Declining Stroke and Myocardial Infarction Mortality Between 1989 and 2010 in a Country of the African Region

Silvia Stringhini, PhD; Flavie Sinon; Joaquim Didon, BA; Jude Gedeon, MD; Fred Paccaud, MD; Pascal Bovet, MD

Background and Purpose—In low- and middle-income countries, the total burden of cardiovascular diseases is expected to increase due to demographic and epidemiological transitions. However, data on cause-specific mortality are lacking in sub-Saharan Africa. Seychelles is one of the few countries in the region where all deaths are registered and medically certified. In this study, we examine trends in mortality for stroke and myocardial infarction (MI) between 1989 and 2010.

Methods—Based on vital statistics, we ascertained stroke and MI as the cause of death if appearing in any of the 4 fields for immediate, intermediate, underlying, and contributory causes in death certificates.

Results—Mortality rates (per 100 000, age-standardized to World Health Organization standard population) decreased from 1669/710 (men/women) in 1989 to 1113/535 in 2008–10 for all causes, from 250/140 to 141/86 for stroke, and from 117/51 to 59/24 for MI, corresponding to proportionate decreases of 33%/25% for all-cause mortality, 44%/39% for stroke, and 50%/53% for MI over 22 years. The absolute number of stroke and MI deaths did not increase over time. In 2008 to 2010, the median age of death was 65/78 years (men/women) for all causes, 68/78 for stroke, and 66/73 for MI.

Conclusions—Between 1989 and 2010, age-standardized stroke and MI mortality decreased markedly and more rapidly than all-cause mortality. The absolute number of cardiovascular disease deaths did not increase over time because the impact of population aging was fully compensated by the decline in cardiovascular disease mortality. Stroke mortality remained high, emphasizing the need to strengthen cardiovascular disease prevention and control. (Stroke. 2012;43:2283-2288.)

Key Words: Africa ■ mortality ■ myocardial infarction ■ stroke ■ trends

Cardiovascular disease (CVD) is the leading cause of death worldwide, but divergent trends in CVD mortality are observed in different populations. In high-income countries, CVD mortality has declined steadily over the past 3 decades. This has been imputed to both favorable changes in population levels of major cardiovascular risk factors such as tobacco use, high blood pressure, unhealthy diet and physical inactivity, and improved treatment of cases. In low- and middle-income countries (LMICs), the total CVD burden is predicted to increase due to aging populations (demographic transition) and, possibly, detrimental lifestyle changes associated with socioeconomic development and urbanization. Few data are currently available on age-standardized mortality rates in LMICs because of the lack of vital statistics, census data, or otherwise reliable information systems covering the entire population, in particular in the African region. Reliable mortality data are essential to inform prevention and treatment strategies.

The Republic of Seychelles, a rapidly developing small island state located east to Kenya, represents a great opportunity to examine trends in cause-specific mortality in the African region, because all deaths are medically certified along vital statistics (numerator) and the age and sex distribution of the population is known (denominator). Besides, health care is available free of charge to all inhabitants through a national health system, which reduces barriers for health care and improves the likelihood of adequate ascertainment of causes of death.

The objective of this study is to examine trends in crude and age-standardized mortality for stroke and myocardial infarction (MI) in Seychelles between 1989 and 2010. The emphasis is on stroke and MI mortality because these 2 main cardiovascular diseases can be diagnosed with minimal investigations and are likely to have been reported fairly reliably during the 22-year investigation period.

Data and Methods

The Republic of Seychelles consists of >100 islands located in the Indian Ocean, east to Kenya, in the African region. Approximately 90% of the population lives on the main island. The large majority of the population is of African descent. The crude national gross domestic product per capita grew from US $600 in 1976 to US $9000 in 2009 as a result of booming tourism and fishing industries and a
Introducing a growing service-oriented economy. All deaths occurring in Seychelles are medically certified using death certificates with 4 separate fields for the immediate, intermediate, underlying, and contributory causes of death. Information for each field is registered into a central database as entered by the certifying doctors (ie, without further validation).

For the purpose of this study, raw textual information appearing in all death certificates of the period 1989 to 2010 was reviewed and we recoded the causes of death manually according to the International Classification of Diseases, 10th Revision.

