Dissonant health transition in the states of Mexico, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013

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Summary

Background **Child and maternal health outcomes have notably improved in Mexico since 1990, whereas rising adult mortality rates defy traditional epidemiological transition models in which decreased death rates occur across all ages. These trends suggest Mexico is experiencing a more complex, dissonant health transition than historically observed. Enduring inequalities between states further emphasise the need for more detailed health assessments over time. The Global Burden of Diseases, Injuries, and Risk Factors Study 2013 (GBD 2013) provides the comprehensive, comparable framework through which such national and subnational analyses can occur. This study offers a state-level quantification of disease burden and risk factor attribution in Mexico for the first time.**

Methods **We extracted data from GBD 2013 to assess mortality, causes of death, years of life lost (YLLs), years lived with disability (YLDs), disability-adjusted life-years (DALYs), and healthy life expectancy (HALE) in Mexico and its 32 states, along with eight comparator countries in the Americas. States were grouped by Marginalisation Index scores to compare subnational burden along a socioeconomic dimension. We split extracted data by state and applied GBD methods to generate estimates of burden, and attributable burden due to behavioural, metabolic, and environmental or occupational risks. We present results for 306 causes, 2337 sequelae, and 79 risk factors.**

Findings **From 1990 to 2013, life expectancy from birth in Mexico increased by 3·4 years (95% uncertainty interval 3·1–3·8), from 72·1 years (71·8–72·3) to 75·5 years (75·3–75·7), and these gains were more pronounced in states with high marginalisation. Nationally, age-standardised death rates fell 13·3% (11·9–14·6%) since 1990, but state-level reductions for all-cause mortality varied and gaps between life expectancy and years lived in full health, as measured by HALE, widened in several states. Progress in women's life expectancy exceeded that of men, in whom negligible improvements were observed since 2000. For many states, this trend corresponded with rising YLL rates from interpersonal violence and chronic kidney disease. Nationally, age-standardised YLL rates for diarrhoeal diseases and protein-energy malnutrition markedly decreased, ranking Mexico well above comparator countries. However, amid Mexico's progress against communicable diseases, chronic kidney disease burden rapidly climbed, with age-standardised YLL and DALY rates increasing more than 130% by 2013. For women, DALY rates from breast cancer also increased since 1990, rising 12·1% (4·6–23·1%). In 2013, the leading five causes of DALYs were diabetes, ischaemic heart disease, chronic kidney disease, low back and neck pain, and depressive disorders; the latter three were not among the leading five causes in 1990, further underscoring Mexico's rapid epidemiological transition. Leading risk factors for disease burden in 1990, such as undernutrition, were replaced by high fasting plasma glucose and high body-mass index by 2013. Attributable burden due to dietary risks also increased, accounting for more than 10% of DALYs in 2013.**

Interpretation **Mexico achieved sizeable reductions in burden due to several causes, such as diarrhoeal diseases, and risks factors, such as undernutrition and poor sanitation, which were mainly associated with maternal and child health interventions. Yet rising adult mortality rates from chronic kidney disease, diabetes, cirrhosis, and, since 2000, interpersonal violence drove deteriorating health outcomes, particularly in men. Although state inequalities from communicable diseases narrowed over time, non-communicable diseases and injury burdens varied markedly at local levels. The dissonance with which Mexico and its 32 states are experiencing epidemiological transitions might**

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strain health-system responsiveness and performance, which stresses the importance of timely, evidence-informed health policies and programmes linked to the health needs of each state.

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Introduction

Between 1990 and 2013, under-5 mortality in Mexico decreased by 76%[1] and disease burden rates from maternal disorders fell by 56%.[2] Nonetheless, this progress masked subnational disparities, particularly in the country's poorest areas (eg, Chiapas and Oaxaca) and richest areas (eg, Mexico City and Nuevo Leon).[3,4] Based on a widely accepted paradigm for epidemiological transitions,[5–8] such advances in maternal and child health outcomes would also be accompanied by a reduction in all-cause adult mortality rates. Yet Mexico has experienced a very different trajectory, recording rising death rates from interpersonal violence and chronic kidney disease, as well as increasing burden due to diabetes and obesity.[3,9] These trends, in combination with health disparities found across states,[3,10] necessitate a more detailed assessment of Mexico's current health challenges, particularly as the trends appear to contradict historical epidemiological transitions.[5]

Several burden of disease studies have been done in Mexico,[3,11,12] which have guided policy agendas and programme implementation[10,13] and facilitated intervention prioritisation.[14] With Mexico's long history of using disease burden research to inform policy decisions,[3,15] continued analytic updates and expanding assessments to more local geographies are in high demand. In this study, we focus on results from 1990 to 2013 and Mexico's rapidly shifting disease burden at national and state levels. These shifts in disease burden are of particular relevance for policy, as states control health-care delivery and administration in Mexico.[16] This study comes at a time when decision makers are assessing policy options to address the country's growing burden of non-communicable diseases and violence.[17–19] Furthermore, comparison of Mexico's performance with that of other countries in the Americas is of particular interest,[20] because a better understanding of Mexico's changing health landscape could have implications for Latin America as a whole. The pace and patterns of Mexico's health transition pose unprecedented challenges, and stress the need for timely, rigorously analysed data on the levels and trends of disease burden.

The Global Burden of Diseases, Injuries, and Risk Factors Study 2013 (GBD 2013) provides improvements in data and methods from previous iterations of the GBD,[1,2,21–23] including substantial advances for risk factor quantification.[23] The subnational analysis reported here supports the mapping of disease burden to potential socioeconomic factors that underlie or affect burden and risks across 32 states in Mexico. Our study not only offers improved methods for measuring Mexico's health landscape, but also builds on previous work and strengthens its applications to current policy priorities.

Research in context

Evidence before this study
Health statistics are routinely collected in Mexico and these data informed previous burden of disease studies, including the Global Burden of Disease Study 2010 (GBD 2010) for Mexico. Yet health data are infrequently aggregated in a systematic manner, and the full range of diseases, injuries, and risk factors are not consistently captured for every state over time. Mexico has done several nationally representative surveys during the past two decades, but survey-based health indicators are often measured in different ways, and information included in each survey can vary considerably. Because of the country's range and heterogeneity of data sources, assembling these data in a comprehensive analytic framework that covers numerous causes and risks is likely to improve population health measurement in Mexico.

Added value of this study
For the first time to our knowledge, GBD results are assessed at the state level in Mexico, using a range of routine and published data sources and by indices of marginalisation. Comprehensive subnational comparisons within Mexico, and with comparator countries, provide new insights into health trends and determinants, as well as areas for heightened policy attention.

Implications of all the available evidence
Despite reductions in the burden from several communicable and child health conditions, burden rates from several non-communicable diseases and interpersonal violence increased in Mexico, particularly since 2000. These dissonant trends underlie minimal gains in life expectancy for men and are associated with increasing burden attributable to behavioural risk factors, such as high body-mass index and high fasting plasma glucose. The scale of non-communicable disease burden and related risks in Mexico point to a need for strong health policies and programmes focused on prevention. In tandem with more integrated models of service delivery, an emphasis on early detection and prevention of non-communicable diseases might help alter the course of Mexico's growing epidemic of non-communicable diseases and related disability. Further, in states where mortality and health loss from interpersonal violence increased, locally led efforts to reduce access to firearms and address environmental factors associated with heightened risk for violence are of high priority.

Methods

Overview

We used data from GBD 2013 for 306 causes of death, disease, injury incidence and prevalence, and years lived with disability (YLDs) to measure the burden of diseases and injuries in Mexico and in the 32 states in Mexico from 1990 to 2013. Additional details on the GBD 2013 cause framework and analyses are provided elsewhere.[1,2,21–23] Unless indicated otherwise, we report results in terms of age-standardised rates, as derived from world population standards,[21] and provide 95% uncertainty intervals (UIs), which capture efforts to propagate levels of uncertainty throughout the GBD modelling process.

Here we focus on specific data and analyses used to quantify mortality, years of life lost (YLLs), YLDs, disability-adjusted life-years (DALYs), and healthy life expectancy (HALE) in Mexico. Additional findings from GBD 2013 are in the appendix, and can be explored online with dynamic data visualisations.

Categorisation of Mexican states and comparator countries

We used seven national population censuses and national and state-level records on all-cause mortality derived from Mexico's national vital registration systems. Vital registration data were available from 1980 to 2013; however, we present results between 1990 and 2013 to align with the rest of GBD 2013. Additional detail on the full range of data sources can be found in the appendix (p 1).

To enable comparisons along a socioeconomic dimension, we categorised states by Marginalisation Index scores from the Consejo Nacional de Población.[24] The Marginalisation Index is a composite indicator based on educational attainment, housing conditions, development, and economic status. States were grouped into three categories based on index scores: very high and high, medium, and low and very low; additional details can be found in the appendix (pp 36–38).

We selected eight comparator countries to benchmark national and state-level health performance in Mexico: the USA, which represented potential similarities in health burdens to Mexican states along its border; and seven Latin American countries, five with similar demographic, economic, cultural, or social conditions to those in Mexico (Brazil, Chile, Colombia, Cuba, and Costa Rica) and two Central American countries (El Salvador and Guatemala), which share social profiles of southern Mexican states.

All-cause mortality and cause of death

Details on GBD 2013 estimation methods for all-cause mortality have been reported previously.[21,25] Briefly, we analysed under-5 and adult mortality rates with a multistage synthesis of all available data from surveys, censuses, sample registrations, and vital registration systems.[1]

As described previously,[21,26] an expanded cause-of-death database was constructed for GBD 2013. To generate cause-specific mortality rate estimates, we analysed state-level vital registration data from 1980 to 2013. We sought to account for vital registration data quality and completeness, which included adjustment of cause-of-death data from incomplete registration systems and standardisation of data to align with cause classifications and GBD cause hierarchies.[21] We then systematically identified causes of death that could not or should not be classified as underlying causes of death (so-called garbage codes), and applied standard GBD 2013 garbage-code redistribution algorithms.[21,26] We modelled causes of death using the Cause of Death Ensemble model (CODEm),[25] which uses an array of models, different measures of mortality, and varying combinations of covariates from a database containing more than 200 diverse country characteristics. The final ensemble model composition is determined by various tests of performance, including out-of-sample performance.

