Cardiovascular Health in Brazil
Trends and Perspectives

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Abstract—Brazil is a large country, with an evolving economy, but marked social inequalities. The population is formed by an admixture of native Brazilians, Europeans, and Africans; is predominantly urban; and faces rapid aging. Time trends related to health behaviors show a substantial reduction in smoking rates, but a rising prevalence of overweight and obesity, unhealthy eating habits, and insufficient physical activity. The high prevalence of hypertension and the increasing prevalence of diabetes mellitus are also causes for concern. Cardiovascular disease (CVD) has been the leading cause of mortality since the 1960s and has accounted for a substantial percentage of all hospitalizations. In 2011, CVD was responsible for 31% of all deaths, with ischemic heart disease (31%) and cerebrovascular diseases (30%) being the leading CVD causes. Despite an increase in the overall number of CVD deaths, the age-adjusted mortality rates for CVD declined 24% between 2000 and 2011. Health care delivered by Brazil's universal public health system, which focuses on primary prevention, has contributed to this achievement. However, the decline in age-adjusted mortality differs according to race, sex, and socioeconomic status with black individuals and lower-income populations sustaining the greatest impact of CVD, especially at younger ages. With one of the world's largest public health systems in terms of population coverage, Brazil has the means to implement actions to confront the high burden of CVD, focusing on health promotion and comprehensive care. Insufficient funding, low education levels, and social inequalities remain as the main barriers to be overcome. **(*Circulation*. 2016;133:422-433. DOI: 10.1161/CIRCULATIONAHA.114.008727.)**

Key Words: Brazil ■ epidemiology ■ health policy ■ mortality ■ risk factors

Our article reviews the current situation of cardiovascular diseases (CVD) in Brazil, focusing on the influence of socioeconomic status and regional variation in the epidemiology of CVD; and on current and novel strategies to confront CVD. After a brief description of the geographic, economic, and demographic aspects, the organizational aspects of the Brazilian healthcare system are explained. Next, risk factors and morbidity and mortality by CVD are described, followed by a discussion of strategies to confront CVD, regarding both prevention and treatment. Finally, the gaps in knowledge and suggested steps to overcome limitations are highlighted. Hence, this article aims to contribute to efforts to raise awareness concerning the CVD burden around the world, while highlighting initiatives that may promote the improvement of health and the reduction of disparities and current problems. Moreover, we hope it creates opportunities for interaction between researchers, clinicians, and health policy makers.

Geographic, Economic, and Demographic Data

Brazil is a country of continental dimensions exhibiting large differences in climate, genetic background, and lifestyle adopted in its distinct regions. It occupies 47% of South America, mainly in the tropical region, and has an estimated population of 202 768 562, with 51% women.[1] The country is the fifth in land area, sixth in population, and currently the seventh economy in the world.[2] Regarding income distribution, Brazil remains one of the world´s most unequal countries.[2] Even though social disparities have decreased considerably over the past 14 years,[3] they are still unacceptable. The Gini coefficient for family income, a measure of inequality in income distribution ranging from 0 (complete equality) to 1 (complete inequality), declined from 0.59 in 2000 to 0.53 in 2012. The proportion of people living in poverty, defined as earning <US$ 2 a day, has fallen from 20.3% in 2001 to 6.8% in 2012.[2]

Brazil is divided into 5 regions: although the northeastern and northern regions (the latter generally sparsely populated in the midst of the Amazon Forest) have the worst socioeconomic indicators, the southeastern region has 42% of the population and is responsible for 56% of the gross domestic product (Figure 1A).[3] Inequalities in Brazil also have a

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social background, in which people who self-report their race as white tend to have higher income and education.[4,5] The racial composition of the Brazilian population draws from an admixture of ethnic groups that include initial Portuguese settlers and native Brazilians, and later, additional European immigrants, African slaves, and a small proportion of Asians, mostly Japanese.[6] In the 2010 Census, individuals self-categorized their race/color as 47.7% white (with a strong increasing gradient from north to south; Figure 1B), 43.1% mixed, 7.6% black, 1.1% Asian, and 0.4% native Brazilians.[1] Although race self-categorization can capture social disparities, it is important to emphasize that most Brazilians share European, African, and native backgrounds, making self-reported race in Brazil a questionable surrogate for genetic ancestry.[6]

The Brazilian Health System

The Brazilian national health system has 2 branches: a universal public health system (*Sistema Único de Saúde* [SUS]), created by the Brazilian Constitution of 1988,[7] and a supplementary health sector, which encompasses private health plans, insurance, and private health professionals. The main differences between these branches are highlighted in Table I in the online-only Data Supplement. The key ethical principles of the SUS are universality of access, equity, and comprehensive care. Its main organizational features are decentralization, with emphasis on the municipal level, and regionalization of health services, so that in a defined area services are built in a network of growing complexity. The 3 spheres of government – federal, state, and municipal – are jointly responsible for SUS governance and funding.[7]

Great achievements have been made since the implementation of the SUS. The SUS may be at least partly responsible for the increase in life expectancy seen for Brazilians over the past 2 decades, from 66.9 years in 1991 to 74.6 in 2012.[3] More than 30 000 primary healthcare multidisciplinary teams, each responsible for a geographically defined population, have been established through the Family Health Strategy, delivering health care to individuals with low income and in the poorest regions of the country (Figure 1C).[4] The SUS also allows universal access to specialized procedures, such as cardiac surgery and transplantation, and to a nationwide emergency care network, including an emergency transportation system.[8] However, the quality of assistance provided by the public system is frequently challenged, particularly the difficulty of accessing secondary and tertiary care and the deficiencies in infrastructure of many hospitals. Most importantly,

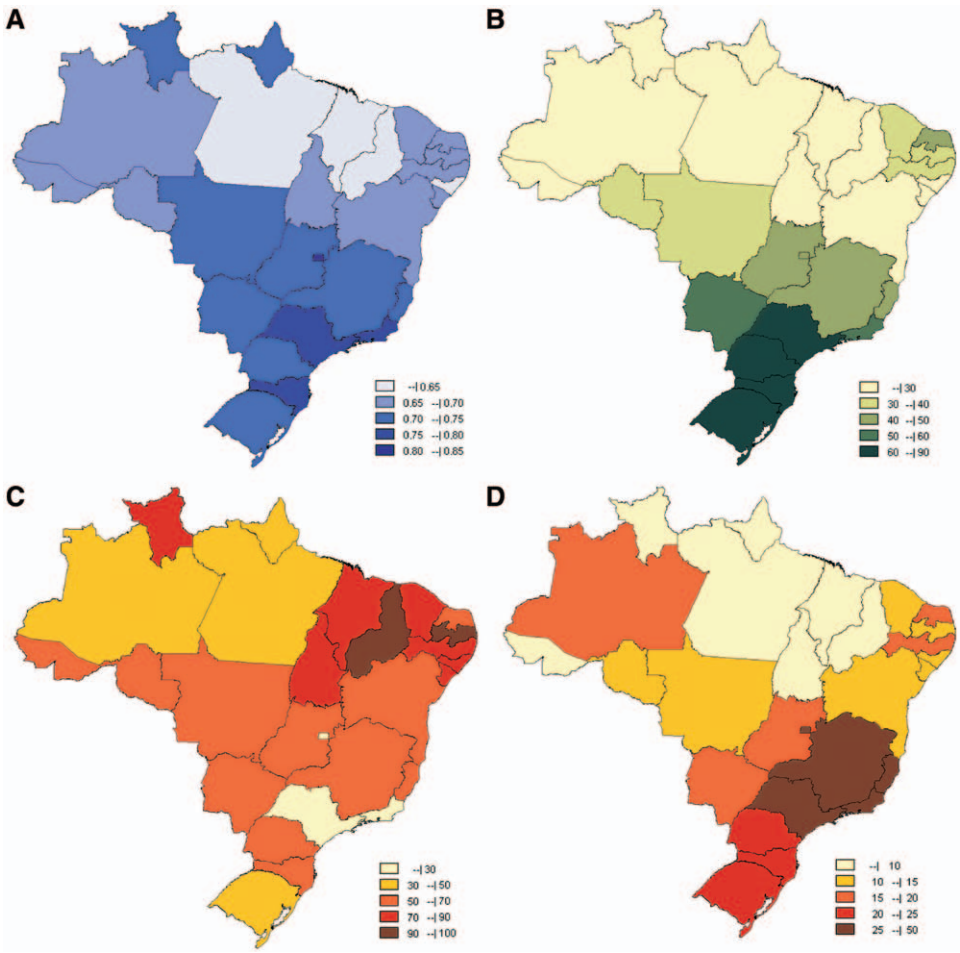

Figure 1. Distribution of health indicators in Brazil by state. **A**, Human Development Index (HDI), a composite statistic of life expectancy, education, and income indices, used the by United Nations to describe the human development of a country or a region (ranging from 0–1). **B**, Self-reported race – proportion of white individuals (%). **C**, Public primary care coverage – proportion of municipalities covered by The Family Health Program (%). **D**, Private health plan coverage – proportion of inhabitants covered by private plans (%).

