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The uneven state-distribution of homicides in Brazil and their effect on life expectancy, 2000-15

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Title: The uneven state-distribution of homicides in Brazil and their effect on life expectancy, 2000-15

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Title: The uneven state-distribution of homicides in Brazil and their effect on life expectancy, 2000-15: A cross-sectional mortality study.

Keywords: violence, demography, health inequality, avoidable/amenable mortality

Abstract

Objective: To determine cause- and age-specific contributions to life expectancy changes between 2000 and 2015, separately by state and sex in Brazil, with a focus on homicides.

Design: Retrospective cross-sectional demographic analysis of mortality.

Setting and population: Brazilian population by age, sex and state from 2000-2015.

Main outcome measure: Using mortality data from the Brazilian Mortality Information System and population estimates from the National Statistics Office, we used Deaths Distribution methods and the lineal integral decomposition model to estimate levels and changes in life expectancy. We also examine how multiple causes of death, including from homicides and amenable/avoidable mortality, contributed to these changes from 2000-2015.

Results: Between 2000 and 2015, life expectancy in Brazil increased from 71.5 to 75.1 years. Despite state-level variation in gains, life expectancy increased in almost all states over this period. However, across Brazil, homicide mortality contributed, to varying degrees, to either attenuate or decrease male life expectancy gains. In Alagoas in 2000-07 and Sergipe in 2007-15, homicides contributed to a reduction in life expectancy of 1.5 years, offsetting gains achieved through improvements due to medically amenable causes. In the period 2007-15, male life expectancy could have been improved by more than half a year in 12 of Brazil's states if homicide mortality were remained at the levels of 2007.

Conclusions: Homicide mortality appears to offset life expectancy gains made through recent improvements related to mortality amenable to medical services and public health interventions, with considerable subnational heterogeneity in the extent of this phenomenon. Efforts combatting the causes of homicides can increase life expectancy beyond what has been achieved in recent decades.

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Summary boxes:

What is already known on this topic: High homicide rates can slow or reverse life expectancy gains. Although life expectancy in Brazil has increased in recent years, this masks state-level variation. We searched Google scholar and PubMed for articles in English and Portuguese using the terms “life expectancy”, “homicides”, “avoidable mortality”, “Brazil”. We found that homicide mortality may be an important contributory factor lowering longevity in Brazil, given that homicide rates are almost 10 times higher than in developed countries. An understanding of the effects of homicides on life expectancy at the state level in Brazil is required to assess the consequences of the rise of violence in some regions of the country.

What this study adds: We examine data from the Mortality Information System and from the National Statistics office from Brazil to assess the impact of homicides and causes of death amenable to medical services on changes to life expectancy across Brazil’s states in 2000-15. We found that in almost all states over this period, homicide mortality contributed, to varying degrees, to either attenuate life expectancy gains, or in some cases to reverse gains in life expectancy. This effect was particularly strong in Brazil’s Northern regions and was restricted to men.

Introduction

Violence and homicides in Brazil present a considerable public health challenge.[1-3] With a risk of mortality from homicides ten times that of most developed countries and it being the leading cause of death among young adults,[4-6] recent improvements in population health attributable to ongoing public health interventions and pushes towards universal health coverage are in jeopardy.[7-12] On average, Brazilians live 20 years longer than half a century ago.[13] These mortality advancements have been driven largely by improvements in medically amenable mortality, in particular, infant and cardiovascular disease mortality which have accompanied the introduction and expansion of a mandated universal healthcare system.[14 15]

However, country-level estimates of life expectancy, estimated at 74.7 years in 2015, mask considerable subnational heterogeneity. For instance, whereas life expectancy in Alagoas was 63.2 years in 2000 it was 71.3 years in Santa Catarina (Figure S1 in the Appendix[16] presents a map of Brazil and its states).[17] Moreover, gains in life expectancy have varied considerably across the country, driven in part by differential gains in average lifespan attributable to amenable mortality; improvements have ranged between 0.6 and 4.1 years between Brazil's Southeast and Northeast regions, respectively, between 2000 and 2010.[18] The high mortality risk from homicides has the potential to reverse gains in life expectancy, as has been reported in other Latin American countries.[19-21] Despite this, the effect of homicides on changes to life expectancy has not been explored in the Brazilian context, a country with over 60 thousand murders reports in 2018.[22] An explanation for the lack of studies investigating this could be that national statistics do not report notable changes in homicide rates in the past decade, however this could be due to the balancing effect of homicide rates increasing in some states while decreasing in others; whereas the homicide rate declined in Brasilia between 2007 and 2011, in the same period, homicides have increased by more than 40% in Bahia.[22]

In this study we aim to examine the impact of homicide mortality on changes in life expectancy by state for men and women separately in the period 2000-15. These results will provide information for interventions and planning aimed at reducing the burden of homicides. Specifically, they will communicate potential improvements to life expectancy gains that could be achieved through reducing homicide mortality, in addition to identifying the states in most need of public policy attention to minimize these violence and health disparities.

Methods

We extracted state-level mortality data by age, sex, year and cause of death from the Mortality Information System produced by the Brazilian Ministry of Health.[23] We obtained state-level population estimates for the years 2000 through 2015 from the National Statistics Office (IBGE).[24] Over the study period (2000-15) death counts registration improved to over 90% completeness, however, in order to correct for the lack of completeness towards the beginning of the study period, we employed Death Distribution Methods (see Appendix Section 1 for further details).[25]

Cause-of-death classification

We use the concept of amenable/avoidable mortality to form the basis of the cause of death classifications in our study to complement the analysis of homicide mortality. The concept of amenable/avoidable mortality refers to deaths that should be absent if both timely and quality

healthcare is available.[26 27] This concept has been successfully employed to link the progress of primary care expansion and reductions in amenable/avoidable mortality in Brazil.[14] More recently the concept has included causes amenable to public health interventions that have been seen to alter health behaviours, e.g. lung cancer via smoking reduction or homicides.[28]

Using a cause of death classification system utilized in similar studies,[20 29 30] we grouped the causes of death into the following 10 categories based on the *International Classification of Diseases* [ICD] 10th revision (Appendix Table 1):[16] (1) homicides, (2) alcoholic liver disease, (3) diabetes, (4) HIV/AIDS, (5) ischemic heart diseases (IHD), (6) lung cancer, (7) road traffic accidents, (8) suicides, (9) amenable to medical service (including conditions that could be reduced by primary care, secondary intervention, and timely medical care up to age 75), and (10) all other causes (*residual causes)*.

Homicides, liver disease, diabetes, HIV/AIDS, IHD, lung cancer and suicide were analysed separately as they are amenable to both health behaviours and medical attention, and pose important public health challenges in Brazil.[31 32] For instance, in 2001 Brazil featured in the top ten countries ranked by number of suicide deaths.[33] The category capturing causes amenable to medical services(9) is linked to major healthcare interventions that have been implemented in the last decades in Brazil, including the Family Health Program.[9 14 15 34]

Demographic Methods

We calculated age- and sex- specific death rates for five-year age groups with an open-age interval at age 90 years for the 27 Brazilian states and constructed sex-specific period life tables for each year from 2000 to 2015.[35] National results did not significantly differ from those reported by the United Nations.[13] We calculated age- and cause- specific contributions to differences in life expectancy at birth following our classification for each subsequent year using the linear integral decomposition procedure (see Appendix Section 2 detailed explanation),[36] and summed up single-year decompositions in order to obtain the aggregate effect for the specified period. We report results for the periods 2000-07 and 2007-15 to have two comparable points in time of the same length. Our estimates refer to the middle of the year, e.g. 2000-07 runs from middle of 2000 to middle of 2007 and 2007-15 runs from middle of 2007 to middle of 2015. The effects for the period 2000-15 are simply the sum of the effects of the two periods. All procedures were performed using the R software[37] and are fully reproducible from the public repository with the data needed at https://github.com/jmaburto/Homicides-and-life-expectancy-in-Brazil.

Results

We arranged the Brazilian states within each broad region in order of the impact of homicides on male life expectancy in 2007-15 in Figures 1-4.