For **additional GBD 2013 data** see http://vizhub.healthdata.org/gbd-compare

See **Online** for appendix

Based on standard GBD methods,[21] we computed YLLs by multiplying the number of deaths from each cause in each age group by the reference life expectancy at the average of age of death in those who died in the age group. This reference life table has a life expectancy at birth of 86·0 years; from this reference table, we computed YLLs for each age group based on reference life expectancies for each respective age group.

Incidence, prevalence, and YLDs

Data sources used for quantifying non-fatal outcomes in Mexico are detailed in the appendix (p 1). We used DisMod-MR 2.0, an updated Bayesian-regression analytic tool,[22] to synthesise consistent estimates of disease incidence, prevalence, remission, excess mortality, and cause-specific mortality rates. Following GBD 2013 methods,[22] prevalence of each sequela was multiplied by the disability weight for the corresponding health state to calculate YLDs for the sequela. The sum of all YLDs for relevant sequelae equated to overall YLDs for each disease. Details on disability weights for GBD 2013, including data collection and disability weight construction, have been described previously.[27]

DALYs, HALE, and attributable risks

Following GBD 2013 methods,[2] national-level and state-level DALYs were computed by summing YLLs and YLDs for each cause, age, and sex in 1990, 1995, 2000, 2005, 2010, and 2013. HALE was calculated for Mexico and each state using multiple-decrement life tables and estimated YLDs per person.[2]

To calculate risk-attributable fractions of disease burden by cause, we modelled the effects of risk exposure levels, documented relative risks associated with risk exposure and specific health outcomes, and computed counterfactual levels of risk exposure on estimates of national and state-level deaths, YLLs, YLDs, and DALYs.

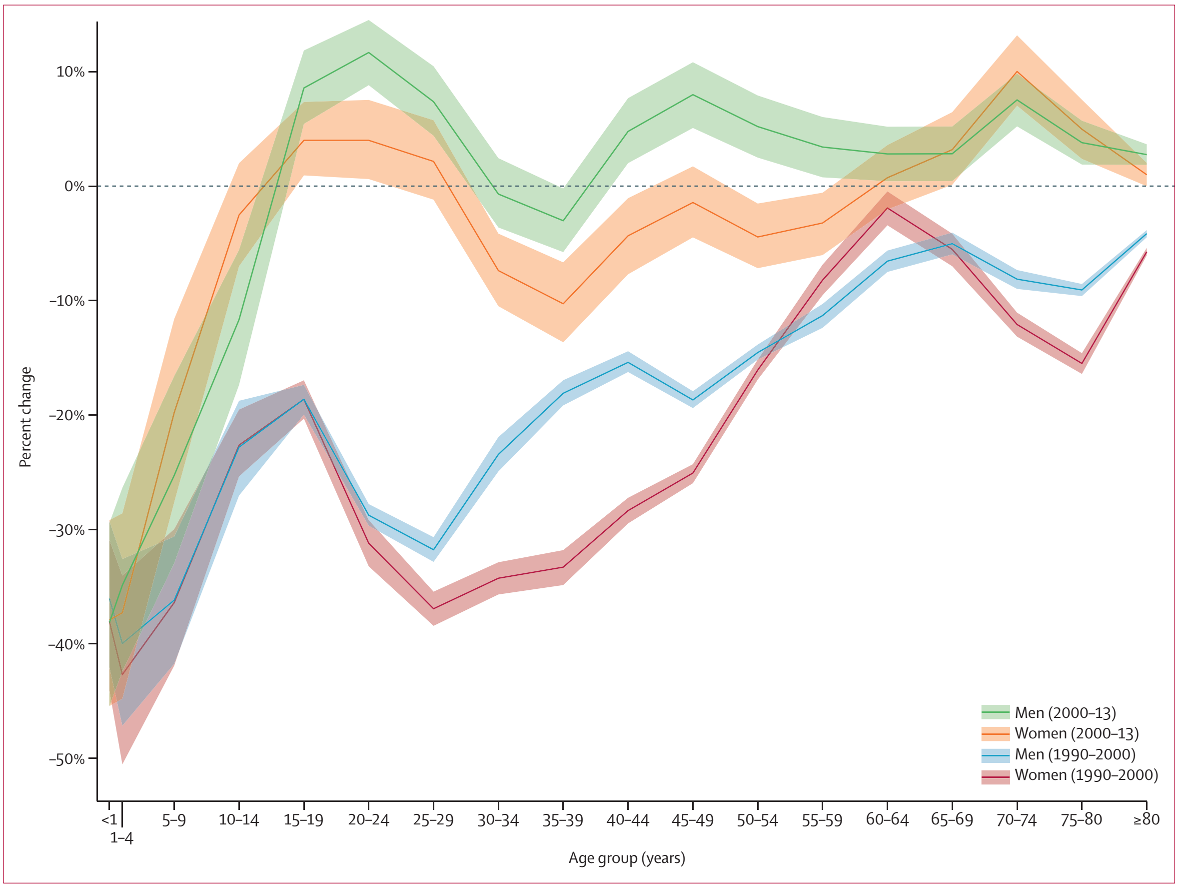


***Figure 1*: Percent change in all-cause mortality rates in Mexico by sex and age group in 1990–2000 and 2000–2013**
95% uncertainty intervals (UIs), as shown by shaded portions of the trend line, are derived from 1000 draws for each measure of all-cause mortality.

Detailed descriptions of the GBD 2013 methods for risk factor assessment and attribution are published elsewhere.[23]

Decomposition of variance and epidemiological transition

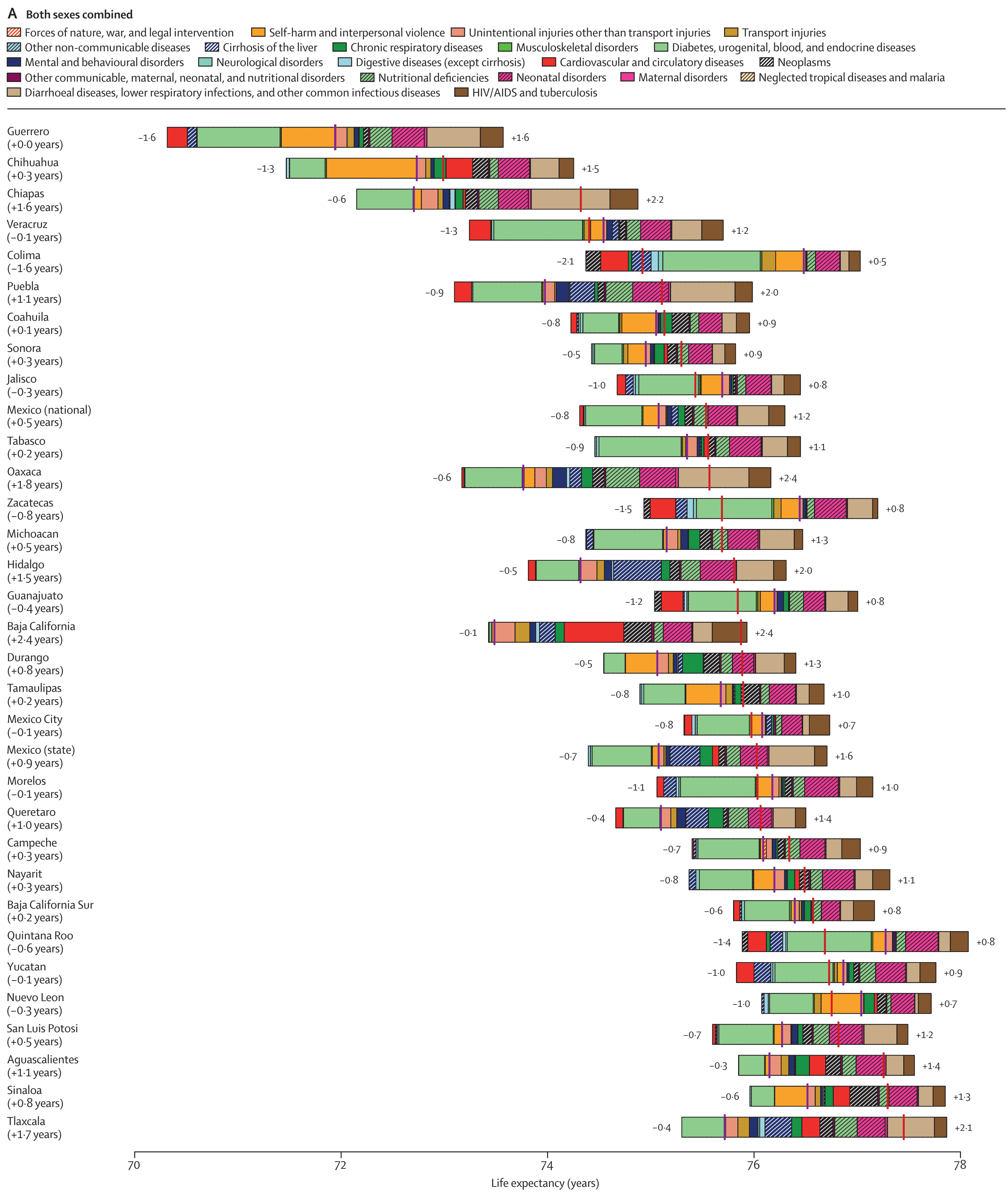
As an expanded analysis for GBD 2013,[2] we compared estimates of observed disease burden with expected burden, or a country's anticipated burden based on its development status. We constructed this summary measure using principal component analysis of four indicators: income per capita, average years of schooling in populations older than 15 years, total fertility rate, and mean population age.[2] Low total fertility rate and high income per capita, educational attainment, and mean population age corresponded with higher sociodemographic status, whereas high total fertility rate and low income per capita, educational attainment, and mean population age corresponded with low sociodemographic status. We then used a hierarchical regression to decompose variance in log DALY rates into components related to this sociodemographic status indicator, intercountry variation, year, and residual variance that could not be fully explained by the aforementioned variables. Results from this regression were then used to predict burden patterns as a function of sociodemographic status, which was binned into 20 equal intervals. These sociodemographic status-predicted estimates subsequently served as an indicator of expected burden.

