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Disability-free life expectancy estimates for Brazil and Major Regions, 1998 and 2013

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Abstract *Life expectancy at age 60 in Brazil has increased by around nine years in a little over 50 years. This general gain in life expectancy at national level has been heterogeneous across the country's major regions. Furthermore, little is known about how increases in life expectancy at age 60 across regions influence the number of years lived with some form of associated disability or the number of years lived free from disability. This study aimed to analyze increases in total life expectancy and its components [disability-free life expectancy (DFLE) and disability life expectancy (DLE)] at ages 60, 70, and 80 in Brazil and Major Regions in 1998 and 2013. The study used data on disability obtained from the 1998 National Household Sample Survey (PNAD – acronym in Portuguese) and 2013 National Health Survey (PNS– acronym in Portuguese) and used the Sullivan method to estimate DFLE by sex and age. The findings show that there was an increase in life expectancy and a concomitant increase in DFLE between 1998 and 2013. However, the gains in DFLE were not statistically significant in the North and Center-west regions. This means that, with the exception of the latter regions, in addition to living longer, the Brazils population aged 60 years can expect to live a greater number of healthy years.*

Key word *Disability-free Life expectancy, The Sullivan Method, Disability, Aged*

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Introduction

Living beings are governed by biological determinism: they are born, grow, mature, age, decline, and die. The length of each of these phases and how they progress depends on each particular individual, the genetic makeup of species, and environmental and behavioral factors. For some individuals, old age is a victory in the struggle against possible death in earlier stages of life. The number of victors is increasing yearly, turning this privilege into a fact of life[1].

In the 1940s in Brazil, a person who reached the age of 60 could expect to live on average another 13.2 years; 11.6 for men and 14.5 for women. In 2014, these figures had increased to 20 and 23.6, respectively. In the 1940s, assuming that mortality patterns at the time remained stable, for every 1,000 people who reached the age of 60, an average of 212 would reach the age of 80. After 74 years, assuming that current mortality patterns remain stable, this figure has increased to 579 people, meaning that 367 lives are saved[2].

Increased life expectancy at age 60 may be accompanied by a corresponding increase or decrease in years lived with some form of associated disability or years lived free of disability. Thus, it is appropriate to undertake a combined analysis of increases in life expectancy at age 60, regarded here as total life expectancy at age 60, considering changes in the two components of this increase: healthy life expectancy at age 60 and unhealthy life expectancy at age 60[3].

Healthy life expectancy, which combines information about mortality and morbidity into a single rate, has gained importance as an indicator of the health of a particular population[4]. It differs from total life expectancy in that it refers to the average number of healthy years that a person can expect to live assuming that current rates of morbidity and mortality prevail. As such, total life expectancy is the expected number of years of life remaining from a particular age in different states of health, while healthy life expectancy is the number of years of life expected to be lived in full health[5].

Given that the number of ways of defining health, there are also different ways of measuring healthy life expectancy[6]. In practice, healthy life expectancy is commonly estimated by measuring disability-free life expectancy[7] or, in other words, free from difficulties in executing activities.

Functional capacity evaluation is important for assessing healthy aging, i.e. that which does not impact the ability to perform activities of daily living, at population level. This indicator is correlated with an individual's sense of well-being, is a predictor of health and the use of social and health services, and has a positive or negative impact on the family[8]. Functional capacity appears as an important new concept, particularly within a new paradigm that has emerged in the health field related to population aging. From this new perspective, what matters is not the disease in itself, but rather the individual's capacity to remain in the community, enjoy independence, and maintain relationships and social activities[9].

A recent study using data from 1998 and 2008 analyzed whether the increase in healthy life expectancy in Brazil was associated with an increase in total life expectancy[3] by determining the following variables of healthy life expectancy: a) disability-free life expectancy (DFLE), b) life expectancy in good perceived health or healthy life expectancy (HLE), and c) life expectancy without chronic morbidity or morbidity-free life expectancy (MFLE). The findings of this study suggest that in addition to an increase in life expectancy, there was a significant similar increase in healthy life expectancy in the dimensions self-perceived health and disability in practically all age groups. In contrast, there was no significant increase for the dimension presence of chronic disease[3].

