

the future nor on an arbitrary and likely dissimilar population. We refer to the state with the highest life expectancy in a given year as the vanguard or record-holder state.

Limitations

Mortality data from Mexico are likely to present inaccuracies in cause-of-death classification due to comorbidities, particularly at older ages [27]. To mitigate this, we focus on ages below 75, grouping causes of death using ICD codes. Our estimates regarding homicide mortality are likely to be underestimated due to inaccurate practices regarding counting, reporting, and due to the large number of "missing" individuals in Mexico [32].

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 [12]. The amount of deaths that should be considered avoidable within the avoidable classification is not clear [33]. For instance, some authors consider only 50 percent of heart diseases as avoidable [34].

We do not have information to precisely measure percentages of avoidable mortality within cause groups in Mexico. Nonetheless, the difference between a given mortality schedule and the best mortality schedule of the same year can be conceived of as a minimal definition of avoidable mortality. The benchmark mortality schedule sets a lower bound to how much mortality could have been avoided. Certainly, even the best mortality schedule will contain elements of mortality that most would consider avoidable. To the extent that the components of the benchmark schedule were indeed attained somewhere in the population universe, one can view any excess mortality with respect to the benchmark schedule as avoidable. Little progress has been made in advancing the concept of avoidable mortality [35]. We believe this perspective improves on the original concept by giving a directly measurable standard against which to estimate avoidable deaths.

Results

Trends in the low mortality benchmark and temporary life expectancy

Figure 1 ^{shows} presents the state-specific trends in temporary life expectancy for young, young-adult and older-adult populations (black lines). The red lines represent the record-holder state in a given year, while the blue line represents the low mortality benchmark. Panel a) shows the trend of convergence and improvements among the ^{young population} young population. Since the 1990's all the states have shown improvements towards the low mortality benchmark, approaching near-complete survival between ages 0 and 14. However, both males and females have lagged behind in states such as Puebla, Tlaxcala and México. ^{← should be labelled in graph}

Opposing this trend, temporary life expectancy between 15 and 39 ^{years} shows a common shift after 2005 in almost every state in Mexico (panel b). Chihuahua and Sinaloa, in the Northern region, experienced the largest downwards trends after 2005. Over the full period Oaxaca, Baja California, and Chihuahua show the largest departures from the low mortality benchmark. ^{Results for females show stagnation close to the maximum attainable survival. However, as in males' results, Chihuahua exhibit reductions in survival after 2005.}

to be consistent?

vanguard

youth below age 15

downward

label mentioned states in fig. using two letter codes (include 2 letter codes in parentheses)

stay = bad
close to max = good

say "Females in this age group held close to the maximum attainable survival over the whole period save for deviations in a

... states ... the whole period save for deviations in a

Temporary life expectancy for adults between 40 and 75 years shows stagnation and deterioration during the entire period (panel c). Even the low mortality benchmark exhibits a gradual downward trend, pointing to increases in adult mortality in every state. From a potential maximum of 35 years, all the states are living on average less than 30 years for males and 32 for females. Importantly, Baja California, Chihuahua and Sonora could potentially live more than two additional years if the low mortality benchmark were achieved for males. Similar to the young-adult males, some states experienced a clear downward trend after 2005. Results for females show stagnation in this age-group.

These results allow us to identify three different patterns between the age groups and states. Mortality in ages 0-14 has been decreasing, approaching almost complete survival. Adults aged 15-39, particularly males, present a clear reversal in temporary life expectancy after 2005. Males and females aged 40-74 showed stagnation and deterioration since the 1990's. This has led to a 2-year gap for males and 1-year gap for females with benchmark survival, which itself falls short of the full 25 years by almost 3 years for males and 2.2 for females. To fully understand the underlying causes of death driving these stories, we decompose the gap between state-specific temporary life expectancy and the low mortality benchmark within each age-group.

[Figure 1 about here]

Causes of death

Of the age groups studied, adults aged 35-74 show the largest deviations from the low mortality benchmark. Figures ?? and ?? show cause-specific contributions to the gap between observed temporary life expectancy and the low mortality benchmark by state and region for females and males, respectively. Light-yellow colors indicate no contributions to the gap, which means that these causes are very close to the low mortality benchmark within each category. Darker red hues indicate larger contributions to the gap. If a particular state is improving during the period, it shows a transition from red to light-yellow.

As shown in figure ??, medically amenable causes of death still contribute to the gap between survival and the low mortality benchmark. However, improvements in this category throughout the period 1990-2015 helped reduce deviations in almost every state. Chihuahua, Coahuila and Baja California, in the Northern region, and Chiapas in the South exhibit the largest deviations from the low mortality benchmark, as mortality due to these causes stagnated in both females and males. Opposing this, the increase of diabetes mortality among females has contributed to widening the gap between temporary life expectancy and the low mortality benchmark. Some states, like Tabasco in the South and Coahuila in the North, show a clear deterioration on the survival in the 2000's due to this cause of death. Ischemic heart diseases (IHD) is the the third most important cause of death contributing to differences with the mortality benchmark among regions. The impact of IHD on the survival of the females aged 35-74 is concentrated in the Northern region. Mortality related to Cirrhosis contributes significantly to the difference with the benchmark mortality in the Central and Southern regions in female survival. Its contribution is such that in states such as Tlaxcala, Querétaro, México and Hidalgo in the central

, contributing over half a year to the gap in central states such as Tl., Qu., Me., and H.

not a requirement: only need deterioration in best performing states, no?

Surprisingly?

"all states" ss = "avg"

survival in this age group overage: "As in other age groups"

add another two years to survival

except for the worst performer (CH?) which converged...

