Original Article

Evolution of Socioeconomic Indicators and Cardiovascular Mortality in Three Brazilian States

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Abstract

Background: Cardiovascular diseases are the major cause of death in Brazil.

Objective: To correlate cardiovascular mortality rates in the states of Rio de Janeiro, São Paulo and Rio Grande do Sul, and in their capitals, between 1980 and 2008, with socioeconomic indicators collected from 1949 onwards.

Methods: Population and death data were obtained from the Brazilian Unified Health System databank (Datasus). Mortality rates due to the following were calculated and adjusted by use of the direct method and compensated for poorly defined causes: ischemic heart diseases; cerebrovascular diseases; cardiovascular diseases; poorly defined causes; and all causes. Child mortality data were obtained from state and municipal health secretariats and from the Brazilian Institute of Geography and Statistics (IBGE). Information on gross domestic product (GDP) and educational level was obtained from the Brazilian Institute of Applied Economic Research (Ipea). The mortality rates and socioeconomic indicators were correlated by using the estimation of Pearson linear coefficients to determine optimized year lag. The inclination coefficients of the regression between the dependent variable "disease" and the independent variable "socioeconomic indicator" were estimated.

Results: The three states showed a reduction in mortality, which was especially due to a decrease in cardiovascular mortality, mainly of cerebrovascular diseases. The decrease in cardiovascular mortality was preceded by a reduction in child mortality, an elevation in the per capita GDP, and an increase in the educational level, and a strong correlation between indicators and mortality rates was observed.

Conclusion: The three indicators showed an almost maximum correlation with the reduction in cardiovascular mortality. Such relationship indicates the importance of improving quality of life to reduce cardiovascular mortality. (Arq Bras Cardiol. 2013;100(2):147-156)

Keywords: Cardiovascular Diseases / mortality; Cardiovascular Diseases / economy; Social Indicators; Epidemiology; Brazil.

Introduction

During the 20th century, especially after World War II, an improvement in socioeconomic indicators was observed in all developed countries, and later in developing countries, followed by a drop in general mortality rate[1,2], particularly a decrease in the number of deaths due to cardiovascular diseases[3].

Based on data available, the progressive drop in the mortality rate due to vascular diseases (coronary or cerebral) cannot be explained by the management of the classical risk factors (arterial hypertension, diabetes mellitus, obesity, dyslipidemia, and smoking). Over the past decades, the prevalence of those factors has increased in Brazil[4-11], except for tobacco use, whose prevalence has decreased, but that reduction trend is recent and posterior to the beginning of the decline in cardiovascular mortality[12]. In addition, high technology procedures, coronary by-pass surgery and angioplasty, do not explain that reduction in mortality because of their poor performance[13-15] and reduced distribution in Brazil. However, that reduction in cardiovascular mortality might be more effectively related to the better protection provided to the general population against exposure to infectious agents, due to the improvement in the quality of life of the populations. That actually preceded the decline in cardiovascular mortality[3].

The most important socioeconomic indicators are per capita Gross Domestic Product (per capita GDP), child mortality, and educational level. Such factors should have contributed to the positive socioeconomic evolution of the populations assessed in this study.

This study was aimed at correlating the compensated and adjusted cardiovascular mortality rates in the states of Rio de Janeiro, São Paulo and Rio Grande do Sul, and in their capitals,

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between 1980 and 2008, with the following indicators: child mortality collected from 1950 onwards; per capita GDP collected from 1949 onwards; and educational level collected from 1960 onwards.

Methods

Socioeconomic and mortality data were collected in the states of Rio de Janeiro, São Paulo and Rio Grande do Sul, and in their capitals. The socioeconomic indicators were per capita GDP, child mortality, and educational level (represented by the years of schooling of individuals over the age of 25 years). Those indicators were chosen based on the need to represent economic factors (per capita GDP), and factors related to health evolution (child mortality) and access to knowledge (educational level). In addition, those three indicators were the most available and had a satisfactory time lag regarding the mortality rates studied.

Information regarding child mortality, number of children who die by the age of one year per thousand live births per year, from 1980 to 2007, originated from the following sources: city of Rio de Janeiro – Municipal Health Secretariat (SMS)[16]; state of Rio de Janeiro – State Health Secretariat (SES)[17]; state and city of São Paulo – Data Analysis State System Foundation (Seade)[18] of the Regional Planning and Development Secretariat of the São Paulo Government; state of Rio Grande do Sul and city of Porto Alegre – SMS of Porto Alegre[19]. For the years before 1980, ten-year means provided by the Brazilian Institute of Geography and Statistics (IBGE)[20], inserted in the years 1945, 1955, 1965 and 1975, were used.

The GDP information was obtained from the Brazilian Institute of Applied Economic Research (Ipea)[21] for the years 1949, 1959, 1970, 1975 and 1980, and from 1985 to 2008. The population data originated from the Brazilian Institute of Geography and Statistics [20] for the years of general censuses (1950, 1960, 1970, 1980, 1991, 2000 and 2010) and of counting (1996). Population estimates for the years between censuses were performed by using the arithmetic method with the census years or counting immediately before or after censuses. Those estimates were performed for the fractions corresponding to the age groups, at ten-year intervals, for each sex. The per capita GDP was calculated by dividing the absolute GDP (in "reais") of the state or its capital by the population in the corresponding year. The educational index corresponds to the ratio between the sum of the years of schooling completed by individuals aged 25 years and over and the total number of individuals in that age group. Those data were obtained from the Ipea[21] for the years 1960, 1970, 1980, 1991 and 2000. For all the years lacking information on any of the indicators, estimates of arithmetic growth were used based on the years immediately before and after the interval lacking information.

