Reconciling Regional-, State-, and County-level Trends in U.S. Cardiovascular Disease Mortality

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Abstract:

Since 2010, the U.S. has experienced adverse trends in cardiovascular disease (CVD) mortality, which dramatically slowed long-standing life expectancy improvements. The extent to which the national trend masks heterogeneity across regions, states, and counties is poorly understood. In this project, we aim to provide a detailed accounting of post-2010 trends in CVD mortality by U.S. region, state, and county. We then examine how features of places (e.g., population composition and socioeconomic status) relate to trends at these different levels. Preliminary results reveal differing trends and associations at different geographic levels of analysis. We explore whether these paradoxical findings can be attributable to the Simpson's Paradox, floor effects, confounding by race/ethnicity, or other processes. Results point to policy-modifiable aspects of economic, social, and built environments that may be targeted to return CVD mortality declines across the United States.

Introduction

Since 2010, U.S. life expectancy improvements have stalled (Mehta et al., 2020). Between 2010 and 2019, U.S. life expectancy increased by only 0.20 years, compared to an increase of 2.00 years in the decade prior (Bell 2002; National Center for Health Statustics). This stall in life expectancy improvements has further deteriorated the U.S. life expectancy ranking relative to other peer countries (Ho, 2022). While deaths from drug overdoses have received widespread attention, the main culprit for the life expectancy stalls has been adverse trends in national-level CVD mortality (Mehta et al., 2020). Heart disease is the leading cause of death in America, outpacing cancer and COVID-19 to kill 693,021 Americans in 2021 alone (Ahmad et al., 2022). Age-standardized U.S. CVD mortality levels have been nearly flat since around 2010, following a long period of robust decline. The reasons for this adverse trend remain unknown, representing a significant and ongoing demographic puzzle and population health challenge.

A growing body of research documents that the adverse trend in CVD mortality is occurring broadly in the United States and at younger and older adult ages. Abrams et al. (2021) found that it is occurring in both rural and urban areas. Vaughan et al. (2017) found that approximately half of U.S. counties experienced mean annual increases in heart disease mortality, a main component of CVD mortality, between 2010 and 2015 among adults ages 35-74 years old. Most of these counties were in rural areas and areas outside of the Northeast. Vaughn et al. (2022) similarly found that about 75% of counties experienced increasing levels of hypertension-related CVD mortality during 2000-2019. However, most studies of trends in geographic disparities in CVD mortality were based on data from 2016 or earlier and therefore have not provided a full picture of the stagnated CVD mortality declines over the past decade.

Research on geographic variation in CVD mortality trends is lacking in the unique recent period (post-2010) when CVD mortality declines have halted.

To improve understandings of recent CVD mortality stagnation, we ask: What are the post-2010 trends in CVD mortality by U.S. region, state, and county? Through this analysis, our aim is to identify outliers that deviate from national patterns of stagnation, either by retaining declines or experiencing increases in mortality rates. Then, we ask, how do population composition and structural features of places relate to CVD mortality trends at the state and county levels? Do processes such as the Simpson's Paradox, floor effects, and confounding by race/ethnicity explain why predictive factors might matter differently for CVD mortality trends depending on the level of analysis (i.e., state versus county mortality)?

Methods

To answer these research questions, we use state level annual CVD mortality (defined as ICD-10 codes I00-I78) from 2000-2019 from public-use death certificate data in the National Vital Statistics System. We extracted this data from CDC Wonder by state, calendar year, 5-year age groups, and gender. Two aggregated age groups represent middle and old age: 40-64 years and 65-84 years. We calculated age-standardized CVD mortality rates for each state in each year for the two age groups separately using the gender-combined U.S. 2010 population age distribution. To capture region, we mapped the average annual change in age-standardized CVD mortality during 2010-2019 across U.S. Census regions. At the county level, we plan to use individual-level restricted-use death certificate data, as the public-use files in CDC Wonder suppress small cells when stratifying by year, gender, age, and county.

