RE: NBER COVID-19 and Health Outcomes Conference Submission

Dear Organizers,

We would like to submit two papers for your consideration for the NBER COVID-19 and Health Outcomes Conference. Each paper is short and the two are related to each other, so if accepted, we would present them jointly.

The first paper (forthcoming, *PNAS*) titled "**Initial economic damage from COVID-19 pandemic in U.S. is more widespread across ages and geographies than initial mortality impacts**" uses publicly available data to look at geographic and age variation in the excess loss of employment versus excess all-cause mortality during the first full month of Covid-19 pandemic – April 2020. The second paper (work in progress) titled "**Racial Differences in All-Cause Excess Mortality During the Early Days of the COVID-19 Pandemic in the United States**" uses restricted death data from SSA's "Numident" file to measure excess all-cause mortality by race, and how this is attenuated (or exacerbated) by differences in age, sex, and geography.

In what follows we have included:

1) Abstracts of both papers
2) A selection of key figures from both papers
3) The manuscript of the first paper

All figures and tables in paper #1 are currently embargoed by PNAS, while the results in paper #2 are under review by US Census, so the results in this submission cannot be cited or circulated.

Thank you for our consideration and we look forward to hearing about your decision!

Sincerely,

Maria Polyakova (Stanford)

Victoria Udalova (US Census)

Geoffrey Kocks (MIT)

Amy Finkelstein (MIT)

Paper #1: Initial economic damage from COVID-19 pandemic in U.S. is more widespread across ages and geographies than initial mortality impacts.

Embargoed by PNAS – please do not cite or circulate

Authors: Maria Polyakova, PhD[1]*; Geoffrey Kocks, BA[2]; Victoria Udalova, PhD[3]*; Amy Finkelstein, PhD[4]

Abstract

The economic and mortality impacts of the COVID-19 pandemic have been widely discussed, but there is limited evidence on their relationship across demographic and geographic groups. We use publicly-available monthly data from January 2011 through April 2020 on all-cause death counts from the Centers for Disease Control and Prevention and employment from the Current Population Survey to estimate excess all-cause mortality and employment displacement in April 2020 in the United States. We report results nationally, and separately by state and by age group. Nationally, excess all-cause mortality was 2.4 per 10,000 individuals (about 30 percent higher than reported COVID deaths in April) and employment displacement was 9.9 per 100 individuals. Across age groups 25 and older, excess mortality was negatively correlated with economic damage; excess mortality was largest among the oldest (individuals 85 and over: 39.0 per 10,000), while employment displacement was largest among the youngest (individuals 25 to 44: 11.6 per 100 individuals). Across states, employment displacement was positively correlated with excess mortality (correlation = 0.29). However, mortality was highly concentrated geographically, with the top two states (New York and New Jersey) each experiencing over 10 excess deaths per 10,000 and accounting for about half of national excess mortality. By contrast, employment displacement was more geographically spread, with the states with the largest point estimates (Nevada and Michigan) each experiencing over 16 percentage points employment displacement but accounting for only 7% of the national displacement. These results suggest that policy responses may differentially affect generations and geographies.

[1] Maria Polyakova is an Assistant Professor in the Center for Health Policy at Stanford University School of Medicine and a Faculty Research Fellow at the National Bureau of Economic Research.

[2] Geoffrey Kocks is a graduate student in the Department of Economics at Massachusetts Institute of Technology

[3] Victoria Udalova is a Research Economist and the Enhancing Health Data (EHealth) program manager at the U.S. Census Bureau.

[4] Amy Finkelstein is a Professor of Economics at Massachusetts Institute of Technology and a Research Associate at the National Bureau of Economic Research

*Polyakova thanks National Institute for Health Care Management (NIHCM) Foundation for financial support

Paper #2: Racial Differences in All-Cause Excess Mortality During the Early Days of the COVID-19 Pandemic in the United States

Any conclusions expressed herein are those of the authors and do not necessarily represent the views of the U.S. Census Bureau. All results were approved for release by the Disclose Review Board of the U.S. Census Bureau, authorization number CBDRB-FY21-ERD002-003. Please do not cite or circulate.

Authors: Maria Polyakova, PhD[5]*; Victoria Udalova, PhD[6]*; Geoffrey Kocks, BA[7]; Katie Genadek, PhD[8]; Keith Finlay, PhD[9]; Amy Finkelstein, PhD[10]

Abstract

Importance: It is critical to understand how the COVID-19 pandemic has increased all-cause mortality differentially by race. Evidence on racial differences to date has focused exclusively on COVID-specific death rates, and has been limitedto Whites, Blacks, and Hispanics due to sample size limitations.

Objective: To measure differences in excess all-cause mortality by race nationwide, and describe the role of other demographics in these racial differences.

Design: Confidential data on nearly 22.5 million deaths between January 2011 and April 2020 were obtained from the Social Security Administration and linked to data on race from the 2010 Decennial Census. Historical data were used to predict all-cause mortality for April 2020; excess all-cause mortality was computed as the difference between observed and predicted outcomes. We estimated all-cause excess mortality for seven race categories; we used multivariate regression models to measure the contribution of differences in age, sex, and geographic location to the differences by race.

Results: April 2020 sample consisted of 241.5 million individuals and 276,000 deaths. Unadjusted excess all-cause mortality per 10,000 individuals was 2.1 among Whites (20% increase relative to predicted mortality), 6.1 among Blacks (80% increase), 2.7 among Hispanics (64% increase), 2.9 among Asians (64% increase), 1.9 among American Indian and Native Alaskan (22% increase), 1.3 among Hawaiian and Pacific Islanders (22% increase), and 2.7 among those with other or two or more races (60% increase). Adjusting for underlying differences in age, sex, and geography increases the differences in excess all-cause mortality between Whites and each other race; the largest adjusted difference is observed between Blacks and Whites at 5.2 per 10,000; the smallest is between Asians and Whites at 1.2 per 10,000.

Conclusions and Relevance: Excess all-cause mortality varied across races during the first full month of the pandemic. White and Asian Americans had the lowest adjusted excess all-cause mortality, while Black Americans had the highest. The Black-White and Hispanic-White differences in excess all-cause mortality appear higher than comparable estimates of these same differences in COVID-specific mortality.

---

[5] Maria Polyakova is an Assistant Professor in the Center for Health Policy at Stanford University School of Medicine and a Faculty Research Fellow at the National Bureau of Economic Research.

[6] Victoria Udalova is a Research Economist and the Enhancing Health Data (EHealth) program manager at the U.S. Census Bureau.

[7] Geoffrey Kocks is a graduate student in the Department of Economics at Massachusetts Institute of Technology

[8] Katie Genadek is a Research Economist at the U.S. Census Bureau.

