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ACCOUNTING FOR THE WIDENING MORTALITY GAP BETWEEN ADULT AMERICANS WITH AND WITHOUT A BA

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Accounting for the Widening Mortality Gap Between Adult Americans with and without a BA
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ABSTRACT

We examine mortality differences between Americans with and without a four-year college degree over the period 1992 to 2021. From 1992 to 2010, both groups saw falling mortality, but with greater improvements for the more educated; from 2010 to 2019, mortality fell for those with a BA and rose for those without; from 2019 to 2021, mortality rose for both groups, but more rapidly for the less educated. In consequence, the mortality gap between the two groups rose in all three periods, unevenly until 2010, faster between 2010 to 2019, and explosively during the pandemic. The overall period saw dramatic changes in patterns of mortality, but gaps rose consistently, not only in all-cause mortality, but in each of thirteen broad classifications of cause of death. Gaps increased for causes of death whose rates have risen in the last thirty years, whose rates have fallen in the last thirty years, and whose rates fell and then rose. Gaps rose for causes where rates were originally higher for those without a BA, and where rates were originally lower for those without a BA. Although mechanisms and stories are different for each cause of death, the widening gap is seen throughout.

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1. Introduction

Outcome gaps between adult Americans with and without a four-year college degree have become increasingly salient in political, economic, demographic, and social domains. Voting patterns, wealth holdings, incarceration, wages and marriage are now sharply different between the approximately one third of the population aged 25 and older with a bachelor's degree and the two-thirds without. Here we focus on health outcomes using two metrics, expected years of life between 25th and 85th birthdays, and age-adjusted mortality. Life expectancy at 25 for those with a BA grew continuously from 1992 up to 2019 while, for those without a BA, progress stalled and reversed after 2010, Sasson (2016a, 2016b), Hayward and Farina (2023). The gap widened further in 2020 and 2021 during the pandemic. We provide a descriptive analysis of the factors contributing to the widening gap, focusing on causes of death, on age, and on gender, both prior to and during the pandemic. We identify the causes of death that make the largest contribution to these widening gaps, particularly "deaths of despair"—from drug overdose, alcoholic liver disease, and suicide—as well as deaths from cancer, cardiovascular disease, chronic lower respiratory diseases, and diabetes.

The differential mortality experiences of those with and without a college degree come not only from the direct effect of education on individual health, for example through health behaviors or enhanced ability to deal with life, including the healthcare system, but also from broader social and economic forces in the communities where people work and live. A good analogy here is with the college wage premium, the percent by which the wage for college-educated workers exceeds the wage of those without a four-year college degree. This premium, which rose from 41 percent in 1979 to 83 percent in 2019,[1] depends not only on what a college education does to the skills and

[1] Authors' calculations using the Current Population Survey Outgoing Rotation Groups, for men and women ages 25-64, comparing median wages for those with less than a four-year college degree to those with a BA or more. The premium for some college, less than a four-year degree, relative to a high school degree did not change over this period (14 percent in 1979, 12 percent in 2019).

ability of each worker—the direct effect—but also on a range of indirect effects, including on how many people go to college, on how the labor market rewards skills, on available jobs and the technology they use, on how easy it is for workers to move to places where their skills are in demand, and on how the cost of employer health insurance affects the demand for more- and less-skilled workers, Finkelstein et al (2023). Similar direct and indirect forces affect health. Among them are the increasingly difficult job situation for less-educated workers and the long-term negative impacts of a deteriorating labor market on their marriages and the communities in which they live. The European countries that have long been more open to trade and trade-related disturbances have built comprehensive welfare systems that help, not only with trade-related job losses but also with losses through automation, Rodrik (1998). While mortality rates and mortality trends for less- and more-educated people in other rich countries differ in both levels and trends, the US appears to be the only western country where life expectancies are trending in different directions, Mackenbach et al (2018), Case and Deaton, (2021, 2022).

This paper is concerned with the gaps in mortality and life expectancy between those with and without a BA, for men, for women, and for both together. We document how the gaps increased from 1992 to 2021, especially rapidly from 2019 to 2021 during the COVID pandemic. We distinguish three periods: from 1992 to 2010 when both groups saw falling mortality, but with greater improvements for the more educated; from 2010 to 2019, when mortality was falling for those with a BA and rising for those without; and from 2019 to 2021, when mortality was rising for both groups, but much more rapidly for those without a BA. We document the contributions of different causes of death to the changing gaps—notably the contributions of deaths of despair and their components, drug overdose, alcoholic liver disease, and suicide, and those of cardiovascular disease, and of a range of cancers—and we offer a complete accounting over all the major classifications of causes of death using the International Statistical Classification of Diseases (ICD). The contributions of different causes of death are markedly different for men and women.

We note that the fraction of the population with a four-year degree has risen over time. As has often been noted in the literature, rising educational attainment can change the kinds of people who do or do not have a four-year degree, a selection that can increase or decrease the educational gap in mortality, even when other effects of education on mortality are unchanging. To control for changing fractions with a BA, we examine how mortality gaps change with age within birth cohorts. If education were constant within birth cohorts after age 25, the results would eliminate any effect of selection into education on the mortality gaps. However, we show that reported educational attainment increases *within* birth cohorts, even long after the normal age of educational completion. Some of the increase can be accounted for by differential mortality, but only for the earlier-born cohorts seen at older ages. The increase among the other groups remains a puzzle and we can do no more than suggest explanations such as adult education, immigration, or people claiming to have a degree when they do not.

There is a large literature examining the relationship between education and mortality, starting from Kitigawa and Hauser (1973). Many later studies focused, as we do, on changes in educational gaps over time, as well as on identifying the causes of death underlying the gaps, on the differences between men and women, and between racial and ethnic groups, see for example Preston and Taubman (1994) for an excellent early review, and the more recent updates by O'Rand and Lynch (2018). Most recently, the perspective by Hayward and Farina (2023) emphasizes the contingent and changing nature of the relationship between education and mortality. From the earliest studies, cardiovascular disease and lung cancer were identified as important in explaining educational gaps, leading back to smoking as a key behavioral determinant, which itself differed by men and women both in prevalence and timing.

Educational attainment began to be recorded on the standard U.S. death certificate in 1989, after which time, in principle, all decedents could be included in studies of education and mortality. Compared with mortality follow-ups using survey data, which have generated several important studies including Hummer and Lariscy (2011), Montez, Hummer et al (2011), Montez and Zajacova (2013a, b), the complete data permit the analysis of relatively minor causes of death, as well as disaggregation over a range of correlates. We use the death certificate information in this paper, and our work most closely follows earlier studies of the gap by Olshansky et al (2012), Meara, Richards, and Cutler (2008) and, most recently, Geronimus, Bound, Waidman et al (2019). Recent studies have documented that, particularly since 2010, drug overdoses, or more broadly deaths of despair, have become important in understanding the mortality gaps between those with and without a college degree, Case and Deaton (2017), Ho (2017), Sasson and Hayward (2019).

In the current paper, we update these studies in several ways. We analyze annual data over the longer period now available, including the pandemic years 2020 and 2021. We choose a different, more limited, but sharper focus on the difference in outcomes between those with and without a four-year college degree. We are less concerned with the many possible mechanisms that account for the relation between education on health, and more with documenting differences in mortality associated with the college divide. This follows the analysis in our book, Case and Deaton (2020) where, among other things, we document the college divide in material wellbeing, morbidity, marriage and religiosity.

We use data for the 30-year period from 1992 to 2021. This covers major changes in mortality patterns, including those for cardiovascular disease mortality—whose longstanding decline came to a halt—and those for a number of cancers, where there have been many improvements. Mortality from deaths of despair grew markedly over this period. We attempt to resolve some of the uncertainty about the relative contributions to declining life expectancy of, on the one hand, changes in mortality from cardiovascular disease and, on the other hand, rising mortality from deaths of despair, especially drug overdoses, Geronimus et al (2019), Mehta, Abrams and Myrskylä (2020). The COVID pandemic at the end of the period was punctuated not only by COVID–19 deaths, but also by excess deaths from other causes, including an additional upsurge in deaths of despair, and we document what happened to the mortality gap as mortality changed in these unprecedented ways.

We also use the classification ICD-10 to offer a complete accounting of the contribution of all causes of death to changes in the gap and examine whether any causes of death act to reduce the mortality gap between those with and without a college degree. We ask if it matters for the gap whether the cause of death is one associated with rising mortality, falling mortality, or a change from falling to rising mortality. We also raise new questions about the measurement of educational attainment, adding to an ongoing debate about self-reports versus post-mortem reports, a debate that has influenced the choice of data for studying the relationship between education and mortality.