All states, with the exception of Pará, experienced increases in life expectancy for females and males from 2000 to 2007 (Figure 1). Relative to the period 2000-07, in 2007 to 2015, life expectancy at birth increased at a slower pace among women in 75% of states and among men in 60% of Brazil's states. In four states, life expectancy at birth declined in the latter period among men; among women, life expectancy declined in one state. Despite this overall slowdown, all but two states (Amapá for females, and Pará and Sergipe for males) showed a continuous increase in

life expectancy since 2000. Life expectancy levels for each state and total changes in 2000-15 are shown in Appendix table 2.

Figure 1 [about here]. Changes in life Expectancy at birth in Brazil (in years), by state and period, from 2000 to 2007 and from 2007 to 2015.

Figures 2-4 show how homicide, IHD and causes amenable to medical service, respectively, contributed to changes in life expectancy at birth in the periods 2000-07 and 2007-15 and represent the causes of death from the amenable/avoidable mortality framework that contributed the most to changes in life expectancy at birth in both periods (results for all causes of death, see Appendix Figures S2-S3).[16]

Homicide mortality increased in 14 states among males in 2000-07 (Figure 2), leading to declines in life expectancy at birth over the period, with especially large contributions in Alagoas state (1.5 years). In 2007-15 there was a clear worsening in life expectancy in 18 of Brazil's states related to increases in homicide mortality, with three of these states losing one or more years of life expectancy at birth, and 11 losing over six months of life on average. Overall, changes in mortality due to homicide were responsible for the largest declines in life expectancy between 2000 and 2015. Over the 15-year period, the decline was most marked in least developed Northeast and North regions of Brazil (Appendix Figure S4), including the states of Sergipe, Rio Grande do Norte, Ceará and Pará. The impact of homicides on life expectancy appeared to be restricted to males. As a sensitivity check in Appendix Figure S5 we show results for the periods 2000-05, 2005-10, 2010-2015.

Figure 2 [about here] Changes in life expectancy at birth in Brazil related to homicide mortality (in years), by state and period, from 2000 to 2007 and from 2007 to 2015

Among females and males, 16 states and 15 states, respectively, experienced increases in mortality from IHD in the period 2000-07, leading to declines in life expectancy. Overall, increases in mortality from IHD in the period 2000-07, leading to declines in life expectancy, was observed in 16 states among women and 15 states among men.

On the other hand, in 2007-15 life expectancy due to IHD increased in most states driven by improvements in cause-specific mortality from IHD (21 and 19 states, respectively, among females and males).

Figure 3 [about here] Changes in life expectancy at birth in Brazil related to mortality resulting from ischemic heart diseases (in years), by state and period, from 2000 to 2007 and from 2007 to 2015

Across most states, we found increases in life expectancy due to causes amenable to medical services below age 75 in both periods. In two states (Acre and Maranhão) we found declines in female life expectancy, whilst negligible effects on male life expectancy was found in Maranhão state in the period 2000-07 (Figure 4). Notably, between 2000 and 2007, 13 states experienced an increase in female life expectancy of more than one year due to medically amenable mortality,

whereas this was the case in 12 states among men. Between 2007 and 2015, improvements due to medically amenable causes persisted, albeit at a slower pace, whereby 18 and 23 states experienced an increased life expectancy by more than six months among females and males, respectively, driven by declines in mortality from causes amenable medical service. Similarly, changes in mortality due to the remaining causes also contributed to increasing life expectancy in most states during the first 15 years of the 21st century (see Appendix Figures S2-S3).[16]

Figure 4 [about here] Changes in life expectancy at birth in Brazil related to mortality resulting from causes amenable to medical service (in years), by state and period, from 2000 to 2007 and from 2007 to 2015

Although diabetes mortality had a smaller impact on changes in life expectancy relative to other causes of death between 2000-15, its impact was considerable in some regions. In the North and Northeast regions, the increase in diabetes mortality led to small decreases in life expectancy between 2000 and 2007, especially among females (Appendix Figure S3).[16] This trend reversed and by 2007-15, only three states from the North region (Amapá, Amazonas and Pará) experienced decreases in female life expectancy. Among males, the impact of diabetes was smaller, however similar to females, was concentrated in the Northern regions of Brazil (Appendix Figure S2).[16]

Contributions to changes in life expectancy due to alcoholic liver disease, HIV/AIDS, lung cancer, suicide and traffic accidents were negligible between 2000 and 2015 (Appendix Figures S2-S3).[16]

Discussion

The period from 2000 to 2015 marked an increase in the life expectancy at birth in Brazil from 71.5 years to 75.1 years, however the extent of this increase differed between men and women and between Brazil's diverse states. Our findings indicate that potentially large gains in state-specific life expectancy driven by mortality improvements from medically amenable causes were partially offset at times by increasing homicide, diabetes and IHD mortality (see Appendix section 3). Brazilian men in particular have experienced a disproportionately higher homicide burden when compared to women[4 38]. Had the homicide mortality stayed as high as at the turn of the century in Brazil's Northern regions, male life expectancy could have increased by at least six months in 11 states during the period 2007-15.

Violence in Brazil

Homicides are unevenly distributed across Brazil's states, representing in some cases a primary driver of the slower increase, and in others, decreases in male life expectancy. In some instances, increases in homicide mortality have been so drastic that it has driven declines in life expectancy by over one year in seven states from the Northeast and North regions (Ceará, Alagoas, Rio Grande do Norte, Bahia, Maranhão, Sergipe and Pará). These states contain eight of the most dangerous cities in the world (Natal, Fortaleza, Belém, Feirá de Santana, Marceió, Vitória de Conquista, Salvador and Aracaju) with homicide rates over 47 deaths per 100,000 people.[39]

Homicides in Brazil are primarily committed with firearms and are related to both drug trafficking, and consumption of drugs and alcohol.[40] Evidence from Brazil suggests that gun control measures can be effective in reducing the burden of violence on population health

through specific legislations aiming at firearm disarmament.[41] Whilst we find that such legislations have been effective in some states, in others, particularly in the North and North East of Brazil, further state-level efforts aimed at disarmament is encouraged, however the implementation of firearm regulations might be more challenging in these regions, relative to the rest of the country.[41] Moreover, the Brazilian government has implemented several measures aiming at reducing violence in the country, such as the National Public Security Force (Força Nacional de Segurança Pública) and the National Public Security Program (Programa Nacional de Segurança Pública com Cidadania).[6] However, there is considerable regional diversity in the success of these government strategies. The most relevant example to this study is the diversity in changes to life expectancy driven by homicide mortality post strategy implementation, which started in 2004, in the period 2007-15, with declines in homicide-related life expectancy most prevalent in the North and Northeast (complementary figure from 2004 is shown in Appendix Fig. S6).

Evidence suggests that violent death varies considerably by ethnicity, whereby black males are at a higher risk of being victims of violent crime.[42 43] In 2007, 55% of the total homicides among males were among mixed race individuals, while 8.2% were among black males. Poverty, social inequality and drug trafficking are important factors determining variation in violent mortality within Brazilian states.[44-46] In this study, we were unable to disentangle the effect of changes in homicide mortality on life expectancy changes by ethnicity or socioeconomic status within states due to the lack of data disaggregated by these levels for long periods of time.

International context with Latin America

Latin America is currently the region with the highest homicide rates globally.[22] As in Brazil, similar detrimental findings of the effect of violence in life expectancy have been reported in other Latin American contexts. In Mexico the rise in homicides has led to a stagnation in country-wide life expectancy between 2000 and 2010,[47] with significant subnational variation,[20] and was identified as a primary determinant of lifespan inequalities.[19] Another study in Venezuela found that an increase in firearm-related deaths led to life expectancy stagnation in 1996-2013.[21]

Strengths and limitations

The analysis has several limitations. Firstly, Brazilian mortality data was still considered 'incomplete' according to the Pan American Health Organization's (PAHO) criteria despite improvements in death counts coverage, particularly regarding certificate completeness and age reporting.[48] To address this, we used death estimates corrected for completeness based on indirect demographic methods (see Appendix section 1).[26] Additionally, we used 5-year age groups to avoid age-heaping bias and applied death distribution methods to minimize the effect of migration on our estimates.[25] Secondly, causes of death could have been misclassified. To minimize chances of misclassification, we used broad cause of death categories that utilizes the concept of avoidable/amenable mortality and used data from 2000 onwards, using only the ICD-10 classification. However, the concept of amenable mortality is not able to allude to differences in the effectiveness of health care interventions over time and between states.[26 49] In addition, the Brazilian Ministry of Health restricts classification of causes amenable to medical services up to age 75 years, a common practice when classifying avoidable mortality.[49] To ensure comparability we did not consider causes of death amenable to medical service above age 75.