Despite the lack of population-based time series studies analyzing health information in Brazil, a number of studies have been conducted in recent decades to estimate healthy life expectancy[3,10-19]. The health components of the National Household Sample Survey (*Pesquisa Nacional por Amostra de Domicílios* - PNAD) and National Health Survey (*Pesquisa Nacional de Saúde* - PNS) partially fill this gap in information by providing important data on the prevalence of chronic disease, self-perceived health status, and disability.

Examining changes in healthy life expectancy or, more specifically, disability-free life expectancy, can provide valuable inputs to policymaking by highlighting the real needs of a given population and thus ensuring efficient targeting of resources. After all, this health indicator provides information not only about the prevalence of disability, but also about potential duration, measured by the number of years lived with disability, and the length of time that needs to be spent on treatment and care[11,20].

The aim of this study is to estimate disability-free life expectancy (DFLE) and disability life expectancy (DLE) at age 60 among the population of Brazil and Major Regions (*Major Regions*) in 1998 and 2013.

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Methodology

Data Source

The study used the results of the 1998 PNAD[21] and 2013 PNS[22] and complete life tables for Brazil and Major Regions for the same years published by the Brazilian Institute of Geography and Statistics (IBGE – acronym in Portuguese)[23,24]. Data from 1998 and 2013 was used to enable a comparison between two points in time with an interval of 15 years.

Disability measurement

The 1998 PNAD assesses functional capacity using seven questions: one addressing activities of daily living (ADLs) and six related to mobility. ADLs include simple tasks related to personal care that are considered important indicators of the health status of elderly people and are therefore frequently used to assess disability[20,25]. ADLs were used to determine prevalence of disability because they assess the degree of disability across a functional spectrum[26]. Disability was assessed using the following question: "Do you normally experience difficulties in feeding yourself, taking a shower, or going to the bathroom due to a health problem". People were classified as disabled if they reported that they were not able to perform or had difficulty performing these tasks. Individuals who did not have difficulty and those who did not provide an answer were classified as disability free.

Although the PNS used more questions addressing functional capacity than the 1998 PNAD, for comparison purposes we adopted the same ADLs selected for the PNAD. It is important to note, however, that the question regarding difficulties in feeding, taking a shower, or going to the bathroom in the PNS was broken down into one separate question for each activity ("In general, what degree of difficulty do you experience in ..."). People were classified as disabled if they reported that they were not able to perform or had difficulty in performing at least one of these ADLs. Prevalence of disability was estimated based on the complex sampling plans of the PNAD and PNS.

Statistical analysis

The Sullivan method[27] was used to estimate disability-free life expectancy (DFLE) and disability life expectancy (DLE).

DFLE and DLE were calculated by combining the data from the life tables and current mortality experience among the population in 1998 and 2013 with the prevalence of disability among the population in the same period, thus estimating the number of years expected to be lived in a particular state of health. The main advantage of the Sullivan method is that it can be applied with data from cross-sectional studies[4,5]. DFLE was estimated by sex and year.

The following formula was used to calculate DFLE:

$$EVLI_x = \frac{\sum ({}_n\pi_x)_n L_x}{l_x}$$

Where:

$DFLE_x$ is disability-free life expectancy, which comprises the average number of disability-free years expected to be lived from age x.

${}_n\pi_x$ is disability-free prevalence in age group x to x+n.

${}_nL_x$ is people-years lived from x to x+n, comprising the total number of years lived by the cohort in the interval.

l_x: probability of living until age x.

DLE is obtained by subtracting DFLE from total life expectancy. In addition, we calculated the proportion of years expected to be lived in a particular state of health based on the ratio between number of years expected to be lived in each state and the total number of years expected to be lived.

Separate life tables were produced by year and sex. The number of years lived in each age in the life tables was distributed according to point and interval estimates of the prevalence of disability in each specific age group. Prevalence was estimated in five-year age groups in order to minimize age estimation errors. We computed 95% confidence intervals (CI95%) considering the interval estimates of prevalence of disability. Differences in DFLE observed between the two periods were compared using the CI95%. Intervals without overlap were considered significant.

Results

As mentioned above, the Sullivan method estimates healthy life expectancy by combining information on health status prevalence with mortality. While the mortality data was obtained from records and population censuses, health status prevalence was taken from sample data.

Thus, the analysis of the evolution of health status prevalence, regardless of which dimension or indicator is used, should evaluate, with some degree of statistical rigor, whether the changes observed are significant bearing in mind the type of sampling approach used to select households and collect information[3].

