Exploring American Life Expectancy Gaps by Socioeconomic Status

Summary

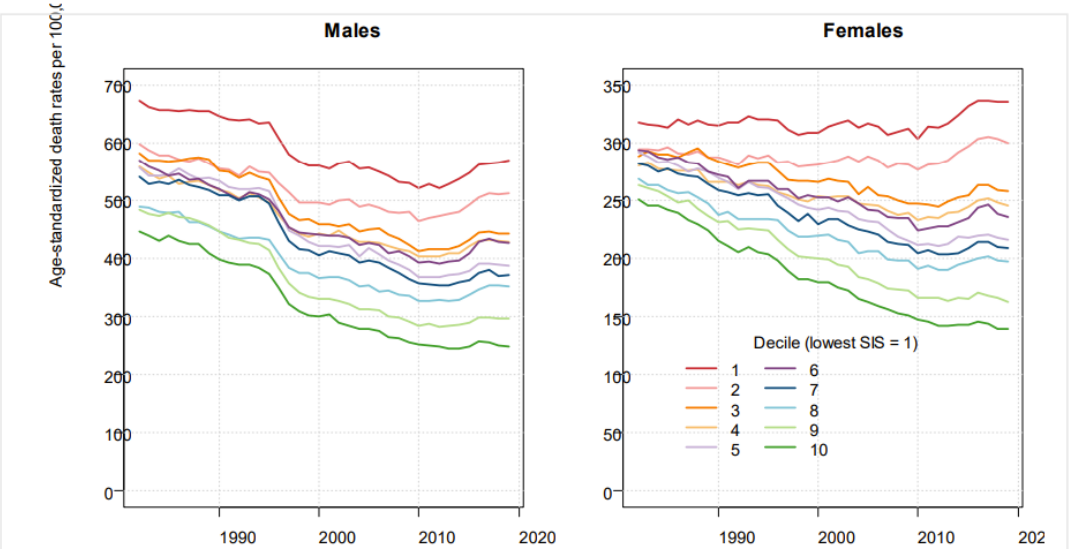
United states life expectancy is deteriorating both in absolute terms and when compared to its international peers. The CDC's "Provisional Life Expectancy Estimates for 2021" report estimates that US life expectancy stands at 76.1 based on 2021 mortality rates, a 2.7-year decline from 78.8 years achieved in 2019. While the deaths from Covid-19 pandemic are behind a significant portion of recent declines, other causes of death are contributing to this worrying trend. By analyzing historical cause of death trends one can see that drug overdoses have grown exponentially since 2010 and improvements from cardiovascular disease have stalled (Barbieri, 2022). In her 2022 SOA study**,** Magali Barbieri explored cause of death by socioeconomic status. Barbieri scored US counties by a socioeconomic index score ("SIS") based on each county's income distribution, level of education, housing market, unemployment and income inequalities (Barbieri, 2022). She grouped counties into 10 deciles by the SIS. She utilized ICD codes to map different causes of death from 1982 to 2019. Barbieri presents age-standardized cause of death mortality rates by various factors (sex, geography and socioeconomic decile).

Unsurprisingly, those in the top socioeconomic deciles had lower mortality compared to those in the bottom deciles. However, this mortality gap has widened since 1982. Table 1 below, summarizes the all-cause mortality rates by sex for the top and bottom socioeconomic deciles (mortality rates presented as deaths per 100,000). While one may reasonably conclude that mortality has improved since 1982, the gap between rich and poor has grown. Further, as mentioned previously, US life expectancy is lagging behind peer nations, especially since 2010 which was partially driven by high drug overdoses. In addition, working age mortality was particularly hard-hit (Harris, et al 2021) which is economically problematic considering that the aging US population. The figure below from Barbieri, illustrates the trend that working-age mortality has actually increased since 2010.

Table 1 Age Standardized All-Cause Mortality by Cause of Death, by Socioeconomic Decile (1982 vs. 2019), All ages (deaths per 100,000)

	1982			2019		
Cause of Death Category	Bottom Decile	Top Decile	Delta	Bottom Decile	Top Decile	Delta
Males All-Cause Mortality	1408	1215	193	1044	670	374
Females All-Cause Mortality	820	750	70	714	467	247

Age-Standardized Death Rates at Ages 20–64 Years, by SIS Decile and Sex, 1982–2019



Figures sourced from Barbieri, M. (2022). Cause-of-Death Contributions to Socioeconomic Inequalities in Mortality in the United States.