The following broad causes of death were considered in this report: stroke, MI, ischemic heart disease, other CVD cause, cancer, accidents and violence, diseases of the respiratory system, infectious diseases, and other noninfectious causes. For 400 deaths out of 13163, the cause of death could not be determined. Stroke (International Classification of Diseases, 10th Revision codes I60–I69) and MI (International Classification of Diseases, 10th Revision codes I21–I23) were the focus of this report and they were considered as causes of death if these diagnoses were reported in any of the 4 fields for immediate, underlying, intermediate, or contributory causes of death. Information for each field is registered into a central database as entered by the certifying doctors (ie, without further validation).

Table 1. Age Distribution of the Population and of Mortality From All Causes, Cardiovascular Disease, Stroke, and Myocardial Infarction

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th></th>
<th></th>
<th>Women</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;55 Y</td>
<td>55–75 Y</td>
<td>&gt;75 Y</td>
<td>&lt;55 Y</td>
<td>55–75 Y</td>
<td>&gt;75 Y</td>
</tr>
<tr>
<td>Population</td>
<td>90.0</td>
<td>8.5</td>
<td>1.5</td>
<td>85.6</td>
<td>10.8</td>
<td>3.6</td>
</tr>
<tr>
<td>Mortality</td>
<td>30.7</td>
<td>40.1</td>
<td>29.2</td>
<td>17.5</td>
<td>28.7</td>
<td>53.8</td>
</tr>
<tr>
<td>All causes</td>
<td>18.9</td>
<td>44.3</td>
<td>36.8</td>
<td>8.9</td>
<td>32.8</td>
<td>58.3</td>
</tr>
<tr>
<td>CVD</td>
<td>10.5</td>
<td>46.9</td>
<td>42.6</td>
<td>7.6</td>
<td>31.3</td>
<td>61.1</td>
</tr>
<tr>
<td>Stroke</td>
<td>15.9</td>
<td>65.2</td>
<td>18.9</td>
<td>10.6</td>
<td>51.1</td>
<td>38.3</td>
</tr>
<tr>
<td>MI</td>
<td>31.3</td>
<td>36.2</td>
<td>32.5</td>
<td>19.1</td>
<td>22.5</td>
<td>58.4</td>
</tr>
<tr>
<td>CVD</td>
<td>18.6</td>
<td>40.3</td>
<td>41.1</td>
<td>10.0</td>
<td>23.2</td>
<td>66.8</td>
</tr>
<tr>
<td>Stroke</td>
<td>19.7</td>
<td>40.9</td>
<td>39.4</td>
<td>11.6</td>
<td>23.3</td>
<td>65.1</td>
</tr>
<tr>
<td>MI</td>
<td>16.7</td>
<td>50.0</td>
<td>33.3</td>
<td>16.2</td>
<td>40.5</td>
<td>43.3</td>
</tr>
</tbody>
</table>

All figures are expressed in percentages.
CVD indicates cardiovascular disease; MI, myocardial infarction.

Results

Between 1989 to 1991 and 2008 to 2010, the population of Seychelles increased by 27% (mean population per year was 68284 in 1989–1991 and 87011 in 2008–2010). The numbers of men and women aged >70 years increased by 56% and 49%, respectively. A total of 13163 deaths (7560 men and 5603 women) occurred over 22 years. The crude all-

cause mortality rate (per 100 000 per year) was 947/671 for men/women in 1989 to 1991 and 857/678 in 2008 to 2010. The corresponding age-standardized figures were 1669/710 in 1989 to 1991 and 1113/535 in 2008 to 2010.

In 1989 to 1991, 23.1% of all deaths underwent autopsy (7.7% of deaths for stroke and 35.3% of deaths for MI). In 2008 to 2010, 74.3% of all stroke deaths and 49.5% of all MI deaths occurred at a hospital. Autopsy was performed in 61.2% of MI deaths occurring outside of a hospital (this can include sudden deaths). An autopsy was performed for 17.6% of persons dying with a stroke outside of a hospital (57.8% for persons aged <70 years).

Table 1 shows the distribution of all causes mortality and of the total population by age and sex in the 2 periods under study. The proportion of deaths of >75 years of age increased between 1989 to 1991 and 2008 to 2010 for all-cause of death apart from stroke death for men. Among men, the median age at death decreased from 72 to 68 years for stroke and increased from 61 to 66 years for MI. Among women, the median age of death increased from 70 to 78 years for stroke and from 71 to 73 years for MI (results not shown).

