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

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## Introduction

By the beginning of the urbanization and industrialization processes in the developed Western countries, urban areas exhibited higher mortality rates than their rural counterparts1,2. Mortality levels among young age-groups (0-14) were more sensitive to the urban environment than adult mortality levels; hence, cities observed higher youth mortality rates than rural areas2. Infant and child mortality rates are affected by wealth and socioeconomic determinants through variables such as sanitation conditions and population dietary intake3. Cities of the XIX century 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.

In the following periods, this scenario changed considerably. Socioeconomic development and economic growth of Western countries subsidized better living conditions in cities4 and these provided resources to overcome communicable diseases deaths and fostered 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 transportation that are still a major issue in cities nowadays2,6–8. In the United States, for example, rural and non-metropolitan residents are in a disadvantaged position in regard to life expectancy and to health indicators9–13. This negative position in relation to their urban counterparts is followed by other features such as higher health information illiteracy among rural residents, lack of access to health equipment and other kinds of socioeconomic deprivation that are more likely to affect non-metropolitan areas9,11–16.

The debate over urban and rural mortality differentials in developing countries is usually divided in two components: infant/child mortality and adult mortality. Infant and child mortality are more impacted by community-level characteristics and socioeconomic situation3,17–20. Latin American countries, for example, present lower urban than rural infant mortality rates, despite most of countries are in a converging trend of urban and rural rates21. In Brazil, urban areas exhibit an under-five mortality advantage in comparison to the country’s rural areas, as a result of its better socioeconomic status such as higher schooling levels and higher access to sanitation and public services in general18,22,23.

In spite of the urban advantaged observed in child and infant mortality levels, most studies documented lower adult mortality rates in rural areas of lower income countries17–19,22,24–26. Metropolitan areas of developing countries present high within-urban mortality gaps among social groups due to the unequal access to essential public services (health equipment, education and sanitation) as a consequence of a rapid urbanization process19,24,27. Living conditions in these developing urbanized centers deteriorate individuals health and expose them to higher mortality risks compared to their rural counterparts in a similar way as observed in the past for more developed countries, resulting in an urban death penalty28.

This is a particular feature of Brazilian mortality differentials. The advantage of urban environments in regard to mortality in Brazil prevails on some specific conditions. 29 showed that urban-rural life expectancy differentials favored the urban areas of wealthier social strata whereas the opposite was observed in poor areas of the country in 1960-70 period. Using 2010 National Census mortality data, 26 verified a mortality advantage for rural areas, especially for the male population. He estimated 73.6 and 69.3 life expectancy at birth for rural and urban male population, respectively, and 77.8 and 77.1 life expectancy for females. 30 disentangled these findings by looking into social groups of different urban areas. He compared Brazilian mortality levels of urban residents from slums and from out of slums with rural residents mortality levels and verified an urban penalty for those living in these marginalized urban environments. The urban periphery of Brazilian metropolitan areas are known for its poor urban assets and damaged social conditions, presenting high violence and criminal rates and deprivation of public assets such as public sanitation31,32. The result of this scenario is a worsened health and mortality status of the urban periphery adult population of the country33–35.

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)36. During the 1990s and 2000s, the public pension system income played an important role for economically vulnerable rural households and was a main driver of poverty reduction within this population groups, especially in North and Northeast regions36–38. However, 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 urban residents39. Estimates of ages at benefit cessation constructed from social security system data are higher for rural residents than for urban residents39. This result was used as an argument to repeal this lower age of retirement benefit of rural workers39. Those contrary to this opinion, nevertheless, have highlighted the different access to public health equipment and health disadvantages of the rural population to justify keeping a lower retirement age for rural workers40.

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 residents37,39,41,42. This scenario echos the higher vulnerability condition of rural areas and other territories with lower economic integration23,43,44. The distance of health equipment, lack of resources to pay for the transportation, the lack of health professionals or unavailability of higher complexity health services are barriers to the access of public health systems by the rural population44–46. This situation is worsened for the elderly, population group with higher demand for such services [46}. Moreover, the access to health services of rural residents relies almost exclusively on the public health system (SUS, from Portuguese *Sistema Único de Saúde*) and on visits of family-care doctors of the Family Health Strategy (ESF, from Portuguese *Estratégia de Saúde da Família*) while urban residents have higher access to health insurance and to a higher diversity of health equipment from both private and public health systems34,42,45,47.

The different tasks and activities demanded by the living environment also shapes the mortality and morbidity outcomes of a population. 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 depression37. Further, rural residents are more prone to report worsened health status37,39,42,48. 49 found that back pain, rheumatism, arthritis and high blood pressure were associated to the agricultural activities and results from intense physical effort in work. The difference in social status also plays a key role in the self-perception of health state44. Then, rural populations usually declare poor health conditions than urban ones42,48. However, looking into social groups, rural residents from lower social strata have higher probability of referring a good state of health than their identicals from urban areas48.