Line graphs were built with each socioeconomic indicator represented as variable Y and the years as variable X.

Building the mortality rates comprised the analysis of data restricted to adults aged 20 years and over. Population data from 1980 to 2008 were obtained from the Brazilian Unified Health System databank (Datasus)[22]. Data regarding death were discriminated in the following areas of major interest in the study: cardiovascular diseases, corresponding to those recorded in chapters VII of the International Code of Disease 9 (ICD-9)[23] or IX of the ICD-10[24]; ischemic heart diseases (IHD), corresponding to codes 410-414 of the ICD-9 or I20-I25 of the ICD-10; cerebrovascular diseases (CBVD), corresponding to codes 430-438 of the ICD-9 or I60-I69 of the ICD-10. In addition, the following were also used: deaths due to poorly defined causes, comprised in chapter XVI of the ICD-9 and XVIII of the ICD-10; and the total of deaths due to all causes. The ICD-9 was in force up to 1995, while ICD-10, from 1996 onwards. Raw mortality rates and those adjusted for sex and age were calculated by use of the direct method[25,26] for the states and their capitals, per 100 thousand inhabitants. Because the poorly defined causes of mortality in the state of Rio de Janeiro have significantly increased since 1990[27], compensation was performed by allocating to the deaths due to cardiovascular diseases, IHD and CBVD their part of deaths due to poorly defined causes. After that, the mortality rates adjusted for sex and age were estimated. The standard population for the adjustments was that of the state of Rio de Janeiro registered in the 2000 census, stratified according to seven age groups (20 to 29 years; 30 to 39 years; 40 to 49 years; 50 to 59 years; 60 to 69 years; 70 to 79 years; and 80 years and over) for each sex. Those rates were denominated compensated and adjusted. Line graphs of mortality rate due to all causes, cardiovascular diseases, IHD and CBVD were built for the years 1980 to 2008.

Further details about the methodology used to calculate the mortality rates in the three states, as well as the compensation maneuvers and graph construction can be obtained in a previously published article by the same authors[3].

The mortality rates and socioeconomic indicators were correlated by estimating Pearson linear coefficients[26] in all combinations of time series to determine the optimized annual lag according to socioeconomic data availability, which could be at most 31 years for per capita GDP, 30 years for child mortality, and 20 years for educational level. The optimum annual lag had the highest Pearson linear coefficient in all combined series. For example, in the case of per capita GDP, 31 coefficients were generated for each group of causes of death, the first corresponding to a 31-year lag (per capita GDP of 1949 to 1977 with mortality due to IHD of 1980 to 2008) and the last corresponding to no annual lag (per capita GDP and mortality due to IHD from 1980 to 2008). Those estimates were obtained for the three socioeconomic indicators (per capita GDP, child mortality, and educational level) and the mortality rates due to cardiovascular diseases, IHD, CBVD, and all causes. In addition, the inclination coefficients of the regression between the dependent variable "disease" (cardiovascular disease, IHD, CBVD, and all causes) and the independent variable "socioeconomic indicator" (per capita GDP multiplied by 100 reais, educational level and child mortality) were also estimated in the series with optimum lag according to the linear correlation coefficient.

Quantitative procedures were performed with the programs Excel-Microsoft[28] and STATA[29].

Results

Child mortality rates (Figure 1A) in the three states and capitals studied showed a progressive and important reduction over the period studied, and that reduction exceeded six times when comparing the rates of the years after 2000 with those of the 1950s. The highest values were found in the states of Rio de Janeiro and São Paulo, and the lowest, from 1980 to the most recent years, in the city of Porto Alegre (Figure 1A).

The educational level, represented by the mean of the years of schooling of individuals over the age of 25 years, increased over the period studied, with better indicators in the capitals. The best educational level indicators were found in the city of Porto Alegre, while the worst were found in the states of São Paulo and Rio Grande do Sul (Figure 1B).

The per capita GDP in the three states and capitals increased from 1949 to 1980, when there was a tendency towards a mild decrease and stagnation. Around 2004, the per capita GDP returned to the growing pattern (Figure 1C).

The mortality rates compensated and adjusted for age and sex of adults aged 20 years and over are shown in figure 2. The cardiovascular mortality in the three states and capitals show a descending pattern over the entire period. The cardiovascular mortality in the state of Rio de Janeiro was higher than those in the other regions over the entire period studied, but that in its capital was close to those of the other states and capitals from 1994 onwards. The city of Porto Alegre showed the lowest rates in all years. The state of Rio de Janeiro showed the highest mortality rates due to IHD until 1993 (Figure 2B). From that year on, the rates were similar in the three states. The capitals of Rio de Janeiro and Rio Grande do Sul showed similar rates over the entire period, and they were higher than that of the capital of São Paulo until the beginning of the 1990s. From 1992 on, the capital of São Paulo showed persistently more elevated mortality rates due to IHD until 2008. The mortality rates due to CBVD in the states and capitals (Figure 2C) declined. The most marked reduction was observed in the state of Rio de Janeiro and its capital, whose rates became similar to those of the other states at the end of the studied period.

