# "Despair" and Death in the United States

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## Abstract

Increases in "deaths of despair" have been hypothesized to provide an important source of the adverse mortality experiences of some groups at the beginning of the 21st century. This study examines this possibility and uncovers the following primary findings. First, mental health deteriorated between 1993 and 2019 for all population subgroups examined. Second, these declines raised death rates and contributed to the adverse mortality trends experienced by prime-age non-Hispanic Whites and, to a lesser extent, Blacks from 1999-2019. However, worsening mental health is not the predominant explanation for them. Third, to extent these relationships support the general idea of "deaths of despair", the specific causes comprising it should be both broader and different than previously recognized: still including drug mortality and possibly alcohol deaths but replacing suicides with fatalities from heart disease, lower respiratory causes, homicides, and conceivably cancer. Fourth, heterogeneity in the *consequences* of a given increase of poor mental health are generally more important than the *sizes* of the changes in poor mental health in explaining Black-White differences in the overall effects of mental health on mortality.

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It is well understood that poor mental health is associated with higher risk of death at the individual level (Walker, McGee, and Druss 2015; Plana-Ripoll et al. 2019, 2020) and there is evidence that the prevalence of psychological distress has increased over time in the United States (Blanchflower and Oswald 2020; Daly 2022; Zheng and Choi 2024). What is not currently known is to what extent the interaction of these two patterns affects aggregate mortality rates nor how any such effects differ across population groups or causes of death.

The answers to these questions are important. US life expectancy has been stagnant or falling since at least 2014 (Woolf and Schoomaker 2019; Currie and Schwandt 2021), an historically almost unprecedented trend that started well before the large reductions resulting from the COVID-19 pandemic. Increases in "despair" have been hypothesized to be the cause of these adverse mortality trends. In their influential research, Case and Deaton (2015) highlight the role of drug, suicide, and some alcohol-related deaths (hereafter DSA) in the rising mortality rates of 45-54-year-old non-Hispanic Whites from 1999-2013. Subsequent evidence shows death rates increased over broader age ranges and may have been more pronounced for younger persons (Kochanek, Arias, and Bastian 2016; Squires and Blumenthal 2016; Kolata and Cohen 2016; Ruhm 2018; National Academies of Sciences, Engineering, and Medicine 2021).

In follow-up studies, Case and Deaton (2017, 2020) emphasize the particularly large mortality rate growth experienced by less educated Whites, which they believe reflect economic and social shocks particularly harmful to these groups. They attribute much of this to growth in DSA mortality, which they label "deaths of despair". The "deaths of despair" framing has become ubiquitous: a Google Scholar search on June 17, 2024, revealed more than 6,400 pieces using the term and a more general Google search obtained almost 300,000 results.

Despite this provocative hypothesis, we do not currently understand the linkages between poor mental health and recent mortality trends. Specifically, we have somewhat limited information of how mental health has changed over time and know even less about how the effects of these trends on mortality differ across population groups or causes of death, nor to what extent deteriorations in mental health can explain the observed the increases in mortality rates recently observed for some groups.[1]

The current analysis investigates these issues in three stages. The first operationalizes and provides empirical evidence on how rates of poor mental health in the US have changed between 1993 and 2019, overall and for population subgroups. The second uses panel data econometric methods to estimate which group-specific and cause-specific mortality rates are most strongly associated with changes in mental health. Counterfactual estimates are then provided examining how much mortality rates in 2019 would have differed from observed rates if poor mental health had remained at 1999 levels. As part of this, the overall effect is decomposed into the contributions of trends in mental health versus the responsiveness of mortality rates to given changes in them. The third analyzes the extent to which worsening mental health from 1999-2019 explain mortality trends over the same period. Some of the analysis focuses on 25-54 year olds (hereafter also referred to as "prime-age") non-Hispanic Whites and Blacks, overall and stratified by educational attainment, since these groups experienced the most adverse changes in death rates.[2]

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[1] There are also reasons to doubt that drug, suicide, and alcohol mortality have uniform causes since patterns of deaths: vary substantially across geographic areas (Stein et al. 2017; Dwyer-Lindgren et al. 2018; Monnat et al. 2019); have markedly different age profiles of increased mortality (Ruhm 2022); and respond heterogeneously to a variety of economic shocks (Ruhm 2019; Brown and Wehby 2019; Pierce and Schott 2020; Dow et al. 2020; Giles, Hungerman, and Oostrom 2023).

[2] To my knowledge, the second and third stages of this analysis have not previously been investigated. Most closely related is a recent study by Zheng and Choi (2024) which uses national data to calculate changes in mortality hazard rates over time for individuals with different levels of psychological distress and then compares these with corresponding trends in mortality rates from a measure of "deaths of despair".

The study uncovers six primary findings. First, mental health deteriorated over time for all population groups examined, with some heterogeneity in the size of the change. Second, increases in poor mental health are associated with higher rates of all-cause mortality, although the estimates are not always statistically significant. The data also suggest more adverse mortality responses for younger than older adults, particularly for prime-age non-Hispanic Whites. Third, trend increases in poor mental health are associated with growth in DSA mortality but largely due to higher drug fatality rates and, for the full population but not prime-age persons, alcohol-related causes; estimated effects for suicides are much smaller. Additionally, there are fairly strong predicted impacts on mortality from heart and lower respiratory diseases as well as, sometimes, homicides and cancer. Fourth, for the full population, the counterfactual reductions in mortality rates estimated to occur if mental health had not deteriorated from 1999-2019 are largest for heart disease deaths, followed by those from DSA and lower respiratory causes. When focusing on prime-age Whites, there are substantial effects across a variety of causes, including heart, cancer, and alcohol mortality, along with extremely large but less precisely estimated impacts on drug deaths. For prime-age Blacks, counterfactual changes in drug and, to a lesser extent, homicide deaths are consequential, although the overall effects are much smaller in absolute terms than for prime-age Whites. The predicted effects are particularly large for prime-age individuals who never attended college. This reflects relatively high baseline death rates, rather than disproportionate percentage responses. Fifth, heterogenous *consequences* of given deteriorations in mental health are generally more important than differential trends in poor mental health in explaining racial differences in the overall mortality effects. Finally,

However, the national data are subject to potentially serious omitted variables biases and the effect of psychological distress on cause-specific mortality rates is not directly examined.

while worsening mental health accounts for a portion of the adverse mortality trends experienced by prime-age individuals, they are not the primary driver of them.

**Data**

Information on poor mental health comes from the *Behavior Risk Factor Surveillance System (BRFSS)*, a large ongoing telephone survey of non-institutionalized adults that collects information on health-related risk behaviors, chronic health conditions, and the use of preventive services (Centers for Disease Control and Prevention 2024a). The key question used asks "Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?" In addition to the number of days of poor mental health, dichotomous variables are created indicating poor mental health in at least 15 and in all 30 days. The first of these was employed in prior research by Kessler et al. (2022) with the threshold chosen based on evidence that it has good concordance with *Patient Health Questionnaire-4 (PHQ-4)* scores of 6 or greater, which indicate clinically significant anxiety and depression (Löwe et al. 2010). The second was previously used by Blanchflower and Oswald (2020) and Blanchflower, Bryson, and Xu (2024), and is characterized by them as an indicator of "extreme distress".

The mental health questions were initially introduced in the *BRFSS* in 1993 and so that is the starting point for the investigation of mental health trends. The final year of analyzed is 2019, since there could be strong idiosyncratic effects of the COVID-19 pandemic, which began in the U.S. early in 2020, on both poor mental health and mortality.

Data on state and national populations are from the *Surveillance Epidemiology and End Results (SEER)* program (National Cancer Institute 2024a). The *SEER* data are designed to supply more accurate population estimates for intercensal years than standard census projections, and to adjust for population shifts in 2005, resulting from Hurricanes Katrina

and Rita. In addition to total population, counts are constructed for demographic subgroups stratified by sex, age, race/ethnicity, and some interactions between them. The *SEER* data do not contain information on education. Education-specific populations are therefore computed using *SEER* populations multiplied by education shares from the *Current Population Survey Merged Outgoing Rotation Group* (*CPS-MORG*) files (National Bureau of Economic Research 2024).

The outcomes include total, group-specific, and cause-specific mortality rates. Information on deaths comes from the *Multiple Cause of Death (MCOD)* files which cover the universe of U.S. deaths and supply information on demographic variables and the underlying cause of death (Centers for Disease Control and Prevention n.d.).[3] Classifications of the underlying cause of death are based on *International Classification of Diseases, Ninth Revision* (ICD-9) codes through 1998 and corresponding ICD-10 codes starting in 1999. Information on state of residence, age, race/ethnicity, gender, education, and year of death are also utilized in this analysis. Special permission was obtained to use restricted data, which provide full individual data on these characteristics for all deaths.[4]

This analysis uses data on the universe of deaths occurring to US residents from 1993-2019.[5] Death counts are converted into mortality rates per 100,000 using the *SEER* population data. Unless otherwise noted, all mortality rates are age-standardized using 2000-year standard population weights for 19-age groups: <1, 1-4, 5-9, five-year intervals through 80-84, and ≥85 years old (National Cancer Institute 2024b). In addition to total death rates, mortality rates are separately calculated for males and females, non-Hispanic Whites (hereafter "Whites"), non-Hispanic Blacks (hereafter "Blacks"), Hispanics, three age

[3] Additional information available on contributory causes of death is not used in this analysis.

[4] Publicly available information on mortality, available from *CDC Wonder* (Centers for Disease Control and Prevention n.d.), is aggregated and does not provide counts when the number of deaths is less than 10 for the specified cell.

[5] Foreign residents dying in the US are excluded.

groups (20-34, 35-54, and ≥55 year olds) and, for persons 25 and older, three education categories (no college, some college but no four-year degree, and college graduates), as well as some interactions between race, age, and education groups.[6]

Crosswalks have been established between the ICD-9 and ICD-10 coding systems, used before and after 1999 but the correspondence in causes of deaths is imperfect, partly because the categorizations have become more detailed over time. To examine the importance of these issues, the National Center for Health Statistics has calculated "estimated comparability ratios", indicating the relative number of deaths in 1996 attributed to a specific cause using the ICD-9 and ICD-10 classifications (Anderson et al. 2001). Comparability ratios close to one indicate that data comparability problems across the two coding systems are likely to be minor.[7] This is frequently the case. For example, the comparability ratios for deaths from heart disease, cancer, diabetes, transport accidents, suicides, and homicides are 0.998, 1.007, 1.008, 0.998, 0.996, and 0.998. The ratios deviate slightly more from one for some causes such as lower respiratory diseases (1.048) and strokes (1.059). However, they differ more drastically for influenza/pneumonia (0.699), kidney diseases (1.232), and Alzheimer's disease (1.554), indicating difficulty in obtaining equivalent estimates for those causes across the two ICD coding systems.[8] In addition, the coding of alcohol-related fatalities changed between the two systems in ways that make

[6] Several factors complicate the calculation of education-specific mortality rates and trends in these rates will at least partially reflect compositional changes in the education groups. These issues are discussed in Appendix B.

[7] Comparability ratios greater (less) than one indicate that more deaths are reported using the ICD-10 (ICD-9) system.

[8] Anderson et al., (2001) discuss sources of the differences for many of these causes of deaths. Importantly: a lower number of influenza/pneumonia deaths occurs using the ICD-10 system because when deaths involving pneumonia also involved another cause, they became more likely to be attributed to that other cause; a higher number of kidney deaths is observed because end-stage renal disease was grouped in this category in the ICD-10 but not the ICD-9 system; a large increase in Alzheimer's disease deaths takes place because of a broadening of the set of conditions classified into this cause of death in the ICD-10 system.

them difficult to compare.[9] Three strategies are used to address this. First, the three major causes of death (influenza/pneumonia, kidney disease, and Alzheimers disease) that are not comparable over time are excluded from the analysis. Second, robustness of the results relating specific causes of death to poor mental health will be examined when limiting the analysis period to 1999-2019, when the ICD-10 coding system is used throughout. Third, the analysis of alcohol and DSA deaths is restricted to 1999-2019 when the ICD-10 system was in place.

Mortality rates are analyzed for six of the 10 leading causes of death in 2019: heart disease, malignant neoplasms (cancer), unintentional injuries (accidents), chronic lower respiratory disease, cerebrovascular disease (stroke), diabetes mellitus, and intentional self-harm (suicide). As just mentioned, deaths from influenza/pneumonia, kidney diseases, and Alzheimer's disease, are excluded. Four additional causes of mortality are also studied: alcohol deaths, drug poisonings (drugs), transport accidents (transport), and assault (homicides). The first and second of these have previously been represented as two of the three causes included in "deaths of despair" by Case and Deaton and others.[10] Therefore, a combined measure of drug, suicide, and alcohol (DSA) deaths is also analyzed. Transport accidents and homicides are examined since they represent external causes of death that might be particularly important for prime-age individuals.[11] Although most of these causes

[9] This includes changes in the procedures used to code deaths for causes classified in both the ICD-9 and ICD-10 systems as well as additional ICD-10 codes (e.g. degeneration of the nervous system due to alcohol and alcohol-induced pancreatitis) that did not have equivalent ICD-9 codes.

[10] In their earlier research, Case and Deaton (2015, 2017, 2020) actually examine chronic liver disease, which includes some deaths that are not alcohol related and excludes others that are. Ruhm (2022) provides a more detailed discussion of this issue. This has been corrected in later research and the current analysis includes in this category deaths that are 100% attributable to alcohol (Centers for Disease Control and Prevention 2024b).

[11] Accidents are also a leading cause of death. This analysis focuses on two key components of them: drug deaths and transport fatalities. Accidents as a group were considered in preliminary estimates but including them did not add value.

are mutually exclusive, some drug and alcohol fatalities are also classified as suicides. Appendix Table A1 details the ICD-9 and ICD-10 codes corresponding to each of these causes.

## Methods

*Poor Mental Health*

The key explanatory variables are days of poor mental health in the last 30 and dichotomous measures of poor mental health in at least 15 of the last 30 days or in all 30 of them. In each case, annual national and state averages are calculated for persons aged 20 and over from 1993-2019, using the *BRFSS* data, with the exception of 2002, where the question providing this information is not included in the core questionnaire.[12] When computing these averages, sampling weights are incorporated to obtain results representative of the state or national population. The poor mental health variables are constructed for the full population (20 and older) in the country or state, as well as for groups stratified by sex (male vs. female), race/ethnicity (White, Black, Hispanic), education (no college, some college, college graduate), and age (20-34, 35-54, and 55+).[13] Interactions between race, education and age are also sometimes incorporated.

State average values of poor mental health could vary over time because of changes in the demographic composition of the population (e.g. age, sex, race/ethnicity). This is partially accounted for by constructing age-standardized measures. For national estimates, this is done using 2000-year standard population weights for 5-year age groups for 20-74 year olds, plus a single category for persons 80 and older (13 groups). For states, since these narrow age-categories result in no survey respondents for some state-year cells, age-

[12] In that year the question is in an optional module included by only 22 states. Data on mental health are also missing in Rhode Island for 1993-1994, DC for 1995, Hawaii for 2004, and New Jersey for 2019.

[13] The some college group includes those who attended college but did not receive a Bachelor's degree, while the college graduate group includes those with at least a Bachelor's degree.

standardization is done using three age-categories: 20-34, 35-54, and 55+. For national estimates, a further check is performed using a procedure providing a more detailed accounting of the potential role of demographic characteristics.[14]

Differences in levels and changes of poor mental health from 1993-2019 are then examined descriptively, with trend differences also more formally investigated by regressing levels and natural logs of them on a linear time trend.

*Poor Mental Health and Mortality*

Primary econometric estimates of the relationship between poor mental health and mortality come from Poisson models of the form:

$$M_{ijt} = P_{jt}\alpha_i + X_{jt}\beta_i + S_{ij} + \mathrm{T}_{it} + \epsilon_{ijt}, \qquad (1)$$

where $M_{ijt}$ indicates the natural log of the age-standardized mortality rate for group or cause $i$ in state $j$ at year $t$, $P_{jt}$ is the proxy of poor mental health, transformed to have a population-weighted standard deviation of one,[15] $X_{jt}$ indicates the state-year population share of Blacks, other races, and Hispanics (three variables), $S_{ij}$ and $\mathrm{T}_{it}$ are vectors of

[14] In the procedure, probit models first regress the poor mental health measure on sex, race/ethnicity (non-Hispanic Black, Hispanic, non-Hispanic other race, race/ethnicity missing), age (5-year categories from 25-79 and ≥80), and education (high school graduate, some college, college graduate, education missing), with predicted values then calculated for each person. *BRFSS* sample sizes increase over time: from approximately 100,000 in 1993 to more than 400,000 in each year after 2006. To avoid having these predictions be overly influenced by the larger sample sizes in later years, inverse weights are applied when estimating the probit models, computed as the total number of observations over the entire period divided by the corresponding number in the survey year. Residual values are then calculated by subtracting actual from predicted values. The demographic characteristic-adjusted poor mental health variables are then aggregated to year-specific national and state levels, with *BRFSS* sampling weights incorporated to obtain representative estimates. Finally, the demographic characteristic-adjusted residuals are renormalized to have the same average value as the age-standardized measures while preserving the computed changes over time. This is done by taking the residual value in the given year and state and adding the difference in average values for the age-standardized and residual values for the same location and over the entire (1993-2019) period.

[15] This is done by dividing the poor mental health variable by the standard deviation of that variable for the entire U.S. from 1993-2019. The standard deviations for days of poor mental health, 15+, and all 30 days are 0.6013, 0.02114, and 0.01311.

state and time dummy variables, and $\epsilon_{ijt}$ is the regression error term.[16] The state fixed-effects control for all time-invariant location-specific influences on mortality rates and the year dummy variables for time-varying nationwide factors. The main estimates are obtained using data for the 1993-2019 period, except for alcohol and DSA mortality where they are for 1999-2019; models covering only 1999-2019 are also estimated for the other death rates to examine whether there are substantial differences when limiting this analysis to the ICD-10 period. The regression models weight observations by the average state population during the 1993-2019 period, with confidence intervals based on robust standard errors clustered at the state level.[17]

The predicted effect of a one standard deviation change in poor mental health on the age-standardized mortality rate is $\exp(\hat{\alpha}_i) - 1$. The changes in 2019-year mortality rates expected if poor mental health had remained at 1999 levels, $M'_{i,2019}$, frequently be referred to below as "Constant MH" reductions or changes, are computed as:

$$M'_{i,2019} = M_{i,2019} \times [\exp(\Delta P_i \times \hat{\alpha}_i) - 1] \tag{2}$$

where $M_{i,2019}$ is the national mortality rate in 2019 for cause or group $i$ and $\Delta P_i$ is the national change in poor mental health (in standard deviation units) from 1999-2019.

If $\Delta P_i \times \hat{\alpha}_i$ is near zero, (2) can be closely approximated by:

$$M'_{i,2019} \approx M_{i,2019} \times \Delta P_i \times \hat{\alpha}_i.^{18} \tag{2'}$$

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[16] The race-ethnicity population shares are excluded when the dependent variable is a race-specific death rate. This model treats poor mental health as having an immediate effect on mortality. In alternative specifications, I experimented with lagging the mental health variables by one year. This did not appreciably or consistently change the results.

[17] The population weights refer to the group-specific population when estimating models for subgroups.

[18] This assumption is always reasonable. For example, when considering all-cause mortality for Whites and using days of poor mental health as the proxy, $\hat{\alpha}_i = 0.0126$ and $\Delta P_i = 2.791$ standard deviations, so that $\Delta P_i \times \hat{\alpha}_i = 0.0352$, while $\exp(\Delta P_i \times \hat{\alpha}_i) - 1 = 0.0358$. Thus, the approximation is quite close in this case

We can use (2') to decompose sources of differences in the Constant MH changes across groups. For example, using the subscripts $w$ and $b$ to indicate Whites and Blacks, the ratio of White versus Black Constant MH changes is:

$$\frac{M'_{w,2019}}{M'_{b,2019}} \approx \frac{M_{w,2019} \times \Delta P_w \times \hat{\alpha}_w}{M_{b,2019} \times \Delta P_b \times \hat{\alpha}_b}, \tag{3}$$

or equivalently

$$\frac{M'_{w,2019}}{M'_{b,2019}} \approx \left(\frac{M_{w,2019}}{M_{b,2019}}\right) \times \left(\frac{\Delta P_w}{\Delta P_b}\right) \times \left(\frac{\hat{\alpha}_w}{\hat{\alpha}_b}\right). \tag{4}$$

(4) indicates that ratio of Constant MH changes between the two groups (the left-hand-side of the equation) can be divided into the portions due to ratios of: 2019 mortality rates (the first term on the right-hand-side), changes in mental health from 1999-2019 (the second term), and mortality *responses* to given changes in poor mental health (the third term).[19]

*Contribution of Declining Mental Health to Mortality Trends*

Finally, the analysis examines how increases in poor mental health are related to the adverse mortality trends from 1999-2019 experienced by some population groups. Particular attention is paid to the results for 25-54 year old Whites and Blacks, overall and by education group, because prime-age individuals, especially less educated Whites, have experienced exceptionally unfavorable mortality changes and have been the focus of considerable prior research.

Since mortality rates have been declining over time for most groups (e.g. see Appendix Figure A1), a simple comparison of 2019 versus 1999 rates is misleading. This is

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and is closer still in most others. For instance, corresponding values of $\Delta P_i \times \hat{\alpha}_i$ and $\exp(\Delta P_i \times \hat{\alpha}_i) - 1$ are both 0.0076 for Blacks.

[19] Equation (4) still applies when considering causes of death but the change in mental health (the middle term on the right-hand-side) is the same for all causes.

addressed by constructing the counterfactual 2019 rates expected if prior mortality trends had continued. Specifically, the national average annual change in mortality rates from 1980-1999 for group $i$, $T_i$, is calculated as:

$$T_i = \left(\frac{M_{i,1999}}{M_{i,1980}}\right)^{\frac{1}{19}} \tag{5}$$

and the counterfactual mortality rate in 2019, $C_{i,2019}$, as:

$$C_{i,2019} = M_{i,1999} \times T_i^{20}. \tag{6}$$

Thus, the counterfactual rates are based on trends from 1980-1999. Using a shorter period might provide erroneous estimates due to transitory idiosyncratic influences. For instance, death rates *increased* from 1992 to 1993 (see Figure A1), largely because of the adverse effects of a severe flu season and the HIV/AIDS epidemic (Centers for Disease Control and Prevention 1996). Similarly, the mortality rates of Blacks were flat or possibly rising during the 1980s, which may have reflected timing of the crack epidemic (Fryer et al. 2013).

A difficulty with using 1980-1999 for calculating annual trend growth in mortality rates is that Hispanic origin was not collected in some states prior to 1990, and so is not identified in the *MCOD* files before that year. Since Hispanics typically have relatively low death rates, including them in the race-specific rates before 1990 but excluding them thereafter likely implies that the mortality rates of non-Hispanic Whites and Blacks will be understated in the early years, leading to an underestimate (overestimate) of any trend decline (increase) in mortality rates over the entire period. The following procedure is used to address this: 1) average annual mortality changes from 1990-1999 are separately calculated for race groups that include and exclude Hispanics; 2) ratios of the annual changes with Hispanics excluded and included are computed; 3) the actual race-specific average annual rate change from 1980-1999 with Hispanics included in the race group is calculated, and this is multiplied by the ratio calculated in step 2) to provide adjusted

annual changes which are then used to project 2019 race-specific mortality rates for non-Hispanics.[20]

An additional issue is that information on education is not provided in the *MCOD* files prior to 1990, and is initially quite incomplete thereafter. Therefore, counterfactual mortality rates cannot be calculated using the procedure just detailed when considering education subgroups. In these cases, counterfactual rates are based on the trend changes in mortality rates for all persons in the same race-age group (for instance, prime-age Whites or Blacks) regardless of education. This introduces error to the extent that the trends differ with education: e.g. the counterfactual mortality rates of non-college educated prime-age Whites will be overestimated (underestimated) if the trend decline in mortality is larger (smaller) for them than for Whites with more education.

