



Dynamics of racial disparities in all-cause mortality during the COVID-19 pandemic

Hélène E. Aschmann^{a,1} , Alicia R. Riley^{b,1}, Ruijia Chen^a, Yea-Hung Chen^a , Kirsten Bibbins-Domingo^a , Andrew C. Stokes^c , M. Maria Glymour^a, and Mathew V. Kiang^{d,2}

Edited by Douglas Massey, Princeton University, Princeton, NJ; received July 1, 2022; accepted August 12, 2022

As research documenting disparate impacts of COVID-19 by race and ethnicity grows, little attention has been given to dynamics in mortality disparities during the pandemic and whether changes in disparities persist. We estimate age-standardized monthly all-cause mortality in the United States from January 2018 through February 2022 for seven racial/ethnic populations. Using joinpoint regression, we quantify trends in race-specific rate ratios relative to non-Hispanic White mortality to examine the magnitude of pandemic-related shifts in mortality disparities. Prepandemic disparities were stable from January 2018 through February 2020. With the start of the pandemic, relative mortality disadvantages increased for American Indian or Alaska Native (AIAN), Native Hawaiian or other Pacific Islander (NHOPI), and Black individuals, and relative mortality advantages decreased for Asian and Hispanic groups. Rate ratios generally increased during COVID-19 surges, with different patterns in the summer 2021 and winter 2021/2022 surges, when disparities approached prepandemic levels for Asian and Black individuals. However, two populations below age 65 fared worse than White individuals during these surges. For AIAN people, the observed rate ratio reached 2.25 (95% CI = 2.14, 2.37) in October 2021 vs. a prepandemic mean of 1.74 (95% CI = 1.62, 1.86), and for NHOPI people, the observed rate ratio reached 2.12 (95% CI = 1.92, 2.33) in August 2021 vs. a prepandemic mean of 1.31 (95% CI = 1.13, 1.49). Our results highlight the dynamic nature of racial/ethnic disparities in mortality and raise alarm about the exacerbation of mortality inequities for Indigenous groups due to the pandemic.

pandemic | racial disparities | all-cause mortality | COVID-19

The COVID-19 pandemic emerged against a backdrop of long-standing structural racism in the United States and resulting racial/ethnic disparities in mortality. Increases in all-cause mortality in the first year of the pandemic were larger in Black and Hispanic than in White groups (1, 2). In addition, the pandemic's indirect effects on mortality were higher in racially minoritized groups in 2020 (3). Although there are indications that some of these disparities may have been reduced in 2021 (4, 5), there is little evidence on how disparities evolved over time, how different racial and ethnic groups were affected, and whether disparities have returned to prepandemic levels or established a new baseline. Evaluating the temporal dynamics of disparities through the pandemic is important because if inequalities vary substantially over time, it suggests inequalities are malleable and responsive to fluctuations in the epidemic and the social response to the pandemic.

Comparisons with non-Hispanic White mortality reflect systemic advantages that have buffered White mortality from COVID-19 and from many indirect negative health effects of the pandemic, such as lower risk of exposure through work (6), protection from underlying conditions due to weathering processes, and better health care access and quality (7). Preexisting inequities associated with mortality, including lack of health care, financial hardship, and housing instability, were likely exacerbated during the pandemic. For example, due to racialized occupational sorting, minoritized groups were at higher risk of job loss and subsequent loss of health insurance during the pandemic. Since the US legacy of racial violence and exclusion is different for Black Americans than for Indigenous Americans and for racialized immigrants from Latin America and Asia, we do not assume that the pandemic will have similar impacts on all relative disparities.

Here, we study the dynamics in all-cause mortality in the United States from January 2018 through February 2022, including the first 2 y of the COVID-19 pandemic, to understand how the pandemic altered racial and ethnic disparities in mortality in the short term and how disparities trends varied across groups. We analyzed monthly dynamics in the relative disparity between White individuals and six other racial and

Author affiliations: ^aDepartment of Epidemiology and Biostatistics, University of California, San Francisco, San Francisco, CA 94158; ^bDepartment of Sociology, University of California, Santa Cruz, Santa Cruz, CA 95064; ^cDepartment of Global Health, Boston University School of Public Health, Boston, MA 02118; and ^dDepartment of Epidemiology and Population Health, Stanford University School of Medicine, Stanford, CA 94304

Author contributions: H.E.A., A.R.R., R.C., M.M.G., and M.V.K. designed research; M.V.K. analyzed data; H.E.A. and A.R.R. wrote the paper; R.C., Y.-H.C., K.B.-D., A.C.S., M.M.G., and M.V.K. provided critical feedback on the manuscript.