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the public system is underfunded. Brazil spends 9.7% of its gross domestic product on health, occupying the 31st position in the world. However, only 4.7% comes from public funding, less than in European countries, such as Germany (8.7%) and France (9.1%), and in the United States (8.0%).[7]

Private sector participation is structured by legislation to be either complementary or supplementary to the SUS.[9] As a complementary measure, private institutions can be hired by the SUS where the public system is insufficient, in general, for secondary or tertiary care. The supplementary sector is regulated by the National Agency of Supplementary Health, linked to the Health Ministry.[9] Although only one-quarter of the population has supplementary health care, more resources are spent per capita and more health facilities are available in this sector than in the SUS (Table I in the online-only Data Supplement).[4,7] Regional distribution also shows that private health plan coverage is concentrated in the richer southeastern and southern regions (Figure 1D). Users of the private sector have broader access to specialized procedures and facilities, although the higher number of procedures performed is not necessarily related to health needs and may reflect inappropriate use of those procedures with high reimbursement values, such as coronary angiography.[10] Another aspect is that the provision of medications and some complex procedures (eg, heart transplantation) is not mandatory for private health plans, which results in their beneficiaries turning to the SUS for such care.

The Epidemiological Transition

A major epidemiological transition occurred in Brazil in the 1960s, with the main causes of mortality changing from infectious diseases and nutritional deficiencies to noncommunicable diseases. The transition happened in parallel with rising rates of urbanization (Figure 2A), better sanitation and nutritional conditions, rising immunization coverage, and economic growth.[7,11] This transition resulted in the current triple burden of diseases: an unfinished agenda of infectious diseases, an increasing number of external-cause deaths (mainly homicides and traffic accidents), and noncommunicable diseases.

CVD has been the main cause of death in Brazil since the end of the 1960s. Two important tendencies have contributed to maintain this ranking over the past 2 decades.[4,11] The first is the occurrence of lifestyle changes related to urbanization and globalization such as higher caloric intake and lower energy expenditure.[11,12] The second is the rapid population aging caused by greater life expectancy and lower fertility (Figure 2B).

Health Behaviors and Cardiovascular Risk Factors

Time trends for selected health behaviors (smoking, overweight, and obesity) obtained from representative samples of the Brazilian population are shown in Figure 3.[13,14] Tobacco consumption declined sharply between 1989 and 2013: from 43.3% to 19.2% in men and from 27.0% to 11.2% in women (Figure 3, Table II in the online-only Data Supplement), a period during which Brazil increased cigarette taxes, implemented bold warnings on cigarette packages, and banned most tobacco-marketing practices.[14,15] About 420 000 deaths were

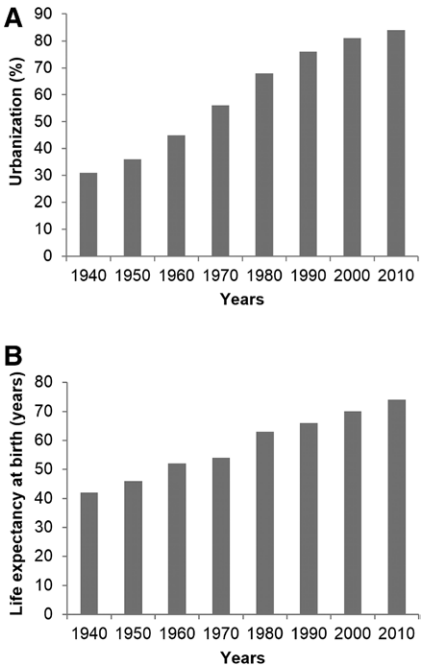

Figure 2. Temporal trends of demographic indicators in Brazil. **A**, Urbanization –proportion of population living in urban areas (%). **B**, Life expectancy at birth (years).

estimated to have been prevented because of tobacco reduction over the years 1989 to 2010.[16] Trends from 1975 to 2013 show marked increases in the prevalence of overweight and obesity (Figure 3, Table II in the online-only Data Supplement),[13] turning obesity into one of the most challenging public health problems in Brazil. The increase in obesity has been more pronounced in men, in rural settings, and in individuals with lower income.[17] Data regarding physical activity levels for the whole country became available only in recent years from the ongoing annual telephone-based survey (Surveillance System for Risk and Protective Factors for Chronic Illnesses using Telephone Survey [VIGITEL]), representative of adults in 27 capitals and the Federal District. It shows improvement in leisure-time physical activity in adults from 2006 to 2012, particularly in the younger adults and in those with higher education.[18] However, in 2013, a high proportion of adults (39.8% of men and 51.5% of women) still did not meet the recommended level of activity (light or moderate physical activity for at least 150 minutes per week or intense activity for at least 75 minutes per week, considering leisure, work, and transportation activity; Table II in the online-only Data Supplement).[14]

Several population-based household surveys have been conducted to estimate the prevalence of hypertension in the past 3 decades in Brazil. Picon and colleagues[19] recently performed a systematic review of 40 studies including >120 000 subjects (mostly ≥18 years) and estimated that hypertension prevalence (Sixth Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure [JNC VI] criteria: blood pressure ≥140/90 mm Hg or the use of antihypertensive medication) in Brazil is 28.7% (95% confidence interval [CI], 26.2–31.4) with no significant differences between sexes or regions. They observed a downward trend in the prevalence over the past 3 decades:

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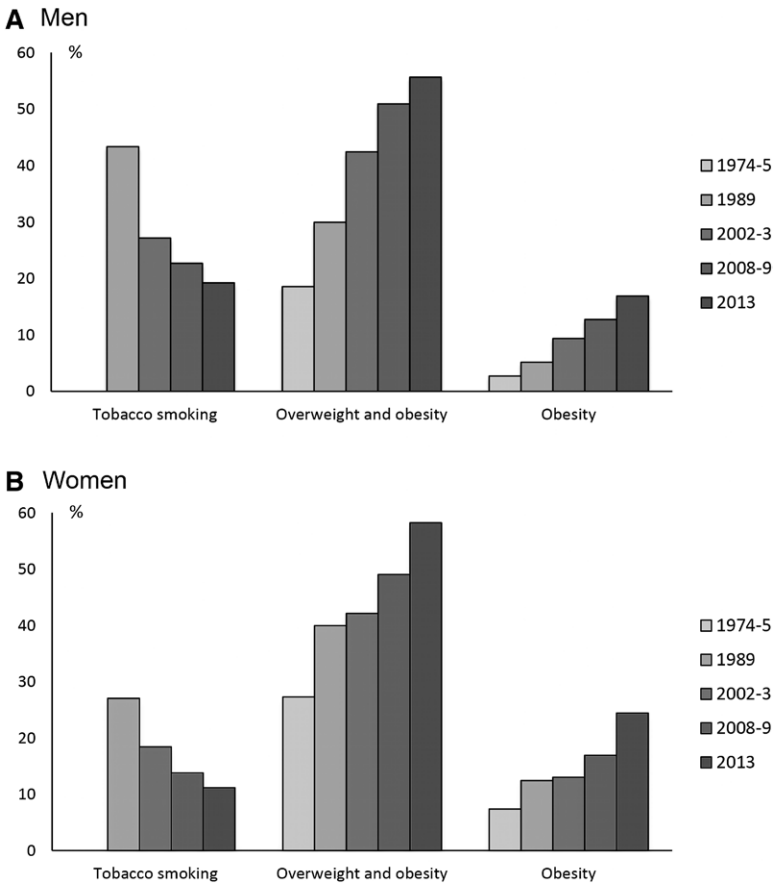

Figure 3. Prevalence of smoking, overweight and obesity (includes any BMI≥25 kg/m^2), and obesity (BMI≥30 kg/m^2) among adults obtained from countrywide population-based surveys in Brazil, 1975 to 2013. No data are available for tobacco smoking in 1974 to 1975. **A**, Men. **B**, Women. Data from Instituto Brasileiro de Geografia e Estatística (IBGE; www.ibge.gov.br) and National Health Survey, 2013.[13,14] BMI indicates body mass index.

from 36.1% in the 1980s to 28.7% in the first decade of the present century. However, this trend may be attributable to the inclusion of some studies based on self-reported hypertension. Indeed, population-based studies conducted in the past 15 years in which blood pressure was directly measured have shown an overall prevalence ≈35% (Table III in the online-only Data Supplement), with a higher prevalence in men than in women (41% versus 32%). Data from the Brazilian Longitudinal Study of Adult Health (ELSA-Brasil) cohort,[20] although not designed to be representative of Brazilian adults, showed that 35.8% were classified as presenting hypertension, from which 80.2% were aware of the condition and only 53.3% had controlled blood pressure.