The difference between actual and counterfactual 2019 mortality rates, $M_{i,2019} - C_{i,2019}$, referred to below as the "adjusted mortality rate change", indicates the amount by which death rates differ from those expected based on prior trends. The Constant MH change, $M'_{i,2019}$, discussed above, shows how much lower estimated mortality rates in 2019 would have been if poor mental health had not increased over time. Therefore, the extent to which deteriorating mental health explains rising mortality, $E_i$, can be calculated as:

$$E_i = \frac{-M'_{i,2019}}{M_{i,2019} - C_{i,2019}} \; . \tag{7}$$

**Results**

*Disparities and Trends in Poor Mental Health*

[20] An example helps to illustrate. The average mortality rate trend factor from 1990-1999 for 25-54 year old White males was 0.98388 (a 1.61% mortality rate reduction per year) with Hispanics excluded versus 0.981581 (a 1.84% annual decrease) with them included. The ratio of these, 1.002345, is multiplied by the average annual mortality trend factor of 0.9850261 from 1980-1999 for all Whites (including Hispanics), to obtain an adjusted trend factor for White non-Hispanic males in this age group of 0.987336 (a 1.27% annual decrease).

Mental health deteriorated substantially from 1993-2019. Figure 1 illustrates this, providing descriptive information on national average values of each of the proxies of poor mental health and demonstrating that all three rose steadily over time.[21] The number of poor mental health days in the last 30 grew 53% (from 2.84 to 4.34) between 1993 and 2019. Probabilities of poor mental health in at least 15 and in all 30 days increased by 68% and 69% (from 7.7% and 3.7% to 13.0% and 6.3%).[22] The overall patterns are quite similar without age-standardization or when more broadly accounting for changes in demographic factors (Appendix Figure A2), although possibly with marginally larger growth in poor mental health in the last case (Figure A3).

Mental health worsened over time for all population groups examined.[23] Figure 2 shows the average number of poor mental health days (in the last 30) for groups stratified by sex, age, education, race/ethnicity, and race-education interactions. It illustrates the relatively high rates of poor mental health for females, prime-age individuals, and the less educated, compared to their counterparts. Appendix Figures A4 and A5 indicate substantially the same patterns using the 15+ and all 30 days measures of poor mental health. The findings, when stratified by race/ethnicity, are more complicated. Whites had the lowest rates of poor mental health in 1993 but larger increases over time, such that they reached or exceeded those of Blacks and Hispanics by 2019. The relative instability of results for Hispanics likely reflects small sample sizes in the early years and changes in the

[21] The mental health proxies are age-standardized throughout, unless otherwise noted.

[22] There was a discontinuous jump in the poor mental health measures between 2010 and 2011, reflecting a change in *BRFSS* weighting procedures and the inclusion of a cell-phone beginning in 2011. These raised the values of the variables by approximately 0.3 days and 1.0 and 0.5 percentage points starting in 2011. The three variables rose further during the pandemic, reaching 5.0 days, 15.2% and 7.2% in 2022. These later increases are not modeled given the unusual nature of the COVID-19 period.

[23] Other studies (Blanchflower and Oswald 2020; Daly 2022) have also uncovered widespread increases in poor mental health, although for a more limited set of mental health proxies and some differences in the groups examined.

composition of this group over time due to immigration. For this reason, the analysis of racial differences below largely focuses on comparisons of Whites and Blacks. When doing so, there are clear education gradients in mortality levels and probably growth rates, particularly for Whites, but with little indication of "threshold" effects – e.g. discontinuous changes for those with a four-year degree.

Trends in poor mental health, overall and for population subgroups, are further examined by regressing the mental health proxies on linear time trends, with 95% confidence intervals computed based on robust standard errors. Primary results are summarized in Figure 3. The left-hand-side of the figure shows findings for groups separated by sex, age, education, and race/ethnicity. The right-hand-side documents those for White and Black 25-54 and 55+ year olds, with the further stratification by education for the prime-age group. Detailed regression results are provided in Appendix Tables A2 and A3.

The estimates confirm that poor mental health became more common over time for virtually all groups. For the full population, the number of poor mental health days increased by an estimated 0.049 days per year and the likelihood of having at least 15 and all 30 poor mental health days grew by 0.17 and 0.08 percentage points annually. The trend coefficients are positive and statistically significant at the 0.05 level for almost all groups, but differences between them are generally not statistically distinguishable, except that young adults experienced larger deteriorations in mental health than their older counterparts and the mental health of college graduates and Hispanics worsened more slowly than those of their peers. For instance, poor mental health days and 15+ or all 30 poor mental health days increased by 0.065 days and 0.24 and 0.12 percentage points per year for 20-34 year olds, versus 0.042 days and 0.13 and 0.05 points for persons 55 and older.

The mental health of 25-54 year old Whites deteriorated faster than for similarly aged Blacks: poor mental health rose by 0.064 days, and 0.23 and 0.12 percentage points

for the 15+ and all 30 days measures annually for Whites versus 0.053 days, and 0.18, and 0.09 percentage points for comparable Blacks. Mental health worsened more for less educated individuals than for their counterparts and, within education categories, more for Whites than Blacks.

The results just described refer to absolute increases in poor mental health. Percentage changes are also examined by using natural logs, rather than levels, of the mental health proxies as the dependent variables in the regression analysis (Appendix Figure A6). The patterns obtained are generally similar to those for levels, with two exceptions. First, males have, if anything, smaller absolute trend growth in poor mental health than females but the percentage changes are larger for them. Second, the 55+ age group have smaller increases than their younger counterparts but, in percentage terms, the rise is more comparable and, sometimes, larger than for 35-54 year olds.

*Poor Mental Health and Group-Specific Mortality*

The relationship between poor mental health and age-standardized mortality rates is next examined through estimates of Equation (1), where year and state fixed-effects, and sometimes population shares are included, robust standard errors are clustered at the state level, and the mental health proxies are transformed to show the effects of a one standard deviation change.

Table 1 summarizes a series of estimates for the full population. The first three columns show results of log-linear models estimated by ordinary least squares; the last three display corresponding estimates using Poisson regression. Similar findings are anticipated for either functional form since there are no state-year cells with zero deaths (which would be excluded from the log-linear models) and the results confirm this. In a basic specification, with time and year fixed-effects, but without supplementary covariates or weighted data, a one standard deviation increase in poor mental health is predicted to raise total mortality

rates by 1.0% to 1.3%, depending on the mental health proxy (models 1a and 2a). Adding controls for the state population share of Blacks, other races, and Hispanics – which may be important if mortality rates differ across race/ethnicity groups and their population shares change substantially over time – lowers the estimated poor mental effect to 0.7% to 0.8% (specifications 1b and 2b). Weighting observations by average state populations further decreases this estimate to a statistically insignificant 0.4% to 0.7% (columns 1c and 2c); when estimated using Poisson regression, this will be treated as the "preferred" model hereafter.

Figure 4 provides results for population groups. Figure 4A shows standard deviation changes in poor mental health from 1999-2019 and confirms the previous findings of particularly adverse trends for females, 20-34 year olds, those with some college but no 4-year degree, and Whites.

Figure 4B summarizes the relationship between poor mental health and mortality, based on estimates of equation (1). The findings are generally similar using any of the three mental health proxies and imprecision of the estimates implies that caution is needed when interpreting some results. With that said, poor mental health is associated with higher mortality rates for all groups, with the point estimates suggesting especially adverse effects for females, 20-34 and 35-54 year olds, Whites, and those with some college but no degree: a one standard deviation increase in poor mental health is predicted to raise age-standardized death rates by around 0.7, 0.9, 0.7, 1.3, and 1.0 percentage points for these groups, compared to 0.3, 0.3, 0.4, and 0.3 percentage points for males, 55+ year olds, Blacks, and the non-college educated.[24] Appendix Table A4 further details these estimates. While these groups are generally the same as those experiencing the largest increases in poor

[24] The exact estimates depend somewhat on the poor mental health proxy used.

mental health from 1999-2019, changes in mental health and their effects on deaths are conceptually distinct. The relative importance of each is investigated below.

Figure 4C translates the changes in poor mental health (shown in Figure 4A) and mortality responses to them (Figure 4B) into Constant MH reductions – the decreases in age-standardized mortality rates that would have been expected if poor mental health had remained at its 1999 level in 2019. Since mental health worsened over time and poor mental health is positively associated with mortality rates, the Constant MH changes indicate that age-standardized death rates would have been *lower* if mental health had not deteriorated. The Constant MH estimates also depend on actual 2019 death rates. Thus, it is possible for a group with relatively high mortality rates to have big Constant MH changes even with relatively small trend changes in poor mental health and mortality responses to it. Indeed, this occurs for 55+ year olds, compared to younger individuals, where the estimated Constant MH reduction is relatively large but imprecisely estimated (Figure 4C),[25] driven by their high age-related baseline death rates.[26]

However, for most groups, the Constant MH estimates are fairly closely (inversely) aligned with the mortality responses to poor mental health. For instance, using the 15+ days proxy, the point estimates indicate larger Constant MH reductions for females than males (-11.0 vs. -4.1 per 100,000), those attending college but not receiving a 4-year degree compared with those who never went to college or who graduated from it (-20.1 vs. -7.9 and -3.1 per 100,000), and for Whites versus Blacks or Hispanics (-27.3 vs. -6.7 and -1.2 per

[25] The point estimates for the Constant MH reductions in mortality rates are -10.9, -14.6, and -7.3 per 100,000 for those 55 and older, using number of days, 15+ days, all 30 days of poor mental health as the mental health proxy. For 20-34 year olds, the corresponding estimates are -4.1, -4.0, and -2.6 per 100,000 and for those aged 35-54 they are -2.1, -3.3, and -2.3 per 100,000.

[26] Age-standardized mortality rates in 2019 are 117.0, 280.9, and 2,826.0 per 100,000 for 20-34, 35-54, and ≥55 year olds (Table A4). The Constant MH estimate for 20-34 year olds is relatively small because mortality rates are so low for them, despite their having a relatively large deterioration in poor mental health and a greater mortality response to it than the other two age groups.

100,000). Again, caution is needed when interpreting these findings given the frequently large standard errors.[27]

Figure 5 and Appendix Table A5 provide results for 25-54 year olds stratified by race (White vs. Black) and education (No College, Some College, College Graduate). These findings are relevant since the original research on "deaths of despair" focused on "midlife" Whites (e.g. 35-54 year olds), with follow-up studies often also highlighting effects for younger adults.

Among prime-age individuals, mental health deteriorated by particularly large amounts for the less educated and more so for White than Blacks: e.g. by 3.5 to 4.0 and 2.3 to 3.0 standard deviations for non-college Whites and Blacks compared to 0.7 to 1.9 and 0.8 to 1.7 standard deviations for corresponding college graduates (Figure 5A). Mortality is also especially responsive to changes in mental health for non-college Whites: a one standard deviation increase in poor mental health raises their predicted mortality rates by 1.3% to 2.0%, versus 0.3% to 0.5% for non-College Blacks, although, interestingly, the estimated responses are actually somewhat higher for prime-age White college graduates than for those attending but not completing college (Figure 5B).

Combining these effects, Figure 5C indicates the very large 2019 Constant MH decreases for 25-54 year old non-college Whites (-22.4 to -38.5 per 100,000), which dwarf the estimates for other prime-age individuals: the corresponding decrease for 25-54 year old non-college Blacks is -4.4 to -8.1 per 100,000, which is modestly higher than for Whites with some college but no degree (-2.8 to -5.4 per 100,000). The Constant MH changes are of

[27] As a robustness check, the mortality responses to worsening mental health are estimated from regressions that used data for only the 1999-2019 period (when cause of death is identified using ICD-10 codes). These estimates are substantially similar to those for the full 1993-2019 period, except for some possibility of more beneficial effects for college graduates (see Appendix Figure A7).

small magnitude, and often statistically insignificant, for Whites with a college degree and Blacks with at least some college (3 per 100,000 or less).

*Poor Mental Health and Cause-Specific Mortality*

This section presents the most direct test of the "deaths of despair" hypothesis by examining whether the causes of mortality estimated to be most strongly affected by worsening mental health do or do not coincide with those defined as being due to "despair" in prior research and media coverage. The methods are identical to those used above, but trends in poor mental health between 1999-2019 are not shown since they are the same for all causes of death for a given population group.[28] Results for the full population are summarized in Figure 6, with details in Appendix Table A6.

Deaths from all causes examined are predicted to rise in response to worsening mental health, although the percentage changes are often small and statistically insignificant (Figure 6A). A one standard deviation increase in poor mental health is estimated to increase DSA death rates by 1.8% to 3.1%, due to an imprecisely estimated 1.8% to 3.2% growth in drug mortality and a 2.7% to 4.0% rise in alcohol deaths. Predicted effects are much smaller for suicides (0.6% to 0.7%).

The one standard deviation growth in poor mental health is estimated to raise mortality from heart disease, lower respiratory disease, and homicides by 1.0% to 1.2%, 1.3% to 1.6%, and 2.9% to 3.8%, with somewhat lower predicted growth in accident and diabetes mortality (0.9% to 1.5%) and minimal (0.1% to 0.5%) increases for deaths from cancer, stroke, and transport accidents.

Figure 6B translates these estimates into Constant MH mortality reductions. By far the largest predicted drop is for heart disease death rates (-2.7 to -4.4 per 100,000).

[28] For the full population, the number of days, 15+ days, and all 30 days proxies of poor mental health rose by 2.23, 2.25, and 1.49 standard deviations respectively from 1999-2019.

Homicides are most responsive to changes in poor mental health, in relative terms, but the Constant MH decreases are fairly small for them (-0.2 to -0.5 per 100,000) because death rates from this cause are relatively low. DSA mortality rates fall by -1.2 to -2.9 per 100,000, which is fairly even split between effects on alcohol and drug causes. The Constant MH decrease in lower respiratory disease mortality rates is also substantial (-0.8 to -1.4 per 100,000), while the reductions are modest for suicides, with point estimates smaller than those from diabetes, strokes, or lower respiratory causes.

*Prime-Age Whites and Blacks*

Prior research and the results above suggest the particular importance of declines in mental health for 25-54 year olds, especially Whites. This is further investigated by examining cause-specific death rates for prime-age Whites and Blacks, overall and for those without college educations.[29] As shown previously, the growth in poor mental health from 1999-2019 is considerably larger for prime-age Whites than for either corresponding Blacks or the full population, and all-cause mortality rates are typically much also more responsive to rising poor mental health for them (Figure 5 and Appendix Table A5). Corresponding results by specific cause of deaths for 25-54 year old Whites and Blacks are summarized on Figure 7, with additional details on Appendix Table A7 and A8.

A one standard deviation rise in poor mental health predicts statistically significant 2% to 3% increases in prime-age White death rates from heart disease and diabetes, and approximately 2% higher cancer mortality rates (Figure 7A). All of these substantially exceed the corresponding estimates for the full population. Responsiveness is even higher for mortality from lower respiratory disease (5% to 7%), homicides (3% to 5%), and drug deaths (4% to 6%), although the confidence interval on the last of these is large. Worsening

[29] As mentioned, prime-age Hispanics are not examined here because compositional changes in this group are likely to be difficult to address and since the estimated Constant MH reductions in all-cause mortality are always small and statistically insignificant for them.

mental health raise alcohol deaths for this group by 2% to 3%, which is somewhat less than for the full population, but suicides are again not very responsive (less than 1%), smaller than for a wide variety of other causes.

Transforming these responses into Constant MH effects, if poor mental health had remained at 1999 levels in 2019, the drug mortality rates of prime-age Whites would have been an imprecisely estimated 3.1 to 7.2 per 100,000 lower than those actually observed (Figure 7B). The Constant MH decreases in heart and cancer deaths are also substantial (-1.4 to -2.5 and -1.1 to -2.1 per 100,000) and precisely estimated. The impacts are smaller (although often still statistically significant) for other causes, with the most consequential being the 0.4 to 0.9 per 100,000 reduction in alcohol mortality rates and the 0.4 to 0.7 per 100,000 drop in death rates from lower respiratory diseases.

The results differ sharply for prime-age Blacks. The estimated responsiveness of mortality rates to worsening mental health is generally similar to the full population and considerably less than for prime-age Whites: a one standard deviation increase in the poor mental health predicts less than a 1% increase in age-standardized death rates from most causes (Figure 7C). The predicted growth in the death rate from lower respiratory disease is more substantial (1% to 2%) and there is an estimated 2% rise in drug fatalities, but heart disease deaths respond much less than for either the full population or prime-age Whites. Notably, essentially no growth is predicted for either suicides or alcohol deaths, yielding a relatively muted 0.5% to 0.8% point estimate for DSA mortality.

Figure 7D summarizes the corresponding estimated Constant MH mortality reductions. For all-cause mortality, these are estimated to be less than one-third as large for 25-54 year old Blacks (-3.3 to -5.8 per 100,000) as Whites (-11.7 to -20.9 per 100,000), with predicted decreases in drug deaths (-1.2 to -1.7 per 100,000) and homicides (-0.3 to -

0.8 per 100,000) being the most important contributors. Constant MH changes for other causes are modest. Additional details are provided in Appendix Table A8.

Figure 8 and Appendix Tables A9 and A10 provide corresponding information for non-college educated 25-54 year old Whites and Blacks. The patterns of relative effects across causes of death are remarkably similar to those for all prime-age individuals but the magnitudes of the absolute impacts are much bigger, particularly for Whites, due substantially to their much higher overall mortality rates. To illustrate, the estimated Constant MH reduction in drug death rates (-8.2 to -18.7 per 100,000) is over twice as high as for all prime-age Whites (-3.1 to -7.2 per 100,000). Magnitudes of the Constant MH reductions are also considerably larger for non-college prime-age Blacks than for their more educated counterparts (while being much smaller than for corresponding non-college Whites), particularly for homicides (-0.6 to -2.0 per 100,000).

*Decomposition of Population Group Differences in Counterfactual Mortality Changes*

Disparities in Constant MH changes across groups reflect the combined effects of: 1) actual 2019 mortality rates, 2) poor mental health trends from 1999-2019, and 3) the responsiveness of mortality rates to changes in poor mental health. The methods detailed in equation (4) are used here to identify the importance of each of these, focusing on the second and third components since their roles in explaining "deaths of despair" are likely to be less well understood than general differences in mortality rates.

Table 2 summarizes the decompositions for all-cause mortality by comparing groups with relatively large estimated Constant MH changes – 20-34 year olds, persons with some college but who did not graduate, and Whites – to their counterparts with smaller Constant MH changes – 35-54 and 55+ year olds, those with no college or 4-year degrees, and Blacks. When comparing Whites and Blacks, education-specific results are also provided for 25-54 year olds. The mortality responses are based on point estimates from the regressions of

equation (1) and should be interpreted with caution when the associated confidence intervals are large.

Age-standardized death rates in 2019 show the expected patterns, increasing with age, decreasing with education, and being lower for Whites than Blacks. For example, mortality rates are 117.0, 280.9, and 2,826.0 per 100,000 for 20-34, 35-54, and 55+ year olds. Dividing rates for the youngest group by those of the two older age categories gives ratios of 0.417 (117.0/280.9) and 0.041 (117.0/2,826) respectively.[30]

Groups with relatively large Constant MH mortality reductions almost universally have *both* worse mental health trends from 1999-2019 and larger mortality responses to them. For the age and education comparisons, there is no clear pattern which of these is more important. However, when comparing Whites and Blacks, group differences in Constant MH reductions primarily result from the heterogenous *consequences* of increases in poor mental health, rather than differential growth in the experience of it. For example, while poor mental health grows 40% to 53% more for Whites than Blacks from 1999-2019, the estimated mortality response is 214% to 323% bigger.[31] Similar racial patterns exist for prime-age individuals overall and stratified by education, except that the two components contribute roughly equally to explaining the larger Constant MH mortality reductions of prime-age Whites than Blacks with some college but no degree.

Table 3 performs similar decompositions comparing 25-54 year old Whites and Blacks for specific causes of death, both overall and for those without college. Since the trends in poor mental health are the same for all causes, only 2019 mortality rates and estimated mortality rate responses to a one standard deviation increase in poor mental health are shown on the table.

[30] The full set of mortality rates is contained in Appendix Tables A4 and A5.

[31] An asterisk is included in the table when the estimated mortality response is positive for the treatment group and negative for the comparison category.

Prime-age Whites have lower 2019 mortality rates than their Black counterparts for most causes and the differences are often quite large: they die around one-eight as often from homicides and less than two-thirds as frequently from heart disease, strokes, or diabetes. However, Whites have higher death rates for all three DSA components.

Once again, larger estimated mortality responses to given declines in mental health are almost always the key factor driving the bigger Constant MH effects of prime-age Whites. White-Black responsiveness ratios for all causes of death are around four for this age group (3.75 to 4.25), while the growth in poor mental health is 25% to 38% greater. In combination, these two factors far overwhelm the approximately one-third lower 2019 mortality rates of 25-54 year old Whites than Blacks. For many causes, these patterns are even more pronounced. For example, the mortality rate coefficient for alcohol deaths is substantial for prime-age Whites (0.0168 to 0.0258) but only one-tenth as large (0.0016 to 0.0021) for analogous Blacks, and this accounts for almost the entire disparity in the estimated Constant MH changes.

For drug deaths, the Constant MH effects are three to four times greater for prime-age Whites than Blacks, with contributions from all three factors: 2019 mortality rates, trend increases in poor mental health, and estimated effects of a one standard deviation increase in poor mental health are 24%, 25% to 38%, and 78% to 175% higher for Whites of this age.

The results for homicides are noteworthy. Death rates in 2019 are more than eight times higher for 25-54 year old Blacks than same age Whites (31.6 vs. 3.8 per 100,000), which overwhelms the greater growth in poor mental health for Whites and their bigger mortality response to it. As a result, the Constant MH estimates are 1.5 to 2.0 times larger for prime-age Blacks than Whites.

The patterns are substantially similar when focusing on the non-college group, with bigger estimated mortality responses to specified declines in mental health generally being the key factor driving the larger Constant MH reductions of Whites. The White-Black responsiveness ratios for all causes of death are again around four, while the growth in poor mental health is 33% to 54% larger. These effects are even more pronounced for drug deaths, where the responsiveness ratios range from 3.28 to 6.40. On the other hand, the responsiveness ratios for homicides and heart mortality are smaller for the non-college group than for all 25-54 year olds.

