Premature mortality projections in the USA through 2030: a modelling study

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Summary

Background Although life expectancy has been projected to increase across high-income countries, gains for the USA are anticipated to be among the smallest, and overall US death rates actually increased from 2014 to 2015, with divergence for specific US populations. Therefore, projecting future premature mortality is essential for clinical and public health service planning, curbing rapidly increasing causes of death, and sustaining progress in declining causes of death. We aimed to project premature mortality (here defined as deaths of individuals aged 25–64 years) trends through 2030, and to estimate the total number of projected deaths, the projected number of potential years of life lost due to premature mortality, and the effect of reducing projected accidental death rates by 2% per year.

Methods We obtained death certificate data for the US population aged 25–64 years for 1990–2015 from the US Centers for Disease Control and Prevention (CDC) National Center for Health Statistics. We obtained US mortality data for 2016 for non-American Indian or Alaska native groups from CDC WONDER; data for 2016 were not available for American Indians or Alaska natives. Our analysis focused on all-cause premature mortality and the commonest causes of premature death (cancer, heart disease, accidents, suicide, and chronic liver disease or cirrhosis) among white, black, Hispanic, Asian or Pacific islanders, and American Indian or Alaska native men and women. We estimated age-standardised premature mortality and corresponding annual percentage changes for 2017–30 by sex and race or ethnic origin by use of age–period–cohort forecasting models. We also did a sensitivity analysis projecting future mortality from cross-sectional mortality and a JoinPoint of the (log) period rate ratio curve. We calculated absolute death counts by use of corresponding age-specific and year-specific US census population projections, and estimated years of potential life lost.

Findings During 2017–30, all-cause deaths are projected to increase among white women and American Indians or Alaska natives, resulting in 239 700 excess premature deaths relative to 2017 rates (a 10% increase). Mortality declines in white men and black, Hispanic, and Asian or Pacific islander men and women will result in 945 900 fewer deaths (a 14% reduction). Cancer mortality rates are projected to decline among white, black, Hispanic, and Asian or Pacific islander women and men, with the largest declines among black women (age-standardised premature mortality rate 2016: 104·5 deaths per 100 000 woman-years; 2030: 77·1 per 100 000 woman-years) and men (2016: 116·8 per 100 000 man-years; 2030: 81·6 per 100 000 man-years). Heart disease death rates are projected to increase in American Indian or Alaska native men (2015: 150·9 per 100 000 man-years; 2030: 175·9 per 100 000 man-years) and decline in other groups, albeit only slightly in white (2016: 35·6 per 100 000 woman-years; 2030: 31·1 per 100 000 woman-years) and American Indian or Alaska native women (2015: 64·4 per 100 000 woman-years; 2030: 62·8 per 100 000 woman-years). Accidental death rates are projected to increase in all US populations except Asian or Pacific islander women, and will increase most rapidly among white women (2030: 60·5 per 100 000 woman-years) and men (2030: 101·9 per 100 000 man-years) and American Indian or Alaska native women (2030: 97·5 per 100 000 woman-years) and men (2030: 298·7 per 100 000 man-years). Suicide rates are projected to increase for all groups, and chronic liver disease and cirrhosis deaths are projected to increase for all groups except black men. A 2% per year reduction in projected accidental deaths would eliminate an estimated 178 700 deaths during 2017–30.

Interpretation To reduce future premature mortality, effective interventions are needed to address rapidly rising mortality rates due to accidents, suicides, and chronic liver disease and cirrhosis.

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Introduction

Since 1980, mortality has decreased and life expectancy has increased globally, except in nations undergoing natural disasters, violence, and war.[1] Although life expectancy has been projected to continue to increase across high-income countries, gains for the USA are anticipated to be among the smallest.[2] In fact, overall US mortality increased from 2014 to 2015.[3]

Although increases in total US mortality trends are recent,[3,4] pronounced heterogeneity in death rates has

Research in context

Evidence before this study

Since 1980, mortality rates have decreased and life expectancy has increased across most countries. However, since 2000, in the USA, increases in premature mortality have been reported in some groups of non-Hispanic white people and American Indians or Alaska natives, mainly due to rising rates of accidental death (primarily drug poisonings), suicides, and chronic liver disease and cirrhosis. These increases contrast with continued decreases in mortality in other countries and among US non-Hispanic black people, Hispanic people, and Asian or Pacific islanders. We searched PubMed on May 10, 2018, using MeSH search terms ("Life Expectancy" OR "Mortality, Premature" or "Death Rate") AND ("Forecasting" or "Projection, Population") AND "United States", restricting our search to articles published since Jan 1, 2010, with no language restrictions. Of the 31 listed results, one study contained mortality or burden forecasts to at least 2020 but did not provide age-specific or burden predictions, and focused only on cancer and heart disease mortality in white and black people.

Added value of this study

In contrast to previous studies that have focused on observed historical trends in mortality, our study focused on projecting premature mortality trends through 2030 using age–period–cohort models. These projections highlight future increases in premature mortality if current trends continue by sex, race or ethnicity, age, and major cause of premature death. Additionally, we estimated the total number of deaths projected to occur, and the projected number of potential years of life lost because of premature mortality. We also estimated the effect of a hypothetical public health intervention that reduced accidental death rates by 2% per year from the base-case projections on all-cause mortality and the total number of projected deaths.

Implications of all the available evidence

Based on our projections, which take into account contemporary birth cohort trends in premature mortality, we expect the observed divergence in mortality trajectories by race and ethnicity to continue. In particular, we expect that mortality will continue to increase among American Indians or Alaska native men and women and non-Hispanic white women through 2030, and continue to decline among non-Hispanic black people, Asian or Pacific islander men and women, Hispanic people, and non-Hispanic white men. The largest increases in premature mortality are projected for accidental deaths, and the largest decreases for cancer deaths. Reductions in accidental death rates of 2% per year would avert an expected 178 700 deaths. However, recent period increases from 2014 to 2016 suggest that such reductions in accidental deaths are unlikely, at least over the next few years. Swift and effective interventions are needed to halt the rapid increase in deaths due to drug poisonings, suicide, and chronic liver disease, in addition to sustained prevention and treatment efforts to continue reductions in cancer and heart disease mortality.

