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

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Abstract:	Background High homicide rates can slow or reverse gains in life expectancy. Despite homicide mortality rates being ten times higher in Brazil compared to most developed countries, there is little exploration of the extent to which homicides are hindering improvements in life expectancy. Methods Using mortality data from the Brazilian Mortality Information System and population estimates from the National Statistics Office, we used demographic techniques to calculate cause- and age-specific contributions to life expectancy changes for the periods 2000-07 and 2007-15, separately by state and sex. Findings 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 latter time period, male life expectancy could have been improved by more than half a year in 12 of Brazil's states if homicide mortality were absent. Interpretation Homicide mortality appears to offset life expectancy gains made through recent improvements related to mortality from medically amenable causes of death, 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. Funding No funding was provided for this study.

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

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

Abstract

Background: High homicide rates can slow or reverse gains in life expectancy. Despite homicide mortality rates being ten times higher in Brazil compared to most developed countries, there is little exploration of the extent to which homicides are hindering improvements in life expectancy.

Methods: Using mortality data from the Brazilian Mortality Information System and population estimates from the National Statistics Office, we used demographic techniques to calculate cause- and age-specific contributions to life expectancy changes for the periods 2000-07 and 2007-15, separately by state and sex.

Findings: 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 latter time period, male life expectancy could have been improved by more than half a year in 12 of Brazil's states if homicide mortality were absent.

Interpretation:
Homicide mortality appears to offset life expectancy gains made through recent improvements related to mortality from medically amenable causes of death, 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.

Funding:
No funding was provided for this study.

Research in context

Evidence before this study

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 exceed those in developed countries by almost 10-fold. Moreover, at the state-level understanding of the effects of homicides on life expectancy in Brazil is required to assess the consequences of the rise of violence in some regions of the country.

Added value of this study

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 2000-07 and 2007-15. 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. The rise of violence in some regions in Brazil has created unequal overall mortality and health. This effect was particularly strong in Brazil’s Northern regions and was restricted to men.

Implications of all available evidence

Our study highlights the role of violence on decreasing longevity at the state level in Brazil. The rise in homicide mortality in the twenty-first century in Brazil must be approached from a public health perspective to further increase life expectancy in all regions of the country.

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]

Compared to half a century ago, Brazilians, on average, live 20 years longer.[13] This has been driven largely by improvements in 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, which was estimated to be 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 studies in Mexico and Venezuela.[19-21] Despite this, the effect of homicides on changes to life expectancy has not been explored in the Brazilian context, a country containing eight of the world's most dangerous cities, and with homicide rates exceeding 47 deaths per 100,000 people.[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. Homicide rates among men are ten times that among women since the turn of the century.[4] These results will provide the basis 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.

Study Data and 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 mortality to form the basis of the cause of death classifications in our study. Specifically, it refers to mortality that should be absent if both timely and quality health care is available.[26,27] This concept has successfully been used to link the progress of primary care expansion and reductions in amenable 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]

We analysed changes in life expectancy during the period 2000-15 by comparing changes within two time periods. This period allowed to capture the spread of violence from the Southeast to the Northeastern parts of the country[35] and the 2004 reform aiming at making less available arms in Brazil along with other major public health interventions in recent years.

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.[36] The national results were compared with those reported by the UN and did not find significant differences.[13] We calculated age- and cause- specific contributions to differences in life expectancy at birth following our classification for each subsequent year using a standard decomposition procedure (see Appendix section 1 for a brief explanation),[37] 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. Because of the additive properties of life expectancy, the effects for the period 2000-15 are simply the sum of the effects of the two periods.

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.[38] Data quality also varies substantially sub-nationally, potentially impacting calculations if

prior assessment of the data is not undertaken. Therefore, we used death estimates corrected for completeness.[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 for several reasons. For instance, medical doctors or coroners may imperfectly assign cause of death, or developments in awareness of certain diseases could lead to higher chances of cause misclassification the further in the past a death occurred. 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.

