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Trends in health equity in mortality in the United States, 1969–2019

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A B S T R A C T :

Rationale: Health equity is a significant concern of public health, yet a comprehensive assessment of health equity in the United States over time is lacking. While one might presume that overall health will improve with rising living standards, no such presumption is warranted for health equity, which may decline even as average health improves.

Objectives: To assess trends in national and state-level health equity in mortality for people up to age 25, ages 25–64 and aged 65 and older.

Methods: A health equity metric was calculated as the weighted mean life expectancy relative to a benchmark level, defined as the life expectancy of the most socially-privileged subpopulation (white, non-Latinx males with a college education or higher).

We analyzed 114,558,346 death records from the National Center for Health Statistics, from January 1, 1969 to December 31, 2019 to estimate health equity annually at the national and state-level. Using ICD-9/ICD-10 classification codes, inequities in health were decomposed by major causes of death.

Results: From 1969 to 2019, health equity in the United States improved (+0.36 points annually [95% CI 0.31–0.41]), albeit at a slower rate over the last two decades (+0.08 points annually [95% CI 0.03–0.14] from 2000 to 2019, compared to +0.57 points annually from 1969 to 2000 [95% CI 0.50–0.65]). Health equity among those under 25 improved substantially (+0.82 points annually [95% CI 0.75–0.89]) but remained flat for adults 25–64 (−0.01 points annually [95% CI -0.03-0.003]) For those over 65, health equity displayed a downward trend (−0.08 points annually [95% CI -0.09 to −0.07]). Gains in equity from reduced unintentional injuries and homicides have been largely offset by rising mortality attributable to drug overdoses.

Conclusions: The US is failing to advance health equity, especially for adults. Keeping policy-makers accountable to a summary measure of health equity may help coordinate efforts at improving population health.

1. Introduction

Relative to other high-income countries, the United States performs poorly across a number of health indicators, including life expectancy (National Research Council; Committee on Population, 2011; National Research Council, 2013). Even before the COVID-19 pandemic, average life expectancy in the United States had begun to decline, a worrying development given that it had been regularly increasing over the previous several decades (Case & Deaton, 2015; Muennig et al., 2018; National Academies of Sciences E. & Medicine, 2021). These trends are disturbing in their own right. They would be even more concerning if they were disproportionately experienced by less-privileged populations, since this would threaten ambitious goals of achieving a more equitable society.

Health equity has many different definitions. Here we adopt Braveman et al., 's 2017 version as the conditions under which "everyone has a fair and just opportunity to be as healthy as possible" (Braveman et al., 2017). Although this definition emphasizes the health of the *entire population*, measurement of health equity tends to devolve into narrow assessments of disparities between 2 socially-distinct groups on specific measures of health.

These concerns apply directly to mortality outcomes in recent years — existing literature describes declining life-expectancy disparities by race/ethnicity, but increasing disparities by income and education (Bosworth, 2018; Chetty et al., 2016; Crimmins & Zhang, 2019; Geronimus et al., 2019; Sasson, 2016; Sasson & Hayward, 2019). Furthermore, these top-line disparities omit important detail. For example, widening educational disparities over recent decades have disproportionately occurred in Midwest and Southern states (Montez et al., 2019). It is therefore unclear to what extent progress has been made in recent decades in achieving overall health equity with respect to life expectancy.

Assessing overall health equity for a single health outcome such as life expectancy requires a metric that can summarize these various subtrends in a single measure, while also encapsulating a set of values exemplary of a more just society. Without a clear understanding of whether health equity on the whole is improving or declining, it is difficult to assess whether health and social policies are having their

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desired effect.

This emphasis on health equity as a whole is consequential: intervention or policy can reduce one kind of disparity while having no effect—or even an adverse effect—on another. For example, Medicare improves access to hospital care among low-income people, but by far more among whites than among Blacks (Card et al., 2008). In this example, Medicare reduces socio-economic disparities but worsens racial disparities.

Previous work has developed a methodology for evaluating health equity tailored to the Braveman et al. definition provided above (Zimmerman, 2019). Results for self-reported subjective health measures show that in the past two and a half decades, health equity among adults has declined, while slightly increasing for children (N. W. Anderson & Zimmerman, 2021; Zimmerman & Anderson, 2019). Yet assessing health equity over self-reported subjective measures of health has limitations. First, health is a multidimensional construct, meaning equity could be increasing for certain outcomes and not others. Second, these results may be subject to shifting perceptions over time of what it means to be healthy or (third) to cultural differences in how health is understood. For these reasons, a measure of overall health equity assessed on a concrete and objective health outcome may either confirm or call into question these previously observed trends. Mortality is one such concrete measure. Moreover, mortality can be decomposed into various causes, thus providing policymakers with additional information as to how they can promote health equity. For these reasons, employing the health equity methodology to the outcome of life expectancy will bring additional insight as to whether the nation is making progress toward its goals.

This analysis applies the health equity metric to more than 50 years of mortality data. The estimates are disaggregated to reveal state and regional trends, and national trends in health equity are decomposed by select causes of death. While we find that health equity has increased for the overall population in this period, there are several worrying developments that suggest greater improvement is required in the future.

2. Methods

2.1. Data

Mortality data for 1969–2019 is from Vital Statistics of the Centers for Disease Control and Prevention (National Center for Health Statistics, 1969-2019). State is assigned to each death record based on the decedent's residence status, rather than where it occurred. For records up to 1989, state and county identifiers are publicly available. We have access to restricted-use death records with state and county identifiers for 1989–2019.

Annual population estimates at the national and state level are calculated using a combination of Surveillance, Epidemiology and End Results population estimates and American Community Survey data (Ruggles et al., 2020; Surveillance Epidemiology, 1969).

