Inequalities and deterioration in average lifespan among adults in Mexico, 1990-2015:A cross-sectional demographic cause-of-death analysis

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May 15, 2018

Abstract

Objective: To quantify the effect of medically-amenable conditions, diabetes, ischemic heart diseases, lung cancer, cirrhosis, suicides, homicides and road-traffic accidents on longevity in Mexico during 1990-2015.

Design: Retrospective cross-sectional demographic analysis using aggregated data.

Setting: Vital statistics from the Mexican civil registration system.

Participants: Aggregated national data (from 91.2 million people in 1995 to 119.9 in 2015) grouped in 64 populations (32 Mexican-states [including Mexico City] by sex) with cause-of-death data.

Main outcome measures: Cause-specific contributions to the gap in life expectancy in three age groups (0-14, 15-49 and 50-84) with a low-mortality.

Results: The population below age 15 shows improvements in survival. Average survival below 15 over states was 14.82 (95% confidence interval, 14.76 to 14.88) and 14.78 years (14.70 to 14.86) in 2015, for females and males respectively. However, the adult population aged 15 to 49 shows deterioration among males after 2006 in almost every state due to an increasing homicides and a slow recovery thereafter. Out of 35 potential years, females and males live on average 34.57 (34.48 to 34.67) and 33.80 (33.34 to 34.27), respectively. Adults aged 50 to 84 show an unexpected decrease in the low mortality benchmark, indicating nationwide deterioration in both females and males with average survival of 28.59 (27.43 to 29.75) and 26.52 (25.33 to 27.73) out of 35, respectively. State gaps from the benchmark were mainly caused by ischemic heart diseases, diabetes, cirrhosis and homicides. We find large health disparities between states, particularly for the adult population after 2005.

Conclusions: Mexico has succeeded in reducing mortality and between-state inequalities in children. However, the adult population is becoming vulnerable as it has not been able to reduce the burden of conditions amenable to health services and violence. This has led to large health disparities between Mexican states in the last 25 years.

Supplemental material

Appendix Table 1. Definitions of cause-of-death categories using the 9th and 10th revision of the International Classification of Diseases.

| Category | ICD-10 | ICD-9 | |
|---|---|--|--|
| I. Amenable to medical service | | | |
| I.A. AM-Infectious & respiratory diseases : intestinal in- | A00-A09, A16-A19, B90, | 001-009, 010-018, 32, 33, 37, | |
| fections, tuberculosis, zoonotic bacterial diseases, other | A20-A26, A28, A32, A33, | 137, 020-027, 38, 45, 55-56, | |
| bacterial diseases, septicemia, poliomyelitis, measles, | A35, A36, A37, A40-A41, | 70, 73, 080-082, 087, 090- | |
| rubella, infectious hepatitis, ornithosis, rickettsioses/ | A80, B05-B06, B15-B19, | 099, 102, 460-479, 500-519, | |
| arthropod-borne, syphilis (all forms), yaws, respiratory | A70, A68, A75, A77, A50- | 480-488, 490-496 | |
| diseases, influenza & pneumonia, chronic lower respira- | A64, A66, J00-J08, J20-J39, | | |
| tory diseases | J60-J99, J09-J18, J40-J47 | | |
| I.B. AM-Cancers: malignant neoplasm of colon, skin, | C16,C18-C21, C43-C44, | 153-154, 172-173, 174, 180, | |
| breast, cervix, prostate, testis, bladder, kidney-Wilm's | C50, C53, C61, C62, | 185, 186, 188-189, 190, 193, | |
| tumor only, eye, thyroid carcinoma, Hodgkins disease, | C67, C64, C69, C73, C81, | 201, 204-208 | |
| leukemia | C91-C95 | , | |
| I.C. AM-Circulatory: active/acute rheumatic fever, | I00-I02, I05-I09, I10-I13, | 390-392, 393-398, 401-405, | |
| chronic rheumatic heart disease, hypertensive disease, | I15, I60-I69 | 430-438 | |
| cerebrovascular disease | , | | |
| I.D. AM-Birth: maternal deaths (all), congenital car- | O00-O99, Q20-Q28, P00- | 630-676, 745-747, 760-779 | |
| diovascular anomalies, perinatal deaths (excluding still- | P96 | , , | |
| births) | | | |
| I.E. AM-Other: disease of thyroid, epilepsy, peptic ulcer, | E00-E07, 40-G41, K25-K27, | 240-246, 345, 531-533, | |
| appendicitis, abdominal hernia, cholelithiasis & cholecys- | K35-K38, K40-K46, K80- | 540-543, 550-553, 574-575.1, | |
| titis, nephritis, benign prostatic hyperplasia, misadven- | K81, N00-N07, N17-N19, | 580-589, 600, E870-E876, | |
| tures to patients during surgical or medical care, cisticer- | N25-N27, N40, Y60-Y69, | E878-E879 | |
| chosis | Y83-Y84, B69 | | |
| | | | |
| II. Diabetes | E10-E14 | 250 | |
| III. Ischemic Heart Diseases (IHD) | I20-I25 | 410-414, 429.2 | |
| , , | | , | |
| IV. Lung cancer | C33-C34 | 162 | |
| V. Cirrhosis | K70 | 571.1-571.3 | |
| VI. Homicides | X85-Y09 | E960-E969 | |
| VII. Road traffic accidents | V01-V99 | E810-E819 | |
| VIII. Suicide and self-inflicted injuries | E950-E959 | X60-X84, Y87.0 | |
| IX. Residual Causes: HIV/AIDS; other cancers and other heart diseases | B20-B24, U03; C00-D48; I00-I99 if not listed above; R00-R99 | 042-044;140-239; 390-459 if not listed above; 780-799 | |