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility to submit for publication.

Results

Between 1990 and 2000, under-5 death rates in Mexico fell by 39·2% (95% UI 32·2–45·3%), and a similar rate of reduction continued from 2000 to 2013 (38·5% [29·9–45·7%]; figure 1). Death rates in people aged 15–49 years decreased by 23·5% (22·4–24·6%) for women and by 18·8% (18·0–19·6%) for men from 1990 to 2000. However, death rates in adult men increased across age groups from 2000–13, diverging from anticipated trends given continued reductions in



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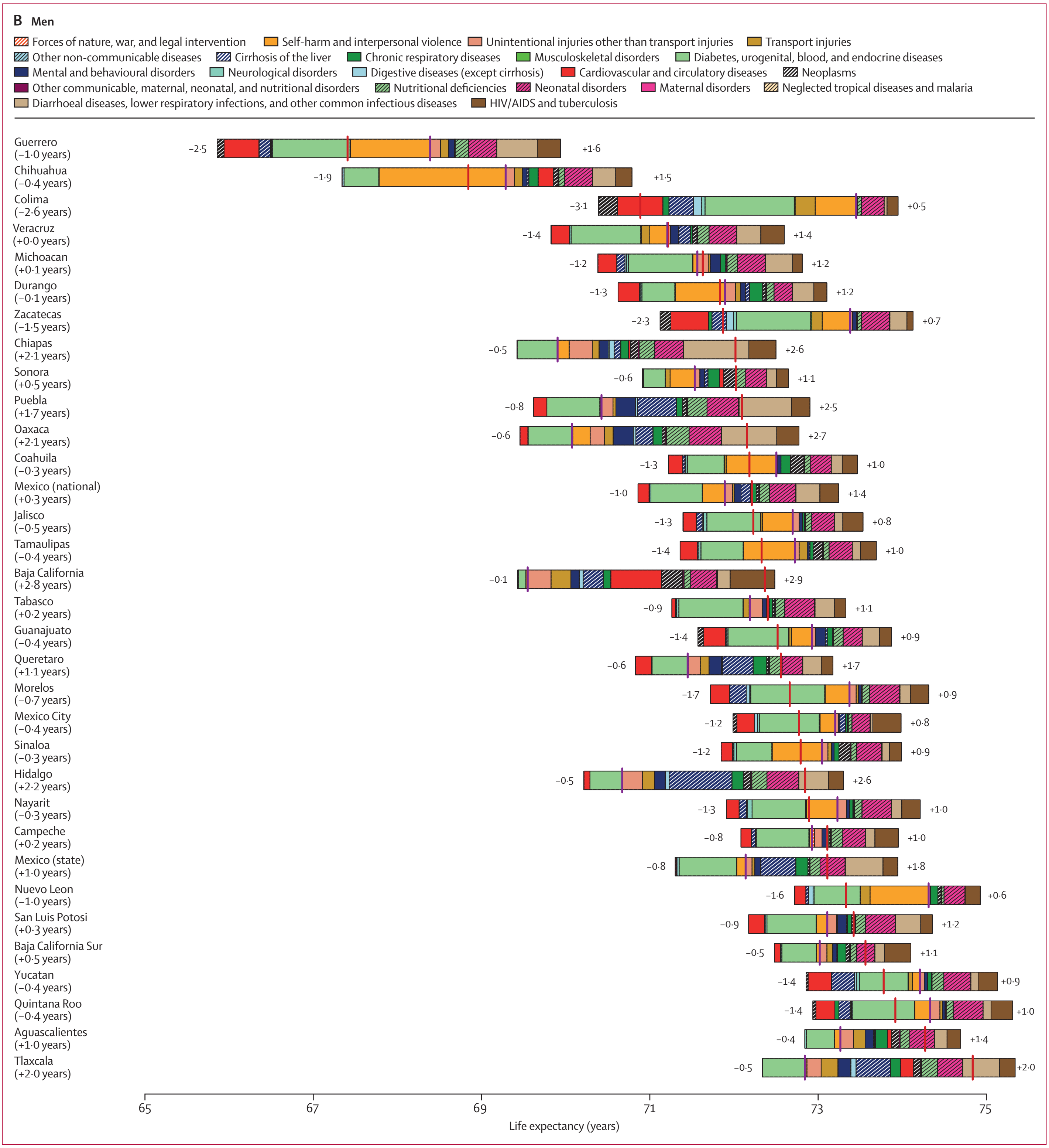

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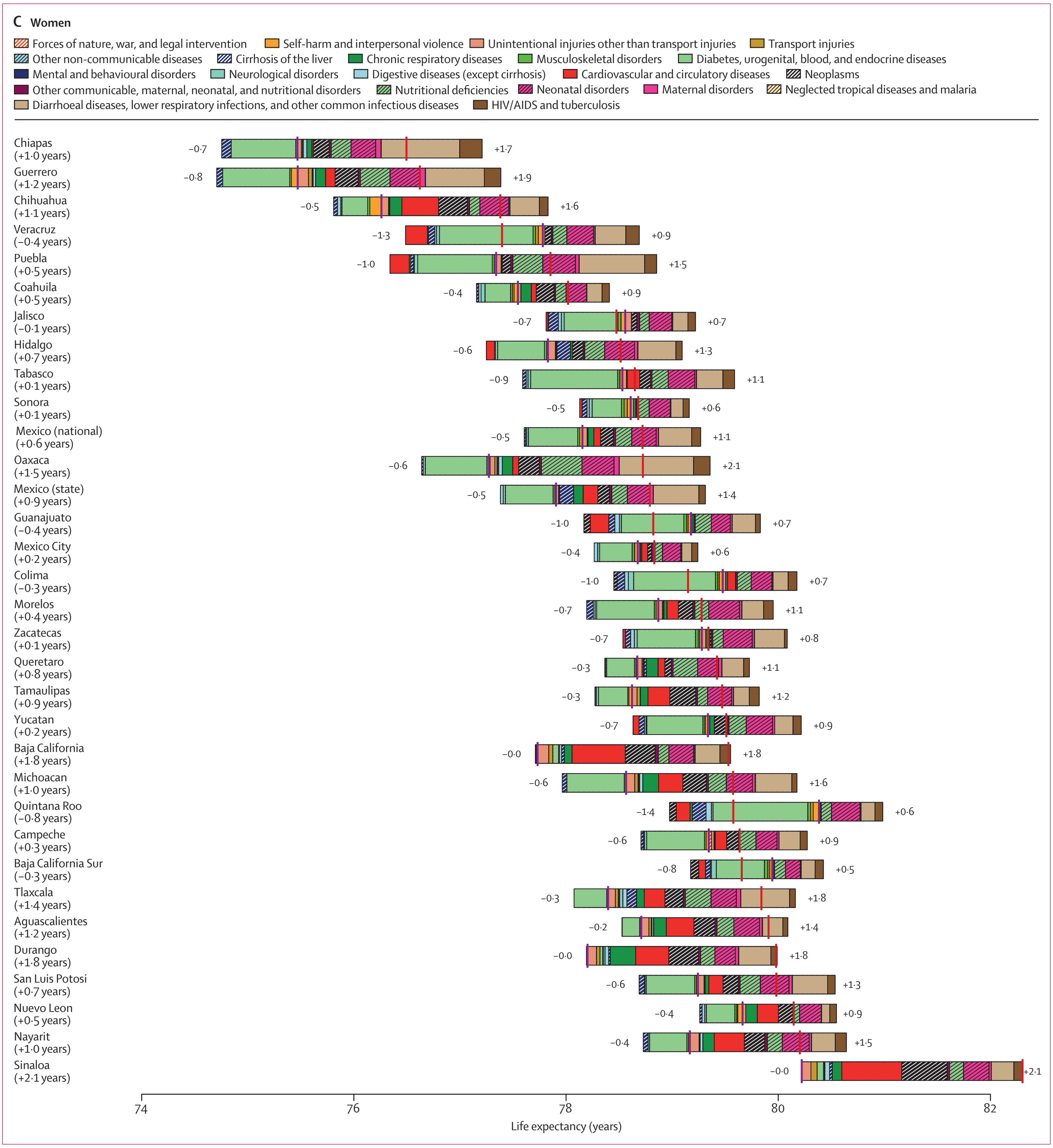

***Figure 2:* Life expectancy at birth in Mexico and Mexican states from 2000 to 2013 by GBD Level 2 cause group**
(A) Both sexes combined. (B) Men. (C) Women. Mexico and Mexican states are ordered from the lowest to highest life expectancy in 2013. Purple bars indicate life expectancy at birth in 2000 and red bars indicate life expectancy at birth in 2013. Causes to the left of the 2000 life expectancy values reflect causes that contributed to reduced life expectancy between 2000 and 2013. Causes to the right of the 2000 life expectancy values reflect causes that contributed to increased life expectancy between 2000 and 2013. The overall change in life expectancy between 2000 and 2013 are shown in parentheses under each geography. GBD=Global Burden of Disease.

under-5 death rates. Although the mortality rate for adult women declined more slowly from 2000 to 2013 than from 1990 to 2000, age-specific death rates in women generally improved more than death rates in men at equivalent ages.

