Homicide, health, and deviations from best practices mortality: Mortality in Mexican states, 1990-2010

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Abstract

We analyze trends in temporary life expectancy for three large age groups from 1990 to 2010 for all 32 Mexican states, and compare these with a synthetic best practices trend. We assess the impact of amenable/avoidable mortality on temporary life expectancy at the state level by sex. We apply demographic measures and use standard decomposition techniques to disentangle the effects of selected causes of death. We find improvements in temporary life expectancy for the population aged 0 to 14, as they continuously approached the best practices trend. However, the adult population aged 15 to 39 shows deterioration among males after 2006 in almost every state. Opposing this trend, females show a convergence trend toward the best practices benchmark between ages 15 and 39. Adults aged 40 to 74 show an unexpected decrease in the best practices indicator, and major variation among states in temporary life expectancy. These findings might strengthen the case for reforms that will enable all the Mexicans to improve in their health status.

Background

The 20th century was marked by sizable improvements in mortality, living conditions and health in most Latin American countries (Organization 2000). In Mexico, these improvements have slowed down recently as a result of opposing trends in particular causes of death. For instance, homicide and diabetes increased drammatically, even as infectious and respiratory diseases continued to fall. While life expectancy at birth increased by 4.3 years for males (from 67.6 to 71.9) and 3.4 for females (from 73.8 to 77.2) between 1990 and 2000 (Sociedad Mexicana de Demografía 2011), between 2000 and 2010, life expectancy at birth entered into a period of stagnation for males and slowed progress for females (Canudas-Romo et al. 2014). This period coincides with the implementation of different public health interventions, such as the Universal Vaccination Program and Seguro Popular, which aim to provide primary and secondary health care to the uninsured population, allocate funds to cover catastrophic health expenditures (Knaul and Frenk 2005). Further, the Oportunidades program was introduced to supply incentives for families to invest in themselves and benefit from education, health, and nutrition (Neufeld 2012). Some evidence suggests that Mexico experienced substantial decreases in infant and child mortality, along with improvements that contributed to the reduction of mortality and in the prevalence of acute malnutrition between 1980 and 2000 because of these interventions (Sepúlveda et al. 2006). Similarly, some evidence suggests that by 2012 Seguro Popular had covered an additional 52 million people in Mexico that did not have any access to public health care and, as a result, there has been a reduction in catastrophic health expenditures (Knaul et al. 2012).

Although these results are important, they do not reveal heterogeneity between Mexican states, which is an important task given the high degree of social and health inequalities in Mexico and the heterogeneity in how public health interventions have taken place within the states (e.g., Oportunidades is focused on the poorest states and Seguro Popular did not started at the same time in the states) (Frenk 2006). Given these

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improvements in health care coverage, the strong role of institutions, and ongoing public health interventions, it is necessary to assess the varied impacts that these health interventions may have had on particular causes of death in states populations and across the country.

One approach to assess the impact of health services is by operationalizing the concept of Avoidable/Amenable Mortality (hereafter abbreviated AM) (Nolte and McKee 2004; 2008). This construct aims to measure the quality of health service systems by selecting certain causes of death that should not occur in the presence of effective and timely health care. Among industrialized countries (e.g., United States, Australia, France, Japan), a reduction in AM rates was observed from the late 1990's into the 21st Century (Nolte and McKee 2008). Avoidable mortality rates fell, on average, by 17% for males and 14% for females in these countries. Despite mortality reductions for both sexes, heterogeneity between countries was identified, with the United States showing the smallest reductions (around 5%) for both sexes. However, each country showed progress in mortality from treatable cancers and circulatory diseases except for ischemic heart diseases.

In Mexico, the components of avoidable mortality had different trends since the late 1990's. Between 2000 and 2004 AM decreased, particularly from infectious diseases and nutrition-related conditions (Franco-Marina et al. 2006), while it increased between 1998 and 2010 due to diabetes, circulatory diseases, perinatal and respiratory conditions (Agudelo-Botero and Dávila-Cervantes 2014). Increases in the latter causes of death were particularly concentrated in the poorest states of the country (Dávila-Cervantes and Agudelo-Botero 2014). We aim to improve on these studies by a more focused segmentation of AM into health intervention-related AM and behavior-related AM. Also, we extend analysis to all 32 states, by sex, and over the full 21-year period from 1990 to 2010.[1] Finally, we compare state mortality patterns with best-practice benchmarks for large age groups (e.g., 0-14, 15-39, 40-75). These best practice benchmarks are calculated on the basis of the lowest observed mortality within ages and causes, among the full set of 32 Mexican states. This concept was first proposed by Wunsch (1975), later explored by Vallin and Meslé (2008), and more recently applied under a different definition by Eikemo et al. (2014). We apply demographic measures and standard decomposition techniques to isolate the cause and age-specific shortcomings between states and the corresponding best-practices lifetable.