Temporary Life Expectancy

Temporary life expectancy between ages x_1 and x_2 , for $x_1 < x_2$, is defined as the average years of life lived between these ages according to a given set of mortality rates (Arriaga 1984). We denote this quantity as $(x_2-x_1)e_{x_1}$, and its benchmark based on minimum death rates for every age and cause of death among the Mexican states for each year as $(x_2-x_1)e_{x_1}^*$. Defined in terms of the lifetable survival function, $\ell(x)$:

$$(x_2 - x_1)e_{x_1} = \frac{\int_{x_1}^{x_2} \ell(x) \, \mathrm{d}x}{\ell(x_1)}$$
 (1)

If full survival is achieved, the life expectancy is $x_2 - x_1$. For example, if we set $x_1 = 0$ and $x_2 = 15$, and no person dies between the ages 0 and 15, on average the population lives 15 full years.

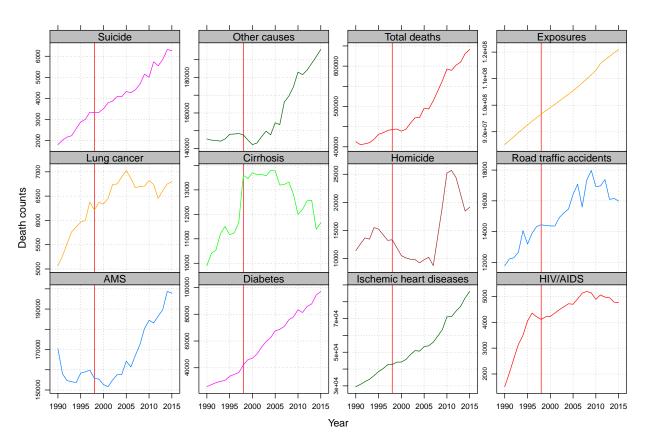
Decomposition method

The decomposition method used in this paper relies on a model of demographic functions based on continuous change (Horiuchi et al. 2008). Suppose P (e.g. temporary life expectancy between ages 15 and 49) is a differentiable function of n covariates (e.g. each age-cause specific mortality rate) denoted by the vector $\mathbf{A} = [x_1, x_2, \dots, x_n]^T$. We assume that \mathbf{A} is a differentiable function between P_1 and P_2 , then the difference in P between P_1 and P_2 can be expressed as follows:

$$P_2 - P_1 = \sum_{i=1}^n \int_{x_i(P_1)}^{x_i(P_2)} \frac{\partial P}{\partial x_i} dx_i = \sum_{i=1}^n c_i,$$
 (2)

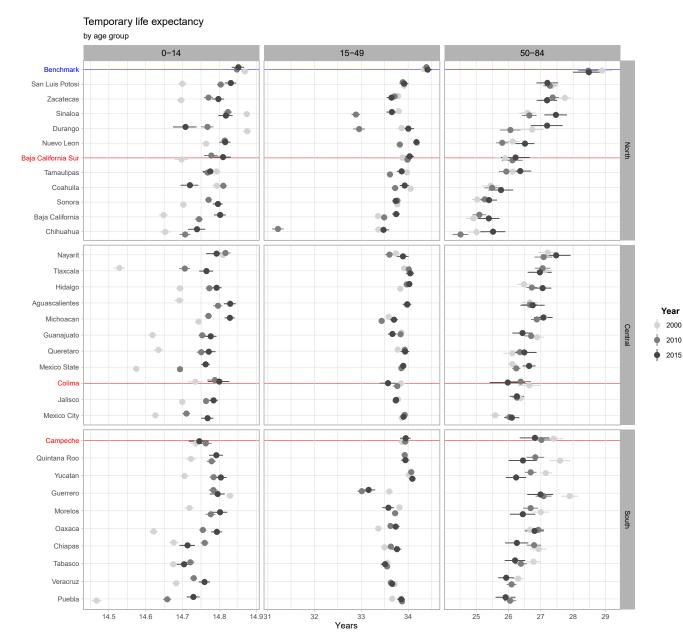
where c_i is the total change in P produced by changes in the i-th covariate, x_i . The c_i 's in equation (2) were computed by numerical integration following the algorithm suggested by Horiuchi et al. (2008). This method has the advantage of assuming that covariates change gradually along the time dimension.