This paper presents a framework for developing policy solutions to the problem of deteriorating life expectancy. While there have been significant improvements in US life expectancy in the twentieth century, those with lower socioeconomic status seem to have been left behind. As an example, from 1974 to 2016 smoking rates declined by 76% for the college educated but only 35% for those with a high school degree or less (as cited in Harris et al., 2021). It is possible to reduce the gap since money does appear to buy improved health. For instance, wealthier people can buy healthier foods, have better access to healthcare, and have better access to exercise among many other things. I am not arguing that simply giving money to the poor will solve all our mortality problems. However, by improving mortality for the poor, life expectancy will improve, healthcare costs should decrease and taxable revenue should increase.

The three main drivers explored in this paper are cardiovascular disease, cancer and deaths of despair. Cardiovascular disease has been a big reason for the reduction of mortality since 1982. However, its continued improvement has stagnated since 2010, especially for the working age population (Barbieri, 2022) and cardiovascular disease still represents the number one cause of deaths for Americans. In addition, the gap for cardiovascular disease between rich and poor has grown from 66 to 115 death per 100,000 for males and from 44 to 75 deaths per 100,000 for females (Barbieri, 2022). Part of this reason could be smoking. As cited above smoking appears to be more prevalent among those in lower socioeconomic deciles. Obesity and lack of access to medical improvements could also be drivers. The cancer gap grew from -9 to 55 deaths per 100,000 for males and -23 to 28 for females (Barbieri, 2022). While the gap by cancer is not as wide as other causes, it is the second leading cause of death in the US. Because cancer is nuanced in that there are many different cancer types with different patterns, policies seeking to reduce mortality gaps should be granular. For instance, the gap driven by socioeconomics for breast cancer and prostate cancer is relatively tight but smoking related cancers is quite large

reinforcing the point that smoking is more prevalent among counties with lower socioeconomic statuses (as cited in Harris et al. 2021).

“Deaths of despair” describe three causes of death; deaths due to drug overdoses, alcohol and suicide. While these deaths are not at the same magnitude as cardiovascular disease and cancer, they increased significantly since 2010 (especially drug overdoses) (Harris, et al., 2021). Drug overdoses particularly affect younger populations in their prime working years. In addition, the CDC estimates that over 100,000 Americans died of drug overdoses in 2021 which is approximately a 50% increase since before the pandemic in 2019 (Ahmad et al., 2022). Drug overdoses appear to have begun their rise in the 1990s in line with an increase in opioid prescriptions (Harris et al., 2021). After the addictiveness of these drugs became apparent prescriptions became more scrutinized (Harris, et al., 2021). However, this caused Americans to turn to the black-market for painkillers which was initially heroin but then transitioned to the deadlier fentanyl in the 2010s (Harris, et al., 2021). A possible lesson of the history of opioids is that policymakers attempted to tackle the supply of the problem rather than demand. Further, tackling the supply often known as the war on drugs has been broadly considered a failure (Harris, et al., 2021). By not developing treatment infrastructure, many Americans who became addicted to these painkillers were hung out to dry.

The remainder of this paper will be structured as follows;

- In the background section, I will discuss current trends in US life expectancy and provide an overview of the SOA cause of Death Study that will be analyzed throughout
- In the analysis section, I will discuss the key drivers of mortality gaps seen between the top and bottom socioeconomic deciles. The key causes of death presented will be cardiovascular diseases, cancers and deaths of despair.
- Lastly, I will provide conclusions and key considerations for policymakers.

Background

US Life Expectancy

The CDC estimates the United States life expectancy to be 76.1 years for 2021 per their "Provisional Life Expectancy Estimates for 2021" report (Arias, et al., 2022). This represents a 0.9-year decline from 2020. The key drivers highlighted in the CDC report were death due Covid-19, drug overdoses (categorized as unintentional injuries), heart disease, suicides and liver disease. Of those 5 causes, Covid-19 was the most impactful followed by drug overdoses. Further, this is the second year in a row that life expectancy declined and it has declined by a cumulative 2.7 years, from the 2019 high of 78.8 years (Arias et. al, 2022).