The authors declare no competing interest.

Copyright © 2022 the Author(s). Published by PNAS. This open access article is distributed under [Creative Commons Attribution-NonCommercial-NoDerivatives License 4.0 \(CC BY-NC-ND\)](https://creativecommons.org/licenses/by-nc-nd/4.0/).

¹H.E.A. and A.R.R. contributed equally to this work.

²To whom correspondence may be addressed. Email: mkiang@stanford.edu.

Published September 20, 2022.

ethnic groups stratified by age. We defined this relative disparity using age-adjusted death rate ratios with the White population as the reference group because of their advantaged racialization in the United States. With this approach, we explore how racial and ethnic mortality disparities unfolded over the pandemic.

Results

All-cause mortality increased in all seven racial and ethnic groups in the United States during the COVID-19 pandemic, in particular during the winter 2020/2021 wave (Fig. 1). Seasonal fluctuations in all-cause mortality before the pandemic were similar in all groups. Racial and ethnic mortality disparities were stable when measured on a ratio scale for the 2 y before the pandemic (Fig. 2). During the pandemic, rate ratios for age-standardized all-cause mortality relative to White mortality remained stable for multiracial and Native Hawaiian and other Pacific Islander individuals aged 65 or older.

For all other racial and ethnic groups across all ages, the all-cause mortality rate ratio relative to White mortality increased with the start of the pandemic (with longer time lags in some groups than others) and again, during subsequent COVID-19 surges (Fig. 2). For example, prior to the pandemic, Black individuals of all ages had 1.19 (95% CI = 1.17, 1.21) times the mortality rate of White individuals; the observed rate ratio peaked at 1.77 (95% CI = 1.75, 1.79) during the initial wave of the pandemic (April 2020) and reached a momentary trough of 1.10 (95% CI = 1.09, 1.11) in December 2021, when White mortality increased earlier in the winter 2021/2022 Omicron wave. The Black–White relative disparity approximated its prepandemic level by February 2022; however, this reflects elevated absolute mortality for both Black and White people compared with prepandemic. Although Hispanic people of all ages had lower all-cause mortality compared with White people prior to the pandemic, during COVID-19 surges, the age-standardized all-cause mortality rate of Hispanic people surpassed that of White people in 3 mo during the 2-y pandemic period (April and July 2020 and January 2021). For Asian Americans of all ages, the increased rate ratio meant a reduced mortality advantage relative to White people from a prepandemic mean rate ratio of 0.50 (95% CI = 0.48, 0.52) to observed rate ratios of 0.72 (95% CI = 0.71, 0.73) in April 2020 and 0.68 (95% CI = 0.67, 0.69) in January 2021. In addition to the

pandemic's exacerbation of the Black–White mortality disparity, the largest exacerbations of disparities relative to White people occurred among American Indian or Alaska Native people and Native Hawaiian or other Pacific Islander people under age 65. Notably, observed rate ratios increased again during the surge in summer 2021, up to 2.25 (95% CI = 2.14, 2.37) for American Indian or Alaska Native people under age 65 from a prepandemic mean rate ratio of 1.74 (95% CI = 1.62, 1.86). Similarly, the observed rate ratios increased to 2.12 (95% CI = 1.92, 2.33) in August 2021 for Native Hawaiian or other Pacific Islander people under age 65 from a prepandemic mean rate ratio of 1.31 (95% CI = 1.13, 1.49).

