TITLE

Temporal dynamics of violent mortality in Colombia. The impact of violence on Colombian life expectancy and lifespan inequality

1. Introduction

In Latin America, violent mortality has left scars on the demographic structures of countries that had experienced high levels of interpersonal violence (Turra & Fernandes, 2020) in the region. Although Latin America has experienced considerable improvements in health care, living standards, and sanitation, which expressed in an increase in longevity in the second half of the 20th century[1], the region is violence-prone, experiencing different types and forms of violence: high levels of crime, presence of violent gangs, the prevalence of domestic violence and violence related to illegal economies such as drug trafficking, smuggling and arms dealing, as well as more persistent forms of conflict like civil wars, state-sponsored terrorism, guerrilla and paramilitary active groups, death squads, social uprisings and violent revolutions (Imbush, 2011)

So a paradox exists in Latin America: a region that has experienced a rapid demographic transition (Guzmán et al, 2006), and at the same time, a region that has experienced extremely high homicide rates. Previous work shows the impact of violence in life expectancy and lifespan inequality on a high violent mortality country of the region: Venezuela. Analyzing life expectancy and lifespan inequality may, as García and Aburto (2019) states: “(…) Give policymakers a better understanding of the effects of violence on population health”

Lifespan variation measures focus on the distribution of the age of death (Van Raalte et al, 2018) and lifespan inequality is an indicator of how similar ages of death are and can be interpreted as a marker of heterogeneity at a macro level (Van Raalte et al, 2011. García y Aburto, 2019). As Tuljapurkar states: “Historical and economic analyses can benefit from an examination of variance in age at death in addition to the traditionally important study of life expectancy” more so because the combination of the life expectancy indicator and the analysis of the variance of the age of death can shed light on individual’s decisions in a framework of uncertainty regarding their moment of death (García & Aburto, 2019)

2. Data

We examined death counts from the microdata recorded in the Colombian vital statistics register (CVSR), which captures yearly births and deaths. This microdata was extracted from the Colombian national administrative department of statistics data repository as a .cvs file,

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[1] WHO. *Health Systems: Improving Performance* Geneva: World Health Organization 2000

for each year. Microdata is available without restriction, given that the records have been anonymized and (supposedly) harmonized during the last 5 years. We used annual population estimates produced by the Colombian national administrative department of statistics (DANE); a set of excel tables produced based on the 2018 census. The Colombian department of statistics adjusted the population projections of 1985-2017 taking into account the demographic changes recorded in the last census (2018). The adjustment on population projection took into account overestimations in mortality on older ages, distortions on migration, and using the cohort component method the population projections were harmonized between the census of 1985, 1993, 2005, and 2018. Internal migration was adjusted via a *top-down* method. Given that this adjustment was made recently, no further correction for the population projections was made by the authors.

We chose to analyze the period comprised between 1998 and 2019. The reason behind this lies in data quality reasons: before 1997, the system of vital statistics is considered extremely unreliable. A series of institutional changes between the late '80s and the early 1990s gave a place for the misplacement of the physical records for births and mortality. A series of administrative decisions reduced drastically the working personnel of the Statistics department and the numbers for births and deaths were not published between 1988 and 1991. According to Ruiz-Salguero[2], in 1994 Colombia had one of the worst statistical systems in the hemisphere, with problems to processing and recording the paper certificates due to lack of equipment, researchers, and an ill-defined questionnaire. This changes in 1997, when DANE starts to invest heavily to improve the vital record system, acquires more data processing power, and changes the questionnaire to record births and deaths, including asking for the place of residence of the deceased person, as well as the place of residence of the mother of the newborn. Starting in 1998, the vital registration system is considered to have an acceptable quality. Efforts have been made to reconstruct the data before 1998 but are considered that statistics before that year are unreliable (Jaramillo, Chernichovsky & Jiménez, 2019), with distortions on infant mortality and problems with codification consistency. To compute age-specific death rates, we used annual population estimates produced by DANE.

Also, we follow the codification proposed by García and Aburto, 2019: To improve the accuracy of our estimates of violent deaths, we defined them as cases in which the death certificate stated that the cause of death was 'homicide' or violent death of undetermined intent.

[2] Ruiz Salguero Magda Teresa. "La Mortalidad: Estadísticas Vitales, Reglamentación y Análisis". Revista Desarrollo y Sociedad, n.o 34 (1994): 53-71. https://doi.org/10.13043/dys.34.2

To ensure data quality, mortality estimations were adjusted proportionally distributing deaths with age misreported. For the Colombian case, the quality of the death record by age has improved exponentially every year, from 4.72% of male recorded deaths with non-defined age of death in 1998 to 0% in 2018. Deaths with non-defined sex were also proportionally imputed into the database and deaths with unknown sex and age were omitted, given that those registrations were a total of 301 deaths in the whole period of 22 years analyzed.