Researchers recently published a report on mortality rates for the working age population in the National Academies of Sciences, Engineering and Medicine. Of note is that mortality rates for younger populations have increased in recent years (Harris, et al., 2021). This is a worrying trend for the US as the US has fund an aging population. Young working-age people are needed in order to fund protections for elderly such as Social Security and Medicare. A driver of this trend appears to be the deaths collectively known as deaths of despair (Harris et al., 2021). For example, in 2021 the CDC estimates that approximately people died of drug overdoses (Ahmad et al., 2022). Note that this figure is slightly less than reported drug overdoses (~107 thousand) due to incomplete data.

The Society of Actuaries ("SOA") published a report in 2022 discussing cause of death by socioeconomic status. In the report, the mortality gap is presented for various causes of death between those in the top socioeconomic deciles and the bottom deciles. By identifying large gaps, public policymakers can identify practical strategies to reduce mortality rates. The reason I say practical is that there is likely little difference between the underlying biology of those who are poor and those who are rich. Transferring money to the poor will not magically reduce the gap but people with better socioeconomic status are likely to have better access to health care, the ability to buy healthier foods, less stress and other benefits. Based on the SOA research, the largest gap is for cardiovascular disease (when comparing working age population, the gap becomes even larger). The gap for cancer is also relatively large but not for all forms of cancer. For example, the gap for smoking related cancers is extremely wide while the gap for breast cancer. This is likely driven by the uniqueness of each cancer.

SOA Cause of Death Study Overview

This subsection will be devoted to discussing the SOA research report on cause of death by socioeconomic status. Barbieri used data from the National Center for Health Statistics from 1982 to 2017 to map cause of death based on death certificates. In addition, Barbieri used July 1st population estimates in order to determine denominator when calculating the mortality rate.

Cause of deaths were grouped based on the International Statistical Classification of Diseases and Related Health Problems ("ICD") codes. The cause of death categories presented are infectious disease, cancers, cardiovascular disease, other diseases, external causes, and unknown causes (Barbieri, 2022). Other diseases include metabolic diseases (e.g. diabetes), digestive diseases, and nervous system diseases (e.g. Alzheimer's). The ICD is updated periodically and the US switched over from the ICD-9 to the ICD-10 for cause of death classification in 1999 (Harris, et. al, 2021). Since, the study period resulted in two versions of the ICD being used (ICD-9 and ICD-10), Barbieri followed methodology conducted in a 1996 "NCHS bridge coding study" to bridge ICD-9 and ICD-10 codes.

The metric used to quantify mortality was the age-standardized death rate. The age-standardized death rate is expressed in deaths per 100,000 and represents the average death rate using a standardized population. Barbieri used the 2000 population demographics to calculate standardized death rates across periods. Standardized population are needed in order to compare death rates between populations. For example, the raw death rate in 1982 and 2019 will not be directly comparable since the 2019 population will have a higher proportion of older people who naturally have higher mortality rates. Thus, the age standardized death rate at a given time can be summarized as follows (it is subsequently be multiplied by 100,000).

$$q^t_{aggr} = \sum_{x=0}^{120} w_x^{2000} * q_x^t$$

$Where\ w_x^{2000} = the\ proportion\ of\ people\ age\ x\ in\ year\ 2000,\ and\ q_x^t =$
$1\ year\ mortality\ rate\ a\ person\ age\ x,\ in\ year\ t$

Barbieri subset the mortality rates by socioeconomic status. A "Socioeconomic Index Score (SIS)" was used to subset US counties into deciles where each decile had approximately 10% of the US population. The SIS was calculated based on each county's income distribution, level of education, housing prices and quality, unemployment and income inequalities (Barbieri, 2022). The age-standardized mortality rate was calculated for each year over the period of 1982 to 2019 for different sub-groups and various causes of death.

Analysis

In the analysis section, attention will be devoted to discussing 3 broad causes of deaths categories. They are heart disease, cancer and death of despair (drug overdoses, alcohol induced deaths and suicides). Within each subsection, we will analyze the mortality gap over time from Barbieri's SOA study as well as discuss potential causes of these deaths. Table 2 below summarizes the mortality gap between 1982 and 2019 presented by Barbieri (2022). Overall, the gap between the top and bottom decile was 193 in 1982 and increased to 374 deaths per 100,000 as of 2019 for males. For females the gap was 70 and increased to 247 in 2019 deaths per 100,000.

