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The upsurge of homicides and its impact on life expectancy and lifespan inequality in Mexico, 2005-2015 --Manuscript Draft--

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Abstract:	<p>Objectives To quantify the effect of the upsurge of violence on life expectancy and lifespan inequality in Mexico after 2005.</p> <p>Methods Age- and cause-specific contributions to changes in life expectancy and lifespan inequality conditional on surviving to age 15 between 1995 and 2015 were calculated. Homicides, medically amenable conditions, diabetes, ischemic heart diseases, traffic accidents by state and sex were analyzed.</p> <p>Results Male life expectancy at age 15 increased by more than twice in 1995-2005 (1.17 years) than in 2005-2015 (0.55 years). Lifespan inequality decreased by more than half a year for males in 1995-2005, while in 2005-2015, the reduction was about four times smaller. Homicides between ages 15-49 had the largest effect in slowing down male life expectancy and lifespan inequality. Between 2005 and 2015, states in the North experienced life expectancy losses, while five states increased lifespan inequality.</p> <p>Conclusions Ten years into the upsurge of violence, Mexico has not been able to reduce the homicide levels to those prior to 2005. Thus, males live less, on average, and experience higher uncertainty in their eventual death.</p>
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Suggested Reviewers:	<p>Alyson van Raalte, PhD Research Scientist, Max-Planck-Institut für Demografische Forschung vanraalte@demogr.mpg.de Dr. van Raalte is expert on lifespan inequality and, as a demographer, would be suitable to evaluate the methods used in this paper.</p> <p>Mark Hayward, PhD Professor, University of Texas at Austin mhayward@prc.utexas.edu Professor Hayward is an expert on public health and epidemiology He would be suitable to assess our manuscript since he has extensive research on health inequalities.</p> <p>Vladimir Canudas-Romo, PhD Australian National University vladimir.canudas-romo@anu.edu.au Dr. Canudas-Romo is expert on Latin American health studies, particularly in Mexico.</p>
Response to Reviewers:	

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Title: The upsurge of homicides and its impact on life expectancy and lifespan inequality in Mexico, 2005-2015

November 08, 2018

Prof Alfredo Morabia
Editor-in-Chief,
American Journal of Public Health (AJPH)

Dear Editor,

We are thankful for the opportunity to revise our manuscript entitled “**The upsurge of homicides and its impact on life expectancy and lifespan inequality in Mexico, 2005-2015**” for consideration in the *American Journal of Public Health*. We thank the editors and reviewers for their useful and valuable recommendations.

In response to the editors and reviewers’ comments, we have followed all the suggestions regarding:

1. Figure 1 has been changed accordingly and properly described in the title and notes.
2. Changed the title to show the contribution of the paper.
3. Typo and minor comments from reviewer 1.

A detailed point-by-point response to the editors’ and reviewers’ comments follows in the next pages.

Thank you for your time and consideration. We look forward to hearing from you.

Sincerely,

José Manuel Aburto
Hiram Beltrán-Sánchez

Editor

Your submitted paper has undergone peer review. Thank you for carefully addressing all the comments you received. You will find some residual ones at the end of this correspondence. I personally still have a problem with the figures. They are atypical and I want to make sure our readers understand them. I think I do but am not sure.

1. Please use the title and footnotes to explain what the data show. A lesser gain in life expectancy in the more recent decade compared to the previous decade is understandable. But a lower reduction in inequality of life expectancy for the recent decade ... is harder to digest. The figure should say how you define inequality.

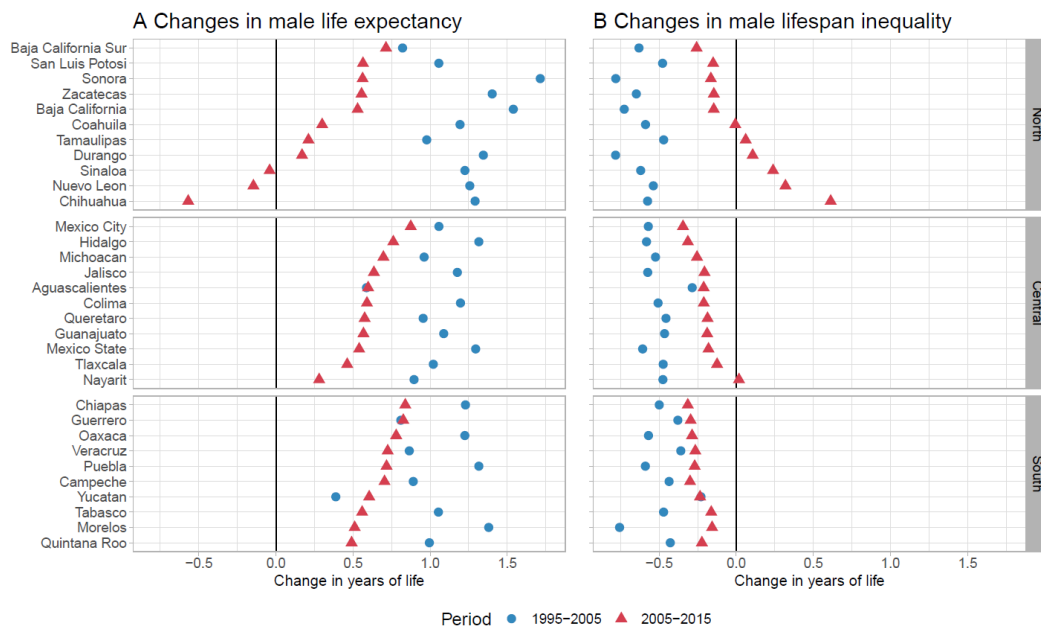
We have rephrased the title of figure 1 and included a footnote explaining what lifespan inequality is:

Title Figure 1: Changes in male life expectancy at age 15 (panel A) and in male lifespan inequality at age 15 (panel B) by state for the periods 1995-2005 (blue dots) and 2005-2015 (red triangles).