*Do Increases in Poor Mental Health Explain Mortality Trends?*

Lastly, I examine to what extent changes in poor mental health from 1999-2019 explain key mortality trends over the same period. Death rates historically decline over time, so the focus is on comparing actual 2019 death rates to those that would have been expected if trends from 1980-1999 had continued over the next 20 years, referred to here as changes in adjusted mortality rates. To illustrate, the all-cause mortality rate falls by 150.2 per 100,000 between 1999 and 2019, from 875.4 to 725.2 per 100,000 but this represents a continuation of prior trends. The corresponding death rate was 1,036.1 per 100,000 in 1980, and the counterfactual 2019 mortality rate (if previous trends had continued) is 733.1 per 100,000, or 7.9 per 100,000 *higher* than the actual death rate in that year. Thus, the adjusted mortality rate change (the actual minus counterfactual 2019 rate) is slightly negative. Adjusted mortality rate changes are similarly small, and often negative, for most population subgroups, with substantial declines for Blacks and persons 55 and older (see Appendix Table A11).

The important exceptions are for White and, to a lesser extent, Black 25-54 year olds where the results, summarized in Table 4, indicate large *positive* adjusted mortality rate changes. For example, the actual 2019 mortality rate for prime-age Whites is 42%

higher than the counterfactual rate (243.4 versus 171.9 per 100,000), a difference of 71.5 per 100,000. Adjusted mortality rates changes are also positive for prime-age Blacks, but of smaller magnitude (24.1 per 100,000). Given these patterns, a more detailed analysis of prime-age Whites and Blacks is provided below, with education-specific results also presented.

Adjusted mortality rate changes are also positive and substantial for non-college Whites and Blacks (251.4 and 167.5 per 100,000). However, as noted, data limitations require these counterfactual mortality rates to be based on changes for *all* prime-age Whites and Blacks, rather than education-specific groups, making these estimates less certain. This is particularly true for non-college Blacks, where actual mortality rates were essentially the same in 1999 and 2019, so that the assumptions about counterfactual trends are critical.

The findings are summarized in Figure 9, with additional information in Appendix Table A12. Point estimates suggest that worsening mental health accounts for 16% to 29% of the adjusted mortality rate changes from 1999-2019 for 25-54 year old Whites, and around half as much (9% to 15%) of the larger overall change for those never attending college.[32] The contribution of deteriorating mental health that operates through DSA fatalities, which have been the focus of much of the "deaths of despair" literature, is smaller: 2% to 6% for all prime-age Whites and 2% to 7% for those without college, almost entirely due to effects on drug mortality. The estimated mental health impacts mediated through deaths from alcohol and suicides together account for 1% to 2% of the overall trend, or even less, which is considerably below the effects channeled through heart disease or cancer mortality, where the combined estimated contribution is 3% to 6% for all prime-age Whites and 2% to 4% for the non-college educated.

[32] If the Constant MH changes are compared to actual, rather than adjusted, mortality rate changes worsening health accounts for between 12% and 21% of the increase in death rates for the no college group.

Changes in mental health account for a reasonably similar 14% to 24% of the much smaller overall mortality trend for Blacks, but with minimal contributions operating through most causes of death. The exceptions are effects through DSA mortality, representing around 2% to 4% of the total change (all due to drug fatalities) and homicides through which declining mental health is associated with 1% to 3% of the total mortality trend, 4 to 6 times more than for same-aged Whites. The shares of mortality changes related to declining mental health are uniformly smaller for non-college Blacks than for other prime-age individuals however, as discussed above, these estimates may be particularly sensitive to the assumptions used to construct the counterfactual trends.

An overall assessment is that increases in poor mental health, played a non-trivial role in explaining the adverse mortality trends of 25-54 year olds but that other factors are considerably more important. The causes of death through which deteriorating mental health operates extend well beyond those previously labeled as "deaths of despair". In particular, for prime-age Whites, effects working through heart disease and cancer are relatively substantial while those related to homicides are also significant for Blacks. Declining mental health is also not the primary explanation of observed increases in DSA mortality rates. For 25-54 year old Whites, the point estimates suggest it accounts for 2% to 6%, 4% to 10%, <1%, and 1% of the growth in mortality rates from all DSA, drug, suicide, and alcohol causes. For prime-age Blacks, the corresponding percentages are 2% to 4%, 5% to 7%, 0%, and 0%.[33]

**Discussion**

Declines in population-wide mental health raise death rates and have contributed to the adverse mortality trends experienced by prime-age non-Hispanic Whites and, to a lesser

[33] These estimates are obtained using the same procedures as above. Also, worsening mental health is estimated to account for 1% to 3% of the increase in homicide rates among prime-age Blacks.

extent, non-Hispanic Blacks from 1999-2019. However, worsening mental health is not the predominant explanation for these trends; the point estimates suggest that they account for 16% to 29% (14% to 24%) of the increase for 25-54 year old Whites (Blacks) and 9% to 15% of it for prime-age non-college Whites. Whether these impacts are considered "large" or "small" may depend on the specific context in which they are considered.

For the full population, the biggest percentage mortality responses to declining mental health are for alcohol, homicide, drug, and lower respiratory causes deaths. The largest absolute responses are for most of the same causes, but with heart disease and cancer replacing homicides. Among 25-54 year old non-Hispanic Whites, drug, heart, and cancer mortality are particularly important, with drug and homicide deaths predominating in the smaller overall effects for corresponding non-Hispanic Blacks. To the extent these findings support the general notion of "deaths of despair", they also suggest that the specific causes comprising it should be different and broader than previously understood: still including drug mortality and possibly alcohol deaths but replacing suicides with mortality from heart disease, lower respiratory causes, homicides, and perhaps cancer.

A negative relationship between mental health and homicides might be obvious and, *ex post*, it is possible to come up with reasons why worsening mental health raises heart and lower respiratory disease deaths. Conversely, it may seem surprising that suicides are so weakly related to changes in population mental health. However, the pathways leading to them are complex, with mental health being only one input and an important role also played by the means available for self-harm (Yip et al. 2012). Famously, suicides in the United Kingdom decreased substantially during the 1960s as a result of the replacement of coal with natural gas stoves, without obvious changes in mental health (Kreitman 1976).[34]

[34] Coal stoves were frequently used in suicide attempts due to the high levels of carbon monoxide emissions. Natural gas stoves emit much less carbon monoxide.

While not an issue for the US during the analysis period, other factors, such as the increasing availability of guns, may be significant (Miller and Hemenway 2008).

Other researchers (Case and Deaton 2020, 2022) have emphasized the particularly adverse mortality experiences of less educated prime-age individuals. This study confirms that declining mental health is associated with large increases fatality rates for them but shows that this reflects their high baseline death rates, rather than any disproportionate impact of worse mental health.

Examination of the larger overall effects of "despair" on White than Black mortality rates reveals that differences in the *consequences* of a given increases in poor mental health, rather than in the size of the mental health changes themselves, are most important. Understanding why is a useful future research topic, but prior studies suggest some possibilities. Mental health may have weaker effects for Blacks because they more frequently live in extended families (D'Vera Cohn and Passel 2018) and since Black churches often provide key community support (Brewer and Williams 2019), both of which may buffer the effects of poor mental health at the individual level. Conversely, rising mortality among less educated Whites may partially reflect a loss of "White privilege" due to improvements in the relative positions of other groups (Metzl 2019; Wilkerson 2020), even while these inequities have not been eliminated. More generally, Whites (particularly White males) may have developed fewer resilience-based coping strategies to mitigate the effects of negative experiences (Smith and Read 2024).

Several potential limitations of the analysis deserve mention. First, the key explanatory variables may measure poor mental health with error and might be less informative for minorities than Whites (Zuvekas and Fleishman 2008), possibly contributing to the Black-White differences observed above. Second, it would be desirable to replicate this analysis using other potential measures of "despair", such as the Kessler-6 psychological

distress scale (Kessler et al. 2003), although this would require different data sources with other shortcomings. Third, the estimated effects of poor mental health on mortality might be overstated if spurious factors influencing both are not adequately controlled for, or if there is reverse causality whereby increased death rates act to worsen mental health. On the other hand, the impacts could be underestimated if some dimensions of "despair" are not captured by the mental health proxies used here. Fourth, the estimates are often less precise than would be ideal, partly due to the coarseness of aggregating the data to the state rather than finer levels of geography. Fifth, the adjusted 2019 mortality rate changes depend upon counterfactual death rates that are estimated based on prior trends but potentially with error.

Evidence that worsening mental health is not the primary cause of adverse mortality experiences of prime-age individuals at the beginning of the 21st century raises the question about what is? The answers, while likely heterogeneous, may be linked to more general failures of the US medical and public health infrastructure. For instance, the role of supply-factors in driving the fatal drug epidemic has been extensively documented (Ruhm 2019; Case and Deaton 2020; Currie and Schwandt 2021; Maclean et al. 2021) and suggest the need for changes in public policy approaches to balance the benefits of medical and recreational drug use against the associated harms. In this regard, it is noteworthy that while opioids have received most of the recent attention, deaths from other drugs categories, particularly stimulants, are now rising extremely rapidly (Spencer, Garnett, and Miniño 2023). Possibly even more important is the reduction in progress since at least 2010 in reducing deaths from heart disease and related causes (Mehta, Abrams, and Myrskylä 2020; National Academies of Sciences, Engineering, and Medicine 2021; Case and Deaton 2022). Potential reasons for this include rising obesity rates, and the lifestyles associated with them, as well as fewer or less effective medical innovations. In these cases and many others, there

may be heterogeneous consequences across individuals and groups, including the likelihood that those in poor mental health are most susceptible to any added health risks. If so, declining mental health may play a mediating role without being the primary cause.

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Table 1: Estimated Effects of Poor Mental Health on Total Mortality Rates

| Mental Health Proxy | (1a) | (1b) | (1c) | (2a) | (2b) | (2c) |
|---|---|---|---|---|---|---|
| Days | 0.0109*** | 0.0067* | 0.0043 | 0.0110*** | 0.0068* | 0.0044 |
| | (0.0037) | (0.0038) | (0.0035) | (0.0038) | (0.0038) | (0.0036) |
| 15+ Days | 0.0130*** | 0.0082** | 0.0057 | 0.0133*** | 0.0083** | 0.0059 |
| | (0.0040) | (0.0041) | (0.0039) | (0.0041) | (0.0041) | (0.0040) |
| All 30 Days | 0.0110** | 0.0074* | 0.0067 | 0.0111** | 0.0073* | 0.0066 |
| | (0.0048) | (0.0040) | (0.0041) | (0.0050) | (0.0040) | (0.0041) |
| Population Shares | N | Y | Y | N | Y | Y |
| Weights | N | N | Y | N | N | Y |
| Model | Log-linear | Log-linear | Log-linear | Poisson | Poisson | Poisson |

Note: Table shows coefficients from regressing the mental health proxy on the natural log of age-standardized total mortality rates (n=1,318). These are estimated as log-linear models in (1a) through (1c) and as Poisson models in (2a) through (2c). Population shares refer to the shares of the state population that are non-Hispanic black, non-Hispanic other nonwhite, and Hispanic (3 variables). In models (1c) and (2c), observations are weighted by the average state population over the 1993-2019 period. Each coefficient shows results of a different regression.

*** p<0.01, ** p<0.05, * p<0.1

Table 2: Ratios of Mortality Rates, Changes in Poor Mental Health and Mortality Responses to Them for Population Groups

| | Age 20-34 vs. | | Some College vs | | White vs. Black | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Ratio | 35-54 | 55+ | No College | College Grad | All Ages | 25-54 | 25-54: No College | 25-54: Some College | 25-54: College Grad |
| *2019 Mortality Rate* | 0.417 | 0.041 | 0.601 | 1.309 | 0.845 | 0.688 | 0.861 | 0.790 | 0.740 |
| *Δ in Poor Mental Health* | | | | | | | | | |
| Days | 2.54 | 2.23 | 1.19 | 1.59 | 1.47 | 1.38 | 1.33 | 1.62 | 1.15 |
| 15+ Days | 2.37 | 2.30 | 1.19 | 2.07 | 1.40 | 1.31 | 1.36 | 1.53 | 1.18 |
| All 30 Days | 2.35 | 2.42 | 0.87 | 2.45 | 1.53 | 1.25 | 1.54 | 1.35 | 0.84 |
| *Mortality Response* | | | | | | | | | |
| Days | 1.89 | 4.21 | 6.67 | 1.47 | 3.14 | 3.75 | 4.14 | 1.87 | $*$ |
| 15+ Days | 1.26 | 2.96 | 3.59 | 2.41 | 3.49 | 4.49 | 4.64 | 1.38 | $*$ |
| All 30 Days | 1.15 | 3.60 | 1.60 | 1.14 | 4.23 | 4.25 | 3.95 | 2.11 | $*$ |

Note: Top panel shows ratio of 2019 mortality rates. Middle panel displays ratio of the change in the poor mental health proxy from 1999 to 2019. Lower panel indicates the ratio of the estimated effects of a one standard deviation increase in the mental health proxy on mortality rates. White and Black refer to non-Hispanics. $*$ indicates cases where the mortality response to worse mental health is positive for treatment group but negative for the comparison group.

Table 3: Ratios of Mortality Rates and Mortality Responses to Changes in Poor Mental Health for 25-54 Year Old Whites vs. 25-54 Year Old Blacks, By Cause of Death and Education

| Ratio | All | Heart | Cancer | Lower Resp | Stroke | Diab-etes | Trans-port | Suicide | Alcohol | Homi-cide | Drug | DSA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| All Education Groups | | | | | | | | | | | | |
| *2019 Mortality Rate* | 0.688 | 0.494 | 0.800 | 0.773 | 0.386 | 0.435 | 0.757 | 2.250 | 1.677 | 0.120 | 1.243 | 1.473 |
| *Mortality Response* | | | | | | | | | | | | |
| Days | 3.75 | 6.89 | ∗ | 4.03 | 4.18 | 4.93 | 5.39 | ∗ | 16.43 | 3.00 | 2.58 | 2.38 |
| 15+ Days | 4.49 | 11.47 | ∗ | 6.12 | 7.12 | 5.53 | 3.66 | ∗ | 11.33 | 4.40 | 2.75 | 2.13 |
| All 30 Days | 4.25 | 11.28 | 54.78 | 4.66 | ∗ | 14.50 | 0.65 | ∗ | 8.20 | 4.66 | 1.78 | 1.62 |
| Non-College | | | | | | | | | | | | |
| *2019 Mortality Rate* | 0.861 | 0.643 | 0.956 | 1.121 | 0.489 | 0.576 | 0.980 | 2.850 | 1.840 | 0.149 | 1.537 | 1.762 |
| *Mortality Response* | | | | | | | | | | | | |
| Days | 4.14 | 2.68 | 13.59 | 4.26 | 3.48 | 7.24 | 1.62 | 13.40 | 4.32 | 2.11 | 6.40 | 10.00 |
| 15+ Days | 4.64 | 2.59 | 4.64 | 4.58 | 1.27 | 6.01 | 1.46 | 63.58 | 3.66 | 2.40 | 5.31 | 14.57 |
| All 30 Days | 3.95 | 2.41 | ∗ | 2.99 | ∗ | ∗ | 0.64 | 7.48 | 2.92 | 3.41 | 3.28 | 6.80 |

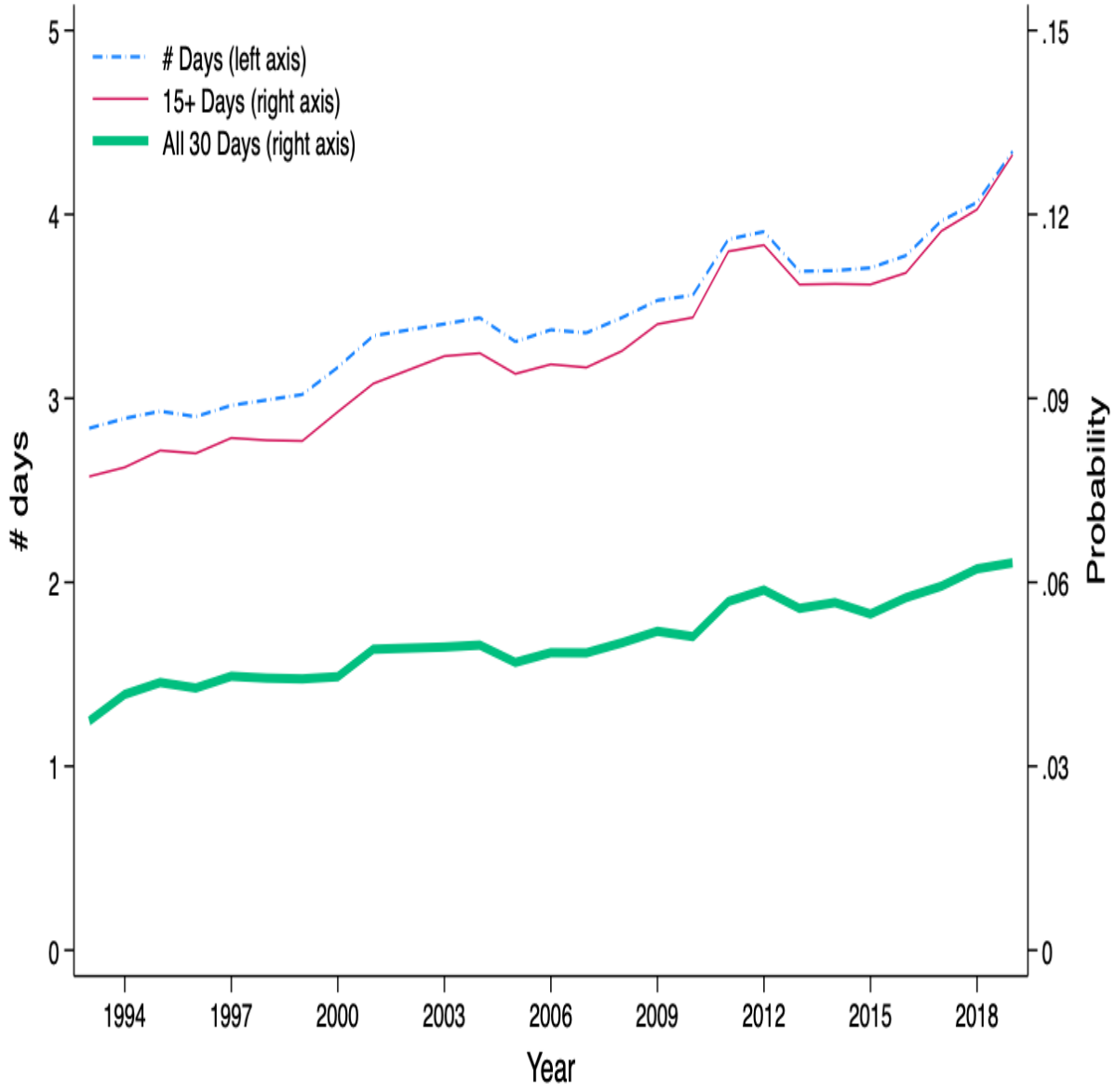
Note: Top row in each panel shows ratio of 2019 mortality rates. Next three rows display ratio of the estimated effects of a one standard deviation increase in the mental health proxy on mortality rates for the specified cause. White and black refer to non-Hispanics. ∗ indicates cases where the mortality response to worse mental health is positive for whites but negative for blacks. Top panel shows results for all 25-54 year old Whites and Blacks. Bottom panel displays findings for non-college 25-54 year old Whites and Blacks. The white vs. black ratio of changes in poor mental health from 1999-2019 is 1.38, 1.31, and 1.25 for mental health days, 15+ days, and all 30 days for all education groups combined and 1.33, 1.36, and 1.54 for non-college individuals..

Table 4: Mortality Rates and Changes for 25-54 Year Olds, by Race and Education

| | All | No College | Some College | College Graduate |
|---|---|---|---|---|
| Non-Hispanic Whites | | | | |
| *Actual Mortality Rates* | | | | |
| 1999 | 215.2 | 333.2 | 146.8 | 109.0 |
| 2019 | 243.4 | 517.6 | 219.5 | 84.1 |
| *Counterfactual 2019 Rate* | 171.9 | 266.1 | 117.2 | 87.1 |
| *Mortality Rate Δ: 1999-2019* | | | | |
| Actual | 28.2 | 184.4 | 72.7 | -25.0 |
| Adjusted | 71.5 | 251.4 | 102.2 | -3.0 |
| Non-Hispanic Blacks | | | | |
| *Actual Mortality Rates* | | | | |
| 1999 | 456.4 | 601.6 | 261.7 | 202.0 |
| 2019 | 353.3 | 601.4 | 277.9 | 113.7 |
| *Counterfactual 2019 Rate* | 329.2 | 433.9 | 188.8 | 145.7 |
| *Mortality Rate Δ: 1999-2019* | | | | |
| Actual | -103.1 | -0.2 | 16.2 | -88.3 |
| Adjusted | 24.1 | 167.5 | 89.2 | -32.0 |

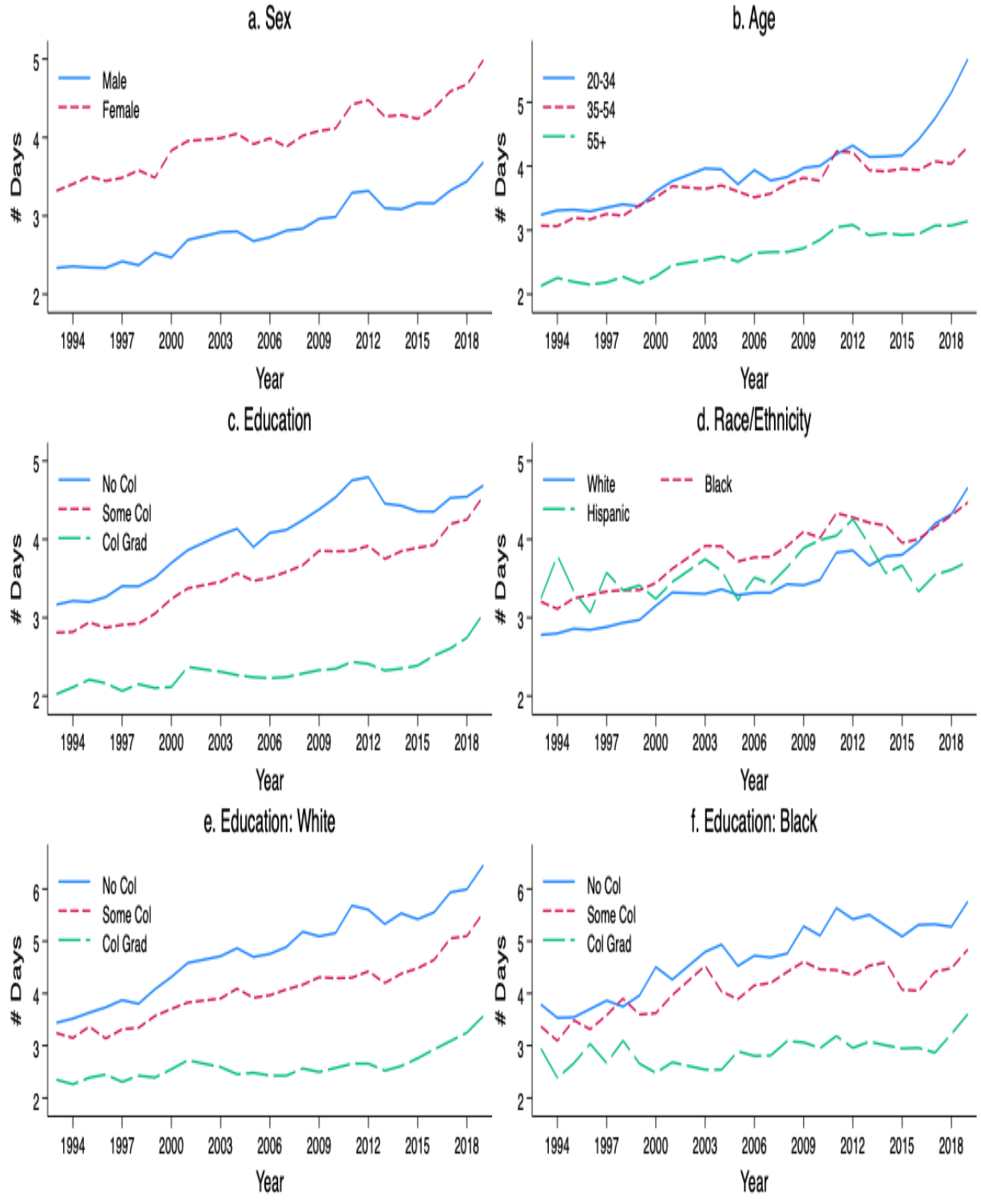
Note: Mortality rates are age-standardized and per 100,000 persons. The Counterfactual 2019 mortality rate is that predicted if average annual mortality rate changes from 1980-1999, calculated for all 25-54 year olds of the specified race, had continued through 2019. Adjusted Mortality Rate Change is the difference between the actual and counterfactual 2019 rate. Mortality rates in 1980 include Hispanics. This is adjusted for when computing adjusted mortality rate changes using the methods discussed in the text.