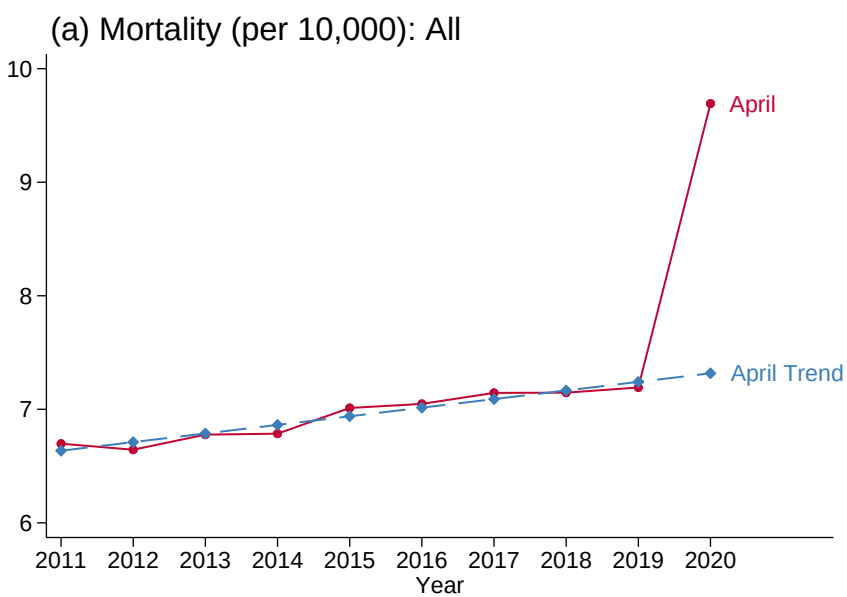
[9] Keith Finlay is a Research Economist at the U.S. Census Bureau.

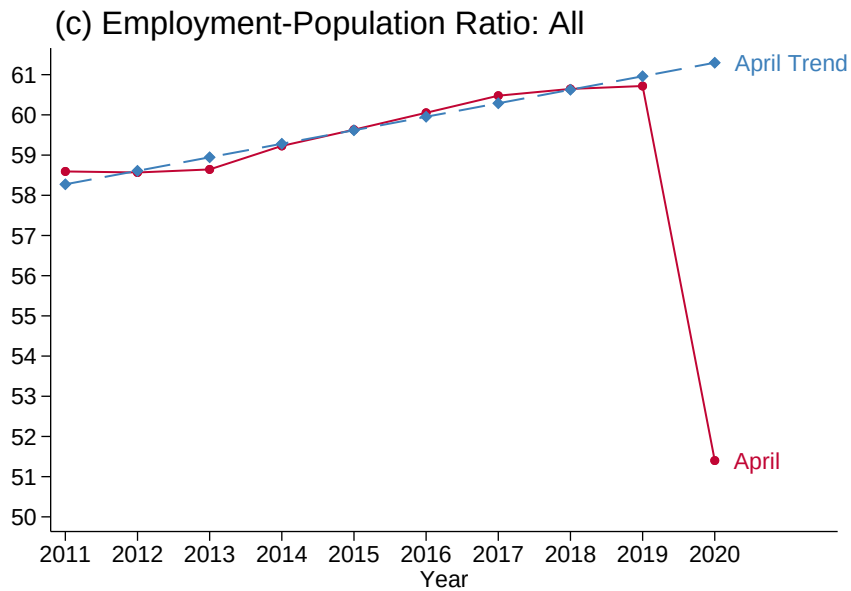
[10] Amy Finkelstein is a Professor of Economics at Massachusetts Institute of Technology and a Research Associate at the National Bureau of Economic Research

*Dr Polyakova and Dr Udalova contributed equally as co-first authors. We thank National Institute on Aging and National Institute for Health Care Management (NIHCM) Foundation for financial support, and James Okun for outstanding research assistance. Any conclusions expressed herein are those of the authors and do not necessarily represent the views of the U.S. Census Bureau. All results were approved for release by the Disclose Review Board of the U.S. Census Bureau, authorization number CBDRB-FY21-ERD002-003

All-cause excess mortality and job loss

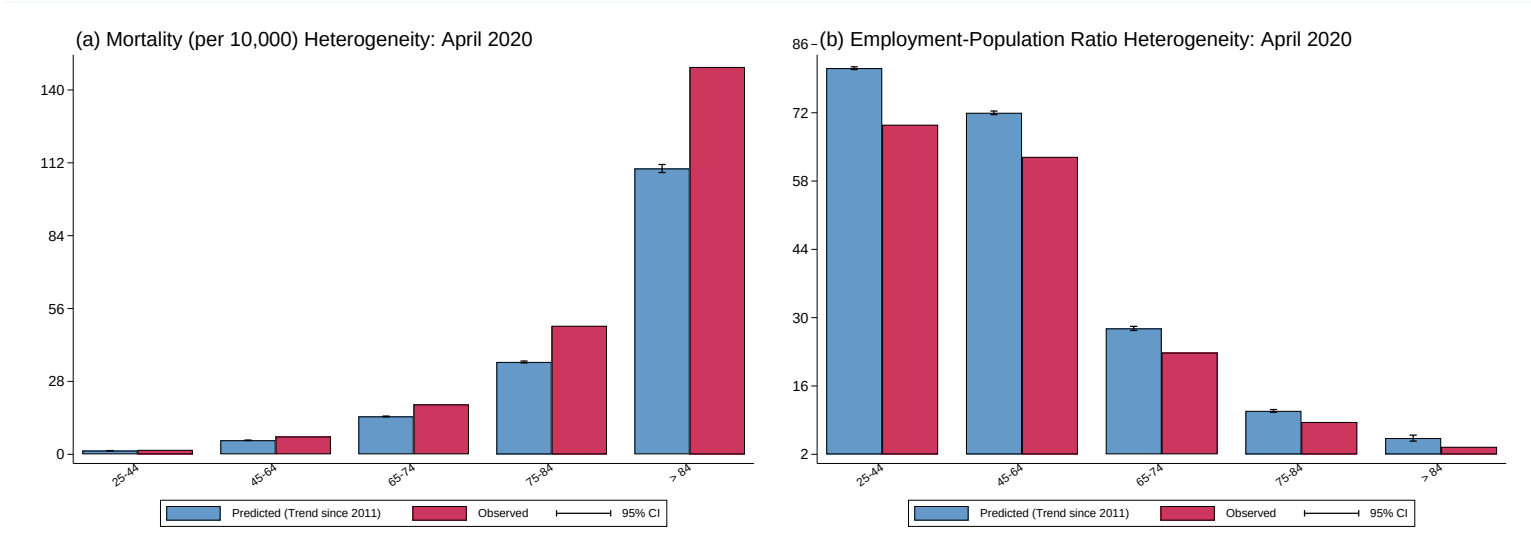
- We document pronounced and abrupt increase in *all-cause* mortality and abrupt drop in employment to population ratio in April 2020





Source: Polyakova, Kocks, Udalova, Finkelstein (2020)