Table 2: Age Standardized Mortality by Cause of Death, by Socioeconomic Decile (1982 vs. 2019), All ages

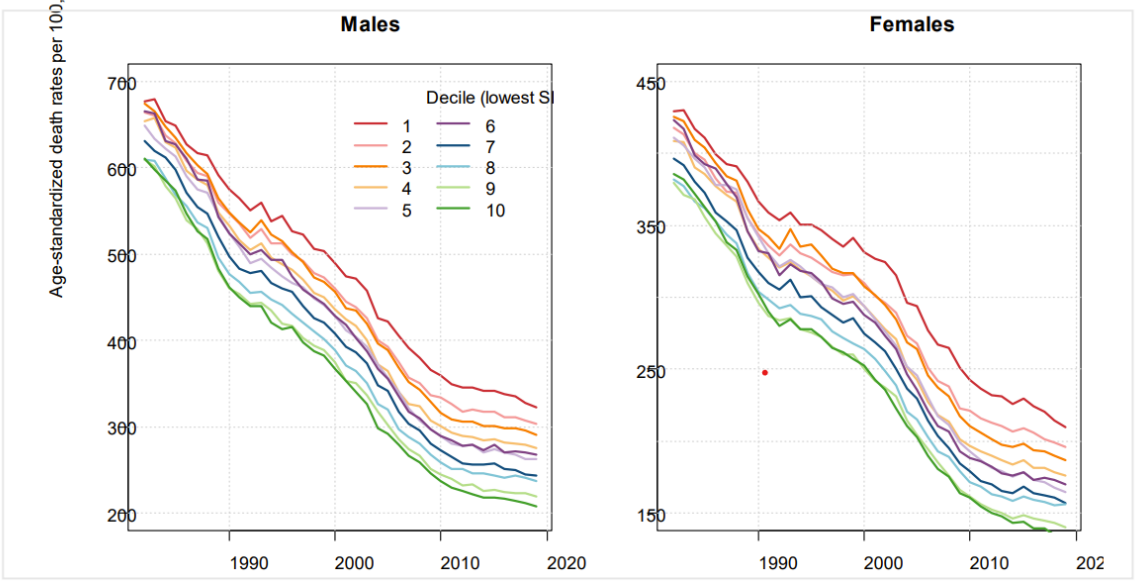
Males	**1982**				**2019**			
Cause of Death Category	Bottom Decile	Top Decile	Delta	Relative Delta	Bottom Decile	Top Decile	Delta	Relative Delta
Infectious/respiratory Diseases	120	102	18	9%	130	70	60	16%
Cancer	276	285	-9	-5%	205	150	55	15%
Cardiovascular Diseases	677	611	66	34%	323	208	115	31%
Other diseases	158	134	24	12%	241	164	77	21%
External causes	139	73	66	34%	134	71	63	17%
Ill-defined/unknown	38	10	28	15%	11	7	4	1%
Total	**1408**	**1215**	**193**	**100%**	**1044**	**670**	**374**	**100%**
Females	**1982**				**2019**			
Cause of Death Category	Bottom Decile	Top Decile	Delta	Relative Delta	Bottom Decile	Top Decile	Delta	Relative Delta
Infectious/respiratory Diseases	52	49	3	4%	98	52	46	19%
Cancer	160	183	-23	-33%	141	113	28	11%
Cardiovascular Diseases	430	386	44	63%	210	135	75	30%
Other diseases	116	96	20	29%	204	134	70	28%
External causes	42	30	12	17%	53	28	25	10%
Ill-defined/unknown	20	6	14	20%	8	5	3	1%
Total	**820**	**750**	**70**	**100%**	**714**	**467**	**247**	**100%**

Data sourced from Barbieri, M. (2022). Cause-of-Death Contributions to Socioeconomic Inequalities in Mortality in the United States.