been documented across age and racial or ethnic groups for the past two decades.[5] Premature mortality among Hispanic, non-Hispanic black or African American, and Asian or Pacific islander men and women declined steadily during the 21st century.[5,6] By contrast, premature mortality has increased among young and middle-aged non-Hispanic white people and American Indians or Alaska natives during the same time period,[5,6] driven largely by increases in accidental deaths, suicide, and chronic liver disease or cirrhosis deaths.[5,6] Increases in accidental deaths are driven by unintentional drug poisonings, as motor vehicle accident deaths have declined.[5] Opioid overdoses are a major contributor to increases in drug poisonings, including prescription opioids, heroin, and fentanyl.[7] Despite policies implemented to curb the opioid epidemic, the number of people in the USA addicted to prescription painkillers continues to increase, heroin use is increasing, and drug overdoses, particularly due to fentanyl, continue to rise.[8–11]

In contrast to previous studies that have addressed observed trends in mortality, we aimed to project premature mortality (here defined as deaths of individuals aged 25–64 years) trends through 2030 using age–period–cohort models. These projections highlight future trajectories of premature mortality if current trends continue, by sex, race or ethnic origin, age, and major causes of premature death. Additionally, we estimated the total number of projected deaths, the projected number of potential years of life lost due to premature mortality, and the effect of reducing projected accidental death rates by 2% per year. Projecting future premature mortality is essential for planning clinical and public health services, to curb rapidly increasing causes of death, and to sustain progress in declining causes of death.

Methods

US mortality data for 1990–2015 for people aged 25–64 years were based on underlying cause of death and demographic information extracted from all death certificates for the entire population of US residents. Data were provided by the US Centers for Disease Control and Prevention (CDC) National Center for Health Statistics (NCHS) and extracted using SEER*Stat in single-year increments of age and year at death.[12] We obtained US mortality data for 2016 for white, black, Hispanic, and Asian or Pacific islander groups from CDC WONDER.[13] Death certificate data were provided by individual states to NCHS. Our analysis focused on all-cause premature mortality (deaths among those aged 25–64 years, as defined in previous studies[5,14]) and the commonest causes of premature death (cancer, heart

disease, accidents, suicide, and chronic liver disease or cirrhosis)[5] among white, black, Hispanic, Asian or Pacific islander, and American Indian or Alaska native men and women (International Classification of Diseases code groupings and racial or ethnic classification details in the appendix; accidental deaths and deaths by suicide were mutually exclusive). We additionally examined deaths from HIV and homicide among black and Hispanic people for some analyses, as HIV deaths have been shown to have strongly contributed to mortality trends in these populations, and homicide is a common cause of premature death in black men and women. Estimates for American Indians or Alaska natives were restricted to counties in Contract Health Services Delivery Areas (CHSDA counties).[15] 2016 data were not available for American Indians or Alaska natives as CDC WONDER does not provide a restriction to these counties. Estimates and projections of yearly US population by age, sex, and race or ethnic origin were obtained from the US Census Bureau.[16] Institutional Review Board approval was unnecessary for this study as all data were deidentified and publicly available.

Statistical analysis

We used age–period–cohort methods[17,18] to model observed all-cause and cause-specific mortality during 1990–2016 (1990–2015 for American Indians or Alaska natives) by sex and race or ethnic origin, and to forecast 2017–30 mortality. These dynamic models are appropriate as there have been notable age and birth cohort trends in US premature mortality rates.[5] We estimated age-specific and period-specific mortality rates through a log-linear Poisson model as a product of three factors: a longitudinal mortality rate for a reference birth cohort, a rate ratio relative to this cohort, and an age invariant period adjustment. Although age, period, and cohort are non-identifiable, this model estimates identifiable and interpretable parameters. Our forecast projected mortality for future periods using these multiplicative factors, as estimated using the observed data; mortality in future periods is estimated as a product of the longitudinal mortality rate, the cohort rate ratio, and a second order period effect. For partly observed birth cohorts, we used the estimated cohort rate ratio, and ratios for unobserved cohorts were projected by extrapolating the last segment of a JoinPoint piecewise linear model fitted to the logarithm of the observed cohort rate ratio curve.[19] All estimates were age-standardised to the 2000 US population in 5-year age groups, and we calculated annual percentage changes in observed and forecast mortality. Full details on model parametrisation and assumptions, selection and validation, and rate summary calculations are in the appendix. We also did a sensitivity analysis projecting future mortality from cross-sectional mortality and a JoinPoint of the (log) period rate ratio curve.

We calculated projected numbers of premature deaths (ie, mortality burden) by multiplying mortality in 2017–30 by corresponding age-specific and year-specific US census population projections. We defined the number of projected excess or averted deaths as the number of deaths projected to occur during 2017–30 minus the number of deaths that would have occurred if rates remained stable at the most recently observed quantities (American Indians or Alaska natives: 2015, others: 2016), which were estimated by multiplying 2015–16 rates by population size projections during 2017–30, stratified by age, sex, and race or ethnicity. We also estimated years of potential life lost, a complementary estimate of premature mortality that weights younger deaths more heavily, by multiplying age-specific mortality burden by the difference between age 65 years and the age at death. Finally, to estimate the effect of a hypothetical public health intervention that could reduce accidental deaths, we reduced the projected 2018–30 accidental deaths by 2% per year (reduction of 26% by 2030). Analyses were done with MATLAB version R2017a; code is available from the authors upon request.

See Online for appendix

Role of the funding source

The funder reviewed the final version of the manuscript but 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 for the decision to submit for publication.