3. Methods

We constructed annual life tables using standard demographic methods (Preston, 2000)

This allowed us to calculate lifespan inequality as

$$\sigma = \sqrt{\int_{a}^{\omega} (x - e_a)^2 f(x) \mathrm{d}x}.$$

Using lifetable notation, $f(x), e_0$ and ω denote the age at death density function, life expectancy at age a, and the open-aged interval (85+ in our case). Lifespan inequality is defined as by the standard deviation of the age-at-death distribution (σ). Changes in both life expectancy and lifespan inequality were decomposed in a continuous change model, under the assumption of this method that covariates change gradually. The decomposition method we used is based on the line integral model (Horiuchi et al 2008) and successfully used by García & Aburto, 2019: assuming a differentiable function f ($e^{\dagger}$ or life expectancy) of n covariates (which are each age-cause specific mortality case) denoted by the vector $\mathbf{A} = [\mathrm{x}_1, \mathrm{x}_2, \dots, \mathrm{x}_\mathrm{n}]^\mathrm{T}$. we assume that f and **A depend on the underlying dimension t**, which is time in this case, and that we have two-time points t_1 and t_2 with available observations. Given the assumption that **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:

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

Where c_i is the total changes in the functions of life expectancy and lifespan variation, produces by changes in the i-th covariate, x_i. For the decomposition, we used the R package DemoDecomp (Riffe 2018), which has been used successfully in other research (García and Aburto, 2019; Aburto et al., 2018)

Although several lifespan inequality indicators exist (e.g. Gini coefficient, life years lost, variance), the high degree of correlation between them suggests that our main results would be consistent with those obtained by another indicator. (Van Raalte and Caswell, 2013). Standard deviation is selected because of its ease of comparability with life expectancy: both indicators are expressed in years. This allows us to easily quantify changes in age and cause-specific mortality over time

4. Findings

Between 1998 and 2019, male life expectancy in Colombia increased 4.04 years, from 72.48 to 76.46, while female life expectancy increased from 79.3 to 81.85 gaining “only” 2.55 years.

Differences in mortality led to a reduction in the life expectancy sex differential from 6.82 years in 1998 to 5.39 in 2019. this at first glance may seem counterintuitive, but if we take into account that a high level of homicidal mortality was affecting males’ life expectancy, and in this period we observed a dramatic reduction in homicidal violence, is to be expected for males to surpass the gains in life expectancy than females’ in the period. What we are witnessing here is an important reduction of mortality due to homicide and violent causes concentrated in ages 15 to 50 and gains in life expectancy above age 50 related to cardiovascular mortality, diabetes, and digestive diseases. On the other hand, the gains in life expectancy for males at age 0 accounted for almost 0.4 and this is closely related to decreases of the diseases of the perinatal period, respiratory diseases, and external mortality. This set of gains in these 22 years explains how males close the gap between their life expectancy and Colombian females. But there are also losses of life expectancy on the period: almost 0.4 years are lost at the oldest age group (85+) due to other causes of death, which comprises several chronic diseases and an important amount of respiratory diseases.

For females, the largest gains in life expectancy for females at ages below 1 year and above 55 years. Females are affected by homicidal violence in a far less intensity than males, which is concordant with the literature that analyzes the dynamics of violent mortality in Latin America (Briceño-León et al, 2018). Homicides affect 10 times more males than females and are concentrated in ages 15 to 50. Women gained by the improvement in cardiovascular health, digestive diseases, and diabetes, but lost almost 1 year to other causes of death at the older ages.

Regarding lifespan inequality, both males and females decreased it. For males, the reduction was -3.19, from 22.79 to 19.6 whole for females, the reduction comprised -2.37 years, from 22.79 to 19.6.

An increase of homicides occurred between 1998 and 2003. On the periods with high levels of homicide, both on males and females' life expectancy has decreased while the variance of ages of death, which is the measure of lifespan inequality, increased

For males in the period 1998-2001, there was a reduction of 0.74 years of life expectancy, and most of the losses occurred in the age groups between 15 and 50. Life expectancy can be negatively affected by a widespread environment of homicidal violence in males, but also, neoplasms, other causes of death, circulatory diseases, and diabetes. There were gains for males on life expectancy in this period: perinatal diseases were curbed, which reduced infant mortality and some gains were experienced on cardiovascular diseases.

Reductions in life expectancy were also experienced (-0.25), although the impact was almost less than half compared to males in the same period. Also, there was a high level of deaths by neoplasms, cardiovascular diseases, diabetes, and other causes on ages 70 and 85.

While males experienced an increase in lifespan inequality, females experienced a decrease in this period 1998-2002. Males experienced losses of life expectancy by violence on ages 15 to 55 and while females also experience homicides on this period, their gains on life expectancy and thus reductions of the spread of the ages of death were concentrated on the first, second, and 19th age groups (ages 0, 1 and 85)

Analyzing the period comprehended between 2001 and 2005, categorized by Acosta et al (2018) as a period of extreme violence, the gains in life expectancy are heavily influenced on males by the reduction of homicidal violence. For that period, homicidal violence accounted for 60% of the losses in life expectancy for males, while for females, homicidal violence accounted for 20% of the losses in life expectancy.

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