
Charles André, MD, PhD; Cíntia Chaves Curioni, MSc; Cynthia Braga da Cunha, MSc; Renato Veras, MD, PhD

Background and Purpose—We describe the trends in stroke mortality in Brazil during 3 decades and investigate their differences according to regional disparities, sex, and age distributions.

Methods—Official data on mortality and population estimates were retrieved to calculate standardized mortality rates (with the 1980 Brazilian population as a reference) in 6 age strata and in the 5 political regions for the initial period (3 first years) of the 1980, 1990, and 2000 decades. Data were corrected for undefined causes of death. The Poisson model was used to estimate risk reduction during the 3 decades and to study the interaction between those rates and sex, age strata, and regions.

Results—The stroke standardized mortality rate decreased consistently in the last 20 years, from 68.2 to 40.9 per 100,000 inhabitants. This reduction paralleled a decrease in total cardiovascular mortality rates in the same period, from 208.2 to 126.1 per 100,000 inhabitants. The reduction in stroke standardized mortality rate was detected in men and women and in all age strata. The reduction was evident in all geopolitical regions of the country, with the wealthiest regions' exhibiting higher initial rates and more marked standardized mortality rate reductions. The risk of dying of stroke in the period 2000 to 2002 was 0.45 (95% CI, 0.44 to 0.45) of that found in the period 1980 to 1982.

Conclusions—The risk of dying of stroke in Brazil declined dramatically between the initial period in the early 1980s and the early 2000s. The decline was especially marked in the most developed regions and may reflect an improvement in general health conditions during the study period. (Stroke. 2006;37:2784-2789.)

Key Words: stroke ■ epidemiology ■ mortality ■ socioeconomic factors

There has been a significant reduction in stroke mortality rates in the United States and many other developed countries during the 20th century. Data from so-called “developing” countries are less plentiful, but decreasing mortality rates have also been detected in a number of countries.1,2 In eastern Europe, an increase in stroke mortality between the 1970s and the 1990s was followed by a more recent decrease between 1990 and 2000.3 The slope of decline may be less marked in Latin America than in the United States or Canada.4

In Brazil, declining mortality rates were found in analyses restricted to specific regions.5,6 A decrease in cardiovascular mortality has been difficult to document during the 1960s and 1970s in Brazil, but a more recent decline may have occurred.7 Inequalities in stroke and cardiovascular mortality distribution in Brazil can be expected to exist, considering the marked discrepancies in general health and socioeconomic conditions throughout the country. Regional disparities in stroke mortality in Brazil have not been previously studied. We studied the evolution of Brazilian stroke mortality rates during the initial periods of the last 3 decades and explored the possible differences according to age and sex and among diverse geopolitical regions that exhibit marked socioeconomic disparities.

Methods

The number of deaths related to stroke was obtained from the Brazilian Mortality Information System made available by the National Health Ministry.8 For the years 1980 through 1993, causes of death were classified according to the International Classification of Diseases (ICD)-9 code system. From 1994 onward, the ICD-10 system was used. The following codes for stroke were included: 430 to 438 (ICD-9) and I60-I69 (ICD-10). The number of deaths related to any cardiovascular cause was also obtained from the same system, as classified by the ICD-9 (codes 390 to 459) and ICD-10 (100 to I99).

The mortality rate estimates, expressed as the number of deaths per 100,000 inhabitants, were calculated for the population estimates derived from the Brazilian census held in 1980, 1991, and 2000 (Brazilian Institute of Geography and Statistics [IBGE]) and also made available by the National Health Ministry.8 To place the evolution of stroke mortality rates in a larger perspective, total cardiovascular mortality rates during the same periods were also calculated. All rates were standardized by age according to the direct

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2784
method, with the whole Brazilian population from the 1980 census as
the standard.

In summary, the procedure consisted of a number of sequential
steps.9 Specific mortality rates for each period were calculated for
the 6 prespecified age groups; these rates were then applied to the
standard population, resulting in an "expected mortality" for each age
group. The ratio between the sum of the expected mortality of all
age groups and the total population in the same period resulted in the
age-standardized mortality rate.