Figure 1 shows the prevalence of disability and respective 95% confidence intervals by sex and region among the population at age 60 in 1998 and 2013. Prevalence was highest among female in the two periods. A statistically significant reduction in the prevalence of disability was observed in both sexes over the period. There was a reduction in prevalence of disability from 8.4% in 1998 (CI95%:7.4 – 9.5) to 3.5% (CI95%: 2.3 – 4.7) in 2013 among male and from 10.3% (CI95%: 9.3 – 11.3) to 4.9% (CI95%: 3.0 – 6.8) among female. At a regional level, a statistically significant decrease in prevalence of disability was observed for all regions except the North (male) and South (female).

Tables 1 and 2 display estimates of total life expectancy (TLE), disability-free life expectancy (DFLE), and disability life expectancy (DLE) in 1998 and 2013 by age group, Major Region, and sex in both absolute and relative terms. Over the 15-year period, life expectancy at age 60 increased by 1.4 years among male and 2.0 years among female. In 1998, the expected number of years of life remaining at age 60 was 2.9 years greater in female than in male, while in 2013 this difference had increased to 3.5 years. In 2013, the expected number of active life years remaining at age 60 was 20.3 in female and 18 among male, while each sex could expect to live 3.1 and 1.9 years, respectively, with disability (Tables 1 and 2).

It is important to note that the difference in total life expectancy and disability-free life expectancy at age 60 between male and female increased by approximately one year. Thus, when total life expectancy is broken down into its two components, healthy and unhealthy, using disability as an indicator of the latter, the average number of remaining active or disability-free years of life expected is greater among female.

Using point and interval estimates of the prevalence of disability and the mortality tables produced by the IBGE, we calculated disability-free life expectancy incorporating the uncertainties raised by the prevalence of disability shown in Figure 1. Figure 2 shows the point estimates of disability-free life expectancy (DFLE) at age 60 and their respective confidence intervals by sex and region.

It can be seen that the increase in the average number of disability-free years lived from age 60 was statistically significant for Brazil as a whole, the Northeast (NE), South (S), and Southeast (SE) regions for both male and female. The increases in DFLE at age 60 for both sexes were not statistically significant for the North (N) and Center-West (CW) regions, where the interval estimates overlap (Figure 2). A reduction in the differences between sexes was observed in some regions; however, in the majority of regions life DFLE at age 60 was higher among female.

The following changes in ranking between regions based on the point estimates of DFLE at age 60 were observed: male - 1998 N < NE < S < BR < CO = SE, 2013 N < NE < CO < BR < SE; female - 1998 NE < N < CO < BR < S < SE, 2013 N < CO < NE < BR < S < SE. However, the overlaps of interval estimates of DFLE (CI95%) reveal that this ranking of regions may not be significant among male.

Figure 3 shows the differences in total life expectancy and disability-free life expectancy at age 60 between men and women in absolute terms (DFLE) and relative terms (DFLE %). The differences, in both absolute and relative terms, are striking for Brazil and all regions.

The magnitude of difference is greatest in the South and Southeast. In all regions except the North, the differences between both total life expectancy and disability-free life expectancy increased between 1998 and 2013. This difference was greatest in the Northeast (Figure 3).

However, the differences in absolute terms should be interpreted with caution. Although female live disability free on average longer than male, the results also show that the expected number of years of life remaining from a particular age with disability is also higher. Therefore, disability-free life expectancy among male and female should be analyzed in relation to total life expectancy and not just in absolute terms, which is the reason why the results of this analysis are included in Figure 3.

The analysis of DFLE in relation to total life expectancy shows that the scenario was more favorable for male both in 1998 and 2013 (Figure 3). Based on the DFLE (%) figures for Brasil, this trend prevails throughout older age groups (Tables 1 and 2). The breakdown of these estimates for the macro regions shows that the regional scenarios are similar to the nationwide scenario, except in the North region in the 80-year age group in 1998, where the proportion of disability-free life expectancy in relation to total life expectancy