We hypothesize age-dependent variations in temporary life expectancy outcomes. In particular, we expect convergence between states in temporary life expectancy for young people, since public health interventions are mainly focused in infant mortality and child health. For instance, the vaccination program and the health reform aim to fully cover children in the entire country, and recent evidence suggests a decrease in mortality between ages 0 to 14 due to a decline in infectious and respiratory diseases (Canudas-Romo et al. 2014). On the contrary, we expect little improvements in temporary life expectancy for the adult and older adult population due to the unprecedented rise in homicide mortality and the increase in diabetes mortality in these ages (Canudas-Romo et al. 2014). Although every state has the commitment to providing universal coverage and equitable access to health care since the early 2000's, we anticipate heterogeneity between states in mortality improvements due to state differences in epidemiological patterns (Frenk 2006).

Data & Methods

We used death counts available from official microdata files produced by the Mexican Statistical Office from 1990 to 2010 (Instituto Nacional de Estadística y Geografía 2015). These data contain information on causes of death by single age, sex, and place of residence at the time of death. In addition, we used population estimates (Exposures) corrected for age misstatement, undercounting, and migration— both internal and international— available from the Mexican Society of Demography to construct cause-age-specific death rates by sex and state from 1990 to 2010 (Sociedad Mexicana de Demografía 2011).

Classification of Causes of Death

To separate causes of death that are susceptible to medical intervention (e.g., infectious and respiratory diseases) and those related to health behaviors and intersectoral policies (e.g., homicides, lung cancer) we use the concept of 'Amenable/Avoidable Mortality' (AM) (Nolte and McKee 2004; 2008). This concept assumes

[1]In the final revision of this paper we will provide series through 2013. Right now the exposures are not yet prepared for years after 2010.

a list of conditions that should not occur with the availability of timely medical care. Recently, this concept has also been used to gauge the effect of causes that can be influenced by public policy (e.g., cirrhosis) (Elo et al. 2014). We classified causes of death into ten groups based on prior studies (Elo et al. 2014, Aburto et al. 2015), as listed in Table 1, with relative frequencies by sex.

Table 1: Avoidable Mortality classification, with crude percentages below age 75.

Group/Cause	Males	Females
Causes amenable to medical service	28.50	40.24
Diabetes	9.07	14.77
Ischemic heart diseases	7.92	6.66
HIV/AIDS	1.80	0.51
Lung cancer	1.58	1.09
Cirrhosis	5.34	1.09
Homicide	5.95	1.05
Road traffic accidents	5.82	2.26
Suicide	1.48	0.46
Other causes	32.53	31.86

We separate diabetes, ischemic heart diseases (IHD), HIV/AIDS, lung cancer, and cirrhosis because all of them are amenable to both health behavior and medical service, and because the first two represent major causes of death in Mexico (Canudas-Romo et al. 2014). In addition to these causes, we also isolate homicide, road traffic accidents, and suicide because they have emerged as leading causes of death among young people, and the first two had a sizeable impact on life expectancy recently in Mexico (Canudas-Romo et al. 2014). All causes of death were classified using the International Classification of Diseases, revision 9 for the period 1990-1997 and the tenth revision for 1998-2010 (see Apppendix Table 1 for details on ICD codes for each cause).

We truncated analysis at age 75 because classification of causes of deaths and age reporting are considered to be innacurate in death registration at older ages (Tobias and Jackson 2001) and because most changes in life expectancy are likely due to changes in mortality patterns below the age of 75 (Aburto et al. 2015). In addition, health care and policy/behavior interventions are more likely to be effective at younger ages Elo et al. (2014).

Demographic Methods

We first smooth cause-specific death rates over age and time for each state and sex separately using the 2-d p-spline method proposed by Camarda (2012). This helps eliminate stochastic zeros, which otherwise would accumulate in the best-practices mortality schedule, and artificially inflate BP life expectancy. Smoothed death rates are then constrained to sum to the unsmoothed all-cause death rates. There are no zeros in all-cause death rates. We then calculate period life tables up to age 74 for males and females from 1990 to 2010 following the HMD Methods Protocol (Wilmoth et al. 2007). Second, we estimated temporary life expectancy to capture differential effects of all-cause mortality among three large age groups: children (ages 0-14), young adults (ages 15-40) and older adults (40-74). We do this following the formulas of Arriaga (1984), as defined below.

We then construct the best practices lifetables (BP) for every year and sex and estimated cause-specific contributions to the difference between state-specific temporary life expectancy and BP temporary life expectancy ($e^{\star}$) applying standard decomposition methods (Horiuchi et al. 2008).[2] All the analyses were carried out using `R`.