Thirdly, the concept of amenable mortality is not able to allude to differences in the effectiveness of health care interventions over time and between states.[26,39]

Fourthly, 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. To ensure consistency with the Ministry of Health's results, we did not change the classification to include mortality among Brazilians aged 75 years or more.[39] We performed sensitivity analysis by examining whether the contribution of causes of death to life expectancy below age 75 years (temporary life expectancy between ages 0 and 75)was consistent with that of the upper limit of the amenable to medical service category. Our results did not vary significantly from those presented of life expectancy at birth.[16]

Study 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 except Pará experienced increases in life expectancy for females and males from 2000 to 2007 (Figure 1). From 2007 to 2015, life expectancy at birth increased at a slower pace in 75% and 60% of the states among females and males relative to the period 2000-07, respectively. The slower extent of the life expectancy improvement in the latter period resulted in four states among males and one among females experiencing declines in life expectancy at birth. Despite this slowdown, all but two states (Amapá for females, and Pará and Sergipe for males) showed a continuous increase in life expectancy since 2000.

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. These are 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 caused 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 S3), 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.

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. 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 effect 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 increased female life expectancy, and 12 experienced an increased male life expectancy, of more than one year due to medically amenable mortality. 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 S1-S2).[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 S2).[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

Trends in life expectancy at birth.

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[40], 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.

Effect of homicides and amenable mortality on life expectancy at birth.

Our findings indicate that the large increases in homicide mortality, particularly in Brazil's Northern regions, have attenuated potential life expectancy improvements (Appendix Figure S4). Brazilian men in particular have experienced a disproportionately higher homicide burden when compared to women[4,41]. If Brazilian men were exposed to homicide mortality rates observed in some developed countries, potential life expectancy gains could be as high as two years on average,[1] and 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 the period 2007-15 in 11 out of 16 states.

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.[42]

Our results indicate that medically amenable mortality contributed significantly to increasing life expectancy throughout the period from 2000 to 2015. These findings highlight the relevance of public health care directed to prevention and control of disease-related complications; two of the primary goals of the Family Health Program. 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.[14,43] 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]

Violence in Brazil.

Homicides are unevenly distributed across Brazil's states, representing a primary driver of the slower increase, and in some cases decrease, in male life expectancy. So severe has been the intensity of the increase in homicide mortality that seven states from the Northeast and North regions (Ceará, Alagoas, Rio Grande do Norte, Bahia, Maranhão, Sergipe and Pará) lost over one year of life expectancy due to the increased homicide mortality. 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.[44]

Similar findings have been reported in other Latin American contexts. In Mexico the rise in homicides, related to the war on drugs, has led to a stagnation in country-wide life expectancy between 2000 and 2010,[45] with significant subnational variation,[20] and was identified as a primary determinant of health and lifespan inequalities.[19] Another study in Venezuela found an increase in lifespan inequality attributable to the uneven improvements in population health, which itself was driven by an increase in firearm-related deaths.[21] Other studies report evidence of further adverse impacts of violence on population health beyond mortality and decreases in life expectancy. For example, the mental health and perception of vulnerability in contexts of increasing homicide mortality are often unquantifiable.[46] Consequently, health systems should also be prepared for a future increases in mental health issues due to potential insecurity felt by Brazilians.[6] In light of this, further studies into the population health burden of homicides beyond, just mortality, across Brazilian states are encouraged.

Homicides in Brazil are primarily committed with firearms and are related to both drug trafficking, and consumption of drugs and alcohol.[42] Homicide-related mortality is especially high among young males (15 and 50 years), similar to other Latin American countries.[1] 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.[47] 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 to disarmament is encouraged, however the implementation of firearm regulations might be more challenging in these regions, relative to the rest of the country.[47]

Another key determinant for decreasing violence is reducing income inequality. Although nationally, homicide rates declined between 2001 and 2007, paralleling the decline in income inequality and a rise in income,[48] our results indicate that the effect of homicides varies considerably across states. Poverty, social inequality and drug trafficking are important factors determining variation in violent mortality within Brazilian states.[49-51]

Evidence suggests that violent death varies considerably by ethnicity, whereby black males are at a higher risk of being victims of violent crime.[48] In 2007, 55% of the total homicides among males were among mixed race individuals, while 8·2% were among black males. In this study, we were unable to disentangle the effect of changes in homicide mortality on life expectancy changes by ethnicity or socioeconomic status by state due to the lack of data disaggregated by these levels. This dearth in the data should be addressed in order to accurately assess the effects of mortality from homicides on life expectancy by subpopulations.

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. The early years of the 21st century have also seen the introduction of other initiatives aimed at strengthening national labour markets, introducing conditional income transfer policies and implementing educational policies, all of which have important steps in reducing poverty levels and alleviating social inequalities.