2.2. Analytic method

The Health Equity Metric (HEM) starts with the deficit of individual health from a benchmark level of health (Zimmerman, 2019). This deficit is then subject to a non-linear transformation, so that larger deficits relative to the benchmark level are weighted more-than-proportionately than multiple smaller deficits. With this non-linear transformation in the HEM, and holding all else equal, a society in which 1% of the population dies 10 years prematurely is less equitable than a society in which 10% of the population dies 1 year prematurely, even though the years of life lost in each are the same. This higher weighting of greater departures from health operationalizes Braveman et al.'s construct of a "fair and just opportunity" for all persons. While widely shared small departures from optimal health may be consistent with a fair and just opportunity—after all, perfect health for all is not attainable—a small number of large departures are not consistent with fair and just opportunity for health. This feature is an important addition for population-health monitoring because it gets at not only average health shortfalls, but also their distribution within society. Note that disparities measures typically used—the difference in means between a privileged group and a marginalized group—lack this important conceptual component of health equity.

The second trait of health equity emphasized by our measure concerns the phrase "as healthy as possible." Although there are inevitable differences across individuals in their health potential, health equity is concerned with differences specifically related to social marginalization. The HEM therefore conceptualizes a single benchmark level of health that can reasonably represent the attainable health potential of the overall population in an equitable society. This is critical because it sets an explicit goal that policymakers can strive towards. That goal, or benchmark, is here conceptualized as the typical level of health of a privileged subgroup, defined here as college-educated, non-Latinx white men. The Health Equity Metric therefore makes an implicit value statement: that all people have a right to be as healthy as those in the most privileged group. Although women have a longer life expectancy, men are used as the benchmark because the construct of health equity refers specifically to social privilege (Braveman et al., 2017).

With these two properties in mind, the health equity metric is defined as follows:

$$HEM = 100 - 10,000 \cdot \left[\frac{1}{N} \sum_{i=1}^{N} \left(\beta^* \max \left\{ \frac{\bar{y}^* - y_i}{\bar{y}^*}, 0 \right\} \right)^{\alpha} \right]$$

where HEM is the health equity metric, N is the total number of individuals in the population, y_i is individual *i*'s health status, $\bar{y}^*$ is the benchmark level of health, α is a leverage parameter that ensures larger deficits from the benchmark level of health are weighted more heavily, and β is a scale parameter. Consistent with prior work in the literature, this analysis uses $\alpha = 2.5$ and $\beta = 2$, which have been shown to exhibit desirable properties for a measure of health equity (Zimmerman & Anderson, 2019). The health equity metric can range from negative numbers indicating very poor health equity to 100, representing perfect health equity.

Health equity is a feature of the distribution of health across a population, and not a measure of any individual's health. Individuals do not have equity - populations do. Like any measure of spread within a distribution, the health equity metric has no intuitive meaning and its units can be difficult to understand. For this reason, the health equity metric, like the Gini coefficient, is best understood by comparing its value across similar jurisdictions at a single time or within a single jurisdiction over time. Further detail on estimating the HEM is provided in Appendix A.

Since trends in health equity may vary within the age distribution of a population, we estimate the HEM for age 0–24, 25–64 and age 65 and older separately. The choice to divide these three groups is based on its extensive use in previous literature examining mortality among adults aged 25 and older, as well as recent efforts to split the working-age adult population from the elderly (Crimmins & Zhang, 2019; National Academies of Sciences E. & Medicine, 2021). For the benchmark level of health we use conditional life expectancy at the youngest year in the age group (0, 25, and 65, respectively).

We also decompose the HEM by select causes of death from 1979 onward, after ICD-9 and ICD-10 codes became available. We begin with any cause found in the top 10 causes for any racial/ethnic group published in the annual Vital Statistics mortality report from 1984 to 2017 (Heron, 2019). Since there has been particular interest in death from drug overdose in recent literature, mortalities caused by unintentional or undetermined deaths from drug overdose are separated from the larger category of deaths from unintentional injury. Occasionally, we group these drug overdose deaths with deaths from suicide and deaths from liver disease to form the category of deaths of despair, as has been done elsewhere (Case & Deaton, 2015; Gennuso et al., 2019; Geronimus

et al., 2019). We also combine several causes surrounding maternal and infant deaths into a single category. The final set of causes is shown in Online Appendix Table B1.

Cause-specific inequity (*HI*) for cause *j* was assessed as:

$$HI_j = 10,000 * \frac{1}{N} \sum_{i=1}^{N} D(j) \cdot \left(\beta^* \max \left\{ \frac{\bar{y}^* - y_i}{\bar{y}^*}, 0 \right\} \right)^{\alpha}$$

Where *D(j)* is 1 if individual *i* died of cause *j* and 0 otherwise. This formulation describes what total health inequity would have been if inequities from all other causes were reduced to 0.

All analyses are conducted in Stata statistical software version 17 (StataCorp LLC).

3. Results

Fig. 1 shows the national health equity metric for mortality from 1969 to 2019 for the entire population, as well as for the populations aged 0–24, 25–64 and 65+ separately. For the total population, health equity improves over the study period, with the HEM increasing from 59.2 in 1969 to 80.7 in 2019. Most of the improvement occurs in the years prior to 1990 (73.1% of the total increase) with only modest improvements (4.0% of the total increase) after 2000.

Table 1 shows trends over time using a linear regression of the HEM on the year. Over the period from 1969 to 2019, health equity increases 0.36 points annually (95% CI 0.31–0.41). However, there is significant effect-modification of this result by age, with health equity increasing for those under 25 (+0.82 annually; 95% CI 0.75–0.89), remaining flat for those 25–64 (−0.01 annually; 95% CI -0.03- 0.003), and slightly declining for those 65 and older (−0.08 annually; 95% CI -0.09 to −0.08). There are also different sub-trends over the past 50 years in health equity, with all three groups performing worse after 2000. Those under 25 experience an annual increase of 1.13 (95% CI 1.00–1.26) between 1969 and 1999, which moderates to only 0.40 (95% CI 0.32–0.48) for 2000–2019. For working-age adults 25 to 64, trends in health equity are not statistically significant from 1969 to 1999 (0.015 annually; 95% CI -0.02- 0.05), and declining from 2000 to 2019 (−0.13 annually afterwards; 95% CI -0.18 to −0.08). For adults aged 65 and over, declines in health equity accelerate post-2000, from −0.05 annually beforehand (95% CI -0.06 to −0.04) to −0.14 annually afterwards (95% CI -0.14 to −0.13).