Figure 1: Cause-specific death counts (different y-scale for each cause), 1990-2010.



Note: AMS "amenable to medical service". The red line indicates the change from ICD 9 to ICD 10.

Robustness check: 95% CIs for male temporary life expectancies



Note: States highlighted in red had less than 1 million population in 2010.

References

Arriaga, E. E. (1984). Measuring and explaining the change in life expectancies. Demography, 21(1):83-96.

Horiuchi, S., Wilmoth, J. R., and Pletcher, S. D. (2008). A decomposition method based on a model of continuous change. *Demography*, 45(4):785–801.

Figure 2: Inequality in life expectancy between states for youngest (0-14), young adults (15-49), and older adults (50-84) by sex, 1990-2015.

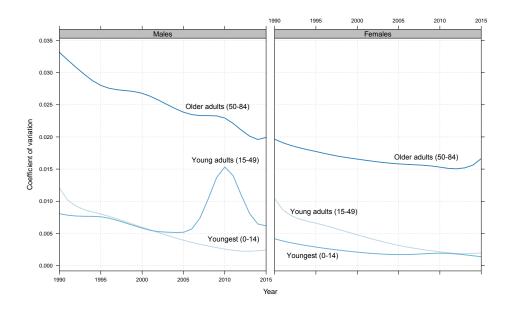
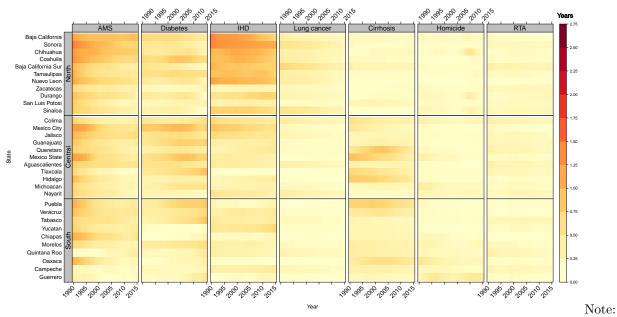


Figure 3: State ranking for average female life expectancy 2010-15 for the youngest (0-14), young adults (15-49), and older adults (50-84).

