate of decline must begin to slow as we reach what is for practical purposes an irreducible minimum, that argument is weakened by the observation that stroke mortality rates were falling much more slowly in the 1960s when annual stroke mortality rates were more than twice what they are today. Substantial gains can still be made in the prevention of stroke mortality, particularly among the elderly.

High rates of hypertension treatment are felt by most authors to have played a major role in the 50% decline in stroke mortality observed in this country since 1970. Demonstrating a cause-and-effect relation between antihypertensive treatment and stroke mortality trends in the population is a difficult and complex undertaking, and a full review of this topic is beyond the scope of this paper. Current published reports provide conflicting evidence. In a previous report it was estimated that the benefit of antihypertensive treatment observed in randomized clinical trials could account numerically for the rapid decline in stroke mortality observed in the 1970s. Recently, a more extensive attempt by Klag et al to relate trends in stroke mortality to changes in hypertension control did not support this hypothesis, however. These authors examined the rank order relation between sex-race-specific increases in the rates of hypertension control, as reported from recurring national surveys, and the decline in stroke mortality. Inspection of these data suggests that the primary discordance lies in a greater-than-predicted fall in stroke mortality among white men. While interesting, this analysis may not be particularly robust given the complicated nature of the underlying assumptions and the transformations required of the original data. In addition, as discussed extensively by the authors, one-to-one correspondence of the rates of hypertension control and stroke mortality among the sex-race groups requires the unlikely circumstance that no other major factors were at work. Bonita and Beagley hole applied estimates of benefit (derived from randomized trials) to population prevalence and rates of control of hypertension and concluded that only 16-25% of the decline in stroke mortality rates from 1970 to 1980 can be attributed to antihypertensive drug therapy. Estimates of benefit derived from randomized trials in which the control group also received antihypertensive therapy may underestimate the true benefit of blood pressure reduction. Despite these caveats, it does appear that pharmacologic control of hypertension in this country can explain only a minority of the accelerated rate of decline in stroke mortality observed during Period II.

With recognition of the value of antihypertensive therapy, the National High Blood Pressure Control Program was initiated by the National Heart, Lung, and Blood Institute in 1972 and profoundly influenced the attitudes of health practitioners toward drug therapy. By the late 1970s, national rates for the treatment and control of hypertension were estimated at 20-25% for men and 40% for women. Rates of control had been >20% for women since 1960-1962 and 13-15% for black and white men as late as 1974-1975. Even higher rates of hypertension control have been reported from local surveys over the last decade and a half. Based on community surveillance efforts, it was estimated that 50-80% of persons with hypertension in the various sex-race
groups were under control in the late 1970s. Additional studies reported slight increases in treatment rates during the first half of the 1980s.

The Minnesota Heart Survey, however, provides the most recent community-based surveillance data on the treatment and control of hypertension and strongly suggests that continued improvement in control has not occurred. Although mean diastolic blood pressure in persons aged 25–59 years fell by 3-4 mm Hg from 1973-1974 to 1980-1982, no further declines were observed in either men or women in 1986. In that survey, the percentage of persons with treated and controlled hypertension rose from 23% in 1973-1974 to 53% in 1980-1982 and declined to 48% in 1986. It is impossible to predict whether major new gains have been made in the United States. More persons are currently without health insurance, regular access to health care may be more limited than a decade ago, particularly among minorities and the poor.

Uncontrolled hypertension has been reported to be the major measurable health effect of termination of health benefits to the poor in 1986. Insurance, regular access to health care may be more limited than a decade ago, particularly among minorities and the poor. Economic barriers to care for hypertension are substantial. There is also abundant evidence that social and economic conditions have a broad influence on mortality, and this may account for the greater slowdown in the rate of decline in stroke mortality among blacks. The leveling off of the all-cause mortality rate has coincided with a period of decreasing economic growth and decreasing personal income. Socioeconomic differentials in mortality in the United States have widened substantially over the last several decades due primarily to more rapid declines in CHD mortality among higher social class groups.

In summary, during the last decade the rate of decline in stroke mortality in the United States has slowed by >50% for all the major sex-race groups except black men, for which a 44% deceleration was observed. This slowdown in the rate of decline in stroke mortality in the United States has been reported to be the major measurable health effect of termination of health benefits to the poor in 1986.

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