Standardized mortality rates for each decade correspond herein to
the mean values of the first 3 years of that period, eg, 1980, 1981,
and 1982 for the 1980 decade. This analysis of data for 3 consecutive
years was thought necessary to attenuate the eventual and unex-
cpected abnormal oscillations in the number of registered deaths in
any particular year. The intercensus population figures (1981, 1982,
1990, 1992, 2001, and 2002) used in these calculations were
expected from the linear projections made by IBGE of the census
population figures, classified according to sex and age stratum. The
age distribution is presented according to the Pan American Health
Organization system, with the 0- to 34-year and

TABLE 1. Number of Stroke Deaths and Average Population Size According to Sex and Age Strata in the
Study Periods

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>All</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–34 y</td>
<td>3104</td>
<td>2956</td>
<td>2115</td>
</tr>
<tr>
<td>35–44 y</td>
<td>4859</td>
<td>5536</td>
<td>4787</td>
</tr>
<tr>
<td>45–54 y</td>
<td>9206</td>
<td>10296</td>
<td>10368</td>
</tr>
<tr>
<td>55–64 y</td>
<td>13537</td>
<td>16414</td>
<td>15513</td>
</tr>
<tr>
<td>65–74 y</td>
<td>2081</td>
<td>23244</td>
<td>24337</td>
</tr>
<tr>
<td>75+ y</td>
<td>28501</td>
<td>37515</td>
<td>44846</td>
</tr>
<tr>
<td>All ages</td>
<td>80188</td>
<td>95961</td>
<td>101966</td>
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</table>

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<tr>
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<tbody>
<tr>
<td>0–34 y</td>
<td>1521</td>
<td>1489</td>
<td>1041</td>
</tr>
<tr>
<td>35–44 y</td>
<td>2332</td>
<td>2625</td>
<td>2445</td>
</tr>
<tr>
<td>45–54 y</td>
<td>3972</td>
<td>4392</td>
<td>4721</td>
</tr>
<tr>
<td>55–64 y</td>
<td>5605</td>
<td>6673</td>
<td>6446</td>
</tr>
<tr>
<td>65–74 y</td>
<td>9513</td>
<td>10184</td>
<td>10685</td>
</tr>
<tr>
<td>75+ y</td>
<td>12100</td>
<td>15317</td>
<td>18012</td>
</tr>
<tr>
<td>All ages</td>
<td>35043</td>
<td>40680</td>
<td>43350</td>
</tr>
</tbody>
</table>

The number of deaths, the corresponding population stratified by
year, region, age, and sex were all entered into the Poisson model.
The regression equation was estimated according to the following
formula: logarithm (event rate)=α+(β×decade)+ε; where α indicates
intercept; β, angular coefficient; and ε, random error.

The Poisson regression was calculated for Brazil and separately
for each sex, age group (6 categories), and geopolitical region (5
categories). Changes in time trends of the age-standardized mortal-
ity rate were additionally tested for possible interactions with sex,
age group, and region. The results of the Poisson regression (β) and
the respective CIs are presented to analyze the mortality trends in the
initial periods of the 1990 and 2000 decades compared with the 1980
decade. For all statistical analyses, a value of P＜0.05 was consid-
ered statistically significant. All analyses were performed with the
statistical software package SAS for Windows 9.12

Results

The number of deaths and corresponding population figures, stratified by age and sex, in the 3 periods studied are pre-
sent in Table 1. The stroke standardized mortality rates consistently decreased between 1980 to 1982 and 2000 to
2002: from 68.2 to 40.9 per 100 000 inhabitants (Figure 1). During the same period, total cardiovascular mortality rates
also declined markedly, from 208.2 to 126.1 per 100 000 inhabitants. The decline in the stroke standardized mortality rate
was evident in both decades, with the strongest decrease observed between 1990 to 1992 and 2000 to 2002. With the
1980 rate as a reference (Table 2), there was a 30% (95% CI, 30% to 31%) risk reduction (RR) in 1990 and a 55% (95% CI, 55% to 56%) RR in 2000 ($P<0.001$ for both measures).

The proportional reduction in stroke mortality was evident for both men and women, although it was more marked among men (Table 2 and Figure 1). Also, the decrease was observed in all age strata (Table 2). An interaction between sex and age was detected, with a more marked decline in standardized mortality rates evident in the young male population (up to 45 years) and a steeper decline for women of all other age strata ($P<0.001$ for all findings).