Results

During 1990–2016, all-cause premature deaths declined among black, Hispanic, and Asian or Pacific islander women and men. These declines are projected to continue to decrease through 2030. During 2017–30, premature death rates in the USA are projected to decrease among women (2016: 249·9 deaths per 100 000 woman-years; 2030: 201·8 per 100 000 woman-years) and men (2016: 419·6 deaths per 100 000 man-years; 2030: 340·3 per 100 000 man-years); however, notable racial or ethnic differences in mortality trends are expected (figure 1, appendix). The largest declines (1·2–3·0% per year) are projected to occur in black women (age-standardised premature mortality rate for 2016: 383·7 per 100 000 woman-years; 2030: 232·9 per 100 000 woman-years), black men (2016: 647·8 per 100 000 man-years; 444·7 per 100 000 man-years), and Hispanic men (2016: 311·6 per 100 000 man-years; 2030: 249·4 per 100 000 man-years). By these estimates, Asian or Pacific islanders are projected to have the lowest mortality rates across the time period (2030 women: 92·6 deaths per 100 000 woman-years, men: 170·2 per 100 000 man-years). Among black men, the projected 2030 mortality rate among those aged 45–54 years (434·3 per 100 000) will decrease nearly to the mortality rate in those aged 25–34 years in 1990 (422·2 per 100 000; appendix). Compared with the mortality burden estimated with 2016 mortality rates, projected mortality rates will result in 445 100 fewer deaths among black

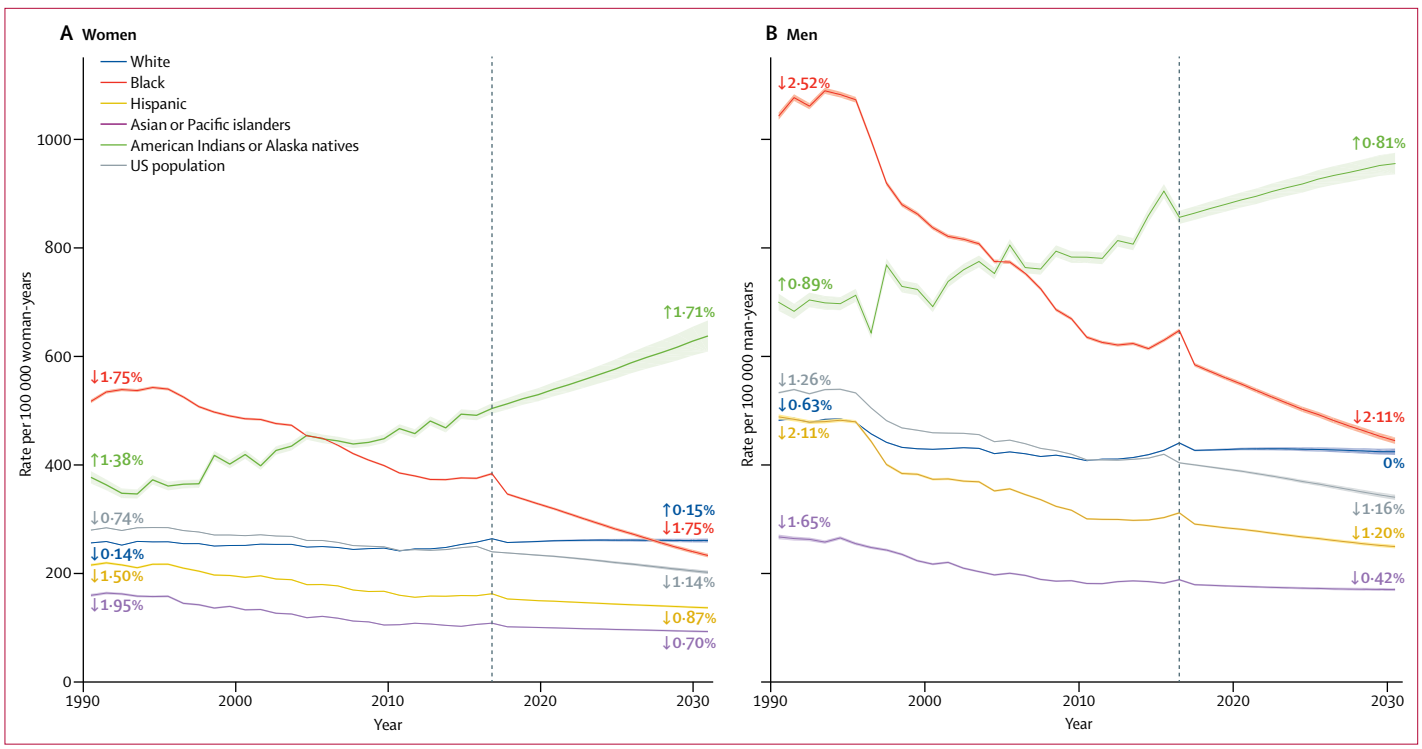

Figure 1: **Observed and projected age-standardised all-cause mortality rates for those aged 25–64 years**

Observed rates are for 1990–2015 for American Indians or Alaska natives and the US population, and 1990–2016 for all other groups, and projected rates to 2030. (A) shows data for women, and (B) shows data for men. The vertical dotted line at 2016 marks the end of the observation period. Annotations indicate estimated annual percentage change during the observed and projected time periods. Shaded areas denote pointwise 95% CIs for the mean age-standardised rate.

people, 296 300 fewer deaths among Hispanic people, and 48 400 fewer deaths among Asian or Pacific islanders during 2015–30 (table, appendix).

Overall, premature mortality rates among white people declined during 1990–2016, and are projected to remain stable through 2030 (women 2016: 263·8 deaths per 100 000 woman-years, 2030: 260·4 per 100 000 woman-years; men 2016: 440·5 deaths per 100 000 man-years, 2030: 424·4 per 100 000 man-years; figure 1, appendix). Trends within age groups are projected to continue to diverge, increasing among those aged 25–44 years and mostly decreasing among those aged 45–64 years (appendix), resulting in a net 156 100 fewer deaths among white men and 221 100 excess deaths among white women during 2017–30 compared with 2016 (table, appendix). Additionally, premature mortality rates for white women are projected to exceed those of black women starting in 2027, and mortality rates for white and black men will be close to convergence in 2030 (figure 1, appendix).

Projected mortality rates in American Indian or Alaska native women (2015: 491·4 deaths per 100 000 woman-years; 2030: 637·8 per 100 000 woman-years) and men (2015: 904·9 per 100 000 man-years; 2030: 955·8 per 100 000 man-years) will continue increasing in all age groups (figure 1, appendix), resulting in a projected 18 600 excess deaths (table, appendix). Projected mortality rates among American Indian or Alaska native women aged 25–35 years in 2030 (319·0 per 100 000 woman-years) will exceed rates for those aged 35–44 years in 1990 (210·9 per 100 000 woman-years; appendix). In 2030, American Indian or Alaska native women (637·8 per 100 000 woman-years) and men (955·8 per 100 000 man-years) are projected to have the highest mortality rates of all races and ethnic groups investigated in this study (seven times that projected for Asian or Pacific islander women, and six times that projected for Asian or Pacific islander men; appendix).

