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# Effect of the elimination of chronic diseases on disability-free life expectancy among elderly individuals in Sao Paulo, Brazil, 2010

## Efeito da eliminação de doenças crônicas sobre a expectativa de vida livre de incapacidade entre idosos em São Paulo, Brasil, 2010

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**Abstract** *The scope of this study was to establish whether the elimination of certain chronic diseases is capable of leading to the compression of morbidity among elderly individuals in Sao Paulo (Brazil), 2010. A population-based, cross-sectional study was carried out with official data for the city of Sao Paulo (Brazil) in 2010 and data from the SABE (Health, Wellbeing and Ageing) study. A total of 907 elderly individuals were evaluated, 640 of whom were women (64.6%). Sullivan's method was used for the calculation of disability-free life expectancy (DFLE). Life tables for cause elimination were used to calculate the probabilities of death with the elimination of health conditions. In absolute terms, the gains in LE and DFLE were greater in the younger age group (60 to 74 years) in both genders. In relative terms (%DFLE in LE), the gains were higher among women aged 75 years or older and among men aged 60 years. If eliminated, heart disease was the condition that would most lead to the compression of morbidity in both genders. The elimination of chronic diseases from the elderly population could lead to a compression of morbidity in men and women at both 60 years of age and 75 years of age or older.*

**Key words** *Chronic disease, Life expectancy, Active life expectancy, Life tables, Morbidity, Elderly*

**Resumo** *O objetivo deste estudo é avaliar se a eliminação de determinadas doenças crônicas é capaz de levar à compressão da morbidade em indivíduos idosos de São Paulo (Brasil), 2010. Estudo transversal analítico, de base populacional, utilizando dados oficiais secundários para o Município de São Paulo, em 2010, e dados obtidos a partir do estudo Saúde, Bem-estar e Envelhecimento (SABE). Um total de 907 indivíduos idosos foram avaliados, sendo 640 do sexo feminino (64,6%). O método de Sullivan foi utilizado para o cálculo de expectativas de vida livre de incapacidade (E.V.L.I.). Tábuas de vida de eliminação de causas foram utilizadas para calcular as probabilidades de morte com a eliminação de doenças. Em termos absolutos, os ganhos em expectativa de vida (E.V.) e E.V.L.I. foram maiores nas idades mais jovens (60 a 74 anos), em ambos os sexos. Em termos relativos (% E.V.L.I. na E.V.), os ganhos foram maiores nas mulheres de 75 anos ou mais e nos homens aos 60 anos. A doença cardíaca apresentou-se como aquela que mais promoveria a compressão da morbidade, caso fosse eliminada, em ambos os sexos. A eliminação de doenças crônicas na população idosa poderia levar a uma compressão da morbidade em homens e mulheres, tanto na idade de 60 anos, quanto na de 75 anos ou mais.*

**Palavras-chave** *Doença crônica, Esperança de vida, Expectativa de vida ativa, Tábuas de vida, Morbidade, Idoso*

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## Introduction

In developing countries, in which the epidemiological transition is still in an intermediate phase and mortality rates will tend to drop progressively over the upcoming years, it is important to assess the potential change in life expectancy and disability-free life expectancy resulting from the elimination of chronic diseases[1,2].

Non-transmittable chronic diseases account for 50% of the total number of diseases in developing countries, with a large portion of deaths related to cardiovascular disease, chronic pulmonary disease and diabetes[1].It is estimated that a 2% reduction in the mortality rate due to chronic diseases would avoid 36 million deaths in these countries between 2005 and 2015[1].

Three theories have been formulated to address the effect of changes in morbidity-mortality patterns on the health status of populations[2,3]. The first is known as the "compression of morbidity" and suggests that the life expectancy of adults has arrived at biological limits. As a result, if the incidence of debilitating diseases could be delayed, morbidity would then be compressed into a shorter period of life[4,5].

The second theory proposes that the decline in the mortality rate results from a reduction in disease lethality rates and not the reduction in incidence or progression; consequently, the decline in the mortality rate is accompanied by an increase in the number of individuals with chronic diseases and disability[6].