2. Data and methods

We work with death certificates from 1992 through 2021, though in some cases we limit analysis to 1999 to 2021 so as to confine cause of death to the reporting structure of ICD-10, formally the International Statistical Classification of Diseases and Related Health Problems. Death certificates record age and sex, as well as highest education attained. We do not consider race or ethnicity in this paper, but see Case and Deaton (2021). There is undoubtedly some misreporting of education on death certificates but the divide between a four-year college degree and less than a four-year college degree appears to be minimally affected, Rostron, Arias and Boies (2010), and, as we shall see, there are also potential problems with self-reports of educational attainment. Education is missing for four states in 1992; Oklahoma began reporting education in 1997, South Dakota (2004), Georgia (2010) and Rhode Island (2016). These states accounted for 4.55 percent of the US population in 1990, and

4.57 percent of adult deaths in 1992. For deaths without education information, we assign a BA or not in the same proportion as non-missings by year, age, and sex. Population totals for each year, age and sex from 25 to 84 are taken from the Census Bureau; the totals are split between those with and without a four-year college degree using ratios estimated from Current Population Surveys until 2000 and from the American Community Surveys thereafter. Our calculated statistics, age-adjusted mortality and adult life expectancy, are averages that reduce the influence of measurement errors.

We use standard life-table methods to calculate life expectancy at age 25, an age by which most people have completed their education; increasing attainment with age beyond 25 is an issue to which we return. The use of death certificates to compute mortality at oldest ages is prone to error, and the official estimates from NCHS use other sources, Arias et al (2022). We avoid this by calculating the number of years of expected life of a 25-year-old between that person's 25th and 85th birthday, in standard demographic notation ${}_{60}e_{25}$, sometimes referred to as "temporary life expectancy," Arriaga (1984). For simplicity, but contrary to standard usage, we refer to this measure as adult life expectancy. The standard usage replaces 60 by infinity or at least the maximum possible years. Our measure of life expectancy from 25 to 85 is different to that used by Geronimus et al (2019); we explain in the Supplemental Text, below, why we believe our measure is to be preferred and, indeed, one of the contributions of this paper is to correct their calculations.

We use causes of death in two different ways. In the first, we compute age-adjusted mortality rates from ages 25 to 84 for selected causes of death. We use the 2000 population and adjust separately for men and women. We do not use separate reference populations by BA status; this is important because college graduates are on average younger than non-graduates, and we do not want age differences to contribute to the gradient. We can use age-adjusted mortality rates, which are linear in both age-specific populations and causes of death, to exactly decompose the educational gaps by cause of death and by age group. For adult life expectancy, we use a variant of the cause deletion method, Beltran-Sanchez et al (2008), in which we hold the age-sex-education specific mortality rates for selected causes at their 1992 levels, and then recompute adult life expectancy using the modified all-cause mortality rates. For example, deaths of despair rose rapidly after 1992, so to calculate the counterfactual excluding the increase we compute ${}_{60}e_{25}$ as if that increase had not taken place, with all other mortality rates at their actual values. This is an accounting exercise, not a prediction of what would have happened. As with COVID-19, deaths from other causes would almost certainly have been different had the increase in deaths of despair not happened. Even so, the calculations are useful in indicating orders of magnitude for the effects of counterfactuals in which different causes of death are eliminated or modified.

3. Results

Figure 1 plots adult life expectancy from 1992 through 2021 for men and women separately, split between those with and without a BA. The lower of the two solid black lines in each case is the

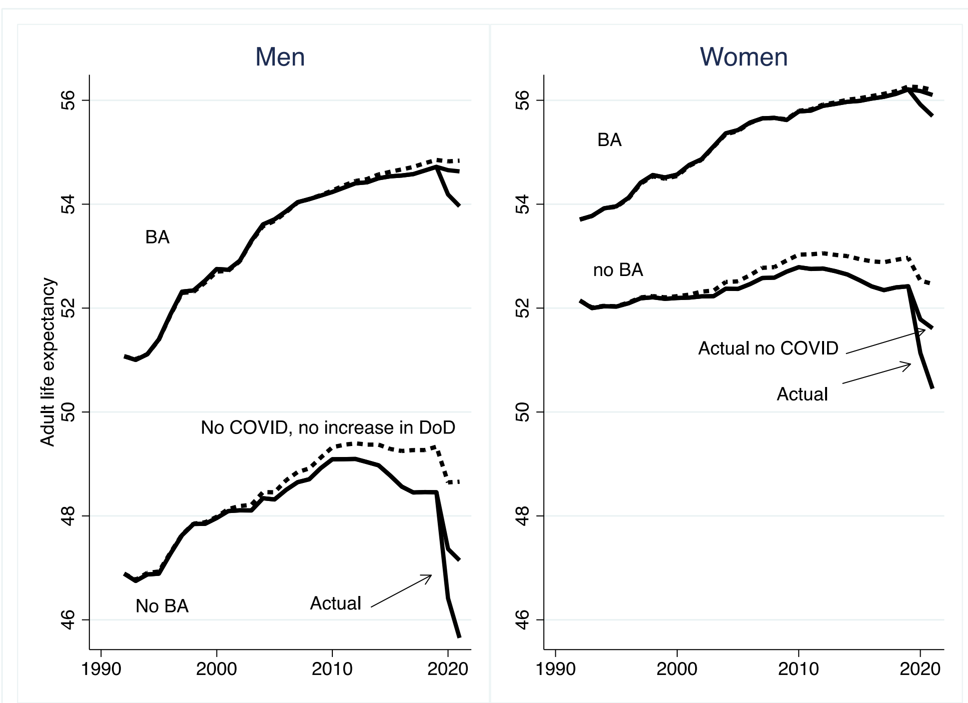


Figure 1. Adult life expectancy, with and without COVID-19 and deaths of despair

actual outcome. For men with a BA degree, adult life expectancy rose by 3.6 years from 1992 until 2019, from 51.1 to 54.7 years, and then fell from 2019 to 2020 by 0.53 years and again from 2020 to 2021 by 0.19 years. For women with a BA degree, adult life expectancy rose by more than 2.5 years from 1992 until 2019, from 53.7 to 56.2 years, and then fell from 2019 to 2020 by 0.29 years and again from 2020 to 2021 by 0.22 years. Educated women gained less than educated men up to 2019 but lost less in the first two years of the pandemic. For men without a BA, adult life expectancy grew from 1992 to 2010, by 2.2 years, more slowly than for the more-educated men over the same period, and then fell by 0.6 years from 2010 to 2017, held steady for two years, and then fell dramatically during the pandemic, by 2.0 years from 2019 to 2020, and by another 0.7 years from 2020 to 2021. For women without a BA, adult life expectancy grew from 1992 to 2010, by only 0.7 years, fell by 0.4 years from 2010 to 2017, held steady for two years, and then fell during the pandemic, by 1.1 years from 2019 to 2020, and by a further 0.6 years from 2020 to 2021. Once again, women gained less before the pandemic, but lost less during it.

The gap in adult life expectancy between the two education groups, which was 2.6 years (4.2 men, 1.6 women) in 1992, almost doubled to 5.0 years (6.3 men 3.8 women) in 2019, and then exploded during the pandemic, to 6.4 years (7.8 men, 4.8 women) in 2020, and 6.9 years (8.3 men, 5.2 women) in 2021. Accounting for these rising gaps is our main interest here. The gaps are smaller for women than for men, but they track in parallel over time, so that for much of what follows we can focus on the combined numbers for men and women.

The higher of the two solid black lines, which differ from one another only in 2020 and 2021, shows the effects of eliminating reported mortality from COVID-19; this deletion removes almost all of the drop for those with a BA, but only half the drop for those without. That excess deaths were greater than those reported as COVID-19 is well-known; the figure shows that the non-pandemic, the changes from 2019 to 2021 for those with and without a BA, as well as the COVID “excess” deaths in the pandemic years were much larger for those without a BA. The higher dashed lines in both panels show estimates of adult life expectancy for each of the four groups when COVID mortality is removed and the mortality rate from deaths of despair is held at its 1992 value. For those with a BA, the adjustment makes little difference beyond eliminating COVID alone. For those without a BA, the actual and adjusted lines increasingly diverge as the epidemic of deaths of despair gathers momentum; indeed, the elimination of the increase in deaths of despair almost removes the post-2010 pre-pandemic decline in adult life expectancy for the less-educated group. It also moderates the declines during the pandemic; although the suicide rate fell in 2020, it rose again in 2021, and both drug overdose and alcohol-related liver disease mortality rates rose in both years.

Figure 1 also shows the three periods: up to 2010 when both groups were improving, but at different rates; from 2010 to the pandemic, when the groups were moving in different directions; and from 2019 when both groups were losing out, but at different rates.