Figure 1 notes: Lifespan inequality refers to life years lost due to death, which indicates heterogeneity in ages at death. A value of zero in lifespan inequality indicates that all cohort members die at the same age (i.e., no inequality in ages at death). This figure shows how lifespan inequality changed in two periods: positive values suggest increases in years of life lost and negative values correspond to reductions in life years lost due to death. Hence, the desirable association would be that as life expectancy increases, lifespan inequality decreases. This figure shows each of the 32 Mexican states grouped in broad regions: North, Central, South. Within each region, states are ordered according to the magnitude in changes in life expectancy at age 15 in the period 2005-2015.

2. In Figure 1 the ranges of the x-axis should be identical for both panels. Otherwise you need to use two figures.

We have changed the figure accordingly, now it looks like



3. Why are the geographical locations (you need to say what they are, states?) grouped the way they are?

The figures show each of 32 states in Mexico. We have clarified this in the figures notes. We grouped the 32 states in three areas that generally represent major geographical locations in the country: North, Central, South. These three regions broadly correspond to areas that clearly show a differential impact of violence on the population (see Aburto et al, 2016 and Flores and Villareal, 2015).

Figure 1 notes: Lifespan inequality refers to life years lost due to death which indicates heterogeneity in ages at death. A value of zero in lifespan inequality indicates that all cohort members die at the same age (i.e., no inequality in ages at death). This figure shows how lifespan inequality changed in two periods: positive values suggest increases in years of life lost and negative values correspond to reductions in life years lost due to death. Hence, the desirable association would be that as life expectancy increases, lifespan inequality decreases. This figure shows each of the 32 Mexican states grouped in broad regions: North, Central, South. Within each region, states are ordered according to the magnitude in changes in life expectancy at age 15 in the period 2005-2015.

Figure 2 notes: This figure shows how homicides contributed to changes in lifespan inequality (i.e., panel B of Figure 1) in two periods: positive values suggest increases in years of life lost due to homicides and negative values correspond to reductions in life years lost due to death. This figure shows each of the 32 Mexican states grouped in broad regions: North, Central, South. Within each region, states are ordered according to the magnitude of the impact of homicides to lifespan inequality at age 15 in the period 2005-2015.

References:

Aburto JM, Beltrán-Sánchez H, García-Guerrero VM, Canudas-Romo V. Homicides in Mexico reversed life expectancy gains for men and slowed them for women, 2000–10. *Health Affairs*. 2016;35(1):88-95

Flores M, Villarreal A. Exploring the spatial diffusion of homicides in Mexican municipalities through exploratory spatial data analysis. *Cityscape*. 2015;17(1):35.

4. The title is also much too complicated. Try: "Relation of Homicides to life expectancy in Mexico, 2005-2015."

We concur with the editors that the title is perhaps too complicated. We want to indicate in the title the main contribution of our work, namely, the use of lifespan inequality alongside life expectancy as an indicator of population health. We suggest the following title: ‘The upsurge of homicides and its impact on life expectancy and lifespan inequality in Mexico, 2005-2015’

Reviewer #1 spotted a probable typo that has to be fixed; I consider the other remarks optional and leave it to the discretion of the authors to incorporate them or not.

We have fixed the typo.

Reviewer #1

Reviewer #1: My thanks to the authors for providing such a detailed and considered response to the reviewer comments, and to the other reviewers for their very thoughtful and informative suggestions.

I think many of the revisions the authors have made, particularly in providing additional context in the introduction and discussion sections and adjusting the presentation of the results, have helped strengthen the paper. I also greatly appreciate the efforts the authors made to clarify other smaller points, and to re-analyze the data using cause-of-death data below age 85.

I have just a couple minor additional comments on reading the revised version which I will provide below.

Results: page 7 the authors write, "Importantly, homicides declined in 1995-2005 which accounted for about 38.5% (0.45 years) of the overall gain in life expectancy in this period." In graph S2A it appears that the value for homicide is 0.44 years instead of 0.45. Perhaps this is a minor typo?

Thank you for catching this error, it was a typo due to rounding, we have corrected it.

Discussion: On page 10, add word male before life expectancy to this sentence, since the referenced figure S7 depicts only male life expectancy: "For example, almost every state experienced a reduction in life expectancy at age 15 across all regions in Mexico due to homicides (SM figure 7)."

We have made the change as suggested.

On page 12, I think the recommendation to focus on women in future research might warrant including a brief mention that violence often affects people significantly even if they are not the direct victim of the crime. For example, women are often placed in a caregiving role where they are caring for loved ones who are victims of violence, and their lives are often profoundly affected by that. I think this also connects to Reviewer 3's observation that there are broader population health impacts of violence beyond measuring homicide. Because this paper is focused on "the most severe form of violence-- homicide" I do not think this point necessarily requires in-depth elaboration. But I think it is worth mentioning as an important area of future research, because a broader perspective on the effects of violence might potentially help account for the apparent paradox that "females are less likely to experience a crime but they perceived greater vulnerability."