The third theory states that the decline in the mortality rate is partially due to the drop in lethality rates, but, at the same time, the incidence and progression of chronic disease must be diminishing, leading to a dynamic balance. According to this hypothesis, the years with severe or debilitating health conditions remain relatively constant, as medical interventions and changes in lifestyle reduce the progression rate of chronic diseases[7].

Summary measures of population health that combine morbidity and mortality data are commonly used to estimate the impact of particular conditions and diseases, enabling the analysis of expected gains with the reduction or elimination of such conditions[8,9]. Thus, life expectancy and disability-free life expectancy may be used to assess the occurrence of the compression of morbidity in a population[9].

The aim of the present study was to determine whether the elimination of certain chronic diseases is capable of leading to the compression of morbidity among elderly individuals, in the city of Sao Paulo (Brazil), through an analysis of changes in life expectancy and disability-free life expectancy.

## Methods

### Study design and sampling

An analytical, population-based, cross-sectional study was carried out with data from the *Saúde, Bem-Estar e Envelhecimento* (SABE [Health, Wellbeing and Ageing]) study, that began in 2000, which was a population-based survey aimed at evaluating the living conditions of elderly individuals in seven cities in Latin American and the Caribbean (Argentina, Barbados, Brazil, Chile, Cuba, Mexico and Uruguay)[10]. In 2010, the SABE study was carried out in the city of Sao Paulo, involving 907 male and female elderly individuals aged 60 years or older. Sampling was probabilistic and representative of the elderly population of the city in 2010[11]. Details on the methodology of the study are described elsewhere[10,12].

### Data collection

The data were collected using a questionnaire drafted by a regional committee made up of the main researchers in each participating country or specialists on specific topics of the study. The questionnaire was made up of 11 sections addressing aspects of the lives of elderly individuals: personal data, cognitive assessment, health status, functional state, medications, use of and access to services, family and social support network, labor history, housing characteristics, anthropometry, flexibility and mobility[13].

### Selected variables

The following socio-demographic characteristics were considered based on the pertinent scientific literature: age, gender, living arrangement, marital status, skin color, labor status and schooling[14,15]. Age was categorized in 60 to 74 years and 75 years and older. Living arrangement was dichotomized as living alone or accompanied. Schooling was categorized as no formal education, elementary education, high school education and university education (including postgraduate education). Marital status was categorized as single, married/stable relationship, widowed and divorced/separated. Labor status was dichotomized as currently working or not working.

Chronic diseases were recorded based on affirmative responses (self-reports) to the presence of

nine group of chronic diseases: systemic arterial hypertension, diabetes mellitus, heart disease, lung disease, cancer, joint disease, cerebrovascular disease, falls in the previous year and nervous or psychiatric problem. The diseases used in the present study was based on the International Classification of Diseases - 10th revision (ICD-10). Functional incapacity was defined as difficulty in performing one or more activities of daily living: dressing, eating, bathing, toileting, ambulation, fecal incontinence and urinary incontinence[16,17].

In addition to self-reports, certain conditions were only considered in the present study when under current treatment (e.g., diabetes) and when a previous medical diagnosis had been established (e.g., cerebrovascular disease).

**Data analysis**

Summary life tables beginning at 60 years of age for the year 2010 were calculated based on mortality and health condition information[18] following the steps described in demographics manuals[19]. The elderly population estimated for the year 2010 was obtained from the 2010 demographic census[11,20] and information on deaths among the elderly population was obtained from the Sao Paulo State Data Analysis Foundation[20,21].

The approach proposed by Nusselder et al.[22] was used to analyze the effect of the elimination of a chronic disease on LE and DFLE. According to the authors, if a disease were eliminated, individuals would not be affected by disability or death stemming from the disease in question. Assuming independence between the causes of death and disability, the elimination of a disease would lead to a decline in the specific probabilities of death for age and the specific prevalence of disability for age.