During 2017–30, projected accidental deaths will increase among white and American Indian or Alaska native women, remain stable among Hispanic and black women, and decline among Asian or Pacific islander women (figure 2). Among men, accidental deaths are projected to increase most in white men (figure 2, appendix). In 2030, we project American Indian or Alaska native women (age-standardised premature mortality rate 97·5 deaths per 100 000 woman-years) and men (298·7 deaths per 100 000 man-years) to have the highest accidental mortality rates, followed by white people (60·5 deaths per 100 000 woman-years, 101·9 deaths per 100 000 man-years; appendix). The most rapid projected increases (70–80% by 2030) will occur among white people aged 25–44 years and American Indian or Alaska native women aged 55–64 years (appendix). Increasing accidental mortality

	Women						Men					
	White	Black	Hispanic	Asian or Pacific islander	American Indian or Alaska native	Total	White	Black	Hispanic	Asian or Pacific islander	American Indian or Alaska native	Total
2017–30 deaths at most recent observed rate												
Accidents	262 500	46 500	36 400	5900	7000	358 300	603 600	123 100	135 600	15 000	16 700	894 000
Suicides	82 200	5100	8100	3700	1400	100 500	247 100	21 000	35 100	9700	4300	317 200
Cancer	733 600	197 400	132 700	51 900	9000	1 124 600	846 000	200 700	142 700	47 500	10 200	1 247 100
Heart disease	325 500	143 600	47 900	11 000	6000	534 000	778 600	248 100	132 100	34 300	13 800	1 206 900
Chronic liver disease or cirrhosis	80 600	11 700	18 600	1300	6100	118 300	150 700	20 100	55 900	4000	8800	239 500
All	2 287 600	704 500	388 700	106 100	47 300	3 534 200	3 745 100	1 048 900	767 000	159 800	83 000	5 803 800
2017–30 deaths at projected rates												
Accidents	337 400	37 900	34 500	4400	8200	422 400	639 500	79 900	100 600	11 400	15 100	846 500
Suicides	88 100	4400	7900	4000	2100	106 500	259 400	16 900	29 900	9200	4500	319 900
Cancer	657 700	165 300	116 700	41 100	9800	990 600	760 000	145 300	128 600	39 400	12 100	1 085 400
Heart disease	349 100	124 800	42 300	9100	8400	533 700	719 700	204 200	114 300	31 400	15 100	1 084 700
Chronic liver disease or cirrhosis	90 400	6400	15 700	1300	7400	121 200	140 500	8500	38 700	3500	9900	201 100
All	2 508 700	574 000	328 400	85 700	64 100	3 560 900	3 589 000	734 300	531 000	131 800	84 800	5 070 900
Deaths averted or in excess 2017–30 (percentage difference from observed rate projection)												
Accidents	74 900 (+29%)	−8600 (−18%)	−1900 (−5%)	−1500 (−25%)	1200 (+17%)	64 100 (+18%)	35 900 (+6%)	−43 200 (−35%)	−35 000 (−26%)	−3600 (−24%)	−1600 (−10%)	−47 500 (−5%)
Suicides	5900 (+7%)	−700 (−14%)	−200 (−2%)	300 (+8%)	700 (+50%)	6000 (+6%)	12 300 (+5%)	−4100 (−20%)	−5200 (−15%)	−500 (−5%)	200 (+5%)	2700 (+1%)
Cancer	−75 900 (−10%)	−32 100 (−16%)	−16 000 (−12%)	−10 800 (−21%)	800 (+9%)	−134 000 (−12%)	−86 000 (−10%)	−55 400 (−28%)	−14 100 (−10%)	−8100 (−17%)	1900 (+19%)	−161 700 (−13%)
Heart disease	23 600 (+7%)	−18 800 (−13%)	−5600 (−12%)	−1900 (−17%)	2400 (+40%)	−300 (−0%)	−58 900 (−8%)	−43 900 (−18%)	−17 800 (−13%)	−2900 (−8%)	1300 (+9%)	−122 200 (−10%)
Chronic liver disease or cirrhosis	9800 (+12%)	−5300 (−45%)	−2900 (−16%)	0	1300 (+21%)	2900 (+2%)	−10 200 (−7%)	−11 600 (−58%)	−17 200 (−31%)	−500 (−13%)	1100 (+13%)	−38 400 (−16%)
All	221 100 (+10%)	−130 500 (−19%)	−60 300 (−16%)	−20 400 (−19%)	16 800 (+36%)	26 700 (+1%)	−156 100 (−4%)	−314 600 (−30%)	−236 000 (−31%)	−28 000 (−18%)	1800 (+2%)	−732 900 (−13%)

Counts are given by sex, race or ethnic origin, and cause of death, and estimates are rounded to the nearest 100 deaths and 1%.

Table: **Total number of projected deaths for 2017–30 among individuals aged 25–64 years at the most recently observed mortality rate (2015 for American Indians and Alaska natives, 2016 for all other groups) and at the model-projected rate, with excess or reduction in deaths in the projection relative to the observed rate**

rates in some groups are projected to result in a total of 1·27 million accidental deaths during 2017–30, compared with 1·25 million accidental deaths over the same time period if rates remain stable (1–3% increase; table, appendix).

Suicide rates are projected to increase in all racial or ethnic groups, with the most pronounced increases in white women (2016: 11·7 deaths per 100 000 woman-years; 2030: 23·8 per 100 000 woman-years), American Indian or Alaska native women (2015: 20·6 per 100 000 woman-years; 2030: 27·7 per 100 000 woman-years), and white men (2016: 34·8 per 100 000 man-years; 2030: 53·6 per 100 000 man-years; figure 2, appendix). A projected 426 400 suicides are expected during 2017–30, compared with 417 700 if rates remain stable (2·1% increase; table, appendix).