Conclusion and future directions

The gains made in reducing mortality attributable to causes amenable to medical services in Brazil is the primary driver of increases in life expectancy, however homicide mortality opposes this increase by over half a year in 12 states. This subnational heterogeneity within Brazil mirrors the diversity found across many Latin American countries. Homicide mortality is a local problem, however one that is a pertinent public health issue across the region, and which continues to inhibit progress towards longer and healthier lives. Better data collection is needed to accurately assess the effects of mortality from homicides on life expectancy by subpopulations, including within states.

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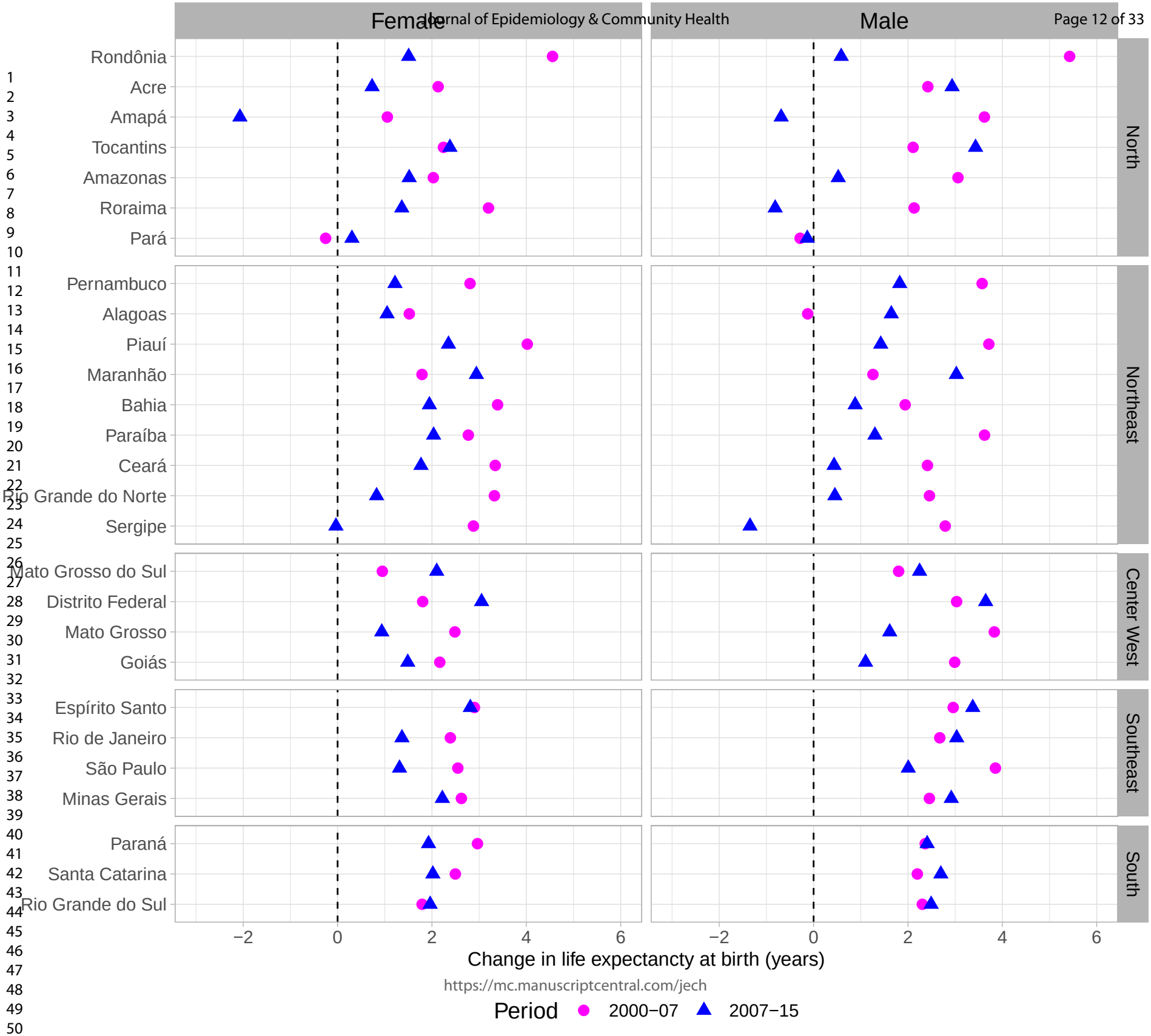
Female
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Maranhão
Bahia
Paraíba
Ceará
Rio Grande do Norte
Sergipe
Northeast
Mato Grosso do Sul
Distrito Federal
Mato Grosso
Goiás