Nationally, age-standardised death rates decreased by 13·3% (95% UI 11·9–14·6%) between 1990 and 2013 (appendix p 17), falling from 848·6 deaths per 100 000 people (842·6–855·2) in 1990 to 736·2 deaths per 100 000 people (726·2–745·6) in 2013. State-level reductions in all-cause mortality varied from 6·3% (1·2–12·9%) in Guerrero to 25·1% (22·9–27·5%) in Oaxaca. Oaxaca and Hidalgo, states with high marginalisation, recorded faster rates of decline in all-cause mortality than the national average. However, Guerrero, also highly marginalised, reported minimal progress since 1990. In fact, death rates in Guerrero increased by 9·2% (1·1–17·0%) since 2005, rising to 906·9 deaths per 100 000 people (850·2–968·5) in 2013.

Between 1990 and 2013, a 3·4-year (3·1–3·8) increase in life expectancy from birth was recorded in Mexico, rising from 72·1 years (71·8–72·3) to 75·5 years (75·3–75·7; appendix p 17). Whereas female life expectancy gradually increased from 75·3 years (75·0–75·7) in 1990 to 78·7 years (78·4–79·0) in 2013, male life expectancy improved at a slower pace, particularly since 2000 (ie, 71·9 years in 2000 [71·6–72·1] to 72·2 years in 2013 [71·9–72·5]). Several states with high or very high marginalisation had the largest increases in life expectancy. In Oaxaca, for example, life expectancy increased from 69·3 years (68·8–69·7) in 1990 to 75·5 years (75·1–76·0) in 2013. Quintana Roo recorded the smallest improvement, only rising from 75·2 years (74·8–75·6) in 1990 to 76·7 years (76·1–77·2) in 2013. In 1990, a 6·2-year gap existed between states with the lowest and highest life expectancies; by 2013, this state longevity gap narrowed to 5·5 years (appendix p 17).

HALE, which reflects years spent in full health, rose from 63·0 years (60·3–65·4) in 1990 to 65·8 years (63·1–68·3) in 2013. Nationally, the difference between life expectancy and HALE was 9·1 years in 1990 and 9·7 years in 2013, though this difference was not statistically significant. In Quintana Roo the gap between life expectancy and HALE decreased from 10·4 years in 1990 to 10·2 years in 2013. All other states recorded minimal changes or widening disparities, with Oaxaca experiencing the largest increase in the gap between life expectancy and HALE (8·6 years in 1990 to 9·9 years in 2013).

Between 2000 and 2013, 15 of 32 states had life expectancy gains in men and 26 of 32 states had increased longevity in women (figure 2). In Guerrero, life expectancy in men decreased by 1·0 year (95% UI 0·6–2·7) whereas female life expectancy increased from 75·5 years (74·6–76·2) in 2000 to 76·6 years (75·5–77·9) in 2013. For both sexes combined in Guerrero, rising mortality due to interpersonal violence and chronic kidney disease were the main drivers of minimal life expectancy gains; mortality rates from interpersonal violence increased by 49·4% (8·3–80·6%) and mortality rates from chronic kidney disease increased by 74·6% (54·8–95·2%), from 2000 to 2013. A similar trend was found in 17 states, whereby negligible improvements in male life expectancy occurred in tandem with rising mortality from interpersonal violence, chronic kidney disease, ischaemic heart disease, and cirrhosis. In some states, such as Nuevo Leon and Zacatecas, a growing death toll from transport injuries contributed to minimal gains for male life expectancy. Increased mortality due to self-harm also accounted for reduced male life expectancy in Yucatan and Quintana Roo. In several states, such as Jalisco, increased mortality rates from breast and colon and rectum cancers negatively affected life expectancy for both sexes. Conversely, reductions in maternal mortality contributed to improved female life expectancy in Oaxaca, Tlaxcala, and Queretaro.

Considerable state-level heterogeneity was observed for several causes (appendix pp 3–6). Age-standardised YLL rates from breast cancer and ischaemic heart disease followed similar geographical patterns in 2013, with northern states recording higher YLL rates than southern states. Nonetheless, several states showed contradictory trends, particularly for breast cancer. For instance, some of Mexico's highest age-standardised YLL rates due to breast cancer were found in Jalisco and Mexico City (385·6 per 100 000 people [95% UI 342·9–433·4] in Jalisco and 374·8 per 100 000 people [338·9–415·6] in Mexico City). A number of states in central Mexico had the highest age-standardised YLL rates from chronic kidney disease, which formed a geographical cluster of areas with high YLL rates due to the condition from the Pacific Coast to the Gulf of Mexico. YLL rates from cirrhosis followed dissimilar geographical patterns to ischaemic heart disease, with northern states experiencing lower YLL rates due to cirrhosis than southern and southeastern states.

Notable differences were found between states with the lowest and highest age-standardised YLL rates in 2013.

***Figure 3:* Age-standardised YLL rates per 100 000 for Mexico relative to Mexican states, the USA, and seven comparator Latin American countries for both sexes combined in 2013**
Geographies are ordered by age-standardised YLL rates due to all causes and for both sexes in 2013, from lowest to highest. The causes shown are the leading 25 causes of YLLs in Mexico. To facilitate comparison, Mexico and comparator countries are shown in bold. For illustrative purposes only, Mexican states have been included where they would rank if they were individual countries; this is not to suggest that the health system in a given Mexican state is equivalent to that of any of the countries to which it is adjacent in the list. Rates are colour-coded to denote statistically significant differences from Mexico's national mean. Green indicates significantly lower age-standardised YLL rates than Mexico, red indicates significantly higher age-standardised YLL rates than Mexico, and yellow indicates age-standardised YLL rates are statistically indistinguishable from Mexico's national mean. Alzheimer's disease=Alzheimer's disease and other dementias. Cirrhosis alcohol=cirrhosis of the liver due to alcohol use. Cirrhosis hepatitis C=cirrhosis of the liver due to hepatitis C. Cirrhosis other=cirrhosis of the liver due to other causes. COPD=chronic obstructive pulmonary disease. Foreign body=pulmonary aspiration and foreign body in airway, and foreign body in other body part. YLLs=years of life lost.

