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Short communication

Post-COVID changes and disparities in cardiovascular mortality rates in the United States

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A B S T R A C T

Introduction: The COVID-19 pandemic disrupted healthcare delivery and increased cardiovascular morbidity and mortality. This study assesses whether cardiovascular mortality rates in the US have recovered post-pandemic and examines the equity of this recovery across different populations.
Methods: We analyzed data from the CDC WONDER database, covering US residents' mortality from 2018–2023. We focused on cardiovascular diseases, categorized by ischemic heart disease (IHD), heart failure (HF), hypertensive diseases (HTN), and cerebrovascular disease. Age-adjusted mortality rates were calculated for three periods: pre-COVID (2018–2019), during COVID (2020–2021), and post-COVID (2022–2023), stratified by demographic and geographic variables.
Results: Cardiovascular age-adjusted mortality rates increased by 5.9% during the pandemic but decreased by 3.4% post-pandemic, resulting in a net increase of 2.4% compared to pre-COVID levels. When compared to pre COVID age-adjusted mortality rates, post COVID IHD mortality age-adjusted mortality rates decreased by 5.0%, while cerebrovascular and HTN age-adjusted mortality rates increased by 5.9% and 28.5%, respectively. Men and younger populations showed higher increases in cardiovascular Age-adjusted mortality rates. Geographic disparities were notable, with significant reductions in cardiovascular mortality in the Northeast and increases in states like Arizona and Oregon.
Conclusion: The COVID-19 pandemic led to a surge in cardiovascular mortality, with partial recovery post-pandemic. Significant differences in mortality changes highlight the need for targeted healthcare interventions to address inequities across demographic and geographic groups.

1. Introduction

The COVID-19 pandemic brought about significant disruptions to healthcare delivery and patients outcomes (Khunti et al., 2022; Schmidt et al., 2020; Kobo et al., 2020), as well as a notable increase in cardiovascular morbidity and mortality (Xie et al., 2022; Kobo et al., 2023; Chaganty et al., 2023). Previous data suggested that all-cause mortality rates in the US have decreased from the 2021 peak associated with the COVID-19 pandemic but remain above the pre-pandemic baseline (Minhas et al., 2024). We aimed to assess whether, after the surge in cardiovascular mortality during the first two years of the COVID pandemic, there has been a recovery in cardiovascular mortality rates in the US and whether this has been equitable amongst different patient populations.

2. Methods

We utilized the Provisional Multiple Cause of Death database, Centers-for-Disease-Control and Prevention Wide-Ranging-Online Data for Epidemiologic Research (CDC WONDER) (Centers for Disease Control and Prevention et al., 2024). This database contains mortality data for all US residents from 2018–2023, based on death certificates. Death certificates include demographic data and a main cause of mortality, per the International Classification of Disease Tenth Revision (ICD-10). Non-

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US residents were excluded from the analysis. We included all decedents with cardiovascular disease (codes I*) as the main cause of mortality ('underlying cause of death'). Further analyses focused on subcategories of cardiovascular diseases, including ischemic heart disease (IHD, I20–I25), heart failure (HF, I50), hypertensive diseases (HTN, I10–I15), and cerebrovascular disease (I60–I69).

To assess changes in cardiovascular mortality rates over time, we calculated the percentage change in age-adjusted cardiovascular mortality rates between three pre-defined two-years periods 2018–2019 (pre-COVID), 2020–2021 (during COVID), and 2022–2023 (post-COVID). Age-adjusted mortality rates were derived using the direct standardization method based on age group weights from the 2000 U.S. population (Sidney et al., 2019; Kyalwazi et al., 2022). Population estimates used as the denominators of rates were Race-, Hispanic origin-, sex-, age-, and state-specific. Pre- to post-COVID age-adjusted mortality rates differences were counted as statistically significant when the CI's did not overlap. The study was exempt from ethical approval as the CDC WONDER database contains anonymized, publicly available data.

3. Results

Compared with the pre-COVID period, we observed a 5.9 % increase in total cardiovascular age-adjusted mortality rates during the COVID pandemic (Table 1). Subsequently, during the post-pandemic period (2022–2023), we observed a 3.4 % decrease in total cardiovascular mortality, with an age-adjusted mortality rateof 221 per 100,000 population, reflecting an overall 2.4 % increase when compared to the pre-COVID period.