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São Paulo
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Change in life expectancty at birth (years)
Period
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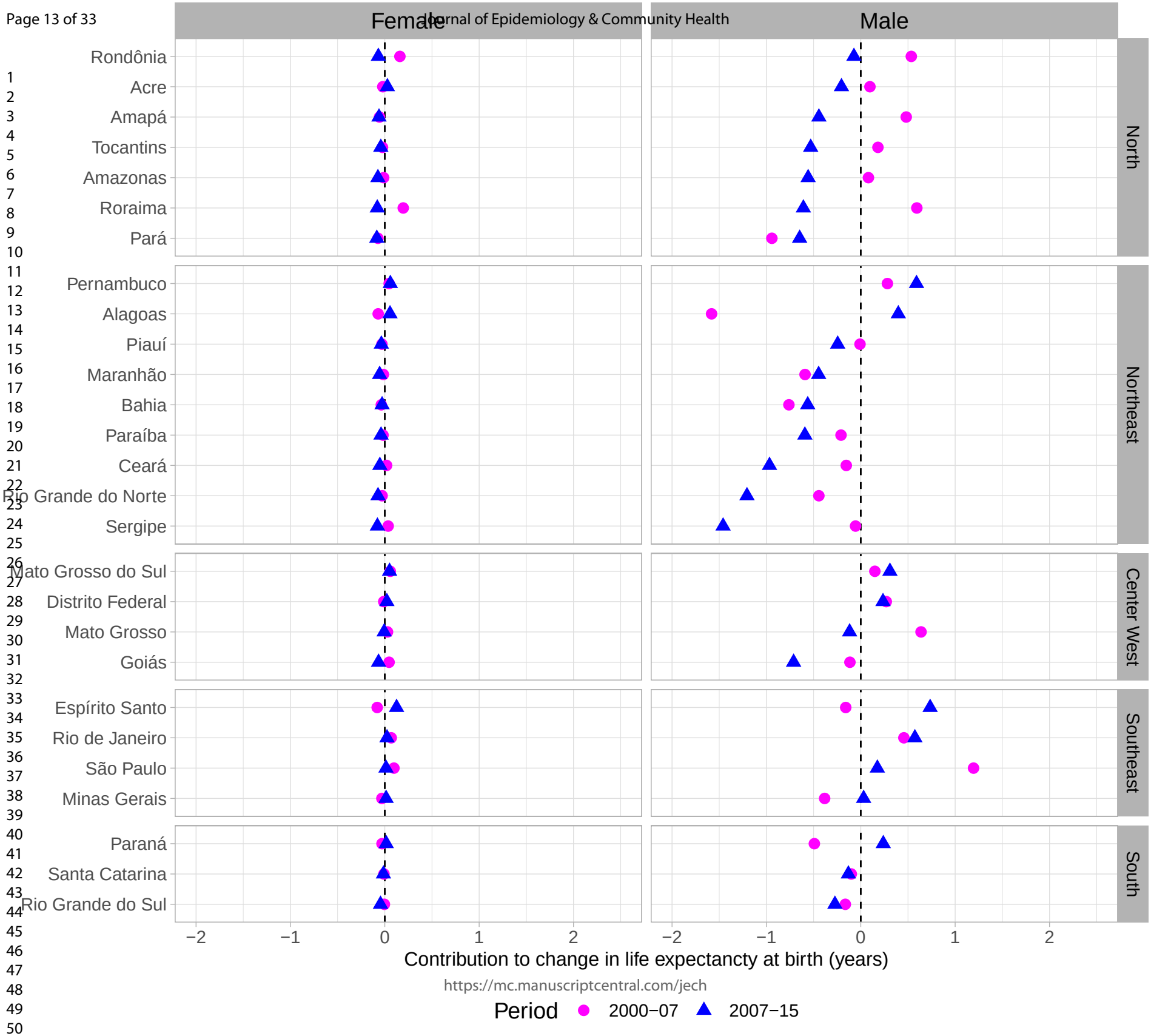
2007−15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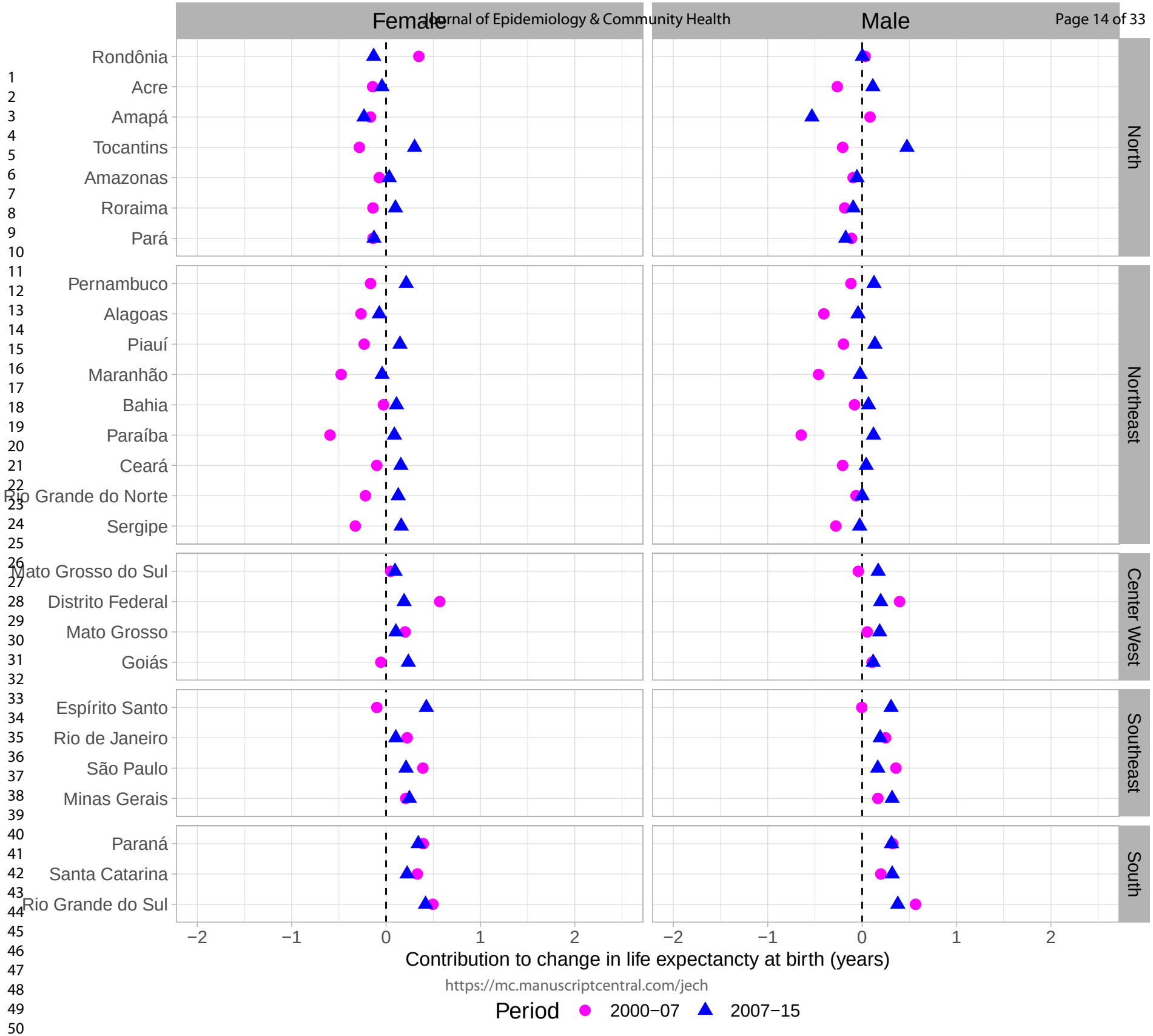
Contribution to change in life expectancty at birth (years)
Period
2000−07
2007−15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Maranhão
Bahia
Paraíba
Ceará
Rio Grande do Norte
Sergipe
Mato Grosso do Sul
Distrito Federal
Mato Grosso
Goiás
Espírito Santo
Rio de Janeiro
São Paulo
Minas Gerais
Paraná
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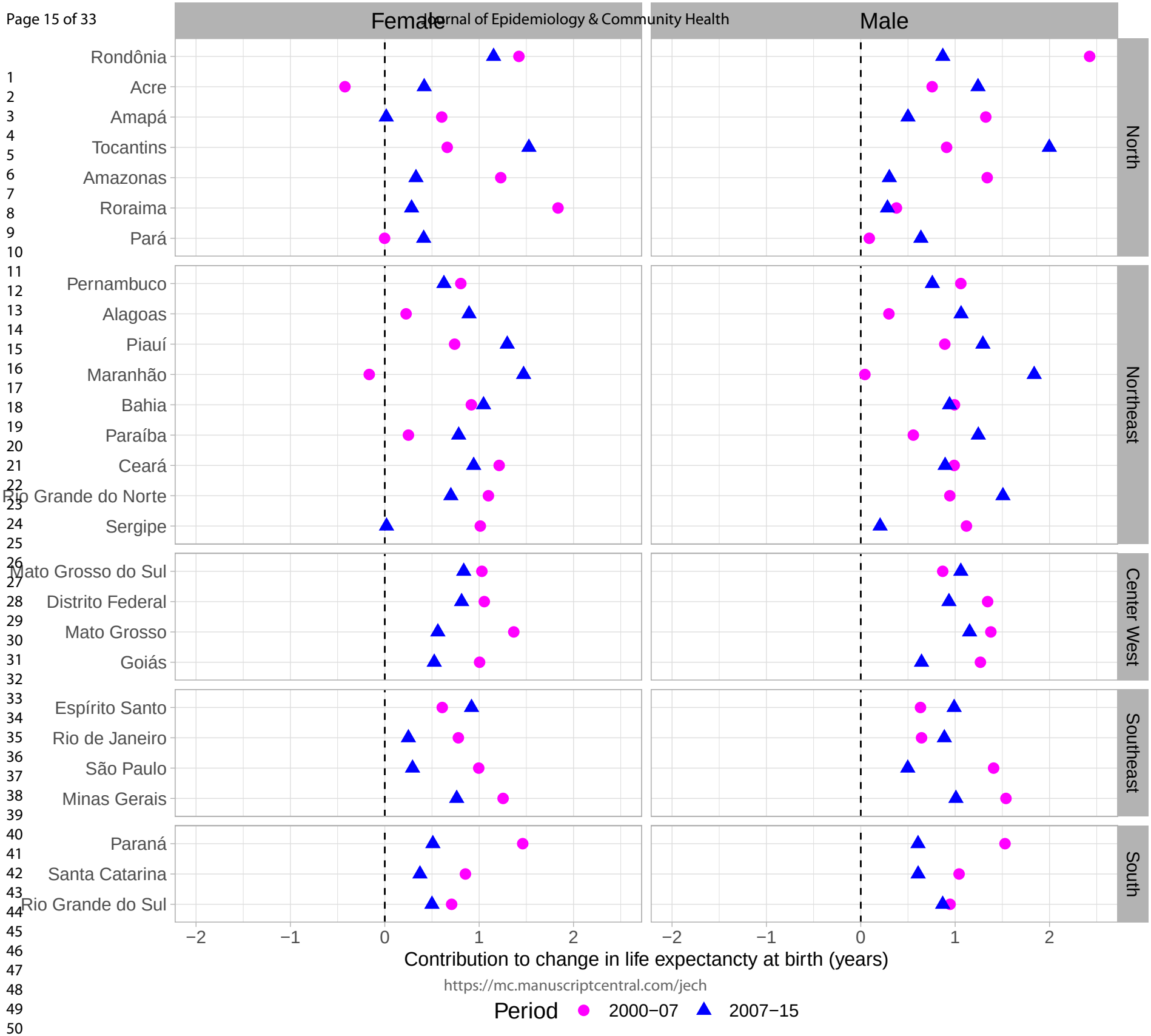
Contribution to change in life expectancty at birth (years)
Period
2000−07
2007−15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South
−2
−1
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Contribution to change in life expectancty at birth (years)
Period
2000−07
2007−15