The largest available survey of dyslipidemia was conducted in 2002 by the Brazilian Society of Cardiology in a convenience sample of 81 262 volunteers aged ≥18 years (mean age, 44.7 years) recruited in 13 Brazilian cities.[21] The mean (standard deviation) of cholesterol was 199 (35) mg/dL; 40% of the studied population had total cholesterol >200 mg/dL and 14% >240 mg/dL. Total cholesterol values increased with age and were similar in both sexes. Besides lacking nationwide representativeness, the survey did not collect information on the use of lipid-lowering drugs.[21] Some local population-based studies have investigated the presence of dyslipidemia, reporting the prevalence of high total cholesterol (≥240 mg/dL) varying from 4.2% to 31.3% (Table IV in the online-only Data Supplement). Unlike hypertension, smoking, and diabetes mellitus, which are more prevalent in socioeconomically less favored groups, cholesterol levels were higher in the upper socioeconomic groups. Data obtained in 6 population-based surveys to determine the prevalence of metabolic syndrome including urban and rural adults revealed that 53.9% of men and 67.5% of women show plasma high-density lipoprotein cholesterol levels <40 mg/dL and <50 mg/dL, respectively.[22] The prevalence of high triglycerides ranged from 13% to 17% in these surveys. Data from the ELSA-Brasil cohort[23] showed that, despite the frequent use of statins, the prevalence of hypercholesterolemia (>200 mg/dL total cholesterol) and hypertrigliceridemia (≥150 mg/dL) were 61.5% and 31.2%, respectively. Although the levels of hypercholesterolemia were similar in men and women (58.9% and 63.6%, respectively), hypertriglyceridemia was nearly twice as frequent in men (40.9% versus 23.0%).[23]

In parallel with the obesity epidemic and rapid population aging, the prevalence of diabetes mellitus is also rising in Brazil. The only population-based multicenter study of diabetes mellitus with blood testing, conducted in 9 large Brazilian cities between 1986 and 1988 in a random sample of 21 847 individuals aged 30 to 69 years reported an overall prevalence of 7.6%, with no sex difference and with 46% of cases being undiagnosed.[24] Data from VIGITEL, starting at a much younger age (18 years), showed a 24% increase in the prevalence of self-reported diabetes mellitus among Brazilians from 2006 to 2013 (5.5%–6.8%).[25] In the ELSA-Brasil baseline evaluation (2008–2010), 20% of adults 35 to 74 years of age had diabetes mellitus, defined by the presence of previously diagnosed diabetes mellitus (self-reported or medication use) or undiagnosed diabetes mellitus (surpassing

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thresholds for fasting or 2-hour plasma glucose on oral glucose tolerance testing, or for glycohemoglobin).[26]

Although a great number of studies about the prevalence of CVD risk factors can be found, most of them have limitations, because of limited spatial coverage or the absence of confirmatory laboratory examinations. VIGITEL, one of the most useful sources of information, is a telephone-based survey performed in state capitals; it therefore includes only self-reported conditions from large urban cities, which could lead to the risk of an underreporting bias. Recognizing these limitations, the Health Ministry, in association with the Brazilian Institute for Geography and Statistics (Instituto Brasileiro de Geografia e Estatística) performed, in 2013, a National Health Survey encompassing 62 986 homes in the whole country, with sampling to permit results representative of the Brazilian population. In this survey, 25% of the sample was selected for clinical examination and blood and urine collection. Data obtained from the questionnaires was recently released (Table II in the online-only Data Supplement)[13,14]; detailed results of these objective measurements are expected in the near future.

The results of the INTERHEART study for Latin America indicate that abdominal obesity, abnormal lipids, smoking, history of hypertension and diabetes mellitus, and lack of regular exercise accounted for ≈86% of the population risk for myocardial infarction in the region.[27] The Brazilian branch of this study included 313 cases and 364 sex- and age-matched controls; the highest population-attributable risks were observed for high ApoB/ApoA-1 ratio (57.0%; 95% CI, 38.6%–73.4%), waist-to-rip ratio (51.0%; 95% CI, 27.2%–74.4%), permanent stress (43.8%, 95% CI, 25%–64.7%), hypertension (43.2%; 95% CI, 35.4%–51.4%), and smoking (40.3%, 95% CI, 28.9%–52.8%).[27] In the Acute Myocardial Infarction Risk Factor Assessment in Brazil (AFIRMAR) case-control study, independent risk factors for myocardial infarction in Brazil demonstrated a conventional pattern (smoking, diabetes mellitus, and central obesity, among others) with different strengths of association; most of the main risk factors described should be preventable through the implementation of adequate policies. Using a methodology similar to the INTERSTROKE study, Mallmann and colleagues found that, in a community in South Brazil, the combination of hypertension, atrial fibrillation, left ventricular hypertrophy, the presence of carotid bruit, heavy smoking status, diabetes mellitus, alcohol abuse, low high-density lipoprotein cholesterol, and physical inactivity explained 98.9% of the ischemic stroke incidence.[28] According to the Prospective Urban and Rural Epidemiological (PURE) Study, the protective behaviors against the development of cardiovascular diseases (healthy diet, regular physical activity, not smoking) are adopted less frequently by populations living in low- and middle-income countries.[29] This pattern also seems to occur within Brazil, where studies have shown a higher prevalence of cardiovascular risk factors, mainly smoking, hypertension, and obesity in the lowest socioeconomic groups.[11,20,26]

Mortality and Morbidity Attributable to Cardiovascular Disease in Brazil

Mortality

CVD, mainly stroke and coronary heart disease, has been Brazil´s leading cause of death for half a century. The age-adjusted risk of death from atherosclerotic heart and cerebrovascular diseases has risen since the 1940s, probably peaked during the 1980s, and since then has presented a progressive decline.[11,30,31] In 2011, after correcting for undernotification and ill-defined causes, 384 615 deaths were attributed to CVD (*International Statistical Classification of Diseases and Related Health Problems, 10th Revision* [ICD-10] codes I00–I99), corresponding to 31.0% of all deaths and 42.0% of all noncommunicable disease deaths. Coronary heart disease (ICD-10 I20–25), now the leading cause of CVD death, accounted for 31% of CVD mortality, cerebrovascular diseases (ICD-10 I60–69) for 30%, hypertensive heart disease

Table 1. Number of Deaths, and Crude and Standardized Mortality Rates for Cardiovascular Diseases, Brazil 2000 to 2011, All Ages

	Deaths			Proportional	Mortality Rate	
Year	CVD, n	Total, N	Population, N	Mortality, %	Crude (/100000)	Standardized* (/100000)
2000	342 743	1 033 644	173 448 347	33.2	198	278
2001	344 875	1 043 753	175 885 229	33.0	196	272
2002	344 925	1 056 863	178 276 128	32.6	193	265
2003	349 685	1 074 157	180 619 108	32.6	194	260
2004	358 444	1 095 164	182 911 487	32.7	196	259
2005	346 363	1 076 611	185 150 806	32.2	187	242
2006	358 383	1 101 817	187 335 137	32.5	191	242
2007	360 605	1 115 275	189 462 755	32.3	190	235
2008	368 539	1 142 159	191 532 439	32.3	192	232
2009	368 542	1 163 796	193 543 969	31.7	190	223
2010	375 296	1 201 601	195 497 797	31.2	192	219
2011	384 615	1 238 708	197 397 018	31.0	195	216

CVD indicates cardiovascular disease; and WHO, World Health Organization.