| Sinaloa Si | You | ung (0–14) | Middle (15-49) | Older (50- | -84) |
|--|---------------------|--|----------------|------------|------|
| Nuevo Leon NL | | | | | Rank |
| Nayarit NA | Sinaloa | SI | NĻ | SI | 1 |
| Colima CL QR SL 4 | Nuevo Leon | NL — | SI | ŅA | 2 |
| Aguascalientes AG San Luis Potosi SL Quintana Roo Michoacan MC Michoacan MC Michoacan MC Morelos MR Yucatan YU MR Baja California Sur Guerrero GR Sonora SO NA Calla CA AG | Nayarit | NA | ΥU | ĢR | 3 |
| San Luis Potosi SL | Colima | CL | QR | ŚL | 4 |
| Quintana Roo QR DU ZA 7 Michoacan MC OE OA 8 Morelos MR SL DF 9 Yucatan YU BS 10 Baja California Sur BS MR NL 11 Hidalgo HI GT CL 12 Guerrero GR DF TL 13 Sonora SO NA QE 14 Tamaulipas TM HI DU 15 Coahuila CA AG 16 AG 16 Zacatecas ZA CL GT 17 TM 18 Queretaro QE TM JA JA JA 18 19 Baja California BN MX MR 20 MX 21 Campeche CM JA MX MX 22 MX 22 Oaxaca OA CA | Aguascalientes | AG | BS | /HI | 5 |
| Michoacan Mc QE QA 8 Morelos MR SL DF 9 Yucatan YU CM BS 9 Baja California Sur BS MR NL 11 Hidalgo HI GT CL 12 Guerrero GR DF TL 13 Sonora SO NA QE 14 Tamaulipas TM HI DU 15 Coahuila CA AG AG 16 Zacatecas ZA CL GT 17 Jalisco JA ZA TM 18 Queretaro QE TM MX MR 20 Baja California BN MX MR 20 Guanajuato GT MC MX 21 Campeche CM JA CM 22 Oaxaca OA CA BN 23 Mexico City DF SO QR 24 Veracruz VE PU PU PU PU Durango < | San Luis Potosi | SL | ŢĻ | / MC | 6 |
| Morelos MR | Quintana Roo | QR | DU | X / ZA | 7 |
| Yucatan YU CM BS 10 Baja California Sur Bs MR MR NL 11 Hidalgo HI GT CL 12 Guerrero GR DF TL 13 Sonora SO NA QE 14 Tamaulipas TM HI DU 15 Coahuila CA AG AG AG 16 Zacatecas ZA CL GT 17 Jalisco JA ZA TM 18 Queretaro QE TM JA 19 Baja California BN MX MR 20 Guanajuato GT MC MX 21 Campeche CM JA CM 22 Oaxaca OA CA BN 23 Mexico City DF SO OR 24 Veracruz VE PU PU PU PU Durango DU OA YU 26 Tlaxcala TL BN SO | Michoacan | MC X | QE V | //QA | 8 |
| Baja California Sur BS | Morelos | MR | SL | DF | 9 |
| Hidalgo HI GT CL 12 Guerrero GR DF TL 13 Sonora SO NA QE 14 Tamaulipas TM HI DU 15 Coahuila CA Zacatecas ZA CL GT 17 Jalisco JA ZA TM 18 Queretaro QE TM JA 19 Baja California BN MX MR 20 Guanajuato GT MC MX 21 Campeche CM JA CM 22 Oaxaca OA CA BN 23 Mexico City DF SO QR 24 Veracruz VE PU PU 25 Durango DU OA YU 26 Tlaxcala TL BN SO 27 Mexico State MX TB VE 28 Tabasco TB QR CP CA 31 Chiapas CP CP CA 31 | Yucatan | YU | ĆW X | BS | 10 |
| Guerrero GR Sonora SO NA Tamaulipas TM Coahuila CA AG | Baja California Sur | BS | MR |) NL | 11 |
| Sonora SO | Hidalgo | HI | X/X GTX | CL | 12 |
| Tamaulipas TM Coahuila CA Zacatecas ZA CL GT 17 Jalisco JA Queretaro QE Baja California BN Guanajuato GT Campeche CM Oaxaca OA Mexico City DF Veracruz VE Durango DU Tlaxcala TL Mexico State MX Chihuahua CH Tabasco TB Chiapas CP CP CA GG AG | | | DF | TL | 13 |
| Coahuila CA Zacatecas ZA CL GT 17 Jalisco JA Queretaro QE Baja California BN Guanajuato GT Campeche CM Oaxaca OA Mexico City DF So Durango DU Tlaxcala TL Mexico State MX Chihuahua CH Tabasco TB GR CA CA BN SO QR CA BN SO Q | | so | X NA | QE | 14 |
| Zacatecas ZA | | TM | HI | DU | 15 |
| Jalisco JA | Coahuila | CA | ÀG / | AG | 16 |
| Queretaro QE TM JA 19 Baja California BN MX MR 20 Guanajuato GT MC MX 21 Campeche CM JA CM 22 Oaxaca OA CA BN 23 Mexico City DF SO OR 24 PU PU PU 25 Durango DU DOA YU 26 Tlaxcala TL BN SO 27 Mexico State MX TB VE 28 Chihuahua CH VE TB 29 Tabasco TB OR CP CP CA 31 | Zacatecas | ZA | CL/ / | GT | 17 |
| Baja California BN MX MR 20 Guanajuato GT MC MX 21 Campeche CM 22 CM 22 Oaxaca OA CA BN 23 Mexico City DF SO QR 24 Veracruz VE PU PU PU 25 Durango DU OA YU 26 Tlaxcala TL BN SO 27 Mexico State MX TB VE 28 Chilhuahua CH TB 29 Tabasco TB GR CP 30 CP CP CA 31 | Jalisco | JA 🗸 | ZÁ | TM | 18 |
| Guanajuato GT | | QE \ | TM | JA | 19 |
| Campeche CM JA CM 22 Oaxaca OA CA BN 23 Mexico City DF SO OR 24 Veracruz VE PU PU PU 25 Durango DU OA YU 26 30 27 Mexico State MX TB VE 28 28 28 28 28 28 28 28 28 28 29 20 | | BN | MX / | MR | 20 |
| Oaxaca OA Mexico City DF Veracruz VF Durango DU Tlaxcala TL Mexico State MX Chihuahua CH Tabasco TB Chiapas CP CA BN 23 CA BN 24 PU PU PU 26 N SO 27 TB VE 28 Chinaps CP CA 31 | | | MC | WX | 21 |
| Mexico City DF SO QR 24 Veracruz VE PU PU 25 Durango DU OA YU 26 Tlaxcala TL BN SO 27 Mexico State MX TB VE 28 Chihuahua CH VE TB 29 Tabasco TB GR CP 30 Chiapas CP CP CA 31 | | | JA // | \\с`м | 22 |
| Veracruz VE PU PU PU 25 Durango DU OA YU 26 Tlaxcala TL BN SO 27 Mexico State MX TB VE 28 Chihuahua CH TB 29 TB 29 Tabasco TB GR CP 30 Chiapas CP CP CA 31 | | The same of the sa | CA / | BN | 23 |
| Durango DU OA YU 26 Tlaxcala TL BN SO 27 Mexico State MX TB VE 28 Chihuahua CH VE TB 29 Tabasco TB CP CA 31 Chiapas CP CA 31 | Mexico City | DF // | | | 24 |
| Tlaxcala TL | | VE | PU | | 25 |
| Mexico State MX Chihuahua CH TB VE TB 29 Tabasco TB GR CP CP CA 31 | | DU// | \ OA / | ÝU | 26 |
| Chihuahua CH VE TB 29 Tabasco TB GR CP 30 Chiapas CP CP CA 31 | | TL/ | BN/ | so | 27 |
| Tabasco TB GR CP 30 Chiapas CP CP CA 31 | | | TB | VE | 28 |
| Chiapas CP CP CA 31 | | - | | | |
| | | | | | 30 |
| Puebla PU CH 32 | | | CP | CA | 31 |
| | Puebla | PU | _CH | ——СН | 32 |