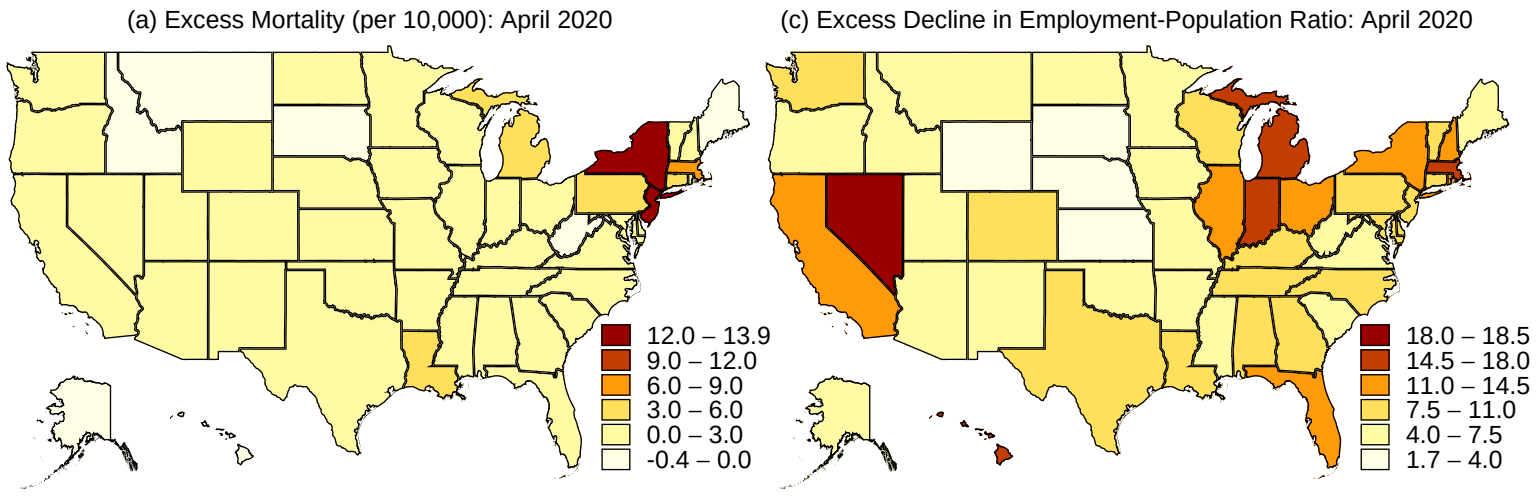
Excess mortality and job loss by age



- Excess all-cause mortality much higher among older groups, while excess employment losses - among younger groups

Source: Polyakova, Kocks, Udalova, Finkelstein (2020)

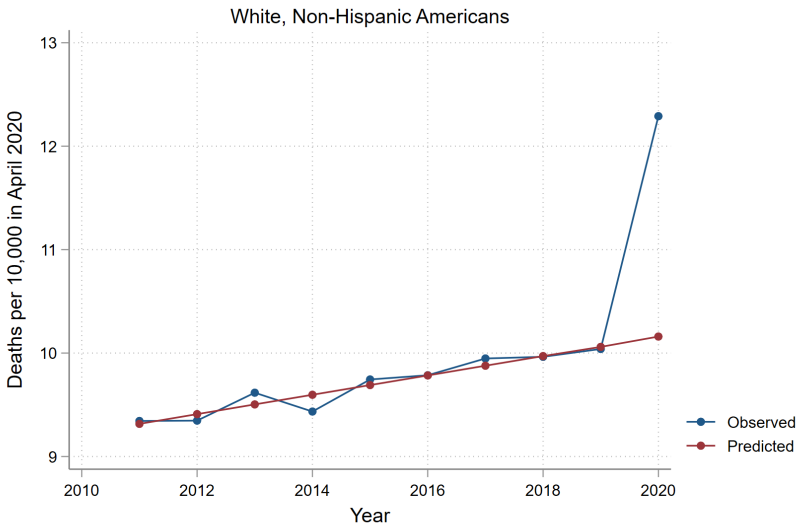
Excess mortality and job loss by state

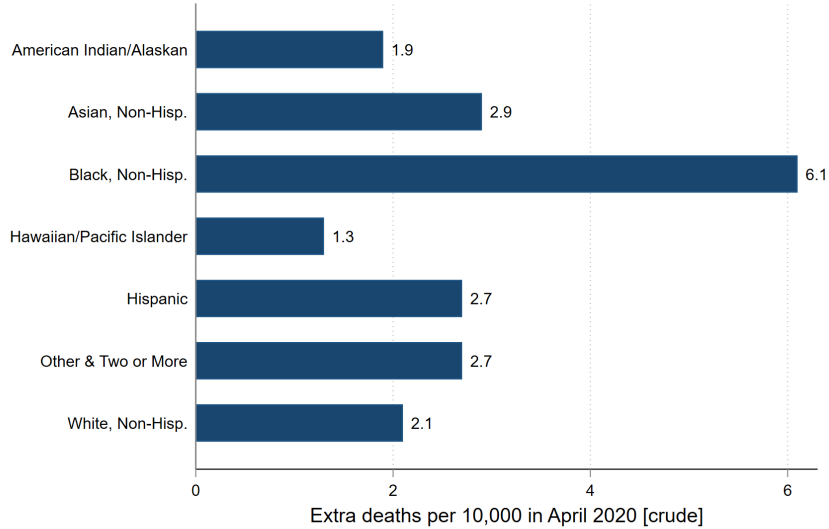


- In early months, excess all-cause mortality was much more concetrated geographically than the drop in employment

Source: Polyakova, Kocks, Udalova, Finkelstein (2020)

Excess all-cause mortality by race





- In early months, much higher excess ***all-cause*** mortality among Black Americans. Even more pronounced once adjusted for age, sex, and geo location [1]

[1] Source: Polyakova, Udalova, Kocks, Genadek, Finlay, Finkelstein (2020) Any conclusions expressed herein are those of the authors and do not necessarily represent the views of the U.S. Census Bureau. All results were approved for release by the Disclose Review Board of the U.S. Census Bureau, authorization number CBDRB-FY21-ERD002-003.

Initial economic damage from COVID-19 pandemic in U.S. is more widespread across ages and geographies than initial mortality impacts.

Maria Polyakova; Geoffrey Kocks; Victoria Udalova; Amy Finkelstein
Stanford University School of Medicine; Department of Economics, Massachusetts Institute of Technology; U.S. Census Bureau; Department of Economics, Massachusetts Institute of Technology

Abstract

The economic and mortality impacts of the COVID-19 pandemic have been widely discussed, but there is limited evidence on their relationship across demographic and geographic groups. We use publicly-available monthly data from January 2011 through April 2020 on all-cause death counts from the Centers for Disease Control and Prevention and employment from the Current Population Survey to estimate excess all-cause mortality and employment displacement in April 2020 in the United States. We report results nationally, and separately by state and by age group. Nationally, excess all-cause mortality was 2.4 per 10,000 individuals (about 30 percent higher than reported COVID deaths in April) and employment displacement was 9.9 per 100 individuals. Across age groups 25 and older, excess mortality was negatively correlated with economic damage; excess mortality was largest among the oldest (individuals 85 and over: 39.0 per 10,000), while employment displacement was largest among the youngest (individuals 25 to 44: 11.6 per 100 individuals). Across states, employment displacement was positively correlated with excess mortality (correlation = 0.29). However, mortality was highly concentrated geographically, with the top two states (New York and New Jersey) each experiencing over 10 excess deaths per 10,000 and accounting for about half of national excess mortality. By contrast, employment displacement was more geographically spread, with the states with the largest point estimates (Nevada and Michigan) each experiencing over 16 percentage points employment displacement but accounting for only 7% of the national displacement. These results suggest that policy responses may differentially affect generations and geographies.