Fig. 2 shows state-level HEMs from 1969 to 2019 by age group. The improvement among youth during this period is clear, as is the general stagnation in health equity for those over 25 in recent years. There are distinct geographic trends in health equity. For all three populations, and in any given year, HEMs are higher in the Northeast, Upper Midwest, and West than elsewhere. Notwithstanding improvement over time, health equity for children in the South in any year is generally lower than for other areas of the country. Similarly, for the population 25–64, levels of health equity in the South and Appalachia are low for the entire study period. This is also the case for the 65 and older population, but the national trend of decline is generally stronger than the regional patterns. See Online Appendix Figure C1 for Census Division trends in health equity.

Table 1
National trends in health equity metrics (HEMs) by age group, 1969–2019

Population	Annual Coefficient	95% Confidence Interval	p-value
Period: 1969–2019			
Total	0.359 (0.023)	0.313–0.405	<.001
Ages 0 to 24	0.818 (0.036)	0.747–0.890	<.001
Ages 25 to 64	−0.014 (0.008)	−0.031– 0.003	0.096
Ages 65+	−0.081 (0.003)	−0.088–−0.075	<.001
Period: 1969–1999			
Total	0.573 (0.037)	0.498–0.648	<.001
Ages 0 to 24	1.127 (0.063)	0.999–1.255	<.001
Ages 25 to 64	0.015 (0.016)	−0.018–0.048	0.356
Ages 65+	−0.052 (0.004)	−0.059–−0.044	<.001
Period: 2000–2019			
Total	0.085 (0.024)	0.034–0.136	.003
Ages 0 to 24	0.400 (0.039)	0.317–0.482	<.001
Ages 25 to 64	−0.131 (0.025)	−0.183–−0.079	<.001
Ages 65+	−0.136 (0.004)	−0.144–−0.128	<.001

Notes: Table shows the coefficients from a linear regression of the national HEM on year. Standard errors are reported in parentheses.

Table 2 shows national levels of health inequity by select causes in 2019 for all three subpopulations. For the population under 25, the largest cause of health inequity is infant/maternal mortality (6.3 HEM points), followed by unintentional injuries (3.8 HEM points), suicide (1.8 HEM points), homicide (1.7 HEM points), and drug overdose (1.1 HEM points). For working-aged adults, the leading causes of inequity in 2019 are cancer (3.6 HEM points), drug overdose (3.3 HEM points), heart disease (3.0 HEM points), unintentional injury (2.0 HEM points), suicide (1.7 HEM points) and diabetes (1.2 HEM points). For the elderly, cancer (2.9 HEM points) and heart disease (2.1 HEM points) are the two clear leading causes.

Fig. 3 further examines cause-specific inequities by charting trends since 1979. Note that this figure shows health *inequity*, not health equity as in previous figures. Reductions in under 25 health inequity are largely driven by improvements in infant/maternal mortality and unintentional injuries. For infant/maternal deaths, health inequity declines from 17.0 points to 6.3 points, a 63% improvement. For deaths from unintentional injury, inequity declines from 11.4 to 3.8 points, a 67% improvement.

Despite the modest decline in health equity over this period for the 25–64 population, there are improvements in some of the causes. For deaths from unintentional injury, health inequity declines from 3.5 points to 2.0 points, a 41% improvement. Additionally, inequity for deaths from homicide declines from 1.3 to 0.9, a 31% improvement. Lastly, inequity from HIV is high in the 1990s – placing it on par with heart disease – but falls off considerably by 2019.

However, the improvements from these causes are offset by increasing inequity attributable to other causes. Drug overdose inequity increases over the period, from 0.2 to 1.1 points for those under 25, and from 0.2 to 3.3 points for those 25 and older. Suicide and diabetes register modest increases in their contributions to health inequity for working-age adults, and the two largest sources of inequity—cancer and heart disease—have seen little net change over time.

The increases in health inequity for the elderly are primarily driven by chronic disease, with the exception of heart disease. Inequity from cancer increases from 1.7 to 2.9 points, or 39% of the total increase in inequity from 1979 to 2019 among the elderly. Inequity from other non-heart chronic diseases increases from 1.2 to 2.9 points.

State-level increases in mortality inequity from drug overdose reveal stark geographic differences (Fig. 4). States in the Northeast, Middle Atlantic, East North Central, and South Atlantic suffered far greater increases in health inequity attributable to drug overdose from 1979 to 2019. Inequity is rising fastest among the working-age adult population, especially in Delaware (8.4 point increase), West Virginia (8.2 point increase), Ohio (6.2 point increase), and Pennsylvania (5.6 point increase). Several of these states have values more than twice as high as the national average (3.1 point increase). Increases in poisoning inequity among the elderly are highest in many of the same states, as well as several in the West. Changes in inequity for other select causes is found in Online Appendix Figures D1-D.3.

4. Discussion

This analysis applies a measure of health equity for mortality to data from the United States from 1969 to 2019. We find evidence that health equity increased for the entire population over this period. However, since 2000 these gains have largely stagnated, and even reversed for the working-age adult population. Among the elderly, health equity has slightly declined over the past 50 years, with an acceleration in the past