[2]The decomposition will be carried out and incorporated in the final paper version.

Best Practices Lifetable

This approach was first proposed by Wunsch (1975), and we summarize it briefly here. The synthetic best practices (BP) lifetable is a composite of the lowest observed mortality rates by age, cause, and state for a given sex and year. In continuous terms, we define life expectancy, $e(0)$, as:

$$\int_0^\infty l(x)\,\mathrm{d}x \qquad , \tag{1}$$

where $l(x)$ is the survivorship function defined with radix of one, or as a function of the force of mortality, $\mu(x)$ as:

$$l(x) = e^{-\int_0^x \mu(a)\,\mathrm{d}a} \tag{2}$$

In general, $\mu(x)$ can be treated as the sum of I cause-specific mortality rates at age x assuming that causes of death are independent of one another:

$$\mu(x)^\star = \sum_1^I min(\mu_i(x)) \tag{3}$$

This BP mortality rate schedule ($\mu^\star(x)$) has a unique age profile, and it determines a pattern of $l(x)^\star$, per (2), that corresponds with a best practices life expectancy, $e(0)^\star$. Thus, $e(0)^\star$ can be treated as a maximum presently achievable life expectancy given the best available practices and technologies within a given set of populations and assuming perfect diffusion (Vallin and Meslé 2008). It is an imaginary quantity because no particular population ever achieves this mortality pattern, and none may ever. However, this value is a real referent not based on a projection of improvements into the future, and so it bounds our optimism in a practical way. This definition of best practices is different from other uses found in the literature, and it is important to notice that it is not the same as the vanguard, or record-holder life expectancy. Vanguard life expectancy is the notion that was treated by Oeppen and Vaupel (2002), and it is different from our definition of best practices in that the vanguard life expectancy of a given year is based on all-cause mortality and refers to a single population.

Temporary Life Expectancy

We require an estimate of temporary life expectancy between ages x_1 and x_2, for $x_1 < x_2$, or the average years of life lived between these ages according to a given set of period mortality rates (Arriaga 1984). We denote this quantity as $e(x_1, x_2)$, and its best practices maximum as $e^\star(x_1, x_2)$. Defined in terms of $l(x)^\star$:

$$e^\star(x_1, x_2) = \frac{\int_{x_1}^{x_2} l(x)^\star\,\mathrm{d}x}{l(x_1)^\star} \tag{4}$$

Limitations

The limitations of our study should be mentioned. First, mortality data are likely to present innacuracies in cause-of-death classification due to comorbidities, particularly at older ages (Tobias and Jackson 2001). To mitigate this, we focus on ages below 75, grouping causes of death using ICD codes according to the avoidable mortality concept. Second, our estimates regarding homicide mortality are likely to be underestimated because of inaccurate practices regarding counting, reporting, and due to the large number of missing individuals in Mexico (Human Rights Watch 2011). Third, avoidable mortality should be understood as an indicator of potential weaknesses with respect to health care and some public health policies and not as a definitive assessment (Nolte and McKee 2008). Fourth, the amount of deaths that should be considered avoidable within the avoidable classification is not clear (Beltrán-Sánchez 2011). For instance, Nolte and McKee (2012) consider only 50 percent of heart disease amenable in industrialized countries, based on a previous review of evidence.

We do not have information to precisely measure percentages of avoidable mortality within cause groups. Nonetheless, the difference between a given mortality schedule and the best practices schedule of the same year can be conceived of as a minimal definition of avoidable mortality, a sort of lower bound to how much mortality could have been avoided. Certainly, even a best practices schedule will contain elements of mortality most would consider avoidable. To the extent that the components of the BP schedule were indeed attained somewhere in the popualtion universe, one can view any excess mortality with respect to the BP schedule as avoidable. The concept of BP is nonetheless a model, and not a real population, but we find it useful. Since we conduct age-cause decompositions against the BP trend in each year, we consider both views of avoidability.