The absolute annual mean numbers of deaths in 1989 to 1991 and in 2008 to 2010 for specific causes of death are presented in Figure 1. Between the 2 periods, the number of deaths increased by 18% in men and by 24% in women. Among men, CVD deaths represented 43% of all deaths in 1989 to 1991 (a mean of 143 cases per year) and 36% in 2008 to 2010 (a mean of 142 cases per year). Among women, CVD deaths represented 48% of all deaths in both time periods. Among men, stroke and MI represented 14% and 7% of all deaths in 1989 to 1991 and 12% and 5% in 2008 to 2010, respectively. Among women, stroke and MI represented 20% and 7% of all deaths in 1989 to 1991 and 16% and 4% in 2008 to 2010, respectively. Comparing the two time periods, the number of CVD deaths increased by 10%; the number of stroke deaths did not change (96 cases per
year in both periods); and the number of MI deaths slightly decreased (39 cases per year in 1989–1991 and 32 in 2008–2010). The number of deaths was larger in 1989 to 1991 than in 2008 to 2010 for cancer, infectious diseases, and other noninfectious diseases in men and for other CVDs, cancer, and infectious diseases in women.

Figure 2 shows age-standardized mortality rates (per 100 000 population) according to broad causes of death in 1989 to 1991 and 2008 to 2010 and Table 2 presents the changes in cause-specific age-standardized mortality rates between the 2 time periods. All-cause mortality decreased by 33% in men and by 25% in women. Age-standardized mortality decreased by 33% in men and by 25% in women. Age-standardized mortality decreased by 44% for CVD, 44% for stroke, and 50% for MI in men and in women by 28% for CVD, 39% for stroke, and 53% for MI. Based on Poisson regression (Table 2; Figure 3), mortality decreased (men/women) by 3.3%/2.7% per year for stroke and 3.0%/3.8% per year for MI (all P < 0.001). The age-standardized mortality rates decreased in all age groups for both stroke and MI (Table 3). In men, the largest decline occurred in the oldest age category for stroke (−4.5% per year) and in the middle age category for MI (−3.7% per year). In women, the decline was greatest in the middle age category for stroke and MI (−4.1% to −4.2% per year, respectively).

**Discussion**

This study shows that age-standardized mortality decreased by approximately 40% for stroke and 50% for MI between 1989 and 2010 in Seychelles, a steeper downward trend than for all-cause mortality. A decline was observed in men and women and in all age categories. Age of death for both MI and stroke was fairly high. The total number of deaths from stroke and MI did not increase over the 22-year interval despite an increasing and aging population.

**Epidemiological and Demographic Transitions**

The age-standardized all-cause mortality rates are similar in Seychelles (1113/530 per 100 000 for men/women in 2008–2010) and in other countries with similar socioeconomic development, for example, 890/610 in Brazil or 1111/620 in Trinidad and Tobago. Decreasing all-cause mortality can be interpreted in light of the demographic and epidemiological transition paradigm. The population of Seychelles increased by approximately 30% over the study period, and the median age of the total population was 10 years greater in 2008 to 2010 than in 1989 to 1991, consistent with rapid socioeconomic development experienced in the same time interval. The fairly low all-cause mortality suggests that Seychelles is going through an advanced stage of the epidemiological transition. However, the population in Seychelles is still relatively young (half of the population was aged <30 years in 2010), suggesting that the demographic transition is not fully completed.

**Declining CVD Mortality**

The decline in age-standardized CVD mortality in Seychelles over a 22-year period (44% for men and of 28% for women) is of similar magnitude as that experienced by high-income countries since the 1970s for ischemic heart diseases and since the 1960s for stroke. For example, age-standardized CVD mortality almost halved between 1960 and 1990 in the United States. Few reliable population-based data on CVD trends are available in sub-Saharan Africa. In South Africa, age-standardized CVD mortality decreased in recent years based on vital statistics data but CVD mortality increased between 1992 and 2005 in a surveillance system based on verbal autopsy in a rural population. However, the decline in stroke mortality in Seychelles is similar to that observed in some other middle-income countries. In Brazil, age-standardized stroke mortality declined by 55% between 1980 and 2002 (from 68.2–40.9 per 100 000 inhabitants). In Argentina, age-standardized stroke mortality declined by 38% among men and by 45% among women between 1970 and 2000.