We have added the next sentence:

“Moreover, often women are placed in caregiving roles for victims or experience the loss of close relatives due to violence that affect their lives and psychological wellbeing.”

Minor re-phrasings: There were a few passages where sentences were a bit confusing to follow and might need to be slightly re-phrased:

Page 9: "In the same period, all but two states for males, Baja California Sur in the North and Tlaxcala in the central region decreased lifespan variation attributed to improvements in medically amenable conditions" --possible missing word? Might read a little more clearly to say: "In the same period, all but two states for males, Baja California Sur in the North and Tlaxcala in the central region, showed decreased lifespan variation attributed to improvements in medically amenable conditions"

We have followed the suggestion.

Page 11: it might read a bit easier to break the following sentence into 2 sentences: "The strongest effect occurred in Guerrero, a state in the Southern region, where life expectancy was reduced by almost 2 years between 2005 and 2015, followed by Chihuahua and Sinaloa in the North, with life expectancy losses of one year each, three additional states in the North (Zacatecas, Baja California Sur and Nuevo Leon), one in the Central region (Colima), and on in the South (Morelos), experienced losses of half a year in expectancy."

We have followed the suggestion, it now reads:

‘The strongest effect occurred in Guerrero, a state in the Southern region, where life expectancy was reduced by almost 2 years between 2005 and 2015, followed by Chihuahua and Sinaloa in the North, with life expectancy losses of one year each. Other states also experienced reductions in life expectancy albeit of lower magnitude, three states in the North (Zacatecas, Baja California Sur and Nuevo León), one in the Central region (Colima), and one in the South (Morelos), experienced losses of half a year.’

Page 14: This sentence appears incomplete and might be missing a word: "For example, programs on improving schooling outcomes and educational and community programs to reduce the risk factors of violence (e.g. alcohol consumption) among others."

It now reads:

‘For example, other countries that underwent a similar upsurge of violence associated with drug cartels successfully implemented programs on improving schooling outcomes and educational and community programs to reduce the risk factors of violence (e.g. alcohol consumption)’



1 **Title: The upsurge of homicides and its impact on life expectancy and lifespan inequality in**
2 **Mexico, 2005-2015**
3

Abstract

Objectives To quantify the effect of the upsurge of violence on life expectancy and lifespan inequality in Mexico after 2005.

Methods Age- and cause-specific contributions to changes in life expectancy and lifespan inequality conditional on surviving to age 15 between 1995 and 2015 were calculated. Homicides, medically amenable conditions, diabetes, ischemic heart diseases, traffic accidents by state and sex were analyzed.

Results Male life expectancy at age 15 increased by more than twice in 1995-2005 (1.17 years) than in 2005-2015 (0.55 years). Lifespan inequality decreased by more than half a year for males in 1995-2005, while in 2005-2015, the reduction was about four times smaller. Homicides between ages 15-49 had the largest effect in slowing down male life expectancy and lifespan inequality. Between 2005 and 2015, states in the North experienced life expectancy losses, while five states increased lifespan inequality.

Conclusions Ten years into the upsurge of violence, Mexico has not been able to reduce the homicide levels to those prior to 2005. Thus, males live less, on average, and experience higher uncertainty in their eventual death.

Keywords: violence, lifespan variation, premature mortality, public health, vulnerability.

Word count: 3397

References: 35

Up to 3500 words in the text, a structured abstract, up to 4 tables & figures combined, and no more than 35 references. The structured abstract must provide the date(s) and location(s) of the study. The text must have an introduction and separate sections for Methods, Results, Discussion, and, Public Health Implications

Introduction

Violence has become a major public health issue in Latin America.¹ This region experiences the highest homicide rate in the world (over 16.3 per 100,000 people), with some countries in Central America undergoing a recent upsurge in homicides.² In Mexico, homicides rates declined from 1995 to 2006 but these trends were reversed and homicides more than doubled between 2007 and 2012 (Supplementary Material [SM] figure S1). This increase has been associated with more enforcement operations trying to mitigate drug cartel activities, increased territorial competition, and higher profitability in the drug-trade flow with the United States.³⁻⁵ This led to a cycle of violence- the so-called war on drugs- and the spillover onto civilians which,⁶ along with an increasing burden of diabetes, led to stagnating male life expectancy in the period 2000-10.⁷ At the subnational level, gains in life expectancy due to medically amenable causes, such as infectious, respiratory diseases and birth conditions, were wiped out by the increase of homicides after 2005 in each of the 32 states in Mexico, with large regional variation.⁸

Trends in life expectancy are important and have been studied in Mexico and its states.⁷⁻⁹ However, life expectancy masks inequality of lifespans or lifespan variation.¹⁰ Variability in age at death (lifespan) is important because it addresses the growing interest in health inequalities¹¹ and because larger variation in lifespans implies greater uncertainty in the timing of death at the individual level, and has implications for the planning of life's events.^{12,13} From a public health perspective, larger lifespan variation implies increasing vulnerability at the societal level, which suggest ineffectiveness of policies aiming to protect individuals against life's vicissitudes.¹² In the context of rising violence, it implies a failure of social protection policies aiming at decreasing homicide/crime rates and increasing vulnerability at the population level. Previous studies have found a negative association between life expectancy and lifespan variation, suggesting that as life

expectancy increases, inequality in lifespans decreases.^{12,14} However, at the subnational level and during periods of life expectancy fluctuation, increases in lifespan variation may simultaneously occur with increases in life expectancy, mostly due to a slowdown in mortality improvements over ages between 20 and 65.^{13,15} This is particularly relevant for countries that have experienced an upsurge in homicides, since this increase has mainly affected young individuals.