Multivariate logistic regression analysis controlled for age was used to estimate the probability of disability with the elimination of a cause (chronic disease). Disability was the dependent variable (1 = present; 0 = absent) and the independent variables were age and disease (1 = present; 0 = absent). The probability of an individual having one or more disabilities was computed substituting the regression coefficients and scores of the respondents in the independent variables of the regression equation:

$$p = \frac{\varepsilon^{\beta x}}{1 + \varepsilon^{\beta x}}$$

in which *P* is the probability of an individual having at least one disability, ε is the basis of the natural logarithm and $\beta x = \alpha + \beta 1x1 + \beta 2x2 + ...$, which is a vector of regression coefficients, with x being the variables.

The effect of the elimination of a disease on the prevalence of disability was simulated by deleting the disease from the regression equation. The difference between the prevalence of disability with and without disease could then be attributed to the deleted disease[22]. With the elimination of a disease, the probabilities of death were estimated using cause-deleted life tables. The estimated probabilities of death with the deletion of a specific cause and the prevalence of disability estimated with the deletion of the cause from the logistic regression model were combined in total LE and DFLE using Sullivan's method[18]. In analyses involving inferences based on the sample of information from each individual, corrections for stratification and non-responses were weighed by the inverse of the sampling fraction.

**Statistical analysis and ethical considerations**

Relative frequencies (%) were used for the prevalence analysis and the Rao-Scott test was used to determine associations[23]. The analyses were performed using either Microsoft Excel 2007 or Stata 11.1. With the latter, the weight of the sample was taken into consideration (svy command).

The original SABE study received approval from the respective ethics committees of the countries involved. In Brazil, the study received approval from the Human Research Ethics Committee of the School of Public Health of the *Universidade de São Paulo* and the National Research Ethics Committee (*Comitê Nacional de Ética em Pesquisa*).

**Interpretation of data**

Changes in heath expectancy based on the elimination of diseases were classified into four possible situations[9]:

1 – Absolute compression and relative compression of morbidity: a reduction in LE-D and increase in the percentage of DFLE in LE.

2 – Absolute compression and relative expansion of morbidity: a reduction in LE-D and a reduction in the percentage of DFLE in LE.

3 – Absolute expansion and relative compression of morbidity: an increase in LE-D and an increase in the percentage of DFLE in LE.

4 – Absolute expansion and relative expansion of morbidity: an increase in LE-D and a reduction in the percentage of DFLE in LE.

## Results

A total of 907 elderly individuals were evaluated (Table 1), 640 of whom were women (64.6%). A greater percentage of women (43.52%) were aged 75 years or more in comparison to men (37.0%). No statistically significant differences were found with regard to the distribution of skin color (p = 0.4329). Regarding schooling, 11.5% and 9.4% of the men had a complete high school and university education, respectively; for women, these figures were 6.9% and 5.0%, respectively. A greater percentage of women were widowed (51.4%) in comparison to men (15.6%) and a greater percentage of women were single (4.9%) in comparison to men (3.5%). A greater percentage of men were employed at the time of the study (39.9%) in comparison to women (12.7%). A greater percentage of women lived alone (21.4%) in comparison to men (8.3%).

Tables 2 and 3 display the changes in health expectancy values with the elimination of chronic diseases among women and men, respectively. In absolute terms, the gains in LE and DFLE were larger in the younger age group (60 to 74 years) in both genders. In relative terms (%DFLE in LE), the gains were higher among those women aged 75 years or older and among those men aged 60 to 74 years. For women at age 60 to 74 years, the eliminated conditions that would generate the greater proportion of years lived free of disabilities were heart disease, diabetes mellitus and hypertension (Table 2, Column 5). Among women aged 75 years or older, the eliminated conditions that would generate the greater proportion of years lived free of disabilities were diabetes, heart disease, hypertension and falls (Table 2, Column 5). For men at age 60 to 74 years, these conditions were

**Table 1.** Distribution of elderly individuals by gender according to age group, skin color, schooling, marital status, labor status and living arrangement; SABE Study, Sao Paulo, Brazil, 2010.