*Standardized to the WHO World Population Standard, corrected for underregistration and ill-defined causes. Data obtained from DATASUS, the data processing system of the Brazilian Health Ministry.

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(ICD-10 I10–15) for 14%, and other forms of heart disease (ICD-10 I30–52, mainly congestive heart failure) for 18%. Rheumatic heart disease and Chagas disease, once important causes of cardiovascular morbidity and mortality, currently account for a relatively small fraction of CVD deaths, <1% each (data obtained from DATASUS, the data processing system of the Brazilian Health Ministry).

Mortality trends in Brazil must be interpreted carefully, given the rapid improvement in the quality of the national mortality information system in terms of completeness of the data (from an estimated 91.0% in 2000 to 94.2% in 2011) and ill-defined causes of death (from 14.3% in 2000 to 6.7% in 2011 after correction for incompleteness).[4] Many deaths were assigned to causes that cannot or should not be considered underlying causes of death, the so-called garbage codes, and a current challenge is to implement the methodology of reclassifying deaths attributed to these garbage codes.[32] Methods are now being implemented to incorporate and reclassify these deaths, but were not available for these analyses.

Table 1 shows trends from 2000 to 2011 for the overall number of CVD deaths, and for proportional, crude, and standardized mortality for CVD, as well, corrected for incompleteness and ill-defined causes of death. As can be seen, the overall number of deaths has risen slightly as the population has increased and aged over this period. However, crude CVD mortality, which takes into account the increasing population size, has been relatively stable, and the proportion of deaths attributable to CVD has decreased slightly over the period. When age-standardized to the World Health Organization world population standard to adjust for population aging, CVD mortality for all ages presents a noteworthy 24.0% decline over the 11-year period, 2.2%/y, mostly for cerebrovascular diseases (Figure 4A) and in the southern and southeastern regions (Figure 4B). Indeed, Brazil falls into the group of countries in which the increase in the number of cardiovascular deaths attributable to population growth and aging has been compensated by a fall in age-specific rates of death, suggesting improvements in the health status of the population.[33] The current picture of CVD mortality shows no consistent geographic pattern, although a cluster of states in the Northeast have high rates (Figure 5A).

The decline in CVD mortality differs according to race, sex, and socioeconomic status. Based on reported race in the death certificates, the age-standardized premature CVD and stroke death rates are higher in blacks than in mixed race and white persons (Figure IA in the online-only Data Supplement).[34] Since 1996, the relative rate of decline of age-standardized premature CVD death rates has been higher in

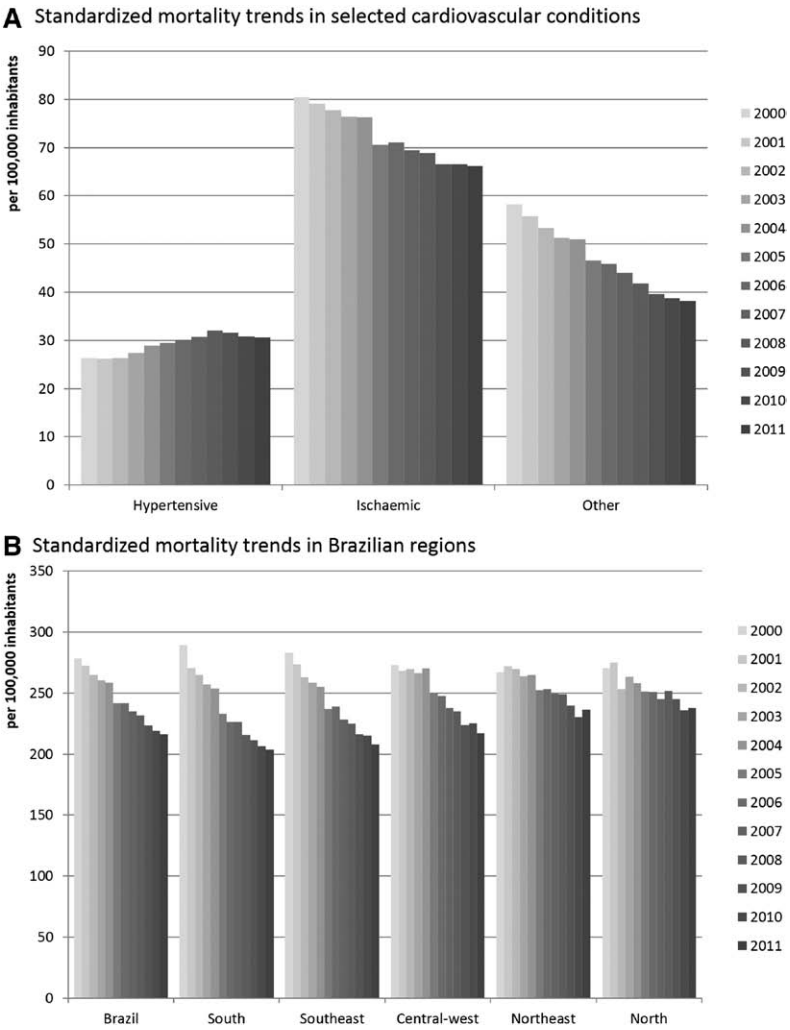

Figure 4. Trends in mortality attributable to cardiovascular disease standardized to the World Health Organization population standard, by year. Brazil, 2000 to 2011. **A**, Trends in selected cardiovascular conditions. **B**, Trends in Brazilian regions.

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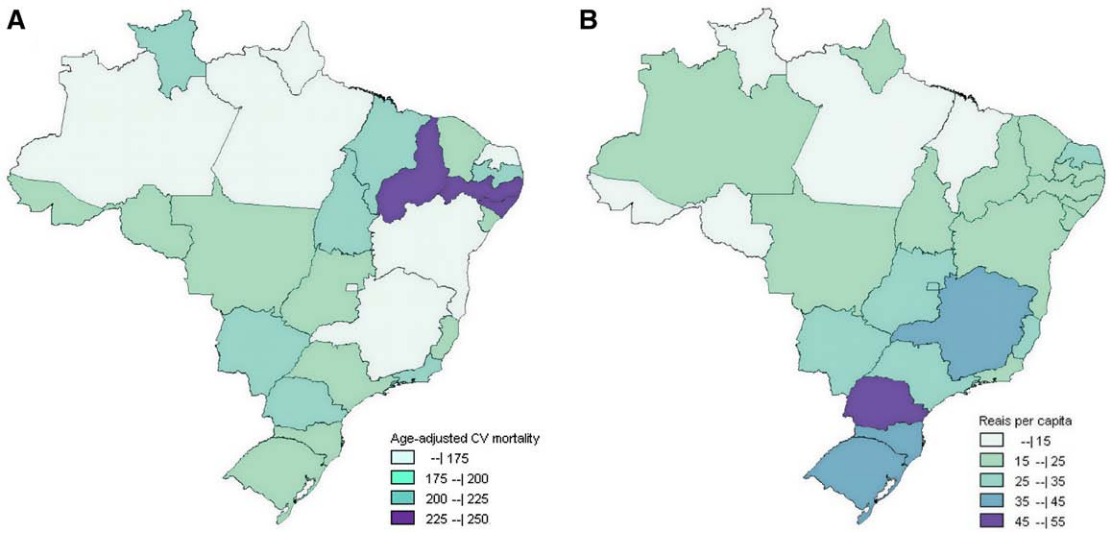

Figure 5. A, Standardized cardiovascular mortality across the different Brazilian states, 2011 (deaths attributable to cardiovascular causes per 100 000 inhabitants). **B**, Per capita cost in reais for hospitalizations financed through the national health system attributable to heart disease among adults aged >40 years. Brazil, 2012. (Currency exchange rate 1 USD = 1.96 Brazilian reais).

women (–3.0%/y) than in men (–2.5%/y, $P<0.001$, Figure IB in the online-only Data Supplement), and this pattern was also observed for coronary heart disease (women, –2.2%/y; men, –1.4%/y, $P<0.001$) and for stroke (women, –3.6%/y; men, –3.3%/y, $P=0.002$). Figure IC in the online-only Data Supplement shows mortality trends from 1996 to 2011 in the 3 areas of Sao Paulo city classified by their geographically defined mean household income.[35] Death rates for CVD, coronary heart disease, and stroke show an inverse gradient according to mean household income throughout the period, which has not decreased as rates declined. In fact, the social gap in death rates seems to be widening in men (Table V in the online-only Data Supplement).