The correlations between the child mortality and cardiovascular mortality rates showed that each death of a child by the age of one year per thousand live births is related to an increase in mortality due to the following: IHD, between 1.5 and 2.4 deaths per 100 thousand inhabitants; CBVD, between 1.2 and 3.8; cardiovascular diseases, between 4.4 and 7.7; and all causes, between 5.0 and 8.1. Thus, the reduction in child mortality correlates with the reduction in the mortality rates studied. The time lag ranged from 0 to 30 years, and the correlation coefficients, from 0.80 to 0.98 (Table 2).

The one-year increase in the mean of years of schooling in individuals over the age of 25 years caused a reduction in deaths per 100 thousand inhabitants due to the following: IHD, a reduction between 28.2 and 42.1; CBVD, between 20.4 and 58.2; cardiovascular diseases, between 77 and 124.5; and all causes, between 79.3 and 119.4. The time lag ranged from 0 to 20 years, and the correlation coefficients were high, ranging from 0.80 and 0.99 (Table 3).

Discussion

In Brazil, over the last three decades, the mortality rates due to cardiovascular diseases, mainly of CBVDs, significantly decreased. However, the magnitude of the problem is still considerable, especially regarding other consequences, such as disability with a high social cost[30]. The cardiovascular mortality rates in the three states studied and their capitals showed intermediate values when compared with those of other countries. Those three states and their capitals showed, from the year 2000 onwards, rates between 300 and 400 deaths per 100 thousand inhabitants, values neither as high as those from Russia, Ukraine, Romania and other former Soviet Republics, whose rates achieved 1000 deaths per 100 thousand inhabitants, nor as low as those from Japan, whose mortality rate was around 110 per 100 thousand inhabitants[31-33].

According to Achutti, changes in the profile of diseases are still controversial. The identification of classical risk factors and the search for new candidate factors have guided the individual stagings of patients and their management through secondary or primary preventive measures. Social and economic determinants not only influence the presence and distribution of traditional risk factors, but also directly influence the biological mechanisms closely related to cardiovascular pathogenesis (ex.: low birth weight and chronic effects on neuroimmune-inflammatory modulation). Because the relationship between social sciences and neuropsychology is yet to be completely understood, as is the interaction of those determinants in the distribution of biological vulnerability to disease, the progress in that field has been slow[34].

The classical risk factors were highly prevalent and increased in the past decades. The population studies of the late 1970s and early 1980s estimated the prevalence of high blood pressure as between 10% and 25%[10]. Currently, the prevalence of that risk factor ranges from 16.75% to 40.3%, depending on the region assessed. In addition, a significant increase is observed with age, from 7.4%-15.7% at the age group of 25-39 years to 39%-59% in those over the age of 60 years[8]. In the Americas, the number of individuals with diabetes has been estimated as 35 million for the year 2000 and projected to 64 million for the year 2025. In developed countries, the increase will affect mainly the more advanced age groups, due to the increase in life expectancy and population growth; in developing countries, the prevalence of diabetes will increase in all age groups, tripling in the 45-64 age group, and doubling in the 20-44 and over 65 age groups[6].

According to the Brazilian National Study on Family Expenditure (Estudo Nacional de Despesa Familiar - ENDEF) carried out in 1974/1975, the prevalence of overweight (BMI $\geq$ 25kg/m^2) in Brazil was as follows: Northeastern region, 11% of men and 19% of women; Southeastern region, 20% of men and 29% of women[11]. Those numbers have increased. The prevalence of overweight in Brazil is currently estimated as 38.5% of men and 39% of women[9]. Dyslipidemias, closely related to obesity and overweight, are present in 38% of men and 42% of women[4]. The Western trend of eating more and moving less has led