In Mexico, homicides are concentrated between ages 15 and 50, affecting mainly males.⁸ It is unclear what their net effect is on lifespan inequality but it certainly had an effect on premature mortality. We thus hypothesize that Mexican males may be experiencing increases in lifespan inequality in tandem with declines in life expectancy. We also expect uneven variability across states in the country due to the changing dynamics of violence and homicides in Mexico.¹⁶ For instance, states in the Northern part of Mexico (e.g., Chihuahua, Durango and Sinaloa) experienced the largest losses in life expectancy between 2005 and 2010⁸ and it is likely they also exhibited large lifespan variation during that period, although this impact may now be larger in other states as homicides spread throughout the country in recent years.¹⁷ On the other hand, medically amenable mortality improvements, which have been Mexico's priority since the 1990s,¹⁸ could have had a substantial effect on reducing variation in lifespans, particularly in the poorer states, which are mostly concentrated in the South.

This paper makes three main contributions. First, it contributes to the literature on lifespan variation and inequalities in health in the context of rising homicides. Most literature in this area focuses on the social determinants of health such as socioeconomic status or educational attainment as proximate determinants of lifespan variation and health inequality.^{12,13} Our paper highlights the role of violence, and its ultimate consequence in the form of homicides, among young adults on increasing lifespan inequality. We describe the observed changes in homicide mortality

and their link with lifespan variation and life expectancy by sex and by region in Mexico. A second contribution is its focus on Mexico with the growing violence associated with the war on drugs making it a serious health policy concern.^{7,8} Understanding the consequences of violence on population health is important for policy makers in Mexico and other countries experiencing similar increases in homicides such as Honduras in Central America, and Venezuela in South America.² Finally, this analysis contributes to our knowledge of regional inequality in lifespans.

We analyzed how life expectancy and lifespan inequality for the young population changed over the period from 1990 to 2015 for females and males in Mexico. This framework allows us to thoroughly analyze premature mortality and to determine the ages and causes of death that contributed the most to the observed changes.

Methods

We used data on deaths from vital statistics files available through the Mexican Institute of Statistics¹⁹ that includes information on cause of death by age, sex, and place of occurrence from 1995 to 2015. Additionally, we used population estimates corrected for completeness, age misstatement, and international migration from the Mexican Population Council to construct age-specific death rates by age, sex and state.²⁰

Cause-of-death classification

We classified deaths into eight categories representing the main causes of death in Mexico using the concept of Amenable/Avoidable mortality (SM Table 1).^{21,22} This concept assumes that some conditions should not cause death in the presence of timely and effective medical care, and

are used as a proxy for the performance of health care systems.²¹ To mitigate biases due to misclassification of causes of death, we focused on deaths occurring below age 85 since cause-specific coding practices above that age are less reliable due to the presence of comorbidities²³ and about 99% of homicide occurred below this age in the study period.

We study two comparable 10-year periods, between 1995 and 2005, and from 2005 to 2015 that represent periods of major changes in homicides (SM figure S1). The first period corresponds to mortality improvements (1995-2005) in which life expectancy increased by 2.1 and 4.3 years for males and females, respectively,²⁰ and homicide rates declined among young adults;¹⁹ while the second period (2005-2015) is characterized by the upsurge of violence and homicides in Mexico.⁸

Lifespan inequality indicator

We use ‘years of life lost’ as a dispersion indicator and refer to it as “lifespan inequality” or “lifespan variation” from age 15. It is defined as the average remaining life expectancy at death, or life years lost due to death (see SM for a summary).¹⁴ For example, if in a cohort of newborns all die at the same age then the value of lifespan inequality is zero; to the extent that death occurs at different ages, those who die “prematurely” will contribute years to lifespan variation. We condition on surviving to age 15 because over 95% of homicides occur above that age and because including infant mortality conceals dynamics of mortality at adult ages.¹⁰

This indicator is easy to understand, to interpret, and to decompose thereby allowing us to quantify the impact of age and cause-specific mortality on changes in lifespan variation over

time.¹⁴ Moreover, the high correlation between our preferred indicator and other measures of variability in lifespans (e.g., variance, Gini coefficient) suggests that our main results would be consistent with those obtained with any of these additional measures.¹⁴

Demographic methods

To mitigate random variation in cause-of-death classification, we smoothed cause-specific death rates over age using a 1-d p-spline separately by year, sex and state, and rescaled them to all-cause death rates to maintain the overall mortality level.²⁴ Using these mortality rates we computed period life tables for each year (1995 to 2015), state and sex following standard demographic methods.²⁵ Finally, we computed life expectancies and lifespan variation conditioned on surviving to age 15 and estimated the age- and cause-specific contributions to yearly differences between the study periods using standard decomposition techniques (see SM).²⁶ All analyses were carried out using R²⁷ and are reproducible (see SM). In addition, we created an interactive app to perform sensitivity analyses available [here](#).