Supplementary material for the paper "The uneven state-distribution of homicides in Brazil and their effect on life expectancy, 2000-15"

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Section 1. Death Distribution Methods summary

The first step of the study is to assess the quality and adjust the mortality data from states in Brazil. This analysis is done using a series of traditional demographic methods, better known as Death Distribution Methods (Hill, You and Choi, 2009). These methods were developed, based on population dynamics equations, to assess the coverage of deaths in relation to the population and the quality of the declaration of information on deaths and population. The methods compare the distribution of deaths by age with the age distribution of the population and provide the age pattern of mortality for a defined period (Murray, et.al, 2010; Hill, You and Choi, 2009). There are three main methods of evaluating the quality of mortality data: general growth balance (GGB), synthetic extinct generation (SEG) and the adjusted synthetic extinct generations (SEG-adj). The methods have very strong assumptions: population is closed to migration or subject to very small migration flows, the degree of coverage of deaths is constant by age, the degree of coverage of the population counts is constant by age, and the ages of the living and of deaths are declared without errors.

GGB is derived from the basic demographic equilibrium equation, which defines the rate of population growth as the difference between the rate of entry and the rate of exit of the population. This relationship, according to Hill (1987), also occurs for any age segment with open interval x +, and the entries occur as birthdays at ages x. Thus, the difference between the entry rate x + and the population growth rate x + produces a residual estimate of the mortality rate x + (Hill, 1987; Hill, You and Choi, 2009). If the residual mortality estimate can be estimated from two population censuses, and compared with a direct mortality estimate using the death registry, the degree of coverage of the death registry can be estimated and mortality data adjusted (Hill, 1987; Hill, You and Choi, 2009; Murray, et.al, 2010).

SEG uses age-specific growth rates to convert an age distribution of deaths into an age distribution of a population. In a stationary population the deaths observed after a certain age x are equal to the population over the same age x, we have that the deaths of a population over age x provide an estimate of the population over the same age. Age-specific population growth rates are used to adjust the number of deaths in the stationary population for an unstable population. The sum of the number of deaths over age x gives an estimate of the population over age x. The degree of coverage of the death record will be given by the ratio between the deaths estimated by the population above age x and the population observed above age x.

Hill, You and Choi (2009) suggest a combination of the methods of GGB and SEG that can be more robust than the application of the two methods separately. The adjusted method consists of applying the GGB to obtain estimates of the change in census coverage , and using that estimate to adjust one of the demographic censuses (population enumeration) and then apply SEG method with the adjusted population to obtain the degree of coverage of the mortality data.

Although they have some limitations, DDMs provide very robust and consistent results for a series of applications across the globe. For instance, Peralta et al., 2019 applied the methods to evaluate data quality at the sub-national level in Ecuador. Glei, Barbieri and Santamaria-Ulloa (2019) studied the quality of mortality estimates in Costa Rica and compared to other estimates. Wang et al. (2016) shows the application of DDM as part of the procedures of the Global Burden of Diseases and Lima and Queiroz (2014) evaluate quality of mortality information for small-areas in Brazil overtime.

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Section 2. Decomposition method summary

The decomposition method used in this paper is based on the line integral model (Horiuchi et al 2008). Suppose f (e.g. $e^{\dagger}$ or life expectancy) is a differentiable function of n covariates (e.g. each age-cause specific mortality rate) denoted by the vector $\boldsymbol{A} = [x_1, x_2, \dots, x_n]^T$. Assume that f and $\boldsymbol{A}$ depend on the underlying dimension t, which is time in this case, and that we have observations available in two time points t_1 and t_2. Assuming that $\boldsymbol{A}$ is a differentiable function of t between t_1 and t_2, the difference in f between t_1 and $t_2$can be expressed as follows:

$$f_2 - f_1 = \sum_{i=1}^{n} \int_{x_i(t_1)}^{x_i(t_2)} \frac{\partial f}{\partial x_i} dx_i = \sum_{i=1}^{n} c_i, \qquad (2)$$

where c_i is the total change in f (e.g. $e^{\dagger}$ or life expectancy) produced by changes in the i-th covariate, x_i. The c_i's in equation (2) were computed with numerical integration following the algorithm suggested by Horiuchi et al (2008). This method has the advantage of assuming that covariates change gradually along the time dimension.

Section 3. Discussion on other causes of death. The period 2000 and 2007 also saw increases in mortality from IHD, again offsetting rising life expectancy due to improvements in mortality from other medically amenable causes, and again mostly concentrated in states in the Northern regions. Additionally, some Northern states saw increases in diabetes mortality over the same period, primarily affecting females. On the other hand, in the period 2007-15, improvements in mortality from IHD and diabetes led to increases in life expectancy among females and males in most states. The extent of subnational variation in the impact of homicides, IHD and diabetes related mortality on life expectancy at birth, with a considerably higher burden in Northern compared to Southern states, demonstrates the persistence of health inequalities in Brazil.[39]

Medically amenable mortality contributed significantly to increasing life expectancy throughout the period from 2000 to 2015. Although in two states, Acre and Maranhão, mortality from amenable causes of death deteriorated between 2000 and 2007, these states recovered and improved life expectancy by reducing mortality attributable to medically amenable causes in 2007-15. Our results mirror findings reported in similar studies. Previous evidence suggests that improvements in primary health care has played an essential role in reducing deaths amenable to health care in Brazil.[14 39] Similarly, our study highlights the importance of building a strong healthcare system in the Northern regions to further reduce IHD-related mortality. Comprehensive and community-based health interventions can contribute to further decrease mortality from IHD in areas with high prevalence, such as Northern states of Brazil, through a combination of measures focused on prevention, health care, and follow-up for heart diseases.[32]

Figure S1. Map of states in Brazil.

Figure S2. Cause specific contributions to changes in male life expectancy by state in Brazil.