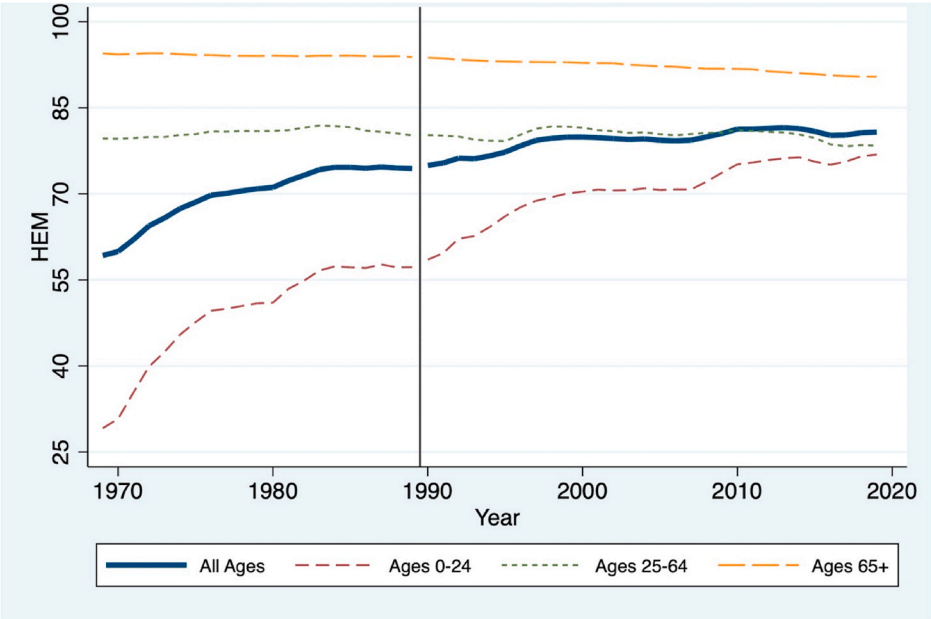

Fig. 1. National Health Equity Metric (HEM) from 1969 to 2019
Notes: HEM is presented in units such that a value of 100 represents perfect health equity. The vertical black line denotes change in definition of privileged group for health potential benchmark (from white males for 1969–
1989 to white, non-Latinx males with at least a college education for 1990–2019). Years prior to 1990 are shifted downwards to make estimates across two periods more directly comparable (see Appendix A).

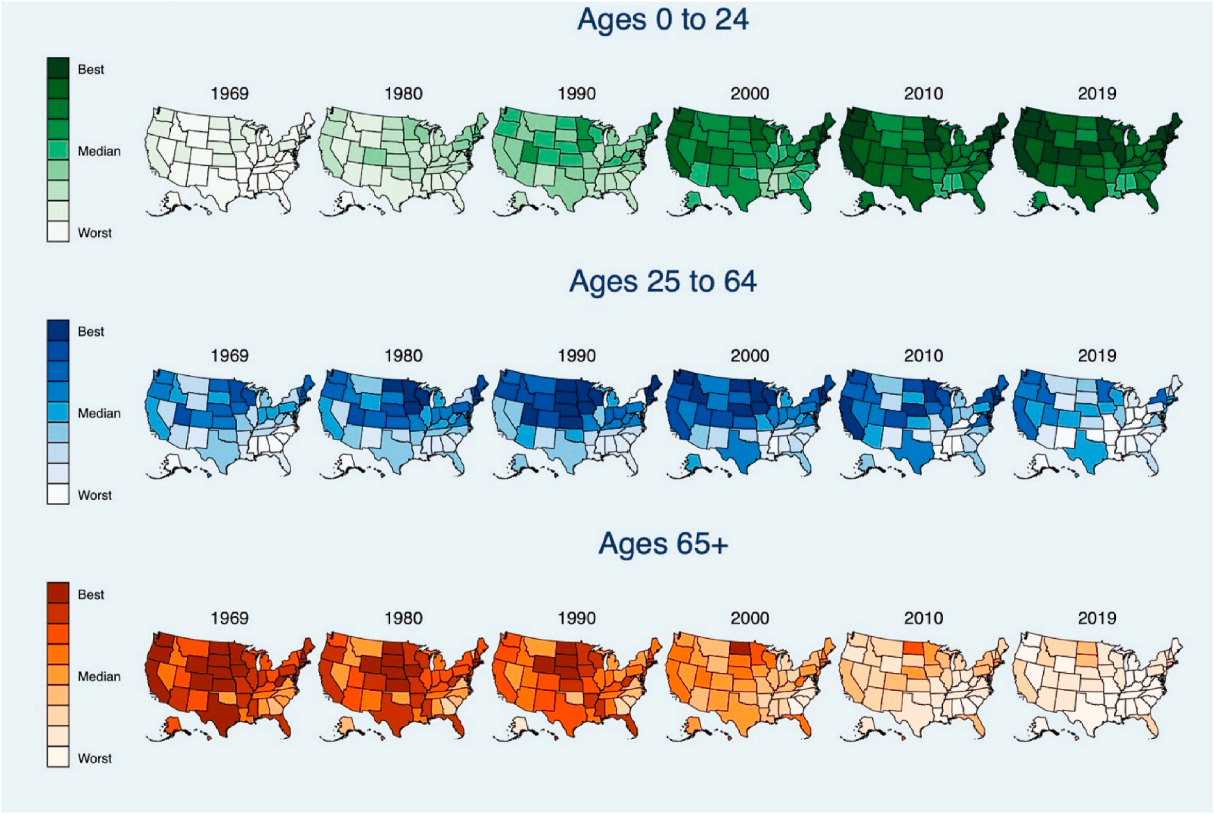

Fig. 2. State Health Equity Metrics (HEMs) by Quantile from 1969 to 2019
Notes: Darker hues indicate better HEM scores. For HEMs from 1969 to 1989, the privileged group for health potential benchmark is white males, while for 1990 and onward, this definition is white, non-Latinx males with at least a college education. Years prior to 1990 are shifted downwards to make estimates across two periods more directly comparable (see Appendix A). For each age group, state HEMs are grouped into nine category quantiles for all years shown in the period (51 states * 6 years displayed = 306 possible HEM values, or 9 groups of 34 states across all years).

two decades.

Notwithstanding recent reversals in the US, life expectancy generally increases over time through improvements in medical technology, rising standards of living, and knowledge surrounding health behaviors. However, unlike average health, which should respond to *average levels* of prosperity in a population, health equity, which reflects the *distribution* of resources in a population, may remain stagnant or even decline during periods of overall prosperity.

Table 2
Leading causes of health inequity in 2019.