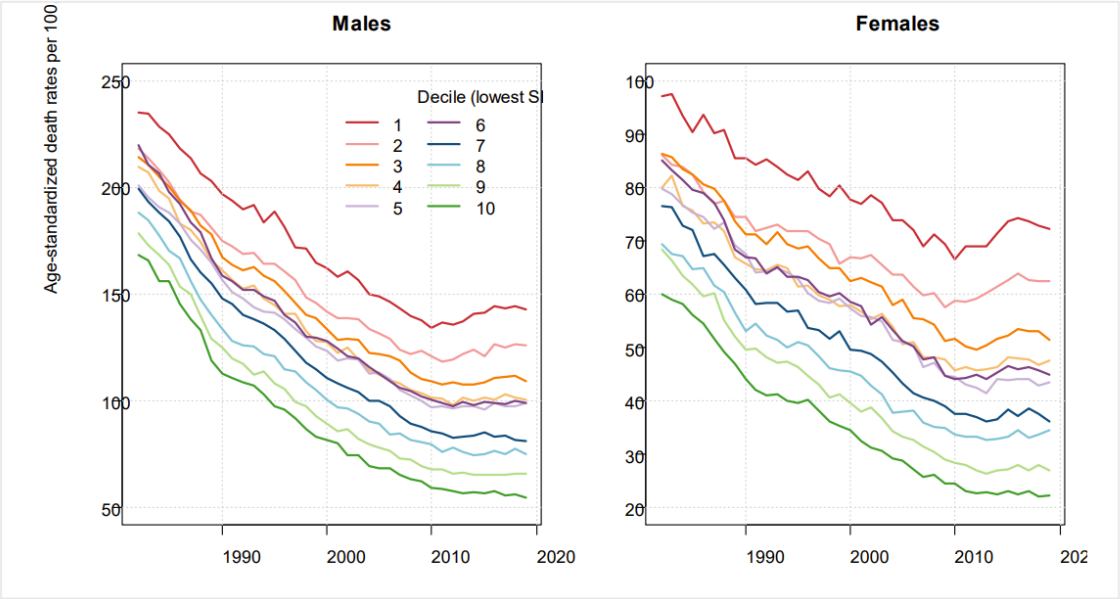
Cardiovascular Disease

The largest gap between those of lowest socioeconomic status and those in the highest socioeconomic decile is cardiovascular diseases. Cardiovascular disease includes heart disease and cerebrovascular disease (related to blood supply to brain, e.g. strokes). In 2019, the top decile males die at rate of 208 compared to 323 per 100,000 for their bottom decile counterparts (115 gap). For females in 2019, the rates are 135 and 210 per 100,000 for top decile and bottom decile respectively (75 gap). In addition, the gap between low socioeconomic status and high socioeconomic status is particularly pronounced for working age adults as seen in the figures below. For some of the bottom deciles, deaths from cardiovascular disease have trended upwards since around 2010. However, cardiovascular disease has generally declined since 1982, but, there is still room for more improvement based on the gap between rich and poor.

Age-Standardized Death Rates from Cardiovascular Diseases, by SIS Decile and Sex, All Ages Combined, 1982–2019



Age-Standardized Death Rates from Cardiovascular Diseases, by SIS Decile and Sex, Ages 20–64, 1982–2019



Figures sourced from Barbieri, M. (2022). Cause-of-Death Contributions to Socioeconomic Inequalities in Mortality in the United States.

Cardiovascular disease declines have been attributed to improvements in risk factors as well medical improvements. Risk factors include smoking, high blood pressure, high cholesterol, sedentary lifestyle and, obesity (Sanchis-Gomar, Perez-Quilis, Leischik, & Lucia, 2016). Note that the obesity rate has not improved and should thus be seen as an offset. Further it appears the prevalence of metabolic diseases (e.g. diabetes) has increased for all socioeconomic statuses but it appears those in the lowest socioeconomic status were particularly hard-hit (Barbieri, 2022). The medical improvements include the development of prevention medications (such as statins

and beta blockers) and improved surgical procedures (Ford, et. al. 2007). Smoking appears to be a strong contributor to the differences between top deciles and bottom deciles. As will be discussed throughout, the socioeconomic mortality gap for smoking related cancers and chronic obstructive pulmonary diseases is immense. This is consistent with the disparity presented in the summary. As a reminder, the high school educated or less experienced a 35% reduction in smoking compared to the 76% reduction for the college educated (as cited in Harris et al. 2021).