There is a need for increased attention and approaches to violence as a public health problem. During the health transition, the emphasis of health care shifted from acute to chronic care without incorporating violence as a dimension of health care. Latin America, including Brazil, is currently the region with the highest homicide rates globally.[22] Homicide mortality in Latin American countries is strongly associated with political instability, economic inequality, social segregation, and drug trafficking. We show that in Brazil there is a need for state-specific interventions to change the cultural, economic and social conditions associated with risk factors for violence.

Conclusion

The most populous country in Latin America, continues to celebrate a rising life expectancy for both females and males. However, we find that greater gains could have been achieved if homicide mortality had been averted. This is particularly the case when examining the considerable state-level heterogeneity in life expectancy changes. The gains made in reducing mortality attributable to causes amenable to medical services 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. The fundamental reasons are the same across borders: social and economic inequality, access to guns and weak rule of law. Solutions to solve this obstacle will need to come from individuals, families, society, institutions and government, as well as from interregional collaboration. Brazil could take a leading role in the region by showing the needed prevention strategies to reduce the number of lives lost to homicides.

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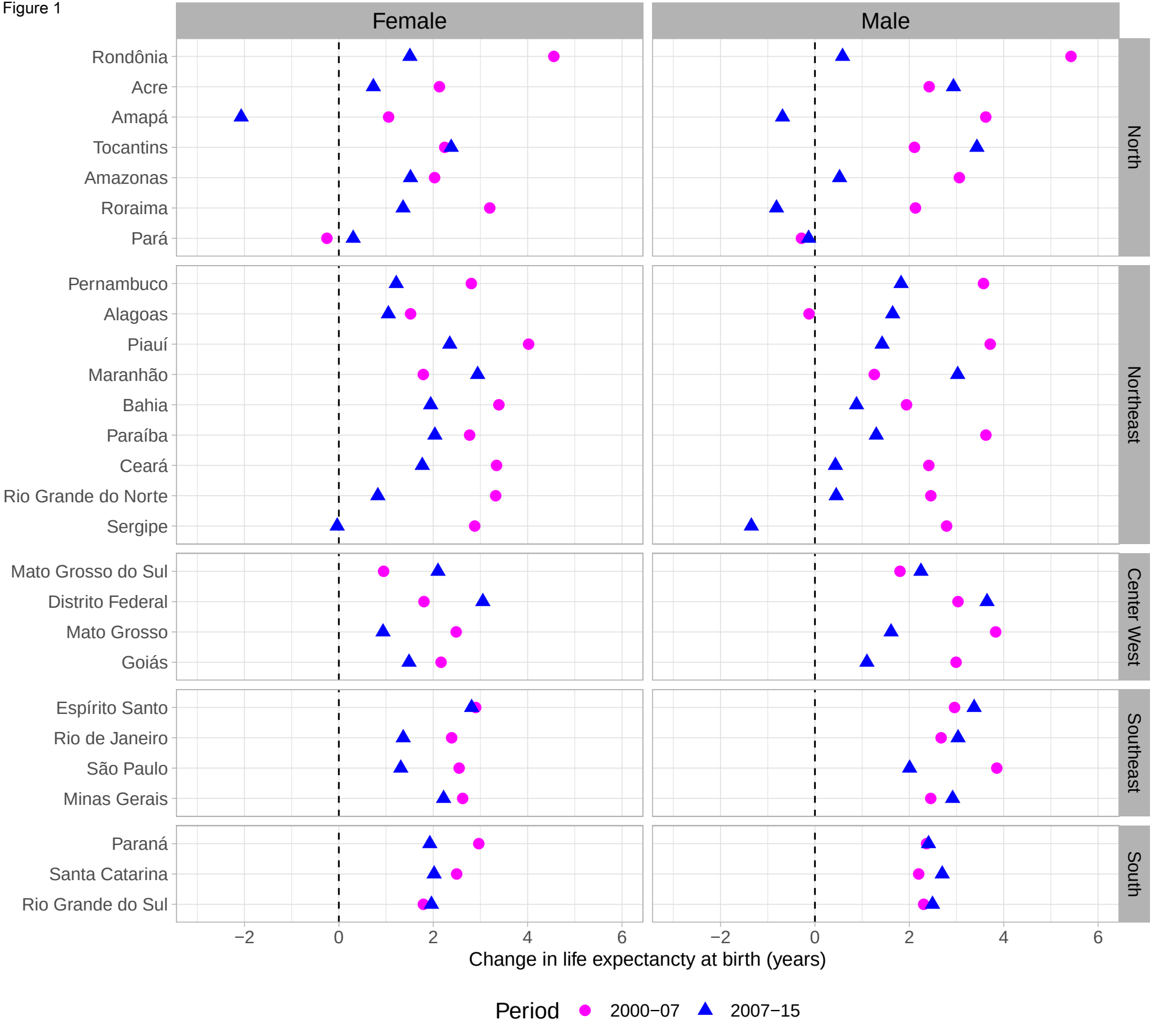
Figure 1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Change in life expectancty at birth (years)
Period
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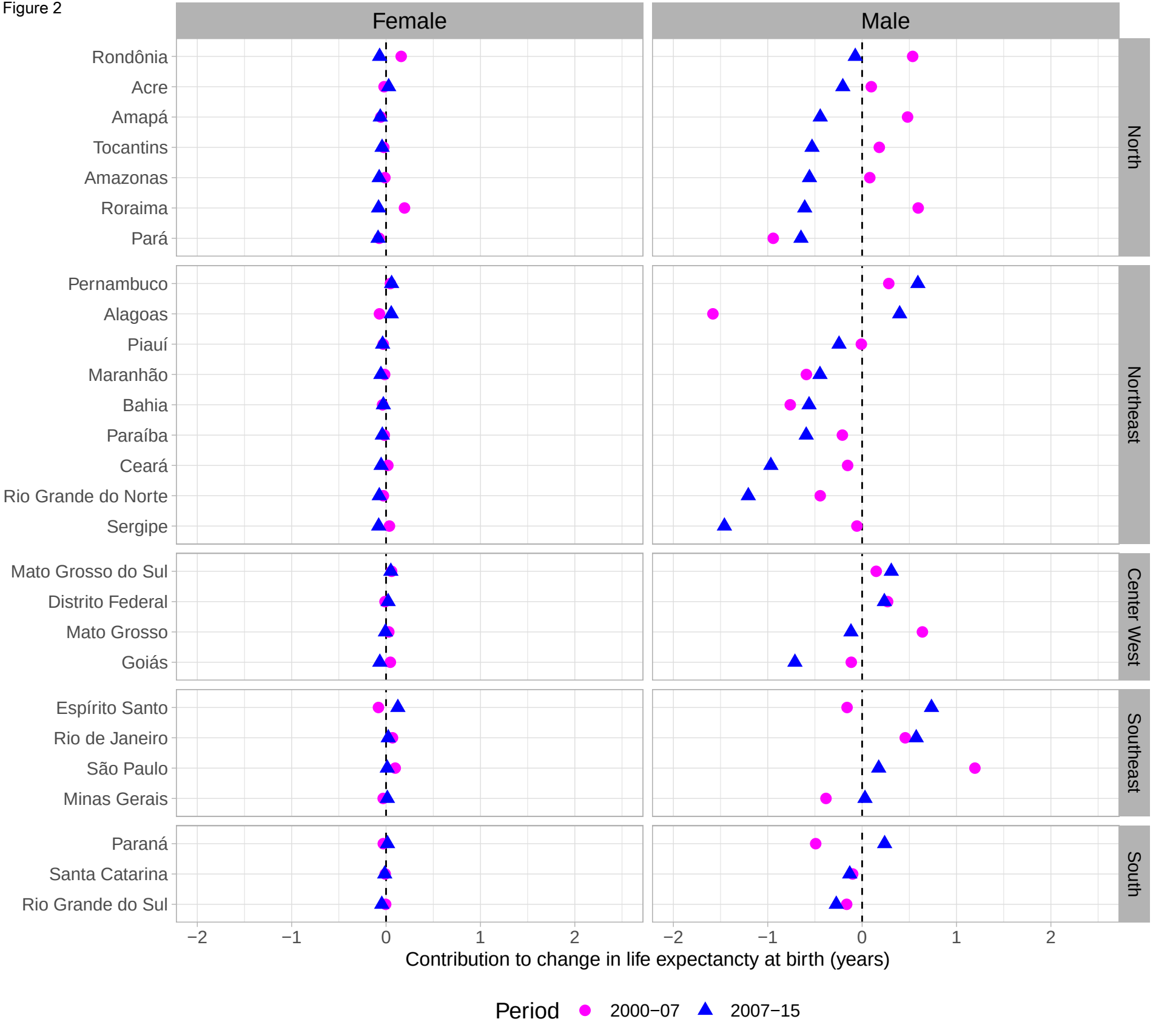
2007−15