Age 0-24		Age 25-64		Age 65+	
Cause	HEM Points Lost	Cause	HEM Points Lost	Cause	HEM Points Lost
Infant/Maternal	6.31	Malignant Neoplasms	3.57	Malignant Neoplasms	2.93
Unintentional Injuries	3.82	Drug Overdoses	3.32	Diseases of Heart	2.11
Intentional Self-Harm (Suicide)	1.77	Diseases of Heart	3.03	Diabetes Mellitus	0.86
Homicide	1.69	Unintentional Injuries	2.03	Chronic Lower Respiratory Disease	0.66
Drug Overdoses	1.12	Intentional Self-Harm (Suicide)	1.75	Cerebrovascular Disease	0.41
Malignant Neoplasms	0.85	Diabetes Mellitus	1.17	Alzheimer's Disease	0.40
Diabetes Mellitus	0.55	Homicide	0.91	Unintentional Injuries	0.25
Diseases of Heart	0.51	Chronic Liver Disease and Cirrhosis	0.78	Chronic Liver Disease and Cirrhosis	0.19
Influenza and Pneumonia	0.24	Alzheimer's Disease	0.63	Nephritis, Nephrotic Syndrome and Nephrosis	0.19
Cerebrovascular Disease	0.16	Cerebrovascular Disease	0.50	Septicemia	0.15
Septicemia	0.15	Chronic Lower Respiratory Disease	0.42	Influenza and Pneumonia	0.15
Chronic Lower Respiratory Disease	0.13	Influenza and Pneumonia	0.24	Hypertension*	0.11
Alzheimer's Disease	0.07	Septicemia	0.23	Intentional Self-Harm (Suicide)	0.09
Nephritis, Nephrotic Syndrome and Nephrosis	0.06	Nephritis, Nephrotic Syndrome and Nephrosis	0.22	Drug Overdoses	0.06
HIV^	0.01	HIV^	0.16	HIV^	0.01
Chronic Liver Disease and Cirrhosis	<0.01	Hypertension*	0.14	Homicide	0.01
Hypertension*	<0.01	Infant/Maternal	0.09	Infant/Maternal	<0.01

Notes: HEM = Health Equity Metric. ^: HIV = Human Immunodeficiency Virus. *: Hypertension = Essential Hypertension and Hypertensive Renal Disease. Health inequity for all causes sums up to the distance between the national HEM and 100. See Online Appendix Table B1 for ICD-10 codes associated with select causes of death.

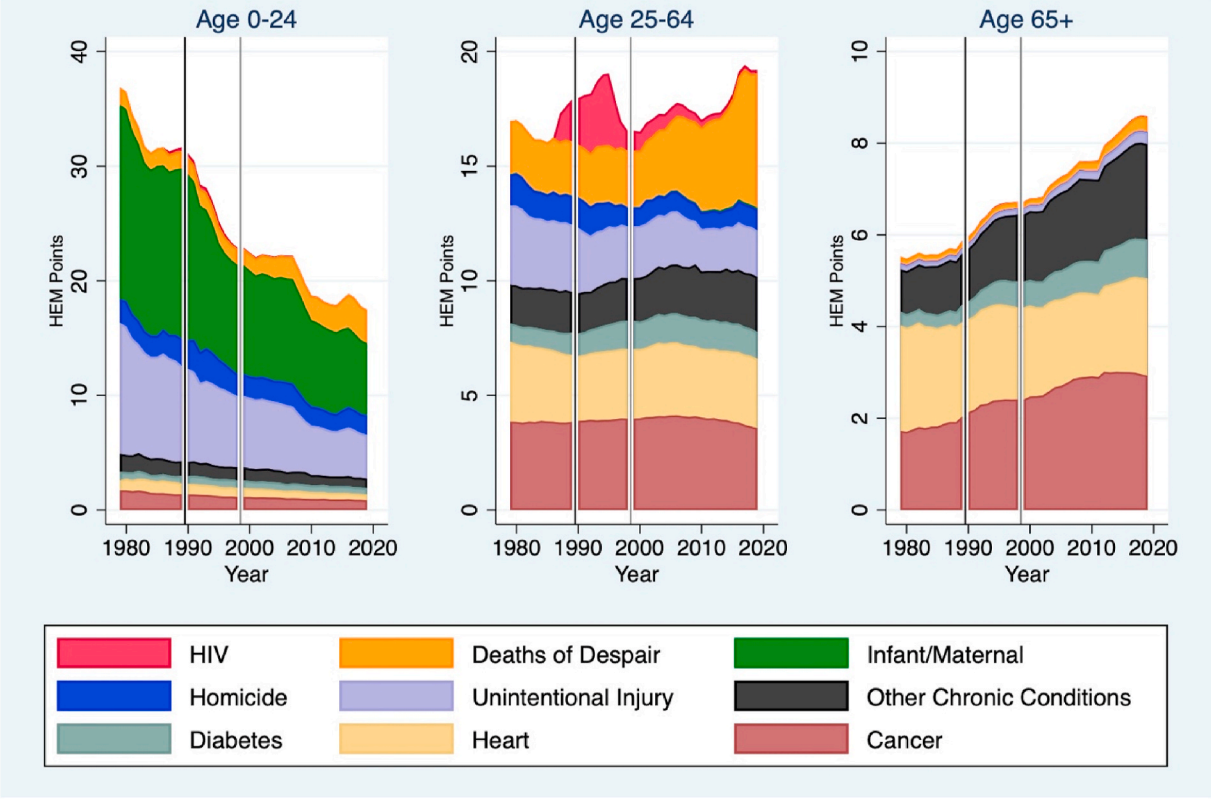

Fig. 3. Cumulative Health Inequity by Grouped Causes, 1979-2019
Notes: This figure shows health inequity, as opposed to previous figures which show health equity. Health inequity for all causes sums up to the distance between the national Health Equity Metric and 100. Causes in the key are arranged from top to bottom in the figure.
Deaths of Despair include mortalities attributed to drug overdose, suicide, and alcohol-related liver Disease. Chronic conditions include mortalities attributed to respiratory disease, stroke, Alzheimer's, kidney disease, flu, septicemia, and hypertension.
Black vertical line represents the change in definition of the privileged: from 1969 to 1989, the privileged group for health potential benchmark is white males, while for 1990 and onward, this definition is white, non-Latinx males with at least a college education. Years prior to 1990 are shifted downwards to make estimates across two periods more directly comparable (see Appendix A).
Gray vertical line represents the change from ICD-9 to ICD-10 cause of death coding. We adopt the comparability ratio methodology proposed by Anderson to make the two periods more comparable (R. N. Anderson et al., 2001).

