Impacts of different death causes and diverse age profiles on the evolution of life expectancy at birth in Minas Gerais state and in the municipality of Belo Horizonte in Brazil between 1996 and 2006

Introduction

Omran (2005) defines epidemiologic transition as a process of change in mortality and morbidity patterns in a specific population group, parallel the demographic transition and socioeconomic development. Basically, these changes are related the replacement of communicable for non-communicable and external causes diseases, displacement of morbidity and mortality burden in the young for advanced age group and dominancy of morbidity with relation the mortality (Schramm et al, 2004).

However, morbidity and mortality patterns, how observed in places like Latin America, challenge the Omran's epidemiologic transition theory. In this region, the stages of transition don't follow a uniform pathway for all countries, with nations in the most advanced stage of the transition, like Cuba and Chile, whereas other, like Haiti and Peru are starting the process, yet (Luna, 2002). Too, there is a group of countries in Latin American that shows exceptional characteristics, with relation the epidemiologic transition, like Brazil and Mexico. Frenk et al (1991) define as *sustained polarized model* this exceptional epidemiologic transition, characterized by *juxtaposition of stages* (predominance of communicable and non-communicable diseases), *counter-transition* (turn and return of infectious diseases) and *epidemiologic polarized* (persistence and worsening of socioeconomic inequalities in health.

In the last decades, Brazil is experiencing an aging process caused mainly by the declining fertility rates observed since the sixties (Carvalho & Garcia, 2006). The relative increase in the proportion of death caused by non-communicable diseases is in part associated to this aging process (Botega, Ribeiro & Machado, 2006). In advanced age groups are increaseling the importance of death's causes like cancer, respiratory diseases, and, mainly, circulatory diseases (Simões, 2002). Although in Brazil the infant mortality rates fell in the last years because gains in life conditions like, sewerage system improvements, the infant deaths are keeping in high levels yet, comparing infant mortality rates of development countries, and there are disparities between regions inside the country with relations the infant deaths (Duarte et al, 2002). About the infectious diseases, in Brazil the mortality rates associated to these causes of deaths are

in high levels relative to others countries, mainly in infant age group and poor regions (Paes & Silva, 1999; Paes, 2004).

Based in a regional variability in levels and frame of mortality associated to socioeconomic disparities in Brazil (Abreu & Rodrigues, 2000), this study aims to analyze the contributions of different death causes and diverse age groups for variations on life expectancy in Minas Gerais's state and its capital, Belo Horizonte, between 1996 and 2006. Minas Gerais is an important Brazilian's state, located in a southeast region and characterized by socioeconomic disparities between its districts, and Belo Horizonte represents an important Brazilian's capital the point of view the socioeconomic development. We chose these localities for to compare areas with different socioeconomic profiles, because mortality patterns can be different by regional level of development.

Material and Methods

Material

We used the SIM database in order to obtain the death numbers by cause, sex and age for the state of Minas Gerais and for the municipality of Belo Horizonte. This database is available electronically in DATASUS. We applied the Growth Balance Method developed by Brass in 1975 (United Nations, 2002). If there is underreporting, the mortality rates can be underestimated. The coverage of Register's System in Belo Horizonte is considered complete, but for Minas Gerais, after to apply the Growth Balance Method we found 83% and 78% of coverage, in 1996, for men and women, respectively. In 2006, the coverage was 86% for men and 89% for women. We chose don't apply this method for extern causes, because in general there isn't underreporting related to this deaths (Costa, 2007).

The actual population in 1996 is from the 1996 Population Count (FIBGE, 1996), and the population in 2005 is an estimative (DATASUS, 2008) also done by IBGE (Instituto Brasileiro de Geografia e Estatística – Brazilian Institute of Geography and Statistics). Both were obtained electronically in DATASUS. Both databases, although they are for 1996 and 2006, have a different date of reference than we needed that is in the middle of the year. Hence, based on these data, we estimated the populations for the 1st of July in 1996 and in 2006 by sex and age group using the actual rate of annual population variation in the years between 1991 and 2000. For to minimize the impact of possible fluctuations in the number of deaths from year to another one, we calculated mortality rates by age and sex, using means for the periods 1996-1997-1998 and 2005-2006-2007.

