Rural-Urban health and mortality differentials in Brazil, 2010-2013

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## Introduction

The rural-urban mortality differential is a topic of great concern of demography, public health and public policy researchers. Different access to services and public health equipment may reflect in different mortality outcomes for population groups, which is broadly documented in the literature and its results are evident from mortality differentials in terms of geographic location. In this paper we target urban-rural mortality and morbidity differentials in Brazil using the national census mortality data of 2010 and National Health Survey (PNS, from portuguese *Pesquisa Nacional de Saúde*) morbidity data of 2013.

By the beginning of the urbanization and industrialization processes in the developed West countries, urban areas exhibited higher mortality rates than their rural counterparts1,2. The mortality levels among young age-groups (0-14) were more sensible to the urban environment than adult mortality levels, which incurred in higher youth mortality rates in cities than in rural areas2. Indeed, infant and child mortality rates are affected by wealth and socioeconomic determinants through variables such as sanitation conditions and dietary intake of a population3. Cities of the XIX century, however, presented poor living conditions and high population density, contributing to the spread of communicable diseases responsible for most deaths in urban centers in that period1.

This scenario changed considerably with socioeconomic development and economic growth of Western countries which subsidized better living conditions in cities4 and provided resources to overcome communicable diseases deaths, fostering the epidemiological transition by the end of XIX century period5. The differential economic growth between metropolitan and non-metropolitan areas, nevertheless, created gaps in access to public services such as health equipment and transportation2. In the United States, for example, rural and non-metropolitan residents are broadly known for its disadvantaged position in regard to life expectancy and to health indicators8–12. This negative position in relation to their urban counterparts follows a higher health information illiteracy among rural residents, lack of access to health equipment and other kinds of socioeconomic deprivation that affect non-metropolitan areas8,10–14.

In Brazil, the advantaged urban mortality situation prevails on some specific conditions. 15 showed that urban-rural life expectancy differentials favored the urban areas for wealthy social strata whereas the opposite is observed in poor areas of the country in 1960-70 period. In this sense, being poor in Brazilian rural areas would be better than being poor in urban areas. The urban periphery of Brazilian metropolis are known for its poor urban assets and damaged social conditions, with high violence and criminal rates and also lack of public assets such as public sanitation16,17 which result in worsened health and mortality status18–20. Under-five mortality, however, is more impacted by community-level characteristics and socioeconomic situation3,21–24. In this sense, the urban advantage in Brazilian urban-rural under-five mortality indicators results from its better socioeconomic conditions22,25.

Despite the urban advantaged observed in child and infant mortality levels, adult mortality rates are lower in rural areas for lower income countries21–23,26–29. 29 verified a mortality advantage for rural areas, especially for the male population. He estimated 73.6 and 69.3 life expectancies for the male rural and urban population, respectively, and 77.8 and 77.1 life xpectancies for females. In a similar way of what have been observed in Brazil, cities of developing countries exhibit mortality differentials across its own borders due to the unequal access to essencial public services - health equipment, education and sanitation - as a consequence of a rapid urbanization process23,27,30. In these cities, the living conditions of urbanized centers deteriorate individuals health compared to the rural couter-parts as observed in the past in more developed countries and imposes an urban death penalty31.

This debate about urban-rural mortality differentials in Brazil has gained momentum over the last years due to the changes proposed in the social security system. Since 1988, rural groups were guaranteed access to almost universal age-retirement pensions at lower ages than urban residents (60/65 for males and 55/60 for females)32. During the 1990s and 2000s, the public pension system income represented a great opportunity for rural poor and resulted in a continued reduction of poverty rates within this population groups, especially in impoverished regions of the North and Northeast32–34. However, the continued deficits of the Brazilian social security system resulted in the need for reforms on age of retirement which brought up the discussion on whether rural residents should continue to retire 5 years before the urban residents35. Some researches using data from the social security system estimated ages at the end of the benefit higher for rural residents than for urban residents and argumented in favor of ending this lower age of retirement benefit35. However, other studies highlight the different access to public health equipment and other health disadvantages of the rural population to justify keeping this lower retirement age36.