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 201026 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 (PNS, from Portuguese *Pesquisa Nacional de Saúde*) 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. By focusing on adult population estimates, this work contributes to the evaluation of urban environment penalties on adult mortality and morbidity in developing countries by analyzing specific groups of diseases and disabilities that result in different mortality outcomes for urban and rural areas24.

## Materials and Methods

### Data

This paper uses data from Brazilian national census of 2010 and Brazilian national health survey of 2013 to estimate basic life table functions and implement further extensions on these functions for the evaluation of population health state. Both household inquiries are conducted by the Brazilian Institute of Geography and Statistics (IBGE, from Portuguese *Instituto Brasileiro de Geografia e Estatística*).

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 characteristics50,51. The survey also conducted checking on some physical measures - blood pressure, weight, height - and collected biological materials from respondents51. PNS survey permits to evaluate specific morbidity indicators of the population, such as the prevalence of chronic diseases, by socioeconomic strata or geographic environment (urban-rural) of the household.

The addition of mortality inquiry in the Brazilian 2010 national census represented an opportunity to implement studies and analysis that could not be done by using the mortality information system (SIM, from Portuguese *Sistema de Informações sobre Mortalidade*) data from the Ministry of Health. Despite the SIM data quality improvements52 and coverage expansion of death registers53, this system data does not provide substantial information about the deceased socioeconomic characteristics which are essential for the evaluation of mortality in sub-national population groups54–56.

Therefore, most of the mentioned studies developed about Brazilian socioeconomic differentials in mortality before 2010 national census applied indirect methods to construct estimates using census or household surveys data18,22,29,31. The addition of mortality inquiry in the 2010 national census enabled the development of several studies on educational mortality differentials57, indigenous groups mortality58, socioeconomic strata mortality differentials33 and on urban groups mortality differentials30,35.

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 and present a death coverage rate of about 80-85%, according to death registration coverage estimation methods55.

### Methods

Our methodological strategy encompasses four stages of analysis: 1) estimation of basic life table functions for each population group (urban and rural residents) from 2010 national census mortality data; 2) estimation and analysis of disease and disability age-specific prevalence data from PNS and national census data on disease and disability prevalence; 3) construction of disease/disability-free life expectancy indicators (also known as health expectancy) for each population group; and 4) decomposition of health expectancy differentials among rural and urban populations in terms of overall mortality profiles contribution and specific morbidity profiles contribution.

#### Correction of mortality levels

As mentioned, Brazilian 2010 national census mortality information has death coverage rates ranging from 80-85%55. Since death registry coverage is sensitive to regional inequalities53, census mortality data might also exhibit this pattern and is very likely to present differences between rural and urban households. Therefore, our first attempt was to estimate death coverage of each of these settings by applying synthetic extinct generations (SEG)59, generalized growth balance (GGB)60 and adjusted synthetic extinct generations (SEG-adjusted)61 methods built in the R package *DDM* (Death Registration Coverage Estimation)62. However, all methods presented poor performance, showing much lower and unexpected death 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 possible omitted deaths. This bias is a direct result closed population assumption required by these death registration coverage methods.

Then, we adopted 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 (North and Northeast regions) are the ones with higher proportions of population living in low-density areas63. Afterwards, we estimated regional death coverage rates (DCR) by the SEG-adjusted method by sex for the five Brazilian regions (North, Northeast, Central-West, Southeast, South). North (DCR males: 0.89, DCR females: 0.92) and Northeast (DCR males: 0.78, DCR females: 0.84) presented the lowest estimated death coverage rates; South (males: 1.05, females: 0.94) and Southeast (males: 0.98, females: 1.03) presented the highest estimates; and Central-West exhibited an intermediate DCR level among the five regions (DCR males: 0.93, DCR females: 0.94). Census death counts were then corrected for each region by dividing the observed death counts by respective DCR. DCR higher than 1 were considered as 1, since there is no evidence that supports a death over-counting in the 2010 national census at any region of the country.

#### Morbidity-free life expectancy estimation 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 or health expectancy64–66. 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 lifetime64.

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

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

In the process of mortality transition, whilst mortality levels converge among populations, other public health indicators may still differ substantially. Hence, Sullivan’s index for morbidity-free life expectancy can provide further insights to compare those groups with different health standards even though they exhibit similar mortality levels64.

We evaluate the morbidity prevalence and compute morbidity-free life expectancy for some specific sets of morbidities grouped in 4 categories available from the two data sources:

* Cardiovascular diseases - high blood pressure, high cholesterol, cerebrovascular accident67
* Diabetes67;
* Osteopathies - arthritis, rheumatism, chronic spine problems (back pain, neck pain, etc), work-related musculoskeletal disorders (WMSD)67;
* Incapacity/disabilities: to walk, see or listen (restricted to severe or total incapacity)68;

Since differences in urban-rural mortality are expected to favor rural residents26, we compare both populations also by a relative measure of morbidity-free life expectancy. That is, we compute the proportion of life expectancy that the synthetic cohort is expected to live free from each related morbidity ( ratio). 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 (15-69 age-groups) because PNS had disease prevalence data available only for adult population (18+)[[1]](#footnote-2).