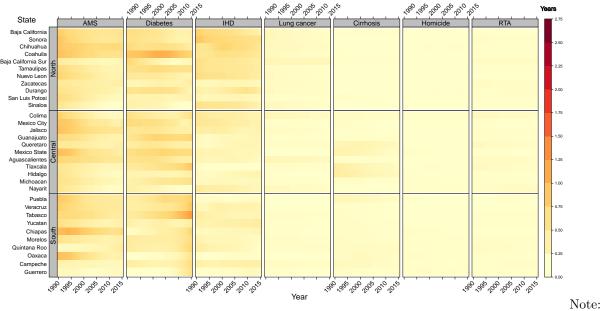
Source: calculations based on INEGI and CONAPO files.

Figure 4: Cause-specific contributions to state differences from low mortality benchmark for older male adults (ages 50-84), 1990-2015. States grouped into three regions. Reproduced from manuscript Figure 4 to have color scale comparable with other Supplementary figures. In subsequent figures 5-9 the color was rescaled to make them comparable over age groups in the supplemental material, the maximum value observed was 2.6 years caused by homicides in Chihuahua in 2010.



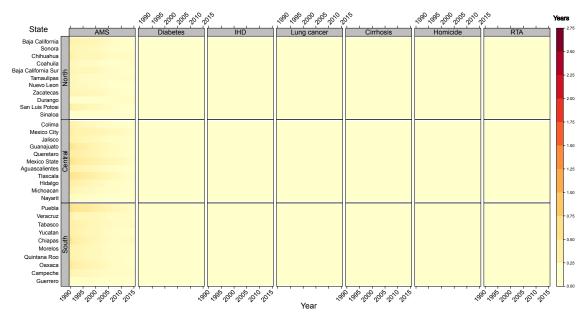
AMS is "amenable to medical service", IHD is "isquemic heart diseases", and RTA is "road traffic accidents". Source: own calculations.

Figure 5: Cause-specific contributions to state differences from low mortality benchmark for older female adults (ages 50-84), 1990-2015.



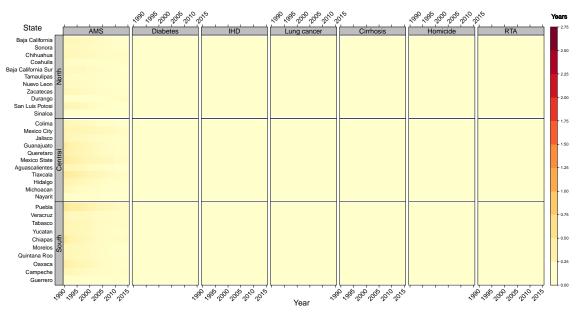
AMS is "amenable to medical service", IHD is "isquemic heart diseases", and RTA is "road traffic accidents". Source: own calculations.

Figure 6: Cause-specific contributions to state differences from low mortality benchmark for male youngest population (ages 0-14), 1990-2015.



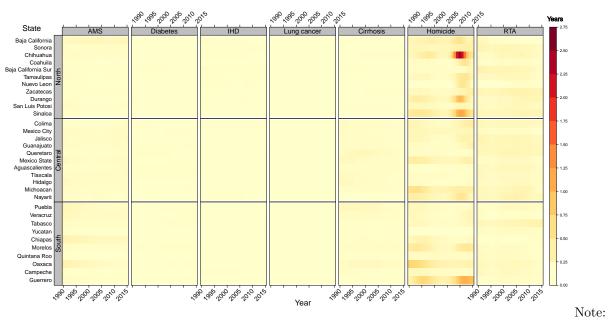
Note: AMS is "amenable to medical service", IHD is "isquemic heart diseases", and RTA is "road traffic accidents". Source: own calculations.

Figure 7: Cause-specific contributions to state differences from low mortality benchmark for female youngest population (ages 0-14), 1990-2015.