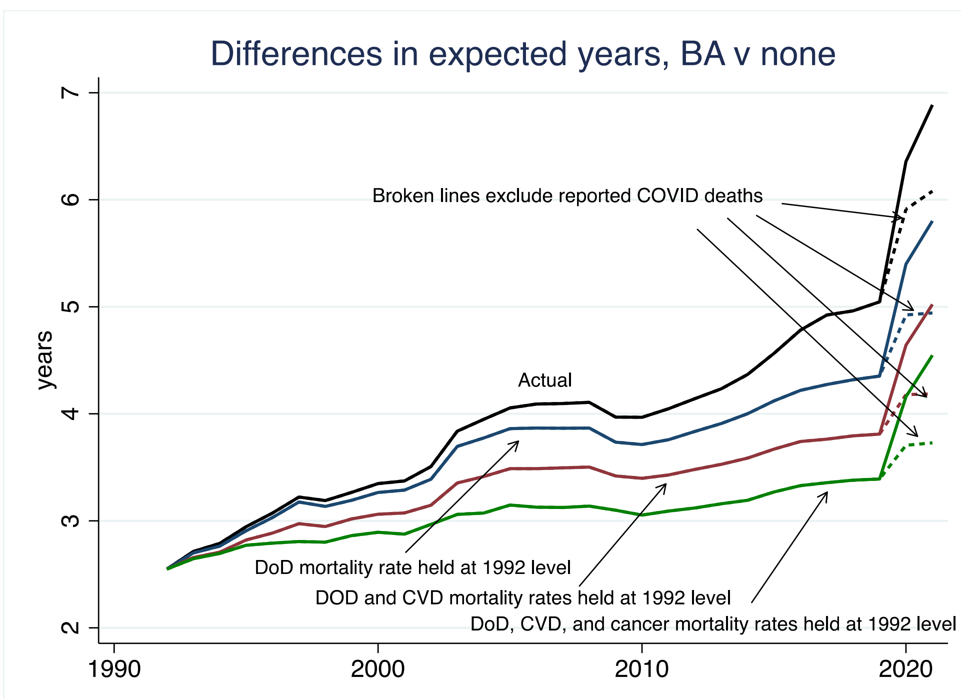


Figure 2. Differences in adult life expectancy with and without a BA

Figure 2, for men and women combined, shows the evolution of the college gap from 1992 to 2021. The solid line marked "actual" is the gap; also shown are several counterfactuals. These include (1) eliminating COVID-19 deaths in 2020 and 2021; (2), as in (1) plus holding deaths of despair mortality rates at their 1992 levels; (3) as in (2) plus holding cardiovascular disease mortality rates constant at their 1992 values; then (4), all the above plus holding cancer mortality rates at their 1992 values. Each step reduces the temporal increase in the educational gradient. Note that both cardiovascular disease mortality and cancer mortality rates were *falling* over the period while the mortality rates from deaths of despair were *rising*. The figure does not show the effect on the *level* of life expectancy of, say, holding cancer mortality rates at their 1992 levels, something that would raise the mortality counterfactual in all subsequent years and lower life expectancy. Rather, the figure shows the effect of holding cancer mortality rates at their 1992 levels on *the educational gap* in life expectancy, and this, like the other counterfactuals, reduces the gap. In other words, the reduction in cancer mortality since 1992 has favored people with a college degree and has thus widened the gap.

Age-adjusted mortality data reproduce the qualitative patterns in Figures 1 and 2 (Supplemental Figures 1 and 2). But because age-adjusted mortality rates are linear in both age-specific mortality rates and in population shares, they permit exact and straightforward decompositions by causes of death and by age groups. Table 1 presents pre- and post-pandemic age-adjusted mortality rates and covers eleven selected causes of death, deaths of despair, and deaths from cancer, cardiovascular disease, lower chronic respiratory diseases, diabetes, transport accidents, Alzheimer disease and related dementias, nephritis, septicemia, and assault. Collectively, these categories accounted for 80 percent of all deaths in 2019 for adults aged 25 to 84. The ICD9 and ICD10 codes associated with these causes of death are listed below the table. The first three columns of Table 1 show age-adjusted mortality rates per 100,000 in 1992 for people aged 25 to 84 with and without a BA, as well as the difference between them. The next three columns do the same for 2019, the last year before the pandemic. The next three columns show the changes from 1992 to 2019, so that the last column of this set, bolded, shows the "differences in differences," the changes from 1992 to 2019 in the gradient between those with and without a BA. The causes of death in the

Table 1. Age adjusted mortality per 100,000 people, ages 25–84

	1992			2019			Change 1992 to 2019			Change 2019 to 2021		
Cause of Death:	BA	No BA	Diff	BA	No BA	Diff	BA	No BA	**Diff**	BA	No BA	**Diff**
D of Despair*[a]	26	43	17	29	95	66	3	52	**49**	3	37	**33**
Cancer	263	297	34	136	212	77	–127	–85	**43**	–5	–1	**4**
CVD[b]	331	418	87	125	247	122	–206	–171	**35**	4	27	**22**
Respiratory[c]	33	50	17	16	55	39	–17	5	**22**	–2	–4	**–2**
Diabetes	18	28	10	13	33	20	–4	5	**10**	3	9	**7**
Transport	13	20	6	6	20	13	–7	0	**7**	0	5	**5**
Alzheimer[d]	11	8	–3	23	28	5	12	19	**7**	1	4	**2**
Nephritis[e]	7	10	4	7	17	10	0	6	**6**	0	1	**1**
Septicemia	6	9	3	6	13	8	0	4	**4**	0	2	**1**
Assault	3	11	8	1	10	8	–2	–2	**0**	0	4	**4**
COVID-19	0	0	0	0	0	0	0	0	**0**	57	164	**107**
Total above[f]	710	895	184	362	730	368	–348	–165	**184**	63	247	**184**
Total mortality	845	1056	211	462	908	445	–382	–149	**234**	66	265	**198**
*Decomposition of D of Despair:												
Drugs	2	6	4	7	45	38	5	39	**34**	2	26	**24**
Suicide	13	16	3	11	22	11	–2	6	**7**	–1	1	**1**
Alcohol	11	21	10	11	28	17	0	7	**8**	2	10	**8**

Notes.

[a] Deaths of despair are from drugs (ICD-9 292, 304, 305.2-305.9, 850-858, 980, ICD-10 F11-F16, F18-19, X40-X44, Y10-Y14); alcohol (ICD-9 291, 303, 305.0, 571.0-571.3, 571.5, ICD-10 F10, K70, K74.6, G31.2, X45, Y15); or suicide (ICD-9 950-959, ICD-10 X60-X84, Y87.0).

[b]Cardiovascular diseases (ICD-9 390-459, ICD-10 I00-I99).

[c]Chronic lower respiratory diseases (ICD-9 490-496, ICD-10 J40-J47).

[d]Alzheimer disease and related dementias (ICD-9 331.0, 290.0-290.4, ICD-10 F01, G30, G31.0, G31.1, G31.8, G31.9).

[e]Nephritis, nephrotic syndrome or nephrosis (ICD-9 580-589, ICD-10 N00-07, N17-19, N25-27).

[f]Differences in partial sums are due to rounding.

table are ordered by their size in this column. Finally, the last three columns show what happened during the differences in differences, showing the contribution of each of the listed causes of death to the widening of the gap from 2019 to 2021. In 1992, age-adjusted all-cause mortality rates for those with and without a BA were 845 and 1056, respectively, a difference of 211. The corresponding figures for 2019 were 462 and 908, a difference of 445, an increase from the 1992 gradient of 234 age-adjusted deaths per 100,000. All-cause mortality fell between 1992 and 2019 for people with a BA, and from 1992 to 2010 for those without, remaining approximately constant thereafter. As a result, the gap in mortality between the two education groups increased from 1992 to 2019. The eleven causes of death in Table 1 account for 184 of these 234 deaths per 100,000, or 79 percent; a complete accounting for the period from 2000 to 2021 is provided below. The largest contribution comes from deaths of despair, which added 49 deaths to the change in the gradient, followed by cancer, 43, cardiovascular disease, 35, and chronic lower respiratory diseases, 22. The contributions of diabetes, transport accidents, Alzheimer, nephritis, septicemia, and assault are smaller at 10, 7, 7, 6, 4, and 0. All estimates are rounded to whole numbers, which accounts for any discrepancies within the table. Apart from deaths of despair, where the increase in the gradient comes from a much larger increase in deaths among those without a college degree, the next largest increases in the gradient come from causes of death that have been falling over time, at least for those with a college degree.

The final three columns of Table 1 track the changes in age-adjusted mortality rates and educational mortality gaps from 2019 to 2021. Three numbers are particularly notable. First, note the increase (from zero) of deaths from COVID-19, and the very much larger age-adjusted mortality for those without a BA. COVID-19 alone added 107 age-adjusted deaths per 100,000 to the educational gap between 2019 and 2021. Second, there was a large increase in deaths of despair from 2019 to 2021, almost exclusively among those without a BA, 37 versus 3. Third, age-adjusted deaths from

CVD also rose rapidly, again largely among those without a BA, 27 versus 4. Those three causes of death widened the gradient by 162, out of 184 for the causes of death shown in the table, and out of a total of 198 age-adjusted deaths from 2019 to 2021.

The last rows of Table 1 decompose deaths of despair into its three components: deaths from drugs, from suicide and from alcohol. All three have seen consistent increases in their contributions to the education mortality gradient since the early 1990s. (See Supplemental Figure 3.) Of the three, drug overdose is the largest contributor to the increase in the gradient and has received the most attention. But suicide and alcohol deaths have increased among those without a BA; particularly notable is the contribution of alcohol deaths to the increase in the gradient during the COVID pandemic.