**TABLE 2.** Age-Standardized Stroke Mortality Rates According to Sex and Age Strata

<table>
<thead>
<tr>
<th></th>
<th>1980–1982* Standardized Mortality Rates</th>
<th>1990–1992 Standardized Mortality Rates</th>
<th>$\hat{\beta}$ (95% CI)†</th>
<th>2000–2002 Standardized Mortality Rates</th>
<th>$\hat{\beta}$ (95% CI)†</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>8.22</td>
<td>6.29</td>
<td>0.70 (0.70–0.80)</td>
<td>1.87</td>
<td>0.40 (0.40–0.50)</td>
</tr>
<tr>
<td>0–34 y</td>
<td>38.76</td>
<td>31.87</td>
<td>0.80 (0.80–0.90)</td>
<td>20.70</td>
<td>0.70 (0.60–0.70)</td>
</tr>
<tr>
<td>35–44 y</td>
<td>102.37</td>
<td>90.47</td>
<td>0.90 (0.90–1.00)</td>
<td>64.79</td>
<td>0.80 (0.60–0.70)</td>
</tr>
<tr>
<td>45–54 y</td>
<td>233.63</td>
<td>208.28</td>
<td>0.90 (0.90–1.00)</td>
<td>152.49</td>
<td>0.80 (0.60–0.70)</td>
</tr>
<tr>
<td>55–64 y</td>
<td>604.94</td>
<td>494.75</td>
<td>0.80 (0.80–0.90)</td>
<td>380.18</td>
<td>0.80 (0.70–0.80)</td>
</tr>
<tr>
<td>65–74 y</td>
<td>1878.21</td>
<td>1543.52</td>
<td>0.70 (0.70–0.80)</td>
<td>1227.04</td>
<td>0.60 (0.60–0.70)</td>
</tr>
<tr>
<td>All ages</td>
<td>68.17</td>
<td>56.85</td>
<td>0.70 (0.69–0.70)</td>
<td>40.90</td>
<td>0.45 (0.44–0.45)</td>
</tr>
<tr>
<td>Male</td>
<td>8.52</td>
<td>6.46</td>
<td>0.78 (0.72–0.83)</td>
<td>1.91</td>
<td>0.29 (0.27–0.32)</td>
</tr>
<tr>
<td>35–44 y</td>
<td>40.88</td>
<td>34.40</td>
<td>0.84 (0.80–0.89)</td>
<td>20.94</td>
<td>0.51 (0.48–0.54)</td>
</tr>
<tr>
<td>45–54 y</td>
<td>117.45</td>
<td>106.08</td>
<td>0.90 (0.87–0.94)</td>
<td>72.91</td>
<td>0.62 (0.60–0.64)</td>
</tr>
<tr>
<td>55–64 y</td>
<td>278.91</td>
<td>260.26</td>
<td>0.93 (0.91–0.96)</td>
<td>188.82</td>
<td>0.68 (0.66–0.70)</td>
</tr>
<tr>
<td>65–74 y</td>
<td>688.76</td>
<td>593.91</td>
<td>0.86 (0.84–0.88)</td>
<td>469.86</td>
<td>0.68 (0.67–0.70)</td>
</tr>
<tr>
<td>75+ y</td>
<td>1933.93</td>
<td>1630.81</td>
<td>0.84 (0.82–0.86)</td>
<td>1322.58</td>
<td>0.68 (0.67–0.70)</td>
</tr>
<tr>
<td>All ages</td>
<td>74.89</td>
<td>64.68</td>
<td>0.69 (0.68–0.70)</td>
<td>46.95</td>
<td>0.30 (0.29–0.30)</td>
</tr>
<tr>
<td>Female</td>
<td>3.41</td>
<td>2.89</td>
<td>1.27 (1.18–1.36)</td>
<td>1.85</td>
<td>0.81 (0.74–0.87)</td>
</tr>
<tr>
<td>35–44 y</td>
<td>36.81</td>
<td>29.56</td>
<td>0.80 (0.76–0.85)</td>
<td>20.54</td>
<td>0.56 (0.53–0.59)</td>
</tr>
<tr>
<td>45–54 y</td>
<td>87.37</td>
<td>75.53</td>
<td>0.80 (0.76–0.85)</td>
<td>57.13</td>
<td>0.56 (0.53–0.59)</td>
</tr>
<tr>
<td>55–64 y</td>
<td>189.77</td>
<td>161.05</td>
<td>0.85 (0.82–0.88)</td>
<td>119.95</td>
<td>0.63 (0.61–0.66)</td>
</tr>
<tr>
<td>65–74 y</td>
<td>527.05</td>
<td>406.85</td>
<td>0.77 (0.75–0.79)</td>
<td>305.49</td>
<td>0.58 (0.56–0.60)</td>
</tr>
<tr>
<td>75+ y</td>
<td>1434.54</td>
<td>1119.97</td>
<td>0.78 (0.76–0.80)</td>
<td>850.99</td>
<td>0.60 (0.59–0.62)</td>
</tr>
<tr>
<td>All ages</td>
<td>53.74</td>
<td>43.22</td>
<td>0.80 (0.79–0.81)</td>
<td>32.15</td>
<td>0.49 (0.49–0.50)</td>
</tr>
</tbody>
</table>