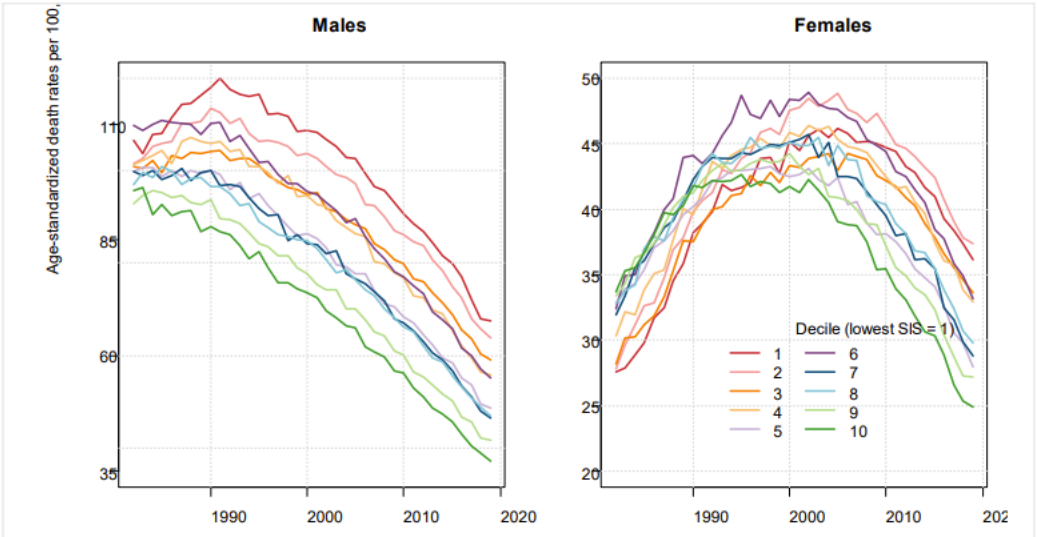
Cancer

Cancer represents the second largest killer of Americans, second to cardiovascular disease. Interesting, in 1982, the socioeconomic mortality gap for cancer was actually negative for cancer deaths (indicating that people in higher socioeconomic deciles died relatively more frequently of cancer). However, this has since changed as the gap is now 55 and 28 for males and females respectively as seen by table 2. Cancer treatments have improved and it appears that top socioeconomic deciles were able capitalize on these improvements more than bottom deciles.

It is important to note that there are many types of cancers and the mortality gap may vary by cancer type. Therefore, it will be sensible for policymakers to target specific cancers with wide gaps. For instance, smoking related cancers and colon cancers appears to be quite wide while the prostate and breast cancer gaps are tighter (Barbieri, 2022). The graph below from Barbieri highlights the wide gap observed for smoking related cancers. This finding is consistent with the fact that people in lower socioeconomic status appear to smoke relatively more. This also partially explains the gap observed in infectious and respiratory diseases which includes chronic obstructive pulmonary diseases, a common disease brought on by smoking.

Figure 12

Age-Standardized Death Rates from Smoking-Related Cancers, by SIS Decile and Sex, 1982–2019