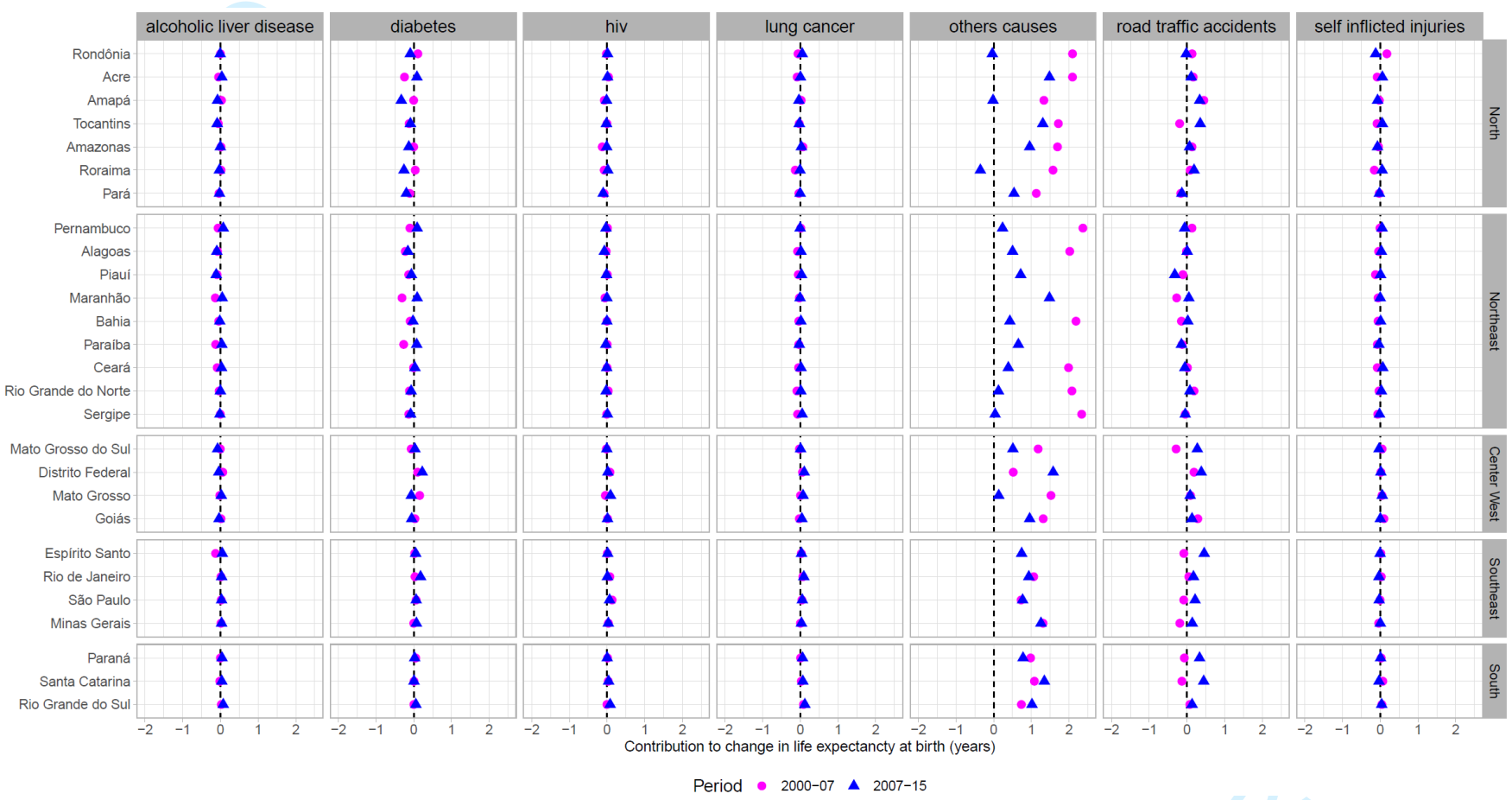


Figure S3. Cause specific contributions to changes in female life expectancy by state in Brazil.

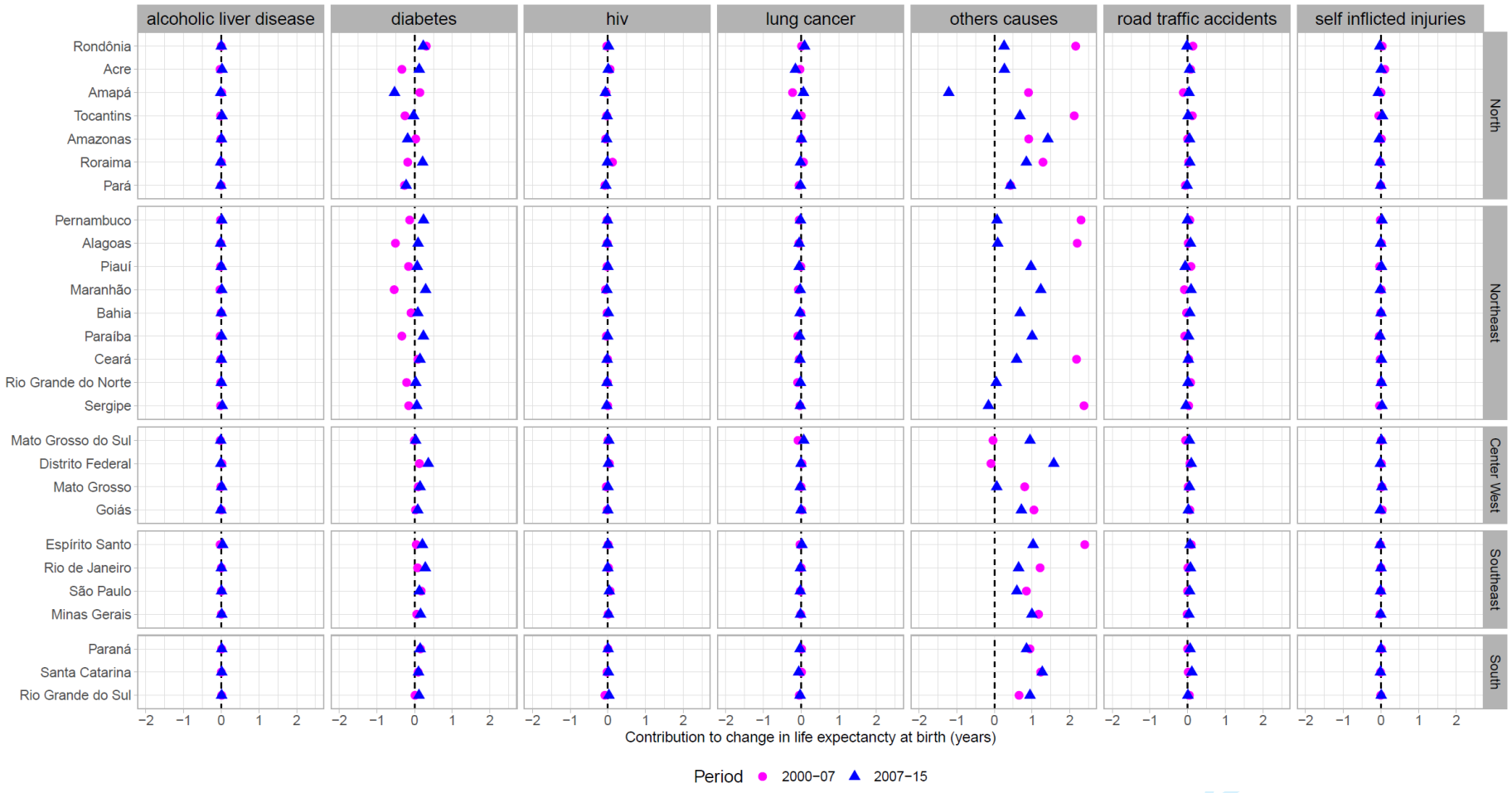


Figure S4. Homicide contributions to changes in male life expectancy by state in Brazil in 2007-15.