Significance Statement

A full picture of the COVID-19 pandemic requires information on how its impact on lives and on livelihoods relates across different groups. We therefore estimate excess all-cause mortality and employment displacement in April 2020 nationally, and separately by state and by age group. Initial economic damages from the pandemic are more widespread across groups than deaths, which were primarily concentrated in a few

states and among the oldest old. While the two states with the largest mortality increase account for about half of national excess mortality, the two most economically affected states account for only 7% of national economic damages. These findings suggest that policy responses to contain the pandemic involve tradeoffs across different demographic and geographic groups.

Introduction

The economic and mortality impacts of the COVID-19 pandemic have been widely discussed, yet most studies to date have examined these effects separately from each other (1–10), with little systematic evidence on their relationship across different groups. As the public discussion of the impact of the pandemic on lives and livelihoods evolves, it is important to understand how the groups most affected by the pandemic's economic impacts compare to those most affected by its health impacts. Focusing on the initial impact of the pandemic in April 2020, we therefore estimate the pandemic's economic damage and its mortality impact, and compare results by state and by age group.

We measure economic damages and mortality impacts relative to what we predict would have happened in April 2020 in the absence of the pandemic. We define economic damages as decreases in the employment to population ratio, which measures the fraction of people in a well-defined group currently working full time or part time. We focus on all-cause mortality rather than COVID-19 deaths for our measure of the pandemic's impact on health. All-cause mortality has two important advantages relative to COVID-specific death counts. First, it is not contaminated by measurement error in the choice of what to label a "COVID" death as opposed to a non-COVID death; this would be particularly problematic if measurement error varies across groups. Second, all-cause mortality captures both direct and indirect mortality effects from the pandemic. Indirect effects could be negative (such as increases in mortality attributable to reduced utilization of routine and emergency healthcare services (11–13)), positive (such as declines in

mortality due to reduction of motor vehicle use (14, 15)), or a priori ambiguous (such as the ongoing debate over the mortality effects of an economic downturn (16–19)).

We use the same approach to compute excess all-cause mortality and to compute excess declines in the employment to population ratio nationally – and separately for each US state and age group – in April 2020: We compare the observed outcome to the outcome predicted based on monthly historical data from 2011 to 2019 (*Materials and Methods*). Across age groups 25 and older, excess mortality was negatively correlated with economic damage, with the mortality impacts concentrated among the elderly – particularly the oldest old – and the economic impacts concentrated among younger workers. Across states, employment displacement was positively correlated with excess mortality, but economic damages were much more widespread. These findings suggest that policies aimed at preserving health or reducing economic damage may involve important tradeoffs across groups.

Results

Nationally

There was a sharp rise in national all-cause mortality in April 2020 relative to predicted mortality (Figure 1a). Historical trends predict 7.3 all-cause deaths per 10,000, while we observed 9.7 per 10,000. This corresponds to 2.4 excess deaths per 10,000 (about a 33% increase in all-cause national mortality). The gap between observed and predicted mortality was not present in January or February 2020, but is already visible – at a much smaller magnitude – in March 2020 (Figure 1b). Reported COVID-19 deaths make up approximately 75% of the estimated all-cause excess mortality (SI Appendix, Section 2.3). We also looked at excess mortality separately for specific causes of death, finding substantial excess mortality from heart disease, and substantially lower mortality due to

unnatural causes (accidents, homicides, and suicides), and to cancer (SI Appendix, Section 7.2).

Analogously, there was a sharp decline in the employment to population rate in April 2020 – our measure of economic damages – relative to the prediction (Figure 1c). Historical trends predict that 61.3% of 16+ year olds would have been working in April 2020. By contrast, the observed employment-to-population ratio in April 2020 is 51.5%. This corresponds to a national excess decline in the employment to population ratio of 9.9 per 100 individuals. As with mortality, the effect is concentrated in April, with some gap opening in March and substantially smaller differences between predicted and observed employment-to-population ratio in January and February 2020 (Figure 1d).

By geography

The increase in all-cause mortality and the decline in employment to population ratio was markedly unequal across different geographic locations. New York and New Jersey were stark outliers in excess all-cause mortality, experiencing more than 10 excess deaths per 10,000 individuals, compared to the median excess all-cause mortality across states of 0.64 excess deaths per 10,000 (Figures 2a and 2b). In relative terms, the increase in all-cause mortality was 207% in New York and 179% in New Jersey. The health damages were highly geographically concentrated – with New York and New Jersey together accounting for 49% of the national change in all-cause mortality in April.

The situation looks remarkably different for economic damages. While there is substantial geographic heterogeneity in the economic impacts of COVID, the distribution of economic damage is far more widespread than the excess mortality impacts. The point estimates indicate that *every single state* experienced economic damage; this damage is statistically significant at the 5% level for all states except Wyoming. The median employment displacement across states was 7.8 percentage points. The states with the largest point estimates – Nevada and Michigan – each experienced employment displacement of over

16 percentage points, or approximately a 30% decrease in employment.[1] However, they accounted for only 7% of the national employment displacement (SI Appendix, Section 5 provides more detail on these and alternative calculations).

Figure 3 plots excess mortality against economic damage by state, with the line of best fit superimposed. Early health and economic consequences of the pandemic are positively correlated across states, although the relationship is far from perfect: the line of best fit has a slope of 0.22 and is significant at the 5% level (P = 0.017). Some states that experienced large economic damages early on in the pandemic – such as Nevada and Hawaii - did not experience a substantial increase in mortality. Other locations – such as Washington, D.C. and Virginia – experienced above median excess mortality but below median economic damage. Industry composition appears to be an important factor in either mitigating or exacerbating the economic effects of the pandemic, as larger economic damages are observed in states with higher exposure to tourism, entertainment, and food industries (SI Appendix, Section 6).

By age

The increase in all-cause mortality and the decline in employment to population ratio affected markedly different age groups (Figure 4). Once again, excess mortality is more concentrated while economic damages are more widespread. Excess mortality is monotonically increasing in age. Among age groups for which we observe both economic and mortality outcomes, the youngest age group (25-44) experienced excess all-cause mortality of 0.3 per 10,000 (a 22% increase) while the oldest age group (85+) experienced

[1] Employment displacement in Michigan is not statistically significantly larger than Massachusetts, the next largest state in terms of the employment displacement point estimates. We choose to focus on the two states with the large point estimates for consistency with the excess mortality outcome.

excess mortality of 39.0 per 10,000 (a 35% increase). This age group (85+) accounted for 3 percent of the population (out of those 25+) but 34 percent of the excess deaths.

The pattern is the opposite for employment displacement, with economic damages falling monotonically in age, which is not surprising given the low rates of employment at older ages. Younger adults (25-44) experienced employment displacement of 11.6 percentage points, compared to 1.8 percentage points for the oldest age group (85+). 25-44 year olds make up 39 percent of the population that is 25 and older, and account for 51 percent of the national displaced employment among all individuals 25 and older. SI Appendix, Section 4 presents additional analyses by age group.