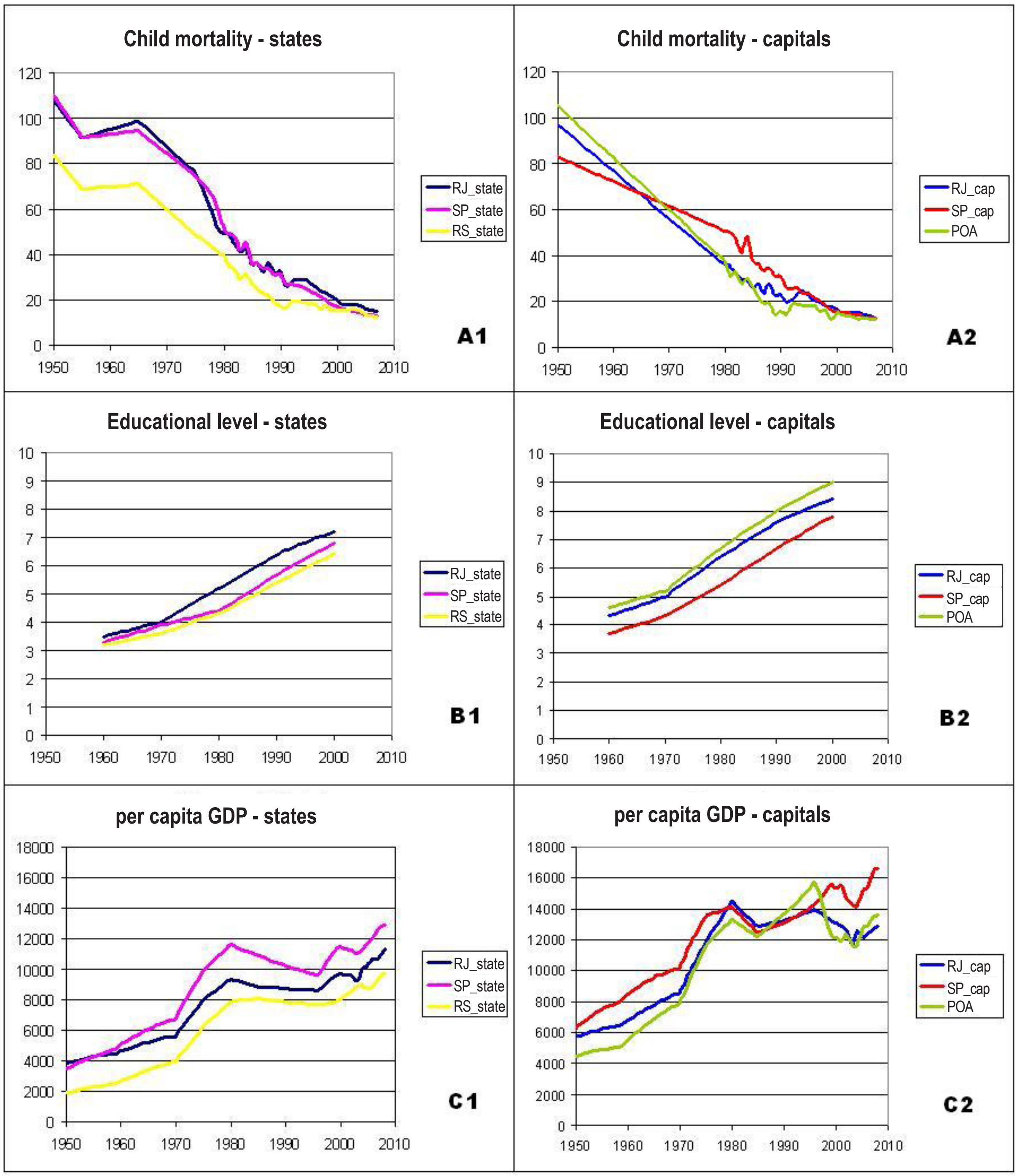

Figure 1 – *Evolution of the major socioeconomic indicators in the states of Rio de Janeiro, São Paulo and Rio Grande do Sul, and in their capitals, from 1950 onwards. A1) Child mortality - states. A2) Child mortality - capitals. B1) Educational level (mean of years of schooling of adults over the age of 25 years) - states. B2) Educational level (mean of years of schooling of adults over the age of 25 years) - capitals. C1) per capita Gross Domestic Product (GDP) - states. C2) per capita GDP - capitals RJ_state: Rio de Janeiro state; RJ_cap: Rio de Janeiro capital; SP_state: São Paulo state; SP_cap: São Paulo capital; RS_state: Rio Grande do Sul state; POA: Porto Alegre city.*

