

# The Contributions of Homicides and Other Health Interventions to the Best Practices Life Expectancy in Mexico, 1990-2010

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## Abstract

Progress in life expectancy in Mexico has

## 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 dramatically, 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 (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 start at the same time in the states) (Frenk 2006). Given these 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

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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.<sup>1</sup> 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 life table.

We hypothesize age-dependent variations in temporary life expectancy outcomes. In particular, we expect convergence between the 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 cover fully children in all the country and recent evidence suggest a decrease in mortality between ages 0-14 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 old 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 have 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 the different epidemiological patterns in the states (Frenk 2006).

## Data & Methods

We used death counts available from official microdata files produced by the Mexican Statistical Office from 1990 to 2010 (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 (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 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.

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).

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<sup>1</sup>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.

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

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 Appendix 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 inaccurate 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 calculated age-sex-cause specific death rates for the 32 states up to age 75 and estimated period life tables for females and males from 1990 to 2010 following standard life table techniques (Preston et al. 2001). Second, we estimated temporal life expectancy to capture differential effects of the mortality categories among three subgroups: child (ages 0-14), young (ages 15-40) and adult (40-75). We did this following procedures previously used (Arriaga 1984).

We then constructed the Best Practices Lifetables (BP) for every year and estimated cause-specific contributions to the difference between state-specific temporary life expectancy and BP temporary life expectancy ( $e^*$ ) applying standard decomposition methods (Horiuchi et al. 2008). All the analyses were carried out using the R software.

## Best Practices Lifetable

This approach was first proposed by Vallin and Meslé (2008), and we summarize it briefly here. The imaginary 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:

$$\int_0^\infty l(x) dx \quad , \quad (1)$$

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

$$l(x) = e^{-\int_0^x \mu(a) da} \quad (2)$$

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 like  $\mu(x) = \sum_1^I \mu_i(x)$ . In the case of best practices mortality we treat  $\mu(x)$  as a composite of the lowest observed cause-specific mortality rates in the given age  $x$ .

$$\mu(x)^* = \sum_1^I \min(\mu_i(x)) \quad (3)$$

This BP life expectancy ( $\mu^*(x)$ ) has a unique age profile, and it uniquely determines a pattern of  $l(x)^*$ , per (2), that corresponds with a best practices life expectancy,  $e(0)^*$ . Thus,  $e(0)^*$  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.

## 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  $e^*(x_1, x_2)$ . Defined in terms of  $l(x)^*$ :

$$e^*(x_1, x_2) = \frac{\int_{x_1}^{x_2} l(x)^* dx}{l(x_1)^*} \quad (4)$$

## Limitations

The limitations of our study should be mentioned. First, mortality data are likely to present inaccuracies 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 according to the avoidable mortality concept using ICD codes and previous used smooth techniques. Second, our estimates regarding homicide mortality are likely to be underestimated because of inaccurate practices regarding counting, reporting and because the large number of missing individuals in Mexico (Warch 2011). Third, the Avoidable Mortality concept 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 previous review of evidence. However, we do not have information to measure precise percentage of the avoidable mortality within the groups. We overcame this by applying a methodological framework based on mortality levels that had been observed and therefore potentially achievable within the country based on previous works (Vallin and Meslé 2008).

Despite these limitations, we made use of the most reliable data available publicly to perform our analyses in a 20-year period at the sub-national level in Mexico accounting for all the categories we were interested.

## Results

### 0.1 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).

### State trends in departures from best practices temp $e(0)$

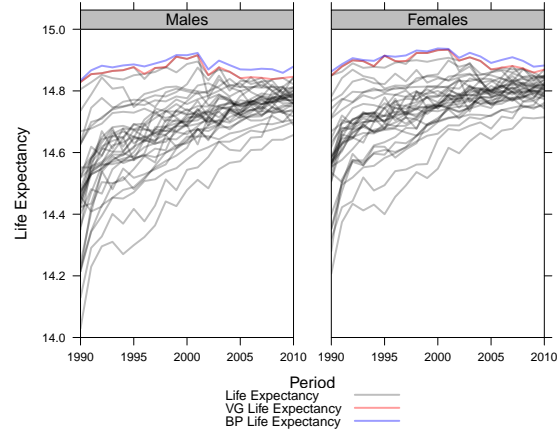
Small multiples maps (time series of maps)

### Age and cause contributions to differences

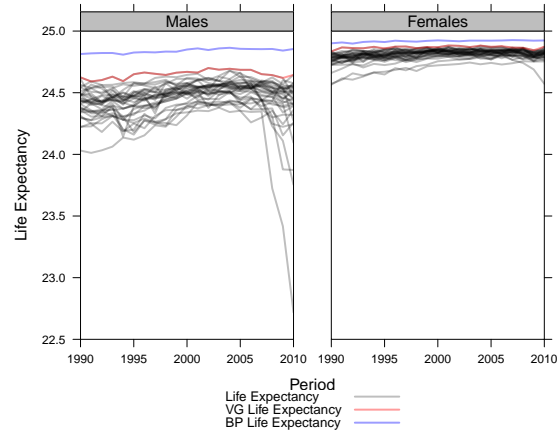
This will show a few small multiples figures, tbd

Figure 1: Temporary life expectancy for states (black line), vanguard life expectancy (red) and best practices life expectancy  $e^*(0, 14)$  (blue) by sex, 1990-2010.

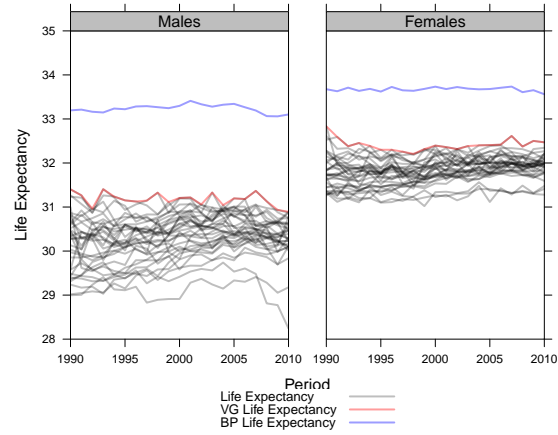
(a)  $e(0, 14)$



(b)  $e(15, 39)$



(c)  $e(40, 74)$



Source: own calculations based on INEGI and SOMEDE files.

## Discussion

Talk about the role of homicide and other major causes. How many years of life were lost? (not just expectancy). maybe..

## Conclusions

Homicide is a public health concern..

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