Discussion

In this paper, we present a comparison of the initial economic and mortality consequences of the coronavirus pandemic across states and ages in the United States. All-cause excess mortality and displacement in the employment-to-population ratio are negatively correlated across age groups and positively correlated across states. Excess mortality is substantially more concentrated, affecting mostly only a few states and the oldest individuals, while the economic damages are more widespread.

Our finding of a significant positive relationship between excess all-cause mortality and economic damages across states is consistent with Chetty et al. (20), who shows that counties with higher COVID case rates experienced larger declines in consumer spending in the first two weeks of April 2020. They contrast with Rojas et al. (21), who find no relationship between increases in unemployment insurance (UI) claims and COVID case rates in March 2020, when the impact of the pandemic on both mortality and the economy was still nascent. Our findings of differences in mortality across age groups are consistent with estimates of COVID deaths by age in the United States (1, 22), in Italy (23), and in South Korea (24), which find that COVID deaths were concentrated among the elderly. Our findings of excess all-cause mortality nationally and across states are consistent with

Woolf et al. (3) and Weinberger et al. (4); our findings of differences in economic outcomes by age are consistent with Bui et al. (25).

Our findings underscore the importance of examining all-cause mortality rather than just mortality labelled as a “COVID death”. COVID deaths account for only 75% of excess all-cause mortality nationally; these results are similar in magnitude to previous comparisons of national excess all-cause mortality and COVID deaths in March and April 2020 (3, 4). And while estimates of excess all-cause mortality by state are positively correlated with reported COVID deaths by state, the difference between the excess all-cause death rate and the COVID death rate is particularly large in states such as New York and New Jersey with the highest official COVID death rates (SI Appendix, Section 2.3).

Some of the differences between excess all-cause mortality and COVID mortality may reflect choices in what is labelled a “COVID death”, which may include both over-counting and under-counting. But the differences may also reflect more than just measurement: Our emphasis on all-cause mortality also highlights that the relationship between economic consequences and excess mortality may include both direct and indirect effects of the COVID pandemic. For example, the national increases in deaths due to heart disease may reflect the results of care foregone during the pandemic; this is consistent with evidence that individuals may be foregoing care for their ongoing chronic conditions or delaying care even for acute episodes of myocardial infarction or strokes (11, 26). The national decline in unnatural deaths may reflect decreased traffic fatalities due to reduced travel (14), and the decline in cancer deaths are potentially due to “harvesting” effects in which individuals who are already very ill may be more susceptible to dying from COVID.

A broader, non-COVID specific, literature has investigated the impact of changes in economic activity patterns on mortality (16–19), highlighting a variety of potential channels leading to mortality effects of varying sign. It is possible that the pandemic-induced economic recession (27) may have direct mortality impacts. For example,

consistent with Ruhm (16), we find that states with higher economic damage are more likely to have reduced mortality from unnatural causes (like traffic fatalities), although the relationship is not statistically significant (see SI Appendix, Figure S.8). Further work on the impact of the economic changes on mortality is needed.

We note several important limitations to our results. First, they reflect the situation during a specific historical moment of the initial stage of the COVID pandemic. As the pandemic progresses, it is likely that the disease's burden will be felt in different geographic areas, and the relationship between the economic burden and mortality burden may shift as consumer behaviors and employment conditions adapt. Second, while mortality is obviously an important health outcome, it is not the only one, and the pandemic may have other important impacts on morbidity that we do not capture. Third, because our analyses rely exclusively on data that are currently publicly available, we can only analyze impacts for a limited set of groups. Perhaps most importantly, we are unable to examine impacts by race; this is a very important area for further work, as existing evidence suggests that COVID deaths are disproportionately concentrated among African-Americans and Hispanics (28–30).

Nevertheless, our results highlight that health crises concentrated in one part of the country and one age group may have substantial economic spillovers that are felt throughout the rest of the country and on other age groups. In the case of age groups, the variation in the incidence of the crises on lives and livelihood may reflect natural differences in health and rates of economic activity by age. In the case of geographic variation, another mechanism may be at play – if successful at preventing the spread of the pandemic, pre-emptive reduction in economic activity in states not yet experiencing the health effects, may also explain the combination of concentrated deaths and dispersed economic damages that we observe in the data. Overall, our results raise the possibility that the combination of concentrated health effects and diffuse economic damage may create challenges for state-level public health mitigation measures.

Materials and Methods

Mortality Data and Variable Construction. All data are publicly available. National population estimates by month (2011-2020) come from the U.S. Census Bureau Table NA-EST2019-01; these 2019 vintage population estimates are the latest, publicly available population estimates that incorporate the latest administrative record data and methodology. State population estimates by year (2011-2019) come from the U.S. Census Bureau Table NST-EST2019-01. We use a linear extrapolation within each state to separately estimate each state's population in 2020. Specifically, we separately for each state estimate the following regression, where P_t is population in year t: $P_t = \alpha_0 + \alpha_1 t + \epsilon_t$ for years $t \in \{2011, \ldots, 2019\}$. A state's population in 2020 is then defined as $\hat{P}_{2020} = \hat{\alpha}_0 + \hat{\alpha}_1 * 2020$. Population estimates by age and year (2011-2019) come from the U.S. Census Bureau Table NC-EST2019-AGESEX-RES; for each year, these estimates are then aggregated into our age groups. Within each age group, we estimate its 2020 population using the same linear extrapolation procedure that we used to estimate 2020 state populations.

We use weekly data on all-cause deaths by state between 2019-2020 from the CDC's National Center for Health Statistics (NCHS) accessed on July 1, 2020, using the CDC's weighted death count estimate, which adjusts for potential underreporting based on the degree of underreporting from each state during previous years. Comparing the CDC's weighted and unweighted death counts for April 2020 suggests that approximately 97.5% of weighted death counts are made up of reported deaths as of July 1, 2020; all states were estimated to have at least 90% of deaths reported except for North Dakota and Connecticut. See Section 2.2 in the SI Appendix for more details. All-cause death counts for each age group between 2019-2020 come from national weekly totals in the NCHS's July 1, 2020 "Weekly counts of deaths by jurisdiction and age group" file, and again use the CDC's adjustment for historical underreporting. We use the finest age groupings that are available from the CDC for all-cause death counts for all years of our data. We omit the youngest age group (0- 24), as the employment to population ratio is not defined for individuals younger than 16 years old in the CPS survey (employment questions are only administered to individuals who are 16 and older). For 2019-2020,

we construct monthly death counts for each state and age group by aggregating weekly death counts, assuming the 1/7 of deaths in a week take place during each day of the week. For all-cause death counts by state and age group from 2011-2018, we use death counts from the CDC Wonder Database based on death certificates that include information about state of residence and age. We calculate national death counts in all months as the sum of death counts in the 50 states and Washington, D.C.

The health outcome that we consider is all-cause mortality per 10,000 people; we construct this for each state as the number of deaths in a state divided by the estimated population in the state, times 10,000. For state-level and age group-level estimates, we use the estimated annual population as the group's population for each month within the year. In SI Appendix, Section 2.1 we show that our estimates of excess all-cause mortality at the state level closely line up with CDC's estimates.