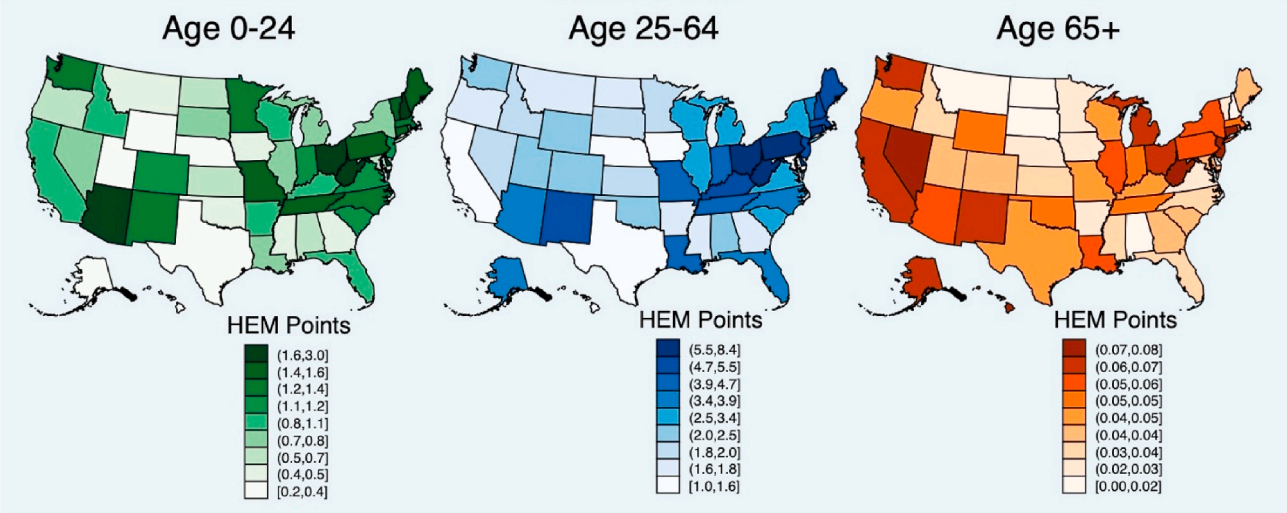

Fig. 4. Increase in Health Inequity from Drug Overdose, 1979-2019
Notes: Health inequity for all causes sums up to the distance between the Health Equity Metric and 100. For reference, in 1990 the poorest performing state for the population 25–64 (NM = 0.91) had lower levels of health inequity attributable to drug overdoses than the best performing state in 2019 (NE = 1.08). For the population 0–24, only one state in 1990 (NM = 0.38) had worse levels of health inequity attributable to drug overdose than any state in 2019 (HI = 0.33). For the population 65 and older, only three states in 1990 (AR, DC, & VT) had worse levels of health inequity attributable to drug overdose than any state in 2019 (NH = 0.01). DC is omitted for the population 65 and older in 2019 because it is an outlier (0.55 points).

The fundamental-causes theory of health suggests that the benefits of improvements in medical technology and care quality will be distributed first to the well-off, and will only later—if at all—reach those who are socially marginalized (Link & Phelan, 1995; Timmermans & Kaufman, 2020). This theory implies that increases in life expectancy are weakly correlated to increases in health equity in mortality, a result that is confirmed here. From 1969 to 2019, life expectancy increased by 8.6 years, and overall health equity increased by about 22 points. Yet from 2000 to 2019, life expectancy increased by 1.9 years, while overall health equity remained unchanged, and even declined by about 3 points for those ages 25–64. Results such as these suggest that efforts to combat individual health disparities without addressing larger social forces may not succeed in advancing health equity (Gutin & Hummer, 2021).

Literature on health disparities in adult mortality prior to the COVID-19 pandemic has found widening socio-economic disparities alongside narrowing racial disparities (Crimmins & Zhang, 2019). The work here suggests that for adults, the adverse effects of economic disparities have outweighed any improvements in racial disparities over that period, leading to a net negative effects on overall health equity.

The HEM has several advantages to understanding population health relative to standard measures of life expectancy. First, it explicitly defines a social-justice-informed level of health potential, against which outcomes of individuals are compared. This is critical in assessing whether longevity for the overall population is improving at a level comparable with those most socially-privileged, a necessary condition for a more equitable society. Second, because of its emphasis on individuals whose health falls short of the benchmark, the HEM is more robust to issues that may bias life expectancy at the top of the age distribution, such as coding errors at age of death for a small number of elderly people (Muennig & Glied, 2010).

Lifespan variation, a measure of the standard deviation of age-at-death, has been proposed as a measure for understanding inequality with regards to mortality (van Raalte et al., 2018). However, these measures do not articulate an objective for policymakers to strive towards that is oriented specifically around health equity, with its emphasis on social marginalization, as opposed to general variance. The goal of minimizing variation around age at death may be more challenging to articulate to constituents than a message that emphasizes all persons living as long as their privileged counterparts.

State-level analysis portrays a more detailed picture of health equity and generally comports with studies of life expectancy (Crimmins & Zhang, 2019). Health equity for the coastal and northern states generally improved at a faster rate than the rest of the country – and in the cases of California and New York, did so dramatically. Conversely, states in the South and the Ohio River Valley experienced declining health equity (see Online Appendix Figure C1). These findings support the view that health equity is under some control of policy-makers, including state and local policy-makers, and therefore represents a social choice (Montez, 2017).

Age differences in health equity trends provide clues to potential policy levers. Consistent with prior research about life expectancy, gains in health equity for the overall population are largely attributable to improvements in infant health (Currie & Schwandt, 2016; Gennuso et al., 2019). From 1970 to 2018, infant mortality in the United States fell from approximately 20 deaths to 5 deaths per 1,000, with a narrowing in absolute black-white disparities over that time period (Singh & Yu, 2019; Thakrar et al., 2018). Expansions to federal programs such as Medicaid; Women, Infants, and Children; and Healthy Start are responsible for improving infant and maternal health, thereby contributing to greater equity (Moss & Carver, 1998). Despite such gains, it is notable that the United States continues to lag behind much of the developed world in infant mortality indicators, suggesting even greater improvements in health equity are possible (Thakrar et al., 2018). Beyond infant mortality, improvements in health equity since 1990 can be attributed to reductions in unintentional injury and homicide. These are both areas in which public health is important, with policies as wide-ranging as firearm regulation, speed limits for motor vehicles, lead abatement, and access to abortion all playing a role (Donohue & Levitt, 2020; Farmer et al., 1999; Lee et al., 2017; Stretesky & Lynch, 2001).