Chronic liver disease and cirrhosis remain major causes of death for American Indians or Alaska natives, and projected mortality rates will increase among women (2015: 72·3 per 100 000 woman-years; 2030: 163·4 per 100 000 woman-years) and men (2015: 105·6 per 100 000 man-years; 2030: 197·2 per 100 000 man-years; figure 2, appendix) in this population. Additionally, projections show chronic liver disease and cirrhosis mortality increasing in both sexes for almost all other racial or ethnic groups, with the most rapid increases noted in younger age groups (appendix). Black men are the only group with a projected rate reduction (2016: 12·4 per 100 000 man-years; 2030: 11·8 per 100 000 man-years; figure 2, appendix). Because of diverging trends by age, we project a net decrease in the chronic liver disease and cirrhosis mortality burden expected during 2017–30 from 357 800 deaths if 2015–16 rates remain stable, to 322 300 deaths under projected rates (9·9% decrease; table, appendix).

Cancer mortality rates are projected to decline among white, black, Hispanic, and Asian or Pacific islander women and men (figure 2, appendix). The most

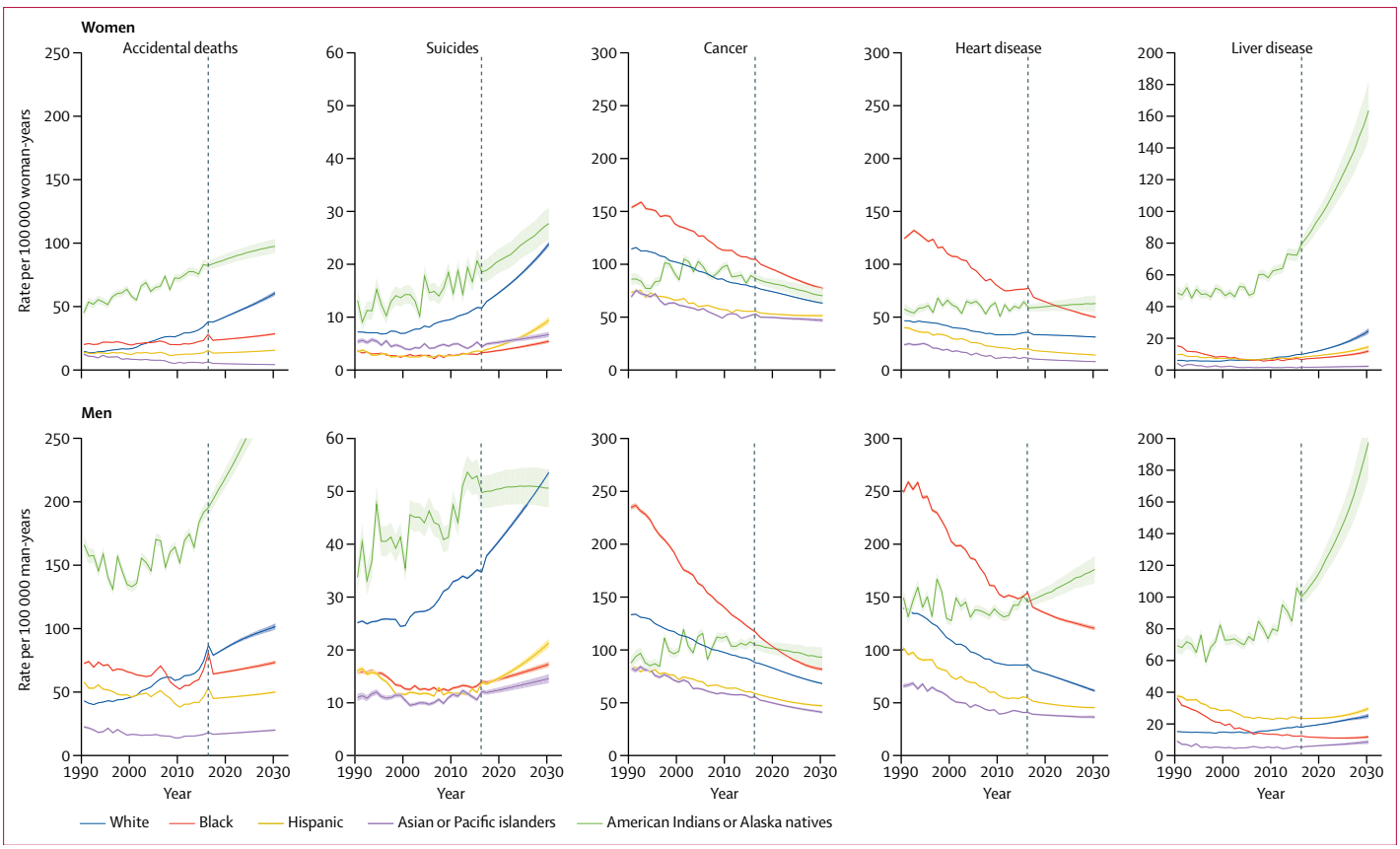

Figure 2: **Observed and projected age-standardised cause-specific mortality rates for those aged 25–64 years**
y-axis limits vary by column. The vertical dashed line indicates the end of the observation period. Shaded areas denote pointwise 95% CIs for the mean age-standardised rate.

profound decreases were forecast among black women (2016: 104·5 per 100 000 woman-years; 2030: 77·1 per 100 000 woman-years) and men (2016: 116·8 per 100 000 man-years; 2030: 81·6 per 100 000 man-years). By contrast, cancer mortality rates are projected to decline more slowly among American Indian or Alaska native women (2015: 89·3 per 100 000 woman-years; 2030: 70·4 per 100 000 woman-years) and men (2015: 107·4 per 100 000 man-years; 2030: 92·9 per 100 000 man-years). Declining cancer rates during 2017–30 are projected to result in fewer deaths (2·1 million) than expected if rates remain stable (12·5% decrease; 2·4 million; table, appendix).

Projected heart disease mortality rates show overall decreases for white men, and black, Asian or Pacific islander, and Hispanic women and men during 2017–30 (figure 2, appendix). However, heart disease mortality rates are projected to decrease only slightly in white women (2016: 35·6 per 100 000 woman-years; 2030: 31·1 per 100 000 woman-years) and American Indian or Alaska native women (2015: 64·4 per 100 000 woman-years; 2030: 62·8 per 100 000 woman-years), and increase in American Indian or Alaska native men (2015: 150·9 per 100 000 man-years; 2030: 175·9 per 100 000 man-years) across age groups. During 2017–30, 1·6 million premature heart disease deaths are expected to occur based on projected rates, compared with 1·7 million premature heart disease deaths estimated with stable rates (7% decrease; table, appendix).