Discussion

Racial and ethnic disparities in all-cause mortality during the pandemic did not simply mirror prepandemic disparities. Instead, relative gaps in monthly age-standardized mortality (relative to White mortality) worsened for most racial and ethnic groups studied with the onset of the pandemic. Relative disparities were most extreme during COVID-19 waves. While mortality increased more for nearly all racialized groups than in the White population, there was heterogeneity in the extent to which exacerbated disparities persisted after the first year. Two years into the pandemic, mortality disparities remain exacerbated above prepandemic levels for American Indian or Alaska Native people and for Native Hawaiian or other Pacific Islander people, driven by a worsening of already extreme disparities in mortality among those under 65 y of age.

It is important to note that the disparities trends we study here are relative to changing mortality rates in the White population. Thus, reductions in disparities in some racial groups may be in large part due to an increase in (age-standardized) COVID-19 deaths in the White population by 35% from 2020 to 2021, while COVID-19 deaths in Hispanic and Asian populations remained largely stable (5). We note three limitations when using death certificate data. First, we use provisional death data, which may differ from the final data. Second, the timeliness of provisional death reporting varies by jurisdiction. Third, misclassification of race on death certificates is more frequent for some minoritized populations compared with the non-Hispanic White population, especially among American Indian and Alaska Native, Asian, and multiracial populations

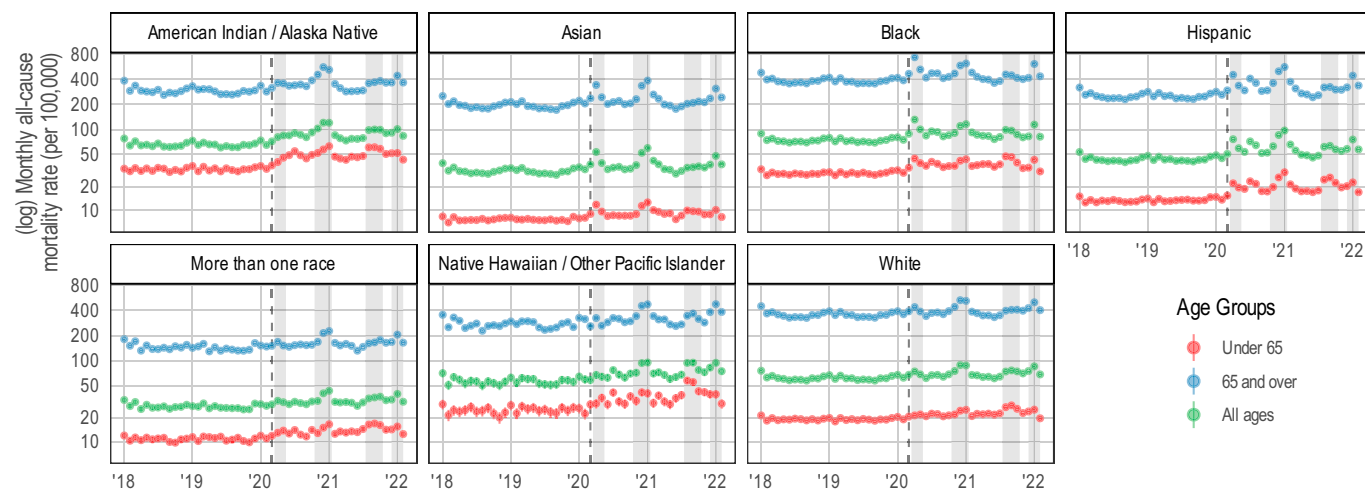


Fig. 1. Monthly age-standardized mortality rates per 100,000 population across racial/ethnic groups shown on a logarithmic scale. The dashed vertical lines indicate March 2020, the start of the COVID-19 pandemic. All racial/ethnic groups are of non-Hispanic ethnicity except for Hispanic. Shaded regions represent the initial, winter 2020/2021, summer 2021, and winter 2021/2022 waves.