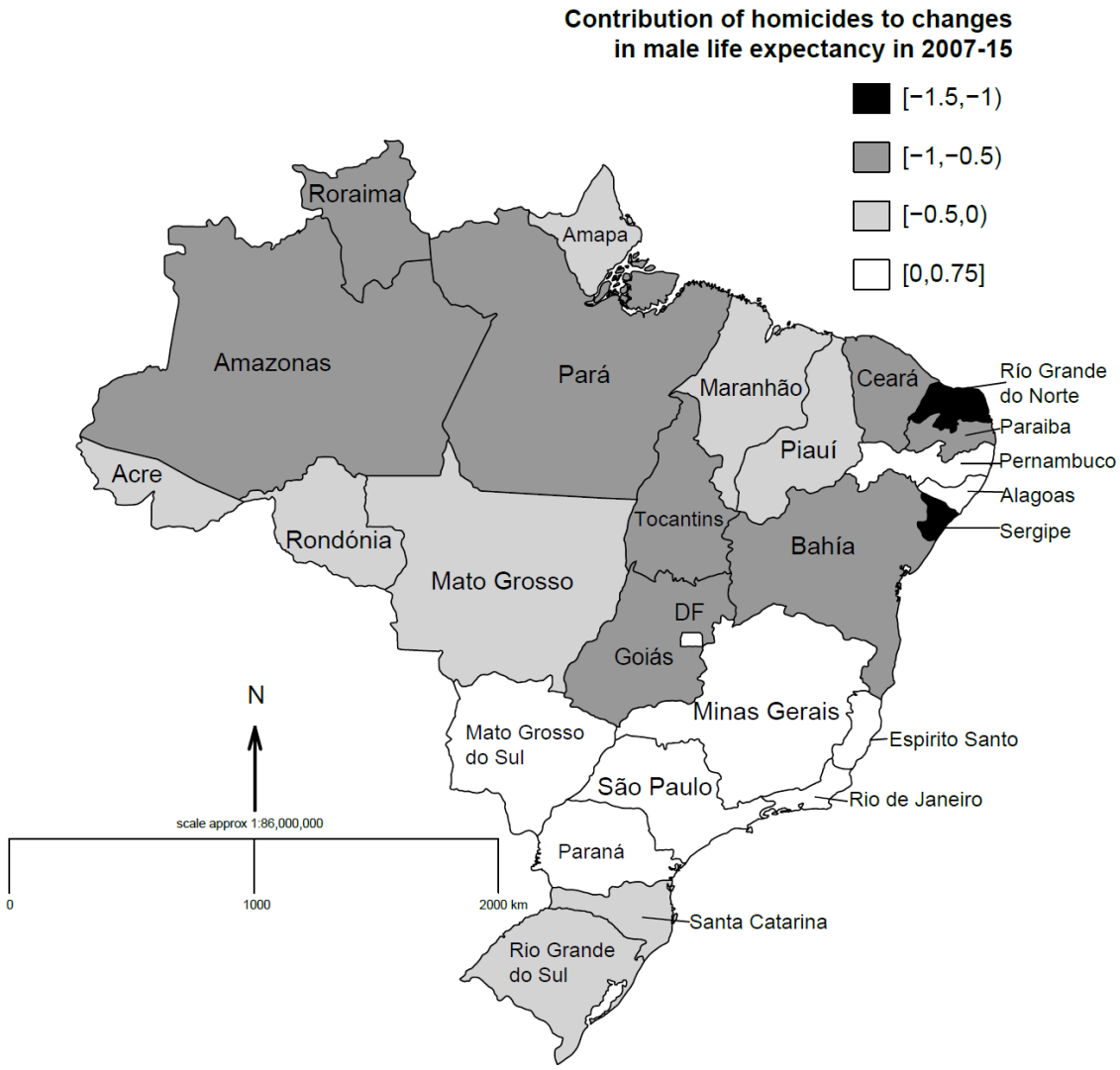


Figure S5 Homicide contributions to changes in life expectancy taking different time periods: 2000-05, 2005-10 and 2010-15.

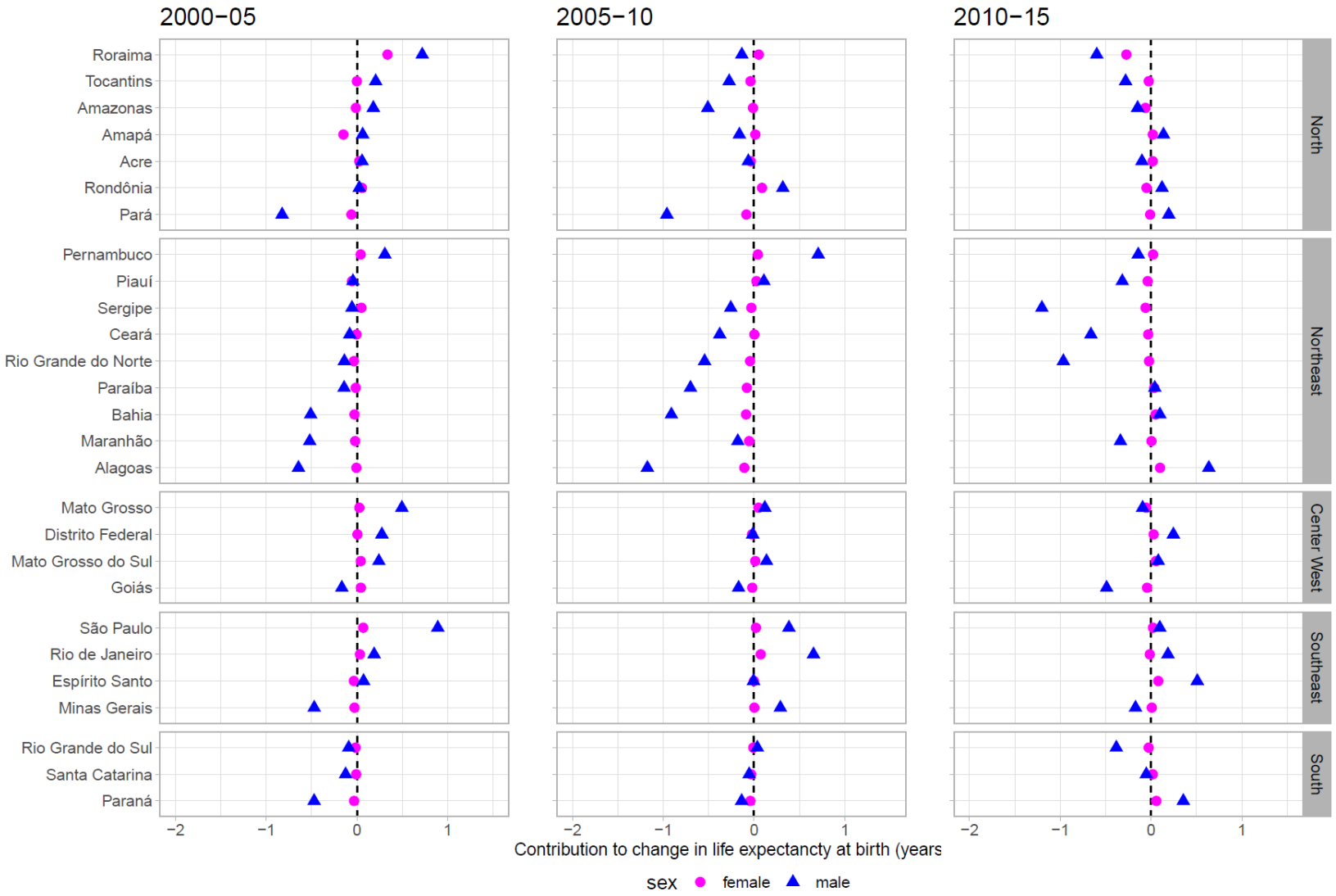
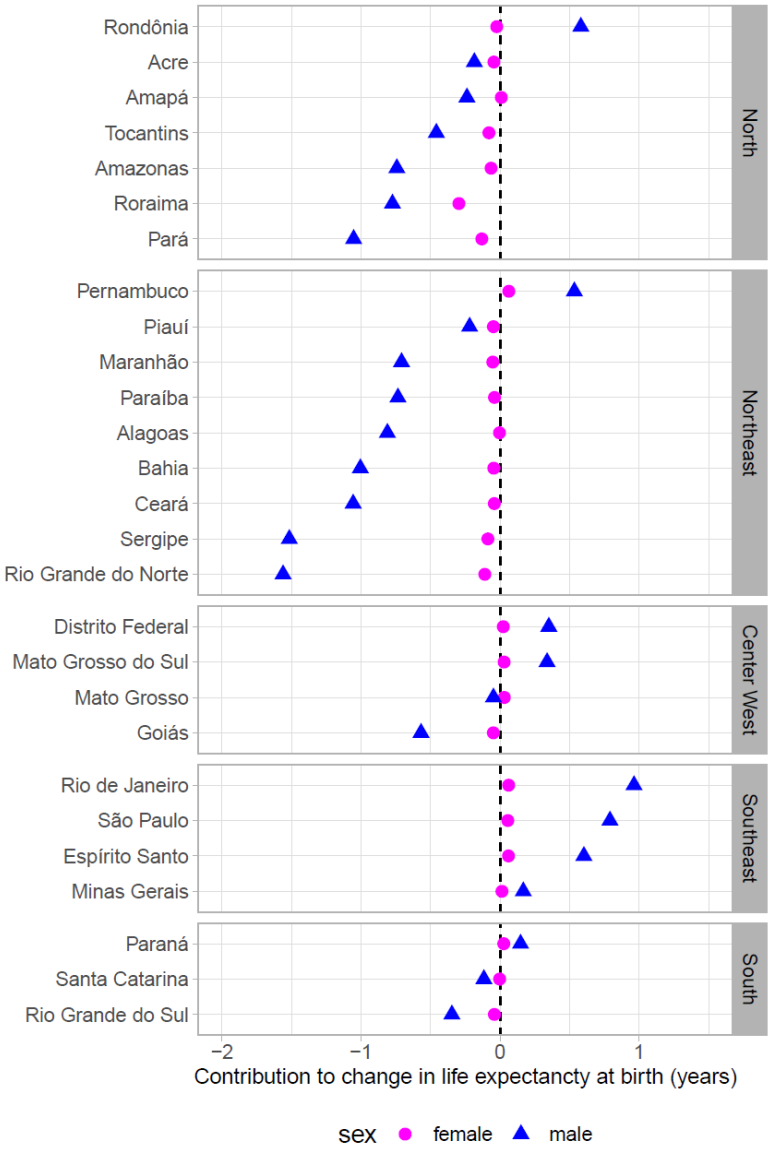