| Variable | Female (%) | Male (%) | p[a] |
|---|---|---|---|
| Age group (years) | | | |
| 60-74 | 56.47 | 62.96 | |
| 75 and older | 43.53 | 37.04 | 0.0894 |
| Total | 100.00 | 100.00 | |
| Skin color | | | |
| White | 62.85 | 62.20 | |
| Brown | 25.70 | 22.74 | |
| Black | 6.38 | 8.82 | |
| Yellow/others | 5.07 | 6.24 | 0.4329 |
| Total | 100.00 | 100.00 | |
| Schooling | | | |
| No formal education | 17.26 | 12.56 | |
| Elementary education | 70.88 | 66.51 | |
| High school education | 6.87 | 11.51 | |
| University + education | 4.99 | 9.42 | 0.0036 |
| Total | 100.00 | 100.00 | |
| Marital status | | | |
| Single | 4.94 | 3.46 | |
| Married | 35.37 | 76.85 | |
| Widowed | 51.44 | 15.60 | |
| Divorced/separated | 8.25 | 4.09 | < 0.0000 |
| Total | 100.00 | 100.00 | |
| Labor status | | | |
| Currently working | 12.71 | 39.89 | |
| Not currently working | 87.30 | 60.11 | < 0.0000 |
| Total | 100.00 | 100.00 | |
| Living arrangement | | | |
| Lives alone | 21.40 | 8.30 | |
| Lives accompanied | 78.60 | 91.70 | < 0.0000 |
| Total | 100.00 | 100.00 | |

[a] Rao-Scott test.

**Table 2.** Change in LE, DFLE, LE-D and proportion (%) of years lived free of disability resulting from elimination of chronic diseases among female elderly individuals according to age group; SABE Study, Sao Paulo, Brazil, 2010.

| | LE[a] | DFLE[b] | LE-D[c] | % DFLE in LE |
|---|---|---|---|---|
| Women at age 60 years | | | | |
| Hypertension[d] | 1.85 | 11 | - 9.15 | 38.39 |
| Joint[e] | 1.71 | 10.13 | - 8.42 | 35.53 |
| Fall[f] | 1.72 | 10.87 | - 9.15 | 38.32 |
| Heart[g] | 2.22 | 11.51 | - 9.29 | 39.09 |
| Diabetes[h] | 1.89 | 11.08 | - 9.19 | 38.55 |
| Mental[i] | 1.7 | 9.83 | - 8.13 | 34.39 |
| Lung[j] | 1.85 | 10.68 | - 8.83 | 37.16 |
| Cerebrovascular[k] | 2.04 | 9.73 | - 7.69 | 33.02 |
| Neoplasm | 2.77 | 11.57 | - 8.8 | 37.43 |
| Women 75 + years | | | | |
| Hypertension | 0.88 | 6.88 | - 6 | 45.24 |
| Joint | 0.84 | 6.3 | - 5.46 | 41.45 |
| Fall | 0.85 | 6.84 | - 5.99 | 45.13 |
| Heart | 1.03 | 7.15 | - 6.12 | 45.24 |
| Diabetes | 0.9 | 6.93 | - 6.03 | 45.46 |
| Mental | 0.85 | 6.09 | - 5,24 | 39.95 |
| Lung | 0.9 | 6.66 | - 5.76 | 43.63 |
| Cerebrovascular | 0.96 | 5.92 | - 4.96 | 38.24 |
| Neoplasm | 1.09 | 6.93 | - 5.84 | 44.42 |

[a] life expectancy; [b] disability-free life expectancy; [c] life expectancy with disability; [d] systemic arterial hypertension; [e] joint disease; [f] fall in previous year; [g] heart disease; [h] type 2 diabetes mellitus; [i] mental illness; [j] chronic lung disease; [k] cerebrovascular disease.