However, these improvements have been offset by a rapid increase in deaths from drug overdose since 1990, particularly among working-age adults. This has been described as part of an epidemic of despair alongside increases in deaths from suicide and liver disease from alcohol-use (Case & Deaton, 2015). Yet despair must be understood in its social and political context (Stein et al., 2017). Similar increases in drug overdoses have not been observed in other countries undergoing deindustrialization, nor can drug overdoses be causally separated from the context of poor regulation of opioid manufacturers (Hadland et al.,

2019). States as diverse as California, Texas, and Iowa have been largely spared from adverse health-equity effects of drug overdoses. In this sense, these results further reinforce that policy has a meaningful role to play, and that improving pharmaceutical regulation is a salient health-equity issue. Furthermore, chronic diseases such as cancer, heart disease, and diabetes have remained stubbornly persistent among the working-age adult population, and even grown in prevalence among the elderly. A recent National Academy of Sciences report argues that prevention-oriented policies promoting healthy nutrition and active lifestyles are the main area where policymakers can address this issue (National Academies of Sciences E. & Medicine, 2021).

This analysis has certain limitations. Additional information on the death certificates about education and ethnicity would have made comparisons over the full study period stronger. However, using an alternative definition of health potential that is consistent across the entire study period does not strongly affect the overall trend in privileged life expectancy (Online Appendix Figure E1). Additionally, state-level variation in missingness of data on race and education, as well as different timelines in implementing a redesigned education measure, complicates comparisons across states early in the second sub-period. We address this by using a previously established imputation strategy that relies on a Bayesian framework, as well as the use of 3-year means for the state-level privileged life expectancies (See Appendix A) (Sasson, 2016). These procedures appear to sufficiently smooth out any major discontinuities in coding scheme introduced by these data quality issues. There is also some concern that estimates of the health equity metric, particularly at the state-level, are biased by immigration dynamics like salmon bias. However, the empirical evidence for the salmon bias remains inconclusive (Diaz et al., 2016). Lastly, while we have used codes included in the mortality files to attribute mortality to identifiable causes, this approach has practical and theoretical limitations. ICD coding may misattribute direct cause of death for example. However, the use of broad UCR categories as well as the acute nature of many drivers of health inequity (i.e. infant mortality, homicide, unintentional injury, drug overdose, etc.) mitigates this concern. More broadly, death certificate data does not consider underlying factors like socioeconomic status to be a cause of death, so one should not assume that causes listed on the records sum up to 100% of the observed inequities in health (Krieger, 2017).

The results of this analysis pose several implications for future work. First, more can be done to extend this analysis to understanding health equity at the local level, with differences between urban and rural jurisdictions providing one such example. Second, researchers could investigate the extent to which health equity varies within subpopulations of race/ethnicity, education, and sex. Third, this analysis does not address associations of health equity with various forms of public policy over time.

5. Conclusions

Leaders in public health have put forward ambitious goals of achieving health equity. While economic progress may generally improve life expectancy, there is no such tendency for health equity to improve over time. Improvement in health equity will require a rededication to improving the conditions in which health happens for all Americans (Zimmerman, 2021).

This analysis can help motivate and inform these efforts. There have been health equity gains over the past 50 years, but they are limited by both age and political jurisdiction. When policy has focused on improving outcomes, such as around infant mortality, health equity has improved. Where policy has been absent or ineffective, such as policing opioid prescriptions, health equity has declined. Several major challenges threatening public health, such as climate change, structural racism, and the COVID-19 pandemic, are themselves inequitably distributed, and thus threaten to erode future progress. Tackling these issues will require comprehensive, interdisciplinary approaches that address the fundamental causes of health while also engaging policymakers, advocates, and the greater public itself in a more robust commitment to health equity.

Ethics approval

The study was deemed exempt from review by the University of California, Los Angeles institutional review board, which waived the need for informed consent owing to use of deidentified data.

CRediT author statement

Nathaniel Anderson: Methodology, Software, Formal Analysis, Data Curation, Writing – Original Draft, Writing – Review and Editing, Visualization. Frederick Zimmerman: Conceptualization, Methodology, Supervision, Project Administration, Funding Acquisition.

Declaration of competing interest

None.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.ssmph.2021.100966.

References

Anderson, R. N., Miniño, A. M., Hoyert, D. L., & Rosenberg, H. M. (2001). Comparability of cause of death between ICD–9 and ICD–10: Preliminary estimates. In N. C. f. H. Statistics (Ed.), *National vital Statistics reports: Centers for disease control and prevention*.

Anderson, N. W., & Zimmerman, F. J. (2021). *Trends in health equity among children in the United States, 1997–2018*. Matern Child Health J.

Bosworth, B. (2018). Increasing disparities in mortality by socioeconomic status. *Annual Review of Public Health, 39*, 237–251.

Braveman, P., Arkin, E., Orleans, T., Proctor, D., & Plough, A. (2017). In *What is health equity? And what difference does a definition make?*. Princeton, NJ: R.W.J. Foundation.

Card, D., Dobkin, C., & Maestas, N. (2008). The impact of nearly universal insurance coverage on health care utilization: Evidence from Medicare. *The American Economic Review, 98*, 2242–2258.

Case, A., & Deaton, A. (2015). Rising morbidity and mortality in midlife among white non-Hispanic Americans in the 21st century. *Proceedings of the National Academy of Sciences, 112*, 15078–15083.

Chetty, R., Stepner, M., Abraham, S., Lin, S., Scuderi, B., Turner, N., et al. (2016). The association between income and life expectancy in the United States, 2001-2014. *Journal of the American Medical Association, 315*, 1750–1766.

Crimmins, E. M., & Zhang, Y. S. (2019). Aging populations, mortality, and life expectancy. *Annual Review of Sociology, 45*, 69–89.

Currie, J., & Schwandt, H. (2016). Inequality in mortality decreased among the young while increasing for older adults, 1990–2010. *Science, 352*, 708–712.