While the increase in total cardiovascular age-adjusted mortality rates during the COVID years was consistent across all four main cardiovascular causes of death, the recovery during the post-COVID years exhibited different patterns (Table 1). IHD age-adjusted mortality rates showed an overall 5.0 % decrease between pre- and post-COVID periods, while cerebrovascular age-adjusted mortality rates increased by 5.9 %. HF age-adjusted mortality rates modestly increased both during and after COVID (overall 1.4 % increase), while HTN-related mortality increased by 22.4 % during COVID and by a further 5 % post-COVID-19, reflecting an overall 28.5 % increase overall when compared to the pre-COVID period.

While an increase in total cardiovascular age-adjusted mortality rates during the COVID period and a subsequent decrease post COVID-19 was observed across most demographic subgroups, a comparison of pre- and post-COVID-19 total cardiovascular age-adjusted mortality rates revealed different patterns (Table 1). An overall increase in total cardiovascular age-adjusted mortality rates was observed across all sex and age groups; however, it was more prominent in men (3.3 % increase vs. 1.5 % in women) and in younger people (6.6 % among individuals aged under 45 years; 3.4 % aged 45–64 years, and 2.0 % aged 65 years and above). Compared to pre-COVID rates, post-COVID total cardiovascular age-adjusted mortality rates were 1.5 % lower among American Indian or Alaska Native individuals, while in other racial groups there was a 2.3 %-2.9 % increase.

Comparing pre- and pre-COVID total cardiovascular age-adjusted mortality rates by place of residence, we observed a 3.7 % decrease in in the northeast region, but a 3–4 % increase in other regions (Table 1). Across most of US states we observed and increase in cardiovascular age-adjusted mortality rates in the post COVID years when compared to pre COVID years (Fig. 1). The most prominent reductions in cardiovascular age-adjusted mortality rates between pre- and post-COVID periods were observed in Columbia District (3.8 %), New Jersey (6.4 %), and New York (6.8 %), while the most prominent increases were observed in Arizona (9.8 %), Maine (9.9 %), and Oregon (10.4 %). It should be noted

Table 1
Pandemic-related changes in age-adjusted total and cause-specific cardiovascular mortality rates and changes in total cardiovascular mortality rates by demographic group within in the U.S, 2018–2023.

	Pre-COVID 2018–2019 (95 % CI)	During COVID 2020–2021 (95 % CI)	Post-COVID 2022–2023 (95 % CI)	% change (from Pre-COVID to During COVID)	% change (from During COVID to Post-COVID)	% change (from Pre-COVID to Post-COVID)
Total CVD	215.9 (215.5–216.2)	228.7 (228.3–229.0)	221.0 (220.8–221.4)	5.93	−3.37	2.36
Cause–specific CVD (%)						
IHD	89.4 (89.2–89.6)	92.2 (92.0–92.4)	84.9 (84.7–85.2)	3.13	−7.92	−5.03
Cerebrovascular	37.0 (36.9–37.2)	39.9 (39.8–40.1)	39.2 (39.1–39.4)	7.84	−1.75	5.95
HF	20.9 (20.8–21.0)	21.1 (21.0–21.2)	21.2 (21.1–21.3)	0.96	0.47	1.44
HTN	24.6 (24.5–24.7)	30.1 (30.0–30.3)	31.6 (31.4–31.7)	22.36	4.98	28.46
Sex						
Men	261.9 (261.3–262.4)	277.5 (277.1–277.8)	270.5 (270.1–270.9)	5.96	−2.52	3.28
Women	177.5 (177.1–177.9)	187.6 (187.0–187.8)	180.1 (180.0–180.3)	5.69	−4.00	1.46
Age group						
Under 45 years	11.3 (11.2–11.4)	12.9 (12.8–13.0)	12.0 (11.9–12.1)	14.16	−6.59	6.64
45–64 years	153.3 (153.1–153.6)	169.5 (169.2–169.8)	158.6 (158.4–158.8)	10.53	−6.43	3.42
65 years and over	1380.2 (1379.9–1380.6)	1446.1 (1445.5–1446.8)	1407.8 (1407.5–1408.2)	4.77	−2.65	2.00
Hispanic Origin						
Hispanic or Latino	157.3 (157.2–157.5)	170.7 (1706.–170.9)	162.6 (162.5–162.7)	8.52	−4.80	3.30
Not Hispanic or Latino	221.7 (221.6–221.8)	235.1 (234.9–235.4)	227.2 (227.0–227.5)	6.04	−3.36	2.48
Race						
American Indian/Alaska Native	143.7 (143.5–143.8)	153.6 (153.4–153.9)	141.6 (141.4–141.8)	6.89	−7.81	−1.46
Asian	121.2 (121.1–121.4)	130.7 (130.5–130.9)	124.3 (124.1–124.4)	7.79	−4.86	2.56
Black or African American	283.5 (283.4–283.6)	309.2 (309.1–309.4)	290.0 (289.8–290.1)	9.06	−6.21	2.29
Native Hawaiian or Other Pacific Islander	203.4 (203.3–203.6)	214.0 (213.8–214.1)	209.3 (290.2–290.4)	5.19	−2.20	2.88
White	213.6 (213/4–213/7)	225.5 (255.3–255.7)	219.3 (219.2–219.5)	5.59	−2.75	2.69
Mixed Race	93.2 (93.0–93.3)	100.1 (99.8–100.2)	95.8 (95.7–95.9)	7.46	−4.29	2.84
Region						
Northeast	204.7 (204.6–204.9)	209.7 (209.7–210.0)	197.1 (197.0–197.2)	2.44	−6.03	−3.74
Midwest	226.1 (226.0–226.4)	240.1 (240.0–240.3)	233.2 (233.0–233.4)	6.21	−2.89	3.14
South	229.0 (228.8–229.3)	245.3 (245.2–245.6)	237.9 (237.7–238.0)	7.14	−3.02	3.91
West	192.2 (192.0–192.3)	205.3 (205.2–205.6)	200.0 (199.8–200.1)	6.84	−2.61	4.06