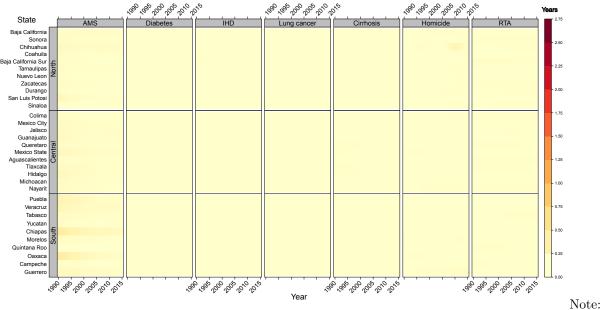
Note: AMS is "amenable to medical service", IHD is "isquemic heart diseases", and RTA is "road traffic accidents". Source: own calculations.

Figure 8: Cause-specific contributions to state differences from low mortality benchmark for male young adults (ages 15-49), 1990-2015.



AMS is "amenable to medical service", IHD is "isquemic heart diseases", and RTA is "road traffic accidents". Source: own calculations.

Figure 9: Cause-specific contributions to state differences from low mortality benchmark for female young adults (ages 15-49), 1990-2015.



AMS is "amenable to medical service", IHD is "isquemic heart diseases", and RTA is "road traffic accidents". Source: own calculations.

Figure 10: State specific gap with low mortality benchmark for selected years between ages 0-14. Source: own calculations.

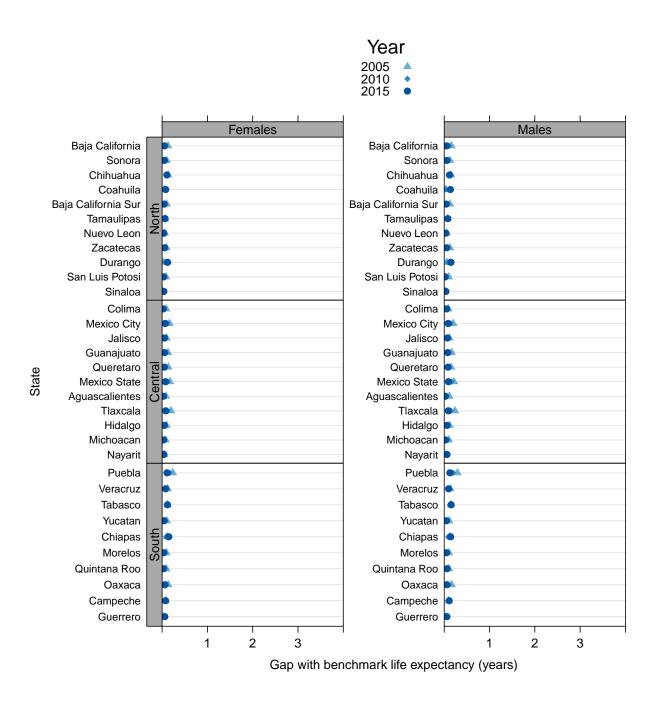


Figure 11: State specific gap with low mortality benchmark for selected years between ages 15-49. Source: own calculations.

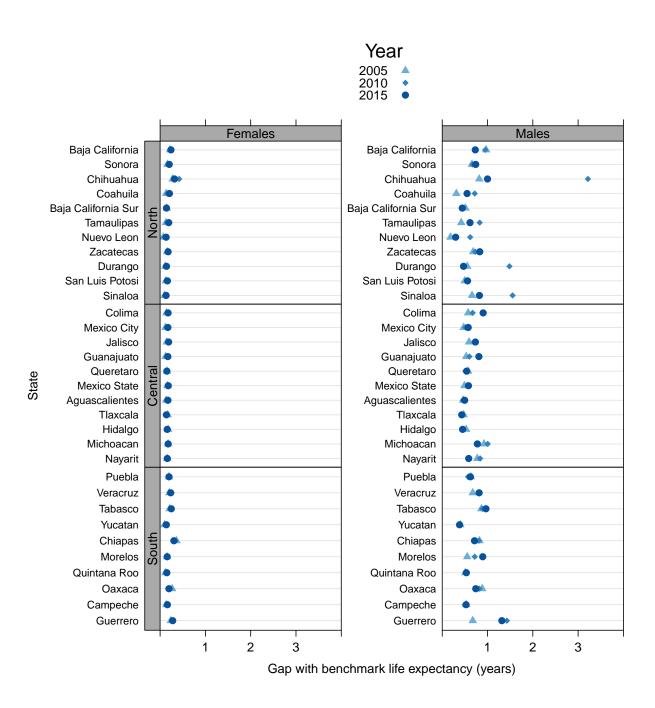


Figure 12: State specific gap with low mortality benchmark for selected years between ages 50-84. Source: own calculations.