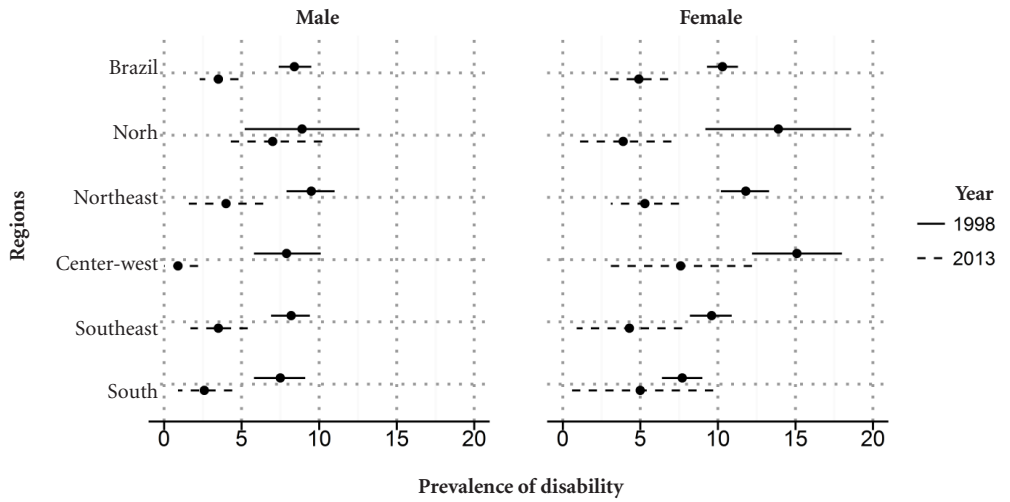

Figure 1. Prevalence of disability and respective 95% confidence intervals for the population at age 60 by sex. Brazil and Major Regions, 1998 and 2013.

Basic data source: IBGE - PNAD, 1998 and PNS, 2013.

Table 1. Estimates of total life expectancy (LEx), disability-free life expectancy (DFLEx), disability life expectancy (DLEx) and the proportion of years expected to be lived free from disability (DFLEx(%)) at 60, 70 and 80 years, male. Brazil and Major Regions, 1998 and 2013.

Age	Region	1998				2013			
			DFLEx	DLEx	DFLEx(%)	LEx	DFLEx	DLEx	DFLEx(%)
60	Brazil	18,5	15,6	2,9	84,4	19,9	18,0	1,9	90,5
	North	18,5	14,9	3,6	80,6	18,7	16,3	2,4	86,9
	Northeast	18,2	15,1	3,1	83,0	18,9	17,3	1,6	91,5
	Center-west	19,6	16,0	3,6	81,8	19,8	17,5	2,3	88,5
	Southeast	18,7	16,0	2,6	85,9	20,4	18,6	1,8	91,1
	South	18,4	15,5	2,8	84,6	20,4	18,3	2,0	90,0
70	Brazil	12,6	9,9	2,7	78,7	13,3	11,4	1,8	86,1
	North	12,6	9,2	3,4	73,1	12,3	10,1	2,2	82,2
	Northeast	12,3	9,4	2,8	77,0	12,5	11,0	1,6	87,5
	Center-west	13,8	10,4	3,4	75,1	13,2	10,9	2,3	82,8
	Southeast	12,9	10,4	2,4	81,1	13,8	11,9	1,8	86,6
	South	12,5	9,7	2,7	78,1	13,6	11,7	1,9	86,3
80	Brazil	8,4	5,7	2,7	68,2	8,3	6,5	1,8	78,8
	North	8,4	4,9	3,5	58,9	7,7	6,0	1,7	78,1
	Northeast	7,8	5,1	2,8	64,9	7,6	5,8	1,9	75,8
	Center-west	9,7	6,5	3,2	67,2	8,3	5,9	2,4	71,3
	Southeast	8,7	6,4	2,3	73,7	8,7	7,0	1,7	80,7
	South	8,4	5,3	3,1	62,7	8,5	7,1	1,5	82,8

Basic data source: IBGE - PNAD, 1998 and PNS, 2013; IBGE - Mortality Tables men, 1998 and 2013.

Table 2. Estimates of total life expectancy (LEx), disability-free life expectancy (DFLEx), disability life expectancy (DLEx) and the proportion of years expected to be lived free from disability (DFLEx (%)) at 60, 70 and 80 years, female. Brazil and Major Regions, 1998 and 2013.