Diaz, C. J., Koning, S. M., & Martinez-Donate, A. P. (2016). Moving beyond salmon bias: Mexican return migration and health selection. *Demography, 53*, 2005–2030.

Donohue, J. J., & Levitt, S. (2020). The impact of legalized abortion on crime over the last two decades. *American Law and Economics Review, 22*, 241–302.

Farmer, C. M., Retting, R. A., & Lund, A. K. (1999). Changes in motor vehicle occupant fatalities after repeal of the national maximum speed limit. *Accident Analysis & Prevention, 31*, 537–543.

Gennuso, K. P., Blomme, C. K., Givens, M. L., Pollock, E. A., & Roubal, A. M. (2019). Deaths of despair(ity) in early 21st century America: The rise of mortality and racial/ethnic disparities. *American Journal of Preventive Medicine, 57*, 585–591.

Geronimus, A. T., Bound, J., Waidmann, T. A., Rodriguez, J. M., & Timpe, B. (2019). Weathering, drugs, and whack-a-mole: Fundamental and proximate causes of widening educational inequity in U.S. Life expectancy by sex and race, 1990–2015. *Journal of Health and Social Behavior, 60*, 222–239.

Gutin, I., & Hummer, R. A. (2021). Social inequality and the future of US life expectancy. *Annual Review of Sociology, 47*. null.
Hadland, S. E., Rivera-Aguirre, A., Marshall, B. D. L., & Cerdá, M. (2019). Association of pharmaceutical industry marketing of opioid products with mortality from opioid-related overdoses. *JAMA Network Open, 2*, e186007. e186007.
Heron, M. (2019). Deaths: Leading causes for 2017. *National Vital Statistics Reports, 68*, 1–77.
Krieger, N. (2017). Health equity and the fallacy of treating causes of population health as if they sum to 100. *American Journal of Public Health, 107*, 541–549.
Lee, L. K., Fleegler, E. W., Farrell, C., Avakame, E., Srinivasan, S., Hemenway, D., et al. (2017). Firearm laws and firearm homicides: A systematic review. *JAMA Internal Medicine, 177*, 106–119.
Link, B. G., & Phelan, J. (1995). Social conditions as fundamental causes of disease. *Journal of Health and Social Behavior*, 80–94.
Montez, J. K. (2017). Deregulation, devolution, and state preemption laws' impact on US mortality trends. *American Journal of Public Health, 107*, 1749–1750.
Montez, J. K., Zajacova, A., Hayward, M. D., Woolf, S. H., Chapman, D., & Beckfield, J. (2019). Educational disparities in adult mortality across U.S. States: How do they differ, and have they changed since the mid-1980s? *Demography, 56*, 621–644.
Moss, N., & Carver, K. (1998). The effect of WIC and Medicaid on infant mortality in the United States. *American Journal of Public Health, 88*, 1354–1361.
Muennig, P. A., & Glied, S. A. (2010). What changes in survival rates tell us about US health care. *Health Affairs, 29*, 2105–2113.
Muennig, P. A., Reynolds, M., Fink, D. S., Zafari, Z., & Geronimus, A. T. (2018). America's declining well-being, health, and life expectancy: Not just a white problem. *American Journal of Public Health, 108*, 1626–1631.
National Academies of Sciences, E., & Medicine. (2021). *High and rising mortality rates among working-age adults*. Washington, DC: The National Academies Press.
National Center for Health Statistics. (1969-2019). *Mortality multiple cause files, birth cohort linked birth – infant death data files, and period linked birth-infant death data files. As compiled from data provided by the 57 vital statistics jurisdictions through the vital Statistics cooperative program*.
National Research Council; Committee on Population. (2011). *Explaining divergent levels of longevity in high-income countries*. National Academies Press.
National Research Council; Committee on Population. (2013). *US health in international perspective: Shorter lives, poorer health*. National Academies Press.
van Raalte, A. A., Sasson, I., & Martikainen, P. (2018). The case for monitoring life-span inequality. *Science, 362*, 1002–1004.
Ruggles, S., Flood, S., Goeken, R., Grover, J., Meyer, E., Pacas, J., et al. (2020). *Ipums USA: Version 10.0*. MN: Minneapolis.
Sasson, I. (2016). Trends in life expectancy and lifespan variation by educational attainment: United States, 1990–2010. *Demography, 53*, 269–293.
Sasson, I., & Hayward, M. D. (2019). Association between educational attainment and causes of death among white and black US adults, 2010-2017. *Journal of the American Medical Association, 322*, 756–763.
Singh, G. K., & Yu, S. M. (2019). Infant mortality in the United States, 1915-2017: Large social inequalities have persisted for over a century. *International journal of MCH and AIDS, 8*, 19–31.
Stein, E. M., Gennuso, K. P., Ugboaja, D. C., & Remington, P. L. (2017). The epidemic of despair among white Americans: Trends in the leading causes of premature death, 1999–2015. *American Journal of Public Health, 107*, 1541–1547.
Stretesky, P. B., & Lynch, M. J. (2001). The relationship between lead exposure and homicide. *Archives of Pediatrics and Adolescent Medicine, 155*, 579–582.
Surveillance Epidemiology and End Results SEER Program Populations. (1969-2019). *National cancer Institute, DCCPS, surveillance research program*.
Thakrar, A. P., Forrest, A. D., Maltenfort, M. G., & Forrest, C. B. (2018). Child mortality in the US and 19 OECD comparator nations: A 50-year time-trend analysis. *Health Affairs, 37*, 140–149.
Timmermans, S., & Kaufman, R. (2020). Technologies and health inequities. *Annual Review of Sociology, 46*, 583–602.
Zimmerman, F. J. (2019). A robust health equity metric. *Public Health, 175*, 68–78.
Zimmerman, F. J. (2021). *Population health science: Fulfilling the mission of public health the milbank quarterly*. https://doi.org/10.1111/1468-0009.12494. epub ahead of print.
Zimmerman, F. J., & Anderson, N. W. (2019). Trends in health equity in the United States by race/ethnicity, sex, and income, 1993-2017. *JAMA Network Open, 2*, e196386. e196386.