For the comparison of all-cause excess deaths with COVID-attributed deaths, we use daily counts of COVID-19 deaths from The New York Times, which maintains a repository of daily confirmed and probable COVID-19 deaths by state, compiled from state and local health departments. These data are available through the website https://github.com/nytimes/covid-19-data.

Economic Data and Variable Construction. All data are publicly available. Monthly economic data from 2011-2020 come from the IPUMS CPS, which harmonizes data across months from the Current Population Survey (CPS). The CPS is a monthly survey that samples over 80,000 residents for each month. Weights are provided to construct nationally representative estimates, so when aggregating individual survey responses we use the "final basic person weight" variable, which is based on the inverse probability that an individual is selected into the sample and adjusts for known nonresponse issues. The main economic outcome that we consider is the employment-to-population ratio; this is defined as the percentage of the non-military and non-institutional population 16 and older that either had full-time or part-time work during the week before the survey week. We construct this measure nationally, within each state, and within each age group; national measures use all 50 states and Washington, D.C. In constructing age groups, we follow the finest age groups that are available for mortality data from the CDC, again omitting

age group 0 to 24, as employment to population ratio is not defined in CPS for individuals younger than 16. We choose to focus on the employment to population ratio rather than the unemployment rate because the unemployment rate also captures the decision to search for work, while official counts of unemployment claims further depend on who qualifies for and applies for unemployment benefits. SI Appendix, Section 1 discusses potential concerns about CPS survey reliability during the pandemic, and validates our approach using both alternative economic measures in the CPS (specifically the unemployment rate and average hours worked per population) as well as economic measures taken from administrative data that are not affected by potential non-response bias; all measures are positively correlated across states and our qualitative findings are not driven by our measurement choice. Throughout, we treat CPS estimates as data, abstracting from any uncertainty around sampling error, because the replicate weights required to accurately construct standard errors are not available for the monthly CPS and sampling error is plausibly very small relative to the employment effects we find.

Predicted and Excess Outcomes. Our goal is to calculate excess mortality and economic damage nationally and for each state and age group, for each month in the year 2020. For each outcome Y (either mortality or the employment-population ratio) we define the excess of the outcome in month m of year t as $EY_{mt} = Y_{mt} - PY_{mt}$, where Y_{mt} is the observed value of the outcome and PY_{mt} is the predicted value of the outcome. Y_{mt} is directly observed in the data. In our main specification, $PY_{m,2020}$ is determined by estimating the following linear regression during the pre-period 2011-2019:

$$Y_{mt} = \beta t + \sum_{\mu=1}^{\mu=12} \tau_\mu Ind(\mu = m) + \epsilon_{mt}$$

where βt is a linear time trend, $\sum_{\mu=1}^{\mu=12} \tau_\mu Ind(\mu = m)$ is a sum of indicator variables for each calendar month to non-parametrically capture seasonal variation in the outcomes, and ϵ_{mt} is an error term. We use heteroskedasticity-robust standard errors, clustering by year. The predicted value of the outcome in month m of 2020 is then $PY_{m,2020} = \hat{\beta} * 2020 + \hat{\tau}_m$, and the excess of the outcome is $EY_{m,2020}$. For our economic outcome (employment-to-population ratio) we define "excess decline in the employment-

population ratio" as $-EY_{mt}$, so that a larger increase in economic damage corresponds to a larger decrease in the employment-to-population ratio.

In SI Appendix Section 3.1 we confirm that our approach for computing excess mortality and economic damages does not produce either meaningful excess mortality or economic damages when we replicate it for February 2020; we do observe emerging deviations from prediction in March, but they are less pronounced than in April 2020.

Comparing Mortality and Economic Impacts. To compare the mortality and economic impacts of COVID-19 across states, we regress excess mortality per 10,000 on economic damage (as measured by the excess decline in the employment-to-population ratio) in April 2020, where each observation is a state or Washington, D.C. We use heteroskedasticity-robust standard errors to construct confidence intervals for the slope of this line. In SI Appendix Section 3.2 we show that our findings are robust to alternative specifications of the predictive model.

Acknowledgments

Any opinions and conclusions expressed herein are those of the authors and do not necessarily represent the views of the U.S. Census Bureau. The research in this paper does not use any confidential Census Bureau information. Polyakova gratefully acknowledges financial support by National Institute for Health Care Management Research and Educational Foundation.

References

1. CDC, COVID-19 Provisional Counts - Weekly Updates by Select Demographic and Geographic Characteristics (2020) (August 3, 2020).

2. CDC COVID-19 Response Team, *et al.*, Geographic Differences in COVID-19 Cases, Deaths, and Incidence — United States, February 12–April 7, 2020. *MMWR Morb. Mortal. Wkly. Rep.* **69**, 465–471 (2020).

3. S. H. Woolf, D. A. Chapman, R. T. Sabo, D. M. Weinberger, L. Hill, Excess Deaths From COVID-19 and Other Causes, March-April 2020. *JAMA* (2020) https:/doi.org/10.1001/jama.2020.11787 (August 3, 2020).

4. D. M. Weinberger, *et al.*, Estimation of Excess Deaths Associated With the COVID-19 Pandemic in the United States, March to May 2020. *JAMA Intern Med* (2020) https:/doi.org/10.1001/jamainternmed.2020.3391 (August 3, 2020).

5. J. Katz, D. Lu, M. Sanger-Katz, Tracking the Real Coronavirus Death Toll in the United States. *The New York Times* (August 3, 2020).

6. D. Lu, There Has Been an Increase in Other Causes of Deaths, Not Just Coronavirus. *The New York Times* (2020) (August 3, 2020).

7. O. Coibion, Y. Gorodnichenko, M. Weber, Labor Markets During the COVID-19 Crisis: A Preliminary View. 15.

8. O. Coibion, Y. Gorodnichenko, M. Weber, The Cost of the Covid-19 Crisis: Lockdowns, Macroeconomic Expectations, and Consumer Spending (2020) https:/doi.org/10.3386/w27141 (August 3, 2020).

9. V. Guerrieri, G. Lorenzoni, L. Straub, I. Werning, Macroeconomic Implications of COVID-19: Can Negative Supply Shocks Cause Demand Shortages? (2020) https:/doi.org/10.3386/w26918 (August 3, 2020).

10. S. R. Baker, *et al.*, The Unprecedented Stock Market Reaction to COVID-19. *The Review of Asset Pricing Studies*, raaa008 (2020).

11. S. M. Desai, F. X. Guyette, C. Martin-Gill, A. P. Jadhav, Collateral damage – Impact of a pandemic on stroke emergency services. *J Stroke Cerebrovasc Dis* **29**, 104988 (2020).

12. L. Rosenbaum, The Untold Toll — The Pandemic's Effects on Patients without Covid-19. *New England Journal of Medicine* **382**, 2368–2371 (2020).

13. , Cancer Patients Face Treatment Delays And Uncertainty As Coronavirus Cripples Hospitals | Kaiser Health News (August 3, 2020).