Methods

We applied the Pollard Method (1982), which enables to estimate the impacts of mortality levels variations on changes in life expectancy at birth. Moreover, this technique allows estimating the contribution of the different death causes and diverse age profiles on variations in life expectancy at birth for a specific population and period (Simões, 2002).

This method is briefly explained as follows. The instantaneous mortality rate is defined as the limit of mortality rates ($_nm_x$) when n tends to zero. Hence, a reduction of this instantaneous rate for an age group (x e x + Δx) with a small Δx impacts positively on life expectancy at birth (e_0). Making the assumption that mortality levels in the other age groups are constant, this impact can be estimated as follows:

$$ {}_xP_0 \times e_x \times \Phi \times \Delta_x \qquad (1) $$

where ${}_xP_0 = \frac{l_x}{l_0}$ is the accumulated surviving probability from birth to age x; e_x is life expectancy at age x; and Φ is the reduction of mortality levels between the ages of x and x + Δx.

This first equation leads to the following relation used to estimate the gains in life expectancy at birth for a specific period:

$$ e_0^2 - e_0^1 = \sum ({}_nQ_x^1 - {}_nQ_x^2) \times W_{mean} \qquad (2) $$

Where the mean weight for the age x is:

$$ W_{mean} = 0.5 \times ({}_xP_0^1 \times e_0^2 + {}_xP_0^2 \times e_0^1); \qquad (3) $$

and $_nQ_x$ is mortality level or force between the ages x and x + n: (4) $ {}_nQ_x = -\ln\left(\frac{l_{x+n}}{l_x}\right)$.

Equation (2) is a good approximation when mortality levels reductions are relatively small. On the contrary, when variations are relative large, the equation underestimates the gains in life expectancy, because it do not take into consideration interaction effects related to age profiles (Yasaki, 1990).

The method also allows estimating the contributions of different death causes by age group in variations of life expectancy at birth. These estimates are obtained

multiplying ${}_nQ_x$ by the proportion of deaths for a specific cause for a group with age between x a x + n, as follows:

$$ {}_nQ_x^i = {}_nQ_x \times \frac{{}_nD_x^i}{{}_nD_x} \quad (5) $$

where ${}_nD_x^i$ is the number of deaths due to a specific cause (i) and ${}_nD_x$ is the total number of deaths, both for the same age group.

Results

Descriptive Analysis: levels and patterns by causes

The decline of mortality between 1996 and 2006 contributed for gains on life expectancy, in both localities, mainly in Belo Horizonte. Furthermore, the period analyzed showed increase in the gap between regions with relation to life expectancy, mainly between women. We verified differentials by sex, principally in Belo Horizonte (TAB. 1).

TABLE 1: Life expectancy at birth and its differentials. Belo Horizonte and Minas Gerais, 1996 to 2006.

	1996	2006	Gains
Belo Horizonte			
male	65,99	69,42	3,43
female	73,53	78,14	4,61
Differentials by sex	7,54	8,72	
Minas Gerais			
male	65,61	67,94	2,33
female	71,79	74,36	2,58
Differentials by sex	6,18	6,43	
Differentials by region			
male	0,38	1,48	1,10
female	1,75	3,77	2,03

Source: Datasus (SIM, 1996 to 2006)

When we observed the deaths by cause proportional distribution, in 1996/98 and 2006/08, for both regions, the major part of female and male deaths concentrated in the circulatory diseases (26,2% and 36,3% for men and women, respectively). For the others causes, there was variation by locality and sex. In Belo Horizonte, extern causes was the second most important cause for man (16,6% and 21,6%, in 1996 and 2006, respectively), and, for women, the cancer group (16,61% e 19,61%, in 1996 and 2006, respectively). For Minas Gerais, although the extern and cancer groups play an important role to female and male causes of deaths distribution, we observed an

important participation of ill-defined causes, for both sexes. In Belo Horizonte, the participation this group was very reduced (variations of de 2,66% to 7,18%) (TAB. 2).

TABLE 2: Proportional distribution of death causes and variations during the period. Belo Horizonte and Minas Gerais, 1996 and 2006.