According to our study, age-standardized CVD mortality decreased at a steeper rate than all-cause mortality. This decline likely underlies a mix of reduced incidence and reduced case-fatality of CVD events. In high-income countries, secular decreases in cardiovascular risk factors in the population and improved treatment for CVD patients have contributed in similar proportions to the CVD decline occurred over the past decades. In Seychelles, favorable trends in the prevalence of several major cardiovascular risk factors...
were observed between 1989 and 2004: blood pressure levels tended to decrease and smoking decreased markedly.19 With regard to health behaviors and the related environment, there have been mixed trends. The number of cars in the country and the overall sales of soft drinks have largely increased. However, most people still eat fish on a daily basis; the number of people engaging in leisure time physical activity increased; there has been a marked shift in sales from whole milk to skimmed milk; and fruit and vegetables are more commonly available in shops than before.20 Furthermore, a comprehensive program for the prevention of noncommunicable diseases has been actively implemented in Seychelles since the early 1990s, including comprehensive tobacco control legislation.21 On the other hand, improved treatment of individuals at high risk of CVD or with overt CVD may also have contributed to the decline of CVD mortality. Case-fatality for stroke and MI has not been assessed in Seychelles so far, but repeated population-based surveys have shown improved control of persons with high blood pressure and diabetes over time.19,20 All main classes of antihypertensive medications have been available in Seychelles for several decades, although low compliance has been reported.22 Although available at the primary healthcare level for many years in Seychelles, statins are not yet used broadly.19 Moreover, invasive procedures such as coronary artery bypass or percutaneous coronary intervention are not yet available in Seychelles and fibrinolysis is used only rarely for acute MI cases. Hence, the decline in age-standardized CVD mortality in Seychelles is probably related more to favorable secular changes in health behaviors than to medical treatment.

**Stroke and MI Mortality**

Despite a 40% decline in men and women over a 22-year period, age-standardized stroke mortality remains high in Seychelles compared with both high- and middle-income countries.2,15,16,23 High stroke mortality in Seychelles is consistent with the still high prevalence of several risk factors, particularly hypertension, and high prevalence of peripheral atherosclerosis.19 One study in the early 2000s showed that salt intake in Seychelles was fairly low (at approximately 6 g of salt per day based on 24-hour urine collection),24 consistent with the staple diet based on unsalted polished rice and fresh fish still largely consumed in the country. Hence, salt intake does not seem to be a major factor underlying high stroke mortality rates in Seychelles.

Stroke mortality was larger in our study than in a previous report (141/86 in men/women versus 24 per 100 000).25 This discrepancy may arise from the different methods used for ascertainment of the main cause of death. Johnston et al considered only the underlying cause of death, whereas all 4 fields of death certificates were screened in our study. Because in Seychelles the causes of death, and their sequence, are recorded as reported by the certifying doctors (ie, no further validation is performed), it is likely that an inclusive approach is more suitable than an approach based on one or 2 fields only, at least for diagnoses that have high case-fatality.26 Adequate ascertainment of the main underlying cause of death would need formal validation along...
standard procedures and coding rules.\textsuperscript{27} Unfortunately, this requires expertise and substantial resources that are currently not available in many LMICs. This underlies a major challenge for the surveillance of CVD events in LMICs.

In our study, we examined mortality for MI only as opposed to the broader category of ischemic heart disease, because acute MI can be ascertained based on minimal investigations, whereas accurate ascertainment of ischemic heart disease is more challenging. Of note, the 2 main paraclinical examinations for the diagnosis of MI (electrocardiogram and serum concentration of creatine kinase) have been available in Seychelles throughout the 22-year period. Furthermore, MI mortality accounts for a large proportion of all ischemic heart disease deaths. However, MI mortality is probably underestimated in our study, because a number of “sudden deaths” occurring outside the hospital are related to MI/ischemic heart disease but are not necessarily recorded as such in their death certificate. Data from high-income countries suggest that approximately 2 MI deaths occur as sudden deaths outside the hospital for each MI death occurring within the hospital.\textsuperscript{28} In our study, half of all MI deaths took place outside of a hospital, and >80% of all MI deaths outside of a hospital before the age of 70 years underwent autopsy, suggesting fairly good quality of our data.

\textbf{Age and Sex Differences in Mortality}

In Seychelles half of all deaths occurred above the age of 65/78 years for men/women. This translates in fairly elevated life expectancy in Seychelles (73 years),\textsuperscript{29} which is higher than in most countries of the region but similar to that of other small island states such as Mauritius (73 years), Cape Verde (74 years), Trinidad and Tobago (70 years), or Cuba (79 years). Life expectancy in Seychelles is 10 years greater in women than in men (78 versus 68 years).\textsuperscript{29} Sex differences in mortality have been found consistently over time and regions,\textsuperscript{30} although the difference is quite large in Seychelles. The much lower prevalence of smoking in women than in men and much higher alcohol consumption in men than in women could partly explain these differences.\textsuperscript{19,30} Noticeably, age at death for MI and stroke was fairly high in our study: only one fourth of all MI and stroke deaths occurred before the age of 57 years among men and this age limit (lowest quartile of age at death) was 63 years for MI and 68 years for stroke among women.