14. A. Brodeur, N. Cook, T. Wright, On the Effects of COVID-19 Safer-At-Home Policies on Social Distancing, Car Crashes and Pollution. 50 (2020).

15. , Preliminary Monthly Estimates. *Injury Facts* (August 3, 2020).

16. C. J. Ruhm, Are Recessions Good for Your Health? *Q J Econ* **115**, 617–650 (2000).

17. C. J. Ruhm, Healthy living in hard times. *Journal of Health Economics* **24**, 341–363 (2005).

18. C. J. Ruhm, Recessions, healthy no more? *Journal of Health Economics* **42**, 17–28 (2015).

19. D. Cutler, A. Deaton, A. Lleras-Muney, The Determinants of Mortality. *Journal of Economic Perspectives* **20**, 97–120 (2006).

20. R. Chetty, J. N. Friedman, N. Hendren, M. Stepner, How Did COVID-19 and Stabilization Policies A↵ect Spending and Employment? A New Real-Time Economic Tracker Based on Private Sector Data↼. 84.

21. F. L. Rojas, *et al.*, “Is the Cure Worse than the Problem Itself? Immediate Labor Market Effects of COVID-19 Case Rates and School Closures in the U.S.” (National Bureau of Economic Research, 2020) https:/doi.org/10.3386/w27127 (August 3, 2020).

22. C. R. Knittel, B. Ozaltun, What does and does not correlate with COVID-19 death rates. *medRxiv*, 2020.06.09.20126805 (2020).

23. C. Modi, Total COVID-19 Mortality in Italy: Excess Mortality and Age Dependence through Time-Series Analysis. 16.

24. J. B. Dowd, *et al.*, Demographic science aids in understanding the spread and fatality rates of COVID-19. *Proc. Natl. Acad. Sci. U.S.A.* **117**, 9696–9698 (2020).

25. T. T. M. Bui, P. Button, E. G. Picciotti, “Early Evidence on the Impact of COVID-19 and the Recession on Older Workers” (National Bureau of Economic Research, 2020) https:/doi.org/10.3386/w27448 (August 3, 2020).

26. S. Garcia, *et al.*, Reduction in ST-Segment Elevation Cardiac Catheterization Laboratory Activations in the United States During COVID-19 Pandemic. *J. Am. Coll. Cardiol.* **75**, 2871–2872 (2020).

27. NBER, Determination of the February 2020 Peak in US Economic Activity (August 3, 2020).

28. T. Ford, S. Reber, R. V. Reeves, Race gaps in COVID-19 deaths are even bigger than they appear. *Brookings* (2020) (August 3, 2020).

29. J. McLaren, “Racial Disparity in COVID-19 Deaths: Seeking Economic Roots with Census data.” (National Bureau of Economic Research, 2020) https:/doi.org/10.3386/w27407 (August 3, 2020).

30. E. G. Price-Haywood, J. Burton, D. Fort, L. Seoane, Hospitalization and Mortality among Black Patients and White Patients with Covid-19. *New England Journal of Medicine* **382**, 2534–2543 (2020).

Figures and Tables



Figure 1. Time Series of Mortality and Economic Outcomes. These figures show time series for the monthly mortality rate per 10,000 (a and b) and employment-population ratio (c and d). (a) and (c) show the time series of the indicated variable in April of each year. (b) and (d) compare predicted outcomes to the point estimates for observed outcomes for each variable in 2020; predictions for each variable are calculated using a linear time trend with month fixed effects during the pre-period 2011-2019. Mortality data use CDC weighted death count. Mortality data include individuals of any age while economic data include individuals 16 and older. Heteroskedasticity-robust standard errors for calculating confidence intervals within each month are computed with clustering by year.

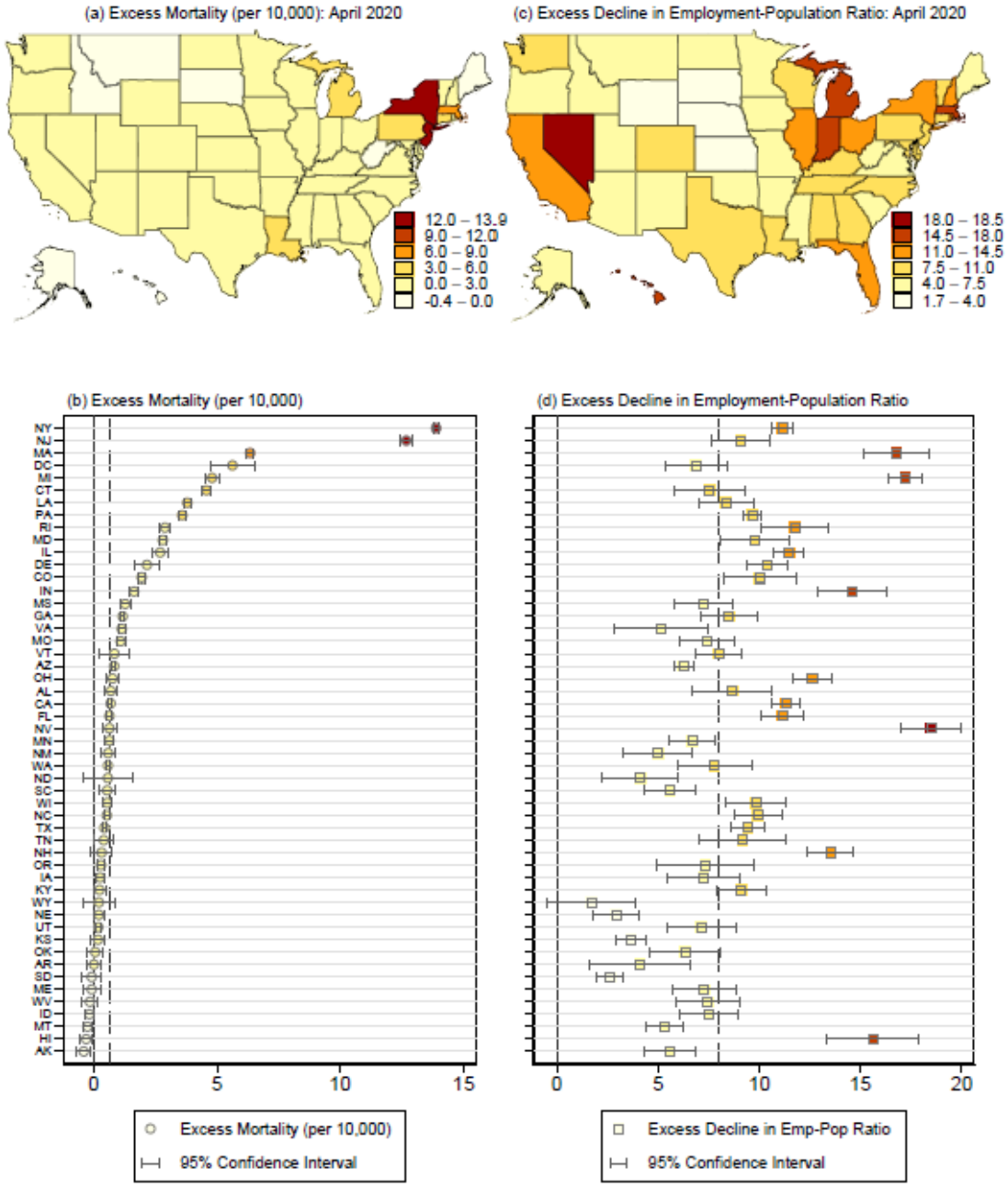


Figure 2. Geographic Heterogeneity in Outcomes by State: April 2020. These figures show deviations from expected (a and c) mortality and (b and d) employment-population ratios within each state in April 2020. For dotplots in panels (c) and (d), states are ordered in descending order of their excess mortality. Dotted lines show the median of each outcome across states in April 2020. CPS data include all individuals 16 and older and CDC data include all individuals of any age. Mortality data use CDC weighted death count estimates. Predicted values are calculated using a linear time trend with month fixed effects with pre-period 2011-2019. Annual