In 2030, the largest proportion of years of life lost due to premature mortality will be accounted for by projected accidental deaths among white women (26%) and men (35%), American Indian or Alaska native women (16%) and men (24%), and Hispanic men (31%), projected cancer deaths among black (25%), Hispanic (32%), Asian or Pacific islander women (43%) and men (23%), and projected heart disease deaths among black men (23%; figure 3, appendix). As HIV and homicide are important causes of premature mortality among black and Hispanic people, we further projected years of life lost due to premature mortality for these causes (appendix). Substantial decreases in years of life lost due to premature mortality are projected for HIV in black (1·5% in 2013) and Hispanic (0·9% in 2030) men and black (0·4% in 2030) and Hispanic (0·2% in 2030) women, whereas years of life lost due to premature mortality caused by homicide are projected to remain relatively stable in all four of these groups (20·9% in

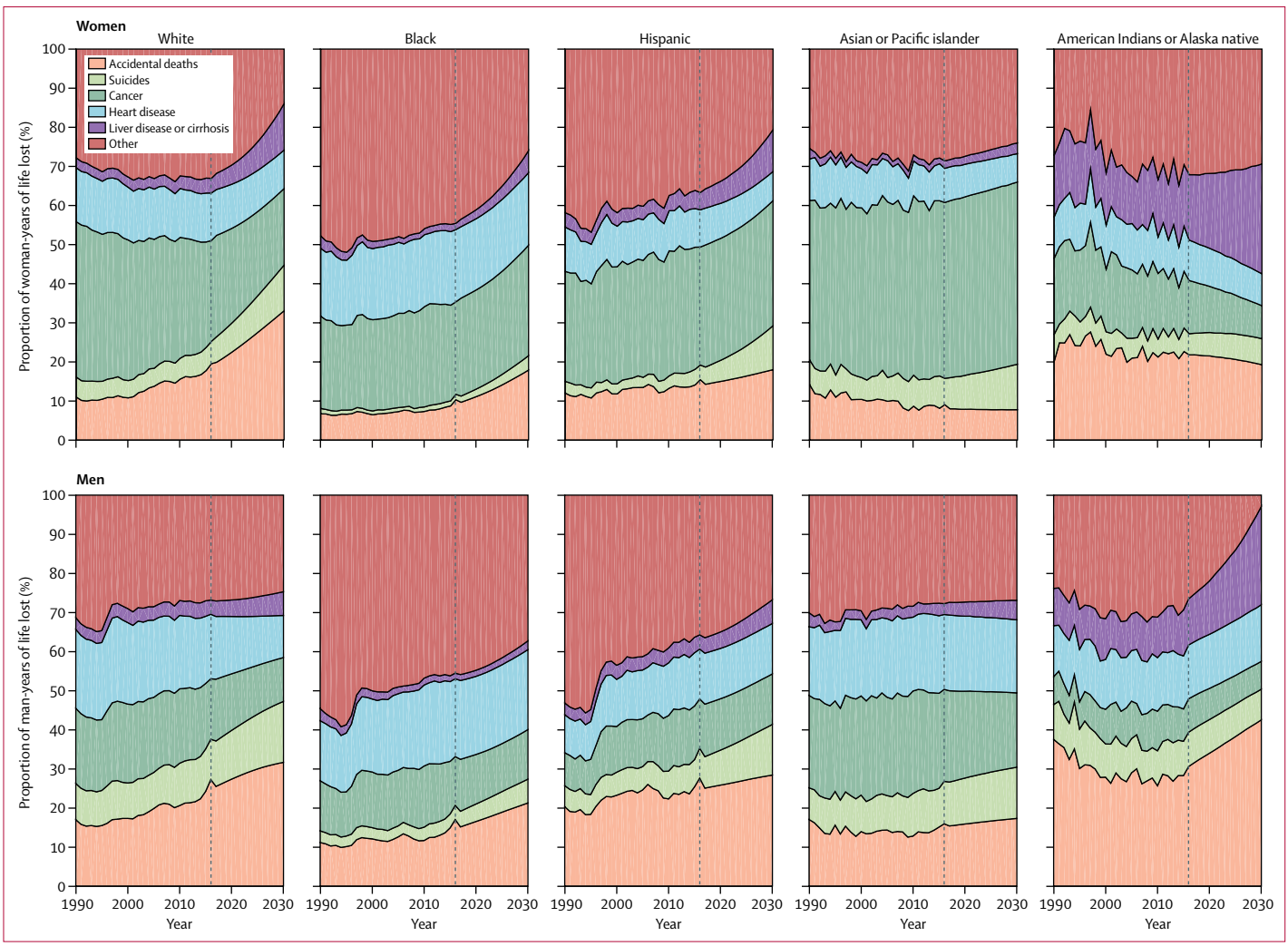

Figure 3: **Observed and projected proportion of total annual person-years of life lost up to age 65 years**

black men in 2030, 4·7% for black women, 5·4% for Hispanic men, and 1·9% for Hispanic women).

Substantial period increases were observed in accidental and all-cause mortality during 2014–15, across ages and racial groups. As a sensitivity analysis, we also projected using trends in the period rate ratio; these forecasts predict substantial increases in all-cause and accidental mortality rates if recent trends continue (appendix).

Public health interventions leading to an overall 2% per year reduction in projected accidental deaths would have the largest effect in white people, resulting in 131400 fewer accidental deaths during 2017–30 (figure 4). An additional 19800 accidental deaths among black people, 20300 among Hispanic people, 2800 among Asian or Pacific islanders, and 4200 among American Indian or Alaska natives would also be averted. Reductions in accidental deaths would also eliminate the projected increase in all-cause mortality among American Indian or Alaska native men and white people aged 25–44 years, but not American Indian or Alaska native women, for whom other causes of death contribute substantially.