#### Decomposition of rural-urban DFLE differentials

Our decomposition approach is based on the step-wise replacement algorithm for decomposition of demographic measures developed by 65. For equation 1, the estimation of person-years lived in good health, e. g., free of morbidity, requires two variable vectors: person-years lived by age group (), derived from age-specific mortality rates vector (), and age-specific healthy condition or morbidity-free prevalence vectors (). Then, the health expectancy () at age x can be stated a function of age-specific mortality rates and age-specific health prevalence (equation 2).

The urban-rural differences for health expectancy can be decomposed into two components computed by applying the stepwise replacement algorithm. The algorithm’s rationale lies behind the transformation of one population group vector of health expectancy (, for example) into the other population group vector of health expectancy ( in our case). Considering the components of function (equation 2), we can obtain rural health expectancy vector estimates out of urban health expectancy vector by transforming each of its elements and into and which is performed in an age-by-age replacement mode: and are the mortality and morbidity-free prevalence rates vectors composed by rates and at ages and and at ages $ x y$, respectively65.

Therefore, the difference is the sum of two components: 1) (equation 3), component of difference due to difference in mortality rates at age x, and 2) (equation 4), component of difference due to difference in morbidity-free prevalence at age x.

## Results

### Urban-Rural mortality differentials

Figure 1 presents age-specific mortality rates by place of residence after death coverage correction by SEG-adjusted estimated DCRs. 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 rates are lower than urban adult mortality rates18,19,24. 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 : Rural and urban age-specific mortality rates by sex - Brazil, 2010. Source: Brazilian National Census 2010. ]

These adjusted mortality rates yields different life expectancy estimates from 26 (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 expectancy at birth values, since two of the three most populated regions (Southeast - the most populated and South - the third most populated) have census death counts coverage rates close to completeness (100%). The rural life expectancy advantage is more pronounced in males than in females and it gets higher for older ages. Female estimates do not show marked urban-rural differentials as male life expectancy estimates.

[ TABLE 1 : Rural and urban life expectancy estimates by sex and age - Brazil, 2010. Source: Brazilian national census 2010. ]

The sex differentials in mortality also favor females for Brazilian rural areas according to 2010 census data. 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 for adult ages. 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 cities33,35.

### 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 health49. Disadvantages in self-reported health conditions have been observed in rural populations in addition to their socioeconomic and transportation disadvantages to access public health equipment42. The difficulties to access health equipment 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, PNS data shows 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 Strategy of the Brazilian Ministry of Health was not successful in reaching remote communities of the countryside of Brazil34,47,69. 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.

For the adult population as a whole, there are rural penalties (higher rural-urban prevalence ratios) in prevalence of osteopathies and physical incapacity for males and of cardiovascular diseases and physical incapacity for females. Also, adult women from rural environments had higher prevalence rates of all morbidities 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 osteopathies and in the national census of 2010 for physical incapacity and their respective smoothed estimates[[2]](#footnote-3). The smoothing methods were used to minimize the high variability of prevalence rates, especially for PNS lower counts of rural residents. Smoothing of incapacity prevalence for census information are presented, but the original prevalence rates were used for Sullivan method estimation of next section, since they showed very low variability.

[ FIGURE 3 : Rural and urban 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, especially 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 also for cardiovascular diseases prevalence rates, which presented a small but continuous gap from age group 30-34 and above. 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 settings. Hence, results are in conformity with previous analysis performed for rural workers in Brazil49. Significant decreases observed in PNS morbidities prevalence for the elderly may be related to poor disease diagnostic of this age-group in rural populations.

### Morbidity-free life expectancy

Table 2 presents the results of morbidity-free life expectancy or heath expectancy () 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. These two groups of diseases exhibited higher prevalence for the urban population for the adult and the older age groups. Female absolute values estimates reported negligible 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 morbidity-free life expectancy by life expectancy ( ratio) (table 2). This ratio can be interpreted as a proxy of the proportion of life expected to be lived free from morbidity for a synthetic cohort with a set of age-specific morbidity prevalence rates and age-specific mortality rates. Relative estimates of health expectancy changes the rural advantage observed for all groups of morbidity so far. The rural advantage prevails only for cardiovascular diseases and diabetes whereas a relative urban advantage is observed for osteopathies and physical disabilities. These results confirms that rural residents are more prone to develop physical incapacity and disabilities and suffer of musculoskeletal pain due to the physically demanding labor required in agriculture48,49. The absolute advantages observed in health expectancy numbers may not reflect in actually better life conditions in terms of life span relative measures. Therefore, we decompose differences in health expectancy into its mortality and morbidity components to investigate positive or negative contributions and provide further evidence on what might seem as a mortality exclusive advantage or mortality and morbidity advantage of rural residents.