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	Ischaemic heart disease	Chronic kidney disease	Diabetes	Interpersonal violence	Road injuries	Congenital anomalies	Lower respiratory infections	Cerebrovascular disease	Cirrhosis alcohol	Neonatal preterm birth	COPD	Cirrhosis hepatitis C	Self-harm	Neonatal encephalopathy	Neonatal sepsis	Alzheimer's disease	Protein-energy malnutrition	Leukaemia	Foreign body	Diarrhoeal diseases	Cirrhosis other	Other neoplasms	Drowning	Stomach cancer	Falls
Costa Rica	1331·4	503·2	192·6	360·5	643·8	665·9	286·0	523·3	202·7	289·5	365·7	169·0	303·1	109·6	50·6	264·9	20·0	159·8	42·6	67·1	65·8	186·0	168·9	372·5	106·6
Chile	999·8	309·1	269·5	235·4	555·9	507·9	423·7	873·3	223·6	213·2	298·5	262·6	522·6	51·5	38·8	394·7	38·0	125·9	48·4	26·6	62·3	213·2	131·6	398·5	105·2
USA	1696·6	228·7	310·0	284·6	614·5	299·6	268·3	456·5	114·2	259·4	471·8	179·1	511·7	62·7	30·6	422·1	10·1	126·7	64·4	30·0	20·1	150·7	78·3	74·2	106·1
Cuba	2094·5	280·7	240·0	239·3	397·4	351·9	538·7	1030·8	111·5	90·2	335·7	69·2	416·7	85·5	67·4	265·1	10·7	128·0	42·8	40·4	41·6	194·0	120·8	112·7	196·5
Sinaloa	1783·2	849·1	992·5	1563·6	969·7	680·3	395·3	636·3	233·0	315·0	504·5	170·2	156·2	116·9	132·5	285·5	127·1	133·0	107·0	91·2	70·3	158·2	190·9	173·8	137·7
Tlaxcala	936·5	1597·0	1258·3	300·6	826·4	750·7	558·2	664·5	526·1	496·1	480·5	425·6	154·6	208·1	217·5	271·9	220·3	165·0	193·0	167·6	179·7	151·8	104·4	130·2	176·8
Aguascalientes	1236·2	1249·5	1097·5	257·0	934·4	859·0	357·0	658·7	356·0	439·6	685·3	261·0	239·2	177·7	194·4	283·0	172·4	174·2	222·3	156·2	119·3	187·9	143·6	149·9	191·4
Yucatan	1690·6	948·5	1034·6	153·8	814·1	664·3	576·6	820·8	733·8	216·0	376·3	606·5	423·3	159·9	154·8	278·1	182·2	172·0	139·4	167·6	244·2	157·8	99·8	210·9	143·4
Nuevo Leon	2028·9	1191·4	975·0	824·5	804·7	754·0	593·7	762·5	312·8	315·0	435·7	246·2	287·7	107·2	121·2	274·7	91·9	171·5	194·8	79·9	105·0	165·0	111·1	154·6	161·4
Quintana Roo	1380·0	1047·9	1235·4	548·9	854·4	643·5	423·6	714·5	573·6	312·6	494·0	459·5	439·4	220·8	195·8	293·2	163·6	148·3	231·1	140·7	176·3	140·0	192·3	203·7	185·5
Baja California Sur	1975·0	1058·7	1141·4	345·1	1078·5	712·5	358·0	664·6	340·2	360·4	432·5	250·3	332·3	134·8	148·0	289·4	165·9	168·9	162·6	115·4	109·9	179·0	162·9	197·2	142·5
San Luis Potosi	1438·0	1083·2	1077·1	586·3	866·6	904·0	585·0	719·5	400·7	382·7	548·4	304·5	262·5	221·0	185·0	286·7	199·9	146·2	139·8	164·2	126·4	162·6	163·2	171·2	171·7
Campeche	1563·8	1043·7	1210·2	467·5	828·5	700·6	429·0	749·1	584·6	398·8	476·0	485·0	420·5	267·7	205·4	287·7	195·6	177·5	148·3	154·3	189·8	162·4	227·4	238·0	162·0
Nayarit	1567·0	1046·8	1073·4	1058·8	1050·3	884·6	462·6	681·3	352·0	437·0	563·4	269·0	182·3	229·0	179·1	290·2	167·3	151·5	138·8	139·3	101·1	181·9	174·0	177·0	163·9
Queretaro	1528·7	1387·7	1129·9	352·4	1086·0	776·4	454·5	755·2	750·7	325·7	539·7	541·2	227·0	149·7	199·4	291·8	219·7	150·5	189·6	170·0	243·5	163·3	148·9	157·7	190·9
Morelos	1396·8	1425·3	1329·8	1056·3	728·6	686·0	407·9	714·1	596·1	327·8	543·4	479·5	187·9	147·4	220·2	287·9	228·2	154·6	147·9	144·0	185·6	156·5	128·6	212·5	185·5
Mexico City	1778·8	1430·5	1409·4	651·9	680·4	754·6	785·2	720·5	468·9	423·5	483·6	367·7	264·4	137·8	222·3	280·3	78·5	168·9	122·4	101·7	153·6	168·0	66·2	184·2	141·5
Guanajuato	1503·2	1651·6	1418·2	508·0	1097·5	737·9	558·9	760·5	483·6	424·1	602·9	363·5	266·5	169·0	201·2	282·0	213·2	151·0	131·3	146·9	160·0	162·7	148·9	174·5	153·5
Mexico (state)	1323·9	1591·5	1394·5	879·7	788·5	786·3	930·7	690·8	600·3	463·5	553·8	458·9	171·8	187·1	267·2	283·6	169·7	144·3	171·3	177·9	184·9	151·9	101·6	161·6	156·2
Baja California	2040·5	1031·7	1238·4	930·2	756·0	729·1	673·2	826·1	427·5	378·0	450·7	325·9	191·1	163·0	152·4	289·7	105·5	153·5	318·0	98·6	125·5	167·5	169·1	179·1	188·5
Tamaulipas	2071·5	1322·0	1287·7	1102·2	935·1	746·1	447·6	772·9	348·3	450·1	497·1	267·7	285·1	162·0	167·8	284·9	142·9	149·9	142·5	95·5	108·6	168·7	248·3	159·2	129·6
Hidalgo	1572·6	1399·4	1092·3	406·6	910·7	809·7	569·2	799·2	704·8	524·2	561·5	533·9	175·7	287·2	256·8	288·4	262·4	162·7	254·8	158·0	227·8	162·1	189·5	178·6	210·4
Colombia	1879·5	363·1	449·6	2294·4	886·2	684·1	654·3	1020·9	97·7	415·6	711·4	105·0	322·8	206·8	137·8	275·9	189·7	190·9	137·6	173·7	41·3	196·3	211·3	384·6	141·0
Zacatecas	1575·7	1187·5	1183·5	682·6	1319·1	703·0	644·1	840·1	322·4	420·7	710·7	240·0	210·4	232·1	205·9	290·5	214·4	163·8	201·1	150·5	100·6	166·8	143·6	219·2	202·6
Tabasco	1561·0	1526·3	1489·6	414·4	1100·3	777·4	429·7	851·6	401·0	352·1	536·2	308·8	449·4	301·2	224·3	287·7	217·5	178·0	132·8	159·4	130·1	170·2	317·0	189·1	160·2
Michoacan	1432·5	1342·2	1363·0	1012·1	1038·9	810·0	567·0	741·1	477·8	549·5	610·3	331·0	217·8	210·0	216·7	288·4	205·1	159·6	202·4	165·4	159·2	171·9	153·1	185·8	175·4
Mexico (national)	1651·5	1386·9	1301·4	869·1	892·7	788·5	672·3	772·2	524·7	449·0	547·4	400·5	245·9	203·7	212·4	287·7	204·3	162·4	172·5	172·6	169·4	168·3	151·4	190·9	170·3
Durango	1857·9	1124·2	1097·3	1387·6	985·2	1015·8	559·2	668·7	283·5	766·4	609·6	208·1	215·9	291·6	184·2	283·4	152·8	169·1	228·3	143·2	85·9	168·3	160·7	152·4	183·3
Jalisco	1589·1	1393·7	1221·2	742·7	1100·6	843·9	696·7	738·6	502·0	427·3	644·8	371·1	301·1	137·7	196·7	294·7	179·9	176·7	174·1	122·3	173·2	194·3	161·1	177·4	174·0
Oaxaca	1310·9	1306·1	1098·9	988·1	741·3	831·1	646·5	812·2	673·5	469·1	476·1	502·3	174·7	300·9	238·6	296·8	433·4	146·1	144·5	326·8	216·8	155·3	123·5	222·3	149·8
Sonora	2372·0	984·5	1182·5	803·1	1139·4	742·5	622·7	738·2	314·9	492·3	565·0	241·5	323·0	195·8	175·3	292·6	194·5	163·3	169·0	142·3	97·3	178·3	201·4	219·5	145·0
Coahuila	2133·9	1496·3	1459·1	906·1	913·6	749·0	510·7	879·8	377·6	528·1	494·1	277·3	307·0	181·7	199·1	294·2	139·9	161·6	183·9	121·8	125·1	182·4	138·1	163·7	170·1
Colima	1780·9	1435·1	1375·6	920·6	1115·3	738·6	364·0	777·3	633·9	294·6	561·3	422·9	289·5	118·9	136·3	299·9	240·3	160·0	146·1	158·0	184·4	181·5	232·8	198·7	200·1
Brazil	1894·6	366·0	594·9	1259·7	1026·3	653·4	850·8	1455·9	205·2	606·1	579·2	174·2	343·3	288·8	308·2	284·6	114·6	119·0	100·8	147·3	88·7	170·9	194·3	230·6	170·4
Puebla	1310·6	1684·3	1396·7	511·5	904·4	879·9	867·9	774·0	773·6	549·4	547·1	620·1	194·8	271·4	247·7	293·1	292·5	173·2	164·3	207·6	264·8	167·7	130·4	173·6	175·6
Veracruz	1694·1	1580·4	1443·6	677·4	802·8	864·5	579·0	941·4	744·3	500·4	557·3	521·9	281·7	251·7	204·4	289·3	301·3	187·5	142·8	166·4	233·0	169·7	226·1	211·1	179·8
Chiapas	1565·2	1366·8	1326·8	529·5	696·8	659·5	963·1	802·5	652·1	400·8	574·4	565·2	189·2	288·2	237·9	298·8	331·1	183·8	177·8	494·5	230·1	189·9	185·6	351·0	191·6
El Salvador	2082·4	1277·0	779·6	3411·9	1395·0	768·7	1041·7	691·6	296·8	366·4	460·6	279·7	464·8	110·9	149·0	276·6	151·0	148·4	44·4	169·3	127·7	114·5	185·6	394·7	178·7
Chihuahua	2385·7	1217·2	1396·2	2656·6	1097·4	674·9	708·0	843·0	443·4	510·5	646·1	325·5	349·6	165·9	175·8	291·6	177·3	156·5	246·6	140·9	139·4	188·0	151·9	205·7	221·4
Guatemala	1519·7	702·0	1115·6	2272·5	535·4	471·7	2684·8	776·7	466·5	628·1	445·6	413·4	573·0	245·6	233·6	285·5	929·7	180·2	211·9	1044·4	222·0	139·9	187·9	530·0	107·3
Guerrero	1873·6	1633·8	1707·1	2785·5	980·1	1089·5	707·0	1023·7	574·6	634·6	639·1	459·6	205·5	371·7	304·2	298·2	376·7	174·8	204·3	349·7	183·4	169·9	164·9	310·0	277·3

Significantly lower than the national average in Mexico · Indistinguishable from the national average in Mexico · Significantly higher than the national average in Mexico

For ischaemic heart disease, Tlaxcala's age-standardised YLL rate—the lowest in Mexico in 2013—was 2·5 times lower than Chihuahua's, which was the highest (936·5 per 100 000 people [788·7–1023·6] and 2385·7 per 100 000 people [2145·2–2684·0], respectively; appendix p 5). State-level disparities were even larger for YLL rates from cirrhosis, with a 3·5-fold difference between the lowest YLL rates (Sinaloa; 487·0 per 100 000 people [444·1–536·3]) and the highest YLL rates (Puebla; 1713·9 per 100 000 people [1617·6–1811·8]). Age-standardised YLL rates due to breast cancer ranged from 161·3 per 100 000 people (143·8–183·3) in Oaxaca to 410·8 per 100 000 people (350·3–483·5) in Baja California Sur (appendix p 6). Notably, states with low marginalisation generally had higher YLL rates due to breast cancer (eg, Jalisco, Colima, and Mexico City).

By comparison with the eight comparator countries, Mexico had significantly higher age-standardised YLL rates from chronic kidney disease, cirrhosis due to alcohol use, and diabetes in 2013 (figure 3). Conversely, several Latin American countries recorded significantly higher age-standardised YLL rates due to interpersonal violence (El Salvador, Colombia, Guatemala, and Brazil) than Mexico. YLL rates from road injuries and lower respiratory infections were significantly higher in El Salvador, Guatemala, and Brazil than in Mexico (figure 3). A number of states with lower marginalisation scores, such as Sonora and Coahuila, recorded higher age-standardised YLL rates due to ischaemic heart disease. Some states, such as Guerrero, Chihuahua, and Durango, had significantly higher age-standardised YLL rates from congenital disorders, preterm birth complications, ischaemic heart disease, cirrhosis due to alcohol use, and interpersonal violence than the national average. The health profiles of these states more closely resembled the profiles of Guatemala and El Salvador than the national average in Mexico. Other states, such as Yucatan and Tlaxcala, had significantly lower YLL rates due to interpersonal violence, chronic obstructive pulmonary disease, and several communicable conditions; their health profiles were more similar to the profiles of Cuba, Chile, and Costa Rica (figure 3). In combination, these results show diversity in health outcomes across states.