Discussion

According to our projections extrapolated from observed age and birth cohort trends in mortality, the unexpected divergence of premature death rate trajectories by race or ethnicity and sex will become more prominent in the coming decade. Projected increases in premature deaths among white women and American Indians or Alaska natives are estimated to cause an additional 239700 premature deaths during 2017–30 relative to expected deaths if rates remain constant at 2015–16 frequencies—an increase of 10%. By contrast, continued declines in white men and black, Hispanic, and Asian or Pacific islander men and women are expected to result in 945900 fewer premature deaths during the same time period—a reduction of 14%. The largest increases in projected mortality rates are in accidental

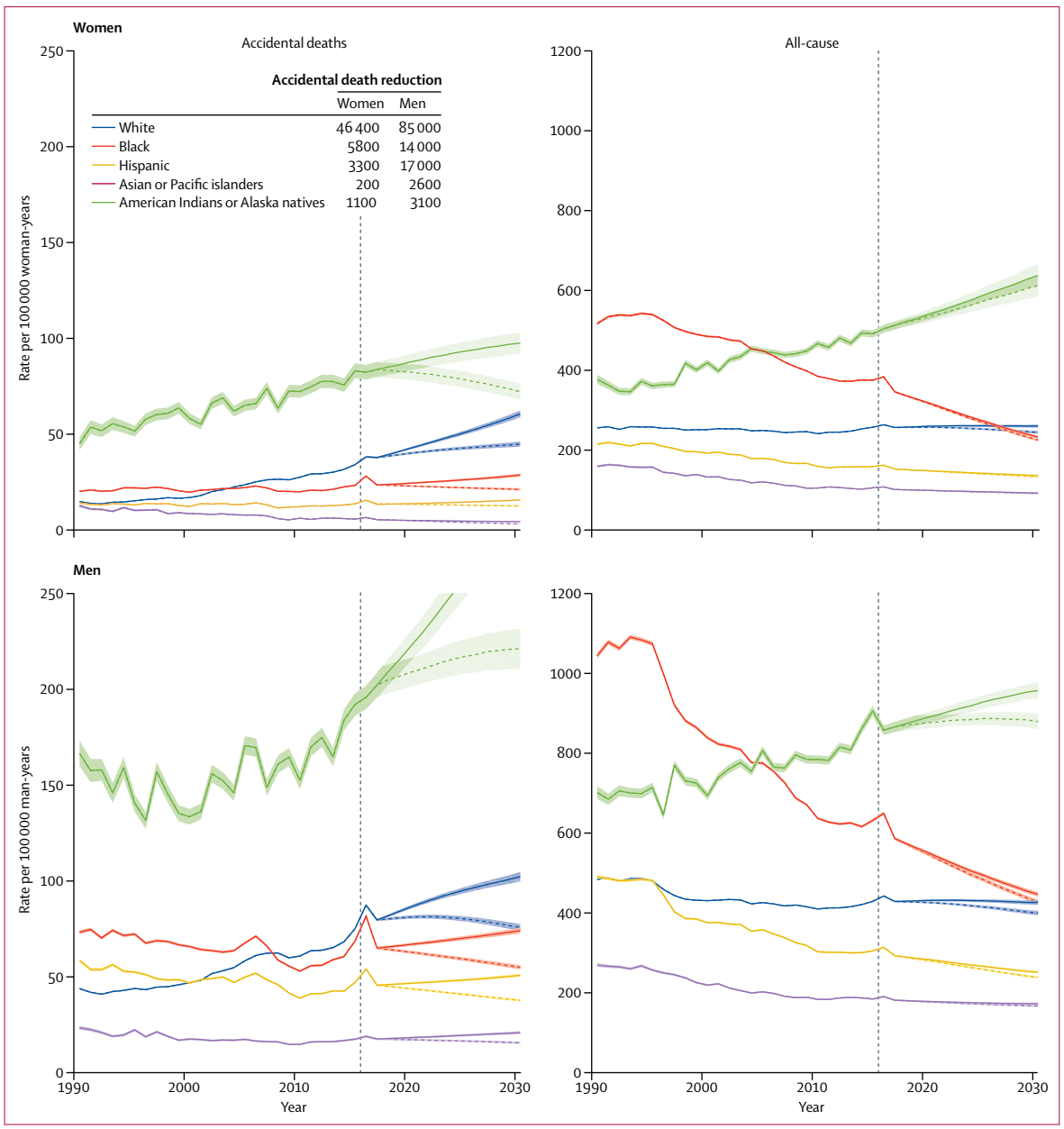

Figure 4: **Observed and projected 1990–2030 age-standardised cause-specific mortality rates for people aged 25–64 years**
Dashed curves show estimates based on optimistic projections (2% per year reduction in projected mortality due to accidental death); solid curves show estimates based on base-case projections. Vertical dotted line at 2016 marks the end of the observation period. Shaded areas denote pointwise 95% CIs for the mean age-standardised rate. Table shows estimated reduction in accidental death burden during 2017–30.

deaths,[5] and cancer mortality rates will have the largest declines.

If current trends continue, increasing accidental death mortality rates in white people and American Indian or Alaska native women will cause 112 000 additional premature deaths during 2017–30. These increases are driven by opioid and other drug poisonings, as deaths due to motor vehicle accidents have declined steadily over time.[5] Large increases in rates of drug poisoning mortality from 2014 to 2016 add further urgency, and immediate intervention is needed to prevent future increases. Federal legislation on addiction was signed into law in July, 2016, focusing on prevention, education, treatment, and recovery.[20] Our analyses show that if newly introduced or expanded and sustainable public health interventions could successfully reduce projected accident-related mortality by 2% per year, 178 700 deaths would be averted during 2017–30, and the projected increase in all-cause mortality rates among American Indians or Alaska natives and 25–34-year-old white people would be eliminated.

Suicides and chronic liver disease and cirrhosis deaths are also projected to increase through 2030 in some racial or ethnic groups. Suicide increases are unlikely to be driven by miscoded opioid overdoses, as only 4% of suicides in 2014 were opioid-related.[21] Chronic liver disease and cirrhosis mortality has multiple causes, predominantly non-alcoholic fatty liver disease, alcoholic liver disease, and hepatitis C virus, which might be attributable to risk factors such as obesity, alcohol use, and injection drug use.[22] As at least 70% of cirrhosis deaths among those aged 25–44 years are due to alcohol,[23] recent increases in alcohol use and abuse could have contributed to the increases.[24] If these increases continue unabated, an additional 19 100 suicides and 11 200 chronic liver disease and cirrhosis deaths will occur among white people and American Indians or Alaska natives during 2017–30 compared with what is expected based on 2015–16 rates.