Figure S6. Effect of homicides to life expectancy between 2004-15



Appendix Table 1. ICD Codes for the classification of avoidable/amenable mortality

Cause	code	descrition
Homicide	X85	Assault by drugs, medicaments, and biological substances
	X86	Assault by corrosive substance
	X87	Assault by pesticides
	X88	Assault by gases and vapors
	X89	Assault by other specified chemicals and noxious substances
	X90	Assault by unspecified chemical or noxious substance
	X91	Assault by hanging, strangulation, and suffocation
	X92	Assault by drowning and submersion
	X93	Assault by handgun discharge
	X94	Assault by rifle, shotgun, and larger firearm discharge
	X95	Assault by other and unspecified firearm discharge
	X96	Assault by explosive material
	X97	Assault by smoke, fire, and flames
	X98	Assault by steam, hot vapors, and hot objects
	X99	Assault by sharp object
	Y00	Assault by blunt object
	Y01	Assault by pushing from high place
	Y02	Assault by pushing or placing victim before moving object
	Y03	Assault by crashing of motor vehicle
	Y04	Assault by bodily force
	Y05	Sexual assault by bodily force
	Y06	Neglect and abandonment
	Y07	Other maltreatment syndromes
	Y08	Assault by other specified means
	Y09	Assault by unspecified means

Suicide and self-inflicted injuries	X60	Intentional self-poisoning by and exposure to nonopioid analgesics, antipyretics, and antirheumatics
	X61	Intentional self-poisoning by and exposure to antiepileptic, sedative-hypnotic, antiparkinsonism, and psychotropic drugs, not elsewhere classified
	X62	Intentional self-poisoning by and exposure to narcotics and psychodysleptics [hallucinogens], not elsewhere classified
	X63	Intentional self-poisoning by and exposure to other drugs acting on the autonomic nervous system
	X64	Intentional self-poisoning by and exposure to other and unspecified drugs, medicaments, and biological substances
	X65	Intentional self-poisoning by and exposure to alcohol
	X66	Intentional self-poisoning by and exposure to organic solvents and halogenated hydrocarbons and their vapors
	X67	Intentional self-poisoning by and exposure to other gases and vapors
	X68	Intentional self-poisoning by and exposure to pesticides
	X69	Intentional self-poisoning by and exposure to other and unspecified chemicals and noxious substances
	X70	Intentional self harm by hanging, strangulation, and suffocation
	X71	Intentional self harm by drowning and submersion
	X72	Intentional self harm by handgun discharge
	X73	Intentional self harm by rifle, shotgun, and larger firearm discharge
	X74	Intentional self harm by other and unspecified firearm discharge
	X75	Intentional self harm by explosive material
	X76	Intentional self harm by smoke, fire, and flames

	X77	Intentional self harm by steam, hot vapors, and hot objects
	X78	Intentional self harm by sharp object
	X79	Intentional self harm by blunt object
	X80	Intentional self harm by jumping from a high place
	X81	Intentional self harm by jumping or lying before moving object
	X82	Intentional self harm by crashing of motor vehicle
	X83	Intentional self harm by other specified means
	X84	Intentional self harm by unspecified means
HIV/AIDS	B20	Human immunodeficiency virus [HIV] disease resulting in infectious and parasitic diseases
	B21	Human immunodeficiency virus [HIV] disease resulting in malignant neoplasms
	B22	Human immunodeficiency virus [HIV] disease resulting in other specified diseases
	B23	Human immunodeficiency virus [HIV] disease resulting in other conditions
	B24	Unspecified human immunodeficiency virus [HIV] disease
Ischemic heart diseases	I20	Angina pectoris
	I21	Acute myocardial infarction
	I22	Subsequent ST elevation (STEMI) and non-ST elevation (NSTEMI) myocardial infarction
	I23	Certain current complications following ST elevation (STEMI) and non-ST elevation (NSTEMI) myocardial infarction
	I24	Other acute ischemic heart diseases
	I25	Chronic ischemic heart disease
Lung cancer	C34	Malignant neoplasm of bronchus and lung
Diabetes	E10	Insulin-dependent diabetes mellitus
	E11	Noninsulin-dependent diabetes mellitus

	E12	Malnutrition-related diabetes mellitus
	E13	Other specified diabetes mellitus
	E14	Unspecified diabetes mellitus
Road traffic acidentes	V00-V09	Pedestrian injured in transport accident
	V10-V19	Pedal cycle rider injured in transport accident
	V20-V29	Motorcycle rider injured in transport accident
	V30-V39	Occupant of three-wheeled motor vehicle injured in transport accident
	V40-V49	Car occupant injured in transport accident
	V50-V59	Occupant of pick-up truck or van injured in transport accident
	V60-V69	Occupant of heavy transport vehicle injured in transport accident
	V70-V79	Bus occupant injured in transport accident
	V80-V89	Other land transport accidents
Alcoholic liver disease	K70	Alcoholic liver disease
Avoidable causes of deaths due to interventions of the Brazilian Health System		See Malta et al (2007) and Malta et al. (2010)

Appendix Table 2. Life expectancy estimates for Brazilian states.

		Females				Males			
Region	**State**	**2000**	**2007**	**2015**	**Increase 2000-15**	**2000**	**2007**	**2015**	**Increase 2000-15**
Center West	Distrito Federal	76.4	78.2	81.3	4.9	68.0	71.1	74.7	6.7
	Goiás	73.7	75.9	77.4	3.7	66.4	69.4	70.5	4.1
	Mato Grosso	73.6	76.1	77.0	3.4	65.3	69.1	70.7	5.4
	Mato Grosso do Sul	75.2	76.2	78.3	3.0	67.8	69.6	71.8	4.0
North	Acre	72.6	74.7	75.5	2.9	65.6	68.0	71.0	5.4
	Amapá	75.9	77.0	74.9	-1.0	65.5	69.1	68.5	2.9
	Amazonas	73.5	75.5	77.0	3.5	66.7	69.8	70.3	3.6
	Pará	75.2	74.9	75.2	0.1	68.5	68.2	68.1	-0.4
	Rondônia	71.6	76.1	77.6	6.1	64.5	69.9	70.5	6.0
	Roraima	71.5	74.7	76.0	4.6	65.7	67.9	67.0	1.3
	Tocantins	72.3	74.5	76.9	4.6	66.8	68.9	72.3	5.5
Northeast	Alagoas	73.3	74.8	75.9	2.6	67.2	67.0	68.7	1.5
	Bahia	73.3	76.7	78.7	5.3	68.4	70.4	71.2	2.8
	Ceará	73.5	76.8	78.6	5.1	67.8	70.2	70.7	2.8
	Maranhão	71.5	73.3	76.2	4.7	66.5	67.8	70.8	4.3
	Paraíba	73.4	76.2	78.2	4.8	65.8	69.4	70.7	4.9
	Pernambuco	72.9	75.7	76.9	4.0	63.9	67.5	69.3	5.4
	Piauí	71.4	75.4	77.8	6.4	65.4	69.1	70.5	5.1
	Rio Grande do Norte	74.4	77.7	78.5	4.1	68.5	71.0	71.4	2.9
	Sergipe	73.9	76.8	76.7	2.8	67.2	70.0	68.7	1.4
South	Paraná	74.1	77.0	79.0	4.9	67.6	70.0	72.4	4.8
	Rio Grande do Sul	76.0	77.8	79.7	3.8	67.9	70.2	72.7	4.8
	Santa Catarina	75.9	78.4	80.4	4.5	68.9	71.1	73.8	4.9
Southeast	Espírito Santo	74.5	77.4	80.3	5.7	66.5	69.5	72.8	6.3
	Minas Gerais	74.7	77.3	79.6	4.8	67.7	70.2	73.1	5.4
	Rio de Janeiro	73.9	76.3	77.6	3.8	64.8	67.5	70.5	5.7
	São Paulo	75.4	78.0	79.3	3.9	66.9	70.8	72.8	5.9

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
Outcome data	15*	Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.