Age	Region	1998				2013			
		LEx	DFLEx	DLEx	DFLEx(%)	LEx	DFLEx	DLEx	DFLEx(%)
60	Brazil	21,4	17,1	4,3	79,9	23,4	20,3	3,1	86,6
	North	21,4	16,4	5,0	76,7	21,6	17,6	4,0	81,3
	Northeast	19,8	15,4	4,4	78,0	22,4	19,0	3,4	84,8
	Center-west	21,9	16,5	5,4	75,5	22,8	18,8	4,0	82,3
	Southeast	22,2	18,1	4,1	81,7	24,1	21,4	2,7	88,9
	South	22,0	17,6	4,4	79,8	24,2	20,7	3,5	85,5
70	Brazil	14,4	10,5	3,9	72,9	15,9	12,9	3,0	81,3
	North	14,4	9,9	4,5	68,8	14,5	10,3	4,2	70,9
	Northeast	13,1	9,2	3,9	69,9	15,0	11,8	3,3	78,3
	Center-west	15,2	10,6	4,6	69,6	15,3	11,3	4,0	73,7
	Southeast	15,2	11,5	3,7	75,9	16,4	13,9	2,5	84,5
	South	14,9	10,7	4,3	71,5	16,4	13,3	3,1	81,3
80	Brazil	9,2	5,8	3,4	63,3	9,8	7,1	2,7	72,3
	North	9,2	5,7	3,5	61,5	8,9	5,1	3,8	57,3
	Northeast	8,0	4,7	3,3	58,9	9,1	6,1	3,0	66,7
	Center-west	10,3	6,4	3,9	62,4	9,3	5,2	4,2	55,3
	Southeast	9,9	6,7	3,2	67,3	10,3	8,1	2,2	78,7
	South	9,6	5,8	3,9	59,8	10,2	7,2	3,0	70,2

Basic data source: IBGE - PNAD, 1998 and PNS, 2013; IBGE - Mortality Tables women, 1998 and 2013.

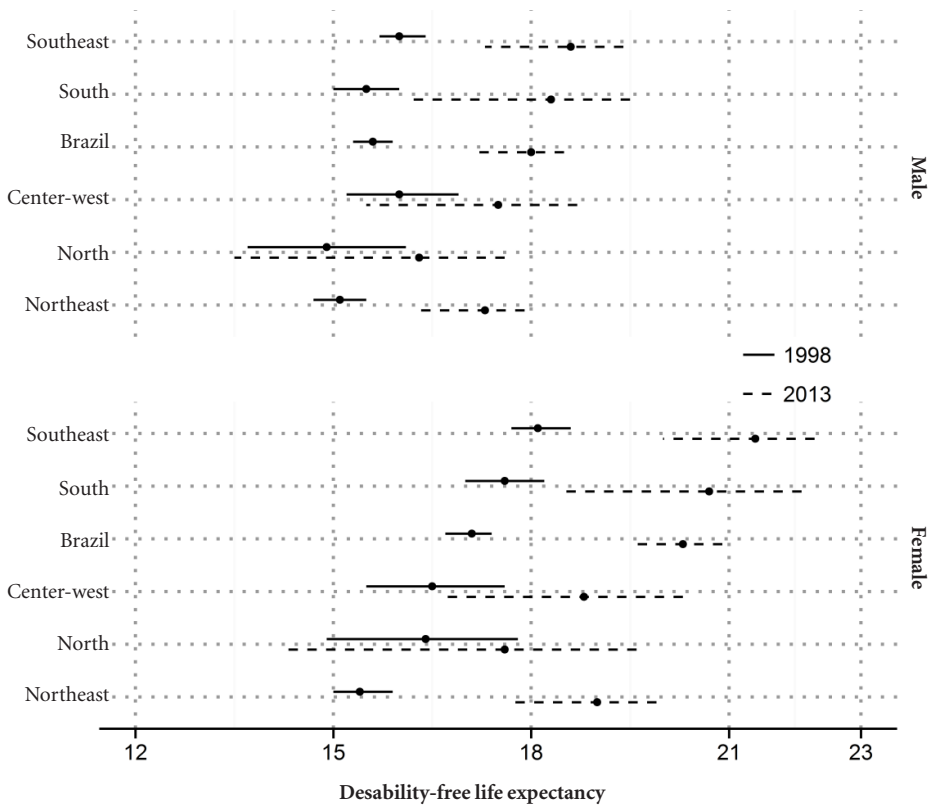

Figure 2. Estimates of disability-free life expectancy (DFLE) and respective 95% confidence intervals at age 60 by sex. Brazil and Major Regions, 1998 and 2013.