Figure 1: Poor Mental Health Days in the U.S. 1993-2019




Note: Figure shows average number of age-standardized poor mental health days in the last 30 and the probability of poor mental health in 15+ or all 30 days during the period.

Figure 2: Days of Poor Mental Health, By Subgroup




Note: Figure shows age-standardized number of poor mental health days in the last 30 days. White and Black refer to Non-Hispanics.

Figure 3: Trend Coefficients on Poor Mental Health 1993-2019, By Subgroup

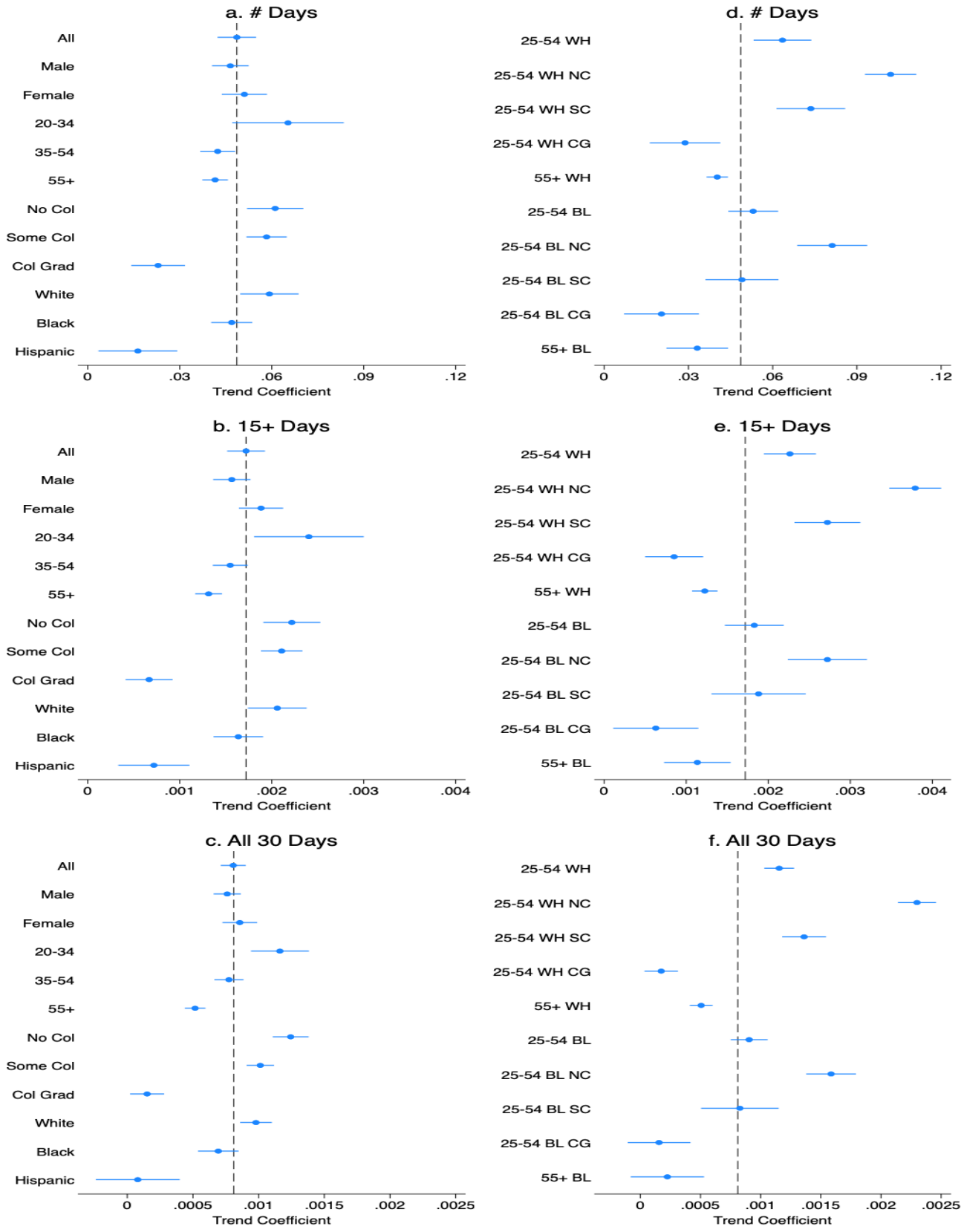
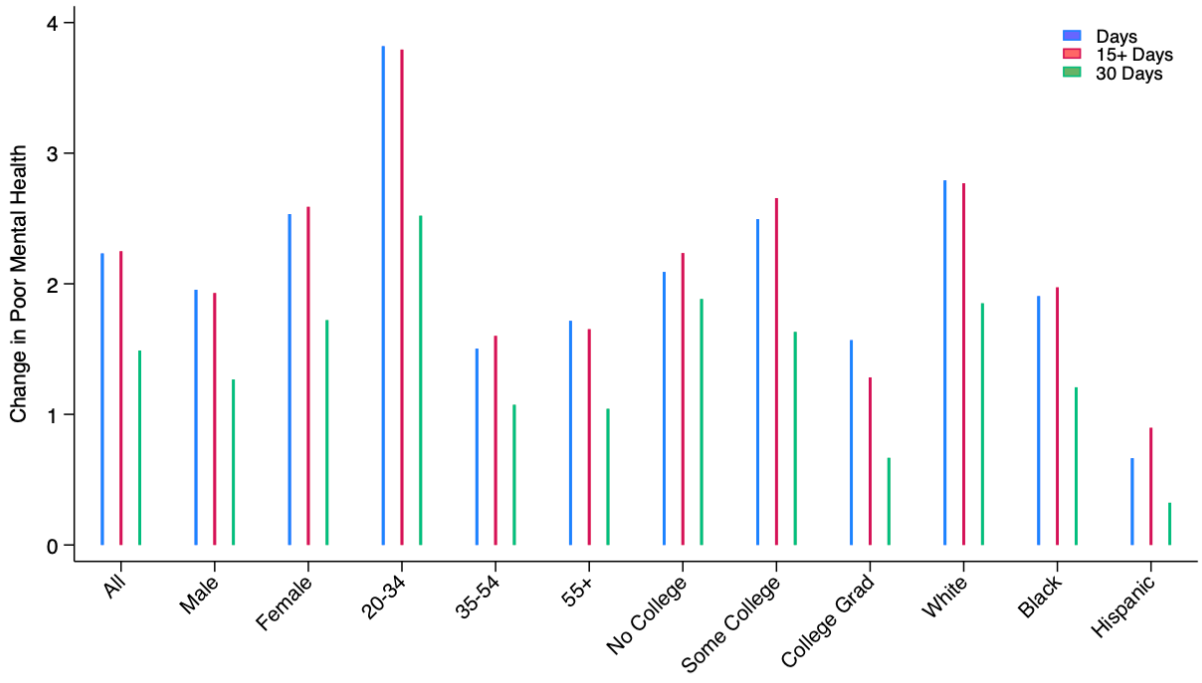


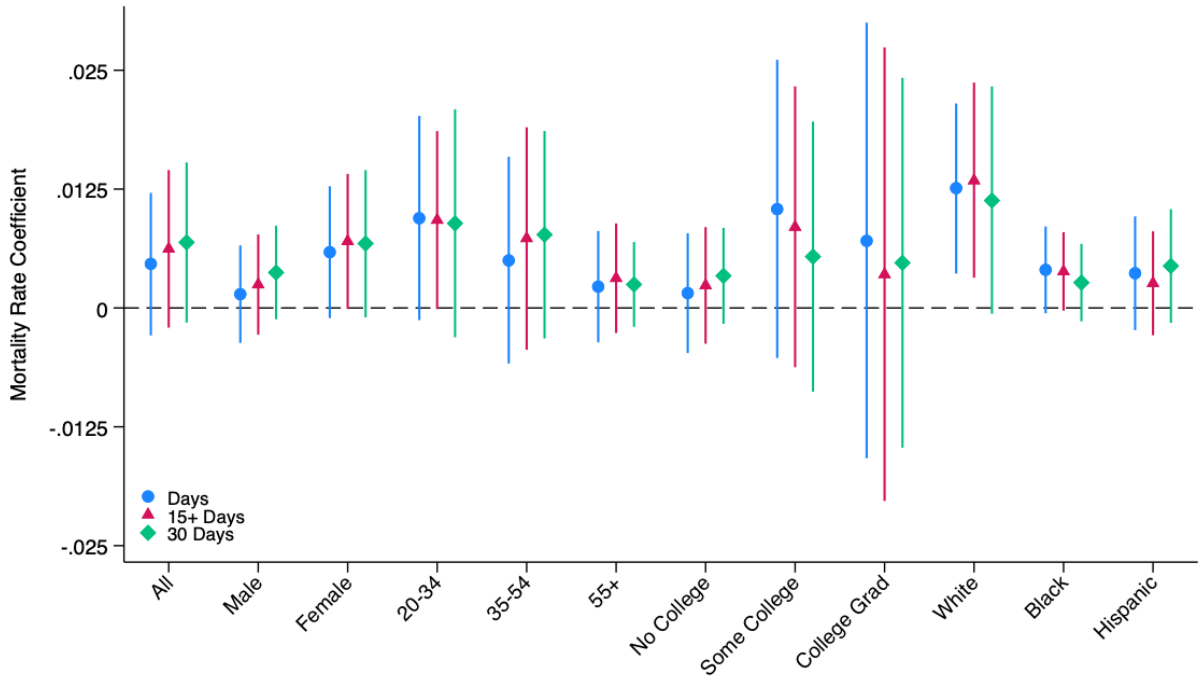
Figure shows coefficient estimates from regressing the proxy for age-standardized poor mental health on a linear time trend. Error bars show 95 percent confidence intervals based on robust standard errors. Vertical dashed lines show the full sample trend coefficient. The dependent variables refer to number of poor mental health days in last the 30. WH, BL, NC, SC, and CG refer to Whites, Blacks, no college, some college, and college graduate, and 25-54 and 55+ to age ranges.

Figure 4: Changes in Poor Mental Health and Predicted Effects On Age Standardized Mortality Rates for Population Groups

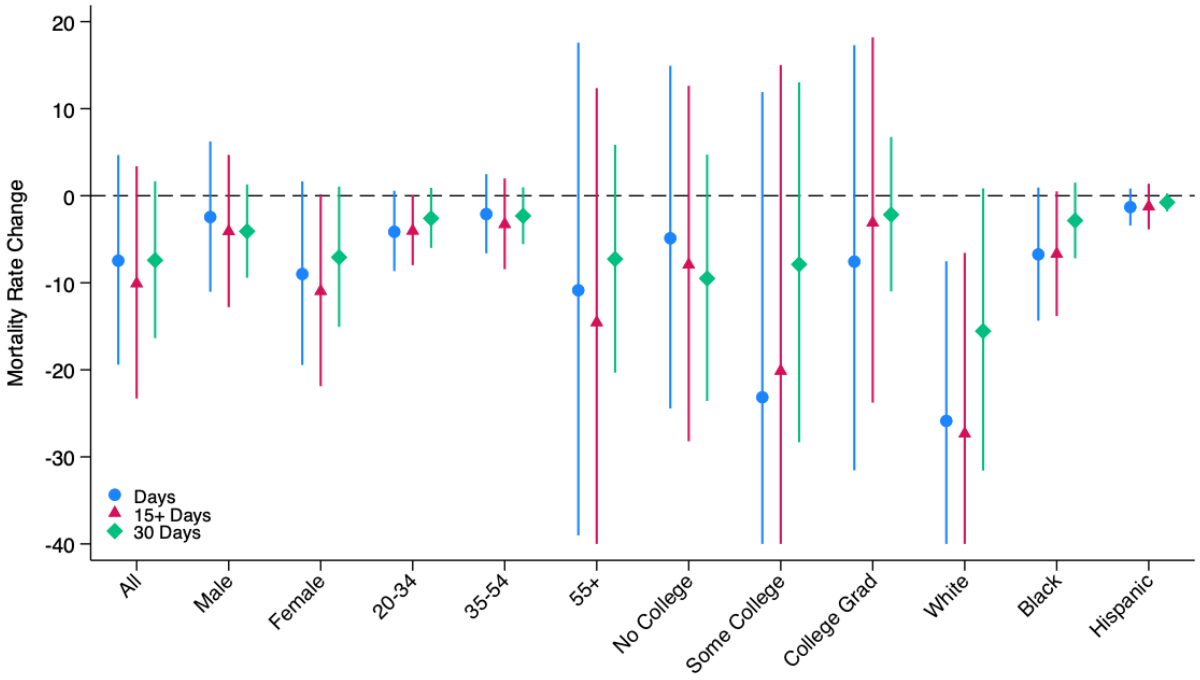
A. Change in Standardized Poor Mental Health, 1999-2019




B. Mortality Response to a One Standard Deviation Increase in Poor Mental Health



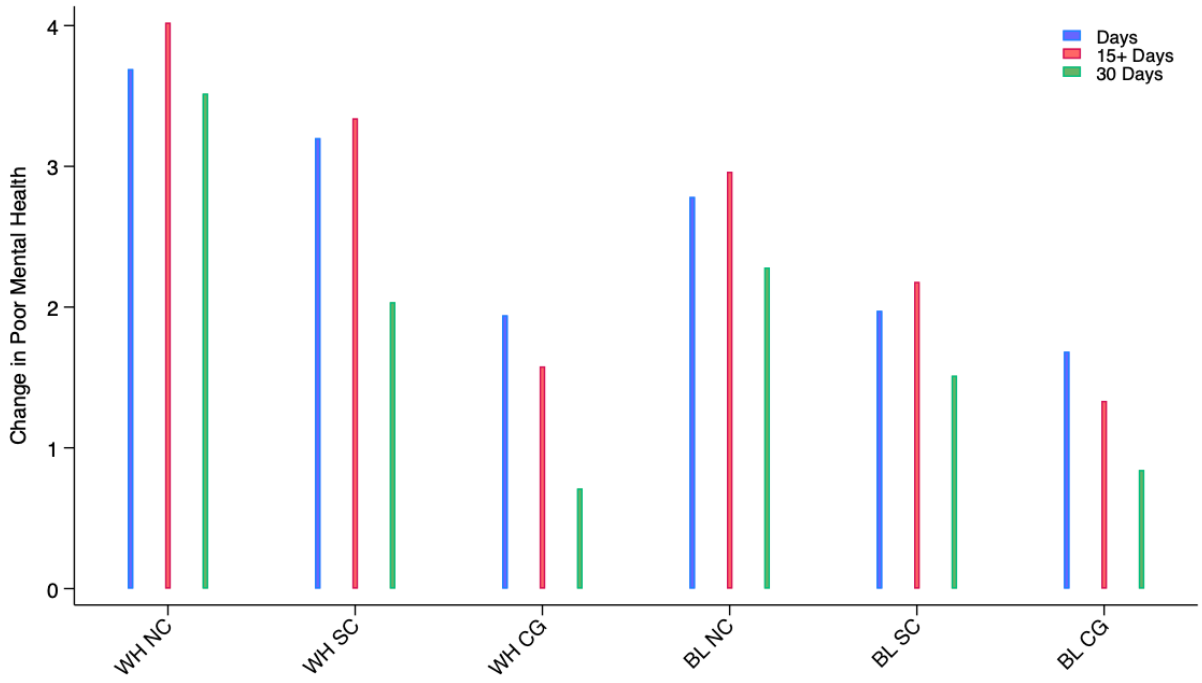
C. Constant Mental Health Δ in 2019 Mortality Rates



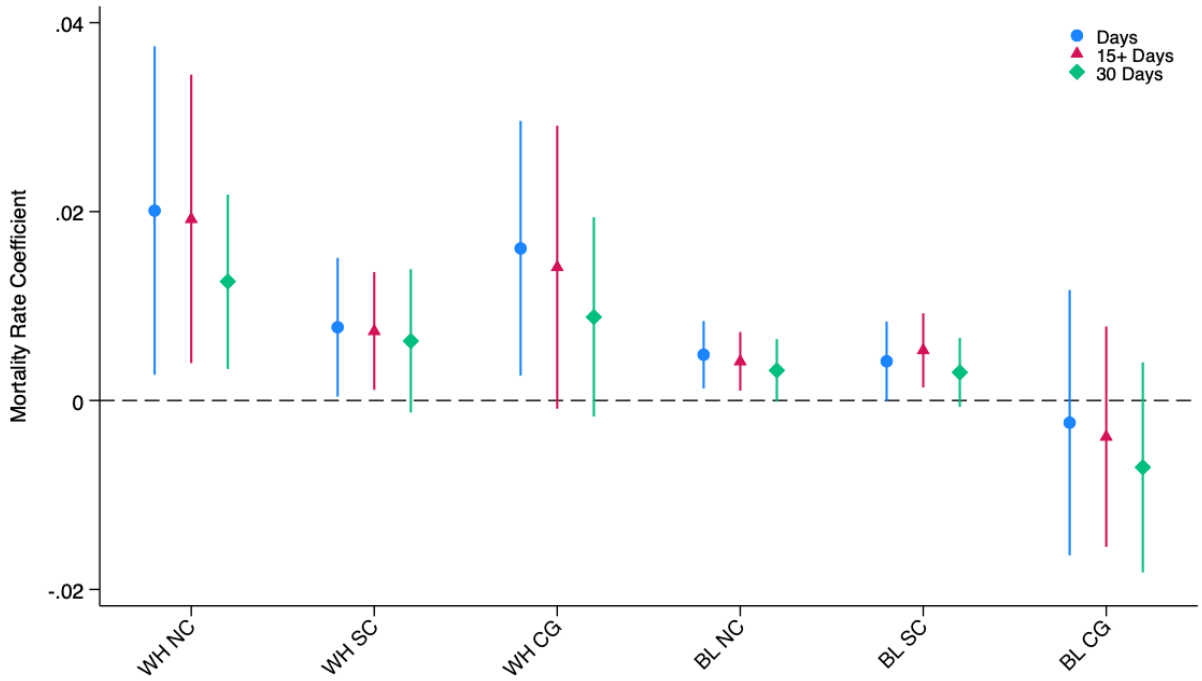

Top figure shows change in poor mental health from 1999 to 2019, measured in standardized units (standard deviations based on national data). Middle figure shows mental health coefficient estimates from Poisson regressions of age-standardized mortality rates (per 100,000) on poor mental health over the 1993-2019 period, plus state and time fixed-effects and, except for race groups, the state population shares of non-Hispanic Blacks, Hispanics, and non-Hispanic other races The mental health coefficients are standardized to indicate effect sizes based on a one-standard deviation change in the national value of the poor mental health proxy. Bottom figure shows estimated reductions in 2019 age-standardized mortality rates (per 100,000) if poor mental health had remained at 1999 levels. Whites and Blacks refer to non-Hispanics. Cells are weighted by average state populations for the specific group over the 1993-2019 period. Error bars show 95 percent confidence intervals (CI's) based on robust standard errors clustered at the state level. For clarity of display, the lower bounds of the CI's are censored at -40 in the lower figure.