Data are mortality rates per 100,000 of the population. CVD, cardiovascular disease; HF, heart failure; HTN, hypertension; IHD, ischemic heart disease.

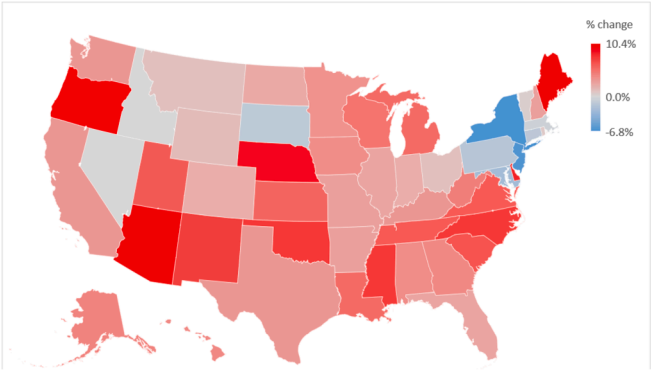

Fig. 1. Percent change in cardiovascular age-adjusted mortality rates between pre-COVID (2018–2019) and post-COVID (2022–2023) years, by state: Data are mortality rates per 100,000 of the population.

that all reported pre COVID to post COVID age-adjusted mortality rates changes were statistically significant with non-overlapping CI's.

4. Discussion

The findings of this study underscore the profound impact of the COVID-19 pandemic on cardiovascular mortality rates in the United States (US). Following a declining trend in cardiovascular mortality rates over the first two decades of the millennium, the emergence of the pandemic in early 2020 led to a notable increase in cardiovascular mortality. Our analysis reveals variations in the changes in cardiovascular mortality rates during the post-pandemic period. While total cardiovascular mortality rates showed a gradual decrease following the peak of the pandemic, the recovery varied across different sub-groups of cardiovascular diseases. Notably, while IHD mortality rates decreased during post-pandemic years, mortality rates for other cardiovascular causes increased when compared to pre-COVID rates. The prominent decrease in IHD mortality may be partly attributed the fact that during COVID individuals with IHD had increased premature mortality, causing a biased low post COVID mortality rates. This phenomenon, known as the "harvesting effect," refers to a period of increased premature mortality followed by a temporary phase of reduced mortality (Walkowiak et al., 2023).