Basic data source: IBGE - PNAD, 1998 and PNS, 2013; IBGE - Mortality Tables men and women, 1998 and 2013.

is greater among female. However, the differences between regions in magnitude of DFLE (%) by sex and age are striking, as are the differences between male and female by region for total life expectancy and its components, DFLE and DLE (Tables 1 and 2). In 2013, for example, the South and Southeast regions showed higher total life expectancy and disability-free life expectancy, while the North showed lower values.

Discussion

Much like developed countries, the demographic changes experienced in Brazil have led to a rapid and accentuated aging process and increased life expectancy. Considering the link between aging, mortality, and disability, such changes are likely to present a persistent problem given the increasing rates of disability. However, the extent to which rates of disability are influenced by demographic trends depends, to a certain degree, on how increases in life expectancy affect rates of disability. A status quo scenario, where the probability of death and disability at older ages remains unchanged, will certainly result in a greater number of people with disability due to the effect of aging on a population's age structure. The most optimistic scenario is that resulting from an eventual compression of morbidity[28-31]. This hypothesis suggests that by postponing the age of onset of the first morbidity (or disability), the period of adult vigor will be prolonged and the duration of time living with a morbidity will be concentrated into a short period before death, thus meaning that people on a whole will live a larger proportion of their lives without disability. In a hypothetical scenario, considering that the dichotomy "active" or "disabled" would be sufficient to analyze the process of change between the states of health and death, the compression of morbidity hypothesis suggests that an increase in the DFLE component of total life expectancy leads to a concomitant reduction in its counterpart, DLE.

In light of the above discussion and the need to understand whether gains in life expectancy are associated with an improvement in the health status of a particular population, we produced estimates that allowed us to compare the number of years lived with disability within the same population and between two different populations in two different periods. Therefore, the present study estimated disability-free life expectancy at age 60 among men and women in 1998 and 2013 for Brazil and Major Regions.

The findings show that between 1998 and 2013 gains in life expectancy led to a concomitant increase in disability-free life expectancy. However, the gains in healthy life expectancy were not statistically significant in the North and Center-west regions. In other words, with the exception of these regions, besides living longer the population at age 60 could expect to live a greater number of healthy years. These results are similar to those found by a national study comparing data from 1998 and 2008[3]. At national level, the gains in number of years lived in full health, or without disability, were greater than those observed for life expectancy at age 60 for both men and women.

Although the number of years expected to be lived with disability is less than that lived without disability, it is important to consider the burden of caring for this population group. After all, on average, Brazilian men and women at age 60 will require around two and three years, respectively, of care for feeding, taking a shower, or going to the bathroom, which will have a direct impact on health care expenditure and their family. This type of discussion reinforces the idea that, both for elderly people and their family and the state and society, investment in prevention aimed at effectively reducing the duration of time living with disability is still the best solution for minimizing costs and enhancing the quality of life remaining. With regard to Brazil, at national level, the number of years lived with disability decreased by 34.5% for male (one year) and 18% for female (1.2 years).

Our findings also show that life expectancy was higher among female in both 1998 and 2013. However, while female may on average live longer than male, the expected number of years of life remaining from a particular age with disability is also higher in both absolute and relative terms. Although the methods used to measure disability may vary between studies, thus hampering comparisons, our results corroborate the findings of previous studies that also highlighted this female disadvantage[3,10-20,32,33].

A number of factors may explain the difference between male and female in relation to healthy life expectancy. First, studies have suggested that the fact that higher rates of mortality among men at younger ages acts as selection mechanism meaning that at an older age male are generally less susceptible and vulnerable to disability than female [34], directly influencing the number of years expected to be lived in poor health[11,13-16].