The rate changes for the study period as calculated by Poisson regression are also presented.

*1980–1982 is the reference period.

†$\hat{\beta}$—Poisson regression exponential, with the respective CIs that reflect how the rates increased or decreased during the study period.
A reduction in stroke standardized mortality rates occurred in all geopolitical regions (Figure 2). An interaction between the studied region and the magnitude of reduction was detected. The wealthiest regions (southern and southeastern) exhibited higher initial rates and also more marked reductions during the study period. The findings were confirmed by the Poisson regression model, in which the least marked reduction in stroke standardized mortality rate was found in the northeastern region: 41% (95% CI, 40% to 42%). The corresponding values for the other regions were as follows: northern, 52% (95% CI, 51% to 52%); central-western, 53% (95% CI, 53% to 54%); southern, 57% (95% CI, 56% to 57%); and southeastern, 59% (95% CI, 58% to 59%).

The total number of deaths related to stroke in Brazil has, however, steadily increased in the last 3 decades. The mean annual number of deaths attributable to stroke increased from 79,862 in 1980 to 1982 to 101,625 in 2000 to 2002. A similar trend was evident for total cardiovascular mortality: 239,876 deaths in 1980 to 1982 and 311,138 in 2000 to 2002. This increase mainly reflects the progressive aging of the Brazilian population.

**Discussion**

We have demonstrated a consistent and progressive decrease in Brazilian stroke standardized mortality rates during the initial periods of the last 3 decades. A parallel reduction in death rates from all cardiovascular causes has also been demonstrated and suggests that factors influencing both phenomena are probably operative.

The slope of decline in Brazilian stroke standardized mortality rates, a 55% RR between 1980 to 1982 and 2000 to 2002, is at least comparable to that found in the United States and Canada and is greater than reductions found in other Latin American countries between 1970 and 2000. The decline was consistent during the whole study period and was even more accentuated in the second half of the study period. This consistent decline during a long period reproduces the pattern seen in western European countries but differs from that seen in eastern European countries, where huge increases between 1970 and 1990 were followed by marked declines between 1990 and 2000 (except in Poland, where it continued to increase).3

The reduction in stroke mortality rate was evident in all age strata but differed in intensity throughout the country, being most noticeable in the 2 wealthiest regions (responsible for 75.4% of the crude internal product) and less so in the poorest regions, which can be considered nonestablished market economy regions.13 The discrepancies probably can be partially explained by variable improvements in the control of classic risk factors14–16 but may additionally reflect marked discrepancies in the still much-understudied social risk factors for stroke and cardiovascular diseases. It has been suggested that general health and economic conditions, even in early life, can be partially responsible for variable death rates attributable to cardiovascular diseases, including stroke.17–20

In the absence of definitive data on stroke incidence and hospital mortality, we can only suggest some reasons to explain the marked reduction in mortality rates from stroke in Brazil, but a decreasing incidence seems probably more important. Recent data from a comprehensive community stroke survey in Joinville, a medium-size city in the southern region with a high human development index (0.86, compared with 0.79 for Brazil
as a whole), suggest that stroke mortality has diminished between 1995 and 2005 in relation to both a decreasing (29%) stroke incidence and a lower (from 26.1% to 20%) hospital mortality (N.L. Cabral, oral presentation at the IV Brazilian Stroke Congress, Salvador da Bahia, October 21, 2005). In other countries, improved acute stroke care has also been implicated in the mortality reduction.21 Between 1984 and 1997, however, there was no apparent decline in hospital mortality from acute stroke in the Brazilian official health system, which encompasses ~65% of the population.22 Also, despite the increasing number of hospitalizations attributable to acute stroke during this period,23 there has been no significant increase in the availability of hospital beds in Brazil during the last 3 decades: 3.7 per 1000 individuals in 1980 versus 3.1 per 1000 in 2001,24 and only a small minority of acute stroke patients are currently treated in specialized stroke units.