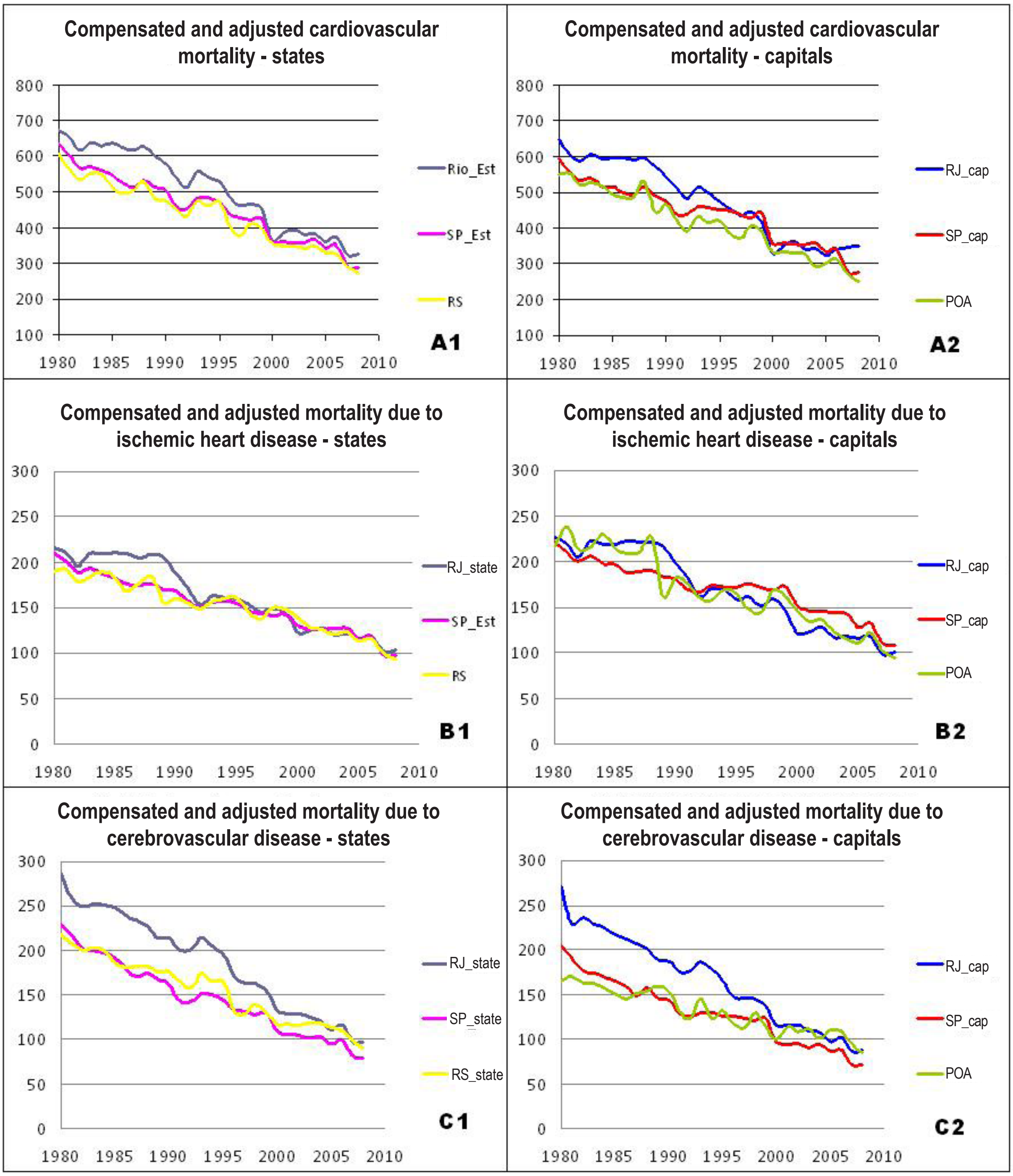

Figure 2 – *Mortality rates of adults over the age of 20 years per 100 thousand inhabitants, adjusted for sex and age, and compensated for poorly defined causes, in the states of Rio de Janeiro, São Paulo, and Rio Grande do Sul, and in their capitals, from 1980 to 2008. A1) Cardiovascular mortality – states. A2) Cardiovascular mortality – capitals. B1) Mortality due to ischemic heart disease – states. B2) Mortality due to ischemic heart disease – capitals. C1) Mortality due to cerebrovascular diseases – states. C2) Mortality due to cerebrovascular diseases – capitals. RJ_state: Rio de Janeiro state; RJ_cap: Rio de Janeiro capital; SP_state: São Paulo state; SP_cap: São Paulo capital; RS_state: Rio Grande do Sul state; POA: Porto Alegre city*

Table 1 – Optimum year lag, linear correlation coefficient and inclination coefficient of the ratio between the standard mortality* of adults due to cardiovascular diseases and all causes per 100 thousand inhabitants, and the per capita Gross Domestic Product (GDP), in reais, in three Brazilian states and their capitals, 1980-2008

Disease**	Indicator per capita GDP	Regions***					
		RJ_Cap	RJ_St	SP_Cap	SP_St	POA	RS
IHD	Lag****	24	21	31	27	28	28
	CorrCoef*****	-0.95	-0.95	-0.97	-0.96	-0.93	-0.95
	R/100******	-1.4	-2.1	-1.2	-1.1	-1.3	-1.4
CBVD	Lag****	24	24	28	24	20	22
	CorrCoef*****	-0.96	-0.98	-0.96	-0.95	-0.93	-0.97
	R/100******	-1.7	-3.0	-1.4	-1.6	-0.8	-1.7
CVD	Lag****	23	24	29	25	26	23
	CorrCoef*****	-0.98	-0.97	-0.97	-0.96	-0.95	-0.96
	R/100******	-3.6	-6.0	-3.4	-3.5	-2.8	-4.1
All causes	Lag****	28	28	29	29	29	28
	CorrCoef*****	-0.91	-0.92	-0.83	-0.90	-0.88	-0.90
	R/100******	-4.1	-6.2	-3.7	-4.1	-3.0	-4.2

**Direct method, according to sex and 10-year age groups, from the age of 20 years – standard: state of Rio de Janeiro, year 2000.*
***IHD : ischemic heart disease; CBVD : cerebrovascular disease; CVD : cardiovascular disease*
****RJ_Cap : Rio de Janeiro capital; RJ_St : Rio de Janeiro state; SP_Cap : São Paulo capital; SP_St : São Paulo state; POA : city of Porto Alegre; RS : Rio Grande do Sul state*
*****Lag : lag in years (maximum: 31 years), optimized according to Pearson correlation coefficient*
******CorrCoef : Pearson correlation coefficient between "disease" and "per capita GDP"*
*******R/100 : Inclination coefficient of the regression between the dependent variable "disease" and the independent variable "per capita GDP", multiplied by 100 reais.*

Table 2 – Optimum year lag, linear correlation coefficient and inclination coefficient of the ratio between the standard mortality* of adults due to cardiovascular diseases and all causes per 100 thousand inhabitants, and child mortality per thousand live births in six Brazilian regions, 1980-2008

Disease**	Indicator Child mortality	Regions***					
		RJ_Cap	RJ_St	SP_Cap	SP_St	POA	RS
IHD	Lag****	25	16	20	0	22	19
	CorrCoef*****	0.97	0.97	0.97	0.97	0.95	0.96
	R******	2.4	1.5	2.4	2.3	2.0	1.5
CBVD	Lag****	25	18	27	0	27	17
	CorrCoef*****	0.99	0.98	0.98	0.98	0.95	0.98
	R******	2.9	2.2	3.8	3.4	1.2	2.0
CVD	Lag****	18	20	22	0	25	18
	CorrCoef*****	0.96	0.98	0.97	0.97	0.98	0.97
	R******	6.3	4.7	7.7	7.3	4.4	4.9
All causes	Lag****	29	23	17	28	27	30
	CorrCoef*****	0.80	0.92	0.83	0.94	0.83	0.89
	R******	5.5	5.0	7.0	8.1	4.0	7.2