Cause group	BELO HORIZONTE						MINAS GERAIS					
	Male			Female			Male			Female		
	1996/98	2006/08	variation	1996/98	2006/08	variation	1996/98	2006/08	variation	1996/98	2006/08	variation
infectious	6,88	4,57	-33,50	5,38	4,60	-14,53	6,06	4,49	-25,83	5,53	4,73	-14,53
cancer	13,37	16,31	21,94	16,61	19,61	18,11	10,52	13,67	29,88	12,07	15,04	24,58
circulatory	29,79	23,78	-20,16	36,25	31,90	-12,01	27,33	26,22	-4,09	32,33	32,22	-0,32
respiratory	11,74	9,13	-22,24	12,98	11,04	-14,94	10,32	9,64	-6,63	11,15	10,78	-3,36
perinatal	4,62	1,67	-63,91	4,50	1,88	-58,20	4,33	2,35	-45,72	4,35	2,47	-43,28
ill-defined	2,66	7,18	169,68	2,73	5,73	110,30	14,15	11,72	-17,17	14,59	11,13	-23,73
extern	16,62	21,65	30,32	6,29	5,77	-8,26	13,91	15,71	12,92	5,14	4,59	-10,69
others	14,32	15,71	9,68	15,26	19,46	27,52	13,37	16,20	21,23	14,84	19,05	28,38
total	100,00	100,00		100,00	100,00		100,00	100,00		100,00	100,00	

Source: SIM (1996 to 2006) and IBGE (Demographics Census)

With relation to relative participation of deaths causes evolution, we observed accentuated decline of perinatal (women and men) and communicable diseases (mainly for men), in both regions. In Belo Horizonte is possible to verify a strong reduction in circulatory and respiratory diseases, but, in Minas Gerais, this decline is not expressive, yet. Other important group is the ill-defined causes. For Minas Gerais, the relative participation this group reduced for women and men, and this can be due a better declaration of deaths causes. Although the participation this group is small for to total deaths, for Belo Horizonte there is an increase in its participation for women and men (TAB. 2).

We stressed too the increase of participation of the cancer group, for both sexes. For men, especially in Belo Horizonte, we observed an increase of participation of extern causes (21,7% and 12,9%, in Belo Horizonte and Minas Gerais, respectively). The group of others cause showed tendency of increase in its participation during the period, for men and women of both regions (TAB. 2).

Pollard Method Application

We observed changes in mortality frame by causes in Belo Horizonte and Minas Gerais, then, is important to measure the impact this chances in gains on life expectancy at birth. Indeed, changes on life expectancy are not related, necessarily, to changes in mortality rates in the same magnitude and direction for all ages. In general, several age groups will to show decline in mortality and gains on life expectancy. On the other hand, for specific age groups, the mortality can to increase, lowering or hampering the increase of life expectancy (Arriaga, 1984).

Contributions of age groups to gains on life expectancy

In Belo Horizonte, the age group with the most important contribution for increases on life expectancy was 0 to 1. The most advanced age groups contributed with a relevant portion for these gains on life expectancy. Between elderly women, the greater contribution was 70 to 74, and for elderly men, was 60 to 64. Other important point was the negative contribution of younger's adult men (15 to 24 years old). For women, all age groups contributed positively for gains on life expectancy at birth in the period analyzed (TAB. 3 e 4).

In Minas Gerais, the 0 to 1 age group showed the most important contribution for gains on life expectancy, with relation all age groups. The contribution of elderly persons was expressive for Minas Gerais too, and for both women and men (TAB. 5 e 6).

TABLE 3: Pollard method application by death causes and age for male population of Belo Horizonte, Brazil, 1996 and 2006.