Despite the reduction in stroke mortality rate detected in the present study, the total number of deaths attributable to stroke has been steadily increasing during the last 3 decades. This is not surprising and can be attributed to a progressive increase in the mean population age in Brazil, which should continue in the next decades. For instance, the mean life expectancy has increased from 62.6 years for people born in 1980 to 71.7 years for those born in 2004.24 This phenomenon is expected to continue during the next several decades (eg, the projected life expectancy for those born in 2020 is 76.1 years).

Similarly, we anticipate that the proportion of deaths related to stroke in the next few decades will increase in the poorest regions of the country, where the lower initial stroke standardized mortality rate in the study period may be partially explained by the younger mean age of the population. For instance, in the southeastern region, the proportion of the population 14 years or younger has decreased between 1980 and 2000, from 34.2% to 26.7%, whereas the older age stratum (≥65 years) has increased, from 4.2% to 6.4%. The corresponding figures for the northern region are 46.2% to 37.2% (0 to 14 years) and 2.8% to 3.6% (≥65 years).25 An additional factor that may, in the future, lead to a relative increase in the proportion of deaths attributable to stroke in poorer regions would be more comprehensive death notification coverage in rural areas and an improvement in the quality of mortality data collection, traditionally worse in regions with lower socioeconomic indices.26 This is especially important in the analysis of trends in mortality attributable to stroke and other cardiovascular diseases, because most of the so-called deaths of undetermined cause are actually caused by cardiovascular conditions.7

An inadequate control of the classic cardiovascular risk factors, if sustained in the next few decades, may contribute to an unnecessary increase in the number of deaths attributable to stroke. Limited data suggest a very low (≤20%) degree of control of hypertension in Rio de Janeiro, 1 of the richest Brazilian states, where antihypertensive drugs of the main classes (β-blockers, calcium channel blockers, angiotensin-converting enzyme inhibitors, and diuretics) can be obtained at no expense through the public health system.27 Also, there has been a progressive increase in the rates of overweight/obesity and diabetes in Brazil.28.29 The detected less marked decrease in stroke mortality rates in the most underdeveloped areas of Brazil suggests that continuing progressive urbanization of these regions may in the near future be accompanied by disproportionate increases in cardiovascular deaths related to unsafe health habits (eg, increases in smoking, obesity, and diabetes). This phenomenon would also be expected as a result of the steeper increase in the mean age of its population. On the other hand, a progressive increase in the human development index of these regions and easier access to the health system in urban settings may lead to progressively better detection and treatment of classic cardiovascular risk factors.

Some recent advances with a probable future impact for the whole country may be cited, including the recent launching of a national program to guarantee free access to the treatment of hypertension and diabetes.28 Also, the prevalence of smoking decreased in Brazil between 1989 and 2003.28 If nothing else is done, however, the number of deaths attributable to stroke and cardiovascular diseases will continue to grow unnecessarily, as in the United States and other countries.30 This possibility should summon immediate action to continuously improve the preventive strategies for stroke, which has just recently been declared a catastrophic disease in Latin America, and other vascular causes of death. Continuing efforts to improve the detection and control of hypertension are associated with further reductions in stroke mortality, even in communities with already less-than-average rates.31 Primary preventive strategies may be particularly indicated in developing countries facing budget restrictions for effectively delivering treatment of hypertension and other risk factors for stroke.32.33

In conclusion, there has been a consistent reduction in stroke and cardiovascular standardized mortality rates between 1980 and 2000 in Brazil. The reduction in stroke mortality rate was most marked in the more developed regions. It does not seem to be entirely explained by control of classic risk factors in high-risk individuals, technological advances, or improvements in acute stroke care but may in part reflect improvement in the general health conditions in Brazil. The progressive aging of the population will, however, lead to a progressive increase in the total number of deaths attributable to stroke and cardiovascular diseases in the next few decades.

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None.

References

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