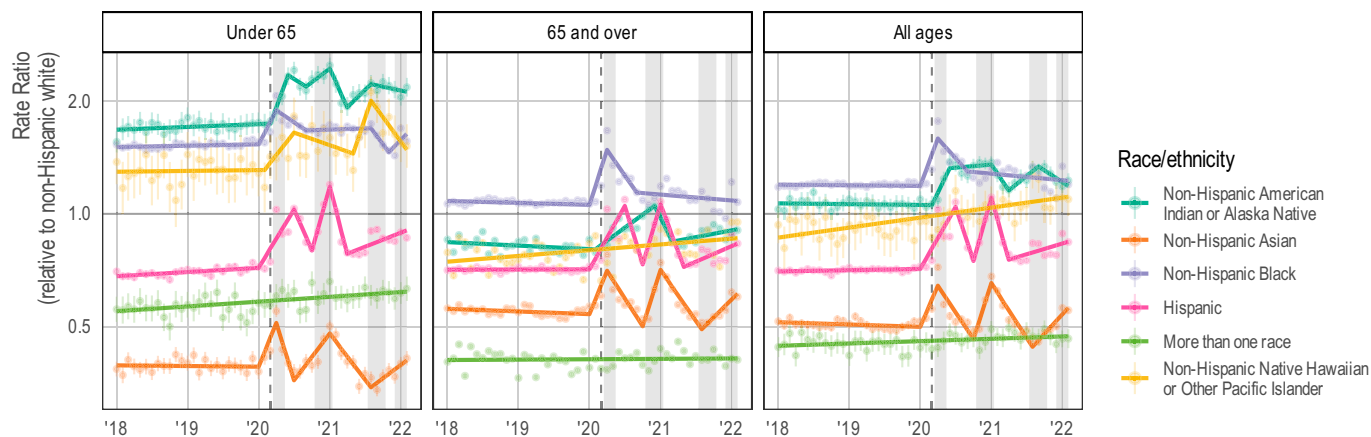


Fig. 2. Monthly rate ratios of all-cause mortality compared with non-Hispanic White. The points and error bars represent the observed monthly rate ratios and corresponding 95% CIs, respectively. The solid lines represent the joinpoint model fits. Shaded regions represent the initial, winter 2020/2021, summer 2021, and winter 2021/2022 waves.

(5, 8). Taken together, both the mortality rates and the rate ratios are likely to be underestimated, especially for minoritized populations (8). While this study focuses on all-cause mortality, emerging evidence suggests that excess mortality during the pandemic mainly resulted from direct COVID-19 deaths in addition to increases in causes other than COVID-19, including cardiovascular deaths, diabetes, drug overdose, and homicide (13, 9, 10).

The temporal variability we documented underscores the modifiability of racial disparities. Substantial variation in the magnitude of disparities in the short term suggests that with appropriate strategies, disparities can be reduced or prevented. While some of our results are likely driven by differential access to vaccines (4), our findings also suggest that interventions to reduce disparities must go beyond COVID-19 vaccine availability in order to counter the multiple mechanisms linking structural racism to mortality (7). These might include long-term interventions, such as guaranteed basic income programs, subsidized housing, health care for all, and childcare subsidies, as well as short-term interventions, such as culturally tailored door-to-door vaccination campaigns and proactive patient navigation for people with multiple comorbidities.

American Indian, Alaska Native, Native Hawaiian, and Pacific Islander populations in the United States below age 65 experienced a sustained widening of mortality disparities during the COVID-19 pandemic. These unprecedented mortality disparities demand new policies and community investments. Policies should attend to the unequal impacts of the pandemic on already

devastating inequities in mortality in the United States (11). We should reject narratives that treat racial and ethnic disparities as inevitable or normal.

Materials and Methods

We used publicly available single-race data on all-cause mortality and single-race population sizes from the Centers of Disease Control and Prevention's Wide-Ranging Online Data for Epidemiologic Research (WONDER) platform (12), accessed 15 July and 15 February 2022, to extract all deaths by age group and race/ethnicity for 1 January 2018 through 28 February 2022. We calculated monthly age-standardized all-cause mortality rates for seven racial/ethnic groups using the direct method and the US 2000 standard population in 5-y age bins (0 to 4, 5 to 9, ..., 85 and over) for the total population and stratified by under 65 y of age vs. 65 y and over. We then calculated ratios of monthly mortality rates in each racial/ethnic group compared with non-Hispanic White. We used joinpoint models (with up to nine joinpoints) to estimate temporal trends in the rate ratios. Joinpoint regression models use segmented weighted linear regression, with the constraint that segments must meet (or "join"), to characterize temporal trends as parsimonious sets of linear regressions (13, 14). Reproducible code and data are available at https://github.com/mkiang/dynamic_inequality.