**Direct method, according to sex and 10-year age groups, from the age of 20 years – standard: state of Rio de Janeiro, year 2000.*
***IHD : ischemic heart disease; CBVD : cerebrovascular disease; CVD : cardiovascular disease*
****RJ_Cap : Rio de Janeiro capital; RJ_St : Rio de Janeiro state; SP_Cap : São Paulo capital; SP_St : São Paulo state; POA : city of Porto Alegre; RS : Rio Grande do Sul state*
*****Lag : lag in years (maximum: 30 years), optimized according to Pearson correlation coefficient*
******CorrCoef : Pearson correlation coefficient between "disease" and "child mortality"*
*******R : Inclination coefficient of the regression between the dependent variable "disease" and the independent variable "child mortality" (deaths/1000 live births).*

Table 3 – Optimum year lag, linear correlation coefficient and inclination coefficient of the ratio between the standard mortality* of adults due to cardiovascular diseases and all causes per 100 thousand inhabitants, and the years of schooling of individuals over the age of 25 years in six Brazilian regions, 1980-2008

Disease**	Indicator Years of schooling	Regions***					
		RJ_Cap	RJ_St	SP_Cap	SP_St	POA	RS
IHD	Lag****	18	16	17	0	14	18
	CorrCoef*****	-0.98	-0.98	-0.96	-0.98	-0.96	-0.97
	R******	-42.1	-40.3	-29.7	-28.2	-35.3	-41.3
CBVD	Lag****	10	15	10	0	12	10
	CorrCoef*****	-0.99	-0.99	-0.98	-0.98	-0.94	-0.98
	R******	-50.4	-58.2	-34.4	-42.9	-20.4	-44.0
CVD	Lag****	10	18	17	10	13	10
	CorrCoef*****	-0.97	-0.98	-0.97	-0.97	-0.97	-0.97
	R******	-99.4	-124.5	-87.1	-104.4	-77.0	-107.8
All causes	Lag****	20	20	20	17	20	18
	CorrCoef*****	-0.84	-0.88	-0.80	-0.90	-0.86	-0.86
	R******	-103.2	-117.3	-101.7	-140.8	-79.3	-119.4

**Direct method, according to sex and 10-year age groups, from the age of 20 years – standard: state of Rio de Janeiro, year 2000*
***IHD : ischemic heart disease; CBVD : cerebrovascular disease; CVD : cardiovascular disease*
****RJ_Cap : Rio de Janeiro capital; RJ_St : Rio de Janeiro state; SP_Cap : São Paulo capital; SP_St : São Paulo state; POA : city of Porto Alegre; RS : Rio Grande do Sul state*
*****Lag : lag in years (maximum: 20 years), optimized according to Pearson correlation coefficient*
******CorrCoef : Pearson correlation coefficient between "disease" and "years of schooling" of individuals over the age of 25 years*
*******R : Inclination coefficient of the regression between the dependent variable "disease" and the independent variable "years of schooling" of individuals over the age of 25 years*

to an excessive intake of calories, favoring the presence of those factors in genetically predisposed individuals and threatening the health of most nations, mainly in the Western world[9].

Tobacco use is the only classical risk factor whose prevalence has decreased in recent years. According to the Brazilian National Research on Health and Nutrition (PNSN) carried out by IBGE in 1989, the prevalence of smoking in Brazil was 31.7% (39.3% of men and 25.2% of women). The prevalence found in the 2002-2003 epidemiological survey carried out in 16 Brazilian capitals ranged from 12.9% to 25.2% (men, 16.9% to 28.2%; women, 10.0% to 22.9%). However, as that reduction is recent, its impact on the mortality rate is yet to occur[12].

From 1930 to 1980, Brazil experienced a significant economic growth that, despite income concentration, made educational, sanitary, economic and infrastructure improvements possible, reducing infectious diseases and subsequent inflammatory processes. In developed countries, the decline in cardiovascular mortality began approximately 15 years after the end of World War II, which followed the great depression in the early 1930s and the 1918 influenza pandemic. In Brazil, that same decline began approximately 40 years after the beginning of the economic growth period. Exposure to infectious agents and other unhealthy conditions in the first years of life can make individuals more susceptible to the development of atherothrombosis. The decline in child mortality preceded that in cardiovascular mortality. In addition, the reduction in the exposure to infectious diseases early in life might be related to the decline observed in the cardiovascular mortality of adults[35-39].

Our study showed that the decline in child mortality, and the increase in per capita GDP and in educational level are strongly correlated with the reduction in cardiovascular mortality in adults from 1980 onwards, evidencing that the improvement in socioeconomic indicators preceded the decline in cardiovascular deaths. The increase in per capita GDP could prevent many deaths due to cardiovascular diseases. That impact was bigger in the states than in their capitals. A greater income increase in the capitals than in the inner areas of the states might seem necessary to cause similar reductions in cardiovascular mortality and its major components; however, it might be due to the fact that the income has increased more in the capitals than in the states as a whole, while the tendency towards mortality reduction was similar in the capitals and in the inner areas. The increase in the educational level over the past decades, which almost doubled in the three states and capitals studied, had a great impact on mortality, reducing in more than 100 cardiovascular deaths in the states and approximately 80 deaths in the capitals with an one-year increase in the mean of years of schooling among adults. The drop in child mortality preceded that in cardiovascular mortality, and for each child death per thousand live births avoided, there were five less cardiovascular deaths per 100 thousand inhabitants in the regions studied. Those three social indicators are closely related and interdependent.