We predict that decades-long progress in prevention of cancer and heart disease deaths will continue in most US populations,[4] with 418 200 fewer deaths during 2017–30 relative to 2015–16 rates. Declines in cancer mortality have largely been attributable to decreases in cigarette smoking, increases in cancer screening, reduced surgical mortality, and advances in therapy.[25] Declines in heart disease mortality have largely been attributed to decreases in risk factors and advances in medical and surgical treatment.[26–28] Premature cancer and heart disease mortality could continue to improve given sustained declines in smoking, cholesterol, and hypertension,[27,29] and presumed future advances in medical care and treatment. However, premature heart disease deaths are projected to decrease only slightly in white and American Indian or Alaska native women and increase in American Indian or Alaska Native men and 25–34-year-old white, Hispanic, and Asian or Pacific islander men, potentially due to increases in obesity and diabetes.[25,28] Additionally, prescription opioids increase the risk of non-overdose-related cardiovascular disease deaths.[30]

We have projected that, by 2027, premature mortality among white women will be higher than among black women, and will be close to convergence for white and black men in 2030, due to a combination of increases in deaths among white people and continuing declines among black people. Importantly, declines in HIV deaths have had a large effect on premature mortality among black people.[5] Nonetheless, substantial health disparities will remain between black people and other races or ethnicities. Projected 2030 all-cause death rates will be two to three times higher in black people than in Hispanic people and Asian or Pacific islanders. Furthermore, projected cancer and heart disease deaths among black people will remain higher than those for white people, reflecting differences in both disease incidence and survival. Black people have a higher burden of chronic disease risk factors (eg, obesity and diabetes),[31,32] unequal access to preventive interventions (eg, statins and cancer screening), and differences in treatment receipt and timeliness.[25,28,33,34] Our analysis forecasts rates for people aged 25–64 years (all ethnicities), and does not project future racial or ethnic health disparities among younger or older people. Increased efforts targeted toward black communities to address chronic disease risk factors, as well as increases in access to affordable health care, are needed to address these disparities.

Projected premature mortality rates appear particularly poor for American Indians and Alaska natives. People in this population who are enrolled in a federally recognised tribe can access health care through the federally funded Indian Health Service (IHS); thus, policy decisions impacting access and delivery can be measured in the health of the population. For example, policies and funding devoted to specific diabetes programmes within the IHS were initiated in 1997, resulting in a 54% decrease in diabetes-related end-stage renal disease during 1996–2013,[35] and a substantial reduction in diabetes mortality.[36] The projected premature mortality in American Indians or Alaska natives will require substantial public health efforts to reverse, with focus on behavioural health and treatment for alcohol and opioid substance use disorder, as well as continued work in preventive health care. Innovations with telehealth are being used to improve treatment and management of liver disease in tribal areas and training for opioid substance use disorder, but it is too early to assess outcomes.[37,38] Additionally, the Affordable Care Act expanded Medicaid with increased coverage for American Indians and Alsaka natives; this has provided IHS with needed revenue for clinical services. Although the effect of this policy change is yet to be observed in population health, with a third of the American Indian or Alaska native population receiving Medicaid coverage, it is expected that there will be measurable health benefits, with potential slowing or reversing of mortality trends,[39,40] although such benefits would be affected by changes in Medicaid funding and coverage.

The main strengths of our analysis are the use of data from all deaths that occurred in the US population from 1990 to 2015–16, and the use of age–period–cohort forecasting methods, which account for different trends across age groups that are a consequence of birth cohort effects. Although these models fit the observed data well, our projections are dependent on model assumptions, and do not consider the possible effects of already implemented interventions that have not yet reached full effectiveness, nor of potential future interventions or catastrophes. However, they offer a plausible estimate of the future if cohort patterns continue on the same trajectory as observed. Our analysis is limited by its reliance on death certificates for cause of death and race or ethnicity data;[41,42] however, the CDC mortality database provides the most comprehensive available information on deaths in the USA. The reported uncertainty in our projections reflects that of our model; additional uncertainty is always

inherent in projections because of the potential for unforeseen events. We were unable to obtain 2016 rates for American Indians or Alaska natives specific to CHSDA counties through CDC WONDER. Finally, future mortality among Hispanic people and Asian or Pacific islanders could be influenced by future immigration patterns, given the large fractions of foreign-born people (34% of Hispanic people and 67% of Asian or Pacific islanders) in these groups.[43]

Our methods provide forecasts based on observed long-term cohort trends and second-order period effects. Therefore, our forecasts are less reflective of very recent period changes—for example, rapid accidental mortality increases in white, black, and Hispanic people during 2014–16 (figure 2). In our primary model, these fluctuations are included as a higher order period effect on the observed periods only, causing a gap from the 2016 observed and 2017 forecast rates (figures 1, 2). Whether these increases represent a temporary perturbation or a harbinger of large future mortality increases is unclear. Our sensitivity analyses include a projection based primarily on period trends, which suggests potentially very large future increases in accidental deaths in white, black, and Hispanic people. In light of these projections, reports of increasing contamination of cocaine and heroin with fentanyl[44,45] are of concern, and recent preliminary data indicate that continued short-term increases are likely.[46] Future descriptive studies tracking trends in accidental deaths over the next few years will be of crucial importance.

On the basis of recent trends, we have projected substantial increases in death rates among American Indians or Alaska natives and 25–44-year-old white people through 2030. These increasing mortality rates are unusual and alarming, given that life expectancy is generally projected to increase worldwide.[1] The largest driver of these increases is the ongoing drug epidemic. Interventions aimed at curbing drug overdoses could prevent deaths across all demographic groups, and would have a substantial impact on mitigation of expected future mortality. However, recent increases in accidental deaths from 2014–16 suggest worsening rather than improving trends. Rapid and effective interventions to address rapidly increasing deaths due to drug poisonings, suicide, and chronic liver disease and cirrhosis, and sustained prevention and treatment efforts toward continued reductions in cancer and heart disease deaths, are urgently needed to prevent future premature deaths.

Contributors

AFB, PSR, and MSS designed the study and analysed the data. AFB, EAH, PSR, and MSS wrote the manuscript. All authors interpreted the data and provided manuscript feedback.

Declaration of interests

We declare no competing interests.

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