\textbf{Strengths and Limitations}

The major strength of this study is the availability, in a country of the African region, of both a population-based registry of deaths in which all deaths were medically certified and the age-and sex-specific distribution of the population over a 22-year period. This is an unusual situation in LMICs, where vital statistics are often not available or do not cover the entire population and health information systems tend to be managed by undertrained staff.\textsuperscript{31} However, several limitations need to be considered. First, it remains a challenge to ascertain reliably the main cause of death from vital statistics, particularly among older persons (because of multimorbidity) and for deaths occurring outside of a hospital. These problems were minimized in this study because: (1) we focused on 2 causes of death that can be diagnosed with minimal investigations; (2) the necessary paraclinical investigations were available throughout the study period; (3) a substantial proportion of deaths that occurred outside of a hospital underwent autopsy; and (4) free health care in Seychelles reduces barriers to health care and improves conditions for adequate diagnosis. A second limitation is related to the way we ascertained causes of death. We considered stroke and MI as causes of death if these diagnoses appeared in any of

\begin{table}
\centering
\caption{Trends in Age-Standardized Mortality For All Causes of Death, All Cardiovascular Diseases, Stroke, and Myocardial Infarction According to Sex and Age}
\begin{tabular}{lcccccc}
\hline
& \multicolumn{2}{c}{Men} & \multicolumn{2}{c}{Yearly Change} & \multicolumn{2}{c}{95\% CI} \\
\hline
All causes & <55 & 370 & 247 & -33\% & -2.0\% & -2.4 to -1.6\% \\
& 55–75 & 594 & 420 & -29\% & -2.0\% & -2.4 to -1.7\% \\
& >75 & 629 & 417 & -34\% & -3.0\% & -3.3 to -2.6\% \\
All CVD & <55 & 116 & 55 & -53\% & -3.5\% & -4.3 to -2.8\% \\
& 55–75 & 288 & 172 & -40\% & -2.6\% & -3.1 to -2.2\% \\
& >75 & 345 & 193 & -44\% & -4.3\% & -4.7 to -3.9\% \\
Stroke & <55 & 22 & 20 & -1\% & 0.1\% & 1.2 to 1.5\% \\
& 55–75 & 102 & 59 & -42\% & -3.2\% & -3.9 to -2.5\% \\
& >75 & 126 & 63 & -50\% & -4.5\% & -5.2 to -3.7\% \\
MI & <55 & 17 & 7 & -60\% & -2.9\% & -4.5 to -1.2\% \\
& 55–75 & 70 & 30 & -57\% & -3.7\% & -4.7 to -2.7\% \\
& >75 & 30 & 21 & -30\% & -1.9\% & -3.2 to -0.6\% \\
Other CVD & <55 & 77 & 28 & -64\% & -6.1\% & -7.1 to -5.0\% \\
& 55–75 & 116 & 83 & -28\% & -1.5\% & -2.2 to -0.7\% \\
& >75 & 189 & 111 & -41\% & -4.6\% & -5.3 to -4.0\% \\
\hline
\end{tabular}
\end{table}
the 4 fields for causes of death. This approach may lead to some overestimation, particularly for stroke, because some deaths attributed to stroke or MI might have actually died of an unrelated disease. However, the main advantage of our approach is that it minimizes misclassification and biases related to changing ranking practices between doctors and over time and our findings on changes in stroke and MI mortality over time (the main aim of this study) are likely to be unbiased.

Conclusions
The sharp decline in age-standardized stroke and MI mortality during the past 2 decades suggests that the peak of cardiovascular mortality has already occurred in Seychelles and that the country is now in an advanced stage of the epidemiological transition. From a health services perspective, our findings suggest that the challenge of an anticipated exploding CVD burden due to an aging population might be less dramatic than expected with numbers of CVD cases admitted to hospital that might not necessarily increase over the next years. However, stroke mortality remains high, which emphasizes the need to further strengthen primary prevention and control of CVD.

Moreover, our data suggest that the epidemiological transition in LMICs, at least in some middle-income countries and/or in small island states, may progress more rapidly than initially thought. Moreover, our findings suggest that the goal of reducing death rates for noncommunicable diseases by 2% per year might be achievable, at least in some middle-income countries or in other small island states.

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Disclosures
None.

References
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