Table 2 shows a more complete characterization of causes of death from 2000 to 2021 using ICD-10 classifications; the shorter span of years obviates the need to match the classifications for ICD-9 and ICD-10. The table shows age-adjusted mortality rates for 2000, 2019, as well as changes from 2000 to 2019 and from 2019 to 2021. Table 2 is constructed in parallel to Table 1, but with different disease classifications. The text below the table explains the letter codes from ICD-10, and allows comparison of the two tables, despite the change in groupings. For example, deaths of despair in Table 1 are now primarily captured in X and K codes. We have excluded causes that account for a small number of adult deaths, so that columns 9 and 12 are now close to adding up to the totals in the last row, 137 out of 139 per 100,000 age-adjusted deaths for the change from 2000 to 2019, and 195 out of 198 per 100,000 for the pandemic years 2019 to 2021. Comparison of Tables 1 and 2 shows that the former did not miss any diseases that made large contributions to the widening gradient, though Table 2 identifies F-codes (mental and behavioral disorders), N-code (diseases of genitourinary system), A-codes (certain infectious and parasitical diseases), and W-codes (certain external causes, including falls) as making minor contributions to the widening gradients both before and during the pandemic.

Table 2. Age adjusted mortality per 100,000 people, ages 25–84, by ICD10 category

	2000			2019			Change 2019-2000			Change 2021-2019		
Cause of Death:	BA	No BA	Diff	BA	No BA	Diff	BA	No BA	**Diff**	BA	No BA	**Diff**
COVID-19	--	--	--	--	--	--	--	--	**--**	57	164	**107**
X-codes	16	34	18	21	77	56	5	43	**38**	1	31	**29**
Cancer	223	278	55	136	212	77	–88	–66	**22**	–5	–1	**4**
J-codes	58	95	37	33	88	56	–25	–6	**19**	–3	–4	**–1**
CVD	247	358	111	125	247	122	–122	–111	**12**	4	27	**22**
G-codes	31	30	-2	44	49	8	10	19	**10**	2	5	**3**
K-codes	23	40	17	19	44	25	–4	4	**8**	2	11	**9**
E-codes	25	44	19	22	50	28	–2	6	**8**	3	12	**9**
F-codes	9	13	5	15	26	12	6	13	**7**	1	4	**3**
V-codes	11	20	9	6	19	13	–5	–1	**4**	0	5	**5**
N-codes	12	21	9	10	23	13	–2	2	**4**	1	3	**2**
A-codes	9	15	6	8	17	9	–1	2	**3**	1	2	**1**
W-codes	7	10	2	9	14	5	2	4	**3**	1	2	**1**
Total above	672	957	285	444	867	423	–228	–90	**137**	65	260	**195**
Total mortality	702	1008	307	462	908	445	–239	–101	**139**	66	265	**198**

Notes on ICD-10 codes.
X: Certain external causes, including accidental drug overdose, suicide, and assault with firearms
J: Diseases of the respiratory system, including chronic lower respiratory diseases, and influenza
G: Diseases of the nervous system, including Alzheimer and Parkinson diseases
K: Diseases of the digestive system, including alcoholic liver disease and cirrhosis
E: Endocrine, nutritional and metabolic diseases, including diabetes
F: Mental and behavioral disorders, including those due to psychoactive substance use
V: Transport accidents
N: Diseases of genitourinary system
A: Certain infectious and parasitic diseases
W: Certain external causes, including falls
Certain causes of death are not shown in the table. These include ICD10 codes B: Certain viral infections; D: Diseases of the blood and blood forming organs; H: Diseases of the eye and adnexa, and diseases of the ear and mastoid process; L: Diseases of the skin and subcutaneous tissue; M: Diseases of the musculoskeletal system; O: Pregnancy, childbirth and puerperium; P: Certain conditions from perinatal period; Q: Congenital malformations, deformations and chromosomal abnormalities; R: symptoms, signs and abnormal clinical and laboratory findings, NEC; and Y: Certain assaults, events of undetermined intent, sequelae of external causes.

An important result in Table 2 is that, between 2000 and 2019, *all* causes of death, grouped by ICD-10 classification, contributed positively to the increase in the gap, and between 2019 and 2021, all except one did so, the exception being J-codes which cover deaths from respiratory diseases. This it true whether the mortality rate for the cause is falling for both groups (cancer, cardiovascular disease), rising for both groups (deaths of despair, respiratory diseases, Alzheimer), or falling for the better educated group and rising for the less educated group (alcoholic liver disease, diabetes). With the one exception noted, the widening gap characterizes all time periods and all causes of death.

Figure 3 shows time series of age-adjusted mortality for the three diseases that contribute most to the increase of the gradient, deaths of despair, cancer, and CVD, by gender and by college degree status. The top panel shows CVD mortality and deaths of despair, while the bottom panel shows cancer mortality. The top panel shows that the rise in deaths of despair is more important for men than for women, and in both cases is almost entirely confined to those without a college degree. CVD mortality also contributes to the widening gap for both men and women. The long-term decline that began in the 1970s lost momentum among those with a BA and stopped falling altogether after 2010 for those without the degree. After 2010, it rose slowly up to the pandemic, and then more rapidly during it. These changes in the pattern of declining CVD mortality are recent, not well understood, and are of major importance, not only for understanding the gaps, but for understanding prospects for mortality more generally. Cancer mortality rates fell much more rapidly for women with a college degree than for women without; indeed, in 1992, mortality rates from cancer were *higher* for more educated women. For men, there is a more modest widening, with substantial decline for both those with and without a degree.

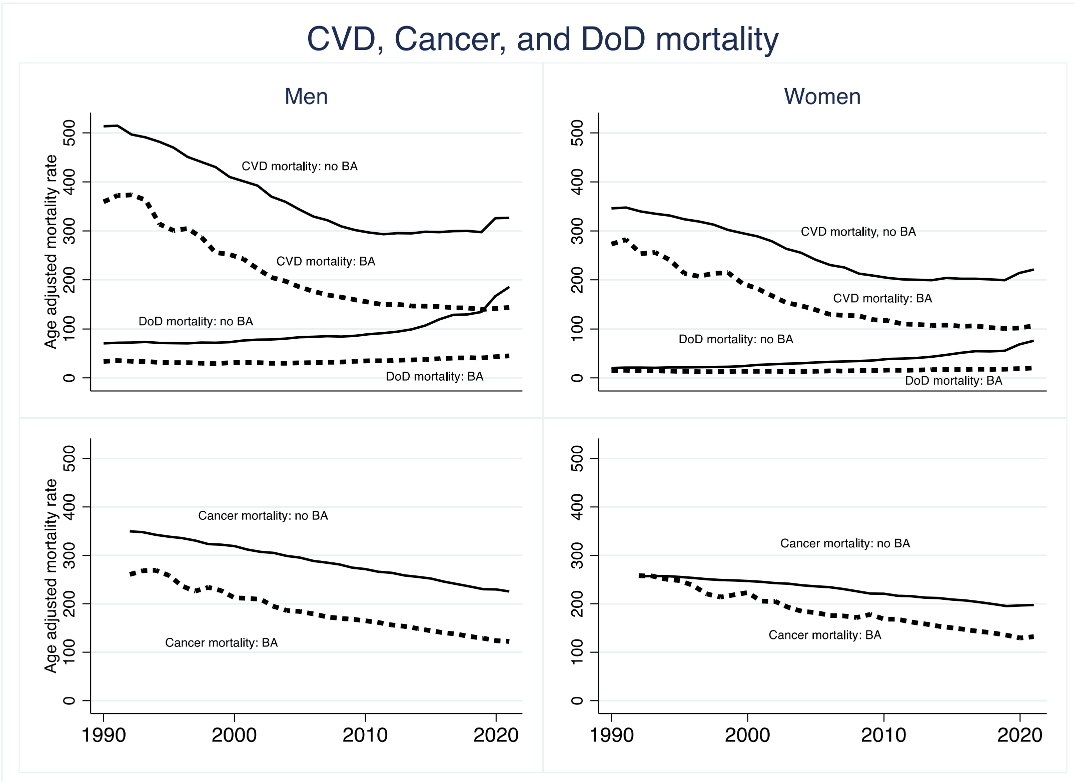


Figure 3. Age-adjusted mortality rates, by educational attainment

Figures 4 and 5, for women and men respectively, document patterns of mortality by education for the major cancers, for women, lung, breast, colon, ovarian, liver, and pancreatic cancer, and for men, lung, prostate, colon, liver, and pancreatic cancer. In the years immediately after 1992, lung cancer mortality was still rising for women without a BA but falling for those with a BA. After 2006, lung cancer mortality fell for both groups in parallel and, after 2014, the mortality gap in lung cancer fell modestly for women. The contribution to widening the gradient comes before 2006. For men, who stopped smoking earlier than women, lung cancer mortality fell for both groups from 1992 to 2021, though more rapidly for those *without* a college degree, so that changes in lung cancer mortality for men worked to narrow the mortality gap. In 1992, breast cancer mortality was higher for women with a college degree, a longstanding finding that is often attributed to the protective effects of early childbearing. But, as predicted by Link, Northridge, Phelan and Ganz (1998), as scanning and effective treatment became available, breast cancer mortality fell more rapidly for the more-educated group, contributing to a widening of the gradient. Prostate cancer mortality has fallen for men with and without a college degree, but more rapidly for those with, adding a relatively small amount to the widening of the mortality gap.