Figure 5: Changes in Poor Mental Health and Predicted Effects On Age Standardized Mortality Rates for 25-54 Year Olds for Race-Education Subgroups

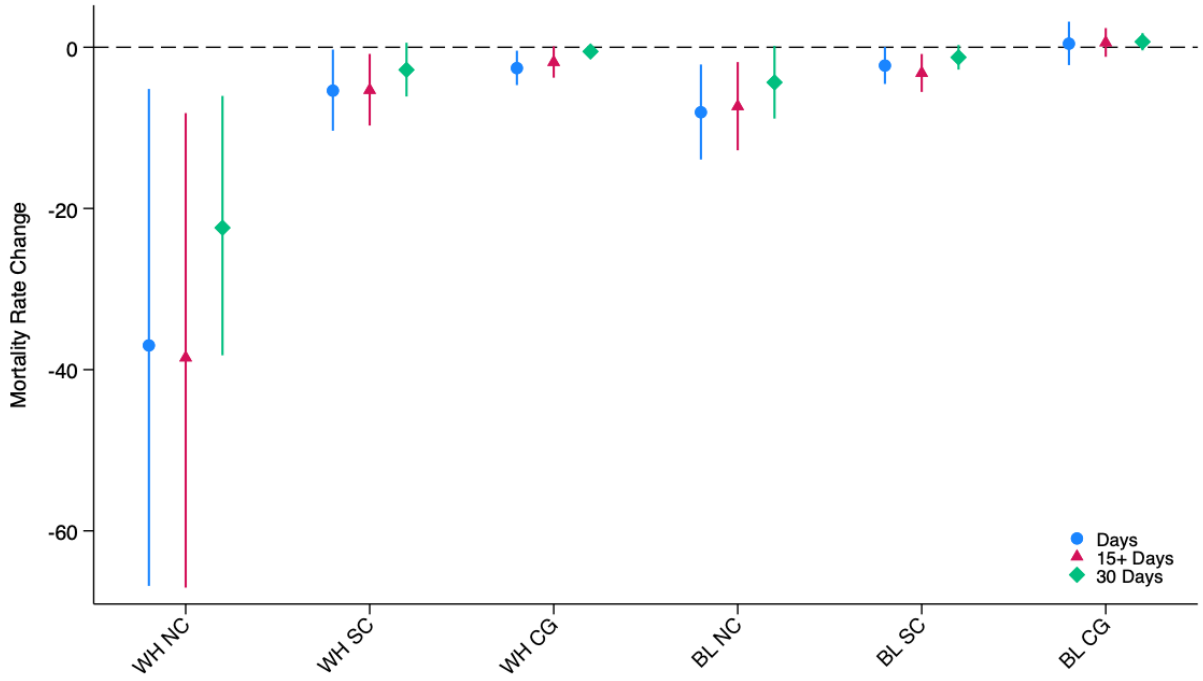
A. Change in Standardized Poor Mental Health, 1999-2019




B. Mortality Response to a One Standard Deviation Increase in Poor Mental Health



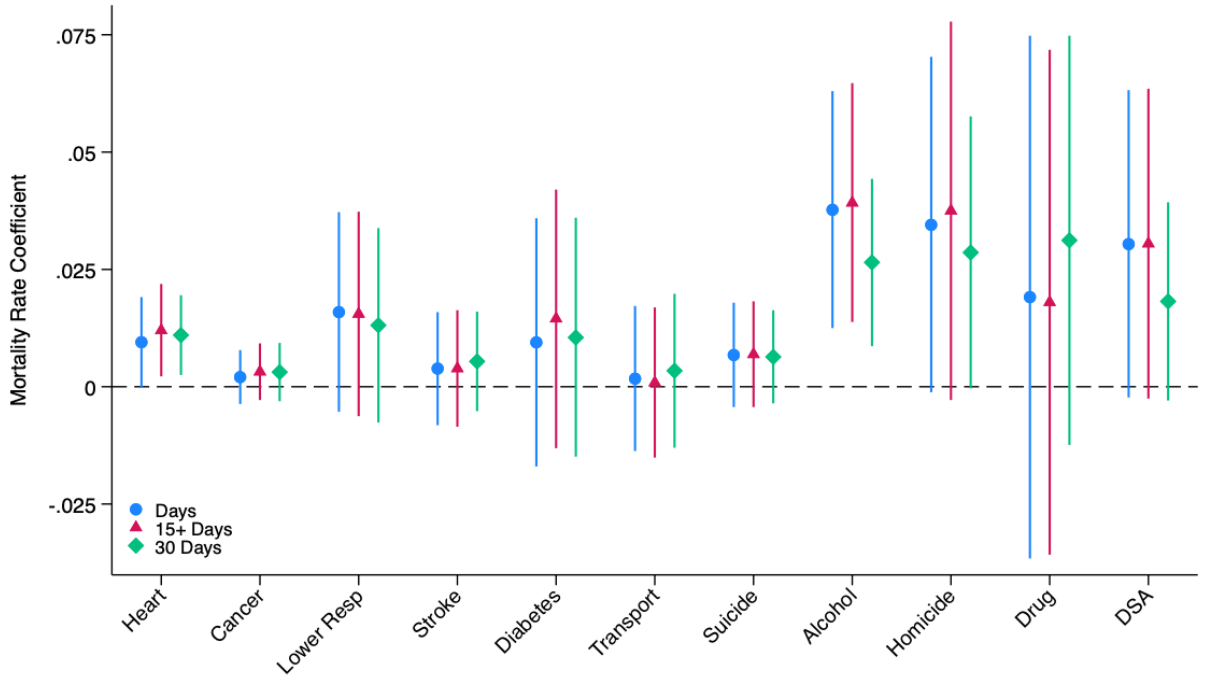
C. Constant Mental Health Δ in 2019 Mortality Rates



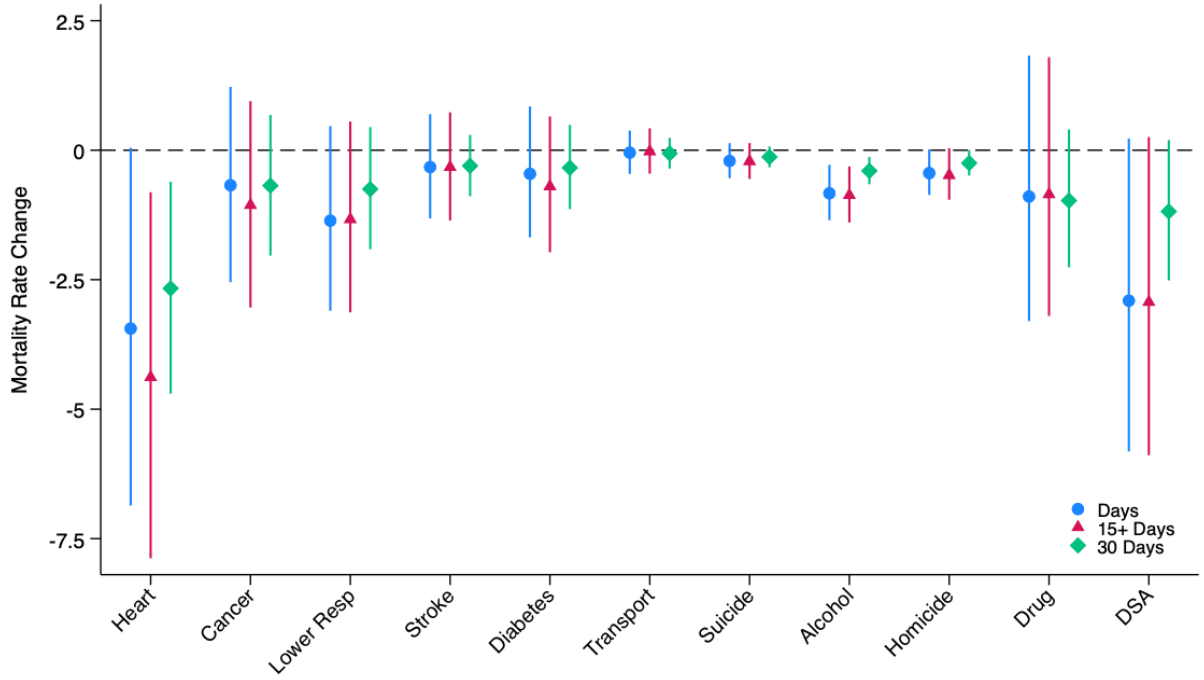

Top figure shows change in poor mental health from 1999 to 2019, measured in standardized units (standard deviations based on national data). Middle figure shows mental health coefficient estimates from Poisson regressions of age-standardized mortality rates (per 100,000) on poor mental health over the 1993-2019 period, plus state and time fixed-effects. The mental health coefficients are standardized to indicate effect sizes based on a one-standard deviation change in the national value of the poor mental health proxy. Bottom figure shows estimated reductions in 2019 age-standardized mortality rates (per 100,000) if poor mental health had remained at 1999 levels. WH and BL refer to Whites and Blacks and NC, SC, and CG refer to no college, some college, and college graduate. Cells are weighted by average state populations for the age-race group over the 1993-2019 period. Error bars show 95 percent confidence intervals (CI's) based on robust standard errors clustered at the state level.

Figure 6: Predicted Effects of Poor Mental Health On Age Standardized Mortality Rates By Cause

A. Mortality Response to a One Standard Deviation Increase in Poor Mental Health

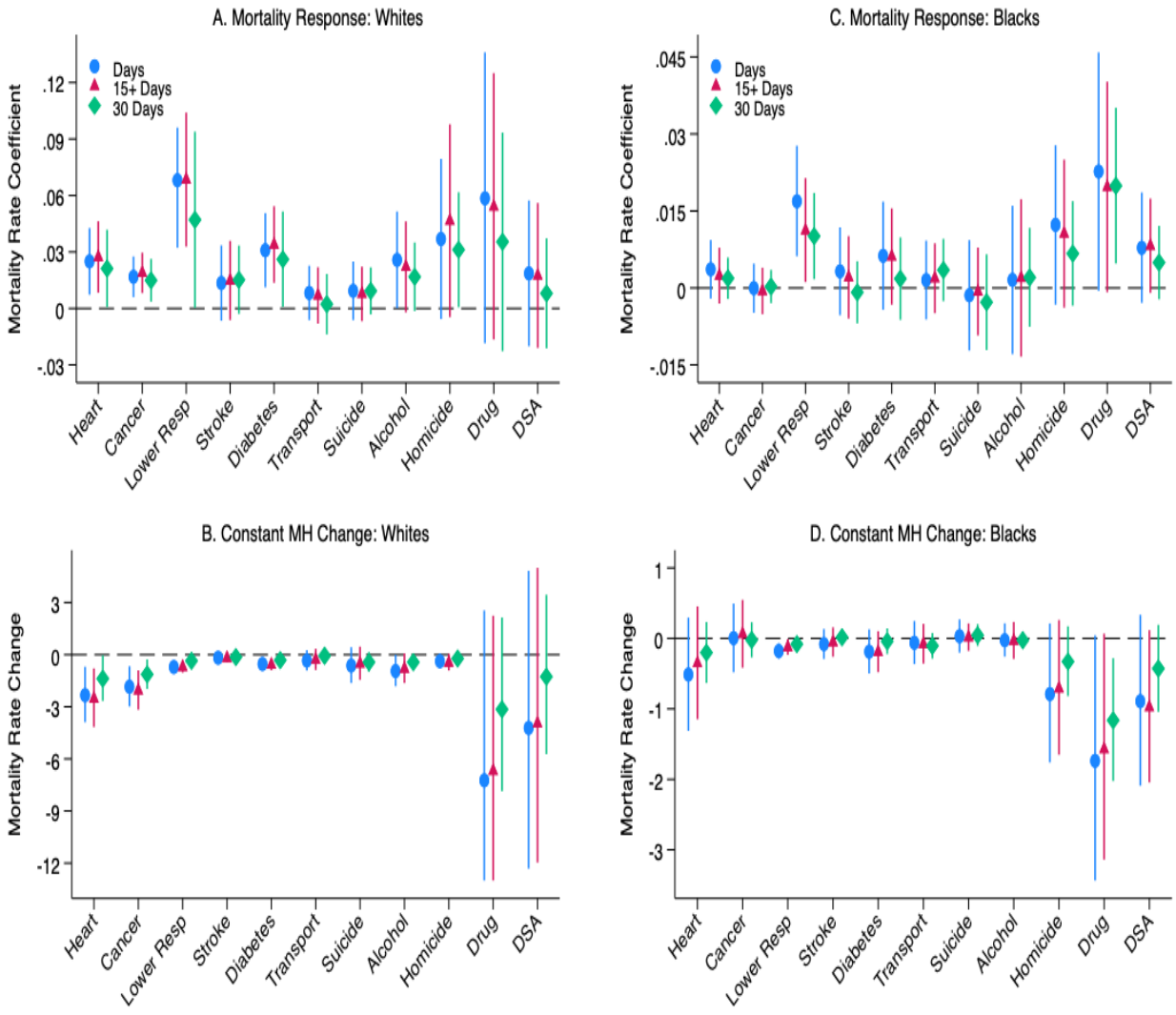



B. Constant Mental Health Δ in 2019 Mortality Rates



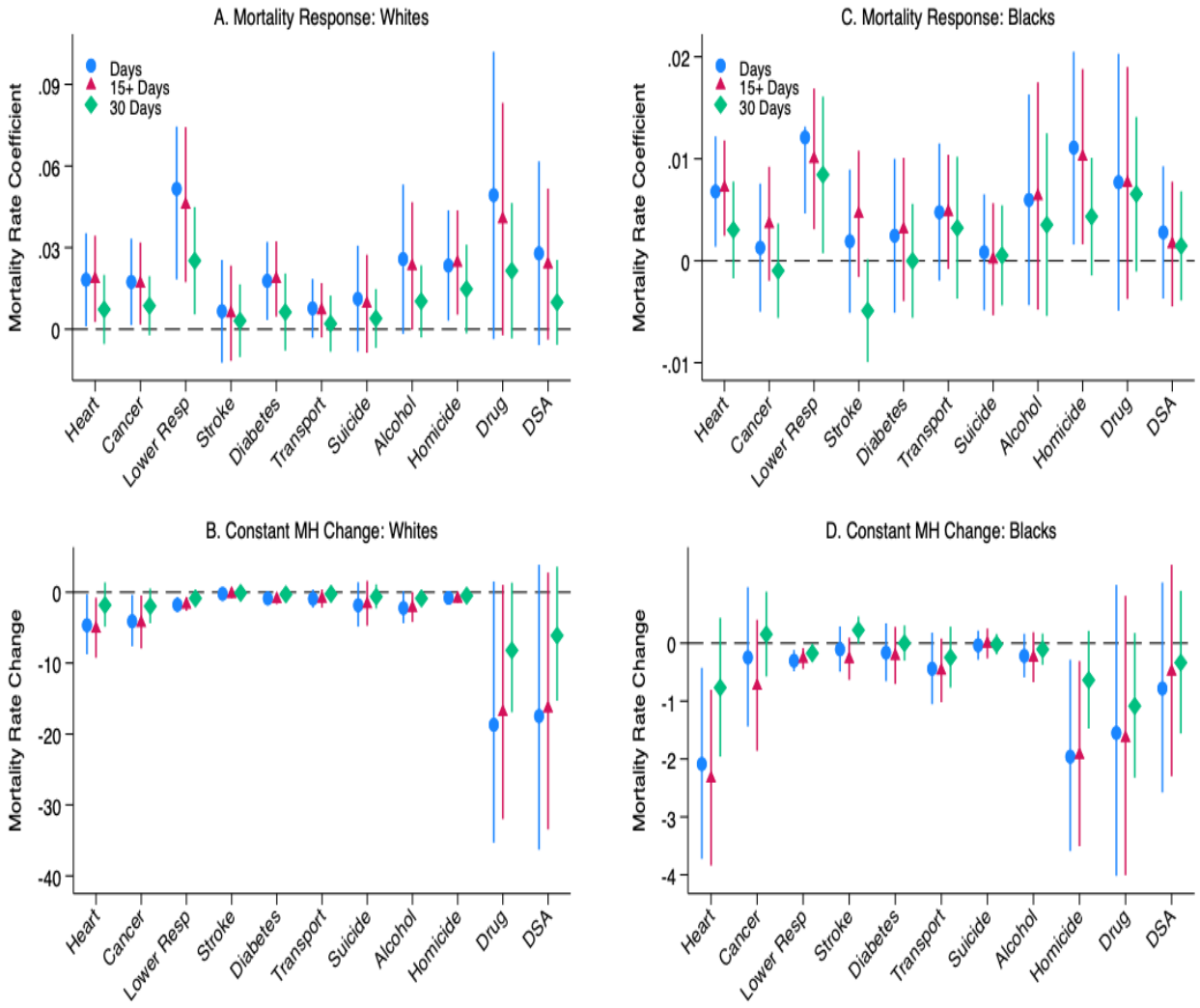
Top figure shows mental health coefficient estimates from Poisson regressions of age-standardized mortality rates (per 100,000) on poor mental health over the 1993-2019 period, plus state and time fixed-effects and the state population shares of non-Hispanic Blacks, Hispanics, and non-Hispanic other races. The mental health coefficients are standardized to indicate effect sizes based on a one-standard deviation change in the national value of the poor mental health proxy. Bottom figure shows estimated reductions in 2019 age-standardized mortality rates (per 100,000) if poor mental health had remained at 1999 levels. Cells are weighted by average state populations over the 1993-2019 period. Error bars show 95 percent confidence intervals based on robust standard errors clustered at the state level.

Figure 7: Predicted Effects of Poor Mental Health On Age Standardized Mortality Rates for 25-54 Year Old Non-Hispanic Whites and Blacks



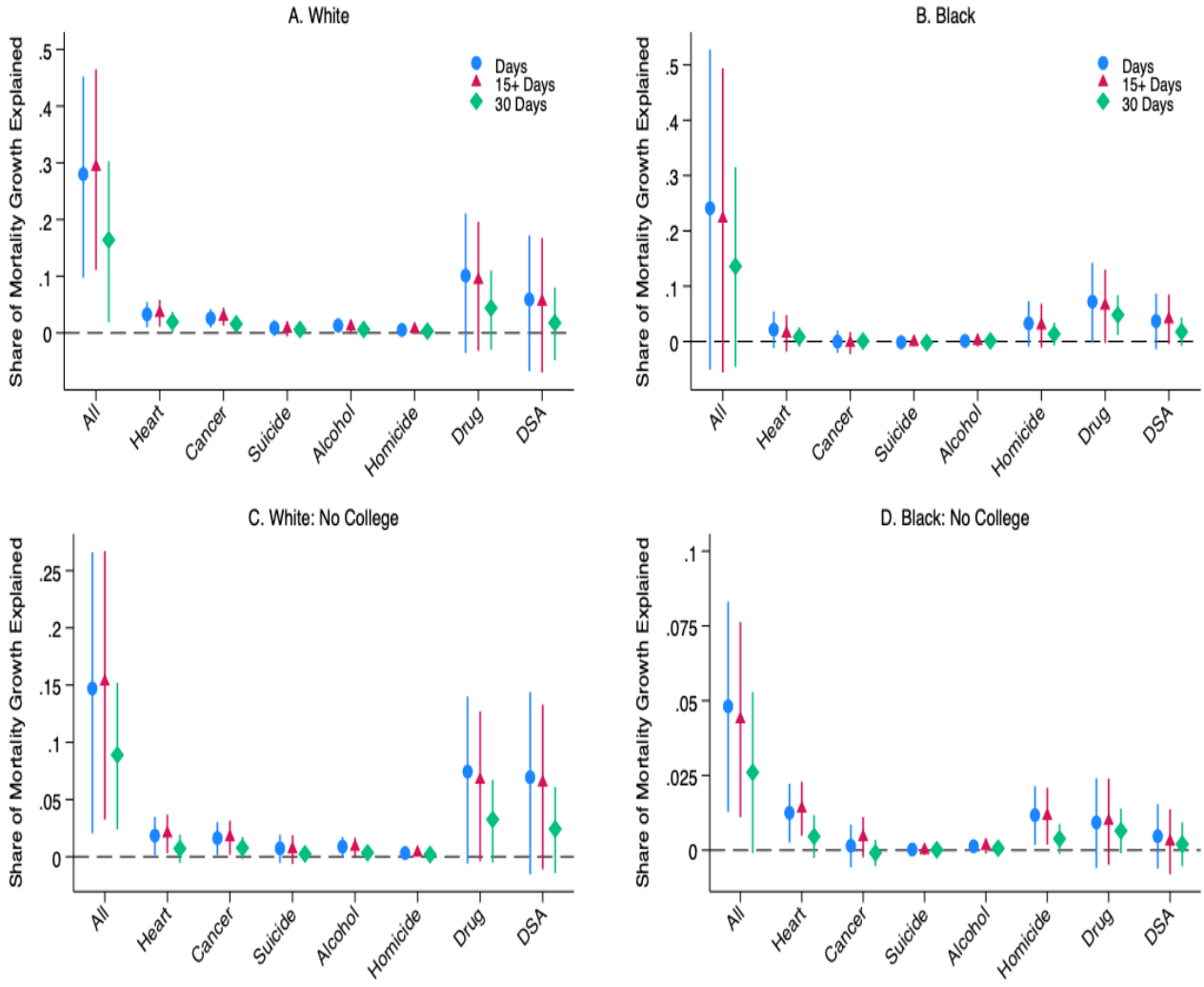

Top figures show mental health coefficient estimates from Poisson regressions of age-standardized mortality rates (per 100,000) on poor mental health over the 1993-2019 period, plus state and time fixed-effects. The mental health coefficients are standardized to indicate effect sizes based on a one-standard deviation change in the national value of the poor mental health proxy. Bottom figure show estimated reductions in 2019 age-standardized mortality rates (per 100,000) if poor mental health had remained at 1999 levels. Cells are weighted by race-age specific average state populations over the 1993-2019 period. Error bars show 95 percent confidence intervals (CI's) based on robust standard errors clustered at the state level. For clarity of display, lower bounds of the CI's are censored at -13 in sub-figure B.

Figure 8: Predicted Effects of Poor Mental Health On Age Standardized Mortality Rates for 25-54 Year Old Non-College Non-Hispanic Whites and Blacks




Top figures show mental health coefficient estimates from Poisson regressions of age-standardized mortality rates (per 100,000) on poor mental health over the 1993-2019 period, plus state and time fixed-effects. The mental health coefficients are standardized to indicate effect sizes based on a one-standard deviation change in the national value of the poor mental health proxy. Bottom figure show estimated reductions in 2019 age-standardized mortality rates (per 100,000) if poor mental health had remained at 1999 levels. Cells are weighted by race-age specific average state populations over the 1993-2019 period. Error bars show 95 percent confidence intervals (CI's) based on robust standard errors clustered at the state level.

Figure 9: Share of Adjusted Mortality Rate Changes From 1999-2019 for 25-54 Year Olds Resulting from Increases in Poor Mental Health, Overall and By Selected Causes of Death




Mortality rates are per 1000,000 and age-standardized. Adjusted mortality rate changes are actual minus counterfactual 2019 mortality rates. Counterfactual 2019 mortality rate is that predicted if average annual mortality rate changes from 1980-1999, calculated for all 25-54 year olds of the specified race, had continued through 2019. The shares accounted for are calculated by dividing the Constant MH changes, described above, by the adjusted mortality rate changes and reversing the sign. Whites and Blacks refer to non-Hispanics. Race-specific mortality rates in 1980 include Hispanics. This is adjusted for when computing adjusted mortality rate changes, as discussed in the text. Error bars show 95 percent confidence intervals. Error bars show 95 percent confidence intervals.

# Appendix A: Additional Tables and Figures

Table A1: ICD-9 and ICD-10 Codes for Underlying Causes of Deaths Analyzed

| Cause of Death | ICD-9 Codes | ICD-10 Codes |
|---|---|---|
| Heart | 390-398, 402, 404-429 | I00-I09, I11, I13, I20-I51 |
| Cancer | 140-208 | C00-C97 |
| Accidents | E800-E949 | V01-X59, Y85-Y86 |
| Chronic Lower Respiratory | 490-496 | J40-J47 |
| Stroke | 430-438 | I60-I69 |
| Diabetes Mellitus | 250 | E10-E14 |
| Chronic Liver | 571 | K70, K73, K74 |
| Alcohol | | F10, G31.2, G62.1, G72.1, I42.6, K29.2, K70.0-70.4, K70.9, K85.2, K86.0, X45, X65, Y15 |
| Transport Accidents | E800-E849, E929.0, E929.1 | V01-V99, Y85 |
| Suicide | E950-E959 | X60-X84, Y87.0 |
| Homicide | E960-E969 | X85-Y09, Y87.1 |
| Drugs | E850-E858, E950.0-E950.5, E962.0, E980.0-E980.5 | X40-X44, X60-X64, X85, Y10-Y14 |

Note: Table shows ICD-9 and ICD-10 underlying cause of death codes for mortality outcomes. Also analyzed are drug, suicide, and alcohol (DSA) deaths which include any of the three specified causes.