Results

Table 1 shows cause-specific contributions to changes in life expectancy and lifespan inequality at age 15 between 1995 and 2015 and between 2005 and 2015. Among men, life expectancy increased more than twice as fast in 1995-2005 (1.17 years) than in 2005-2015 (0.55 years). Most causes of death contributed to life expectancy's improvement in 1995-2005 (except for diabetes and accidents). Importantly, homicides declined in 1995-2005 which accounted for about 38.5% (0.45 years) of the overall gain in life expectancy in this period. About 80% (0.36 years) of the homicide reduction was concentrated between ages 15-49 (red bars in SM figure S2, panel A). In

contrast, the slowed-down improvement in life expectancy in 2005-2015 was mainly the result of rising homicides and heart diseases, hence their negative contributions. Female life expectancy increased by 0.58 year in 1995-2005 and 0.57 year in 2005-2015. These gains resulted from mortality improvements in most causes of death with a negative impact of diabetes and a negligible impact of homicides, traffic accidents and heart diseases.

[Table 1]

Lifespan inequality declined by more than half a year between 1995 (14.31) and 2005 (13.77) for males. This means that, on average, Mexican males were losing six months of life less at their time of death in 2005 than in 1995. Although lifespan inequality also declined between 2005 and 2015 (-0.15), the reduction in 1995-2005 was about four times larger. In other words, male lifespan inequality was stagnant in recent times. Nonetheless, improvements in other causes of death contributed to a reduction in lifespan inequality in both periods; for example, mortality declines in accidents and cirrhosis at younger ages (figure S1). Importantly, homicides (about 0.19 years) had the largest effect on increasing lifespan variation in 2005-2015 (i.e., positive contribution). For females, lifespan variation decreased since 1995 due to improvements in most causes of death. However, in 1995-2005 increased mortality from diabetes and traffic accidents increased lifespan inequality, while in 2005-2015 homicides were the major contributor to slowing down improvements in variation of lifespans. These results underscore the major role of rising homicide rates among young adults in recent times and the consequent slow improvement in reducing lifespan inequality.

In figures 1-2 we focus on results for males because the impact of homicides is larger among them, results for females are in SM figures S3-S4. Figure 1 shows changes in life expectancy (panel A) and in lifespan inequality (panel B) for males in each of the 32 states in Mexico between 1995 and 2005 (blue dots) and between 2005 and 2015 (red triangles). We grouped states into three broad regions: North, Central and South.

Life expectancy among males had a larger increase in 1995-2005 than in 2005-2015 across all states (panel A) except for Yucatán, some states even experienced reductions in life expectancy in 2005-2015 particularly in the North (e.g., Chihuahua, Nuevo León and Sinaloa). Lifespan inequality (panel B) was reduced in most states over the two decades, 1995-2015, except for those in the North and Nayarit. For example, almost every state between 1995 and 2005 had major reductions in lifespan inequality of at least 0.4 years, but between 2005 and 2015, all states in the north had negligible reductions in lifespan inequality with five states having a large increase (Chihuahua, Nuevo León and Tamaulipas --all bordering with Texas in the US, Sinaloa and Durango).

[Figure 1]

Figure 2 shows the contribution of homicides to changes in lifespan inequality between 1995 and 2005 and between 2005 and 2015 by state. For contributions from all cause-of-death categories and for females see Supplementary Material figures S4-S5.

Every state decreased lifespan inequality due to reductions in homicide mortality between 1995 and 2005. In the same period, all but two states for males, Baja California Sur in the North and Tlaxcala in the central region, showed decreased lifespan variation attributed to improvements in medically amenable conditions (SM figures 5 and 6). As we hypothesized, the states showing

the larger reductions were mostly concentrated in the southern region of Mexico (e.g., Chiapas, Oaxaca, Puebla, Guerrero and Morelos). A decade later (2005-2015), however, there is more heterogeneity in the contribution of causes of death to lifespan inequality. For example, conditions amenable to medical service contributed to reductions in lifespan inequality in some states but small increases in nine states for males distributed across the country, while cirrhosis decreased variation in lifespans in the central and northern regions. Homicides increased variation in lifespans. Although the increase in homicides affected lifespan inequality in all states after 2005, one state in the South was affected the most (about a 1 year increase for males and about two months for females in Guerrero), followed by some states in the North (increase of about 0.75 and 0.5 years in Chihuahua and Sinaloa) and in the central part of the country (e.g. Colima). Mortality due to diabetes showed negligible contributions to lifespan inequality in both periods. Results for females indicate substantial reductions in lifespan inequality from medically amenable conditions and diabetes in the period 1995-2015.

[Figure 2]

Discussion

Ten years after the beginning of the war on drugs, Mexico has not been able to reduce homicides and their effect on longevity, at least to the levels observed back in 2005. As violence spread throughout the country,¹⁷ life expectancy gains slowed down between 2005 and 2015, with a temporary reversal in average lifespan in 2005-10.^{7,8} Despite recent efforts from the Mexican government to contain the upsurge of violence in the country,^{5,28} data up to 2015 shows that life circumstances among young adults have not improved and are actually deteriorating. For example, almost every state experienced a reduction in male life expectancy at age 15 across all regions in Mexico

due to homicides (SM figure S7). The strongest effect occurred in Guerrero, a state in the Southern region, where life expectancy was reduced by almost 2 years between 2005 and 2015, followed by Chihuahua and Sinaloa in the North, with life expectancy losses of one year each. Other states also experienced reductions in life expectancy albeit of lower magnitude, three states in the North (Zacatecas, Baja California Sur and Nuevo León), one in the Central region (Colima), and one in the South (Morelos), experienced losses of half a year. These detrimental consequences offset increases in life expectancy due to ongoing public health interventions, such as the enactment of a universal health insurance program (*Seguro Popular*).^{8,9,18}