Among women, mortality from both colon and ovarian cancer were higher among those with a college degree in 1992, but as was the case for breast cancer, mortality fell more rapidly among women with a BA, crossing over in colon cancer, and converging for ovarian cancer. As with breast cancer, screening and treatment were almost certainly both important. Mortality from liver cancer, for which risk factors include excessive alcohol use and cirrhosis, has been rising over time for both men and women, primarily among men and women without a college degree. Pancreatic cancer mortality has risen for both men and women without a college degree, while holding relatively steady after 2000 among those with a degree.

A key takeaway from Figures 4 and 5 is that while different cancer mortality rates have behaved differently, with some falling and some rising, and while, for some cancers, mortality is or was higher for those with a college degree, for all the cancers examined here, with the exception of lung cancer for men, the educational gaps in mortality widened over time. Advances in medical treatments for many cancers, and protective behavioral changes, have had larger effects for those with a BA.

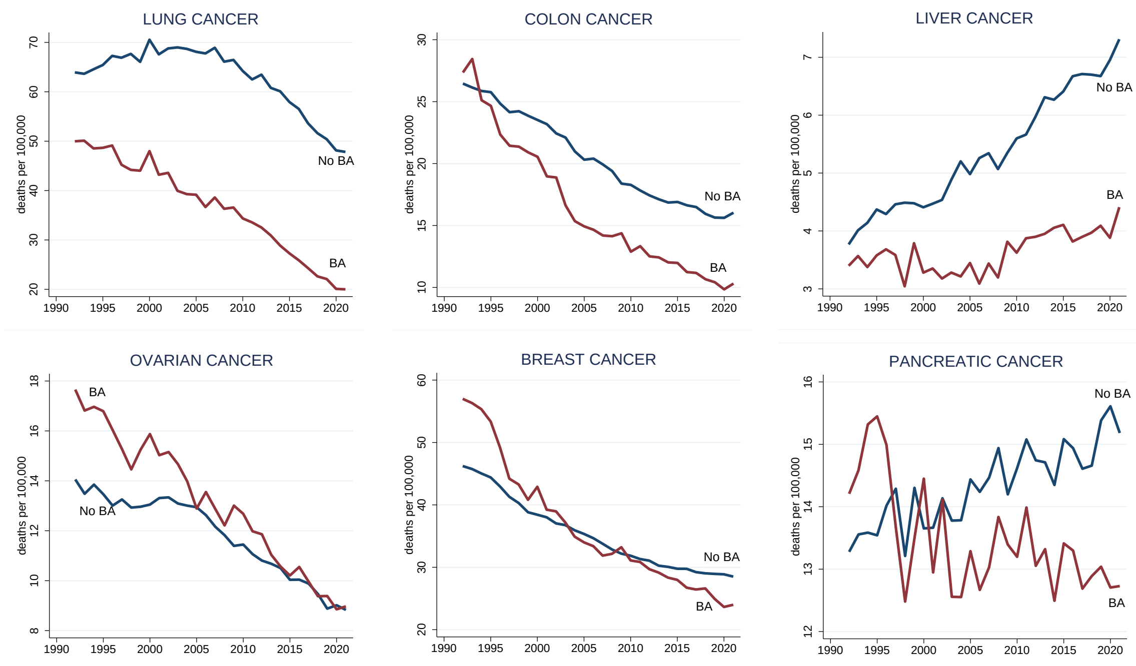


Figure 4. Age-adjusted cancer mortality rates, WOMEN, by BA status

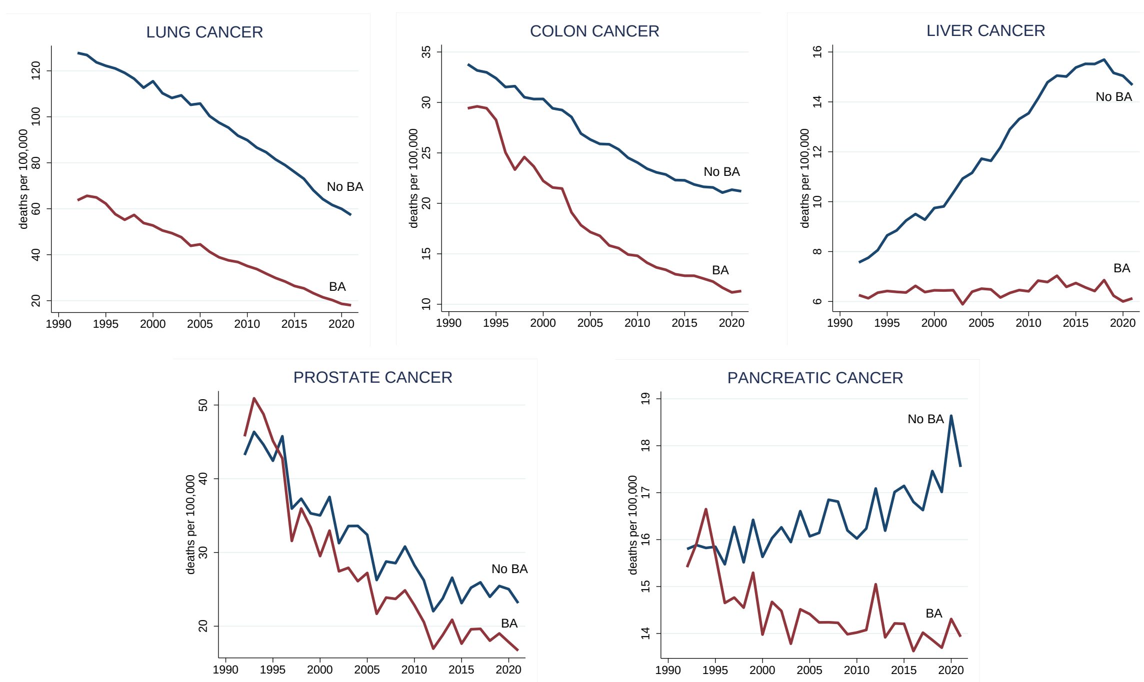


Figure 5. Age-adjusted cancer mortality rates, MEN, by BA status

Table 3 calculates the college mortality gap by age-group for 1992, 2019 and 2021. Column (1) gives the shares of each group in the population in 2000; these are the weights that can be applied to columns (2) through (6) to give the population totals in the bottom row. Column (2) gives the age adjusted mortality rates in 2000 irrespective of educational status, while columns (3), (4) and (5) give the gaps, the differences in age-adjusted mortality rates between those with and without a

Table 3. College gaps in age adjusted mortality by age groups.

Age group:	(1) Population shares in 2000 (%)	(2) Age-Adjusted mortality rate[a] in 2000	(3) Mortality gap[b] 1992	(4) Mortality gap[b] 2019	(5) Mortality gap[b] 2021	(6)=(5)-(3) Change 1992 to 2021	(7)=(6)/(2) Change as a percent of 2000 rate
25-34	22.3	102	96	149	231	135	132
35-44	25.3	199	126	203	324	198	99
45-54	21.3	422	213	334	502	289	68
55-64	13.7	986	409	649	882	472	48
65-84	17.3	3,706	327	1,157	1,629	1,301	35
All 25-84	100	939	211	445	643	432	46

[a]Deaths per 100,000 persons.
[b]Difference in mortality rate for people without and with a four-year college degree.

four-year college degree. Column (6) shows the change in the gaps from 1992 to 2021; these changes are, unsurprisingly, larger in groups with higher baseline mortality, and the final column shows the changes as a percentage of the baseline (2000) mortality rates. The baseline of 2000 was chosen to align with its use in age-standardization.

The overall increase in the gradient from 1992 to 2021 is 431 deaths per 100,000, to which the largest contribution comes from those aged 65 and over, (0.173*1301)/431=52 percent. The largest share of this is due to education differences in COVID-19 mortality, though there are also substantial contributions from cancer and CVD. As a percentage of baseline mortality, younger age groups saw larger increases in education gradients over this period; for the age group 25 to 34, the increase in the gap exceeded baseline mortality. Two-thirds of the increase among the youngest group was from deaths of despair. As we move from young to old, COVID mortality becomes more important in contributing to the gradient, as do, to a lesser extent, mortality from CVD and cancer; deaths of despair become progressively less important.

4. The effects of rising educational attainment

Our main interest here is in documenting the changing differences in mortality between those with and without a four-year college degree, breaking up the patterns by cause of death, by gender, and by age. Beyond our scope here is a delineation of the *reasons* for the better health of college-degree holders, whether more schooling in and of itself brings better health and better health behaviors, or whether social and economic treatment of the college-degree credential has created an increasingly difficult environment for those without it. One account, however, needs to be discussed here, which is that the rising fraction of Americans with a four-year college degree may be contributing to the rising gap and can perhaps even account for it. If the new college attendees are healthier than those who remain in the non-college group, then a rising proportion of the population going to college will leave a non-college group that is increasingly negatively selected on health. In 2021, 35 percent of the population aged 25–84 had a four-year college degree compared with 22 percent in 1992; the increase for women, 18 percentage points, was larger than that for men, 10 percentage points.