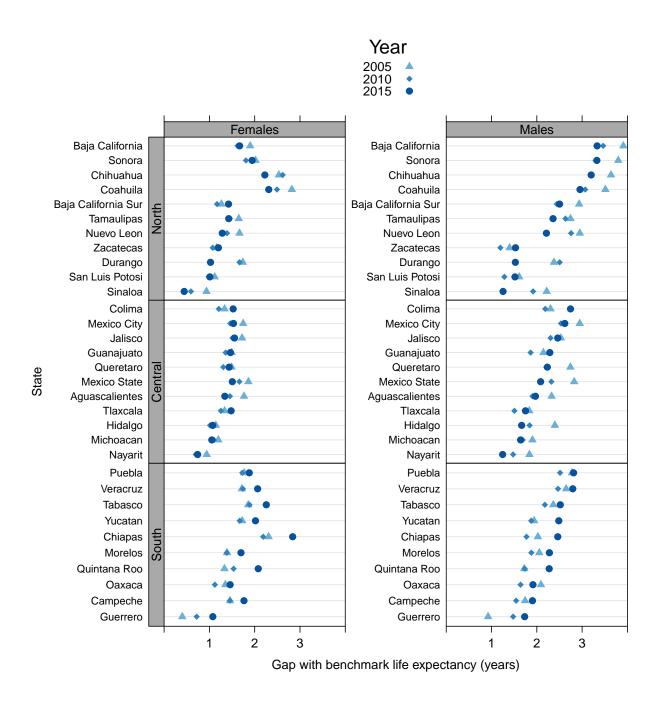


Figure 13: Proportion by cause of death from benchmark mortality for youngest females (ages 0-14). Source: own calculations.

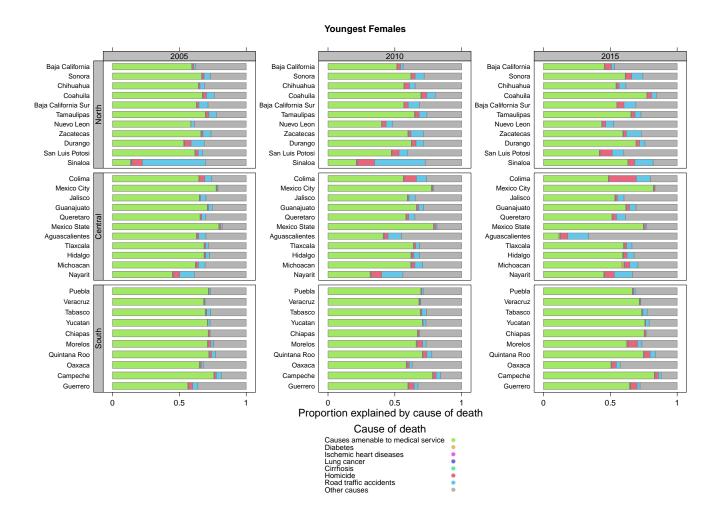


Figure 14: Proportion by cause of death from benchmark mortality for youngest males (ages 0-14). Source: own calculations.

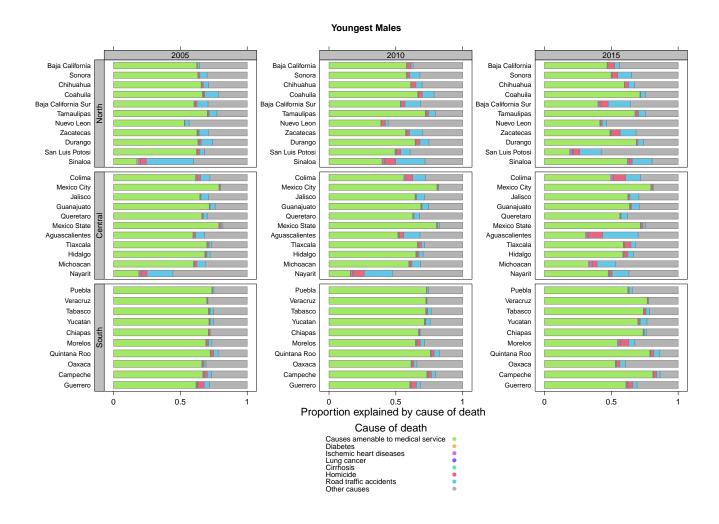


Figure 15: Proportion by cause of death from benchmark mortality for young adult females (ages 15-49). Source: own calculations.