Furthermore, homicides have slowed down the progress in reducing lifespan inequality among young adults in Mexico. While lifespan inequality declined by more than half a year between 1995 and 2005, a decade later this progress was stagnant and barely reached a reduction of less than two months. Increase in homicide mortality, concentrated in the young population (between ages 15 and 50), accounted for most of this outcome. Thus, males in Mexico not only live less on average, as shown by life expectancy, but they also face more uncertainty in their time of death due to the increase in homicides. Larger variation of lifespans underlies greater vulnerability at the population level. For example, in Mexico the expected years lived vulnerable of becoming victim of violence increased by 30.5 million person-years between 2005 and 2014.²⁹ Moreover, increasing inequality of lifespans means larger heterogeneity in population health which translates into the need for more resources to optimize health over the life course.¹³

At the subnational level, the states that experienced reductions in life expectancy after 2005 also showed increases in lifespan inequality due to homicides. These results are consistent with the upsurge in violence in these parts of the country. Although homicides have spread across Mexico,¹⁶ they are not evenly shared between states and over time. By 2010, the North of Mexico was

the region most affected by homicide mortality.⁸ In contrast, by 2015 all regions showed similar patterns of the effects of homicides on lifespan inequality. Moreover, while in 2010 Chihuahua (Northern region) was the state affected the most by homicides relative to the 2005 level, in 2015 Guerrero (Southern region) had overtaken this place. The impact of violence in the population in these states is staggering. For instance, in 2010 males aged 15-50 in Chihuahua had three times higher mortality than the US-troops in Iraq between 2003 and 2006.⁸ Recent evidence suggests that the second and fifth most dangerous cities in the world are located in the state of Guerrero, along with cities in countries with higher homicide rates than Mexico.³⁰ As a result, young males in Guerrero experienced an increase in lifespan inequality of almost an additional year. These results complement previous evidence on adult health inequalities between states^{9,22} by identifying homicides as a direct contributor to inequalities in population health between and within states. Moreover, homicides are the ultimate form of violence but they do not fully represent its burden on population health. As a social determinant of health, exposure to violence can increase the likelihood that young people will perpetrate gun violence,³¹ and increases the risk of depression, alcohol abuse, suicidal behavior, and psychological problems, among other detrimental consequences over the life course.³² Even witnessing violence can affect the wellbeing of the population by increasing rates of post-traumatic stress disorder and depression.³³

Here, we quantified the effect of rising homicides on longevity and on lifespan inequality. However, our understanding of the consequences of violence would benefit from future research examining if indeed individuals living in states with increases in lifespan inequality do perceive higher vulnerability and how this might affect their long-term decisions. These studies should also focus on women since females are less likely to experience a crime but they perceived greater vulnerability.²⁹ Moreover, often women are placed in caregiving roles for victims or experience

the loss of close relatives due to violence that affect their lives and psychological wellbeing.²⁹ In addition, more research is needed to quantify the long-lasting consequences of rising violence in the context of the war on drugs to anticipate and intervene in the pathways through which the current violence might affect future health outcomes. For example, the health system might need to be prepared for mental health issues such as depression, suicidal behavior and post-traumatic stress disorder.

In an international context, Mexico's level of violence is not even the highest in the region. Countries in central America, such as El Salvador and Honduras, and Venezuela, Colombia and Brazil in south America have higher homicide rates.^{1,2} It is likely that these countries experience higher variation in lifespans which, along with the existence of high levels of homicides, points to possible failure of policies to reduce the burden of violence. These policies should pay more attention to social determinants of premature mortality, psychosocial factors and get to the root of violence to prevent its diffusion towards the young population.

Limitations

This study has some limitations. First, inaccuracies in cause-of-death practices are likely to be present in the data that we used.⁸ To reduce these inaccuracies, we used broad causes of death and adjusted them with a smoothing process over age to have reliable cause-of-death distributions.²⁴ Second, our estimated effects of homicides could be a lower bound due to undercounting, underreporting, and the large number of missing individuals.⁸ Third, we were not able to disentangle whether a homicide is drug-related (i.e., a homicide resulting from altercations between drug cartels and army operations). Thus, our results provide an upper bound for the possible impact of the war on drugs at the population level. Finally, we were not able to disaggregate deaths by socioeconomic status and other social factors that are closely linked with homicides given that the data is

at the aggregate national-level. Future research should try to shed light into the individual-level pathways of violence and its effects on life expectancy and lifespan inequality.³¹ This illustrates the need of reliable estimates of mortality by cause of death and population by socioeconomic status and other social factors in Mexico.

Conclusion

Mexico has failed to recognize and correct the detrimental consequences in health and human rights that suppressive and drug-prohibition policies have had on the population.³⁴ There is an urgent need to stop these policies and complement them with policies that are less focus on military actions against drug cartels. For example, other countries that underwent a similar upsurge of violence associated with drug cartels successfully implemented programs on improving schooling outcomes and educational and community programs to reduce the risk factors of violence (e.g. alcohol consumption)³⁵. This will prevent homicides and contribute significantly to increases in life expectancy as well as greater equality of individual lifespans in Mexico.

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Figures & Tables

Table 1. Contribution to the change in life expectancy and lifespan inequality at age 15 in the periods 1995-2005 and 2005-2015 at the National level by cause of death below age 85.