Age group	infectious	cancer	circulatory	respiratory	perinatal	ill-defined	extern	others	TOTAL
0 a 1	0,166	-0,001	0,007	0,208	0,890	0,000	0,030	0,139	1,439
1 a 4	0,041	0,009	0,014	0,072	-0,002	0,004	0,036	0,036	0,208
5 a 9	0,006	0,005	0,005	0,008	-0,001	0,005	0,021	0,005	0,053
10 a 14	0,006	0,000	0,006	0,008	0,000	0,004	0,020	0,012	0,056
15 a 19	0,013	0,017	0,014	0,010	0,000	-0,002	-0,298	-0,006	-0,251
20 a 24	0,034	0,001	0,016	0,019	0,000	0,007	-0,207	0,000	-0,130
25 a 29	0,063	0,000	0,039	0,030	0,000	-0,014	-0,139	0,022	0,001
30 a 34	0,101	-0,003	0,067	0,046	0,000	-0,027	0,013	0,047	0,243
35 a 39	0,085	0,018	0,103	0,042	0,000	-0,032	0,007	0,079	0,302
40 a 44	0,053	0,002	0,152	0,032	0,000	-0,059	0,025	0,084	0,289
45 a 49	0,019	-0,022	0,161	0,053	0,000	-0,076	0,003	0,032	0,171
50 a 54	0,002	-0,001	0,178	0,032	0,000	-0,073	0,033	0,015	0,186
55 a 59	0,016	-0,016	0,189	0,046	0,000	-0,090	0,024	0,032	0,201
60 a 64	0,006	0,053	0,301	0,046	0,000	-0,062	0,031	0,020	0,394
65 a 69	0,011	0,017	0,276	0,081	0,000	-0,075	0,023	0,005	0,338
70 a 74	0,006	0,002	0,237	0,088	0,000	-0,054	-0,001	0,003	0,281
75 a 79	0,011	0,000	0,112	0,054	0,000	-0,038	-0,016	-0,051	0,072
80 e mais	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
TOTAL	0,638	0,082	1,876	0,875	0,886	-0,583	-0,394	0,475	3,854

Source: SIM (1996 to 2006) and IBGE (Demographics Census)

TABLE 4: Pollard method application by death causes and age for female population of Belo Horizonte, Brazil, 1996 and 2006.

Age group	infectious	cancer	circulatory	respiratory	perinatal	ill-defined	extern	others	TOTAL
0 a 1	0,145	0,001	0,004	0,177	0,830	0,003	0,024	0,182	1,365
1 a 4	0,037	0,004	0,009	0,086	-0,001	-0,004	0,039	0,037	0,207
5 a 9	0,006	0,008	0,001	0,005	0,000	-0,002	0,033	0,002	0,054
10 a 14	0,003	0,013	0,010	0,007	0,000	-0,004	0,010	0,009	0,047
15 a 19	0,012	0,024	0,009	0,010	0,000	0,007	0,016	0,012	0,090
20 a 24	0,011	0,009	0,014	0,008	0,000	0,001	0,016	0,011	0,069
25 a 29	0,030	0,005	0,013	0,009	0,000	-0,005	-0,003	0,013	0,064
30 a 34	0,034	0,020	0,041	0,018	0,000	-0,002	0,033	0,034	0,178
35 a 39	0,014	0,010	0,081	0,021	0,000	0,004	0,020	0,066	0,216
40 a 44	0,009	0,010	0,093	0,023	0,000	-0,019	0,030	0,031	0,177
45 a 49	0,002	0,042	0,123	0,011	0,000	-0,024	0,010	0,004	0,168
50 a 54	0,027	0,015	0,099	0,043	0,000	-0,027	0,019	0,015	0,191
55 a 59	0,013	0,018	0,178	0,035	0,000	-0,037	0,003	-0,006	0,203
60 a 64	0,025	0,096	0,217	0,056	0,000	-0,030	0,013	0,027	0,406
65 a 69	0,029	0,027	0,287	0,082	0,000	-0,038	-0,006	0,051	0,432
70 a 74	0,016	0,025	0,293	0,122	0,000	-0,016	0,025	0,055	0,520
75 a 79	0,001	0,027	0,237	0,066	0,000	-0,045	0,026	-0,055	0,256
80 e mais	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
TOTAL	0,414	0,353	1,707	0,780	0,829	-0,238	0,310	0,489	4,645

Source: SIM (1996 to 2006) and IBGE (Demographics Census)

TABLE 5: Pollard method application by death causes and age for male population of Minas Gerais, Brazil, 1996 and 2006.