Morbidity

Data obtained from the SUS hospital database show that the public health system financed 940 323 hospitalizations for CVD (472 hospitalizations/100 000 inhabitants) in 2012. In relative terms, cardiac conditions accounted for 8.3% of all hospitalizations and for 18.6% of all reimbursement for hospital expenses by the SUS. Based on hospital billing codes, the frequency and cost of hospitalizations can be categorized by the procedures rendered and, if no major procedure was performed, by the underlying condition receiving treatment (Table 2). From 2008 to 2012, the proportion of publicly financed hospitalizations attributable to cardiac conditions decreased from 17.8% to 16.6%, and the fraction of total hospitalization costs reimbursed for cardiac procedures and treatments decreased from 31.3% to 29.9%. Over this period, the rates of hospitalization for heart failure and hypertension have decreased, and those for angioplasty and myocardial infarction have increased (Figure 6). Atrial fibrillation, although not a frequent cause of hospitalization, seems to be an important cause of morbidity, because the prevalence and age distribution is similar to that observed in high-income countries, but the proportion of patients who reported use of anticoagulants is alarmingly low.[36]

Important regional inequalities exist in public financing of hospitalizations for heart disease. Figure 5B color codes the ranking of Brazilian states in terms of per capita hospital expenditures for heart conditions in 2012. In 2012, median per capita outlay for adults ≥40 years of age in states of the northern and northeastern regions was US$6.07 and US$10.28, respectively, which is considerably less than the median per capita outlay in states of the southern region, US$20.32. This difference was present despite the fact that CVD mortality now varies little across regions (Figure 5B).

Tropical Diseases

Chagas disease, caused by the infection of the protozoa *Trypanosoma cruzi,* has been recognized as a major cause of cardiac morbidity and mortality in Brazil since its discovery by the Brazilian scientist Carlos Chagas in the beginning of the 20th century. Urbanization and effective public health measures to reduce transmission through controlling vectors and screening blood transfusions have almost eliminated new cases in recent decades and have led to reductions in disease prevalence and mortality in the past 20 years.[37] The current number of infected individuals is estimated at 4.6 million (95% CI, 2.9–7.2 million),[38] but most patients remain asymptomatic for decades. In its chronic phase, Chagas disease produces clinically apparent heart disease in 20% to 40% of the infected patients, manifesting as heart failure, arrhythmia, heart block, thromboembolism, stroke, and sudden death.[37] Clinical disease is now a problem mostly of later middle-aged and older adults.[39] Chagas disease remains an important cause of pacemaker and cardioverter defibrillator implantation, heart transplantation, and stroke, especially in the central part of the country.[37]

Rheumatic heart disease in Brazil has had a marked reduction in incidence over the past decades, but the disease persists as a health problem. The Brazilian Society of Cardiology, based in small studies of schoolchildren, estimated its prevalence as 1 to 7 cases/1000, which is significantly higher than the

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Table 2. Frequency and Associated Costs of Procedures Performed and of Conditions Treated in Publicly Financed Hospitalizations for Cardiac Causes, Brazil 2012

	N (in thousands)	N per 100 000 inhabitants	Cost (US$, millions)
Procedures performed			
Angioplasty	66.8	33.5	207.8
Cardiac transplant	0.2	0.1	4.0
Coronary revascularization	23.9	12.0	151.9
Implantable cardiac defibrillator	1.5	0.7	32.3
Electrophysiological study	6.4	3.2	14.7
Heart valve surgery	14.0	7.0	93.7
Pacemaker	27.2	13.6	98.1
Surgery aorta	0.8	0.4	6.4
Total	140.8	70.5	608.9
Condition treated*			
Acute coronary syndrome	75.6	38.0	38.3
Aortic aneurysm	2.9	1.5	1.8
Arrhythmia	28.7	14.4	10.4
Cardiac arrest	2.3	1.1	2.3
Endocarditis	2.0	1.0	2.5
Heart failure	279.7	140.4	171.6
Hypertension	111.7	56.1	15.2
Myocardial infarction	59.4	29.8	53.4
Myocardiopathy	1.6	0.8	0.8
Pericardial pathology	1.4	0.7	1.4
Total	565.3	283.8	297.7

*Without the procedures here shown being performed. Data obtained from DATASUS, the data processing system of the Brazilian Health Ministry.

prevalence of the disease (0.1–0.4 cases/1000 schoolchildren) in high-income countries.[40] Indeed, during 2013, 5169 hospitalizations were registered in the SUS because of acute rheumatic fever and 8841 because of chronic rheumatic heart disease, at a total cost of R$103 million, mostly for heart valve surgeries.

Current and Novel Strategies for Disease Prevention and Treatment

Brazil has implemented many policies aiming to monitor, reduce, and control cardiovascular risk factors over recent decades.[7,11] Countrywide multisector antitobacco policies, started in 1989,[16] have been successful. Obesity prevention and control have received special attention with recent implementation of a comprehensive national plan. The plan focuses on confronting social and environmental causes of obesity, through the development of a food and nutrition education framework, the provision of healthy food in school environments, the promotion of healthy diets through food guidelines, the regulation for marketing of food to infants and children, and the negotiation with industry for voluntary reductions in trans fatty acids and salt, among other actions.[41] Large-scale population-based interventions to promote physical activity initiated in the 1990s with the Agita São Paulo (Move São Paulo) and Agita Brazil (Move Brazil) programs.[42,43] This approach, which provides simple health promotion messages aimed at stimulating physical activity, was later adopted internationally as Move for Health. Recent national actions have focused on the creation of community health clubs, for which the Health Ministry provides financing with the aim of reducing structural barriers to the access to physical activity practice, particularly among low-income populations.[44]

In 2011, these actions were consolidated in the Strategic Action Plan to Confront Noncommunicable Diseases in Brazil, 2011 to 2022, which emphasizes population-based health promotion and prevention, and also prioritizes actions and investments in surveillance and comprehensive care.[45] It includes several quantitative goals to be achieved by 2022 (summarized in Table 3).

Hypertension, diabetes mellitus, and CVD prevention and treatment are among the priorities of primary care in Brazil. Drugs for hypertension and diabetes mellitus and also statins are freely dispensed in public primary care facilities, although at times availability is incomplete.[46] In 2004, the Health Ministry launched the People´s Pharmacy Program that expanded public pharmacies and, more importantly, has subsidized the prices of certain priority drugs dispensed via commercial drugstores, greatly increasing access to free or low-cost medicines for chronic diseases such as hypertension and diabetes mellitus, irrespective of the prescribing source (SUS or private sector).[46]

Cardiovascular care in Brazil is regulated by policies operationalized by the Health Ministry and its agencies National Agency of Supplementary Health (for the private sector) and Brazilian Health Surveillance Agency. The incorporation of new drugs and devices requires approval by Brazilian Health Surveillance Agency. Their release for use in clinical care also requires a health technology assessment done by the Health Ministry under the aegis of the National Committee for Technology Incorporation.[47] Based on technology assessment and cost-effectiveness analysis, some new technologies, such as the transcatheter aortic valve implantation, have not been incorporated in the SUS.

