**Title: The effect of homicides on life expectancy in Brazil (Aim: Health Affairs, AJPH,…)**

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**Abstract [Max 150 words]:**

**\maintext[~ 4500 words]**

**Introduction [450 words]**

Recent increases in homicide in Latin America may be jeopardizing population health gains,1-4 brought about by efforts towards universal health coverage5 and reductions in health-related financial insecurity in the past half a century.

Between 1960 and 2015, life expectancy in Brazil increased from 54.2 to 74.7 years, converging with many developed countries.6 Reductions in amenable mortality have contributed to these gains, in particular, infant and cardiovascular disease mortality,7-11 and has coincided with the introduction of a mandated universal healthcare system in the past three decades,12-15 including since 1994 the Family Health Program has led to substantial benefits, and the subsequent Unified Health System (Sistema Único de Saúde).16

Violence and homicides, however, present a major public health concern in the Latin America.17 In Brazil specifically, homicides are the third leading cause of death with accidents for the total population and the main cause of death among young adults.18 19 Between 2000 and 2007, the homicide rate was 23 per 100,000 people, a rate considerably higher than most neighboring countries.17 Currently, the homicide risk is ten times higher than in most developed countries.19

Although informative for the purpose of cross country comparisons, national statistics for Brazil mask large disparities subnationally, and between females and males. For instance, life expectancy ranged from 63.2 years in Alagoas to 71.3 in Santa Catarina in 2000,20 and the rate of change in life expectancy in recent years has varied from 0.6 to 4.1 years between Southeast and Northeast regions,21 respectively. A large contributory factor may be inequality in amenable mortality reductions in 2000-12, which varied between 11% and 4.3% in states with high and low governance scores, respectively.7

Further complicating our understanding of Brazil’s mortality experience is the variation in homicide rates between men and women. 17 22 High homicide rates have the potential to reverse life expectancy gains, as was recently reported in the context of Mexico,23 and homicide rates among Brazilian men are ten times that of women. Although national statistics do not indicate any change in homicide rates in the last decade,24 this could be due to the balancing effect of homicide rates increasing in some states while decreasing in others. For instance, whilst the homicide rate has declined in Brasilia between 2007 and 2011, in the same period, homicides have increased by more than 40% in Bahia.1

Despite the considerable inter-gender and subnational variation in mortality and homicides in Brazil, studies examining the contributing effect of homicide mortality to changes in life expectancy are scarce. This paper aims to examine the effect of homicide mortality on changes in state-level life expectancy between in the new century, in order to inform public health planning aiming to reduce the burden of violence and health disparities in Brazil.

**Study Data and Methods [800 including limitations]**

We used state-level mortality data by age, sex and causes of death to compute proportions of deaths by cause, age, sex and state in a given year.25 We obtained the data from the Mortality Information System produced by the Brazilian Ministry of Health. Additionally, we used death estimates corrected for completeness, age misstatement, and migration available from Queiroz and colleagues,26 and population estimates available from the National Statistics Office (IBGE) from 2000 to 2015 at the state-level.27

**Cause-of-death classification** The concept of amenable mortality formed the basis of the cause of death classifications in our study, and refers mortality that should be absent in the presence of timely and quality health care.28 29 This concept has successfully been used to link the progress of primary care expansion and reductions in amenable mortality in Brazil,7 and more recently the concept has also included causes amenable to public health interventions through health behaviors, such as lung cancer via smoking reduction, and homicides.30

Using a cause of death classification system utilized in similar studies,23 31 32 We grouped the causes of death into the following eight categories based on the *International Classification of Diseases* [ICD] 10th revision (Appendix Table 1):33 (1) amenable to medical service (including conditions that could be reduced by primary care, secondary intervention, and timely medical care), (2) homicides, (3) causes related to public health policies and health behaviors (e.g. drunk driving, smoking), (4) diabetes, (5) ischemic heart diseases (IHD), (6) HIV/AIDS, (7) suicide and self-inflicted injuries, and all other causes (*residual causes)*.

The first category is linked to major health care interventions that have been implemented in the last decades in Brazil, including the Family Health Program, guaranteeing healthcare free at the point of use.7-9 16 The third category includes deaths caused by lung cancer, cirrhosis, and accidents. We analyze diabetes, IHD, HIV/AIDS and suicide separately as they are amenable to both health behaviors and medical attention, and pose important public health challenges in Brazil.10 34 For instance, Brazil was in the top ten countries ranked by number of suicide deaths in 2001.35

In order to avoid cause of death misclassification at older ages, due to the high prevalence of comorbidities, 36 37 we restricted our analysis to mortality below age 75. In addition, the concept of avoidable or amenable mortality often truncates causes of death at age 75,30 and most homicides occur below this age.38

We analyzed changes in life expectancy during the first 15 years of the 20th century by comparing changes within two time periods: 2000-04 and 2004-15. These periods allowed us to capture the stabilization in firearm since 2004 homicides and 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 85 for the twenty-seven Brazilian states, and constructed sex-specific period life tables for each year from 2000 to 2015.39 We then calculated age- and cause- specific contributions to differences in life expectancy at birth for each following year using a standard decomposition procedure.40 We summed up single-year decompositions in order to obtain the aggregate effect for the specified period.

**Limitations** The analysis had several limitations. Firstly, despite improvements in death counts coverage, particularly regarding certificate completeness and age reporting, at the turn of the century Brazilian mortality data was still considered ‘incomplete’ according to the Pan American Health Organization’s (PAHO) criteria.41 Problems due to different levels of data quality by state could also affect calculations if not prior assessment of the data is done. To overcome any resultant bias in our output, we used death estimates corrected for completeness, age misstatement, and migration.26

Secondly, cause of death could have been misclassified for the following reasons: 1) We treat causes of death as mutually exclusive, whereas, they may actually be more ambiguous, for instance, poor eyesight, due to diabetes, may lead to an external cause of death; 2) medical doctors, or coroners, may have imperfect knowledge about causes of death; and 3) developments in awareness of certain diseases in the past may lead to the same cause to be misclassified depending on when the individuals died. To overcome this limitation, we used broad cause-of-death categories before age 75, and used data from 2000 onwards, using only the *ICD*-10 classification.

Finally, although the concept of amenable mortality can be used to capture the effect of health care interventions on a set of causes of death, it is not able to allude to differences in the effectiveness of health care interventions over time and between states.28 Although more likely to be underreported in states with higher homicide rates, estimates of homicides as a cause of death are generally of good quality, especially due to the consistency of its definition, and as trained medical professionals or coroners may have little incentive to intentionally misreport it on a death certificate. Level of information and standardization of procedures to collect information of external causes of death in Brazil and states are homogeneous.[CITATION]

**Results [750]**

**Discussion [1200]**

**Conclusion [200]**

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