Figure 2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Contribution to change in life expectancty at birth (years)
Period
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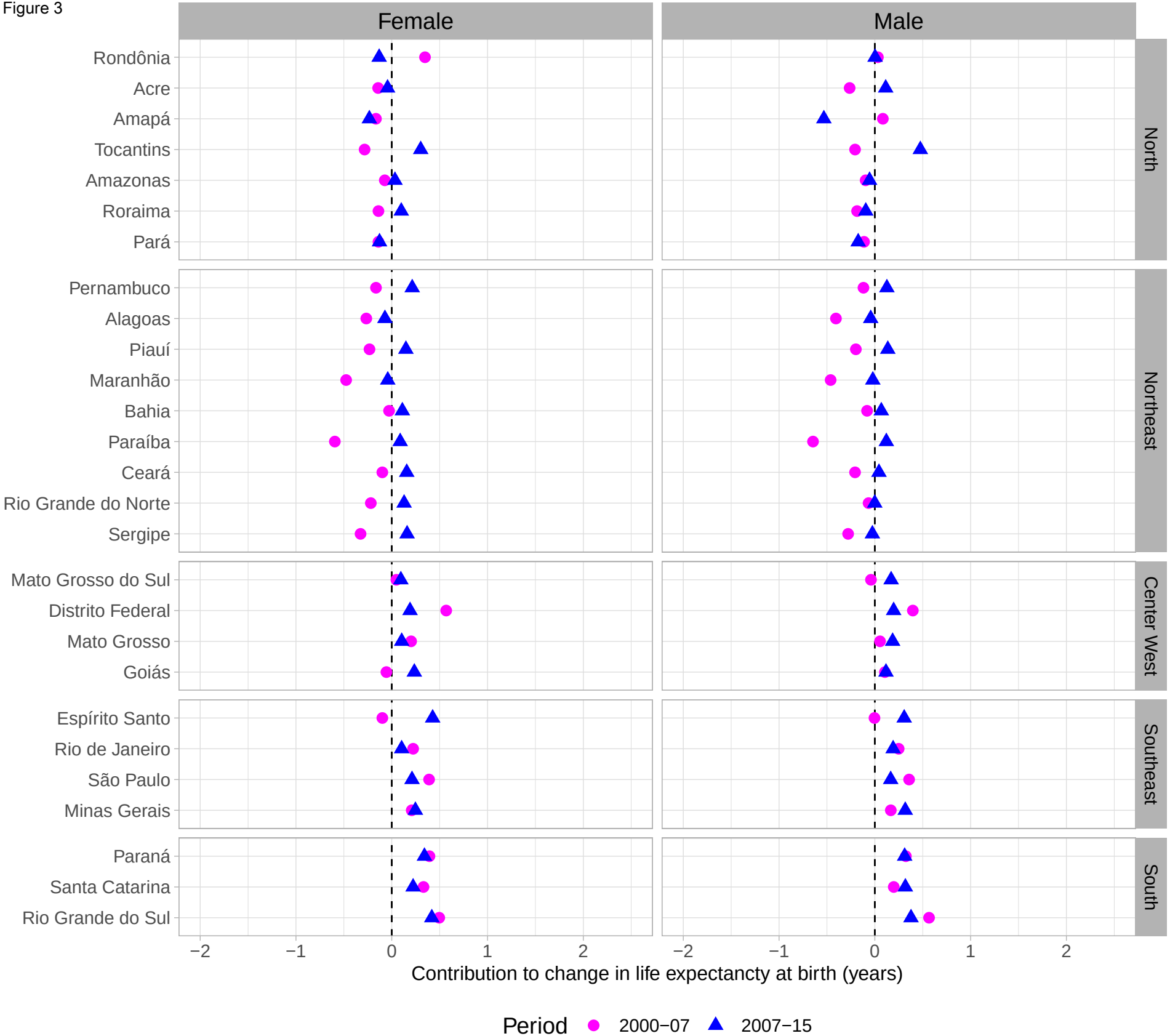
2007−15