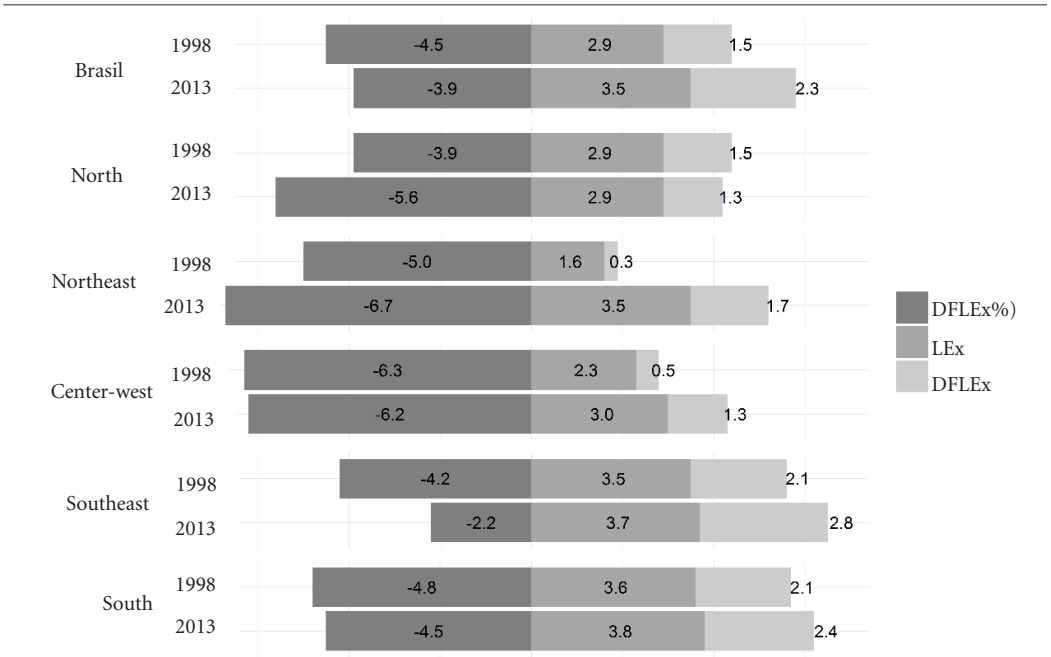

Figure 3. Differences (male and female) in total life expectancy (LE) and disability-free life expectancy in absolute terms (DFLE) and relative terms (DFLE%) at age 60. Brazil and Major Regions, 1998 and 2013.

Basic data source: IBGE - PNAD, 1998 and PNS, 2013; IBGE - Mortality Tables men and women, 1998 and 2013.

Second, it is believed that one of the main explanatory factors is that longer life expectancy means that female tend to reach a much more advanced age, when they are more likely to suffer from a chronic disease. Furthermore, it is suggested that women's health is affected by economic, social and cultural inequalities at various moments in their lives[35-39]. Historically, female have been and continue to be the ones primarily responsible for household tasks and childcare. Increasing female labor force participation means that women have to struggle to reconcile productive and reproductive activities (relative to the family). Furthermore, the gender pay gap persists, rooted, among other factors, in gender differences in the occupational distribution endowed with unequal status[40].

With regard to differences in the macro regions of Brazil and their evolution between 1998 and 2013, the most favorable scenario can be found in the South and Southeast regions. Furthermore, in all regions, except the North, differences between male and female in relation to EV and DFLE increased during the period under study. In light of the sex-specific mortality hypothesis, a possible explanation may be an increase in male "super mortality" due to external causes[41-43].

Some limitations of this study should be highlighted. First of all, the fact that we did not use longitudinal data meant that possible changes in relation to improvements in population health status and mortality rates during the study period were not incorporated into the estimates. This problem is not inherent in the method, but rather in the elaboration of the life tables. It is important to note that the Sullivan method allows researchers to compare health status within populations and between different populations in different periods. Previous studies have demonstrated that, provided there are no sudden changes both in prevalence and rates of mortality, this method is highly reliable for this type of analysis[44]. Furthermore, it is reasonable to assume that as people age a return to full health free of disability is increasingly unlikely, meaning that the use of multi-state models would not have resulted in significant gains. As such, we believe

that our estimates reflect the reality of Brazil's elderly population in 1998 and 2013.

A second limitation is the use of data from studies that were not specifically designed to assess the health of the elderly population. This limitation hinders analysis in more disaggregated geographical levels such as states. Although the PNS was designed to analyze population health status, a preliminary study (data not presented here) showed inconsistent findings in relation to DFLE by state. Another limitation relates to the use of different surveys (the PNS and PNAD) which used different ways of asking questions. However, it is important to note that this study sought to determine the number of years expected to be lived with disability at age 60 at two points in time among the population of Brazil and Major Regions.

This study's findings relating to disability-free life expectancy provide a valuable input for estimating the demand for health care and health interventions targeting the elderly population and facilitating the efficient and equitable allocation of health care resources.

Collaborations

MCS Camargos, MR Gonzaga and JV Costa contributed to the conception of the study, analysis and interpretation of the data, elaboration of the article and approval of the final version. WC Bomfim contributed with the revision and normalization of the article.

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