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**Table 3.** Change in LE, DFLE, LE-D and proportion (%) of years lived free of disability resulting from elimination of chronic diseases among male elderly individuals according to age group; SABE Study, Sao Paulo, Brazil, 2010.

| | LE[a] | DFLE[b] | LE-D[c] | % DFLE in LE |
|---|---|---|---|---|
| Men at age 60 years | | | | |
| Hypertension[d] | 2.72 | 5.92 | -3.2 | 17.87 |
| Joint[e] | 2.59 | 5.63 | -3.04 | 17.87 |
| Fall[f] | 2.65 | 5.72 | -3.07 | 18.05 |
| Heart[g] | 3.4 | 6.73 | -3.33 | 19.74 |
| Diabetes[h] | 2.79 | 5.74 | -2.95 | 17.6 |
| Mental[i] | 2.6 | 5.65 | -3.05 | 17.9 |
| Lung[j] | 2.8 | 5.85 | -3.05 | 18.08 |
| Cerebrovascular[k] | 3.03 | 5.7 | -2.67 | 16.57 |
| Neoplasm | 3.85 | 6.54 | -2.69 | 17.33 |
| Men 75 + years | | | | |
| Hypertension | 1.34 | 2.8 | -1.46 | 16.98 |
| Joint | 1.31 | 2.62 | -1.31 | 15.7 |
| Fall | 1.33 | 2.67 | -1.34 | 16.01 |
| Heart | 1.51 | 3.16 | - 1.65 | 18.9 |
| Diabetes | 1.36 | 2.62 | -1.26 | 15.4 |
| Mental | 1.31 | 2.63 | -1.32 | 15.76 |
| Lung | 1.39 | 2.73 | -1.34 | 16.12 |
| Cerebrovascular | 1.44 | 2.5 | -1.06 | 13.93 |
| Neoplasm | 1.62 | 2.81 | -1.19 | 15.47 |

[a] life expectancy; [b] disability-free life expectancy; [c] life expectancy with disability; [d] systemic arterial hypertension; [e] joint disease; [f] fall in previous year; [g] heart disease; [h] type 2 diabetes mellitus; [i] mental illness; [j] chronic lung disease; [k] cerebrovascular disease.

heart disease, chronic lung disease and fall (Table 3, Column 5). Among men aged 75 years or older, the eliminated conditions that would generate the greater proportion of years lived free of disabilities were heart disease, hypertension and chronic lung disease (Table 3, Column 5).

## Discussion

The results demonstrate that the elimination of chronic diseases would lead to gains in disability-free life expectancy between the ages of 60 and 74 years and at 75 years of age or older.

Regarding women in both age groups, the elimination of chronic diseases would lead to a reduction in life expectancy with disability (LE-D), signifying an absolute compression of morbidity and consequent gain in years to be lived without disability. The magnitude of this finding was greater in the younger age group (60 to 74 years). The data on DFLE in LE for women exhibited inverse behavior: for both age groups, the elimination of chronic diseases would increase the percentage of DFLE in LE, signifying a relative compression of morbidity, which would be greater in the older age group (Table 2).

Using heart disease as an example (Table 2), its elimination at age 60 to 74 years would imply a gain of 2.22 years in life expectancy among women. Moreover, these years gained would simultaneously correspond to a gain of 11.51 years of DFLE and a reduction of 9.25 years in LE-D. The greater gain in DFLE in relation to the gain in LE signifies a compression of morbidity.

Among men (Table 3), in both age groups, all diseases eliminated would lead to an decrease in LE-D, which signifies an absolute compression of morbidity, although these values are lower than the corresponding values for women. On the other hand, as the elimination of chronic diseases would lead to an increase in the percentage of DFLE in LE, a relative compression of morbidity would be expected (also at percentages far below those found among women). One may therefore say that the gains in LE would be greater among men than women, but at the cost of a smaller absolute compression of morbidity and a smaller conversion of years with disability into years without disability (relative compression of morbidity). However, the relative compression of morbidity among men would be greater in the younger age group.