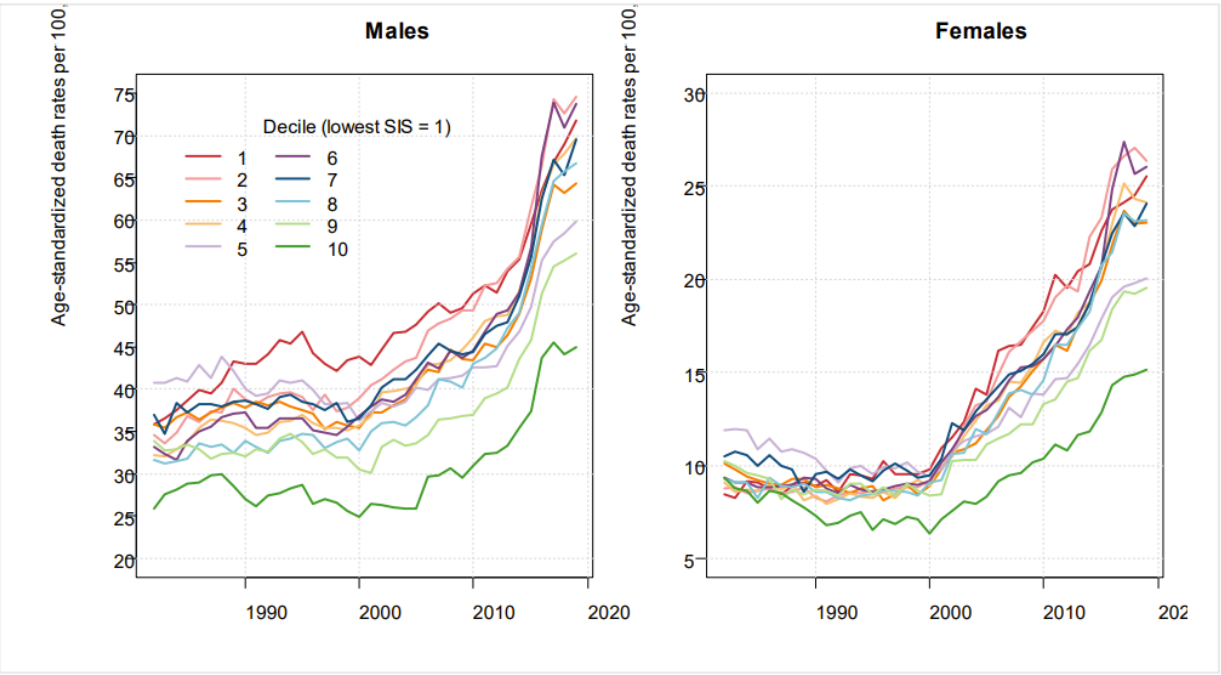
Figures sourced from Barbieri, M. (2022). Cause-of-Death Contributions to Socioeconomic Inequalities in Mortality in the United States.

Deaths of Despair

Deaths of despair represent a combination of deaths driven by drug overdoses, alcohol induced deaths and suicides (Harris et al., 2021). In Barbieri's study these are included in external causes category. As seen in the graph below from the Barbieri paper, deaths of despair have significantly risen since 2010 for all socioeconomic statuses. Most of this increase in deaths of despair was driven by drug overdoses. In their study of high mortality in the working age population Harris et al (2021) summarize the history of rising drug overdoses since 2021. Before the 1990s, opioids were mainly used for the terminally ill. In the 1990s prescription drugs began to be utilized more thanks to pharmaceutical drug developments (e.g. Perdue Pharma's OxyContin), lobbying by pain advocacy groups and regulatory bodies inability to detect the danger these drugs posed (Harris et al., 2021). Later, as the addictive nature of these drugs were realized and prescriptions became sparse, people turned to heroin (Harris et al., 2021). In 2010, a new deadly synthetic opioid was introduced and subsequently increased deaths from drug overdoses (Harris et al., 2021). As discussed in the introduction over 100 thousand people died in 2021 due to drug overdoses (Ahmad et al., 2022). Perhaps the issue was that when the US attempted to curb the supply of opioids, we failed to treat those addicted who turned to the black-market for solutions.

Figure 19

Age-Standardized Death Rates from Diseases of Despair, by SIS Decile and Sex, 1982–2019



Figures sourced from Barbieri, M. (2022). Cause-of-Death Contributions to Socioeconomic Inequalities in Mortality in the United States.

Conclusions

Overall, there are mortality gaps between the rich and the poor for many causes of deaths. The largest gap exists for cardiovascular diseases. While this category has broadly declined since 1982, the gap has almost doubled since 1982 for males and females. Further, since 2010, mortality from cardiovascular diseases has been increasing since 2010 for the working age population and this is economically problematic. Cancer was an additional driver of the gap. However, the gaps appear to vary by types of cancer and it may be wise for policymakers to be granular in developing solutions. For instance, it might be more economic to develop policies to close wide gaps than tight gaps. For example, lung cancer, often driven by smoking has a significant gap. Lastly, a significant amount of the adverse mortality experienced since 2010 has been driven by deaths of despair, specifically drug overdoses. In summary, many of these gaps could be driven by obesity (cardiovascular diseases and metabolic diseases), smoking (smoking related cancers and chronic obstructive pulmonary diseases), and access to healthcare (likely affects many causes of disease).