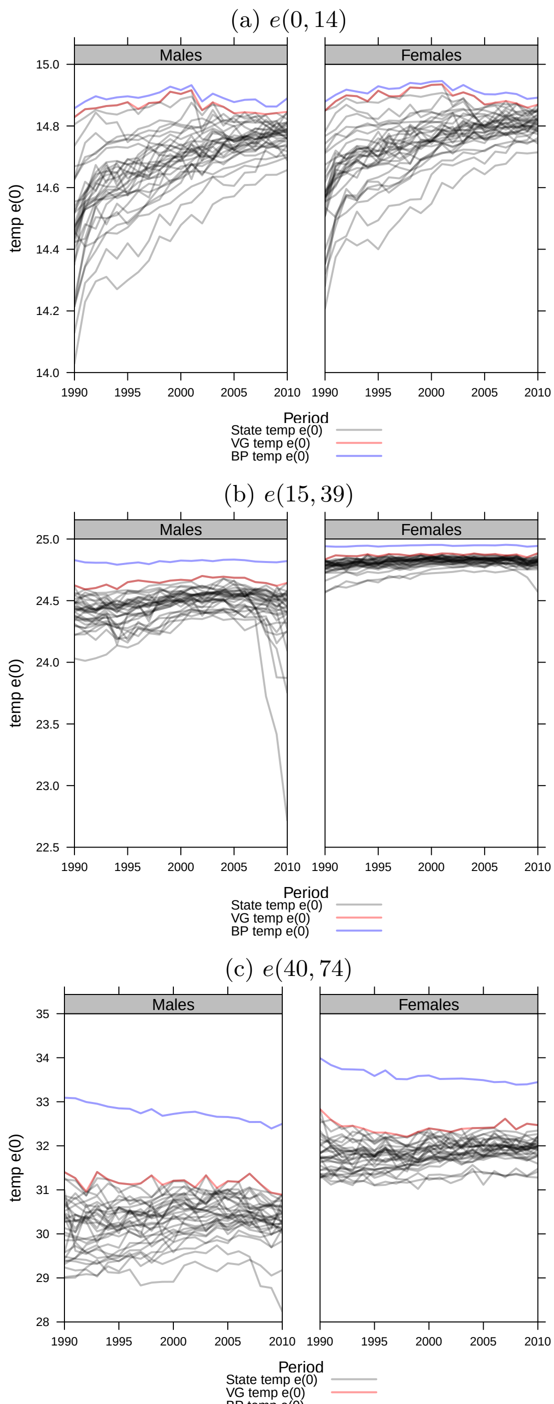
Despite limitations in data, we made use of the most reliable data available publicly to perform our analyses at the sub-national level in Mexico accounting for all the cause codes required for this study.

Results

Trends in best practices life expectancy

Figure 1 shows state-specific (black lines), vanguard (red lines) and BP (blue lines) remaining life expectancies for ages 0-14 (1a), 15-39 (1b) and 40-74 (1c). The red line represents the vanguard life expectancy out of the 32 states within each year and the blue line represents the maximum potentially achievable for the Mexican population under the best practices definition. The figures clearly shows a convergence pattern among the states toward the BP expectancy through at least the year 2000; however the latter period shows stagnation and even decreases for some states.

Figure 1: Temporary life expectancy for states (black line), vanguard life expectancy (red) and best practices life expectancy by sex, 1990-2010.



Source: own calculations based on INEGI and SOMEDE files.

Age and cause contributions to state differences from the best practices trend.

This section will be completed at a later date.

Discussion

It is both curious and concerning that the best practices trends have not been steadily increasing over the period studied. Rather, trends were irregular for children, flat for adults, and decreasing for older adults. We expected that the geographic diversity in Mexico would offset the recent mortality setbacks known from states such as Chihuahua and Durango. If the best practices trend determines our expectations for future mortality, we can conclude that our expectations ought to have been stagnant or deflating over time, depending on the age group considered. It would still represent a great success if mortality were to drop to the best practices level in all states, as unrealistic as this may seem, but at the same time we expect the best practices trend to increase given a mix of new technologies, reforms, and improved material wellbeing.

Despite this pessimistic finding about the best practices trend, all states have converged toward the best practices temporary life expectancy for the age group from 0 to 14 over the 21 years studied. This is an important finding to report, and it could be related to decreases in infectious and respiratory diseases (Canudas-Romo et al. 2014), which is consistent with public health interventions in the period. A forthcoming age-cause decomposition exercise will shed more light on this point.

Males experienced the same positive trend of convergence in the age group 15 to 39 until the year 2006, when a sudden and sizeable excess in homicide mortality began in particular states, especially on the Northern border with the U.S.A. The surge in violent deaths overlapped with a more widespread and earlier trend in increasing diabetes mortality. It is important to note that the so-called accident hump grew manifold in size due to violent deaths in particular states. Here too, our forthcoming decomposition will shed further light on these observations. Between-state variance in temporary life expectancy was much smaller for females over the same period, though females showed the same overall trend of convergence, followed by divergence after 2006.

For older adults in the 39 to 74 age group, all states except for Chihuahua and Baja California converged, albeit not toward the best practices trend. Instead, the best practices trend decreased toward the state trends. Males experienced no notable improvements in these age groups over the period, while females only experienced minor improvements, excepting Chihuahua and Baja California. Of the three age groups considered, the older adult age group has the most potential for gains in the future. All age groups considered have room to improve, and many states have much potential for recovery.

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