Diarrhoeal disease burden substantially declined since 1990 (appendix pp 22, 31), including a 90·3% reduction in YLL rates (95% UI 89·0–91·6%). Age-standardised YLL rates due to road injuries decreased by 28·0% (20·8–30·9%), while YLD rates from road injuries fell by more than 50%. By contrast, age-standardised YLL rates and DALY rates due to chronic kidney disease sharply increased by 2013; YLL rates rose by 180·3% (80·0–191·8%) and DALY rates climbed by 135·9% (64·8–150·9%) since 1990. Whereas mortality indicators changed minimally for ischaemic heart disease, age-standardised YLD rates for ischaemic heart disease increased by 104·0% (85·2–124·6%). A similar trend was observed for diabetes, with negligible changes in age-standardised death rates and YLL rates, whereas age-standardised YLD rates rose by 48·0% (39·1–57·9%). Although age-standardised YLL and YLD rates from breast cancer and colon and rectum cancer increased between 1990 and 2013, age-standardised YLD rates, particularly from breast cancer, rose at a faster rate than YLLs.

Tracking shifts in cause-specific DALYs further illustrates Mexico's rapid health transition from 1990 to 2000, and the continued rise of non-communicable disease burden from 2000 to 2013 (appendix p 14). Nationally, age-standardised DALY rates from diarrhoeal diseases fell during both time periods, decreasing by 71·1% (65·6–71·6%) from 1990 to 2000 and 52·0% (45·9–57·5%) from 2000 to 2013. Similar trends were found for lower respiratory infections and preterm birth complications. Diarrhoeal diseases, lower respiratory infections, and preterm birth complications were the leading three causes of DALYs in 1990; by 2013, all three fell below the leading ten causes of disease burden. Since 1990, age-standardised DALY rates due to protein-energy malnutrition decreased by 63·5% (52·4–66·9%) and DALY rates from iron-deficiency anaemia declined by 27·9% (24·8–35·0%). By contrast, age-standardised DALY rates from chronic kidney disease increased by 54·8% (11·5–57·1%) from 1990 to 2000 and by 48·3% (38·2–55·2%) from 2000 to 2013. Notably, age-standardised DALY rates from interpersonal violence decreased by 39·3% (19·6–42·1%) between 1990 and 2000, but increased by 43·8% (4·8–51·6%) from 2000 to 2013. In absolute terms, DALY rates due to depressive disorders, as well as low back and neck pain, did not substantially change since 1990. In 2013, diabetes, ischaemic heart disease, and chronic kidney disease were the leading causes of burden in Mexico, accounting for 19·2% of total DALYs.

Observed and expected levels of burden, based on sociodemographic status alone, as measured by age-standardised YLL and YLD rates from broad cause categories in 1990, 2000, and 2013 are shown in figure 4. Observed age-standardised YLL rates decreased in Mexico, particularly between 1990 and 2000, bringing overall YLLs closer to expected rates given the country's sociodemographic status. From 1990 to 2013, the main discrepancies between observed and expected YLL rates were found for two cause groups in Mexico: cardiovascular and circulatory diseases, and diabetes, urogenital, blood, and endocrine diseases. Based on sociodemographic status alone, Mexico was expected to record higher YLL rates from ischaemic heart disease and lower YLL rates due to chronic kidney disease. By contrast, age-standardised YLD rates remained relatively unchanged over time (ie, 9833·9 per 100 000 [7207·5–12 826·8] in 1990 and 9624·9 per 100 000 [7090·8–12 448·2] in 2013), and thus by 2013, non-fatal health outcomes accounted for a larger proportion of total DALYs than in 1990.

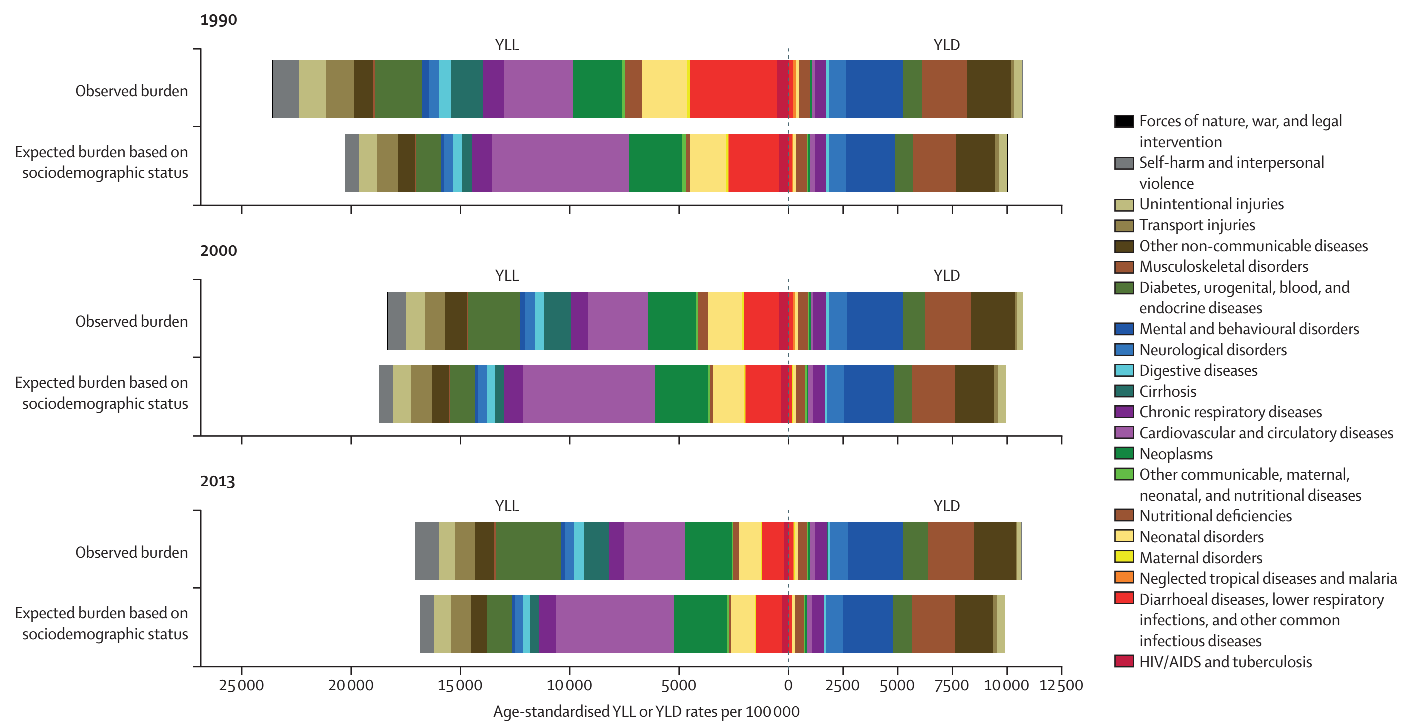

Figure 4: **Observed and expected age-standardised YLL and YLD rates (per 100 000) in Mexico, by GBD Level 2 cause group and for both sexes combined, in 1990, 2000, and 2013**
Expected YLL and YLD rates per 100 000 are functions of the level of Mexico's sociodemographic status. GBD=Global Burden of Disease. YLL=year of life lost. YLD=year lived with disability.

In 2013, 39·3% (37·7–40·8%) of total DALYs in Mexico were attributable to risk factors in 2013 (appendix pp 7–11). Behavioural risks accounted for the largest proportion of attributable risk (37·5%), followed by metabolic risks (24·7%) and the overlap of behavioural and metabolic factors (24·5%). Attributable risk was substantially higher for cardiovascular and circulatory diseases and diabetes, each with less than 15% unattributable burden. Diabetes burden in Mexico was fully attributable to metabolic risk factors (24·9%) and the combined effects of behavioural and metabolic risks (75·1%), whereas only 40·4% (37·2–43·6%) of DALYs from road injuries could be attributed to specific risks (appendix pp 9–10).

Nationally, leading risk factors for DALYs were similar for men and women in 2013 (figure 5). A number of metabolic risks, such as high fasting plasma glucose (11·7% [95% UI 11·0–12·6%]), high body-mass index (BMI; 11·1% [9·9–12·3%]), and high systolic blood pressure (6·8% [5·9–7·7%]), were among the five leading risk factors for attributable DALYs in both sexes combined. Dietary risk, including diets high in sugar-sweetened beverages and processed meat, was the third leading risk for DALYs in men (11·1% [10·0–12·3%]) and women (10·1% [8·8–11·5%]) in 2013. State-level risk factor results are detailed in the appendix (p 11).

Alcohol and drug use was the second leading risk factor for Mexican men, accounting for 11·4% (10·4–12·6%) of DALYs in 2013; such health loss was largely associated with interpersonal violence and transport injuries (figure 5). Undernutrition accounted for 4·0% (3·5–4·7%) of DALYs for women in 2013, decreasing 12·6 percentage points since 1990. This reduction corresponds with Mexico's shifting risk composition, because undernutrition and unsafe water, sanitation, and hygiene were associated with a large proportion of total DALYs in Mexico in 1990 (15·3% [13·9–16·7%] for undernutrition and 7·9% [7·1–8·8%] for unsafe water, sanitation, and hygiene). Tobacco smoke accounted for 47·4% (44·4–50·9%) fewer DALYs in 2013 than in 1990.