Figure 1. Changes in male life expectancy at age 15 (panel A) and in male lifespan inequality at age 15 (panel B) by state for the periods 1995-2005 (blue dots) and 2005-2015 (red triangles).

Notes: Lifespan inequality refers to life years lost due to death which indicates heterogeneity in ages at death. A value of zero in lifespan inequality indicates that all cohort members die at the same age (i.e., no inequality in ages at death). This figure shows how lifespan inequality changed in two periods: positive values suggest increases in years of life lost and negative values correspond to reductions in life years lost due to death. Hence, the desirable association would be that as life expectancy increases, lifespan inequality decreases. This figure shows each of the 32 Mexican states grouped in broad regions: North, Central, South. Within each region, states are ordered according to the magnitude in changes in life expectancy at age 15 in the period 2005-2015.

Figure 2. Contribution of homicide mortality to changes in male lifespan inequality by state for the periods 1995-2005 (blue dots) and 2005-2015 (red triangles).

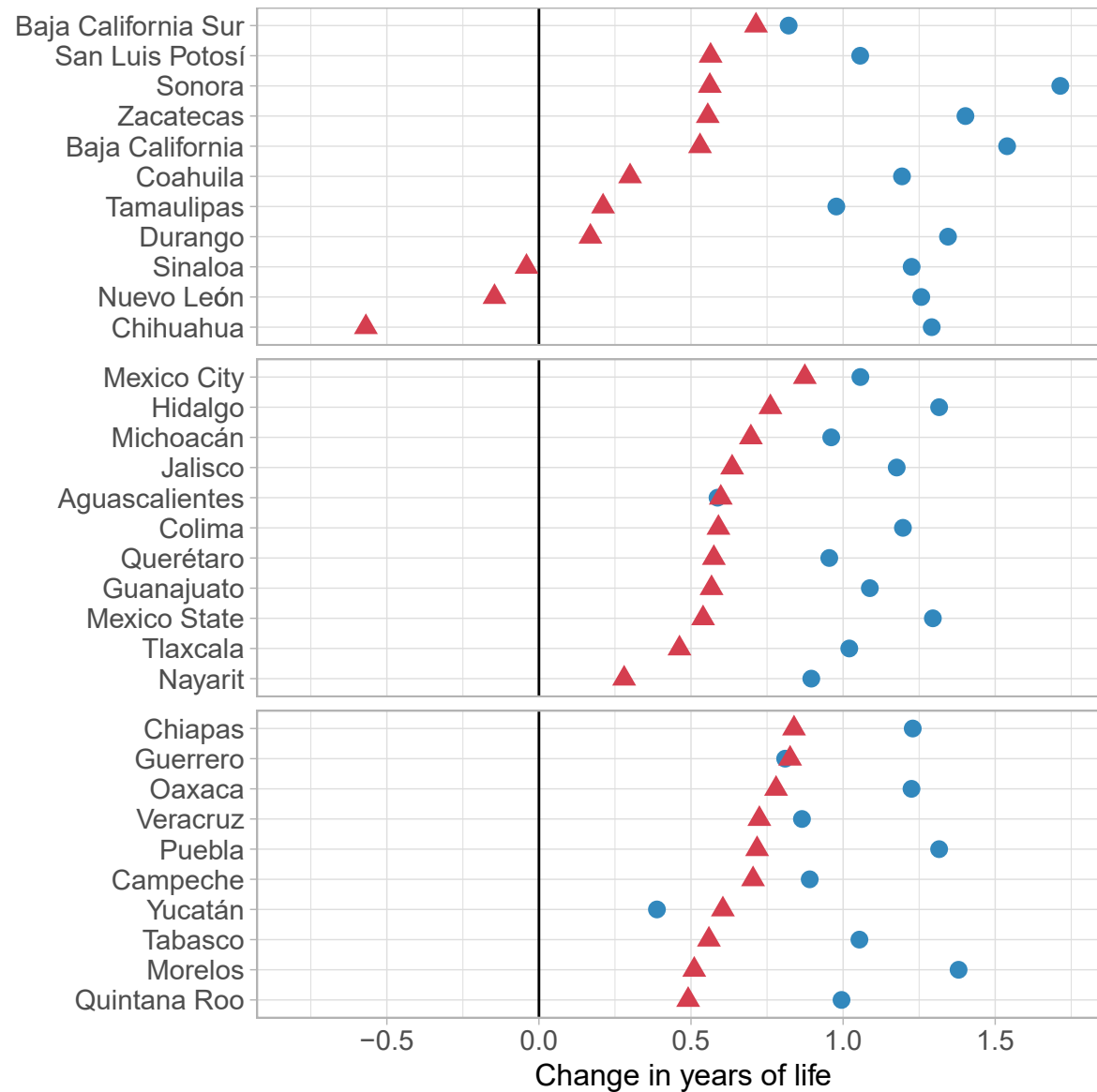
Notes: This figure shows how homicides contributed to changes in lifespan inequality (i.e., panel B of Figure 1) in two periods: positive values suggest increases in years of life lost due to homicides and negative values correspond to reductions in life years lost due to death. This figure shows each of the 32 Mexican states grouped in broad regions: North, Central, South. Within each region, states are ordered according to the magnitude of the impact of homicides to lifespan inequality at age 15 in the period 2005-2015.

Table 1. Contribution to the change in life expectancy and lifespan inequality at age 15 in the periods 1995-2005 and 2005-2015 at the National level by cause of death below age 85.