Age group	infectious	cancer	circulatory	respiratory	perinatal	ill-defined	extern	others	TOTAL
0 a 1	0,136	-0,001	-0,002	0,117	0,464	0,071	0,019	0,109	0,914
1 a 4	0,030	0,006	0,002	0,038	-0,002	0,028	0,019	0,028	0,149
5 a 9	0,002	0,003	0,003	0,006	0,000	0,000	0,018	0,000	0,031
10 a 14	0,003	-0,001	0,002	0,002	0,000	0,003	0,013	0,006	0,028
15 a 19	0,006	0,005	0,008	0,011	0,000	0,010	0,018	0,012	0,071
20 a 24	0,013	0,003	0,012	0,010	0,000	0,015	0,013	0,020	0,086
25 a 29	0,014	-0,004	0,015	0,007	0,000	0,018	0,002	0,016	0,068
30 a 34	0,010	0,007	0,028	0,012	0,000	0,019	0,020	0,016	0,111
35 a 39	0,003	0,007	0,053	0,013	0,000	0,023	0,012	0,030	0,141
40 a 44	0,008	-0,006	0,052	0,014	0,000	0,018	0,011	0,012	0,109
45 a 49	0,007	0,001	0,067	0,008	0,000	0,032	0,003	0,002	0,120
50 a 54	0,013	-0,017	0,048	0,011	0,000	0,046	0,007	-0,018	0,090
55 a 59	0,010	-0,019	0,071	0,018	0,000	0,056	0,000	-0,028	0,109
60 a 64	0,015	-0,002	0,122	0,031	0,000	0,069	0,010	-0,012	0,234
65 a 69	0,027	-0,012	0,128	0,043	0,000	0,083	0,009	-0,009	0,269
70 a 74	0,015	-0,014	0,152	0,048	0,000	0,113	0,009	-0,011	0,312
75 a 79	-0,001	-0,042	0,064	0,029	0,000	0,106	0,005	-0,084	0,077
80 e mais	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
TOTAL	0,312	-0,083	0,823	0,419	0,461	0,712	0,188	0,088	2,920

Source: SIM (1996 to 2006) and IBGE (Demographics Census)

TABLE 6: Pollard method application by death causes and age for female population of Minas Gerais, Brazil, 1996 and 2006.

Age group	infectious	cancer	circulatory	respiratory	perinatal	ill-defined	extern	others	TOTAL
0 a 1	0,136	-0,001	-0,002	0,117	0,464	0,071	0,019	0,109	0,914
1 a 4	0,030	0,006	0,002	0,038	-0,002	0,028	0,019	0,028	0,149
5 a 9	0,002	0,003	0,003	0,006	0,000	0,000	0,018	0,000	0,031
10 a 14	0,003	-0,001	0,002	0,002	0,000	0,003	0,013	0,006	0,028
15 a 19	0,006	0,005	0,008	0,011	0,000	0,010	0,018	0,012	0,071
20 a 24	0,013	0,003	0,012	0,010	0,000	0,015	0,013	0,020	0,086
25 a 29	0,014	-0,004	0,015	0,007	0,000	0,018	0,002	0,016	0,068
30 a 34	0,010	0,007	0,028	0,012	0,000	0,019	0,020	0,016	0,111
35 a 39	0,003	0,007	0,053	0,013	0,000	0,023	0,012	0,030	0,141
40 a 44	0,008	-0,006	0,052	0,014	0,000	0,018	0,011	0,012	0,109
45 a 49	0,007	0,001	0,067	0,008	0,000	0,032	0,003	0,002	0,120
50 a 54	0,013	-0,017	0,048	0,011	0,000	0,046	0,007	-0,018	0,090
55 a 59	0,010	-0,019	0,071	0,018	0,000	0,056	0,000	-0,028	0,109
60 a 64	0,015	-0,002	0,122	0,031	0,000	0,069	0,010	-0,012	0,234
65 a 69	0,027	-0,012	0,128	0,043	0,000	0,083	0,009	-0,009	0,269
70 a 74	0,015	-0,014	0,152	0,048	0,000	0,113	0,009	-0,011	0,312
75 a 79	-0,001	-0,042	0,064	0,029	0,000	0,106	0,005	-0,084	0,077
80 e mais	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
TOTAL	0,312	-0,083	0,823	0,419	0,461	0,712	0,188	0,088	2,920

Source: SIM (1996 to 2006) and IBGE (Demographics Census)

In Minas Gerais, as observed for its capital the younger's age group contributed negatively for the increase on life expectancy, but, in minor magnitude than the observed in Belo Horizonte. Minas Gerais showed too a positive contribution of females age groups for gains on life expectancy, and in general the contributions of infant and advanced ages were more expressive than the observed for Belo Horizonte (TAB. 3 a 6).