Discussion

From 1990 to 2013, Mexico experienced an epidemiological transition that, compared with traditional transition models documented in other countries,[5–7,9] is dissonant. Outside of the HIV/AIDS epidemic in sub-Saharan Africa and the rapid rise of alcohol-related deaths in eastern Europe and central Asia,[8,28] few places share Mexico's current epidemiological trajectory: an unexpected rise in age-specific mortality rates in adults, which threatens to reverse Mexico's health gains achieved in reducing under-5 mortality rates and communicable diseases. These trends are particularly dissonant in light of Mexico's relatively small HIV/AIDS burden and minimal changes in alcohol consumption over time, further defying hallmarks of traditional epidemiological transitions identified by Omran[5] and others.[6,7] Policy implications of such unusual health

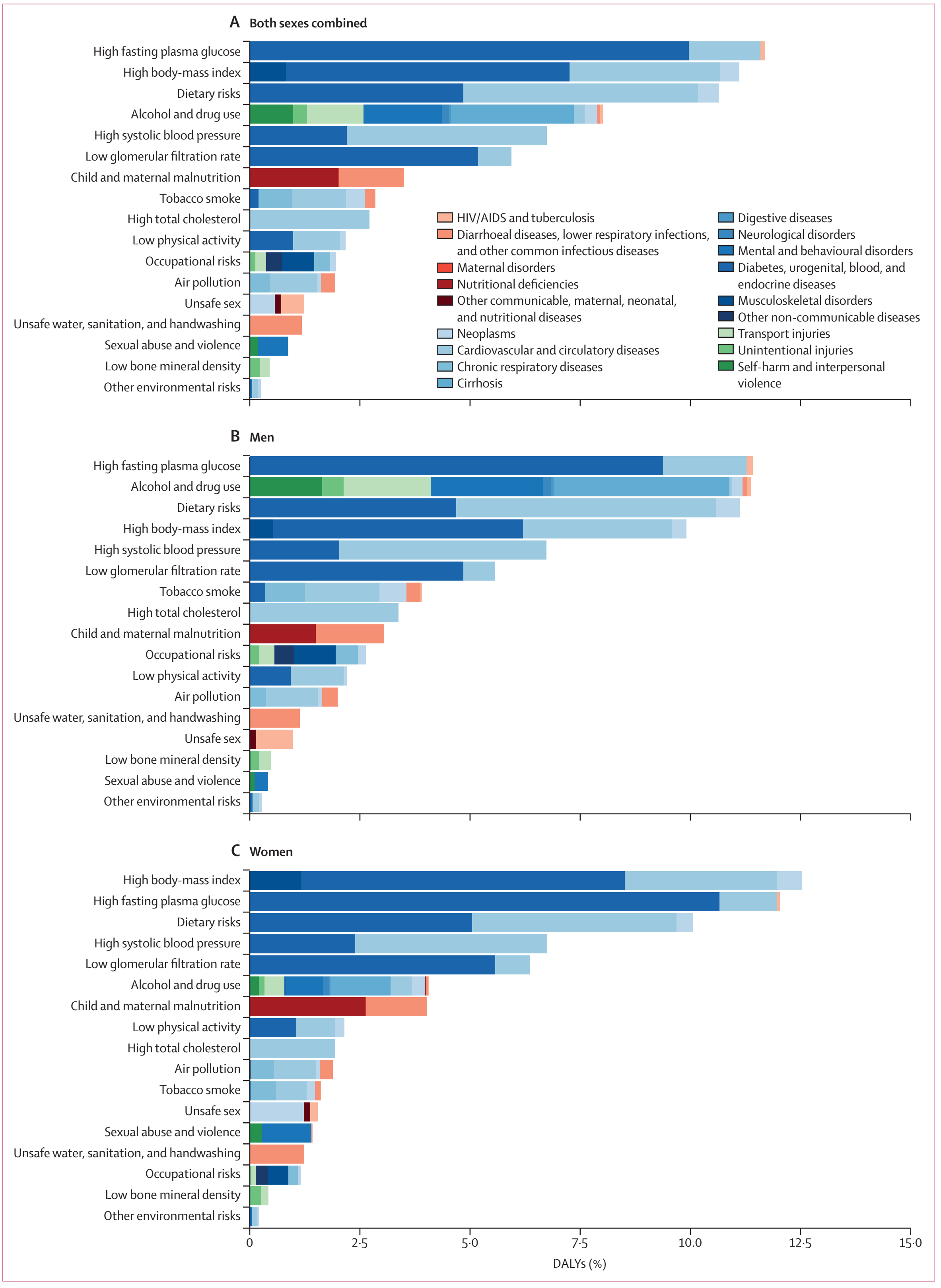

***Figure 5*: Proportion of all age DALYs attributable to GBD Level 2 risk factors in 2013**
(A) Both sexes combined. (B) Men. (C) Women. GBD=Global Burden of Disease. DALYs=disability-adjusted life-years.

patterns are of crucial importance, particularly because our results show that sustained progress in reducing mortality across age groups is far from inevitable, even amid large gains in development. Prior to the present analysis, few studies considered the extent to which health trends in various countries and subnational geographies might differ from traditional epidemiological trajectories.[5] Through GBD 2013, we harnessed the strength of several types of health data in Mexico, which tracked Mexico's dissonant health patterns at both national and state levels over time.

Between 1990 and 2000, YLL rates due to communicable and child health conditions, such as diarrhoeal diseases, preterm birth complications, and protein-energy malnutrition substantially decreased in Mexico, and life expectancy steadily improved. This progress was found at both national and state levels, which contributed to narrowing health disparities between states. Such declines in cause-specific mortality probably underpinned large improvements in life expectancy for many states with high marginalisation scores. Burden from road injuries and interpersonal violence also fell during this time, advancing the potential for continued health gains in Mexico. Yet progress achieved from 1990 to 2000 was quickly disrupted from 2000 to 2013, as rising YLL rates due to chronic kidney disease and interpersonal violence hindered further improvements in life expectancy and HALE, particularly in men. The gap between life expectancy and HALE widened in several states, showing how gains in longevity do not inherently equate to more years lived in full health, particularly as non-communicable diseases and related disabilities escalate. By 2000, risks associated with non-communicable diseases, including high BMI and high fasting plasma glucose, replaced undernutrition and unsafe water, sanitation, and hygiene as leading risk factors, fuelling the rise of non-communicable diseases throughout the country. Of Mexico's 32 states, 20 documented similar changes in disease burden.

Mexico's health patterns since 2000 further emphasise its dissonant health transition. From 1990 to 2000, Mexico and other Latin American countries followed more traditional epidemiological transitions, experiencing sizeable reductions in communicable, neonatal, maternal, and nutritional diseases across age groups, while overall age-specific mortality rates decreased, albeit at a smaller magnitude. After 2000, rising age-specific adult mortality rates caused by diabetes, chronic kidney disease, and interpersonal violence drove a dramatic shift in Mexico's disease profile, whereas most other Latin American countries remained on more traditional trajectories. El Salvador emerged as the exception from 2000 to 2013, following a similar course as Mexico with climbing levels of adult mortality paired with continued progress in improving child survival.[21] For Mexico, and probably El Salvador, drawing attention to dissonant health transitions has important ramifications for policy design and resource allocation, because the optimal intervention packages and programme options for effectively addressing such unusual burden trends and composition might need to be revisited.

Mexico reduced under-5 mortality rates by 76% from 1990 to 2013, effectively achieving the fourth Millennium Development Goal before 2015.[1] Such progress has been linked to several health initiatives and government-led investments,[4] including enhanced sanitation facilities,[4,29] expanded vaccination programmes,[30] and facilitation of improved nutrition for the poor.[31] Increased access to affordable curative and preventive care, through insurance plans such as *Seguro Popular*,[14,16] is also associated with increased use of health services.[10] Nonetheless, gains in child survival have been uneven; 20 states failed to reduce under-5 mortality rates by more than two-thirds. We found that states, such as Guerrero and Puebla, still had high YLL rates from diarrhoeal diseases and preterm birth complications in 2013. These results highlight Mexico's progress in child health, but also underscore potential gaps in the country's health system at local levels and the importance of tracking subnational policy implementation and quality of care.

Mexico decreased its maternal mortality ratio by more than 50% between 1990 and 2013,[21] and several states, including Oaxaca, Tlaxcala, and Queretaro, recorded even larger reductions in their maternal mortality ratio since 1990,[32] which probably contributed to state-level improvements in female life expectancy. Leading causes of maternal deaths—haemorrhage during childbirth, maternal hypertension, and indirect causes—have decreased since 1990, though indirect causes increasingly account for a greater proportion of YLLs.[32] Additional gains against such maternal causes are crucial for further improvement of women's health in Mexico, particularly in states with high marginalisation. Nonetheless, other conditions, especially cancers, led to comparable, or even higher, DALY rates in women of reproductive age.[2] These results emphasise the continued need to further scale-up universal coverage of maternal health services and to strengthen the overall health system capacity to support women's health needs in Mexico.

Several non-communicable diseases emerged as some of Mexico's largest health threats. Diabetes was the leading cause of age-standardised DALY rates in 2000 and 2013, and Mexico has one of the highest diabetes burdens worldwide.[2] Although effective interventions and lifestyle modifications exist,[33,34] improvement of local health service access, appropriate diagnosis of diabetes and related risk factors, and ensuring treatment adherence remain substantial constraints to fully addressing the diabetes epidemic in Mexico.[18] The 2013 Mexican National Strategy on the Prevention and Control of Overweight, Obesity and Diabetes stresses a crucial need for intersectoral collaboration to "reverse the epidemic condition of non-communicable disease (in particular, diabetes)….[which] may compromise our viability as a nation."[18] Scaling up programmes that support early detection and treatment of high blood glucose, as well as implementation of initiatives focused on diabetes prevention, are of increasing priority.