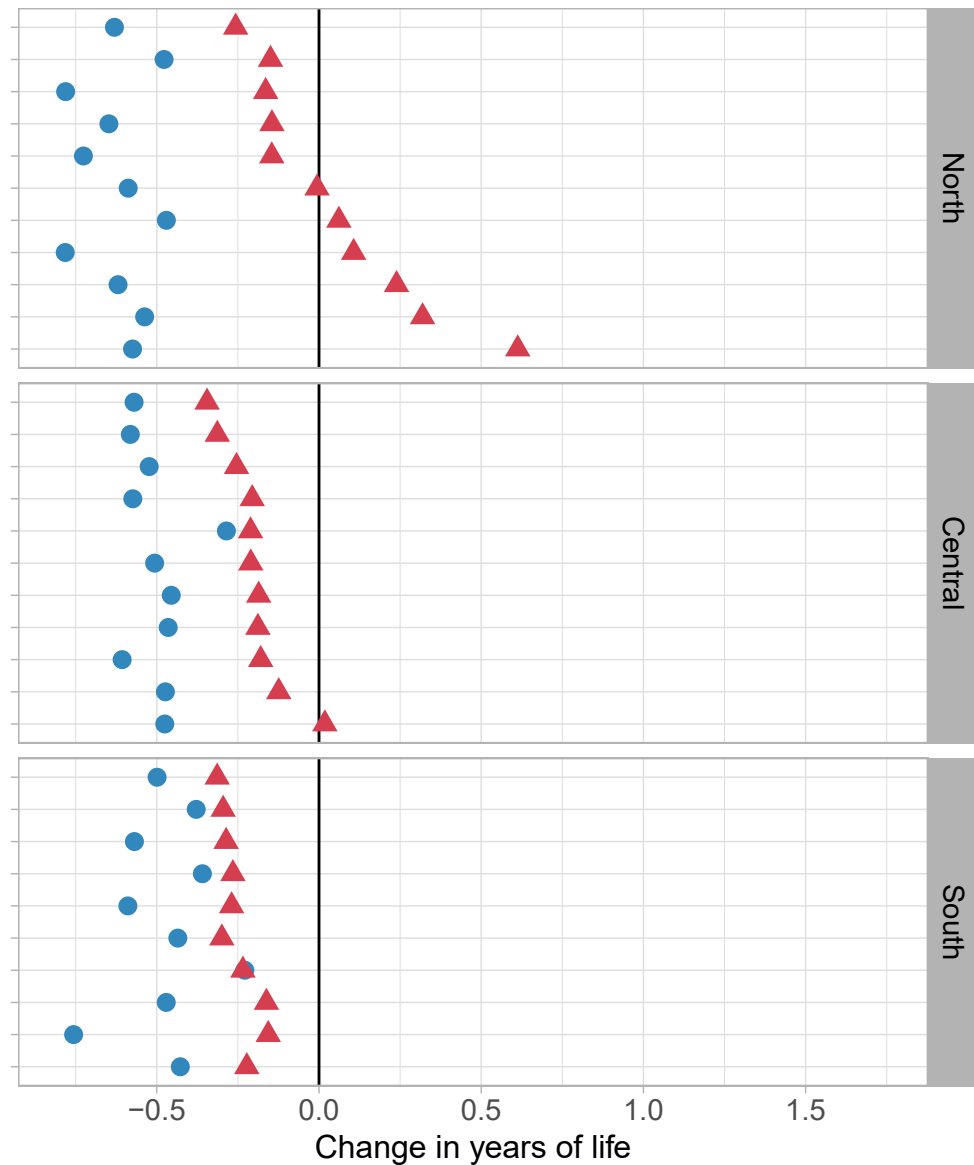
Sex	Cause of death	Contribution to life expectancy		Contribution to lifespan inequality	
		Period		Period	
		1995-2005	2005-2015	1995-2005	2005-2015
Males	Amenable to medical service	0.508	0.169	-0.073	0.005
	Diabetes	-0.572	-0.076	0.028	-0.029
	IHD	0.007	-0.116	-0.023	0.003
	Lung Cancer	0.048	0.099	-0.004	-0.003
	Cirrhosis	0.041	0.280	-0.026	-0.105
	Homicide	0.447	-0.290	-0.265	0.186
	Traffic accidents	-0.069	0.180	0.048	-0.097
	Rest	0.767	0.303	-0.193	-0.107
	Total Change	1.17	0.55	-0.54	-0.15
		From 57.08 to 58.25	From 58.25 to 58.80	From 14.31 to 13.77	From 13.77 to 13.62
Females	Amenable to medical service	0.630	0.393	-0.236	-0.144
	Diabetes	-0.612	0.106	0.100	-0.060
	IHD	0.074	-0.048	-0.023	-0.012
	Lung Cancer	0.017	0.021	-0.005	-0.002
	Cirrhosis	0.032	0.060	-0.017	-0.028
	Homicide	0.023	-0.039	-0.014	0.029
	Traffic accidents	-0.021	0.044	0.015	-0.024
	Rest	0.443	0.030	-0.156	0.030
	Total Change	0.58	0.57	-0.34	-0.21
		From 62.75 to 63.33	From 63.33 to 63.90	From 12.40 to 12.06	From 12.06 to 11.85

Figure 1

A Changes in male life expectancy



B Changes in male lifespan inequality



Period ● 1995–2005 ▲ 2005–2015