[ TABLE 2 : Rural and urban health expectancy estimates and health expectancy to life expecanty ratios by sex and age - Brazil, 2010-2013. Source: Brazilian National Census 2010 and National Health Survey 2013. ]

### Decomposition of health expectancy

Figure 3 presents the results of decomposition of differences in health expectancy from rural and urban settings by related morbidity. For males, positive values of mortality contribution to rural-urban health expectancy differentials shows that the overall mortality curve differences among rural and urban populations favors the first ones. However, as expected by morbidity prevalence curves, ostheopaties and physical disabilities have negative impacts on the health expectancy differences between rural and urban populations. These differences are, however, lower than the differences of the overall mortality shape. Hence, positive differences in rural-urban health differentials are still evident even though some morbidities act towards reduction of rural advantages.

Estimated differences from rural to urban morbidity-free life expectancy at 20 years old of these two morbidities resulted in a 0.5 difference for osteopathies and 2.4 for physical disabilities. For osteopathies, the disease prevalence profiles difference accounted for -2.4 of the estimated difference and the mortality shape differences accounted for 2.9 of the differences. Therefore, muscoeskeletal and physical morbidities are responsible for slowing down the rural mortality curve advantaged condition. For census reported disabilities, the difference in morbidity profiles accounted for -0.5 of rural-urban health expectancy difference, much lower than morbidity contribution of osteopathies, but also in the opposite direction of the mortality profiles difference contribution.

This decomposition exercise highlights that health expectancy differences observed between rural and urban populations are not only due to overall mortality difference but also related to differences of age-specific morbidity prevalence. The results are in consonance with the bibliographic review, which show that cardiovascular diseases and diabetes are city related morbidities and physical disabilities and osteopathies are rural related morbidities that result from physically harming work performed at rural areas. Hence, rural residents present a double advantage (in mortality and in morbidity) when we compare health expectancy for cardiovascular diseases and diabetes, however, this advantage becomes exclusively a mortality profile advantage when we decompose differences for osteopathies and physical disabilities.

For women, cardiovascular diseases and diabetes prevalence seems to damage the health expectancy of urban elderly, but minor differentials were found among physical or muscoeskeletal related morbidities. However, we must evaluate this results with caution, since there is a lower diagnosis of morbidities in rural areas due to lack of measurement and lower quality of reported information on the elderly.

[FIGURE 3: Decomposition of rural-urban health expectancy differentials by sex and age - Brazil, 2010-2013. Source: Brazilian National Census 2010 and National Health Survey 2013.]

## Discussion

This paper extended the discussion on rural-urban mortality towards health expectancy differentials. Mortality differencials have already been addressed in previous researches26,29,30 and our results reflect those previous findings. The main contribution of the paper was to look into health expectancy differentials based on available age-specific prevalence data of the PNS survey of 2013 and evaluate this estimates relative to life expectancy estimates and decompose differences into mortality shape difference contribution and morbidity profiles contribution.

Over the last 30 years, Brazil has experienced substantial changes on its public health policy represented by the implementation and consolidation of the country’s unified health system (SUS)70. SUS guaranteed a massive expansion of the health care assistance for the most vulnerable social groups through an universal and free of charges health services. Moreover, the gradual implementation of the family health strategy (ESF) - a public health policy approach focused on primary care at the community level - provided several positive outcomes such as the reduction of infant mortality rates69,71–73, improvement of child health74, reduction of maternal mortality rates69 and reduction of hospitalizations due to causes sensitive to primary care75. ESF policy approach is oriented towards the needs of poorest regions and most vulnerable social groups, therefore, its positive outcomes were mostly visible in regions and areas of the country with worsened health and socioeconomic conditions73,76. Additionally, ESF community-level policy provides further positive spillover effects on other socioeconomic variables such as education and employement73.

In 2013, 54.4% of Brazilian households were registered in the local family health unit, 74.9% of rural households and 50.6% of urban households47. This higher ESF coverage and primary care assistance in rural areas might account for the favorable results of rural residents in regard to mortality and cardiovascular diseases and diabetes morbidity differentials, since ESF professionals provide not only health care support, but also health information, enhancing health literacy levels of local communities. Nevertheless, these numbers also indicate that rural communities have a higher reliance on public health services and lower access to higher complexity health services and health insurance than urban residents46.

The differences of health expectancy observed in diet related morbidities (cardiovascular diseases and diabetes) provide insights on cultural differences of living conditions in rural and urban settings, especially in regard to different diets. In the developing world, diet changes are increasing the consumption of fat and sugar and the result is the increase of excess weight in populations from both urban and rural (in a lower extent) settings77. In Brazil, higher consumption of ultra-processed food is associated with higher prevalence of obesity and excess weight78 and it has been increasing through time79. Ultra-processed food consumption is usually higher among higher income households and accounts for diet quality deterioration80,81. In general, urban household diets in Brazil rely on supermarket food and are composed by a large share of processed food whereas rural diets have considerable shares of local and minimally processed food on its composition82,83.