Such as in the case of USA, Brazilian rural residents experience higher deprivation in access to services and health facilities and usually report worse health status conditions and are in worse economic situation than urban residents33,35,37,38. This scenario echos the higher vulnerability condition of rural and areas other territories with lower economic integration39. The distance of health equipment, lack of resources to pay for the transportation, the lack of health professionals or higher complexity health services are barriers to the access of public health systems by the rural population40,41. This situation is worsened in the case of the elderly, population group with higher demand for such services [41}. Moreover, the access to health services of rural residents relies almost exclusively on the universal public health system (SUS) and on visits of family-care doctors of the Family Health Program while urban residents have higher access to health insurance and to a higher diversity of health equipment19,38,40,42. Additionally, rural poverty is concentrated in the already disadvantaged Northern regions of the country17,25.

The different tasks and activities demanded by the living environment also shapes the mortality and morbidity outcomes of a population. In this aspect, rural populations observe higher prevalence of specific disabilities and diseases such as chronic pains, back pains, arthritis and urban populations are usually more susceptible to diabetes, high blood pressure, heart diseases and depression33. Further, rural residents are more prone to report worsened health status33,35,38. 43 found that back pain, rheumatism, arthritis and high blood pressure were associated to the agricultural activities and results from intense physical effort in work.

This study aims to provide further information for the discussion on urban-rural mortality differentials. The rural life expectancy advantage expressed in the Brazilian national census of 201029 may not reflect a real disease free life expectancy or healthy life expectancy advantage, e. g., people from rural areas might live for longer periods, but they would have to live with disabilities that can mitigate their capacity to develop daily activities. In this sense, we investigate the prevalence of some specific diseases in urban and rural populations and construct disease-free life expectancy estimates for both residents using data from the national census of 2010 and from the national health survey of 2013. Our hypothesis is that urban areas may exhibit relative advantages in disease/disability-free life expectancy than rural areas for health problems related to physical effort while a higher prevalence of chronic diseases may be more harmful in the urban environment. This work contributes to the evaluation of urban environment penalties on adult mortality in developing countries by analysing specific groups of diseases and disabilities that result in different mortality levels in urban and rural areas27.

## Materials and Methods

### Data

This paper uses data from Brazilian national census of 2010 and Brazilian National Health Survey of 2013 to estimate life table functions such as mortality rates and life expectancy of rural and urban population groups. The inclusion of mortality inquiries in national census is a recommendation of the United Nations for countries with deficient register systems44. Several Latin American and Caribbean countries have included a question of deaths in the household within 12 months before the reference period in their national censuses45. Despite some issues, in particular those related to deceases in mono-parental households or deaths that result in breaks in family ties, the mortality inquiry in national censuses is important for performing complex analysis which might not be assessed by national register systems, such as urban-rural mortality differentials44,45.

The addition of mortality inquiry in the Brazilian 2010 national census represented an opportunity to implement analysis which could not be done by using regular mortality information system data from the Ministry of Health. Most of the mentioned studies developed about Brazilian socioeconomic differentials in mortality until 2010 national census used indirect methods to construct estimates using census or household surveys data15,16,22,26. From 1980 to 2010, Brazil experienced an increase in death registers coverage rates46 and death cause classification47. Nevertheless, the death registers data available in the data system of the Ministery of Health do not supply substantial information on socioeconomic characteristics of the population. Mortality differentials analyses are usually related to small areas mortality estimation, subnational populations studies or socioeconomic disparities, topics documented in census data variables48. Hence, the addition of mortality inquiry in the 2010 national census forstered the development of several studires on 1) educational mortality differentials49; 2) indigenous mortality50; 3) socioeconomic strata differentials18 and on 4) urban groups mortality differentials20.

The national census of 2010 investigated household deaths over the last 12 months before the reference period of the census (August 2009 - July 2010). Household respondents answered questions about age and sex of household’s deceases within this period. The use of death counts from national census for computing death rates has the advantage of considering both numerator and denominator from the same data source which contributes for the robustness of mortality pattern estimation. However, an individual’s report on the household’s deaths might be mistaken, then mortality levels computed from national census must be corrected. Death counts from national census are under-enumerated in comparison to mortality information system data, presenting a death coverage of about 80-85% according to death registration coverage estimation methods48.

In 2013, the Brazilian Institute of Geography and Statistics (IBGE) conducted the National Health Survey (PNS) in Brazil. The PNS was created to describe and assess the health situation and lifestyles of the Brazilian population by asking questions in regard to access and use of services, to preventive actions and also to socio-demographic characteristics51,52. The survey also conducted checking on some physical measures - blood pressure, weight, height - and collected biological materials from respondents52. PNS survey permits to evaluate specific morbidity indicators of the population, such as the prevalence of chronic diseases, by socioeconomic strata or geographic location (urban-rural) of the household.