(and slight recuperation since 2001)

by cause of death

like to meaning that the cause is contributing more to the absolute gap of death, lags further behind the lowest observed states benchmark.

the gap between states and benchmark survival

are therefore visible with color ramps transitioning from red to yellow and vice versa

amenable mortality among

diabetes

Ischemic?

mortality is a major contributor to the gap?

6 months?

area, this cause of death accounts with more than half a year of the difference with the benchmark. The rest of AM-categories do not contribute significantly to the gap between female survival and the low mortality benchmark, which means that they are very close to the latter.

[Figure 2 about here]

Causes amenable to medical service follow a similar pattern for males (figure ??). However, diabetes, IHD and cirrhosis still contribute significantly to the difference between the observed mortality and the low mortality benchmark. The increase in diabetes has led to decreasing survival among male adults. For instance, Tamaulipas, Coahuila (Northern area); Tlaxcala, México state, Guanajuato and the Federal District in the central region; along with Veracruz, Tabasco and Puebla in the South, show clear deterioration during the study period, while other states experienced improvements that led to reducing the gap towards the low mortality benchmark due to diabetes (such as Sinaloa in the North, Nayarit in the central region, and Yucatán in the South). As in females, IHD exhibits a very different pattern between regions. Nearly every state in the North could gain more than one year of life if IHD mortality were reduced to the low mortality benchmark. On the contrary, cirrhosis affects male survival mainly in the Central and Southern regions, Querétaro, Michoacán, Jalisco, Puebla and Oaxaca show the largest deviations from the low mortality benchmark due to cirrhosis mortality. Finally, homicide mortality also affects older-adult survival in particular states, as the gaps between the low mortality benchmark and the observed life expectancy are wider after 2005. Similar to young adults patterns, Sinaloa, Durango, Chihuahua and Guerrero could potentially increase the survival in one year if homicide mortality converges to the low mortality benchmark. Nevertheless, Michoacán and Oaxaca show gradual improvements over the last 20 years. Road traffic accidents (RTA) and the rest of AM-categories do not contribute notably to the gap between the observed survival and the low mortality benchmark.

[Figure 3 about here]

Males and females in all 32 states increased survival between 0 and 14 due to reductions in causes amenable to medical service (see SI figures ?? and ??). The convergence towards the low mortality benchmark was more intense in states in the Central and Southern region for males. For instance, Tlaxcala, Mexico, Puebla and Chiapas reduced the gap between the benchmark and the observed survival, gaining almost an entire additional year of life.

Among the adult population aged 15-39, deviations from the low mortality benchmark observed in males after 2005 were mainly driven by homicide mortality (see SI figure ??). The unexpected increase of homicide led to widening the gap between the benchmark and the observed survival in almost every state. In the Northern region, the gap went from around a quarter of year in 2002 to more than one year by 2010 in Sinaloa (pacific coast), Durango and Chihuahua (state bordering Texas in the U.S.). Nayarit, Michoacán, in the central region, and Guerrero in the South were the states that showed the largest deviations due to homicide mortality following trend otherwise observed only in the North. Road traffic accidents contributed

*Should we be clear here or in the discussion that this does not imply necessarily that such causes are not important factors in years of life lost in the interval — just that improvement of that kind hasn't happened anywhere.

to the gap between the benchmark and the observed temporary life expectancy but with a minor effect. ^{Among} In females, the gap due to homicide mortality after 2005 is only large in the state of Chihuahua (see SI figure ??). The impact of the remaining AM categories in ages 0-14 and 15-39 is negligible.

[Figure 4 about here]

Discussion

Child and young-adult mortality

This analysis demonstrates the potential contribution of achieving the low mortality benchmark to improvements in survival. However, it is concerning that the low mortality benchmarks have not been steadily increasing over the period studied. Trends were flat for children, they are experiencing almost full survival before age 15. More worrisome is the common shift after 2005 in adults aged 15-39 and decreasing survival among older adults aged 35-74.

Despite the flattening pattern of the low mortality benchmark in children, our results show that all states in Mexico have improved survival towards this benchmark and to the maximum survival. Causes amenable to medical service are at the heart of such improvements, consistent with decreases in infectious and respiratory diseases associated with public health interventions targeted to children in Mexico previously documented [6]. For example, Puebla and Tlaxcala improved survival over half a year since the 1990's. By 2010 survival was improved so that all states' temporary life expectancy ranged between 14.6 and 14.8 years. We further estimated survival inequalities between states by age group calculating Gini coefficients for every year (Figure ??). Indeed, survival equality before age 15 is almost achieved paralleling improvements in mortality rates during the period. In addition, our results are also consistent with advances in coverage for skilled attendance at delivery, which by 2012 remained above 90% and more than 78% of children under age one visited the doctor to monitor their development and growth [8]. Moreover, vaccination coverage has been achieved for the entire young population, the success of such public health interventions are in line with our results, underscoring the improvements in survival in the population younger than 15 years associated to the progress detected in health insurance coverage due to vaccination programs and the implementation of the Seguro Popular [8]. Although average years lived below 15 has improved, there still exist areas of opportunity to achieve full-survival under age 15 in causes amenable to medical service, mainly in states in the Central and Southern regions of the country.

Older-adult mortality

Adults aged 15-39 show a converging pattern towards the low mortality benchmark in all states just until 2005. A sudden increase in homicide rates widened the gap with the low mortality benchmark by almost four times on average in 2010 relative to the level observed in 2005. Previous research documented losses in the overall life expectancy up to three years in the state of Chihuahua (the bordering state with Texas, USA) and almost two years in Sinaloa, Durango (North) and Guerrero (South) between 2005 and 2010 due to homicides [25]. Our findings show that

Let's focus this in ~~the~~ a call

not concerning

in child/young adult section