However, there is evidence that the on-going nutritional transition in some rural communities and lower income groups in Brazil is leading to a higher supermarket dependence on food consumption, resulting in lower demand local and unprocessed food84,85. Further, cardiovascular mortality has been spreading throughout the countries’ less developed areas86. In this sense, public health policies and especially family health professionals must take into account this changing diet movement in order to avoid an increase of processed food-related non-communicable diseases such as cardiovascular diseases and diabetes in rural communities.

In regard to the investigated physically related morbidities, our results show that rural residents are penalized by the higher physically demanding lifestyle of rural activities49,87–89. The results are in consonance with studies from other countries, which found rural mortality and morbidity advantages except concerning muscoeskeletal disorders89. Despite physical health hazards of rural activities, there are also several other hazards such as chemical exposure (pesticides) or biological threats (zoonoses) that were not part of our analysis that must be taken into account by health policy designers49,87,90.

The results of this work support the efforts of family health strategy towards health coverage of most vulnerable and remote areas of the country76. ESF expansion provides diagnosis and follow-up of chronic diseases in rural populations and provides an enhancement of its health literacy which might also have contributed for further mortality improvements of this groups69,73. Also, lower exposition to urban-related mortality causes such as violence and accidents is likely to play a key role for lower mortality observed in rural areas30.

This paper results should be analyzed with caution. As mentioned, rural population lower access to health services reflects in lower diagnostic rates of health indicators such as glycemic level and blood pressure. Then, prevalence rates for rural groups might be underestimated due to lack of diagnosis. In spite of this important detail, the data collected is robust enough and results are in consonance with previous studies on rural and urban health and mortality differentials. We verified the existence of an urban adult mortality penalty and also in an urban adult morbidity penalty for cardiovascular diseases and diabetes. Finally, we verified a rural morbidity penalty related to physical disabilities (to walk, see and listen) and osteopathies. This penalty contributes for lower health expectancy differences in regard to these two morbidities, but it is compensated by the rural mortality advantage. Therefore, rural residents exhibit higher life expecancies, but a significant share of this life expectancy co-occur with physical and muscoeskeletal related morbidities.

## References

1 Davis K. *Cities and mortality*. Liege, Belgium: International Union for the Scientific Study of Population, 1973.

2 Woods R. Urban-rural mortality differentials: An unresolved debate. *Population and Development Review* 2003;29:29–46.

3 Mosley WH, Chen LC. An analytical Framework for the study of child survival in developing countries. *Population and Development Review* 1984;10.

4 Preston SH. The changing relation between mortality and level of economic development. *Population Studies* 1975;29:231–48.

5 Omran AR. The epidemiologic transition: a theory of the epidemiology of population change. *The Milbank Memorial Fund Quarterly* 1971;49:509–38.

6 Fotso J-C. Child health inequities in developing countries: Differences across urban and rural areas. *International Journal for Equity in Health* 2006;5.

7 Jedwab R, Vollrath D. The urban mortality transition and poor-country urbanization. *American Economic Journal: Macroeconomics* 2019;11:223–75.

8 Torres C, Canudas-Romo V, Oeppen J. The contribution of urbanization to changes in life expectancy in scotland, 1861–1910. *Population Studies* 2019;1–18.

9 Singh GK. Area deprivation and widening inequalities in us mortality, 1969–1998. *American Journal of Public Health* 2003;93:1137–43.

10 Singh GK, Siahpush M. Widening rural–urban disparities in all-cause mortality and mortality from major causes of death in the usa, 1969–2009. *Journal of Urban Health: Bulletin of the New York Academy of Medicine* 2013;91:272–92.

11 Spencer JC, Wheeler SB, Rotter JS, Holmes GM. Decomposing mortality disparities in urban and rural u.s. Counties. *Health Services Research* 2018;53:4310–31.

12 Chen X, Orom H, Hay JL, et al. Differences in rural and urban health information access and use. *The Journal of Rural Health* 2019;35:405–17.

13 Henning-Smith C, Prasad S, Casey M, Kozhimannil K, Moscovice I. Rural-urban differences in medicare quality scores persist after adjusting for sociodemographic and environmental characteristics. *The Journal of Rural Health* 2019;35:58–67.

14 Strasser R. Rural health around the world: challenges and solutions\*. *Family Practice* 2003;20:457–63.

15 Henning-Smith C, Evenson A, Corbett A, Kozhimannil K, Moscovice I. Rural transportation: challenges and opportunities. University of Minnesota Rural Health Research Center, 2017.

16 Voigt M, Ordanovich D, Viciana Fernández F, Cilek LA, Canovas Balboá R, Ramiro Fariñas D. Urban environment and mortality differentials in spain. *Population, Space and Place* 2019;25.