Significant efforts have been undertaken by the Health Ministry and hospitals to improve the quality of care of hospitalized patients with CVD. Mortality related to cardiovascular hospitalizations in Brazil for cardiac surgery[48] and myocardial infarction[49] has been reported as higher than international standards. The results are worse among patients whose hospitalization was financed by the SUS.[50,51] This disparity can be attributed both to the lower socioeconomic conditions of SUS patients and the greater difficulty in timely access to health facilities, as in the case of myocardial infarction, and to lesser use of evidence-based therapies, as well.[49] A recently published cluster-randomized clinical trial showed that quality improvements tools for acute coronary syndrome implemented in Brazilian public hospitals resulted in significant improvement of in-hospital cardiovascular event rates and 30-day all-cause mortality.[52]

Myocardial infarction and stroke have recently received special attention by the Health Ministry with the aim of improving the organization of regionalized systems of care for both conditions.[53–55] New procedures and drugs were made reimbursable by the SUS, and financial incentives were given to create regionalized networks. For myocardial infarction,

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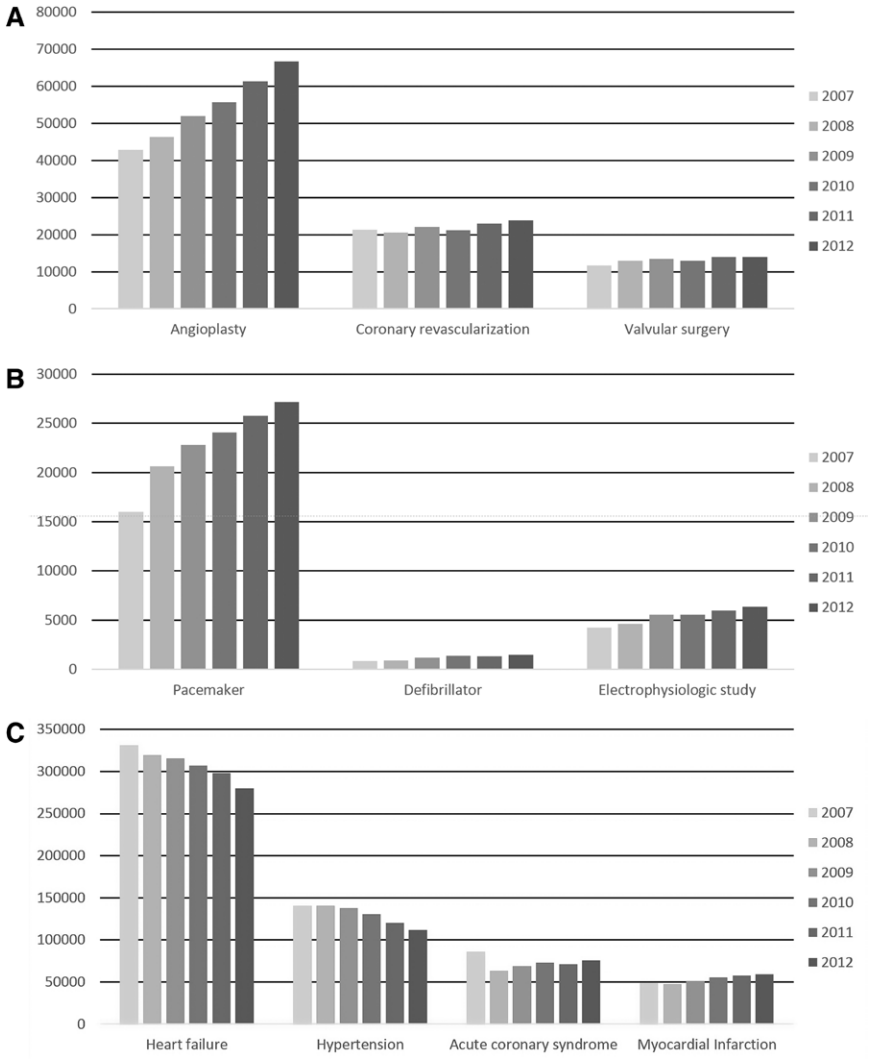

Figure 6. Trends in the annual frequency of hospitalizations for procedures and for other treatment of cardiac conditions in the SUS, Brazil, 2007 to 2012. **A**, Coronary angioplasty, coronary revascularization, and valvular surgery. **B**, Pacemaker, cardiac defibrillators, and electrophysiological studies. **C**, Heart failure, hypertension, acute coronary syndrome, and myocardial infarction.

different strategies, including prehospital thrombolysis and transfer for primary percutaneous coronary intervention, have shown improvement in cardiovascular outcomes.[53,56,57] Most of these successful experiences include a component of telehealth, with prehospital ECG being sent to a central hub to guide further management of the patients. Telehealth has been a focus of health authorities, not only for emergency care, but also as a support for primary care, specifically for the interpretation of ECGs performed in distant small cities.[58]

Perspectives and Challenges

Despite major age-adjusted declines over the past decades, CVD remains the main cause of death and a major cause of morbidity in Brazil. A summary of the main gaps in knowledge and suggested next steps for the improvement of cardiovascular health in Brazil are shown in Table 4. Considerable data relevant to cardiovascular health are now available from governmental health surveillance and administrative databases and from epidemiological studies. However, representative and reliable nationwide data on many health behaviors and cardiovascular risk factors, and on morbidity assessed in both the public and the private sectors, remain sparse. Although the striking reduction of tobacco use is to be celebrated, the obesity and diabetes epidemics and the widespread existence of unhealthy habits are sources of current concern. Of note is the difficult challenge of reducing social inequities in cardiovascular risk factors and in morbidity and mortality, as well, in Brazil. Mounting evidence supports greater preventive action to deal with these current challenges, a task not only for health authorities and professionals, but for the Brazilian society, which needs to be educated to get involved with health public

Table 3. Quantitative goals of the Strategic Action Plan to Confront NCD in Brazil to be Achieved by 2022

1. To reduce premature mortality from NCD by 2% per year
2. To decrease the prevalence of obesity among children and adolescents by about the half of current rates and to prevent further increases in obesity among adults
3. To drop smoking prevalence to 9.1%
4. To boost the prevalence of adequate leisure time physical activity from 14.9% to 22%
5. To raise daily consumption of fruits and vegetables from 18.2% to 24.3%
6. To reduce the average daily intake of salt per person from the current 12 g to 5 g

NCD indicates noncommunicable disease.

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Table 4. Summary of the Main Gaps in Knowledge and Suggested Next Steps for the Improvement of Cardiovascular Health in Brazil

Gaps in Knowledge	Suggested Next Steps
Brazilian health system	
1. Health care data are difficult to integrate across databases, complicating the planning and evaluation of health policies	• Implement unique individual identification codes in information systems to facilitate data integration in studies of causes, outcomes, quality of care, and cost-effectiveness. • Implement academic-governmental partnerships to link data across databases through methods that protect patient confidentiality.
2. The proper mix of public and private care is uncertain	• Stimulate data generation and debate on the proper mix, incorporating information on effectiveness and cost of competing approaches.
Health behaviors and CVD risk factors	
3. The role and basis of age, sex, racial/ethnic, genetic and regional variations of health behaviors, risk factors and outcomes are poorly understood.	• Obtain representative and reliable nationwide data on health behaviors and cardiovascular risk factors in greater detail. • Strengthen cohort studies to permit better understanding of the epidemiology and the genetic basis of CVD, promoting opportunities for local and international collaboration in research. • Stimulate combined efforts from different governmental sectors to incorporate available evidence to make healthy choices easier.
Mortality	
4. The national mortality information system is still incomplete, with a relatively high proportion of ill-defined causes of death and of garbage codes.	• Improve quality of death certificate data through increased use of supplemental methods (eg, linkage to hospitalization and other databases); implement a methodology of redistributing garbage codes.
Morbidity	
5. Data on cardiovascular care in the private sector are not available.	• Remove obstacles to the availability of private sector healthcare data and stimulate expertise in its analysis.
Tropical diseases	
6. The evidence base for management of Chagas disease is weak.	• Develop and evaluate strategies of recognition and treatment of more severe cases of Chagas disease. • Evaluate the need and efficacy of currently available and new trypanocidal drugs.
7. The prevalence of RHD is poorly described, although still high.	• Evaluate the prevalence of subclinical rheumatic heart disease in school children by using screening protocols, • Improve the use of specific measures of primary and secondary prevention of RHD in the primary care setting.
Disease prevention and treatment	
8. Nationwide prevalence and trends of CVD and its risk factors are poorly described.	• Expand the scope of future representative health surveys to include more direct measurements of CVD risk factors.
a. Information necessary to guide public health policies to control the obesity and diabetes epidemics is incomplete.	• Strengthen the evidence base for public health initiatives and implement policies that stimulate healthy eating, weight control, an active lifestyle, and reduction of alcohol consumption.
b. Specific prevention strategies taking epidemiological and cultural aspects of the Brazilian population into account are lacking.	• Construct and validate risk scores for CVD calibrated to the Brazilian population. • Develop strategies to mobilize communities to play an active part in the prevention of CVD.
9. Access to primary and specialized care is still unequal across regions and social groups.	• Strengthen public health system funding and management capacity. • Use innovative technology, such as telehealth, to improve the access to specialized care. • Expand regionalized networks for specific diseases, such as myocardial infarction. • Stimulate, through public policies, transferring of healthcare workers to areas where they are lacking, such as the Amazon region.
10. Information on quality of health care, while scanty, suggests that the quality of care needs improvement.	• Implement quality-of-care programs and supporting information systems; promote the conduction of quality-of-care studies Stimulate means of incorporating the evidence base for CVD care into clinical practice.
11. Cost-effectiveness of many high-cost diagnostic and therapeutic procedures is unknown in the Brazilian context.	• Strengthen capacity for rapid evaluation of cost-effectiveness in the process of incorporation of new technologies.