### Methods

Our methodological strategy encompasses three stages of analysis: 1) estimation of basic life table functions by geographic area; 2) analysis of disease and disability prevalence data from PNS and National Census by geographic area; 3) Construction of disease/disability-free life expectancy (DFLE) indicators by geographic area; and 4) decomposition of DFLE differences among geographic areas in terms of overall mortality profiles contribution and morbidity profiles contribution.

#### Correction of mortality levels

Death coverage from Brazilian 2010 national census mortality information ranges from 80-85%48. Since death registry coverage is sensitive to regional inequalities46, census mortality data might also exhibit this pattern and may also present differences by urban-rural location. Therefore, our first attempt was to estimate death coverage by geographic location of deaths applying synthetic extinct generations (SEG)53, generalized growth balance (GGB)54 and adjusted synthetic extinct generations (SEG-adjusted)55 methods built in the R package ‘DDM’ (Death Registration Coverage Estimation)56. However, all methods presented poor performance, showing much lower and unexpected completeness of death counts coverage in rural areas. We speculate that intense rural exodus to urban areas may affect the estimates and decrease the death coverage rates of rural areas by considering the population reduction due to migration as omitted deaths, a result of the assumption of closed population of these methods.

We addopted a different strategy for completeness of death counts correction. We considered that regional inequalities of death coverage may already account at some extent for urban-rural differences in death coverage, especially because the regions with lower coverage (Northern regions) are the ones with a higher percentage of population in low-density areas57. Afterwards, we computed death coverage by the SEG-adjusted method for the five Brazilian regions: North, Northeast, Central-West, Southeast, South (table 1). Death counts were then corrected for each region by dividing the observed death counts by the presented death coverage values. Death coverage values higher than 1 were considered as 1, since there is no information that supports an over-counting of deaths in the national census at any region of the country.

SEG-adjusted death coverage estimates by sex and region, 2010. Source: Brazilian national census 2010.

|  |  |  |
| --- | --- | --- |
| Region | Males | Females |
| North | 0.89 | 0.92 |
| Northeast | 0.78 | 0.84 |
| Central-West | 0.93 | 0.94 |
| Southeast | 0.98 | 1.03 |
| South | 1.05 | 0.94 |

#### Disease-free life expectancy (DFLE) by Sullivan method

The Sullivan method of life tables uses data from diseases prevalence to construct a single index of mortality and morbidity, named disease-free life expectancy (DFLE)58,59. This index provides an estimate of years free of disability that a member of the life table’s synthetic cohort would experience if the current age-specific rates of mortality and disease/disability prevalence prevailed throughout the cohort’s lifetime58.

The basic inputs of the method are the age-specific mortality rates for life table functions estimation and age-specific disease or disability prevalence. After estimating the life table functions by the mortality rates of the synthetic cohort, the complement of the disability prevalence are multiplied by the person-years lived () by the respective age group (equation 1).

The Sullivan person-years lived by the age-group represents the life-years free of disability of that age interval. This value is used to estimate the remaining functions of the life table (cumulate life-years free of disability expected to be lived at age x - and disease-free life expectancy at age x ). Therefore, the life expectancy computed by the Sullivan method () is an estimate of the disease-free life expectancy (DFLE) of the respective age-group.

In the process of mortality transition, as countries and population groups converge to similar life expectancy levels, other public health indicators may still differ substantially. Hence, Sullivan’s index for disease-free or disability-free life expectancy can provide further insights to compare those groups with different health standards even though they exhibit similar mortality levels58.

We intend to evaluate the disease prevalence and compute DFLE for some specific sets of diseases grouped in 4 categories available from the two data sources:

* Cardiovascular diseases: high blood pressure, high cholesterol, cerebrovascular accident - PNS, 2013;
* Diabetes: citar quais doenças - PNS, 2013;
* Osteopathies: arthritis, rheumatism, chronic spine problems (back pain, neck pain, etc), work-related musculoskeletal disorders (WMSD) - PNS, 2013;
* Incapacities/disabilities: to walk, see or listen (severe or total incapacity) - Brazilian National Census, 2010;

Since differences in urban-rural mortality are expected to favor rural residents29, we compare both populations by the relative measure of DFLE. That is, we compute the proportion of life expectancy that the synthetic cohort is expected to live without the disability/disease (, equation 2). We adopt this strategy to compare relative measures and avoid distortions that might come from absolute values. We focus our attention to adult mortality differentials (15-64 age-groups) because PNS had disease prevalence data available only for adult population (18+)[[1]](#footnote-26).