17 Gould WTS. African mortality and the new ’urban penalty’. *Health and Place* 1998;4:171–81.

18 Sastry N. Urbanization, development and under-five mortality differentials by place of residence in São Paulo, Brazil, 1970-1991. *Demographic Research* 2004;355–86.

19 Fink G, Günther I, Hill K. Urban Mortality Transitions: The Role of Slums. In: Ramiro Fariñas D, Oris M, editors *New approaches to death in cities during the health transition*. Cham: Springer International Publishing, 2016; 197–216.

20 Garenne M. Will Urban and Rural Mortality Converge in Africa? In: Ramiro Fariñas D, Oris M, editors *New approaches to death in cities during the health transition*. Cham: Springer International Publishing, 2016; 181–96.

21 Garcia J. Urban–rural differentials in Latin American infant mortality. *Demographic Research* 2020;42:203–44.

22 Sastry N. What explains rural-urban differentials in child mortality in brazil? *Social Science & Medicine* 1997;44:989–1002.

23 Soares S, Souza LR, Silva WJ, Silveira FG, Campos A. Poverty Profile: The Rural North and Northeast of Brazil. International Policy Centre for Inclusive Growth, 2016.

24 Günther I, Harttgen K. Deadly cities? Spatial inequalities in mortality in sub-saharan africa. *Population and Development Review* 2012;38:469–86.

25 Oren AM, Stecklov G. Urban–rural disparities in adult mortality in sub-saharan africa. *Demographic Research* 2018;39:136–76.

26 Albuquerque FRPC. Tábuas de Mortalidade segundo a situação do domicílio utilizando-se o Censo Demográfico de 2010. Ministério da Economia, 2019.

27 Brueckner M. Adult mortality and urbanization: Examination of a weak connection in sub-saharan africa. *World Development* 2019;122:184–98.

28 Reher DS. In search of the ’urban penalty’: Exploring urban and rural mortality patterns in spain during the demographic transition. *International Journal of Population Geography* 2001;7:105–227.

29 Carvalho JAM, Wood CH. Mortality, income distribution, and rural-urban residence in brazil. *Population and Development Review* 1978;4:405–20.

30 Pereira FNA. Penalidade urbana na mortalidade por local de moradia no brasil: Diferenciais de mortalidade entre moradores de áreas urbanas em favelas, fora de favelas e de áreas rurais. 2020.

31 Merrick TW. The effect of piped water on early childhood mortality in urban Brazil, 1970 to 1976. *Demography* 1985;22.

32 Rodella A-S. Poverty and Shared Prosperity in Brazil’s Metropolitan Regions: Taking Stock and Identifying Priorities. World Bank Group, 2015.

33 Pereira FNA, Queiroz BL. Differences in mortality in brazilian youth: The importance of household socioeconomic factors and living conditions in brazilian municipalities and states. *Cadernos de Saúde Pública* 2016;32.

34 Albuquerque MV de, Viana ALd, Lima LD de, Ferreira MP, Fusaro ER, Iozzi FL. Regional health inequalities: changes observed in Brazil from 2000-2016. *Ciência e Saúde Coletiva* 2017;22:1055–64.

35 Pereira FNA. *Geografia é destino? Diferenciais de mortalidade por local de moradia no brasil dentre moradores de áreas urbanas de favela e não favela*. Poços de Caldas, Brasil: Associação Brasileira de Estudos Populacionais, 2018.

36 Beltrão KI, Oliveira FEB, Pinheiro SS. A população rural e a previdência social no Brasil: uma análise com ênfase nas mudanças constitucionais. Instituto de Pesquisa Econômica e Aplicada, 2000.

37 Camarano AA. Brazilian population ageing: differences in well-being by rural and urban areas. Instituto de Pesquisa Econômica e Aplicada, 2002.

38 Maia AG, Buainain AM. O novo mapa da população rural brasileira. *Confins [Online]* 2015;25.

39 Paiva LH, Stivali M, Rangel LA. Devemos unificar as idades de elegibilidade das previdências urbana e rural? Instituto de Pesquisa Econômica e Aplicada, 2018.

40 Arbex A, Galiza M. Reforma da previdência, agricultura familiar e os riscos de desproteção social. Instituto de Pesquisa Econômica e Aplicada, 2017.

41 Wanderley MNB, Neil E. The brazilian rural world: Access to goods and services and coutryside-city integration. *Estudos Sociedade e Agricultura* 2008;4.

42 Arruda NM, Maia AG, Alves LC. Desigualdade no acesso à saúde entre as áreas urbanas e rurais do Brasil: uma decomposição de fatores entre 1998 a 2008. *Cadernos de Saúde Pública* 2018;34.

43 Travassos C, Oliveira EXG, Viacava F. Desigualdades geográficas e sociais no acesso aos serviços de saúde no Brasil: 1998 e 2003. *Ciência e Saúde Coletiva* 2006;11:975–86.