CVD indicates cardiovascular disease; and RHD, rheumatic heart disease.

policies and to assume shared responsibility for care at the individual level.

Brazil has one of the largest publicly financed patient care systems in terms of population coverage. Technical expertise, excellence in hospital care, and innovative solutions for improving health care for heart disease exist in many centers; the challenge is to make them available on a nationwide scale. Funding remains a central issue. An increase in the budget of publicly financed health care is essential to allow investments in infrastructure and to organize the system. The proposal of offering universal, comprehensive, and equitable high-quality health care to the

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population, sustaining a model centered on health promotion and primary health care without leaving behind conditions that require incorporation of expensive technology, will remain a challenge for Brazil in the years to come. Although improvements in health quality and outcomes, including longevity, are rapidly occurring in Brazil, differences remain across regions and social groups, with the poorest population experiencing the greatest impact of CVD, especially at a younger age. Reducing these disparities with a combination of cost-effective multisector strategies and population involvement will be one of the main future challenges.

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Cardiovascular Health in Brazil: Trends and Perspectives

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SUPPLEMENTAL MATERIAL

Cardiovascular health in Brazil: trends and perspectives

Table S1: Characteristics of Public and Private Health Systems in Brazil.

	Public Health System (SUS)	Private Health System
Access	Universal, free of charges	Direct payment to health professionals or through health plans
Coverage (Number of Inhabitants) [1]	202,768,562	47,879,706 (**Figure 1D**)
Assistance model	Centered on primary care – The Family Health Program	Centered on specialized care
Governance and Regulation [3,4]	• Committees including Federal, State and Municipalities authorities • Decentralized – focus on municipalities • Social control – Health Councils and Conferences	• Autonomous health professionals or health plan/insurance • Regulated by National Agency of Supplementary Health
Funding [3,4]	• Tax-based with transfer between spheres of government – fixed amount *per capita* • Payment per capita – primary care • Payment for service (mainly for secondary and tertiary care): Government to health care provider	• Insurance and out-of pocket: 5,6% of family income • Employees: subsidized by companies or the government
Revenue - proportion of GDP* [2]	3.8%	5.0%
Procedure coverage [3,4]	• List reviewed every two years by Health Ministry	• List of Mandatory Medical Procedures defined by the government through ANS† and revised periodically

Medication coverage [2,3]	• List reviewed every two years by Health Ministry – free of charges • "Popular Pharmacy" Program – free or 85% discount for selected drugs for chronic diseases	• Mostly out-of-pocket by beneficiaries – 2.7% of family income
Number of facilities [2]		
1. Hospital beds	152,892	279,104
2. Health establishments	74,159	188,815

*GDP: gross domestic product.

Table S2. Prevalence (%) of selected health behaviors and risk factors related to cardiovascular diseases among adults (≥18 years old) according to sex and urban/rural residence, from the Brazilian National Health Survey, 62982 households, Brazil, 2013.

Health behaviors and risk factors	Total	Men	Women	Urban	Rural
Recommended intake of fruits and vegetables*	37.3	34.8	39.4	38.2	31.2
Recommended leisure time physical activity†	22.5	27.1	18.4	23.8	13.8
Insufficient physical activity‡	46.0	39.8	51.5	45.6	48.3
Tobacco use	15.0	19.2	11.2	14.6	17.4
Overweight (BMI≥25 kg/m^2)	56.9	55.6	58.2	NA	NA
Obesity (BMI≥30 kg/m^2)	20.8	16.8	24.4	NA	NA
Abnormal waist circumference (≥ 102 [men], ≥ 88[women])	37.3	21.8	52.1	NA	NA
Self-reported medical diagnosis of high blood pressure	21.4	18.3	24.2	21.7	19.8
Self-reported medical diagnosis of diabetes	6.2	5.4	7.0	6.5	4.8
Self-reported medical diagnosis of high cholesterol levels	12.5	9.7	15.1	13.0	10.0
Self-reported medical diagnosis of cardiovascular disease	4.2	12.4	13.0	3.9	4.4
Self-reported medical diagnosis of stroke	1.5	1.6	1.4	1.6	1.0

BMI = body mass index. NA= non-available. Data obtained by questionnaire, except BMI and waist circumference, by direct measurement.

* Consumption of fruits and vegetables at least five portions a day at least five days per week. † Engaging in light or moderate physical activities for at least 150 min per week or intense activity for at least 75 min per week, during leisure time. ‡ Absence of physical activity for at least 150 minutes per week in one of the three domains: leisure, work or transportation for work place.

Table S3. Prevalence of hypertension estimated by population-based household surveys in selected Brazilian cities from 1999-2009.

Study	Sample size	Sample characteristics			Prevalence of Hypertension (%)		
City/region/year	N	Age group (y)	Age mean	Male (%)	Overall	Men	Women
Vitória/Southeast/1999-2001[5]	1,656	25-64	44.6±10.9	47.6	34.2	45.2	32.2
Goiânia/Central-West/2006[6]	1,739	≥18	39.7±15.6	34.6	35.3	41.8	31.8
Nobres//Central-West/2001[7]	1,003	≥18	42.6±15,4	51.3	30.1	29.1	31.1
Campo Grande/Central-West/2005[8]	892	≥18		44.8	41.5	51.8	33.1
Florianópolis/South/2009-2010[9]	1,720	20-59	38.0	44.5	40.1	51.6	30.5
Tubarão/South/2003[10]	707	≥18	45.3	43.1	37.1	40.0	34.6
Lages/South/2009[11]	2,022	20-59	31.2±11.6	47.7	33.7	31.1	38.1
Overall	9,737				35.9 (34.9-36.9)	41.0 (39.5-42.5	31.9 (30.7-33.1)

Table S4. Prevalence of dyslipidemia in household population-based studies in selected cities in Brazil in the past 15 years.

City/Region	Year of data collection	n	Age group (years)	Mean Age (years)	Male (%)	Cholesterol 200-239 mg/dL	Cholesterol ≥240 mg/dL	Triglycerides ≥ 200 mg/dL
Bambuí/Southeast[12]	1997	816	30-59	36.3	43.9	24.9 (21.9-27.9)	9.8 (8.8-11.8)	14.1 (11.7-16.5)
Rio Grande do Sul/ South[13]	1999/2000	1,066	≥20	NA	48.2	NA*	5.6 (4.2-7.0)	NA*
Vitória/ Southeast [14,15]	1999/2001	1,656	25-64	44.6	47.6	32.8 (30.5-35.1)	26.2 (24.1-28.2)	17.5(15.7-19.3)
Salvador/Northeast[16]	2000	1,298	≥20	40.9	42.3	14.8 (12.9-16.7)	31.3 (30.1-32.5)	13.3 (11.5-15.1)
São Paulo/Southeast [17]	2001/2002	2,103	15-59	38.4	44.4	NA*	9.9 (8.6-11.2)	16.0 (14.4-17.6)
Campos/ Southeast [18]	2001/2002	1,039	18-96	48.8	47.8	19.6 (17.2-22.0)	4.2 (3.0-5.4)	17.1 (14.8-19.4)
Goiânia/Central-West[19]	2004	2,920	15-97	48.0	39.1	16.7 (15.3-18.1)	17.6 (16.3-19.1)	13.3 (12.1-14.6)

Prevalence is given as % (CI 95%). *NA: not available.

Table S5. Average annual percent change of mortality for all cardiovascular diseases, coronary heart disease and stroke for both sexes from 1996 to 2010 according to household family income in São Paulo city.