Contributions of death causes to gains on life expectancy

The reduction of perinatal diseases in Belo Horizonte explain about 60% of the first one age group contribution to gains on life expectancy at birth for men and women. For elderlies, the circulatory diseases showed the major contribution for gains in life expectancy at birth, followed to respiratory and cancer groups. For men, we stressed the contribution of extern causes for reductions on life expectancy. The ill-defined causes contributed for reductions in life expectancy too, and this can be a signal of increase on deaths by ill-defined report, especially between adult's men. This tendency was similar for women, but in minor magnitude (TAB. 3 e 4).

In Minas Gerais perinatal diseases contributed too for expressive gains on life expectancy in the first age group, but its weight relative were minor than the observed for Belo Horizonte. Between elderlies, men and women, circulatory diseases

contributed for increases on life expectancy during the period analyzed, beyond others diseases like respiratory diseases and ill-defined causes.

Opposite than observed for Belo Horizonte, increases of cancer diseases contributed for reductions on life expectancy, for almost all age groups and for both sexes. In general, contributions of non-communicable diseases were stressed in Minas Gerais, and this can be a clue of expressive reduction the mortality rates by this causes in this state, with relation to Belo Horizonte (TAB. 5 e 6).

Discussion

This study applied the Pollard Method (1982) for to analyze the life expectancy evolution, between 1996 and 2006, for two regions with different socioeconomic profiles. We verified the participation of death causes and age groups to increases on life expectancy during the period analyzed, by sex, in Belo Horizonte and Minas Gerais. The differentials between life expectancy values by Pollard Method and life tables are related to adopted method, as showed in methodological section. However, the differences were very small and we considered our estimations satisfactory.

The results showed differentials on gains on life expectancy between Belo Horizonte and Minas Gerais, and the capital displayed the major gains with relation the Minas Gerais's state, probably due socioeconomic development differentials. Regions with better levels of development offer better socioeconomics conditions, like education and health services access, and these points can be related to increases on life expectancy.

Circulatory diseases were in this study the most important deaths causes for both regions, but for Belo Horizonte, we observed a consistent tendency of reductions in deaths by these causes and increase on cancer participation to total deaths. This view reflects association between epidemiologic and demographic transition, because the rise in relative weight of non-communicable diseases, like cancers, aim for the aging population process, related consequently to socioeconomic development. For both regions, reductions in perinatal diseases weight is an indicator of the association between transition and epidemiologic transition in curse, because this death causes are proper of infant group.

With relation to contributions of age groups, we highlighted the contribution of infant group, because this reflect reductions in infant mortality rates observed in the last decades, although these rates are elevated yet, with relations infant mortality rates of others countries in Latin America and developed nations. The advanced age groups, for

both regions, contributed for gains in life expectancy, mainly female age groups, and this is an expression of differentials by sex in mortality characterized by excess male mortality. We observed for men between 15 to 24 years old, negative contribution to life expectancy due, for the most part, the life conditions in a capital Belo Horizonte characterized by urban violence like murder rates and traffic accidents that affect young men, particularly. Indeed, in period analyzed we observed increase in this negative contribution of young men, especially for Belo Horizonte, with relation the study of Ribeiro, Botega & Machado (2004) for Belo Horizonte between 1990 and 1999.

For Belo Horizonte and Minas Gerais the circulatory diseases were the most important for gains in life expectancy, for women and men. Particularly in Belo Horizonte the increase in the group of ill-defined causes contributed negatively for gains in life expectancy, mainly between male adults. This result can be an indicator of deterioration in deaths causes report. For Minas Gerais, we observed a major contribution of non-communicable diseases for gains in life expectancy, and this can be a result of major state control of diseases related population life conditions. Until a recent past non-communicable diseases were responsible for a significative portion of total deaths in Minas Gerais, mainly between children.

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