Figure 3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Contribution to change in life expectancty at birth (years)
Period
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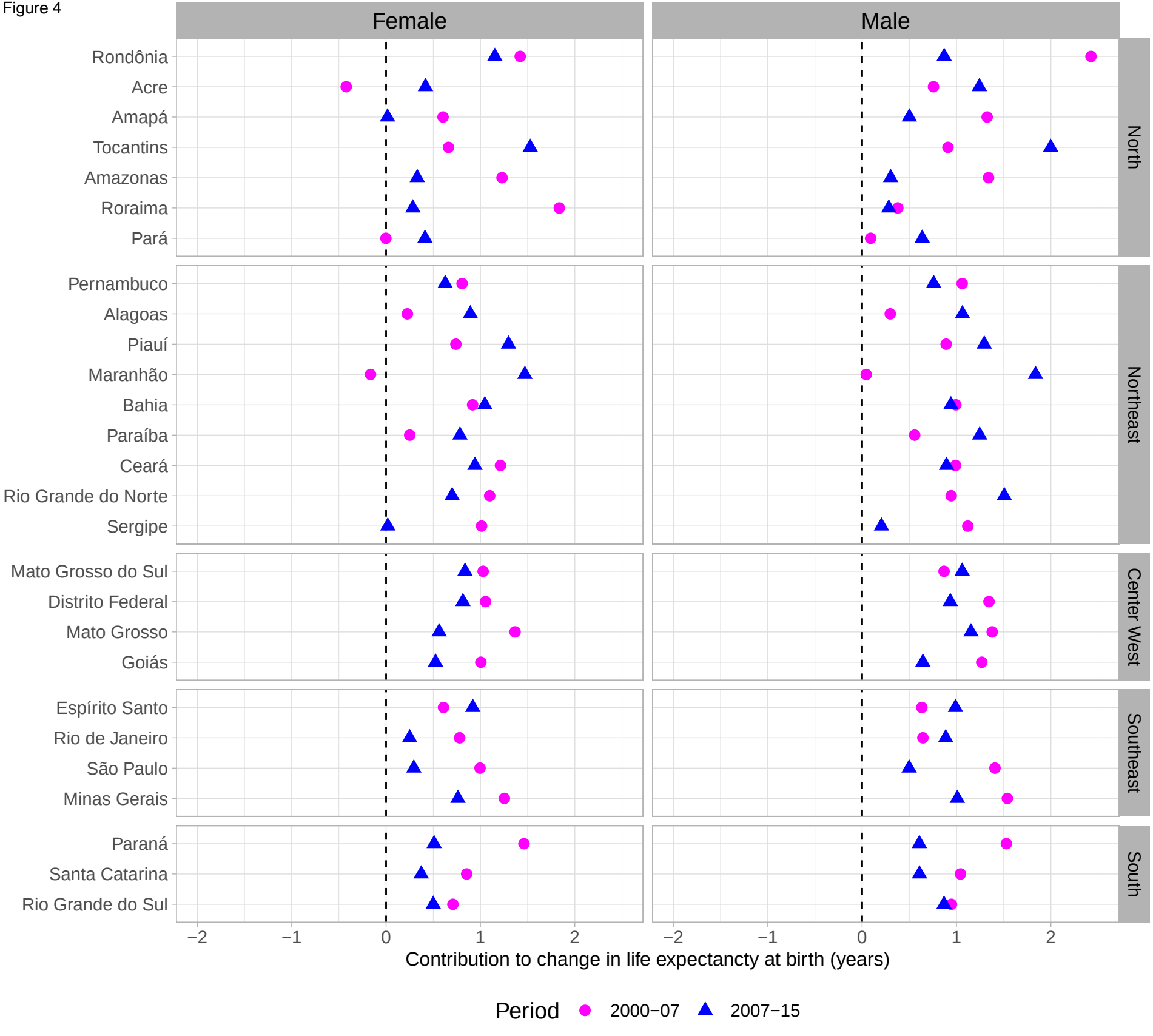
2007−15

Figure 4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Contribution to change in life expectancty at birth (years)
Period
2000−07
2007−15

Appendix

Cover letter