Household Income	All Cardiovascular Diseases	Coronary Heart Disease	Stroke
		Men	
High	-4.1 (-4.5 to -3.8)	-3.8 (-4.8 to -3.8)	-4.9 (-5.6 to -4.2)
Middle	-2.8 (-3.2 to -2.4)	-2.4 (-3.6 to -2.4)	-2.9 (-3.8 to -2)
Low	-2.3 (-2.6 to -2.1)	-1.9 (-2.7 to -1.9)	-1.8 (-3.6 to -0.1)
		Women	
High	-3.1 (-4.4 to -1.8)	-4.9 (-5.6 to -4.2)	-4.5 (-5.3 to -3.8)
Middle	-3.5 (-3.9 to -3.0)	-3.7 (-4.3 to -3.2)	-3.6 (-4.3 to -3)
Low	-3.2 (-3.5 to -3.0)	-3.3 (-3.8 to -2.9)	-3.9 (-4.4 to -3.4)

Figure legends

Figure S1. Age-adjusted Premature Deaths (30-69 years) by Cardiovascular Diseases in Brazil per 100,000 inhabitants. A. Age-adjusted mortality rates of all cardiovascular diseases (CVD), coronary heart disease (CHD) and stroke according to race and sex, 2010. B. Temporal trends for all cardiovascular diseases according to sex, 1996 to 2011. C. Age-adjusted mortality for cardiovascular diseases according to sex and homogenous areas according to household income (high, middle and low) in the city of São Paulo, Brazil, from 1996 to 2011. M: Men. W: Women. AAPC: Average annual percent change. All data obtained from the database of the Brazilian Health Ministry (www.datasus.gov.br) for all Brazilian states (**Figures S1a and S1b**) and for São Paulo city (**Figure S1c**). For analysis shown in **Figure S1c,** 96 districts of the city of São Paulo were categorized into three groups according to household income as high, middle, and low. Age-adjusted premature deaths (30–69 years-old) rates were standardized using the World Population as standard for all cardiovascular diseases (chapter IX of the 10th ICD) coronary heart disease (codes: I20-25), and stroke (codes: I61-69) separately. (95% confidence interval) calculated using the Joinpoint Regression Program 4.0 (National Cancer Institute, Bethesda, MD, 2013).

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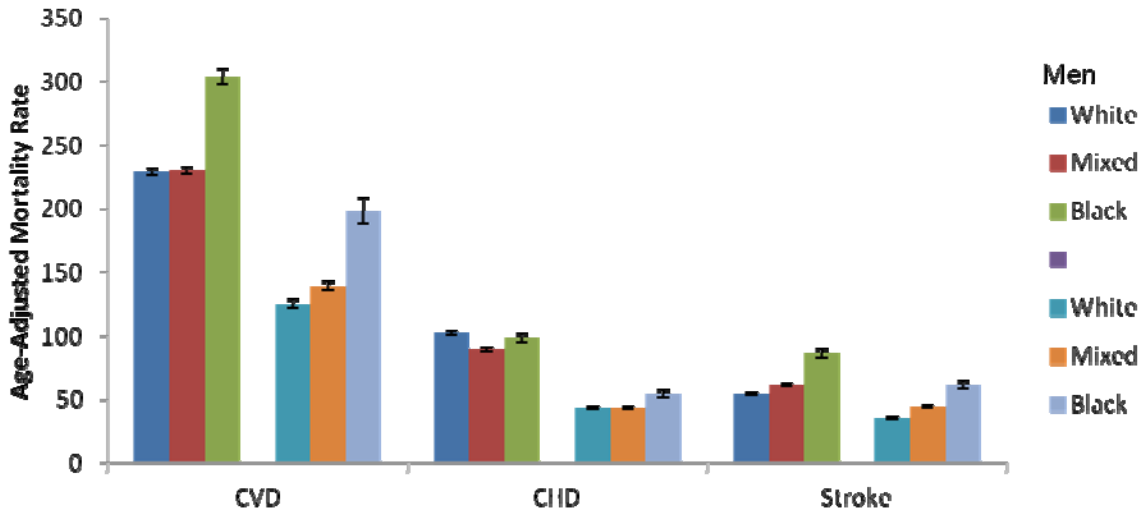
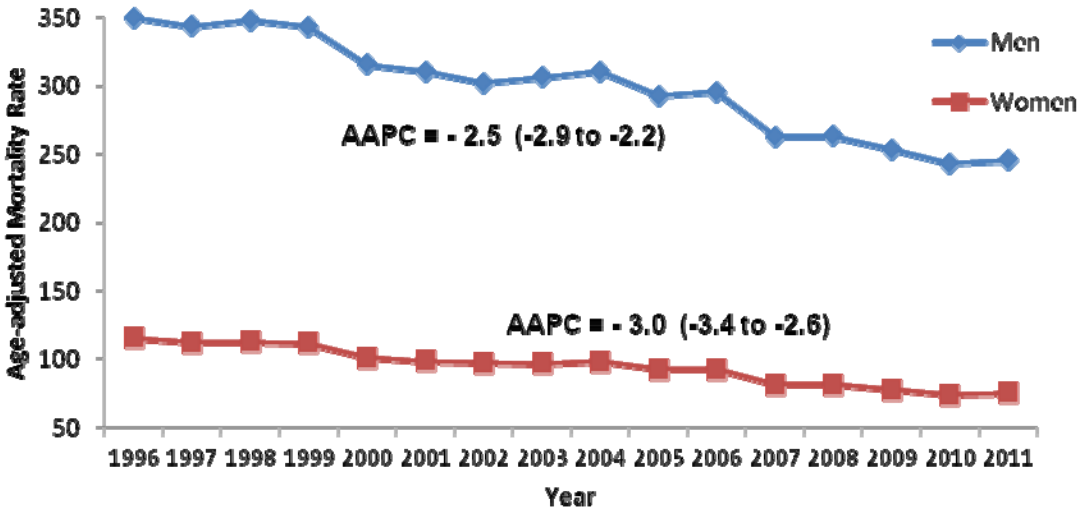
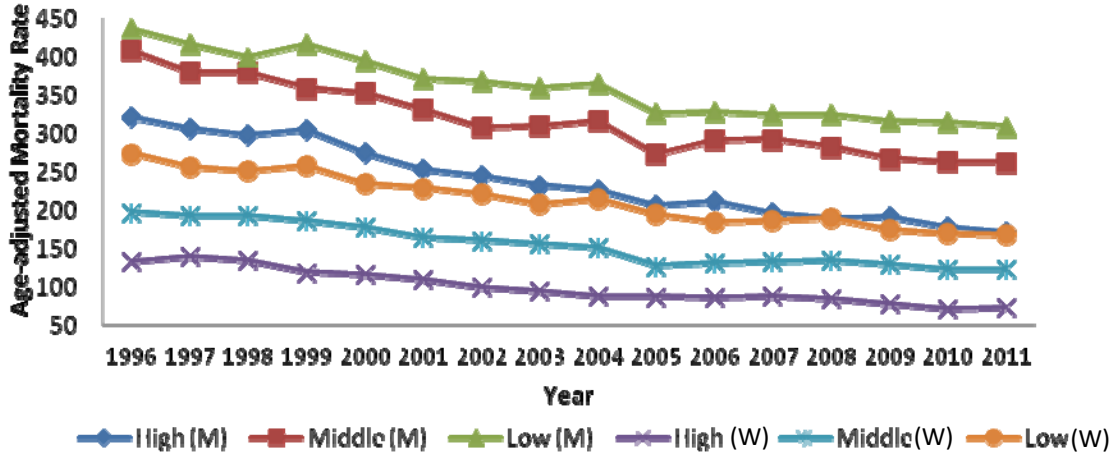
A


Age-Adjusted Mortality Rate
350
300
250
200
150
100
50
0
CVD
CHD
Stroke
Men
White
Mixed
Black
White
Mixed
Black

B


Age-adjusted Mortality Rate
350
300
250
200
150
100
50
Men
Women
AAPC = - 2.5 (-2.9 to -2.2)
AAPC = - 3.0 (-3.4 to -2.6)
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Year

C


Age-adjusted Mortality Rate
450
400
350
300
250
200
150
100
50
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Year
High (M)
Middle (M)
Low (M)
High (W)
Middle (W)
Low (W)