Table A2: Trend Coefficients for Population Groups

| Outcome | All | Male | Female | 20-34 | 35-54 | 55+ | No College | Some College | College Grad | White | Black | Hispanic |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # Days | 0.04861*** | 0.04649*** | 0.05107*** | 0.06530*** | 0.04235*** | 0.04153*** | 0.06161*** | 0.05996*** | 0.02561*** | 0.05922*** | 0.04695*** | 0.01632** |
| | (0.00305) | (0.00290) | (0.00357) | (0.00881) | (0.00276) | (0.00202) | (0.00400) | (0.00418) | (0.00512) | (0.00461) | (0.00325) | (0.00623) |
| Log # Days | 0.01417*** | 0.01638*** | 0.01278*** | 0.01611*** | 0.01170*** | 0.01601*** | 0.01552*** | 0.01673*** | 0.01016*** | 0.01704*** | 0.01257*** | 0.00460** |
| | (0.00073) | (0.00083) | (0.00078) | (0.00170) | (0.00078) | (0.00080) | (0.00107) | (0.00094) | (0.00178) | (0.00099) | (0.00087) | (0.00174) |
| 15+ Day Rate | 0.00172*** | 0.00157*** | 0.00188*** | 0.00240*** | 0.00155*** | 0.00131*** | 0.00224*** | 0.00218*** | 0.00078*** | 0.00206*** | 0.00164*** | 0.00072*** |
| | (0.00010) | (0.00010) | (0.00012) | (0.00029) | (0.00009) | (0.00007) | (0.00013) | (0.00015) | (0.00016) | (0.00015) | (0.00013) | (0.00019) |
| Log 15+ Day Rate | 0.01752*** | 0.01911*** | 0.01655*** | 0.02188*** | 0.01477*** | 0.01679*** | 0.01868*** | 0.02121*** | 0.01231*** | 0.02079*** | 0.01501*** | 0.00681*** |
| | (0.00079) | (0.00095) | (0.00087) | (0.00186) | (0.00089) | (0.00092) | (0.00122) | (0.00110) | (0.00218) | (0.00107) | (0.00117) | (0.00173) |
| 30 Day Rate | 0.00081*** | 0.00076*** | 0.00086*** | 0.00116*** | 0.00077*** | 0.00052*** | 0.00124*** | 0.00102*** | 0.00017** | 0.00098*** | 0.00069*** | 0.00008 |
| | (0.00005) | (0.00005) | (0.00006) | (0.00011) | (0.00005) | (0.00004) | (0.00007) | (0.00006) | (0.00006) | (0.00006) | (0.00007) | (0.00015) |
| Log 30 Day Rate | 0.01607*** | 0.01781*** | 0.01496*** | 0.02370*** | 0.01423*** | 0.01136*** | 0.01893*** | 0.02011*** | 0.00629** | 0.01967*** | 0.01197*** | 0.00184 |
| | (0.00098) | (0.00105) | (0.00133) | (0.00172) | (0.00116) | (0.00087) | (0.00128) | (0.00116) | (0.00225) | (0.00097) | (0.00140) | (0.00278) |

Note: Table shows coefficient estimates from regressing the measure of poor mental on a linear time trend, with robust standard errors shown in parentheses. The dependent variables refer to number of poor mental health days in last 30. Analysis period is 1993-2019. *p<0.10, **, p<0.05, ***p<0.01

Table A3: Trend Coefficients for Race by Age, Education and Sex Groups

| Outcome | White: 25-54 | White 25-54 No Col | White 25-54 Some Col | White 25-54 Col Grad | White 55+ | Black 25-54 | Black 25-54 No Col |
|---|---|---|---|---|---|---|---|
| # Days | 0.06349*** | 0.10199*** | 0.07359*** | 0.02881*** | 0.04026*** | 0.05306*** | 0.08120*** |
| | (0.00497) | (0.00443) | (0.00593) | (0.00608) | (0.00184) | (0.00430) | (0.00604) |
| Log # Days | 0.01677*** | 0.02170*** | 0.01817*** | 0.01049*** | 0.01622*** | 0.01334*** | 0.01790*** |
| | (0.00100) | (0.00097) | (0.00116) | (0.00198) | (0.00066) | (0.00108) | (0.00142) |
| 15+ Day Rate | 0.00226*** | 0.00379*** | 0.00272*** | 0.00085*** | 0.00123*** | 0.00183*** | 0.00272*** |
| | (0.00015) | (0.00015) | (0.00019) | (0.00017) | (0.00008) | (0.00017) | (0.00023) |
| Log 15+ Day Rate | 0.02117*** | 0.02636*** | 0.02356*** | 0.01292*** | 0.01649*** | 0.01577*** | 0.01992*** |
| | (0.00100) | (0.00110) | (0.00132) | (0.00234) | (0.00091) | (0.00146) | (0.00173) |
| 30 Day Rate | 0.00115*** | 0.00230*** | 0.00136*** | 0.00017** | 0.00051*** | 0.00090*** | 0.00159*** |
| | (0.00006) | (0.00008) | (0.00009) | (0.00007) | (0.00005) | (0.00007) | (0.00010) |
| Log 30 Day Rate | 0.02182*** | 0.02983*** | 0.02408*** | 0.00626** | 0.01169*** | 0.01481*** | 0.02083*** |
| | (0.00102) | (0.00167) | (0.00140) | (0.00239) | (0.00100) | (0.00124) | (0.00143) |

| Outcome | Black 25-54 Some Col | Black 25-54 Col Grad | Black 55+ | White 25-54 Male | White 25-54 Female | Black 25-54 Male | Black 25-54 Female |
|---|---|---|---|---|---|---|---|
| # Days | 0.04906*** | 0.02042*** | 0.03314*** | 0.05899*** | 0.06833*** | 0.05892*** | 0.05145*** |
| | (0.00629) | (0.00646) | (0.00531) | (0.00474) | (0.00571) | (0.00544) | (0.00478) |
| Log # Days | 0.01247*** | 0.00706*** | 0.01083*** | 0.01913*** | 0.01520*** | 0.01830*** | 0.01123*** |
| | (0.00164) | (0.00218) | (0.00176) | (0.00114) | (0.00103) | (0.00176) | (0.00105) |
| 15+ Day Rate | 0.00188*** | 0.00063** | 0.00114*** | 0.00202*** | 0.00252*** | 0.00195*** | 0.00183*** |
| | (0.00028) | (0.00025) | (0.00020) | (0.00015) | (0.00018) | (0.00022) | (0.00017) |
| Log 15+ Day Rate | 0.01661*** | 0.00852** | 0.01226*** | 0.02311*** | 0.01990*** | 0.02084*** | 0.01364*** |
| | (0.00257) | (0.00331) | (0.00217) | (0.00124) | (0.00111) | (0.00239) | (0.00129) |
| 30 Day Rate | 0.00083*** | 0.00016 | 0.00023 | 0.00103*** | 0.00129*** | 0.00105*** | 0.00084*** |
| | (0.00016) | (0.00013) | (0.00015) | (0.00007) | (0.00008) | (0.00012) | (0.00013) |
| Log 30 Day Rate | 0.01461*** | 0.00448 | 0.00429 | 0.02331*** | 0.02085*** | 0.02119*** | 0.01204*** |
| | (0.00288) | (0.00354) | (0.00280) | (0.00132) | (0.00149) | (0.00257) | (0.00199) |

Note: Table shows coefficient estimates from regressing the measure of age-standardized poor mental on a linear time trend, with robust standard errors shown in parentheses. Analysis period is 1993-2019. *p<0.10, **, p<0.05, ***p<0.01

Table A4: Mortality Rates, Changes in Poor Mental Health, and Counterfactual Mortality Rate Changes for Population Groups

| Outcome/ Mental Health Proxy | All | Male | Female | 20-34 | 35-54 | 55+ | No College | Some College | College Grad | White | Black | Hispanic |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age-Standardized Mortality Rate | | | | | | | | | | | | |
| Rate: 1999 | 875.4 | 1,072.0 | 731.2 | 98.6 | 298.5 | 3,497.0 | 1,489.0 | 921.5 | 988.0 | 861.5 | 1,159.0 | 683.7 |
| Rate: 2019 | 725.2 | 864.7 | 609.2 | 117.0 | 280.9 | 2,826.0 | 1,499.0 | 900.6 | 687.8 | 749.7 | 886.7 | 537.2 |
| Δ: 1999-2019 | -150.2 | -207.3 | -122.0 | 18.4 | -17.6 | -671.0 | 10.0 | -20.9 | -300.2 | -111.8 | -272.3 | -146.5 |
| Δ in Poor Mental Health Variable: 1999-2019 | | | | | | | | | | | | |
| Days | 2.23 | 1.95 | 2.53 | 3.82 | 1.50 | 1.72 | 2.09 | 2.49 | 1.57 | 2.79 | 1.91 | 0.66 |
| 15+ Days | 2.25 | 1.93 | 2.59 | 3.79 | 1.60 | 1.65 | 2.24 | 2.66 | 1.28 | 2.77 | 1.97 | 0.90 |
| All 30 Days | 1.49 | 1.27 | 1.72 | 2.52 | 1.07 | 1.04 | 1.88 | 1.63 | 0.67 | 1.85 | 1.21 | 0.32 |
| Mental Health Regression Coefficient | | | | | | | | | | | | |
| Days | 0.0046 | 0.0015 | 0.0059* | 0.0094* | 0.0050 | 0.0022 | 0.0016 | 0.0104 | 0.0071 | 0.0126*** | 0.0040* | 0.0037 |
| | (0.0038) | (0.0026) | (0.0035) | (0.0055) | (0.0055) | (0.0030) | (0.0032) | (0.0080) | (0.0117) | (0.0046) | (0.0023) | (0.0031) |
| 15+ Days | 0.0062 | 0.0025 | 0.0070* | 0.0093* | 0.0073 | 0.0031 | 0.0024 | 0.0085 | 0.0035 | 0.0134** | 0.0038* | 0.0026 |
| | (0.0042) | (0.0027) | (0.0036) | (0.0048) | (0.0060) | (0.0029) | (0.0031) | (0.0075) | (0.0122) | (0.0052) | (0.0021) | (0.0028) |
| All 30 Days | 0.0069 | 0.0037 | 0.0068* | 0.0089 | 0.0077 | 0.0025 | 0.0034 | 0.0054 | 0.0048 | 0.0113* | 0.0027 | 0.0044 |
| | (0.0043) | (0.0025) | (0.0040) | (0.0061) | (0.0056) | (0.0023) | (0.0026) | (0.0072) | (0.0099) | (0.0061) | (0.0021) | (0.0031) |
| Constant Mental Health Δ in 2019 Mortality Rates | | | | | | | | | | | | |
| Days | -7.5 | -2.4 | -9.0 | -4.1 | -2.1 | -10.9 | -4.9 | -23.2 | -7.6 | -25.9 | -6.7 | -1.3 |
| 15+ Days | -10.1 | -4.1 | -11.0 | -4.0 | -3.3 | -14.6 | -7.9 | -20.1 | -3.1 | -27.4 | -6.7 | -1.2 |
| All 30 Days | -7.4 | -4.1 | -7.1 | -2.6 | -2.3 | -7.3 | -9.5 | -7.9 | -2.2 | -15.6 | -2.9 | -0.8 |

Note: Top panel shows age-standardized national mortality rates (per 100,000) in specified years and changes between them. Second panel shows changes 1999-2019 in the mental health proxies, in standardized units, constructed as unstandardized measures divided by the full population standard deviation (0.6013, 0.02114, and 0.01311, respectively, for days, 15+ days, and all 30 days). Third panel displays coefficient estimates from Poisson regressions with cells weighted by average state populations over the 1993-2019 period, with robust standard errors clustered at the state level shown in parentheses. *p<0.10, **, p<0.05, ***p<0. Bottom panel shows the estimated counterfactual reduction in 2019 age-standardized mortality rates, relative to actual levels, if the specified mental health proxy had remained at its value in 1999. White and Black refer to non-Hispanics. Education groups are for persons aged 25 and older.

Table A5: Mortality Rates, Changes in Poor Mental Health, and Counterfactual Mortality Rate Changes for Race-Age-Education Subgroups

| Outcome/Mental Health Proxy | White 25-54 | White No Col 25-54 | White Some Col 25-54 | White Col Grad 25-54 | White 55+ | Black 25-54 | Black No Col 25-54 | Black Some Col 25-54 | Black Col Grad 25-54 | Black 55+ |
|---|---|---|---|---|---|---|---|---|---|---|
| Age-Standardized Mortality Rate | | | | | | | | | | |
| Rate: 1999 | 216.2 | 333.2 | 146.8 | 109.0 | 3,488.0 | 450.0 | 601.6 | 261.7 | 202.0 | 4,301.0 |
| Rate: 2019 | 247.7 | 517.6 | 219.5 | 84.1 | 2,923.0 | 360.2 | 601.4 | 277.9 | 113.7 | 3,254.0 |
| Δ: 1999-2019 | 31.5 | 184.4 | 72.7 | -24.9 | -565.0 | -89.8 | -0.2 | 16.2 | -88.3 | -1,047.0 |
| Δ in Standardized Poor Mental Health Variable: 1999-2019 | | | | | | | | | | |
| Days | 2.84 | 3.69 | 3.20 | 1.94 | 1.77 | 2.06 | 2.78 | 1.97 | 1.68 | 0.96 |
| 15+ Days | 2.82 | 4.02 | 3.34 | 1.58 | 1.65 | 2.15 | 2.96 | 2.18 | 1.33 | 0.87 |
| All 30 Days | 1.95 | 3.52 | 2.04 | 0.71 | 1.14 | 1.56 | 2.28 | 1.51 | 0.84 | 0.08 |
| Mental Health Regression Coefficient | | | | | | | | | | |
| Days | 0.0296*** | 0.0201** | 0.0078** | 0.0161** | 0.0030 | 0.0079 | 0.0048*** | 0.0042* | -0.0024 | -0.0002 |
| | (0.0100) | (0.0089) | (0.0037) | (0.0069) | (0.0032) | (0.0049) | (0.0018) | (0.0021) | (0.0072) | (0.0009) |
| 15+ Days | 0.0313*** | 0.0192** | 0.0073** | 0.0141* | 0.0030 | 0.0070 | 0.0041*** | 0.0053*** | -0.0038 | -0.0000 |
| | (0.0101) | (0.0078) | (0.0032) | (0.0076) | (0.0034) | (0.0044) | (0.0016) | (0.0020) | (0.0060) | (0.0008) |
| All 30 Days | 0.0249** | 0.0126*** | 0.0063 | 0.0088 | 0.0008 | 0.0059 | 0.0032* | 0.0030 | -0.0071 | -0.0003 |
| | (0.0113) | (0.0047) | (0.0039) | (0.0054) | (0.0027) | (0.0040) | (0.0017) | (0.0019) | (0.0057) | (0.0008) |
| Constant Mental Health Δ in 2019 Mortality Rates | | | | | | | | | | |
| Days | -20.0 | -37.0 | -5.4 | -2.6 | -15.5 | -5.8 | -8.1 | -2.3 | 0.5 | 0.8 |
| 15+ Days | -20.9 | -38.5 | -5.3 | -1.9 | -14.6 | -5.3 | -7.3 | -3.2 | 0.6 | 0.1 |
| All 30 Days | -11.7 | -22.4 | -2.8 | -0.5 | -2.7 | -3.3 | -4.4 | -1.2 | 0.7 | 0.1 |

Note: Top panel shows age-standardized national mortality rates (per 100,000) in specified years and changes between them. Second panel shows changes 1999-2019 in the mental health proxies, in standardized units, constructed as unstandardized measures divided by the full population standard deviation (0.6013, 0.02114, and 0.01311, respectively, for days, 15+ days, and all 30 days). Third panel displays coefficient estimates from

Poisson regressions with cells weighted by average state populations over the 1993-2019 period, with robust standard errors clustered at the state level shown in parentheses. *p<0.10, **, p<0.05, ***p<0. Bottom panel shows the estimated counterfactual reduction in 2019 age-standardized mortality rates, relative to actual levels, if the specified mental health proxy had remained at its value in 1999. White and Black refer to non-Hispanics.

Table A6: Age-Standardized Mortality Rates and Changes for Causes of Death

| Outcome/Mental Health Proxy | Heart | Cancer | Lower Resp | Stroke | Diabetes | Trans-port | Suicide | Alcohol | Homicide | Drug | DSA |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Age-Standardized Mortality Rate | | | | | | | | | | | |
| Rate: 1999 | 266.4 | 200.7 | 45.4 | 61.6 | 25.0 | 16.6 | 10.5 | 7.1 | 6.0 | 6.0 | 22.5 |
| Rate: 2019 | 164.2 | 147.8 | 38.9 | 37.7 | 21.8 | 12.2 | 13.8 | 10.3 | 6.0 | 21.5 | 44.2 |
| Δ: 1999-2019 | -102.2 | -52.9 | -6.5 | -23.9 | -3.2 | -4.4 | 3.4 | 3.2 | 0.0 | 15.4 | 21.8 |
| Mental Health Regression Coefficient | | | | | | | | | | | |
| Days | 0.0095* | 0.0021 | 0.0159 | 0.0039 | 0.0094 | 0.0017 | 0.0068 | 0.0377*** | 0.0345* | 0.0191 | 0.0304* |
| | (0.0049) | (0.0029) | (0.0109) | (0.0062) | (0.0135) | (0.0079) | (0.0057) | (0.0129) | (0.0182) | (0.0284) | (0.0167) |
| 15+ Days | 0.0120** | 0.0032 | 0.0155 | 0.0039 | 0.0145 | 0.0009 | 0.0069 | 0.0392*** | 0.0375* | 0.0180 | 0.0305* |
| | (0.0050) | (0.0031) | (0.0111) | (0.0063) | (0.0141) | (0.0082) | (0.0057) | (0.0130) | (0.0206) | (0.0274) | (0.0169) |
| All 30 Days | 0.0110** | 0.0031 | 0.0131 | 0.0054 | 0.0105 | 0.0034 | 0.0064 | 0.0265*** | 0.0286* | 0.0312 | 0.0182* |
| | (0.0043) | (0.0032) | (0.0106) | (0.0054) | (0.0130) | (0.0084) | (0.0051) | (0.0091) | (0.0148) | (0.0223) | (0.0108) |
| Constant Mental Health Δ in 2019 Mortality Rates | | | | | | | | | | | |
| Days | -3.4 | -0.7 | -1.4 | -0.3 | -0.5 | 0.0 | -0.2 | -0.8 | -0.4 | -0.9 | -2.9 |
| 15+ Days | -4.4 | -1.1 | -1.3 | -0.3 | -0.7 | 0.0 | -0.2 | -0.9 | -0.5 | -0.9 | -2.9 |
| All 30 Days | -2.7 | -0.7 | -0.8 | -0.3 | -0.3 | -0.1 | -0.1 | -0.4 | -0.2 | -1.0 | -1.2 |

Note: Top panel shows age-standardized national mortality rates (per 100,000) in specified years and changes between them. Second panel displays coefficient estimates from Poisson regressions with cells weighted by average state populations over the 1993-2019 period, with robust standard errors clustered at the state level shown in parentheses. *p<0.10, **, p<0.05, ***p<0. Lower panel the estimated counterfactual reduction in 2019 age-standardized mortality rates, relative to actual levels, if the specified mental health proxy had remained at its value in 1999. Poor mental health days, 15+ days, and all 30 days increase by 2.23, 2.25, and 1.49 standard deviations, respectively, from 1999-2019.

Table A7: Age-Standardized Mortality Rates and Changes for Causes of Death, 25-54 Year Old Non-Hispanic Whites

| | Heart | Cancer | Lower Resp | Stroke | Diabetes | Transport | Suicide | Alcohol | Homicide | Drug | DSA |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Age-Standardized Mortality Rate | | | | | | | | | | | |
| Rate: 1999 | 40.2 | 55.9 | 3.4 | 5.5 | 5.1 | 16.9 | 16.1 | 8.0 | 3.8 | 11.4 | 33.2 |
| Rate: 2019 | 34.0 | 39.6 | 4.0 | 4.7 | 6.4 | 14.7 | 23.9 | 13.4 | 3.8 | 47.2 | 82.0 |
| Δ: 1999-2019 | -6.1 | -16.3 | 0.6 | -0.8 | 1.2 | -2.2 | 7.8 | 5.3 | 0.0 | 35.9 | 48.8 |
| Mental Health Regression Coefficient | | | | | | | | | | | |
| Days | 0.0250*** | 0.0168*** | 0.0681*** | 0.0135 | 0.0309*** | 0.0082 | 0.0094 | 0.0258** | 0.0369* | 0.0585 | 0.0186 |
| | (0.0090) | (0.0055) | (0.0183) | (0.0102) | (0.0101) | (0.0074) | (0.0079) | (0.0131) | (0.0217) | (0.0393) | (0.0198) |
| 15+ Days | 0.0273*** | 0.0189*** | 0.0685*** | 0.0148 | 0.0339*** | 0.0069 | 0.0077 | 0.0221* | 0.0466* | 0.0541 | 0.0175 |
| | (0.0097) | (0.0055) | (0.0183) | (0.0107) | (0.0104) | (0.0076) | (0.0074) | (0.0123) | (0.0261) | (0.0360) | (0.0196) |
| All 30 Days | 0.0212** | 0.0149*** | 0.0471** | 0.0152 | 0.0261** | 0.0023 | 0.0093 | 0.0168* | 0.0312** | 0.0354 | 0.0080 |
| | (0.0105) | (0.0058) | (0.0239) | (0.0093) | (0.0129) | (0.0082) | (0.0064) | (0.0093) | (0.0156) | (0.0296) | (0.0149) |
| Constant Mental Health Δ in 2019 Mortality Rates | | | | | | | | | | | |
| Days | -2.3 | -1.8 | -0.7 | -0.2 | -0.5 | -0.3 | -0.6 | -0.9 | -0.4 | -7.2 | -4.2 |
| 15+ Days | -2.5 | -2.1 | -0.7 | -0.2 | -0.6 | -0.3 | -0.5 | -0.8 | -0.5 | -6.7 | -3.9 |
| All 30 Days | -1.4 | -1.1 | -0.4 | -0.1 | -0.3 | -0.1 | -0.4 | -0.4 | -0.2 | -3.1 | -1.3 |

Note: Top panel shows age-standardized national mortality rates (per 100,000) in specified years and changes between them. Second panel displays coefficient estimates from Poisson regressions with cells weighted by average state populations over the 1993-2019 period, with robust standard errors clustered at the state level shown in parentheses. *p<0.10, **, p<0.05, ***p<0. Lower panel shows the estimated counterfactual reduction in 2019 age-standardized mortality rates, relative to actual levels, if the specified mental health proxy had remained at its value in 1999. Poor mental health days, 15+ days, and all 30 days increase by 2.84, 2.82, and 1.95 standard deviations, respectively, from 1999-2019.

Table A8: Age-Standardized Mortality Rates and Changes for Causes of Death, 25-54 Year Old Non-Hispanic Blacks

| | Heart | Cancer | Lower Resp | Stroke | Diabetes | Transport | Suicide | Alcohol | Homicide | Drug | DSA |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Age-Standardized Mortality Rate | | | | | | | | | | | |
| Rate: 1999 | 90.1 | 87.7 | 7.1 | 19.9 | 14.3 | 19.8 | 7.7 | 11.8 | 26.1 | 14.9 | 33.6 |
| Rate: 2019 | 68.9 | 49.5 | 5.2 | 12.2 | 14.6 | 19.4 | 10.6 | 8.0 | 31.6 | 38.0 | 55.7 |
| Δ: 1999-2019 | -21.2 | -38.2 | -1.9 | -7.8 | 0.3 | -0.4 | 2.9 | -3.8 | 5.5 | 23.1 | 22.1 |
| Mental Health Regression Coefficient | | | | | | | | | | | |
| Days | 0.0036 | -0.0000 | 0.0169*** | 0.0032 | 0.0063 | 0.0015 | -0.0014 | 0.0016 | 0.0123 | 0.0227* | 0.0078 |
| | (0.0029) | (0.0024) | (0.0055) | (0.0044) | (0.0054) | (0.0039) | (0.0055) | (0.0074) | (0.0079) | (0.0119) | (0.0055) |
| 15+ Days | 0.0024 | -0.0006 | 0.0112** | 0.0021 | 0.0061 | 0.0019 | -0.0007 | 0.0020 | 0.0106 | 0.0197* | 0.0082* |
| | (0.0028) | (0.0023) | (0.0052) | (0.0041) | (0.0048) | (0.0035) | (0.0044) | (0.0078) | (0.0074) | (0.0105) | (0.0047) |
| All 30 Days | 0.0019 | 0.0003 | 0.0101** | -0.0009 | 0.0018 | 0.0035 | -0.0028 | 0.0021 | 0.0067 | 0.0199** | 0.0049 |
| | (0.0021) | (0.0016) | (0.0043) | (0.0031) | (0.0041) | (0.0031) | (0.0048) | (0.0049) | (0.0052) | (0.0077) | (0.0037) |
| Constant Mental Health Δ in 2019 Mortality Rates | | | | | | | | | | | |
| Days | -0.5 | 0.0 | -0.2 | -0.1 | -0.2 | -0.1 | 0.0 | 0.0 | -0.8 | -1.7 | -0.9 |
| 15+ Days | -0.4 | 0.1 | -0.1 | -0.1 | -0.2 | -0.1 | 0.0 | 0.0 | -0.7 | -1.6 | -1.0 |
| All 30 Days | -0.2 | 0.0 | -0.1 | 0.0 | 0.0 | -0.1 | 0.0 | 0.0 | -0.3 | -1.2 | -0.4 |

Note: Top panel shows age-standardized national mortality rates (per 100,000) in specified years and changes between them. Second panel displays coefficient estimates from Poisson regressions with cells weighted by average state populations over the 1993-2019 period, with robust standard errors clustered at the state level shown in parentheses. *p<0.10, **, p<0.05, ***p<0. Lower panel shows the estimated counterfactual reduction in 2019 age-standardized mortality rates, relative to actual levels, if the specified mental health proxy had remained at its value in 1999. Poor mental health days, 15+ days, and all 30 days increase by 2.06, 2.15, and 1.56 standard deviations, respectively, from 1999-2019.