Moreover, our study highlights disparities in cardiovascular mortality rates across demographic and geographic subgroups. Men and individuals of Hispanic or Latino origin, and Black or African American adults, experienced disproportionately higher increases in total cardiovascular mortality across the 6-year observation period spanning the pandemic. This may be a consequence of higher COVID infection rate in these populations, which had longer term impact (Bassett et al., 2020); however, socioeconomic factors likely contribute to these disparities (Lee and Singh, 2021; Harrington et al., 2020). These groups often face barriers to accessing quality healthcare, including limited health insurance coverage, fewer healthcare facilities in their communities, and financial constraints that make it difficult to seek timely medical care. Additionally, they are more likely to work in essential jobs that cannot be done remotely, increasing their exposure to COVID-19 and its long-term health consequences. The pandemic also exacerbated existing social determinants of health such as housing instability, food insecurity, and chronic stress, which are known to negatively impact cardiovascular health. Addressing these socioeconomic challenges is crucial for mitigating the lingering effects of the pandemic on cardiovascular mortality and improving overall health equity.

The regional variations in cardiovascular mortality recovery observed in our study highlight significant disparities that necessitate tailored healthcare strategies. For instance, while the Northeast region experienced a 3.7 % decrease in total cardiovascular age-adjusted mortality rates, other regions saw increases of 3–4 %. States like New York, New Jersey, and the District of Columbia showed the most prominent reductions, with decreases of 6.8 %, 6.4 %, and 3.8 % respectively. In contrast, states such as Arizona, Maine, and Oregon experienced substantial increases of 9.8 %, 9.9 %, and 10.4 % respectively. Regional differences in short and long term impact of COVID-19 on mortality were previously reported (Polyakova et al., 2021). These variations could be attributed to differences in public health policies, healthcare infrastructure, and the effectiveness of pandemic response measures. Additionally, socioeconomic factors such as income levels, education, and employment opportunities vary across regions, impacting healthcare access and outcomes. The observed regional disparities underscore the importance of developing region-specific interventions that address the unique healthcare needs and challenges of each community to promote equitable recovery in cardiovascular health outcomes post-pandemic.

In conclusion, the COVID-19 pandemic significantly impacted cardiovascular mortality rates in the U.S., with uneven recovery observed across various demographic and geographic groups. Men, Hispanic or Latino individuals, and Black or African American adults faced higher mortality increases, likely due to socioeconomic barriers. Regional disparities further emphasize the need for tailored public health strategies. Addressing these disparities through targeted interventions is essential to improving cardiovascular health equity in the post-pandemic era.

CRediT authorship contribution statement

Ofer Kobo: Writing – original draft, Methodology, Formal analysis, Data curation. **Shivani Misra:** Writing – review & editing. **Amitava Banerjee:** Writing – review & editing. **Martin K Rutter:** Writing – review & editing. **Kamlesh Khunti:** Writing – review & editing. **Mamas A Mamas:** Writing – review & editing, Supervision, Project administration, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: KK has acted as a consultant, speaker or received grants for investigator-initiated studies for Astra Zeneca, Bayer, Novartis, Novo Nordisk, Sanofi-Aventis, Lilly and Merck Sharp & Dohme, Boehringer Ingelheim, Oramed Pharmaceuticals, Pfizer, Roche, Daiichi-Sankyo and Applied Therapeutics. SM has received speaker Honoraria from Lilly and Sanofi, UK.

Data availability

Data will be made available on request.

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References

Bassett, M.T., Chen, J.T., Krieger, N., 2020. Variation in racial/ethnic disparities in COVID-19 mortality by age in the United States: A cross-sectional study. Erratum. In: PLoS Med. 2021 Feb 4;18(2):e1003541. doi: 10.1371/journal.pmed.1003541. PMID: 33079941; PMCID: PMC7575091 PLoS Med. 17 (10), e1003402.

Centers for Disease Control and Prevention, National Center for Health Statistics. National Vital Statistics System, Provisional Mortality on CDC WONDER Online Database. Data are from the final Multiple Cause of Death Files, 2018-2021, and

from provisional data for years 2022-2024, as compiled from data provided by the 57 vital statistics jurisdictions through the Vital Statistics Cooperative Program. Accessed at http://wonder.cdc.gov/mcd-icd10-provisional.html on Mar 31, 2024.