#### Decomposition of rural-urban DFLE differentials

## Results

### Urban-Rural mortality differentials

Figure 1 presents age-specific mortality rates by place of residence with and without correction of death coverage factors estimated by SEG-adjusted. In consonance to the literature about rural-urban mortality differentials in Brazil and in other developing countries, the infant and child mortality rates are higher in rural areas than in urban areas and rural adult mortality are lower than urban adult mortality rates22,23,27. This compensatory effect of rural adult mortality advantage in relation to lower under-five mortality indicators results in the higher life expectancy estimates for rural populations, especially for males (table 2).

[ FIGURE 1 : Age-specific mortality rates by sex and geographic area - Brazil, 2010. Source: Brazilian National Census 2010. ]

These adjusted mortality rates yields different life expectancy estimates from 29 (table 2). The author used the official life tables estimated for Brazil from IBGE for 2010 as reference to adjust the observed deaths from the 2010 census while we used the SEG-adjusted method taking in account regional differences in death coverage completeness. In this sense, our estimates resulted in higher life expenctancy at birth values, since two of the three most populated regions (Southeast - the most populated and South - the third most populated) have census death coverages close to completeness. The rural mortality advantage is more pronounced in males than in females and it gets higher in advanced ages life expectancies. Female mortality does not seem to be affected by urban-rural geographic areas at the same level as male mortality.

[ TABLE 2 : Life expectancy (SEG-adjusted) estimates by sex, age and geographic area, 2010. Source: Brazilian national census 2010. ]

The sex differentials in mortality also favor females for Brazilian rural areas according to 2010 census data (figure 2). Nevertheless, the female advantage in rural areas is lower than the urban female mortality advantage. Large differences from male/female mortality ratios are observed between rural and urban areas especially in ages 15-24 and 30 onwards. In this sense, the male mortality excess observed in Brazilian young adult males is more evident in urban areas and, in particular, in disadvantaged and suburban areas of cities18,20.

[ FIGURE 2 : Female-male mortality ratios by geographic area - Brazil, 2010. Source: Brazilian National Census 2010. ]

### Urban-rural health conditions

Urban and rural environments shape the life styles and type of work performed by each population. These environment differences have direct impacts on workers health43. Disadvantages in self-reported health conditions have been observed in rural populations in addition to their socioeconomic and transportation disadvantages to access public health equipment38. The difficulties to access health equipments due to distance or lack of resources were mentioned by 56% of rural residents who did not access health services and needed to against 17% of urban residents in the PNS survey of 2013. Urban residents mostly did not access health services when they needed to because of long waiting time (28% against 8% of rural population. Thus, these differentials in access to health services may incur in lower disease diagnosis. Indeed, the 2013 PNS survey showed that rural population had higher percentage of people that never had measured their glycemic levels (21% against 10% for urban residents) or blood pressure (6% against 3% for urban residents). This scenario could have been worse if the Family Health Program of the Brazilian Ministry of Health was not successful in reaching remote communities of the countryside of Brazil19,42,60. Even though rural residents showed lower diagnosis rates than urban residents, we still had sufficient data to evaluate disease prevalence of urban and rural populations (table 3).

[ TABLE 3 : Urban and rural disease and disability prevalence of adult population (15-64) by sex - Brazil, 2010-2013. Source: Brazilian National Census 2010 and National Health Survey 2013. ]

For the adult population (15-64 years old) as a whole, there are rural penalties (higher rural-urban prevalence ratios) in prevalences of osteopathies and physical incapacities for males and of cardiovascular diseases and physical incapacities for females. Also, adult women fom rural environments had higher prevalence rates of all diseases investigated. Figure 3 extends the analysis by age group. We present the prevalence rates estimated in the PNS survey of 2013 for cardiovascular diseases, diabetes and osteopathis and in the national census of 2010 for physical incapacities and their respective smoothed estimates[[2]](#footnote-31). The smoothing methods were used to minimize the high variability of prevalence rates, especially for the lower counts of rural residents of the PNS survey of 2013. Smoothing of incapacities prevalence for census information are presented, but the original prevalence rates were used for Sullivan method estimation of next section.