The effects on the educational health *gap* are not clear a priori because health selection as described above can increase mortality rates for both groups, as the healthier non-graduates leave the pool of non-graduates, making the non-graduate group less healthy, and join an initially healthier graduate group, also reducing health in that group. It is straightforward to construct examples in which the gap does not change as more or fewer people go to college. For example, if health h is uniformly distributed between 0 and 1, and those with $h > \theta$ go to college, a fraction $(1-\theta)$, the average health in the two groups is $\theta/2$ and $(1+\theta)/2$, and the gap is always $1/2$, which does not depend on θ. This example illustrates only one possibility. Another comes from assuming that health h has a standard normal distribution, where those with $h > \theta$ go to college. Average health among the non-college group is $\phi(\theta)/\Phi(\theta)$ and among the college group is $-\phi(\theta)/[1 - \Phi(\theta)]$, where $\varphi(.)$ and $\Phi(.)$ are the probability density function and the cumulative distribution function of the normal distribution. Both these expressions are declining in θ, but the gap between average health of the college and the non-college groups, which is $-\phi(\theta)/\Phi(\theta)[1 - \Phi(\theta)]$, increases with θ until half the population is in college and decreases thereafter.

Our primary focus here is the mortality gap between those with and without a college degree, no matter who is in the two groups—again note the parallel with the earnings of those without a college degree. The fraction going to college, although it may affect the mortality gap, just as it may affect the wage premium, is not a source of bias in our estimates—we are not estimating a parameter of interest that would be biased by the selection—though it may certainly be a *cause* of what we find. Our view is that selection is one cause of health gaps among others, including the opportunities for and treatment of those with and without college degrees.

A number of papers in the literature have made corrections for possible selection effects. Meara, Richards and Cutler (2008) randomly reallocate some of their observations to keep constant the proportions in each of their groups. Others have worked with percentiles of the distribution of years of schooling, including Novosad, Rafkin and Asher (2022), and Geronimus et al (2019), whose focus, similar to ours, is on mortality gaps between more and less educated Americans. While we look at people with and without a college degree, Geronimus et al (2019) compare outcomes for people in the bottom quartile of the education distribution with those in the top three quartiles. Even if educational qualifications were measured continuously, it is unclear why what happens at a particular percentile is of interest, given that jobs and social standing depend more on qualifications, nor how, in the presence of health selection, looking at percentiles identifies a specific parameter of interest. Geronimus et al assign quartiles within (birth year, sex, race) cells for Black and White non-Hispanics. For Whites non-Hispanics, examination of the data shows that the bottom quartile has been defined by a high school degree since the birth cohorts born in the early 1920s, and for Blacks, since the early 1940s. As a result, a comparison of the bottom quartile to the rest of the distribution is quite similar to a comparison between those with no more than a high school degree to those with at least some college education. Their categorization differs from ours, in practice, in allocating the group with some college, but less than a BA, to their "high" education category. In previous work, we have shown that socioeconomic outcomes and mortality patterns for those with some college, but no BA, are more similar to those with a high school degree or less than to those with a college degree. (We update and explore this in Supplemental Figure 4.) Despite this difference, and despite their use of what we believe is an incorrect outcome measure (see Supplemental Text), their estimates are qualitatively similar to ours. That this is so could also be taken as evidence that the selection effects on the gap are not very important, a finding that is echoed by Novosad et al (2022), as well as by Hayward and Farina (2023) based on a review of other relevant studies.

One useful procedure is to examine changes in education-mortality gaps within each birth cohort. On the assumption that education levels are fixed once education is completed, here taken to have happened by age 25, changes of health within each cohort cannot come from selection effects. Changes over time in the effects of a four-year degree on health will show up within cohorts; we have in mind changes in working or living conditions that differ between those with and without a college degree.

We define a relative gap measure for each age and year. For each age and year, we calculate the mortality gap ratio $(m_1 - m_3)/m_0$, the mortality difference between group 1—those without a BA—and group 3—those with a BA or more, scaled by the mortality rate for the population of that cohort. Note that this measure is at least crudely corrected for age effects, which are in both numerator and denominator. Figure 6 plots the mortality gap ratio by age for birth cohorts born at ten-year intervals for men and for women; the plots for all cohorts are too crowded to read. (Figure 6 echoes the cohort graphs in Case and Deaton (2020, Chapter 4) which show similar patterns of upward movement and rotation, but only for those without a college degree, consistent with the pattern for the gap ratios in Figure 6.)

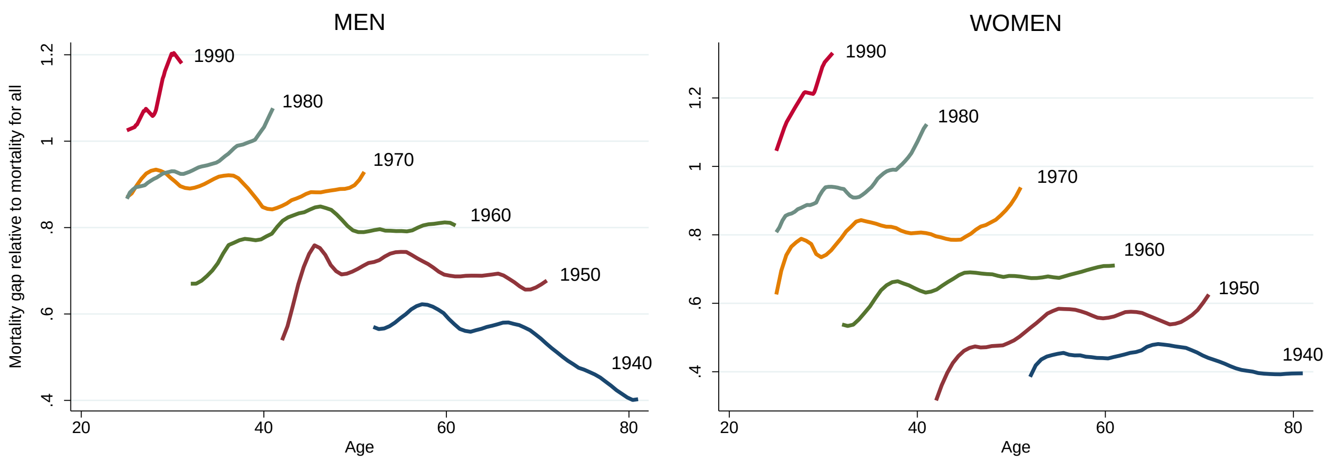


Figure 6. Mortality Gap as a fraction of mortality by age and birth year

Figure 6 shows that most of the increase in the relative mortality gap is *between* cohorts, and that there is no consistent increase in the gap within cohorts. For the birth cohorts of 1970 and after, the plots slope upward at higher ages. For those born in 1960 they are approximately flat, while, for those born in 1940, the plots decline with age. For the younger cohorts only, the upward slope with age can be thought of as a *period* effect operating after 2010. These increases cannot be due to selection nor to age-invariant health behaviors associated with education if educational attainment within each birth cohort does not increase with age after age 25.

However, examination of educational attainment within each birth cohort shows that the fraction of those reporting a college degree does indeed increase as the cohort ages. For example, for those born in 1940, a regression of degree attainment on age attracts a coefficient of 0.0011, so that between when we first see them at age 52 and last see them at age 81, the fraction with a college degree has increased by more than three percentage points. For younger cohorts, the numbers are larger; for example, for the cohort born in 1970, the fraction reporting a degree increases by 14 percentage points from age 25 to 51. Differential mortality rates—which we know—will differentially select out the less educated as each cohort ages, but this effect is negligible for the younger cohorts. For the cohort born in 1940, which we see from age 52 to age 81, differential mortality should increase the fraction with a degree by 4 percentage points, but for the 1970 cohort, the increase is less than 1 percentage point. According to the National Center for Education Statistics (2023), about a quarter of college graduates in 2012 obtained their degree between ages 25 and 39, presumably mostly at the lower end of that range. Even so, there is upward drift within cohorts beyond age 30 (and even beyond age 40) in the reported fraction of degree holders.

The upward drift in reported possession of a bachelor's degree for later-born cohorts cannot be explained by differential mortality, and is unlikely to be fully explicable by people going back to college. Immigrants are about as likely as native-born Americans to have a college degree, Krogstad and Radford (2018), so we are left with the supposition that people are granting themselves degrees as they age. There are certainly great incentives to do so, and perhaps few risks to people checking a box on a website for jobs in the hope that prospective employers will not check.