44 Viacava SMAC Francisco AND Porto. Health inequalities by region and social group based on data from household surveys (Brazil, 1998-2013). *Ciência & Saúde Coletiva* 2019;24:2745–60.

45 Kassouf AL. Acesso aos serviços de saúde nas áreas urbana e rural do Brasil. *Revista de Economia e Sociologia Rural* 2005;43:29–44.

46 Travassos F Claudia AND Viacava. Acesso e uso de serviços de saúde em idosos residentes em áreas rurais, Brasil, 1998 e 2003. *Cadernos de Saúde Pública* 2007;23:2490–2502.

47 Malta MASAS Deborah Carvalho AND Santos. Family Health Strategy Coverage in Brazil, according to the National Health Survey, 2013. *Ciência & Saúde Coletiva* 2016;21:327–38.

48 Maia CG Alexandre Gori AND Rodrigues. Saúde e mercado de trabalho no Brasil: diferenciais entre ocupados agrícolas e não agrícolas. *Revista de Economia e Sociologia Rural* 2010;48:737–65.

49 Moreira JPL, Oliveira BLCA de, Muzi CD, Cunha CLF, Brito A dos S, Luiz RR. A saúde dos trabalhadores da atividade rural no Brasil. *Cadernos de Saúde Pública* 2015;31:1698–1708.

50 Szwarcwald CL, Malta DC, Pereira CA, et al. Pesquisa Nacional de Saúde no Brasil: concepção e metodologia de aplicação. *Ciência e Saúde Coletiva* 2014;19:333–42.

51 Damacena CLAM Giseli Nogueira AND Szwarcwald. The Development of the National Health Survey in Brazil, 2013. *Epidemiologia e Serviços de Saúde* 2015;24:197–206.

52 Lima EEC de, Queiroz BL. Evolution of the deaths registry system in Brazil: associations with changes in the mortality profile, under-registration of death counts, and ill-defined causes of death. *Cadernos de Saúde Pública* 2014;30:1721–30.

53 Queiroz BL, Freire FHM de A, Gonzaga MR, Lima EEC de. Estimativas do grau de cobertura e da mortalidade adulta (45q15) para as unidades da federação no Brasil entre 1980 e 2010. *Revista Brasileira de Epidemiologia* 2017;20:21–33.

54 United Nations. Principles and recommendations for population and housing censuses. Nova York: United Nations, 2017.

55 Queiroz BL, Sawyer DOT. O que os dados de mortalidade do Censo de 2010 podem nos dizer? *Revista Brasileira de Estudos de População* 2012;29:225–38.

56 Queiroz BL, Sacco N. Es relevante incorporar la medición de la mortalidad en los censos de américa latina y el caribe? *Revista Brasileira de Estudos de População* 2018;35.

57 Silva LE da, Freire FHM de A, Pereira RHM. Diferenciais de mortalidade por escolaridade da população adulta brasileira, em 2010. *Cadernos de Saúde Pública* 2016;32.

58 Campos MB, Borges GM, Queiroz BL, Santos RV. Diferenciais de mortalidade entre indígenas e não indígenas no brasil com base no censo demográfico de 2010. *Cadernos de Saúde Pública* 2017;33.

59 Bennett NG, Horiuchi S. Estimating the completeness of death registration in a closed population. *Population Index* 1981;47:207–21.

60 Hill K. Estimating census and death registration completeness. *Asian Pac Popul Forum East-West Popul* 1987;1:23–24.

61 Hill K, You D, Choi Y. Death distribution methods for estimating adult mortality: Sensitivity analysis with simulated data errors. *Demographic Research* 2009;21:235–54.

62 Riffe T, Lima E, Queiroz B. *DDM: Death registration coverage estimation*. 2017.

63 IBGE. Classificação e caracterização dos espaços rurais e urbanos do Brasil. Instituto Brasileiro de Geografia e Estatística, 2017.

64 Sullivan DF. A single index of mortality and morbidity. *HSMHA Health Reports* 1971;86:347–54.

65 Andreev EM, Shkolnikov VM, Begun A. Algorithm for decomposition of differences between aggregate demographic measures and its application to life expectancies, healthy life expectancies, parity-progression ratios and total fertility rates. *Demographic Research* 2002;7:499–522.

66 Jagger C, Oyen HV, Robine J-M. Health Expectancy Calculation by the Sullivan Method: A Practical Guide. EHEMU, European Health Expectancy Monitoring Unit, 2014.

67 IBGE. 2013 national health survey. 2013.

68 IBGE. 2010 census. 2010.

69 Bhalotra S, Rocha R, Soares RR. Can Universalization of Health Work? Evidence from Health Systems Restructuring and Expansion in Brazil. Instituto de Estudos para Políticas de Saúde, 2020URL <https://ieps.org.br/wp-content/uploads/2020/02/WPS3.pdf>.