[ FIGURE 3 : Urban and rural disease and disability prevalence by sex and age - Brazil, 2010-2013. Source: Brazilian National Census 2010 and National Health Survey 2013.]

As expected, rural males presented higher prevalence rates of osteopathies, mainly in advanced ages, for women there is no clear pattern due to high data variability for rural residents. On the opposite direction, rural men are in better off situation in regard to diabetes prevalence rates, which presented a wide gap for advanced ages, and for cardiovascular diseases prevalence rates, which presented a small but contiuous gap from age group 30-34 onwards. Female prevalence curves for diabetes did not present any significant gap while the prevalence curves of cardiovascular diseases for women in rural areas exhibited higher rates than urban curves. For both males and females, the prevalence rates of physical disabilities declared in the national census of 2010 were slightly higher in rural settlements. Hence, results are in conformity with previous analysis performed for rural workers in Brazil43.

### Disease-free life expectancy (DFLE)

Tables 4 and 5 present the results of disease-free life expectancy (DFLE) estimates for males and females of rural and urban areas at birth, at 20 years old, at 40 years old and at 60 years old. For males, rural-urban disease-free life expectancy ratios show a continuous increase in the rural-urban gap through advanced ages. Indeed, these results corroborate to the idea of an existing urban mortality penalty in lower income countries and announces also a morbidity penalty for the urban elderly. These absolute values present worse scenarios in urban areas for life expectancy without cardiovascular diseases and without diabetes estimates, the two groups of diseases the exhibited higher prevalences for the urban population than their rural counterparts among the adult and the older age groups. Female absolute values estimates did not show any significant difference between urban and rural areas, even though a slight rural advantage was observed for diabetes-free life expectancy at ages 40 and 60.

Absolute differences highlight rural advantages in mortality and morbidity indicators. We now turn our attention to relative differences in healthy life expectancy estimates, e. g., we evaluate the ratio of disease-free life expectancy by life expectancy for age groups 15-74 (figure 4). This ratio can be interpreted as a proxy of the proportion of life expected to be lived without the disease/disability for a synthetic cohort with a set of age-specific disease prevalence rates and age-specific mortality rates.

When we analyze relative estimates of disease-free life expectancy the rural advantage observed for all groups of diseases/disabilities changes. The rural advantage prevails only for cardiovascular diseases and diabetes whereas a relative urban advantage in relative disease-free life expectancy is observed for osteopathies and incapacities. These results confirms that rural residents are more prone to develop physical incapacities and disabilities and suffer of musculoskeletal pain due to the physically demanding labour required in agriculture43. Therefore, the absolute advantages observed in DFLE numbers may not reflect in actually better life conditions in terms of life span relative measures.

[ TABLE 4 : Disease-free life expectancy estimates by age and geographic area - males, 2010. Source: Source: Brazilian National Census 2010 and National Health Survey 2013. ]

[ TABLE 5 : Disease-free life expectancy estimates by age and geographic area - females, 2010. Source: Source: Brazilian National Census 2010 and National Health Survey 2013. ]

[ FIGURE 4 : Proportion of life expected to be lived without disability/disease by sex and geographic area - Brazil, 2010. Source: Brazilian National Census 2010 and National Health Survey 2013. ]

These results should be analyzed with caution. As mentioned, rural population lower access to health services reflects in lower measurement rates of health indicators such as glycemic level and blood pressure. Then, prevalence rates for rural groups might be underestimated due to lack of diagnostic. In spite of this important detail, the data collected is robust enough and went in the same direction of previous studies on rural and urban health and mortality differentials. Thus, we verified the existence of an urban adult mortality penalty and also in an urban adult morbidity penalty for cardiovascular diseases and diabetes. Finally, it was verified a rural morbidity penalty in regard to incapacities (to walk, see and listen) and osteopathies, e. g., physical disabilities. Therefore, rural residents have a higher life expecancy, but a higher fraction of this life expectancy is accompanied by physical disabilities or musculoskeletal pain.

## Discussion

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1. Even though PNS had prevalence data available only for adults aged over 18 years old, we considered the prevalence distribution of diseases for age group 15-19 equal to the rates observed for the age group 18-19. For age groups 0-14 the prevalence rates for PNS survey were considered equal to 0, in order to get estimates for disease-free life expectancy at birth. [↑](#footnote-ref-26)
2. Prevalence rates of diseases and disabilities were smoothed by apply the localy estimated scatterplot smoothing method (LOESS) [↑](#footnote-ref-31)