Mexico's growing chronic kidney disease burden is of serious concern, because Mexico recorded a 136% rise in DALY rates from chronic kidney disease since 1990 and the world's second highest DALY rate due to chronic kidney disease in 2013. Overall chronic kidney disease awareness is low,[35] which, combined with the need for more complex diagnostics and expensive interventions for late-stage chronic kidney disease, poses health system and financial challenges for Mexico. In some Latin American countries, very high chronic kidney disease rates are termed as Mesoamerican nephropathy, or chronic kidney disease thought to be associated with high exposure to agricultural toxins and chemicals, as well as other infectious agents and stressors (eg, dehydration, heat exposure).[36] However, given the steadily increasing chronic kidney disease burden in both rural and urban environments, agricultural production and related risks are not likely to account for all chronic kidney disease found in Mexico. Community-based screening efforts, such as the Kidney Early Evaluation Program, show promising results for high-risk populations.[37] Treatment of leading risk factors for chronic kidney disease, including high fasting plasma glucose and high systolic blood pressure, might also reduce chronic kidney disease severity and slow disease progression,[38] which could ease the high costs of late-stage chronic kidney disease.

The rise in YLL rates due to interpersonal violence was regarded as another primary factor in Mexico's dissonant health transition. After a 28% decline between 1990 and 2000, YLL rates from interpersonal violence increased by more than 75% since 2000 and improvements in male life expectancy stalled. States such as Guerrero and Chihuahua had YLL rates due to interpersonal violence that were comparable to levels in some Latin American countries known for widespread violence,[39] and many people attribute recent rises in violence to drug trafficking and organised crime.[40] These results highlight a need to reduce access to firearms and address environmental and societal factors related to heightened violence. For instance, policies restricting firearm sales and alcohol consumption in high-risk environments have been considered effective in reducing homicides in communities such as Cali, Colombia.[41]

Mexico had one of the highest burdens of cirrhosis in 2013 worldwide,[2] although DALY rates from cirrhosis markedly varied across states; this finding might be related to variable state-level risk patterns, including alcohol use.[23] Notably, per person alcohol consumption in Mexico is not particularly high, yet the burden of alcohol-related cirrhosis in Mexico far exceeds that of countries with high alcohol consumption such as Russia.[2] From 1990 to 2013, age-standardised DALY rates from colon and rectum cancer increased by more than 40%, and DALY rates from breast cancer increased by about 12%. Although highly fatal if untreated, these two cancers generally have favourable prognoses if detected early. By expanding cancer screening programmes, particularly in high-risk populations, and ensuring the implementation of a national cancer registry, Mexico could substantially improve the early detection and clinical outcomes of high-burden cancers.[42,43]

Depressive disorders accounted for nearly 10% of YLDs in 2013, and became a leading cause of disability in Mexican women. Although a combination of medical and psychological treatment can substantially improve mental health outcomes,[44] the availability of mental health care remains insufficient throughout Mexico.[45] Particularly large treatment gaps are observed in 18–29 year olds diagnosed with depression in Mexico, which might be associated with increases in suicide deaths in younger populations in several states.[46] Another leading cause of disability in Mexico, low back and neck pain, accounted for more than 11% of YLDs in 2013. These causes are related to work absenteeism and reduced quality of life.[47] When aggregated over time and in ageing populations, health loss from musculoskeletal conditions might have negative ramifications for overall economic productivity.

Underlying Mexico's dissonant health transition are dramatic shifts in leading risk factors and their contributions to disease burden. Age-standardised DALY rates attributable to tobacco smoke decreased by more than 47% since 1990, a result that might be linked to Mexico's widely lauded adoption and adherence to the WHO Framework Convention on Tobacco Control.[48] Led by the national government, Mexico implemented expansive prevention campaigns, banned smoking in public places, and enacted taxation policies on tobacco products.[49] Similar government-sponsored activities have sought to reduce alcohol-related injuries and mortality,[50] yet the effectiveness of such regulatory efforts often competes with transnational business expansion and trade agreements.[51]

Mexico's rapid nutrition transition,[52] as well as growing disease burden from metabolic and dietary risks, directly reflects the interplay of economic and sociocultural factors. Prevalence of overweight or obese adults in Mexico increased to 69% in 2013,[53] and by 2013, nearly 29% of children were overweight or obese. At the societal level, past studies view urbanisation, changes in Mexico's food industry, and the influence of global economic policies as drivers of these trends.[54] For example, sugar-rich foods became significantly less expensive—and thus more financially attractive commodities—as sugar prices fell amid the implementation of the North American Free Trade Agreement. Studies suggest that price reductions of sugar-rich foods could explain up to 20% of Mexico's increased rates of diabetes between 1996 and 2010.[55] In recent years, the Mexican Government enacted legislation to offset lowered sugar prices, such as a 10% tax on beverages containing added sugars.[56]

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GBD analyses indicate that sugar-sweetened beverages could account for more than 30% of the burden of high BMI. Nationally representative surveys also show that the average caloric intake in Mexican women and children increased by 350 kilocalories between 1999 and 2012.[57] Health policies and programmes targeting risk factors related to poor diet and physical inactivity are regarded as promising approaches to address these risks and corresponding disease burdens. For instance, in 2013, the Mexican Alliance for Health Nutrition launched a high-profile media campaign against highly sweetened beverages, such as soda,[58] and various initiatives have sought to restrict school-based availability of sugar-rich and high-fat foods.[59] In tandem, government initiatives and local communities have advocated improving access to physical activity and expanding nutrition education.[59]

Our analyses are subject to the same limitations described for GBD 2013,[1,2,21–23] as well as specific limitations related to data availability for Mexico. First, our subnational results might be affected by variable completeness of state-level vital registration. Future analyses should incorporate additional national surveys to provide updated estimates of state-level under-5 mortality. Second, previous studies document tendencies to overassign diabetes as an underlying cause of death in Mexico.[60] Future GBD updates will aim to improve correction methods for this tendency. Third, we found few data on disease-specific causes in Mexico (eg, lower respiratory infections and hepatitis), and thus state-level estimates for these causes had particularly wide uncertainty. Fourth, for a subset of diseases, we borrowed strength from regional or global data and covariates to estimate subnational prevalence and incidence. Recent efforts to create individual-level registries with patient records for cancer, diabetes, hypertension, and other chronic diseases will substantially improve future analytic efforts.[43] Fifth, we experienced sparse data availability for a subset of risk factors, which might affect estimates' precision. We also had limited local data access for dietary risks, but additional surveys, such as the 2012 National Health Survey, will be incorporated into future GBD analyses. Sixth, without cancer and renal registries, our estimates for cancer, chronic kidney disease, diabetes, hypertension, glomerulonephritis, and other kidney diseases were dependent on vital registration data and thus could not fully account for comorbidities. Subsequent analyses of Mexico's cancer burden would markedly improve by the creation of a national cancer registry.[42] Seventh, data quality certification and prevalence of so-called garbage codes varied across years and states in Mexico, which resulted in difficulty in distinguishing between variance due to improved diagnosis and variance due to the implementation of automated coding in 2007. Eighth, we used hospital discharge records to estimate non-fatal outcomes due to injuries, but we only had data from one health provider in Mexico. Without additional records from social security and the private sector, injury burden might be underestimated. Last, we could not fully account for within-state heterogeneities. Future iterations of GBD will seek to expand subnational assessments to lower administrative levels as data and interest by country leadership permit.

A first of its kind, this study provides a comprehensive picture of disease burden and patterns in Mexico and its states since 1990. These results can help identify successful implementation of state-level policies and areas where more targeted policy attention might be required. We view the publication of these subnational results as a first step toward a greater understanding of state-specific health priorities amenable to local health policy and programme implementation. Programme implementation is of particular importance, as many state-level challenges related to Mexico's dissonant health transition are likely best addressed by direct recognition and redress from local health authorities. Strengthening the use of state-level burden results to inform decision making and onward evaluations of health programmes will require additional training and development of accessible visualisation tools tailored for local stakeholders. For the overarching GBD study and collaboration with Mexico, such initiatives are a priority, and so are efforts to support the formal integration of disease burden assessments as part of Mexico's health information systems and local policy processes.

Improved health system responsiveness, such as ensuring service provision corresponds with changing population health needs, is a crucial component to advancing Mexico's health outcomes. This study emphasises the importance of routinely tracking subnational health trends, which can support more efficient feedback response processes for health programmes. The rise of non-fatal, disabling conditions demands more integrated service provision, particularly for primary care, and a heightened emphasis on preventive measures. Creating cause-specific national registries and ensuring their uptake into Mexico's existing health information systems will also help improve responsiveness. Finally, coordinated multisectoral action is needed to successfully address the country's substantive burdens from mental health disorders, interpersonal violence, and behavioural risks.

Mexico's dissonant health transition places the country at a turning point. Immediate policy intervention is needed to halt accelerating burden from violence and non-communicable diseases, but long-term government investments and health-system planning are also vital to accommodate Mexico's new epidemiological profile. Persisting state inequalities currently hinder further health gains, but if addressed, Mexico could notably improve overall health outcomes and become one of the best-performing countries in Latin America. Implementation of policies focused on effective prevention and treatment is a likely catalyst for improved health, but policies designed to alleviate local inequalities also offer the potential for long-term, enduring advances in health for all populations in Mexico.

Contributors
HG-D, NF, HL-F, CJLM, and RL prepared the first and subsequent drafts, and finalised the manuscript based on feedback from reviewers and co-authors. LC-H, LA-B, BD, RC-R, and SB contributed to writing the first draft and content on specific conditions. HW, TV, MHF, MN, and ADL were involved in the initial generation of results and development of this manuscript. JAR, TB-G, GB, TGdC, MCH-M, CM-R, MEM-M, HR-R, ES-M, TS-L, and MMT-R provided data, reviewed results, reviewed the manuscript, and contributed to interpreting results for the GBD 2013 Mexico study. MJRB, PM, CR-G, and AM prepared and analysed data. EG-P, TA-S, EFAdC, ACB-A, CB, IC-N, JCC-R, AdJC-P, AGC-M, VVdlC-G, LC-N, JLD-O, MdLG-G, AG-G, LDG-C, IH-P, AJ, AJ-C, NL-O, CM-G, FM-R, JCM, GLM-B, AP-T, RP-P, ADQ, VLR-L-C, MPRM, TGS-P, LMS-R, AS, and JLT-S reviewed and interpreted results.

Declaration of interests
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