Chaganty, S.S., Abramov, D., Van Spall, H.G.C., et al., 2023. Rural and urban disparities in cardiovascular disease-related mortality in the USA over 20 years; have the trends been reversed by COVID-19? Int. J. Cardiol. Cardiovasc. Risk Prev. 30 (19), 200202 https://doi.org/10.1016/j.ijcrp.2023.200202. PMID: 37675096; PMCID: PMC10477062.

Harrington, R.A., Califf, R.M., Balamurugan, A., et al., 2020. Call to action: rural health: A presidential advisory from the American Heart Association and American Stroke Association. Circulation 141 (10), e615–e644. https://doi.org/10.1161/CIR.0000000000000753. Epub 2020 Feb 10 PMID: 32078375.

Khunti, K., Aroda, V.R., Aschner, P., et al., 2022. The impact of the COVID-19 pandemic on diabetes services: planning for a global recovery. Lancet Diabetes Endocrinol. 10 (12), 890–900. https://doi.org/10.1016/S2213-8587(22)00278-9.

Kobo, O., Efraim, R., Saada, M., et al., 2020. The impact of lockdown enforcement during the SARSCoV-2 pandemic on the timing of presentation and early outcomes of patients with ST-elevation myocardial infarction. PMID: 33095801; PMCID: PMC7584161 PLoS One 15 (10), e0241149.

Kobo, O., Abramov, D., Fudim, M., et al., 2023. Has the first year of the COVID-19 pandemic reversed the trends in CV mortality between 1999 and 2019 in the United States? Eur. Heart J. Qual. Care Clin. Outcomes. 9 (4), 367–376. https://doi.org/10.1093/ehjqcco/qcac080.

Kyalwazi, A.N., Loccoh, E.C., Brewer, L.C., et al., 2022. Disparities in cardiovascular mortality between black and white adults in the United States, 1999 to 2019. Circulation 146 (3), 211–228. https://doi.org/10.1161/CIRCULATIONAHA.122.060199. Epub 2022 Jul 18. PMID: 35861764; PMCID: PMC9310198.

Lee, H., Singh, G.K., 2021. Monthly trends in self-reported health status and depression by race/ethnicity and socioeconomic status during the COVID-19 Pandemic, United States, April 2020 - May 2021. Ann. Epidemiol. 63, 52–62. https://doi.org/10.1016/j.annepidem.2021.07.014. Epub 2021 Aug 4. PMID: 34358622; PMCID: PMC8435379.

Minhas, A.M.K., Fudim, M., Michos, E.D., et al., 2024. Has mortality in the United States returned to pre-pandemic levels? An analysis of provisional 2023 data. J. Intern. Med. 296 (2), 168–176. https://doi.org/10.1111/joim.13811. Epub 2024 Jun 3 PMID: 38829151.

Polyakova, M., Udalova, V., Kocks, G., et al., 2021. Racial disparities in excess all-cause mortality during the early COVID-19 pandemic varied substantially across states. Health Aff. (millwood). 40 (2), 307–316. https://doi.org/10.1377/hlthaff.2020.02142. PMID: 33523748; PMCID: PMC7996479.

Schmidt, A.L., Bakouny, Z., Bhalla, S., et al., 2020. Cancer care disparities during the COVID-19 pandemic: COVID-19 and Cancer Outcomes Study. Cancer Cell 38 (6), 769–770. https://doi.org/10.1016/j.ccell.2020.10.023.

Sidney, S., Go, A.S., Jaffe, M.G., et al., 2019. Association between aging of the US population and heart disease mortality from 2011 to 2017. JAMA Cardiol. 4 (12), 1280–1286. https://doi.org/10.1001/jamacardio.2019.4187. PMID: 31663094; PMCID: PMC6822092.

Walkowiak, M.P., Domaradzki, J., Walkowiak, D., 2023. Unmasking the COVID-19 pandemic prevention gains: excess mortality reversal in 2022. Public Health 223, 193–201. https://doi.org/10.1016/j.puhe.2023.08.004. Epub 2023 Sep 5 PMID: 37672832.

Xie, Y., Xu, E., Bowe, B., Al-Aly, Z., 2022. Long-term cardiovascular outcomes of COVID-19. Nat. Med. 28 (3), 583–590. https://doi.org/10.1038/s41591-022-01689-3.