population counts to calculate mortality come from the Census Bureau in each state from 2011-2019. Heteroskedasticity-robust standard errors to construct 95% confidence intervals are computed with clustering by year.

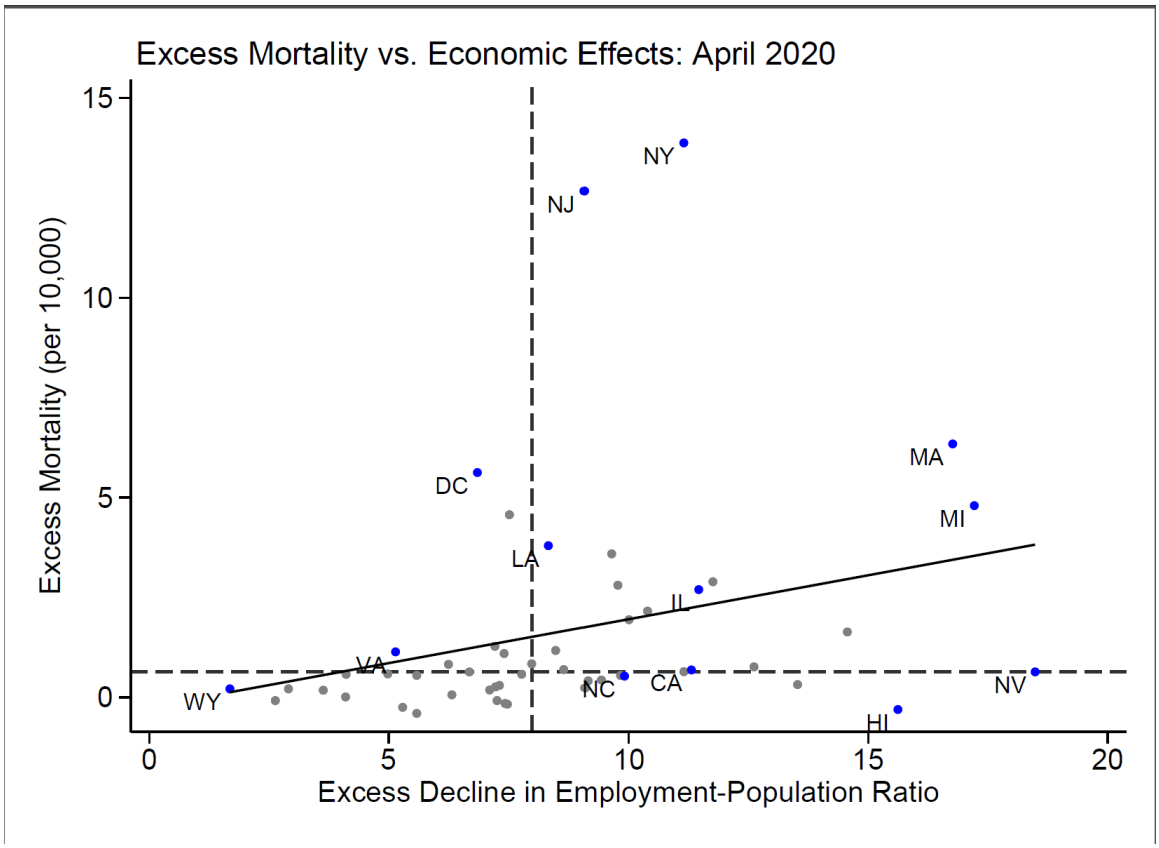


Figure 3. Excess Mortality and Economic Damage Comparison by State. This figure compares excess mortality and the economic impacts of COVID-19 in April 2020; each point is one state. Economic measures are calculated using the IPUMS CPS microdata and mortality measures are calculated using aggregate CDC data. Excess amounts are calculated by comparing observed values in April 2020 to predicted values. Predicted values are calculated using a linear time trend with month fixed effects; the pre-period starts is 2011-2019. The solid line shows the line of best fit from an unweighted regression. Dashed lines show the median value of excess mortality and the excess decline in employment-population ratio.

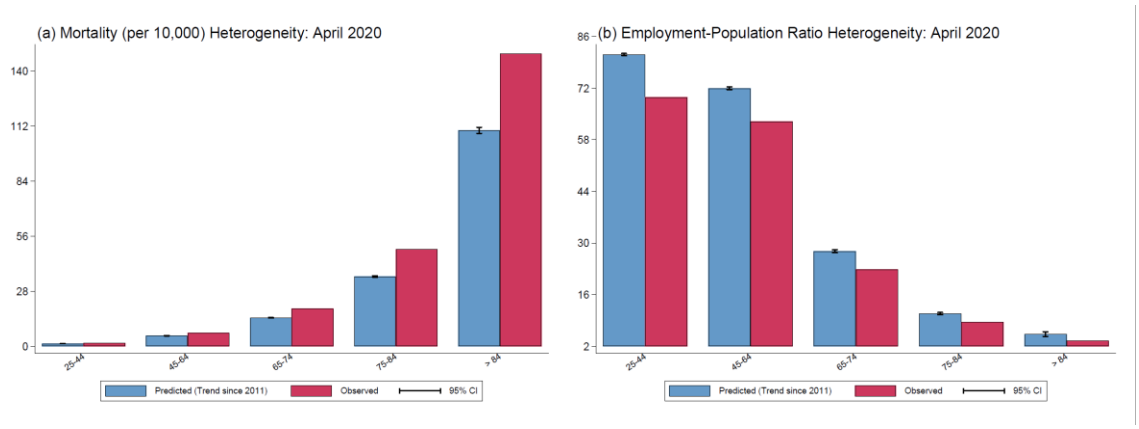


Figure 4. Predicted vs. Observed Outcomes by Age Group. These figures compare predicted and observed (a) mortality per 10,000 and (b) employment-population ratio, both in April 2020, for the age groups for which the CDC publishes recent weekly death counts, using point estimates for observed outcomes. The employment-population ratio is calculated using the IPUMS CPS microdata and mortality measures are calculated using aggregate CDC data by age group. Predicted values for each outcome are calculated using a linear time trend with month fixed effects; the pre-period is from 2011-2019. Heteroskedasticity-robust standard errors to construct 95% confidence intervals are computed with clustering by year.