Table A9: Age-Standardized Mortality Rates and Changes for Causes of Death, 25-54 Year Old Non-College Educated Non-Hispanic Whites

| | All | Heart | Cancer | Lower Resp | Stroke | Diabetes | Trans-port | Suicide | Alcohol | Homicide | Drug | DSA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age-Standardized Mortality Rate | | | | | | | | | | | | |
| Rate: 1999 | 333.2 | 61.4 | 75.6 | 6.1 | 8.3 | 7.9 | 25.9 | 23.3 | 12.5 | 6.5 | 18.5 | 51.1 |
| Rate: 2019 | 517.6 | 71.7 | 66.0 | 10.2 | 9.8 | 13.8 | 32.9 | 45.3 | 24.5 | 9.6 | 112.5 | 178.3 |
| Δ: 1999-2019 | 184.4 | 10.3 | -9.6 | 4.2 | 1.5 | 5.8 | 6.9 | 22.0 | 12.1 | 3.1 | 94.0 | 127.2 |
| Mental Health Regression Coefficient | | | | | | | | | | | | |
| Days | 0.0201** | 0.0182** | 0.0174** | 0.0516*** | 0.0066 | 0.0178** | 0.0077 | 0.0112 | 0.0258* | 0.0234** | 0.0493* | 0.0279 |
| | (0.0089) | (0.0087) | (0.0081) | (0.0170) | (0.0096) | (0.0073) | (0.0055) | (0.0099) | (0.0140) | (0.0103) | (0.0270) | (0.0172) |
| 15+ Days | 0.0192** | 0.0185** | 0.0168** | 0.0458*** | 0.0059 | 0.0185*** | 0.0070 | 0.0094 | 0.0233* | 0.0245** | 0.0405* | 0.0239* |
| | (0.0078) | (0.0081) | (0.0077) | (0.0145) | (0.0089) | (0.0070) | (0.0051) | (0.0092) | (0.0120) | (0.0098) | (0.0218) | (0.0142) |
| All 30 Days | 0.0126*** | 0.0073 | 0.0087 | 0.0252** | 0.0031 | 0.0063 | 0.0021 | 0.0040 | 0.0103 | 0.0148* | 0.0215* | 0.0099 |
| | (0.0047) | (0.0065) | (0.0055) | (0.0100) | (0.0068) | (0.0072) | (0.0053) | (0.0055) | (0.0068) | (0.0083) | (0.0127) | (0.0080) |
| Constant Mental Health Δ in 2019 Mortality Rates | | | | | | | | | | | | |
| Days | -37.0 | -4.7 | -4.1 | -1.8 | -0.2 | -0.9 | -0.9 | -1.8 | -2.2 | -0.8 | -18.7 | -17.5 |
| 15+ Days | -38.5 | -5.1 | -4.3 | -1.7 | -0.2 | -1.0 | -0.9 | -1.7 | -2.2 | -0.9 | -16.9 | -16.4 |
| All 30 Days | -22.4 | -1.8 | -2.0 | -0.9 | -0.1 | -0.3 | -0.2 | -0.6 | -0.9 | -0.5 | -8.2 | -6.1 |

Note: Top panel shows age-standardized national mortality rates (per 100,000) in specified years and changes between them. Second panel displays coefficient estimates from Poisson regressions with cells weighted by average state populations over the 1993-2019 period, with robust standard errors clustered at the state level shown in parentheses. *p<0.10, **, p<0.05, ***p<0. Lower panel shows the estimated counterfactual reduction in 2019 age-standardized mortality rates, relative to actual levels, if the specified mental health proxy had remained at its value in 1999. Poor mental health days, 15+ days, and all 30 days increase by 3.69, 4.02, and 3.52 standard deviations, respectively, from 1999-2019.

Table A10: Age-Standardized Mortality Rates and Changes for Causes of Death, 25-54 Year Old Non-College Educated Non-Hispanic Blacks

| | All | Heart | Cancer | Lower Resp | Stroke | Diabetes | Trans-port | Suicide | Alcohol | Homicide | Drug | DSA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age-Standardized Mortality Rate | | | | | | | | | | | | |
| Rate: 1999 | 601.6 | 111.7 | 101.9 | 9.6 | 24.0 | 17.9 | 24.6 | 9.1 | 16.7 | 38.1 | 20.8 | 45.6 |
| Rate: 2019 | 601.4 | 111.5 | 69.1 | 9.1 | 20.1 | 23.9 | 33.5 | 15.9 | 13.3 | 64.6 | 73.2 | 101.2 |
| Δ: 1999-2019 | -0.2 | -0.2 | -32.9 | -0.5 | -3.9 | 6.0 | 9.0 | 6.8 | -3.4 | 26.5 | 52.4 | 55.6 |
| Mental Health Regression Coefficient | | | | | | | | | | | | |
| Days | 0.0201** | 0.0182** | 0.0174** | 0.0516*** | 0.0066 | 0.0178** | 0.0077 | 0.0112 | 0.0258* | 0.0234** | 0.0493* | 0.0279 |
| | (0.0089) | (0.0087) | (0.0081) | (0.0170) | (0.0096) | (0.0073) | (0.0055) | (0.0099) | (0.0140) | (0.0103) | (0.0270) | (0.0172) |
| 15+ Days | 0.0192** | 0.0185** | 0.0168** | 0.0458*** | 0.0059 | 0.0185*** | 0.0070 | 0.0094 | 0.0233* | 0.0245** | 0.0405* | 0.0239* |
| | (0.0078) | (0.0081) | (0.0077) | (0.0145) | (0.0089) | (0.0070) | (0.0051) | (0.0092) | (0.0120) | (0.0098) | (0.0218) | (0.0142) |
| All 30 Days | 0.0126*** | 0.0073 | 0.0087 | 0.0252** | 0.0031 | 0.0063 | 0.0021 | 0.0040 | 0.0103 | 0.0148* | 0.0215* | 0.0099 |
| | (0.0047) | (0.0065) | (0.0055) | (0.0100) | (0.0068) | (0.0072) | (0.0053) | (0.0055) | (0.0068) | (0.0083) | (0.0127) | (0.0080) |
| Constant Mental Health Δ in 2019 Mortality Rates | | | | | | | | | | | | |
| Days | -8.1 | -2.1 | -0.2 | -0.3 | -0.1 | -0.2 | -0.4 | 0.0 | -0.2 | -2.0 | -1.6 | -0.8 |
| 15+ Days | -7.3 | -2.3 | -0.7 | -0.3 | -0.3 | -0.2 | -0.5 | 0.0 | -0.2 | -1.9 | -1.6 | -0.5 |
| All 30 Days | -4.4 | -0.8 | 0.2 | -0.2 | 0.2 | 0.0 | -0.2 | 0.0 | -0.1 | -0.6 | -1.1 | -0.3 |

Note: Top panel shows age-standardized national mortality rates (per 100,000) in specified years and changes between them. Second panel displays coefficient estimates from Poisson regressions with cells weighted by average state populations over the 1993-2019 period, with robust standard errors clustered at the state level shown in parentheses. *p<0.10, **, p<0.05, ***p<0. Lower panel shows the estimated counterfactual reduction in 2019 age-standardized mortality rates, relative to actual levels, if the specified mental health proxy had remained at its value in 1999. Poor mental health days, 15+ days, and all 30 days increase by 2.78, 2.96, and 2.28 standard deviations, respectively, from 1999-2019.

Table A11: Actual and Adjusted Mortality Rate Changes by Population Group

| Outcome/Group | All | Male | Female | White | Black | 20-34 | 35-54 | 55+ |
|---|---|---|---|---|---|---|---|---|
| Mortality Rate: 1980 | 1,036.1 | 1,351.2 | 812.9 | 1,009.5 | 1,316.8 | 133.8 | 385.9 | 4,032.8 |
| Mortality Rate: 1999 | 875.4 | 1,072.0 | 731.2 | 861.1 | 1,162.2 | 98.6 | 298.5 | 3,496.6 |
| Mortality Rate: 2019 | 725.2 | 864.7 | 609.2 | 747.8 | 883.7 | 117.0 | 280.9 | 2,825.9 |
| Counterfactual MR: 2019 | 733.1 | 840.1 | 654.1 | 725.0 | 999.0 | 71.5 | 227.7 | 3,009.0 |
| MR Δ: 2019 - 1999 | -150.2 | -207.2 | -122.1 | -113.3 | -278.5 | 18.3 | -17.6 | -670.7 |
| Adjusted MR Δ | -7.9 | 24.6 | -45.0 | 22.8 | -115.2 | 45.4 | 53.1 | -183.1 |

| Outcome/Group | White: 25-54 | | | | Black: 25-54 | | | |
|---|---|---|---|---|---|---|---|---|
| | All | No College | Some College | College Grad | All | No College | Some College | College Grad |
| Mortality Rate: 1980 | 274.1 | | | | 604.2 | | | |
| Mortality Rate: 1999 | 215.2 | 333.2 | 146.8 | 109.0 | 456.4 | 601.6 | 261.7 | 202.0 |
| Mortality Rate: 2019 | 243.4 | 517.6 | 219.5 | 84.1 | 353.3 | 601.4 | 277.9 | 113.7 |
| Counterfactual MR: 2019 | 171.9 | 266.1 | 117.2 | 87.1 | 329.2 | 433.9 | 188.8 | 145.7 |
| MR Δ: 2019 - 1999 | 28.2 | 184.4 | 72.7 | -25.0 | -103.1 | -0.2 | 16.2 | -88.3 |
| Adjusted MR Δ | 71.5 | 251.4 | 102.2 | -3.0 | 24.1 | 167.5 | 89.2 | -32.0 |

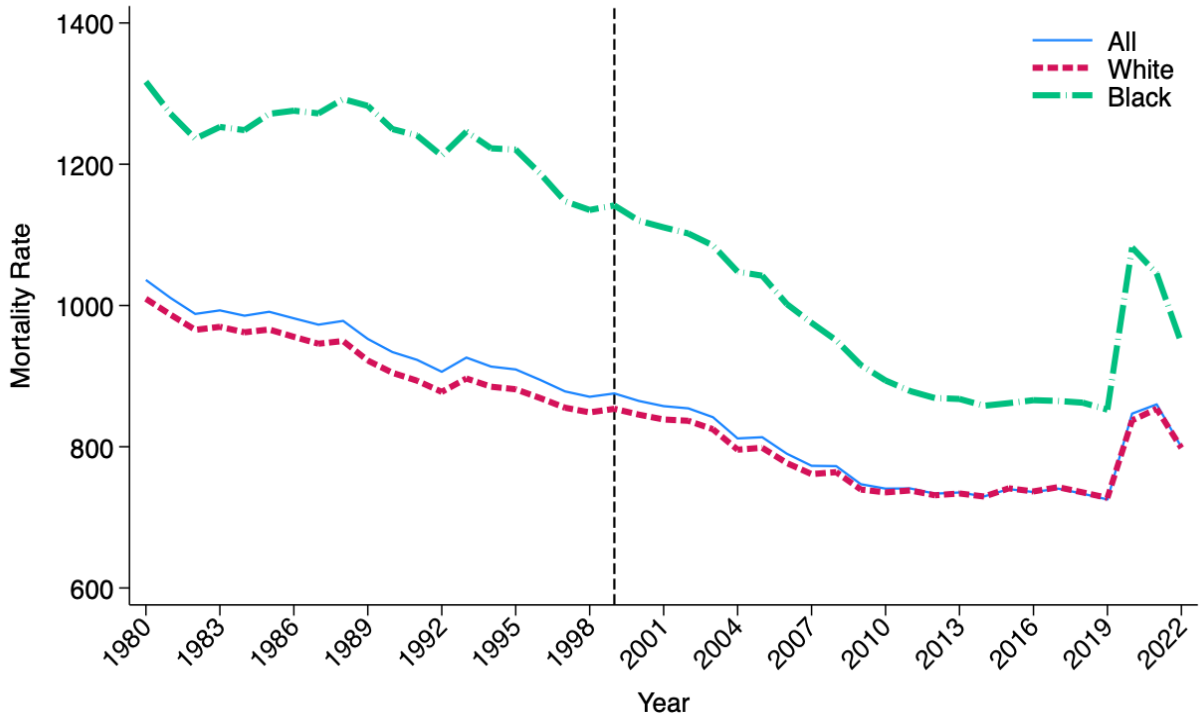
Note: Mortality rates are per 100,000 and age-standardized. Counterfactual 2019 mortality rate is that predicted if average annual mortality rate changes from 1980-1999 had continued through 2019. Adjusted Mortality Rate Change is the difference between the actual and counterfactual 2019 rates. Race-specific mortality rates in 1980 include Hispanics. This is adjusted for when computing adjusted mortality rate changes, as discussed in the text.

Table A12: Share of Adjusted Mortality Rate Changes From 1999-2019 for 25-54 Year Olds Resulting from Increases in Poor Mental Health, Overall and By Selected Causes of Death

| Cause of Death | Poor Mental Health Proxy | | | Poor Mental Health Proxy | | |
|---|---|---|---|---|---|---|
| | # Days | 15+ Days | All 30 Days | # Days | 15+ Days | All 30 Days |
| | White | | | Black | | |
| All | 28.0% | 29.3% | 16.4% | 24.1% | 22.2% | 13.6% |
| Heart | 3.3% | 3.5% | 1.9% | 2.1% | 1.5% | 0.8% |
| Cancer | 2.6% | 2.9% | 1.6% | 0.0% | -0.3% | 0.1% |
| Suicide | 0.9% | 0.7% | 0.6% | -0.1% | -0.1% | -0.2% |
| Alcohol | 1.3% | 1.1% | 0.6% | 0.1% | 0.1% | 0.1% |
| Homicide | 0.5% | 0.7% | 0.3% | 3.3% | 2.9% | 1.4% |
| Drug | 10.1% | 9.4% | 4.4% | 7.2% | 6.5% | 4.8% |
| DSA | 5.9% | 5.5% | 1.8% | 3.7% | 4.0% | 1.8% |
| | White: No College | | | Black: No College | | |
| All | 14.7% | 15.3% | 8.9% | 4.8% | 4.4% | 2.6% |
| Heart | 1.9% | 2.1% | 0.7% | 1.3% | 1.4% | 0.5% |
| Cancer | 1.6% | 1.7% | 0.8% | 0.1% | 0.4% | -0.1% |
| Suicide | 0.7% | 0.7% | 0.3% | 0.0% | 0.0% | 0.0% |
| Alcohol | 0.9% | 0.9% | 0.3% | 0.1% | 0.1% | 0.1% |
| Homicide | 0.3% | 0.4% | 0.2% | 1.2% | 1.2% | 0.4% |
| Drug | 7.4% | 6.7% | 3.3% | 0.9% | 1.0% | 0.6% |
| DSA | 7.0% | 6.5% | 2.4% | 0.5% | 0.3% | 0.2% |

Note: Adjusted mortality rate changes are actual 2019 age-standardized mortality rates per 100,000 minus counterfactual 2019 mortality rates per 100,000. The latter are computed assuming that annualized rate of changes between 1980 and 1999 had continued through 2019. The shares accounted for are calculated by dividing the Constant MH changes, described above, by the adjusted mortality rate changes (and reversing the sign). Whites and Blacks refer to non-Hispanics.

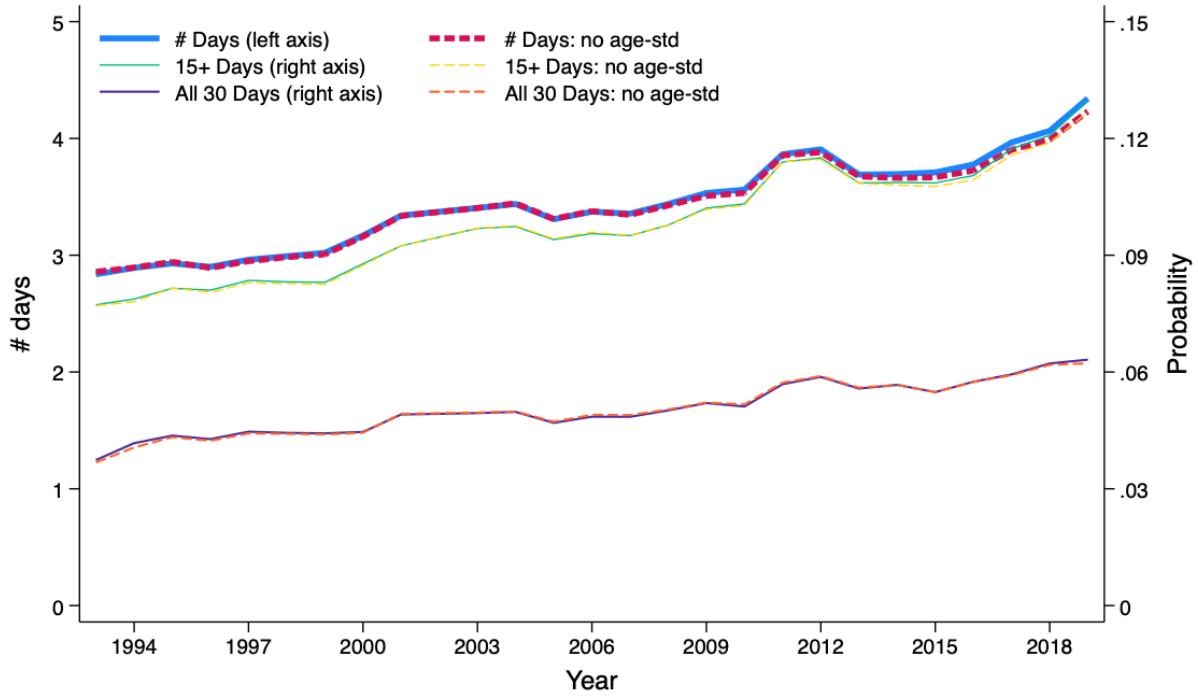
Figure A1: Age-Standardized Mortality Rates for Selected Groups, 1980-2022



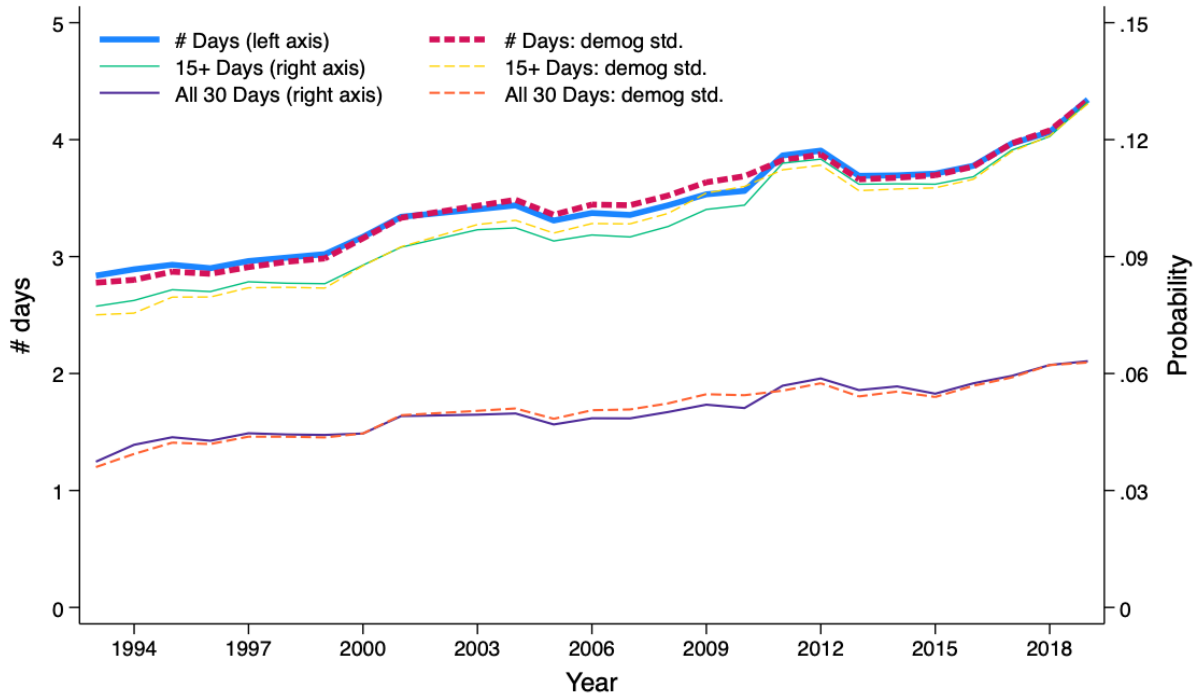

Note: Figure shows national age-standardized rates per 100,000. Unlike most other results, Whites and Blacks include both Hispanics and Non-Hispanics of the specified race. This is done because prior to 1990 Hispanic origin was often not identified. The vertical line shows 1999, the beginning of the primary analysis period.