The per capita GDP has represented the social and economic improvement of the Brazilian society since the second half of the 20th century, and its evolution over the years studied shows a strong relationship with the mortality variation, especially with the cardiovascular mortality rates, whose correlation coefficient is very close to 1. The improvement in the three indicators has related to the drop in cardiovascular mortality and in all-cause mortality. Of the cardiovascular causes, CBVD represents a large group with the greatest reduction in mortality rates, especially considering the fact that CBVD had higher values in the initial years of the period, favoring a higher drop as compared to IHD.

An elevated variation in the optimal correlation lag occurred in some cases, in which the variation in correlation was actually very slight. This was observed in the correlations of IHD and CBVD with child mortality in the state of São Paulo. In such cases, the correlation ranged from 0.93 to 0.97 in the 30-year and 0-year lags, respectively, for IHD, and from 0.92 to 0.98 in the 30-year and 0-year lags, respectively, for CBVD. Thus, those correlations were very elevated in any year lag because both pairs of indicators maintained the tendency towards a constant drop over the periods with data available, and the latencies of the associations could not be precisely inferred. The joint follow-up of the indicators for longer periods might be the only way to better elucidate that question. The same is valid for all indicators studied, and the possibility of investigating crossed determinations might apply.

The major limitations resulted from the difficulty of acquiring socioeconomic data of the years prior to 1980. Data available often corresponded to 10-year periods and only to census years, requiring interpolation maneuvers for the years whose data were unavailable. The compensation maneuver for poorly defined causes might have under- or overestimated deaths due to poorly defined causes. All three states and capitals analyzed showed the same pattern: a drop in the mortality rates studied and an improvement of the socioeconomic indicators. To better support those correlations, places whose evolution of social and mortality indicators differed, and where mortality increased as the indicators worsened should have been studied. Greater heterogeneity in the selection of the states or areas with more varied indicators would be desired; however, most Brazilian states have neither long nor reliable historical series of data necessary for analysis. Another limitation is the maximum time lag between 20 and 31 years, depending on the indicator. In addition, longer historical series initiating in more remote times, which could encompass more than one generation, would be better.

In conclusion, in the past three decades, a significant reduction in all-cause mortality was observed in the three states assessed. That reduction occurred especially due to a decrease in cardiovascular mortality, especially that due to CBVD. The decrease in cardiovascular mortality was preceded by an improvement in socioeconomic indicators, and the evolution of those indicators showed an almost maximum correlation with the reduction in mortality. Such relationships indicate the importance of the improvement in the quality of life to reduce cardiovascular mortality.

Author contributions

Conception and design of the research, acquisition of data, analysis and interpretation of the data, statistical analysis, writing of the manuscript and critical revision of the manuscript for intellectual content: Soares GP, Brum JD, Oliveira GMM, Soares GP, Brum JD, Oliveira GMM, Klein CH, Silva, NAS.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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References

1. Prata PR. The epidemiologic transition in Brazil. Cad Saude Publica. 1992;8(2):168-75.
2. Yunes J, Ronchezel VS. Evolução da mortalidade geral, infantil e proporcional no Brasil. Rev Saude Publica. 1974;8(supl):3-48.
3. Soares GP, Brum JD, Oliveira GM, Klein CH, Souza e Silva NA. Mortalidade por todas as causas e por doenças cardiovasculares em três estados do Brasil, 1980 a 2006. Rev Panam Salud Publica. 2010;28(4):258-66.
4. Sposito AC, Caramelli B, Fonseca FA, Bertolami MC, Afiune Neto A, Souza AD, et al.; Sociedade Brasileira de Cardiologia. IV Diretriz brasileira sobre dislipidemias e prevenção da aterosclerose. Arq Bras Cardiol. 2007;88(supl 1):1-18.
5. Peres LA, Matsuo T, Delfino VD, Peres CP, Almeida Netto JH, et al. Aumento na prevalência de diabete melito como causa de insuficiência renal crônica dialítica: análise de 20 anos na Região Oeste do Paraná. Arq Bras Endocrinol Metab. 2007;51(1):111-5.
6. Sartorelli DS, Franco LJ. Tendências do diabetes mellitus no Brasil: o papel da transição nutricional. Cad Saúde Pública. 2003;19(sup. 1):S29-36.
7. Gus I, Fischmann A, Medina C. Prevalência dos fatores de risco da doença arterial coronariana no estado do Rio Grande do Sul. Arq Bras Cardiol. 2002;78(5):478-90.
8. Passos VM, Assis TD, Barreto SM. Hipertensão arterial no Brasil: estimativa de prevalência a partir de estudos de base populacional. Epidemiol Serv Saúde. 2006;15(1):35-45.
9. Repetto G, Rizzolli J, Bonatto C. Prevalência, riscos e soluções na obesidade e sobrepeso: here, there, and everywhere. Arq Bras Endocrinol Metab. 2003;47(6):633-5.
10. Klein CH, Silva NA, Nogueira AR, Bloch KV, Campos LH. Hipertensão arterial na Ilha do Governador, Rio de Janeiro, Brasil. I. Metodologia. Cad. Saúde Públ. 1995;11(2):187-201.