70 Castro MC, Massuda A, Almeida G, et al. Brazil’s unified health system: The first 30 years and prospects for the future. *The Lancet* 2019;394:345–56.

71 Macinko J, Guanais FC, Fátima Marinho de Souza M de. Evaluation of the impact of the family health program on infant mortality in brazil, 19902002. *Journal of Epidemiology & Community Health* 2006;60:13–19.

72 Aquino R, Oliveira NF de, Barreto ML. Impact of the family health program on infant mortality in brazilian municipalities. *American Journal of Public Health* 2009;99:87–93.

73 Rocha R, Soares RR. Evaluating the impact of community-based health interventions: Evidence from brazil’s family health program. *Health Economics* 2010;19:126–58.

74 Santos P de A Anderson Moreira Aristides dos AND Jacinto. O Impacto do Programa Saúde da Família Sobre a Saúde das Crianças da Área Rural do Brasil. *Revista de Economia e Sociologia Rural* 2017;55:227–46.

75 Pimenta L, Dutra V, Castro] A [de, Guimarães R. Analysis of conditions sensitive to primary care in a successful experience of primary healthcare expansion in brazil, 1998–2015. *Public Health* 2018;162:32–40.

76 Guimarães RM. A teoria da equidade reversa se aplica na atenção primária à saúde? Evidências de 5 564 municípios brasileiros. *Revista Panamericana de Salud Pública [online]* 2018;42. doi:[10.26633/RPSP.2018.128](https://doi.org/10.26633/RPSP.2018.128).

77 Mendez MA, Popkin BM. Globalization, urbanization and nutritional change in the developing world. *Journal of Agricultural and Development Economics* 2004;1:220–41.

78 Canella DS, Levy RB, Martins APB, et al. Ultra-Processed Food Products and Obesity in Brazilian Households (2008–2009). *PLOS One* 2014;6:S181–S191.

79 Martins RBAC Ana Paula Bortoletto AND Levy. Increased contribution of ultra-processed food products in the Brazilian diet (1987-2009). *Revista de Saúde Pública* 2013;47:656–65.

80 Louzada ML da C, Ricardo CZ, Steele EM, Levy RB, Cannon G, Monteiro CA. The share of ultra-processed foods determines the overall nutritional quality of diets in brazil. *Public Health Nutrition* 2018;21:94–102.

81 Santos Simões B dos, Barreto SM, Carmen Bisi Molina M del, et al. Consumption of ultra-processed foods and socioeconomic position: a cross-sectional analysis of the Brazilian Longitudinal Study of Adult Health. *Cadernos de Saúde Pública* 2018;34.

82 Nardoto GB, Silva S, Kendall C, et al. Geographical patterns of human diet derived from stable-isotope analysis of fingernails. *American journal of physical anthropology* 2006;131:137–46.

83 Nardoto GB, Murrieta RSS, Prates LEG, et al. Frozen chicken for wild fish: Nutritional transition in the brazilian amazon region determined by carbon and nitrogen stable isotope ratios in fingernails. *American Journal of Human Biology* 2011;23:642–50.

84 Reinaldo EDF, Silva MRFD, Nardoto GB, Garavello MEDPE. Mudanças de hábitos alimentares em comunidades rurais do semiárido da região nordeste do brasil. *Interciencia* 2015;40:330–36.

85 Rodrigues LPF, Carvalho RC, Maciel A, Otanasio PN, Paula Eduardo Garavello ME de, Nardoto GB. Food insecurity in urban and rural areas in central brazil: Transition from locally produced foods to processed items. *Ecology of Food and Nutrition* 2016;55:365–77.

86 Baptista EA, Queiroz BL. The relation between cardiovascular mortality and development: Study for small areas in Brazil, 2001–2015. *Demographic Research* 2019;41:1437–52.

87 Hegney D. Agricultural occupational health and safety: Farming families presenting a challenge to wellness. *Australian Journal of Rural Health* 1993;1:27–33.

88 Alessi VL Neiry Primo AND Navarro. Saúde e trabalho rural: o caso dos trabalhadores da cultura canavieira na região de Ribeirão Preto, São Paulo, Brasil. *Cadernos de Saúde Pública* 1997;13:S111–S121.

89 Thelin N, Holmberg S, Nettelbladt P, Thelin A. Mortality and morbidity among farmers, nonfarming rural men, and urban referents: A prospective population-based study. *International Journal of Occupational and Environmental Health* 2009;15:21–28.

90 Soares RMVRAM Wagner AND Almeida. Trabalho rural e fatores de risco associados ao regime de uso de agrotóxicos em Minas Gerais, Brasil. *Cadernos de Saúde Pública* 2003;19:1117–27.

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 of morbidity-free life expectancy at birth. [↑](#footnote-ref-2)
2. Prevalence rates of diseases and disabilities were smoothed by apply the localy estimated scatter plot smoothing method (LOESS) [↑](#footnote-ref-3)