Figure A2: Poor Mental Health Days in the U.S. With and Without Adjustments

a. With and Without Age-Standardization

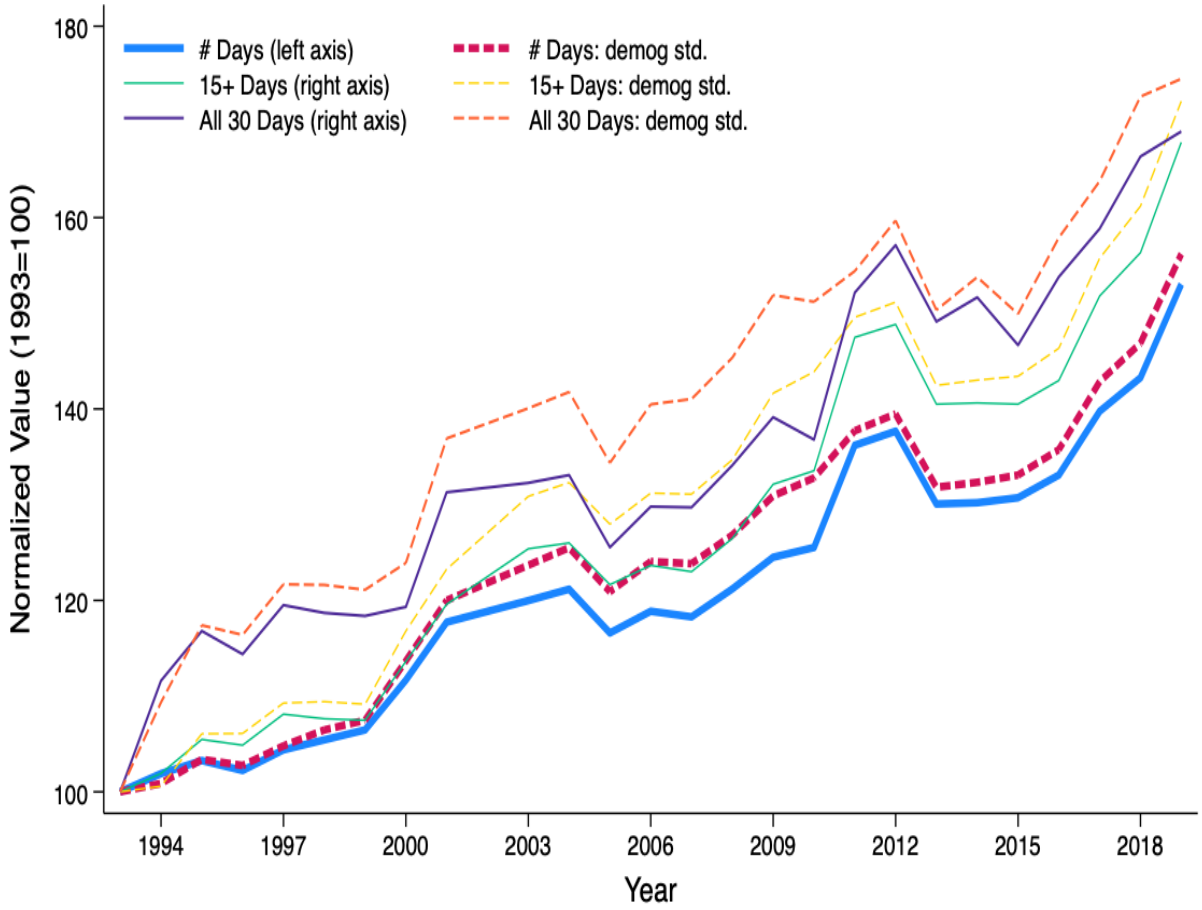



b. With and Without Demographic Standardization



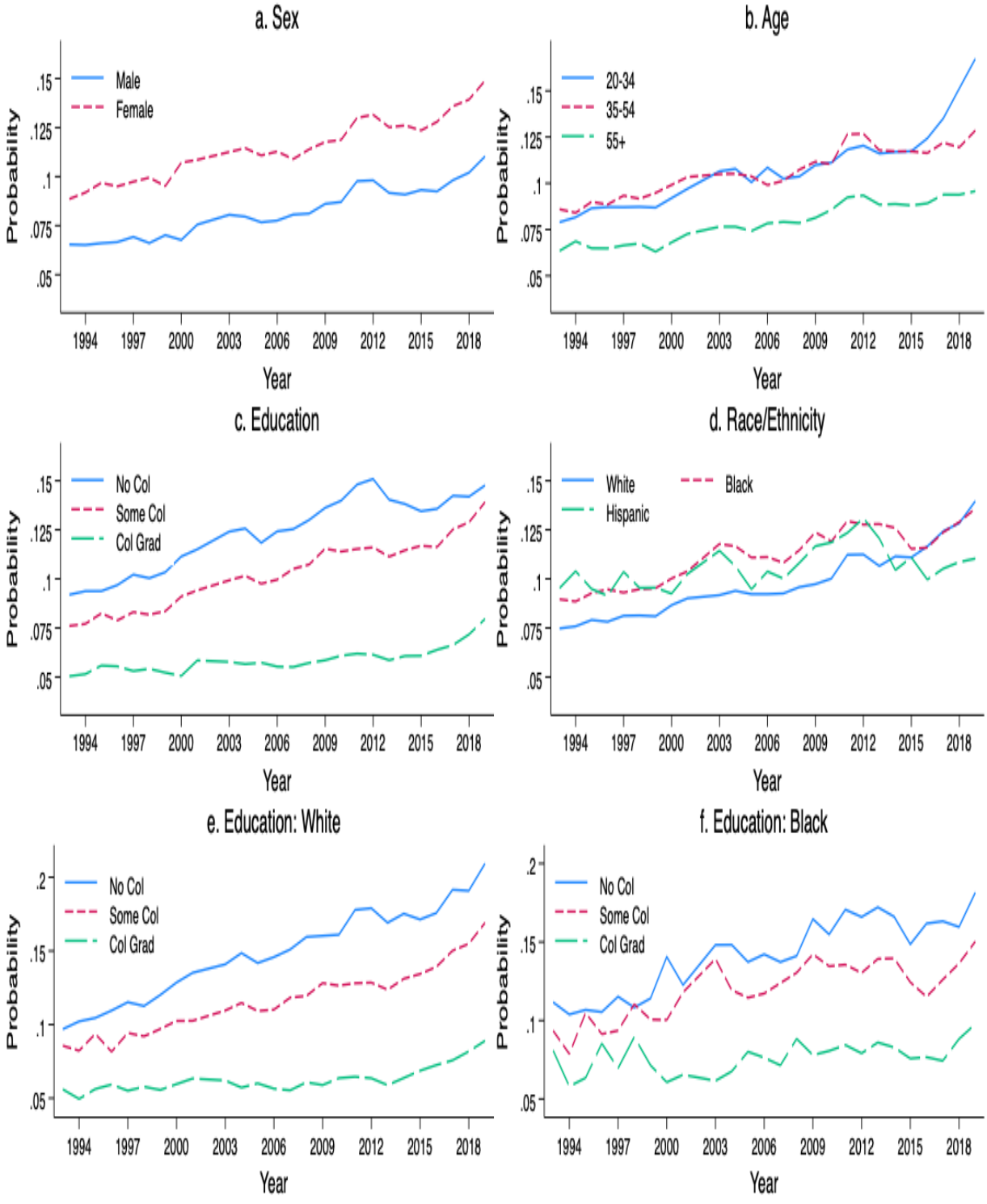
Note: Figure shows values of poor mental health proxies with and without age standardization (top figure) and with and without also accounting for differences in sex, race/ethnicity, and education (bottom figure).

Figure A3: Change in National Poor Mental Health Days in the U.S. Relative to 1993



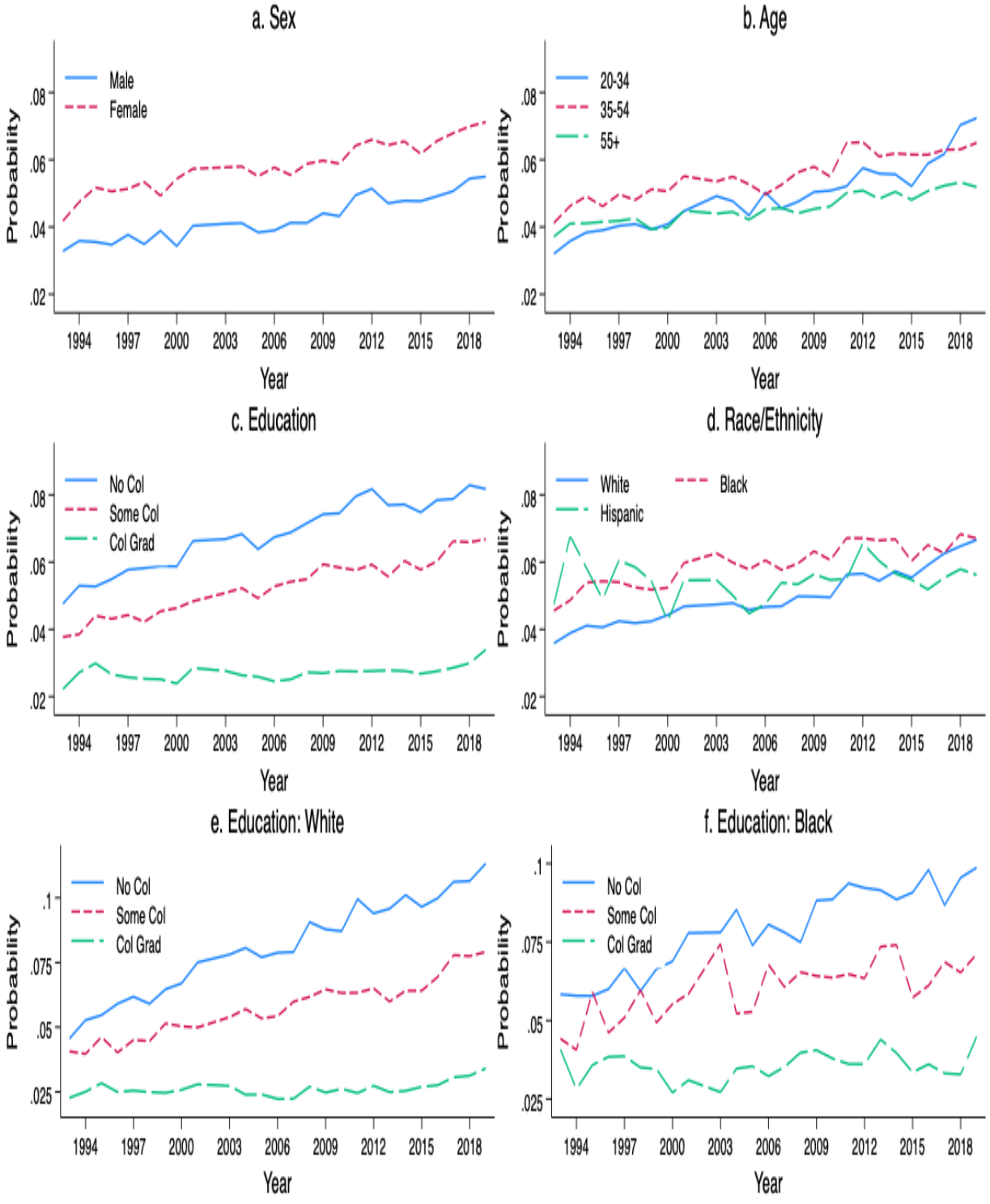

Note: Figure shows changes in age-standardized poor mental health days in the last 30 and probability of poor mental health in ≥15 or all 30 days, relative to 1993. Standardized changes also account for differences in sex, race/ethnicity, and education.

Figure A4: 15+ Days of Poor Mental Health, By Subgroup




Note: Figure shows the age-standardized percentage of group with poor mental health in at least 15 of last 30 days. White and Black refer to Non-Hispanics.

Figure A5: Poor Mental Health in All of Past 30 Days, By Subgroup




Note: Figure shows age-standardized percentage of group with poor mental health in all of the last 30 days. White and Black refer to Non-Hispanics.

Figure A6: Trend Coefficients on the Natural Log of Poor Mental Health 1993-2019, By Subgroup

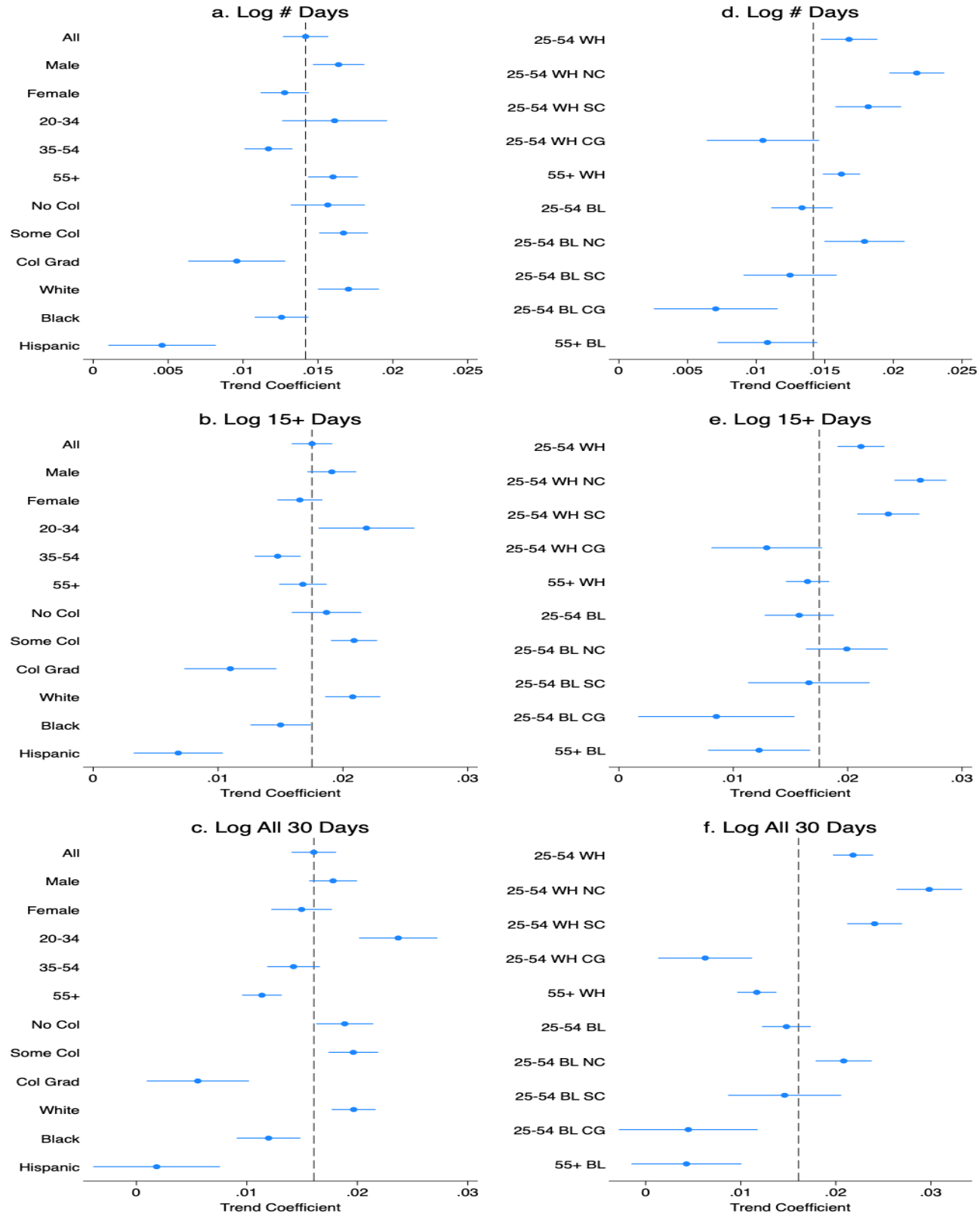
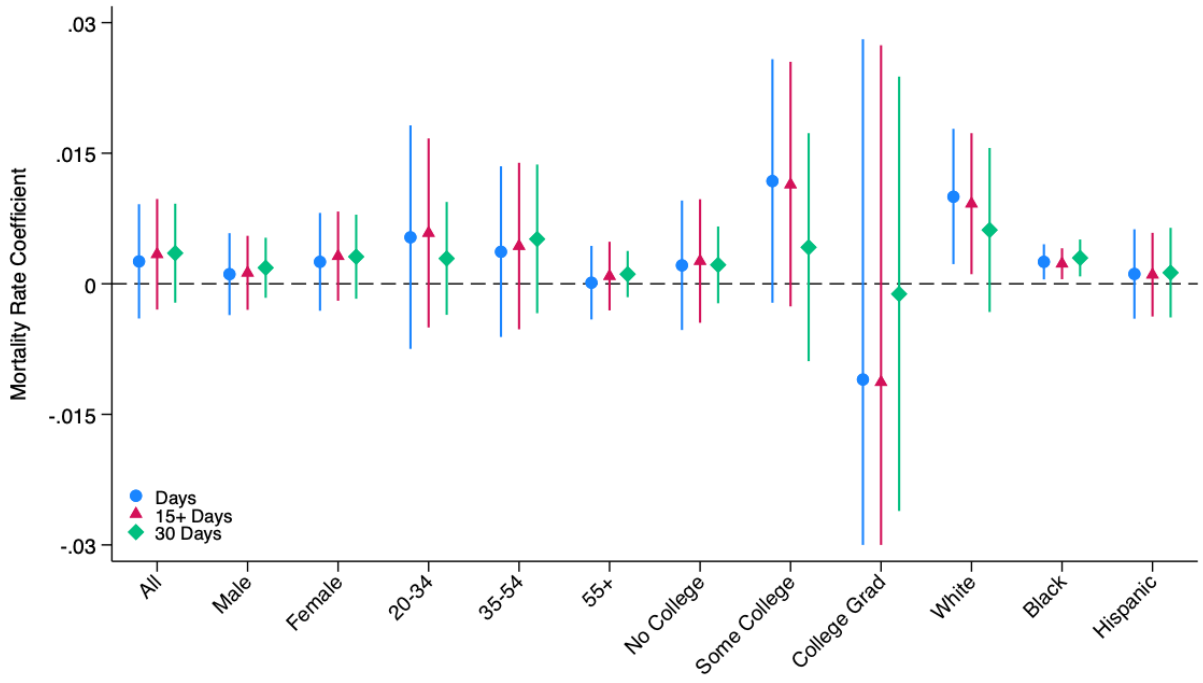


Figure shows coefficient estimates from regressing the natural log of the proxy for age-standardized poor mental health on a linear time trend. Error bars show 95 percent confidence intervals based on robust standard errors. Vertical dashed lines show the full sample trend coefficient. The dependent variables refer to number of poor mental health days in last the 30. WH, BL, NC, SC, and CG refer to Whites, Blacks, no college, some college, and college graduate, and 25-54 and 55+ to age ranges.

Figure A7: Predicted Effects of Poor Mental Health On Age Standardized Mortality Rates Using 1999-2019 Data

A. Groups




B. Causes

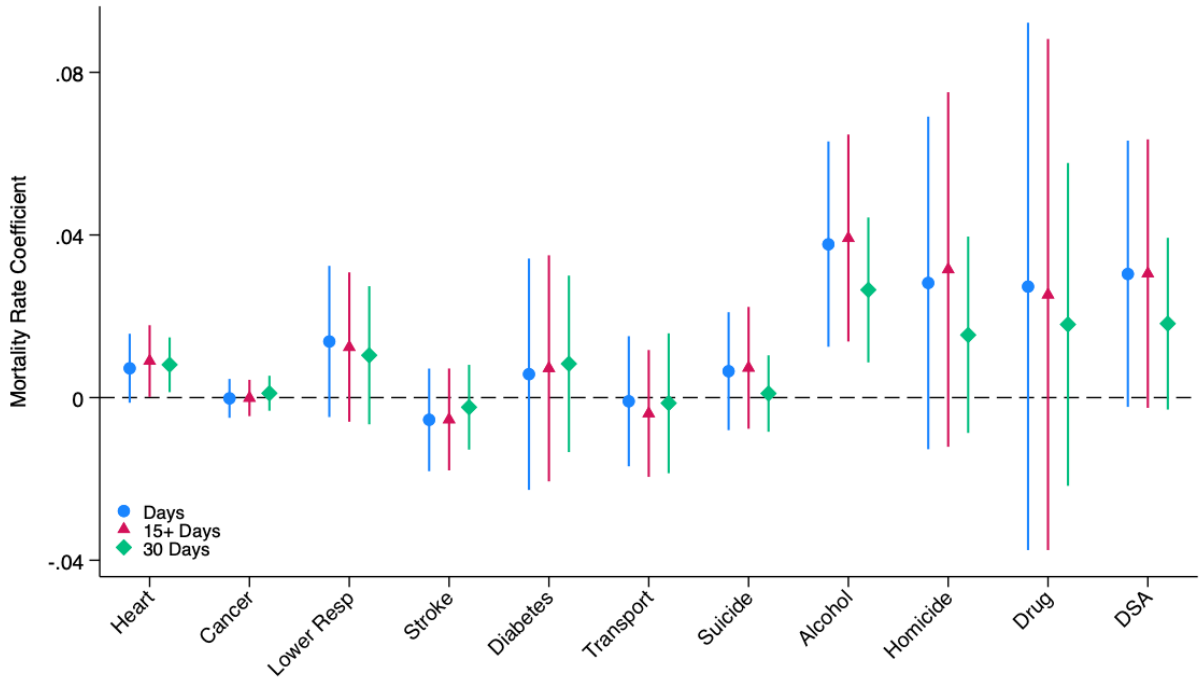


Figure shows mental health coefficient estimates from Poisson regressions of age-standardized mortality rates (per 100,000) on poor mental health over the 1999-2019 period, plus state and time fixed-effects, and, except in the race-specific models, the state population shares of non-Hispanic Blacks, Hispanics, and non-Hispanic other races. The mental health coefficients are standardized to indicate effect sizes based on a one-standard deviation change in the national value of the poor mental health proxy from 1993-2019. Cells are weighted by average state populations over the 1993-2019 period. Error bars show 95 percent confidence intervals (CI's) based on robust standard errors clustered at the state level. For clarity of display, the lower bound of the CI's are censored at -0.03 in the upper figure.

## Appendix B: Education-Specific Mortality Rates

There are multiple challenges in calculating levels and changes in education-specific mortality rates. First, education is sometimes reported in years of schooling completed, rather than for specific thresholds. Difficulties introduced by this have been discussed elsewhere (Jaeger 1997; Rostron, Boies, and Arias 2010). In these cases, $\leq$12, 13–15 and $\geq$16 years are classified as high school graduate or less, some college and college graduate.

Second, information on education is missing for some deaths, particularly early in the sample period (e.g. for 17% of deaths in 1993 and 4% in 2019). Education-specific mortality rates are computed by assuming that the state-specific distribution of educational attainment is the same for the missing and non-missing cases, provided that at least half of deaths in the state and year have education recorded on the death certificate. If this condition is not met, the education-specific mortality rates are coded as missing.

Third, since the *SEER* data do not provide education-specific population estimates, these are calculated by multiplying *SEER* total or group-specific populations by the relevant state education share, obtained from the *CPS-MORG* files discussed above.

Fourth, for the state-level analysis, the *BRFSS* will sometimes not have any observations for a given race-age cell. This is rarely occurs for non-Hispanic Whites, but is more frequent for other race/ethnicity groups. The measures of poor mental health will be unavailable in these cases and so will be coded as missing.

Fifth, educational attainment is not available in the *MCOD* data before 1990. This means that it is not possible to calculate the adjusted 2019 mortality rate changes based on projections of annual rate changes from 1980-1999, as is done elsewhere. Therefore, in the analysis of 25-54 year old non-Hispanic Whites and Blacks, trends are calculated for the entire group, regardless of education.

Finally, this analysis focuses on specific education categories because this has frequently been done in the prior literature (Case and Deaton 2020, 2022) but it is important to recognize that the results are likely to be strongly affected by changes in the composition of these groups over time due to the overall increase in educational attainment.[35] Assuming increasing education results in the lowest educational category becoming more negatively selected over time, rising mortality rates may fully or partially result from compositional changes in the group, rather than changes in mortality probabilities for individuals at the same place in the educational distribution.[36]

This issue has long been recognized (Dowd and Hamoudi 2014; Bound et al. 2015) and a number of researchers have addressed this it by examining changes in mortality rates over time for persons at the same rank in the educational distribution (Leive and Ruhm 2020, 2022; Novosad, Rafkin, and Asher 2022). Although it would be interesting to incorporate such comparisons in the analysis, this has not been done so as to provide the most direct comparisons with the prior literature, which has focused on absolute levels of educational attainment.

[35] For example, in 1999, 49% of adults aged 25 and over had not attended college and 26% had four year degrees. In 2019, the corresponding percentages were 38% and 36%.

[36] Interestingly, the highest educational group may also become more negatively selected for the same reason.