What does this imply for the analysis in this paper, or indeed for other papers in the literature that assume that education is complete by age 25? Effects ascribed to having a college degree are, at least in part, confounded with the effects of compositional change, even within birth cohorts. Several papers have questioned the use of education as reported on death certificates on the grounds that it is *not* self-reported and take that as a reason to work with the (much smaller) mortality follow-up of the National Health Interview Survey, Hendi (2017), Masters, Hummer, and

Powers (2012). Yet our results show that self-reports may also be problematic. If the main concern is adults going back to college, the analysis can be confined to those ages 35 (or 45) and above; but the years before 35 (or 45) make little contribution to the widening gap, and Figures 1 and 2 show the same patterns of widening gradients if we work with ${}_{50}e_{35}$ or ${}_{40}e_{45}$ in place of ${}_{60}e_{25}$. Note that our parallel with calculations of the college wage premium is unaffected in the sense that the health and wage premia are both based on potentially exaggerated degree attainment. Each should be interpreted as the difference in earnings or mortality outcomes between those who have or claim to have a college degree and those who do not. Many people who falsely claim to have a degree may still receive the social and economic benefits of having one.

5. Discussion

In 2008, Meara, Richards and Cutler examined mortality by education up to 2000 and entitled their paper "the gap gets bigger." Their title works just as well for the mortality gap between Americans with and without a bachelor's degree in the subsequent years, from 2000 to 2021. Indeed, the rate of widening accelerated after 2010 and exploded during the pandemic.

The years between 1992 and 2021 were years in which patterns of mortality changed dramatically, and those changes were different for men and for women. What is remarkable is that the widening of the gap transcended these changes in the mortality patterns. This would have been remarkable enough for the gap in all-cause mortality as the underlying causes of death changed. What is more surprising is that the widening gap is seen in virtually all the major groupings of causes of death. We see it in deaths whose rates have risen in the last thirty years, like deaths of despair and COVID-19, we see it in deaths whose rates have fallen in the last thirty years, like cancer, we see it in deaths whose rates have fallen and then risen, like deaths from cardiovascular disease, and we see it in deaths whose rates were originally higher for those without a BA, most diseases, and those that were originally lower for those without a BA, colon, liver, ovarian and breast cancer for women, and prostate and pancreatic cancer for men. Even though the mechanisms and stories are different for each disease, and sometimes different for men and women, the widening gap is almost always there.

The "virtual" and "almost" are there to note the only exception that we have found, which is the category in ICD-10 labeled "diseases of the respiratory system, including chronic lower respiratory diseases, and influenza," but excluding deaths from COVID-19, and then only during the two-year period from 2019 to 2021, the pandemic years. For the 2000 to 2019, the gap in this category widened, as in other causes of death, so the only exception was during the pandemic. During 2020 and 2021, some respiratory diseases may have been misclassified as COVID-19 and, given that COVID-19 deaths were much more common among those without a BA, the narrowing of the gap in respiratory diseases could plausibly be due to this misattribution.

We note too that while the increasing gap is seen in cancer as a group, the gap is shrinking for one specific cancer, lung cancer mortality for men. Men with a BA gave up smoking much earlier than men without, but in recent years, the latter have been quitting too, which has narrowed the gap. For women, the mortality gap in lung cancer has continued to increase, as it has for mortality from other cancers, as well as for all cancers together for both men and women.

Fundamental cause theory says that, whenever there exists the means to prevent death, those means will be more effectively seized by those with power and resources, Link and Phelan (1995). What we are seeing here is fundamental cause mechanisms on steroids; the gap is not just present, but expanding, and expanding at an accelerating rate. Either the gap in power and resources is expanding or the means of preventing disease has been growing; we suspect both are true. However, we do not have a well-documented account of how and why this is happening, but point instead to the fact that these gaps, between those with and without a BA, are widening across a range of life outcomes that we have reason to care about, not just mortality, but also morbidity—including many kinds of pain—as well as in marriage rates, out-of-wedlock childbearing, religious observance, institutional attachments, and in wages and participation in employment, see Case and Deaton (2020).

Figure 7 illustrates with one such comparison, between wage rates and deaths of despair. The blue line, labeled on the left-hand axis, shows the college wage premium, defined as the ratio of median wages for those with a BA or more to median wages for those without a BA, while the red line, labeled on the right-hand axis, shows the ratio of the age-adjusted mortality rate from deaths of despair for those without a BA to the age-adjusted mortality rate from deaths of despair for those with a BA or more. In both cases, we look at ages 25 to 64. Note that we are not arguing for a direct causal connection here; instead, we think of these series as two of many ways of documenting the deterioration in the situation of less-educated people in today's United States. Note that both comparisons show rising gaps up to 2000, then a period of relative pause, followed by an acceleration after 2010. A closing of mortality gaps may be an elusive goal while gaps in other domains continue to increase.

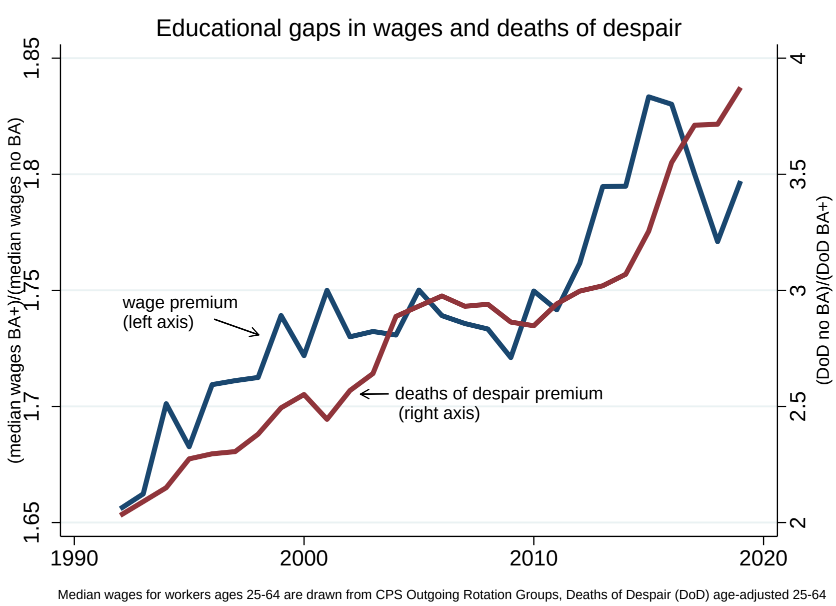


Figure 7: Educational gaps in wages and deaths of despair

Supplemental Text

Measures of mortality

We use two summary measures of mortality in the paper. One is age-adjusted mortality for those aged 25 to 84; this is straightforward and non-controversial. The other is the years of life to be expected by someone on their 25th birthday in the 60 years up to their 85th birthday; this measure is computed, like other life-expectancy measures, using the current age-specific mortality rates in each year, and like them, it is a summary measure of age-limited mortality rates in each year. (It should be regarded as a summary measure of mortality, not a forecast, and does not require any assumption about mortality rates remaining constant.) The measure was first developed by Arriaga (1984), who referred to it as temporary life expectancy, and it can be applied to any span of years. The standard notation is ${}_ne_a$, with the first subscript referring to the period over which the expectation is taken, and the second referring to the age at which it is taken. In life-table notation, it is calculated as

$$ {}_ne_a = \frac{T_a - T_{n+a}}{I_a} \qquad (1) $$

Where *a* is age, here 25, *n* is the span of years being used, here 60, I_a is the number of people surviving to exact age *a*, out of 100,000 at age 0, and T_a is the total number of years lived beyond age *a* by the survivors of the original 100,000.

Geronimus et al (2019) (GBWRT) use the difference in life expectancies between age *a* and age *n*+*a*, which is $e_a - e_{n+a}$. (They actually work with the difference between this and *n*, which they refer to as years of life lost, which is *n* minus the difference in expectancies.) The difference between the two measures is given by

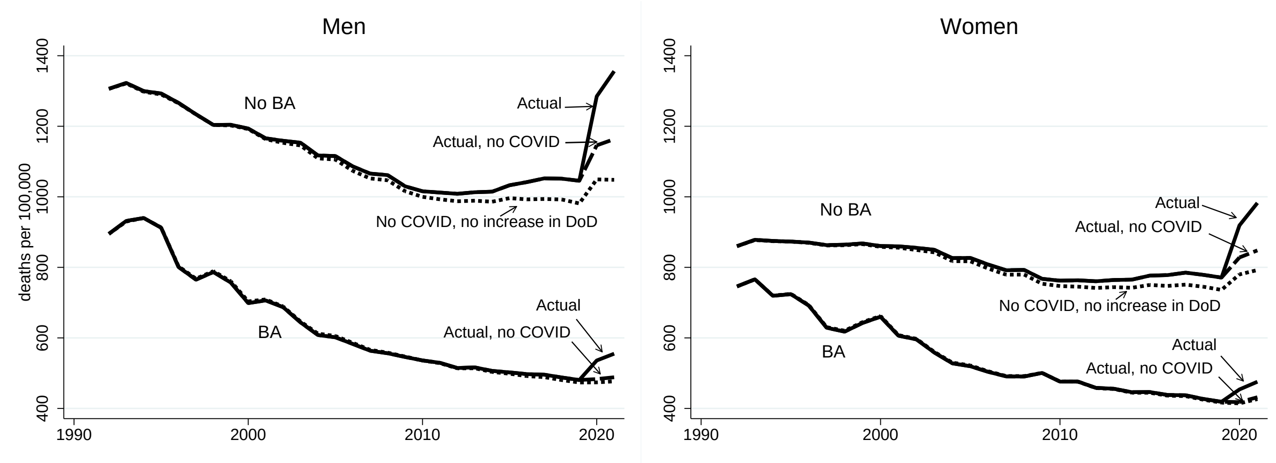
$$ {}_ne_a - (e_a - e_{n+a}) = e_{n+a}\left(1 - \frac{I_{n+a}}{I_n}\right) \qquad (2) $$

The difference is always positive, so that the GBWRT measure always understates the expected years of life between *a* and *n*+*a*. Indeed, there is nothing to stop the GBWRT measure being *negative*.