In addition, there are other drivers of gaps besides socioeconomics. For instance, Harris, et al 2021, identify gaps between races and geographic conditions. It should be acknowledged that these two variables, may be correlated with socioeconomics but that does not mean they should be ignored. Further, by looking at gaps by race we can find a successful example of a mortality gap being tightened. During the AIDS outbreak, the black population experienced extremely elevated mortality relative to whites but this disparity was dampened in the 21st century thanks in part to the US PEPFAR program. In 1990, the deaths per 100,000 for black males 25-44 was 135 (36 for whites) deaths per 100,000, and was decreased to 10 (1 for whites) deaths per 100,000 (Harris, et al 2021). While the gap still exists, it significantly smaller than previously. In addition, there are gap between US life expectancy and other countries which should be understood. Overall, understanding the causes of the various gaps will be essential for policymakers if they are craft longevity increasing solutions.

This paper's framework argues for identifying mortality gaps based on socioeconomics and causes of death in order to develop policy solutions. Some may accept these mortality gaps as merit based (i.e. people in higher socioeconomic status should have better health outcomes). I do not dispute the underlying logic but, I believe this view is zero sum. By improving life expectancy for the poor, it will reduce healthcare expenditures, increase taxable income (especially if working age mortality is improved) and improve well-being. As George Bailey famously defended providing loans to folks in Bedford Falls, "But he did help a few people get out of your slums Mr. Potter. And What's wrong with that? Why… Here, you're all the businessmen here. Doesn't it make them better citizens? Doesn't it make them better customers…" (It's a Wonderful Life).

Appendix A: Life Expectancy Calculation

Actuarily there are generally two ways to present life expectancy estimates; period life expectancy and cohort life expectancy. Period life expectancy is what is quoted by the CDC. In period life expectancy the mortality rates used for each age are based on the mortality rates for one year (in this case 2021). This represents the implied life expectancy if current mortality rates stay constant into the future. In cohort life expectancy, it requires judgement on the future mortality rates. It is called cohort life expectancy as it tracks with people born in the same year and estimates future life expectancy based on projected future mortality. So, the cohort life expectancy for someone born today would represent the expected number of years they will live when taking into account future changes in mortality rates. Since mortality rates generally improve over time, cohort life expectancy will generally be higher than period life expectancy.

Life expectancy is calculated as the expected number of years a person will live. The life expectancy can be calculated at any reasonable starting age. The top-line life expectancies presented by the US are life expectancies at birth or "age 0". I will now present some actuarial notation and formulas used to calculate life expectancy. Note that these formulae will be similar for both period and cohort life expectancy. However, the future mortality rates will vary for cohort life expectancy.

Notation:

q_x = probability a person aged x will die within in 1 year.

${}_tP_x$ = probability a person aged x will live for t more years.

In discrete situations, ${}_tP_x = {}_{t-1}P_x * q_{x+t-1}$

e_x = expected additional years a person aged x is expected to live.

Formula: The formula for life expectancy is similar to the expected value formula where;

- $E[x] = \sum_{k=0}^{\infty} k * p(x = k)$

Thus, when applying it to life expectancy; $e_x = \sum_{t=0}^{\infty} t * {}_tP_x * q_x$

This equation can be simplified to; $e_x = \sum_{t=1}^{\infty} {}_tP_x$

Note that these formulas can be calculated for the desired time period granularity (years, months, days, etc.)

For those that do not have a math background, I recommend trying a simple example. Pretend that people can either live to be 0 years old or 1 year old. In this made-up world, after they reach their 1st birthday they instantly die. Further, let the probability they die in year 1 (age 0) be 20%. Now let's calculate the life expectancy. This can be calculated as 0 years times the probability they live 0 years plus 1 year times the probability they live 1 year. See calculation below.

$$e_0 = \sum_{t=0}^{1} t * {}_tP_0 * q_0 = 0 * {}_0P_0 * q_0 + 1 * {}_1P_0 * q_1$$

We know $q_0 = 20\% \Rightarrow {}_1P_0 = 1 - 20\% = 80\%$ and $q_1 = 100\%$.

Thus; $0 * {}_0P_0 * q_0 + 1 * {}_1P_0 * q_1 = 0 * 1 * 0.2 + 1 * 0.8 * 1 = 0 + 0.8$

Thus, the life expectancy is 0.8 years. Further for completeness we can use the other equation, to show the result is the same.

$$e_0 = \sum_{t=1}^{1} {}_tP_0 = 1 - 0.2 = 0.8$$

Lastly note that the underlying population can be segmented into various sub-groups as desired. For example, the CDC provides life expectancies based on sex and race.

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