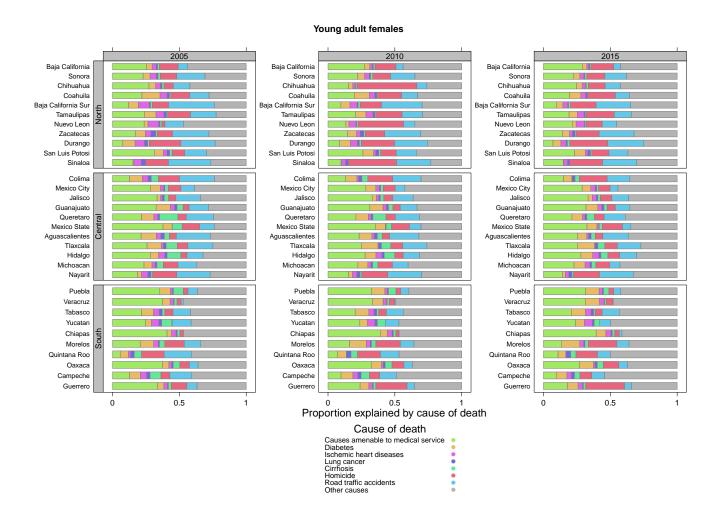


Figure 16: Proportion by cause of death from benchmark mortality for young adult males (ages 15-49). Source: own calculations.

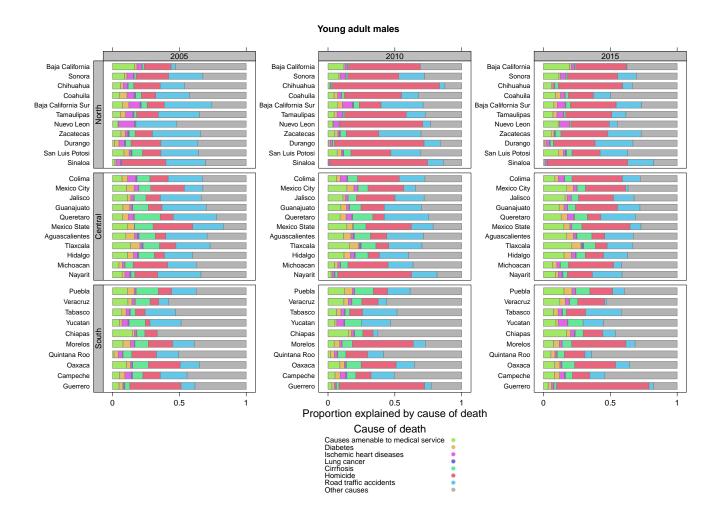


Figure 17: Proportion by cause of death from benchmark mortality for older male adults (ages 50-84). Source: own calculations.

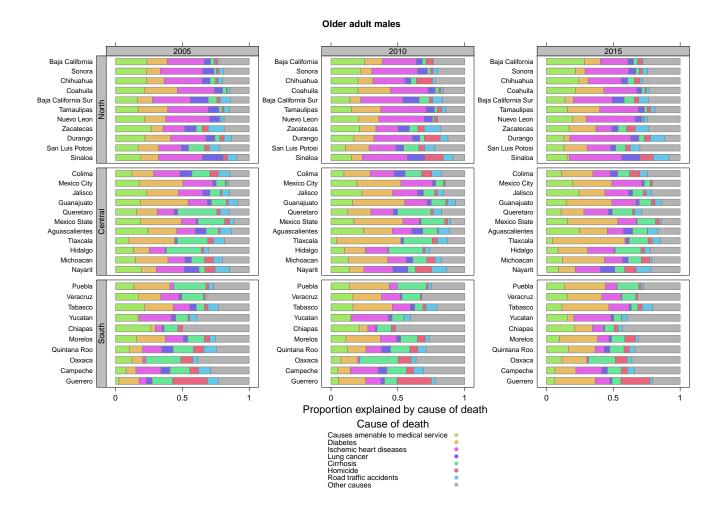


Figure 18: Proportion by cause of death from benchmark mortality for older female adults (ages 50-84). Source: own calculations.

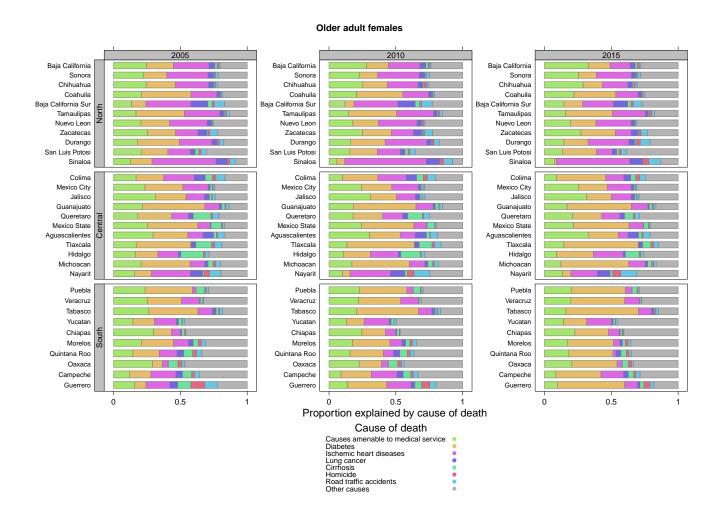


Figure 19: Suicide contribution to the gap with benchmark by age group for males Source: own calculations.