Data, Materials, and Code Availability. This study uses publicly-available data from the Centers of Disease Control and Prevention's WONDER platform (12). All code and data used in this manuscript have been deposited in GitHub [https://github.com/mkiang/dynamic_inequality (15)].

1. A. N. Luck, S. H. Preston, I. T. Elo, A. C. Stokes, The unequal burden of the Covid-19 pandemic: Capturing racial/ethnic disparities in US cause-specific mortality. *SSM Popul. Health* **17**, 101012 (2022).
2. M. S. Shiels *et al.*, Racial and ethnic disparities in excess deaths during the COVID-19 pandemic, March to December 2020. *Ann. Intern. Med.* **174**, 1693–1699 (2021).
3. L. C. Zalla, G. E. Mulholland, L. M. Filiatreau, J. K. Edwards, Racial/ethnic and age differences in the direct and indirect effects of the COVID-19 pandemic on US Mortality. *Am. J. Public Health* **112**, 154–164 (2022).
4. A. R. Riley, M. V. Kiang, Y. H. Chen, K. Bibbins-Domingo, M. M. Glymour, Recent shifts in racial/ethnic disparities in COVID-19 mortality in the vaccination period in California. *J. Gen. Intern. Med.* **37**, 1818–1820 (2022).
5. B. I. Truman, M.-H. Chang, R. Moonesinghe, Provisional COVID-19 age-adjusted death rates, by race and ethnicity—United States, 2020–2021. *MMWR Morb. Mortal. Wkly. Rep.* **71**, 601–605 (2022).
6. Y.-H. Chen *et al.*, Excess mortality associated with the COVID-19 pandemic among Californians 18–65 years of age, by occupational sector and occupation: March through November 2020. *PLoS One* **16**, e0252454 (2021).
7. M. A. Garcia, P. A. Homan, C. Garcia, T. H. Brown, The Color of COVID-19: Structural racism and the pandemic's disproportionate impact on older racial and ethnic minorities. *J. Gerontol. B Psychol. Sci. Soc. Sci.* **76**, e75–e80 (2021).
8. E. Arias, W. Schauman, K. Eschenbach, P. Sorlie, E. Backlund, National Center for Health Statistics of the Centers for Disease Prevention and Control, Hyattsville, MD. "The Validity of Race and Hispanic-origin Reporting on Death Certificates in the United States" (Tech. Rep. Vital and Health Statistics Series 2, 2008).
9. Y.-H. Chen *et al.*, Excess natural-cause deaths in California by cause and setting: March 2020 through February 2021. *PNAS Nexus* **1**, pgac079 (2022).
10. R. Chen *et al.*, Racial and ethnic disparities in estimated excess mortality from external causes in the US, March to December 2020. *JAMA Intern. Med.* **182**, 776–778 (2022).
11. E. Wrigley-Field, US racial inequality may be as deadly as COVID-19. *Proc. Natl. Acad. Sci. U.S.A.* **117**, 21854–21856 (2020).
12. Centers of Disease Control and Prevention, Wide-Ranging Online Data for Epidemiologic Research (CDC WONDER). <https://wonder.cdc.gov>. Accessed 15 July 2022.
13. Statistical Methodology and Applications Branch, Surveillance Research Program, National Cancer Institute, National Cancer Institute of the National Institutes of Health, Bethesda, MD. Joinpoint Regression Program (Version 4.9.1.0, 2022).
14. H. J. Kim, M. P. Fay, E. J. Feuer, D. N. Midthune, Permutation tests for joinpoint regression with applications to cancer rates. *Stat. Med.* **19**, 335–351 (2000). Erratum in: *Stat. Med.* **20**, 655 (2001).
15. M. Kiang, Dynamics of racial disparities in all-cause mortality during the COVID-19 pandemic. GitHub. https://github.com/mkiang/dynamic_inequality. Accessed 21 August 2022.