11. Mendonça CP, Anjos LA. Aspectos das práticas alimentares e da atividade física como determinantes do crescimento do sobrepeso/obesidade no Brasil. Cad Saúde Públ. 2004;20(3):698-709.

12. Instituto Nacional do Câncer (INCA). Prevalência de tabagismo no Brasil: dados dos inquéritos epidemiológicos em capitais brasileiras. Rio de Janeiro: Coordenação de Prevenção e Vigilância; 2004.

13. Godoy PH, Klein CH, Souza e Silva NA, Oliveira GM, Fonseca TM. Letalidade na cirurgia de revascularização do miocárdio no Estado do Rio de Janeiro – SIH/SUS – no período de 1999–2003. Rev SOCERJ. 2005;18(1):23-9.

14. Peterson ED, Coombs LP, DeLong ER, Haan CK, Ferguson TB. Procedural volume as a marker of quality for CABG surgery. JAMA. 2004;291(2):195-201.

15. Clark RE. Outcome as a function of annual coronary artery bypass graft volume. The Ad Hoc Committee of cardiac surgery credentialing of the Society of Thoracic Surgeons. Ann Thorac Surg. 1996;61(1):21-6.

16. Secretaria Municipal de Saúde e Defesa Civil. Rio de Janeiro (RJ). [Acesso em 2011 ago 10]. Disponível em: http://www.saude.rio.rj.gov.br.

17. Secretaria de Estado da Saúde. Rio de Janeiro (RJ). [Acesso em 2011 mar 13]. Disponível em: http://www.saude.rio.rj.gov.br.

18. Secretaria de Planejamento e Desenvolvimento. São Paulo (SP). Fundação Sistema Estadual de Análise de Dados. [Acesso em 2011 mar 12]. Disponível em: http://www.seade.gov.br.

19. Secretaria Municipal de Saúde. Porto Alegre (RS). [Acesso em 2011 mar 16]. Disponível em: http://www.portoalegre.rs.gov.br/sms.

20. Instituto Brasileiro de Geografia e Estatística. (IBGE). [Acesso em 2011 abr 10]. Disponível em: http://www.ibge.gov.br.

21. Presidência da República Federativa do Brasil. Instituto de Pesquisa Econômica Aplicada. [Acesso em 2011 mar 16]. Disponível em: http://www.ipeadata.gov.br.

22. Ministério da Saúde. Secretaria Executiva. Datasus. Informações de Saúde. Morbidade e informações epidemiológicas. [Acesso em 2011 mar 19]. Disponível em: http://www.datasus.gov.br.

23. Organização Mundial de Saúde (OMS). Manual da classificação internacional de doenças, lesões e causas de óbitos, 9ª. rev. Centro da OMS para Classificação das Doenças em Português. São Paulo; 1978.

24. Organização Mundial de Saúde (OMS). Classificação estatística internacional de doenças e problemas relacionados à saúde: classificação internacional de doenças. 10ª. rev. São Paulo: EDUSP; 1995.

25. Vermelho LL, Costa AJL, Kale PL. Indicadores de saúde. In: Medronho RA. Epidemiologia. São Paulo: Editora Atheneu; 2008.

26. Pagano M, Gauvreau K. Princípios de bioestatística. São Paulo: Pioneira Thompson Learning; 2004.

27. Soares GP, Brum JD, Oliveira GM, Klein CH, Souza e Silva NA. Mortalidade por doenças isquêmicas do coração, cerebrovasculares e causas mal definidas nas regiões do Estado do Rio de Janeiro, 1980-2007. Rev SOCERJ. 2009;22(3):142-50.

28. Microsoft Excel. Microsoft Corporation. Version 2007. Redmond, Washington, 2007.

29. Statistics/Data Analysis. STATA Corporation: STATA, Version 8,2. University of Texas, USA; 2005.

30. Lotufo PA. Mortalidade pela doença cerebrovascular no Brasil. Rev Bras Hipertens. 2000;7(4):387-91.

31. Sans S, Kesteloot H, Kromhout D. The burden of cardiovascular diseases mortality in Europe: Task Force of the European Society of Cardiology on cardiovascular mortality and morbidity statistics in Europe. Eur Heart J. 1997;18(8):1231-48.

32. Yusuf S, Reddy S, Ôunpuu S, Anand S. Global burden of cardiovascular diseases: Part II: variations in cardiovascular disease by specific ethnic groups and geographic regions and prevention strategies. Circulation. 2001;104(23):2855-64.

33. Müller-Nordhorn J, Binting S, Roll S, Willich SN. An update on regional variation in cardiovascular mortality within Europe. Eur Heart J. 2008;29(10):1316-26.

34. Achutti A, Azambuja MI. Interessa saber e discutir sobre as causas das DCV? Rev Soc Cardiol do Estado Rio Grande do Sul. 2010;20:1-3.

35. Lesbaupin I, Mineiro A. O desmonte da nação em dados. Petrópolis: Vozes; 2002.

36. Finch CE, Crimmins EM. Inflammatory exposure and historical changes in human life-spans. Science. 2004;305(5691):1736-9.

37. Bloom G. Equity in health in unequal societies: towards health equities during rapid social changes. Washington: Institute of Development Studies; 2000. p. 112.

38. World Development Report 2000/2001: attacking poverty. Oxford: Oxford University Press/World Bank; 2000.

39. United Nations Economic and Social Council. Report of the Secretary General: health and sustainable development (E/CN.17/2001/PC/6). New York: CSD; 2001.