Analyzing studies carried out in other countries, the elimination of chronic diseases would lead to the compression of morbidity in some situations[24]. Data from Australia indicate that the elimination of circulatory disease from the elderly population would lead to greater gains in years of healthy living in both men and women, followed by the elimination of neoplasms in men and musculoskeletal disease in women[25]. Similar results are found in a study carried out in the United Kingdom, with the exception of gains obtained from the elimination of accidents and poisoning in both genders[26].

In the Netherlands, the elimination of heart disease, arthritis and low back pain would lead to greater gains in DFLE. Arranging the diseases in terms of impact, differences were noted between genders. The elimination of heart disease would have the greatest impact among men, whereas the elimination of arthritis and low back pain would have the greatest impact among women. Similar results were found in this population for individuals aged 65 years or older, with the exception of the finding regarding heart disease, the elimination of which did not imply either a relative expansion or

compression of morbidity[22]. In Denmark, a study involving an elderly population found that the elimination of fatal diseases (such as cardiovascular disease) would lead to a relative compression of morbidity, whereas an absolute compression would be achieved with the elimination of non-fatal diseases, such as osteoarticular diseases[27]. In the USA, the elimination of deaths due to heart disease would result in greater gains in life expectancy (3 years for men and 4 years for women at 70 years of age); most gains in DFLE occurred at 70 years of age, while this trend changed with the advance in years, as the elimination of heart disease among very elderly individuals would lead to the addition of more years with disability than without disability[26,28].

One limitation of the present study is the presupposition of independence in causes of death. However, information on multiple causes of death is not widely available and this limitation will continue to be difficult to overcome until greater knowledge is acquired regarding the relationship of dependence among different causes of death in Brazil. Furthermore, the presupposition of independence may have led to an overestimation of the reduction in mortality at more advanced ages, when the coexistence of several diseases becomes more frequent. The fact that some diseases are risk factors for others could lead to the underestimation of the final cause of death. Moreover, as groups of diseases were considered (e.g., joint diseases), no consideration was given to the fact that different diseases have different impacts in terms of disability depending on the age group.

Another limitation regards the fact that the probability of death was not related to disability in the regression analysis. Moreover, the fact that disability can predispose an individual to fatal disease was not taken into account (e.g., disability stemming from cerebrovascular disease can lead to pneumonia, with a consequent increase in the mortality rate).

Self-reported information can lead to biases in the results. However, previous studies on the elimination of diseases have involved self-reported diagnoses[22,26,29]. Studies carried out in Brazil demonstrate the validity of self-reported information in detecting health conditions[30-34]. Cardiovascular disease and diabetes appear to be adequately reported by individuals due to the universal coverage of the Brazilian public health system[35].

Another aspect to consider regards the non-inclusion of institutionalized elderly individuals, which may have led to the overestimation of the effect of eliminating chronic disease for this population, as such individuals could be living in institutions for reasons other than chronic diseases and their consequences[36].

The lack of longitudinal data and the use of prevalence rates based on Sullivan's method have disadvantages when considering changes in mortality and disability among the elderly population over time[37]. However, when disease-related mortality and disability are eliminated simultaneously, the dynamic effects of these transformations in a particular population no longer exist. Moreover, due to their simplicity, life tables in a number of studies have been calculated using Sullivan's method, which is the most widely used technique in different countries, thereby facilitating future comparisons[38,39].

Future studies should employ a longitudinal design, which would permit a better understanding of the relationships between different chronic diseases and transitions in health status, especially with regard to functional capacity[29,40]. Moreover, studies addressing the multi-causality of deaths and relationships between multi-morbidity and functional capacity could contribute toward the understanding of the compression of morbidity in this population.

Based on the findings of the present study, the elimination of chronic diseases from the elderly population could lead to a compression of morbidity in men and women at both 60 to 74 years of age and 75 years of age or older. Greater gains in disability-free life expectancy would occur in the female gender due to absolute and relative compression of morbidity.

## Collaborations

AG Campolina, F Adami, JLF Santos e ML Lebrão participated equally in all stages of preparation of the article.

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