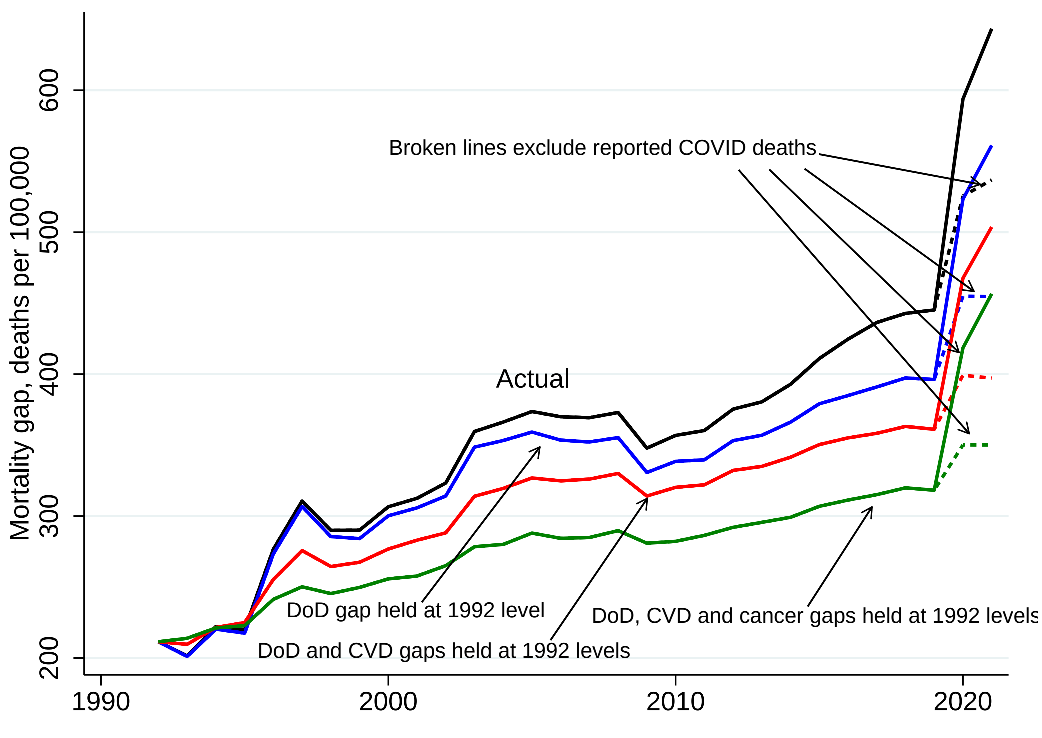
In high child mortality situations, such as Britain in the 19^{th} century, life expectancy at age 15 was frequently higher than life expectancy at birth, even though the expected years of life from age 0 to age 15 was positive. In the US today, the understatement is around 4 years if we use the current life table for the whole population. When mortality is falling, the two terms on the right-hand side of (2) change in opposite directions, so there is no reason to expect a trend over time.

More problematic than the discrepancy, which may not much affect the temporal evolution of the gap, is the fact that calculation of the GBWRT measure requires knowledge of life expectancy at 85, which depends on mortality rates at ages higher than 85. This is not true of the Arriaga measure, which is independent of mortality rates above age 85 (Arriaga, 1984). Indeed, it was this consideration, and the difficulty of measuring mortality rates in old age, that led Arriaga to propose the temporary life expectancy measure in the first place. That difficulty remains, and the CDC's official lifetables for the US do not use the information from the death certificates but use data from Medicare. Calculating life expectancy at 85 from the death certificate data would typically require the use of mortality curves to project mortality at high ages, though it is not clear from Geronimus et al (2019) exactly how it was done. We regard the Arriaga measure as both conceptually superior—because it is a measure of expected years of life—and computationally superior—because it does not depend on mortality rates at ages 85 and above. Even so, as we note in the text, the two sets of results are qualitatively similar over the years that are covered by both.

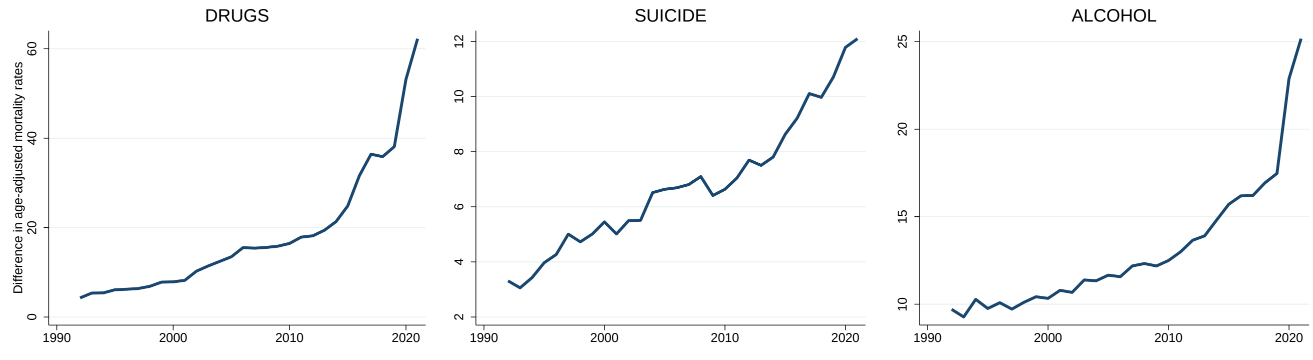
Supplemental Figure 1.
Age-adjusted 25-84 mortality rates, with and without COVID-19 and deaths of despair



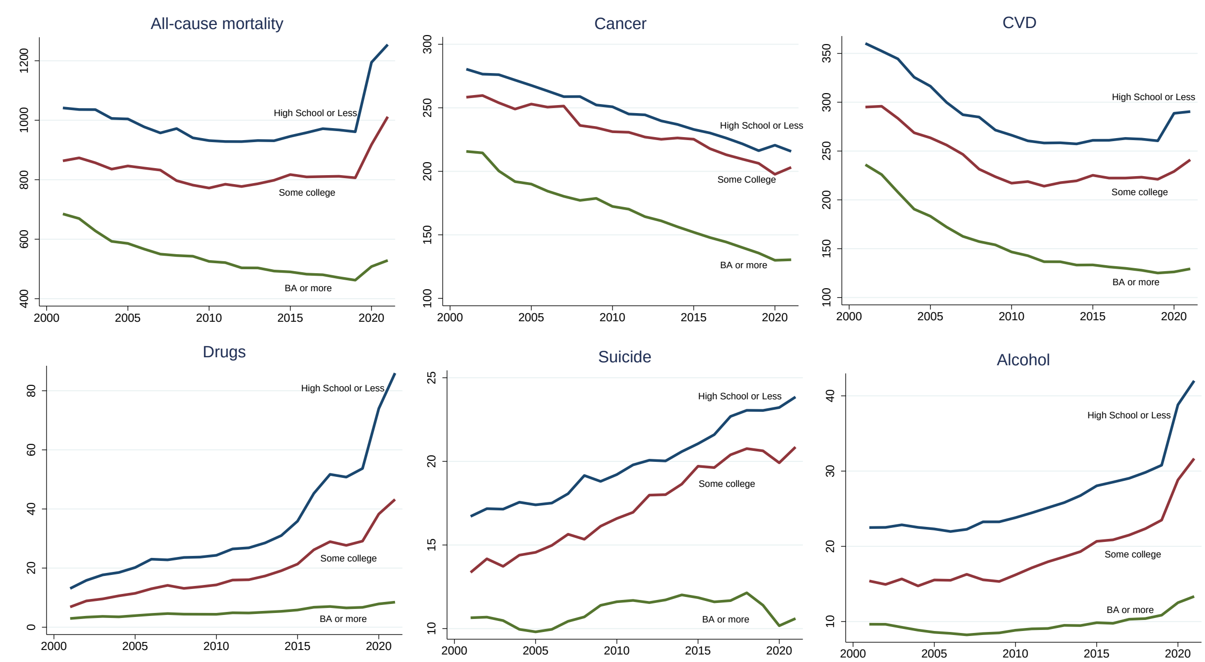
Supplemental Figure 2.
Age-adjusted 25-84 mortality gaps between those without and with a BA



Supplemental Figure 3.
Age-adjusted 25-84 mortality gaps between those without and with a BA



Supplemental Figure 4.
Mortality by cause for three education groups: High School or Less, Some College, and BA or more



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