First, we characterized change in age-standardized CVD mortality in each age group post-2010 at the state and region levels. This highlights regions and states that have maintained declines or experienced increases in CVD mortality in recent years. To do so, we compared state-level average annual change in CVD in 2000-2009 and in 2010-2019, tested the association of 2010 CVD mortality levels with post-2010, and mapped average annual change by region. Finally, we examined CVD mortality trends by race/ethnicity to determine if differential trends in those sub-populations might explain our geographic findings.

Preliminary findings

Figure 1 shows average annual change in CVD death rates across states in 2000-2009, when CVD was robustly declining, versus 2010-2019 when declines stagnated. Panels A and B some women and men in middle age (40-64) and panels C and D show women and men in old age (65-84). Across gender and age groups, the lack of declines in CVD in the more recent period is apparent in nearly every state and the District of Columbia. In midlife, more states exhibit increases in CVD in 2010-2019. In old age, states are mostly still declining, but the absolute difference between the change in the two periods is more pronounced. In midlife but not in old age, states with the largest declines in 2000-2009 tended to have bigger differences in average annual change in that period versus 2010-2019 (correlated at 0.71 and 0.72 for women and men respectively, $p<0.001$).

Figure two shows results pertaining to floor effects, plotting states' CVD death rates in 2010 against their average annual change in 2010-2019, once again by gender and age groups. A floor effect would be apparent if states with the lowest CVD rates in 2010 exhibited the smallest decline over the next decade, because they could not fall further. We do not find strong evidence of this trend, as there was no statistically significant association between 2010 CVD rate and 2010-2019 annual change in middle-aged women, middle-aged men, or old-age men. The only evidence suggesting a floor effect was found among older women, where there was a statistically significant negative correlation (-0.47, p=0.001), with higher rates of CVD in 2010 being associated with steeper declines in 2010-2019.

Figure 3 maps state-level average annual change in CVD death rates from 2010-2019, again by gender and age group, separating states by Census region to observe geographic patterns in stagnation. In this case, there were not clear differences by sex and age group. We can see that decreasing states are in economic advantaged regions, such as New York, New Jersey, and Massachusetts in the Northeast. However, there are also states with strong decreases in CVD in the South such as Georgia, South Carolina, North Carolina, and West Virginia. Stagnation in declines was observed most in the Midwest in states such as Iowa and Ohio, and in Western states such as New Mexico.

Having ruled out floor-effects in populations aside from older women, we next examined whether racial/ethnic composition could explain continued declined in CVD in places such as the Southern “stroke belt” that typically exhibit poor cardiometabolic health. Figure 4 reveals that CVD levels differ substantially by race/ethnicity, but trends from 2000-2019 show similar stagnation around 2010. There is no evidence of continued or steeper declines among Black or Hispanic Americans, who make up more of the population in the South than other regions of the country.

Conclusions and next steps

Overall, we find that there is variation in CVD mortality trends geographically, but the stagnation in declines since 2010 is rather ubiquitous. Many states exhibit concerning increasing trends in CVD mortality in midlife. While trends in late life appear to still be declining, the shift in the rate of decline since 2010 is larger in older adults compared to middle age. We only find evidence suggesting floor effects in older women and observed stagnation across races and ethnicities, making the continued declines in the Southern region especially surprising.

This research is the first to our knowledge that thoroughly examines geographic variation in post-2010 CVD stagnation across the U.S. When we receive the restricted county-level CVD mortality data, we plan add that finer geographic category to this analysis. We will categorize counties based on median income, which we have found to be highly correlated with other environmental characteristics available in U.S. census data and Robert Wood Johnson Foundation databases (i.e., percentage with a bachelor's degree, percent rural, violence rate, percent smoker, etc.). In doing so, we will be able to see if richer, more advantaged counties have been able to maintain CVD mortality declines. In addition, by examining several different geographic levels, we can see how data aggregation may be shaping findings on the correlates of CVD mortality levels and trends.

Tables and Figures

Figure 1 (Panels A and B)

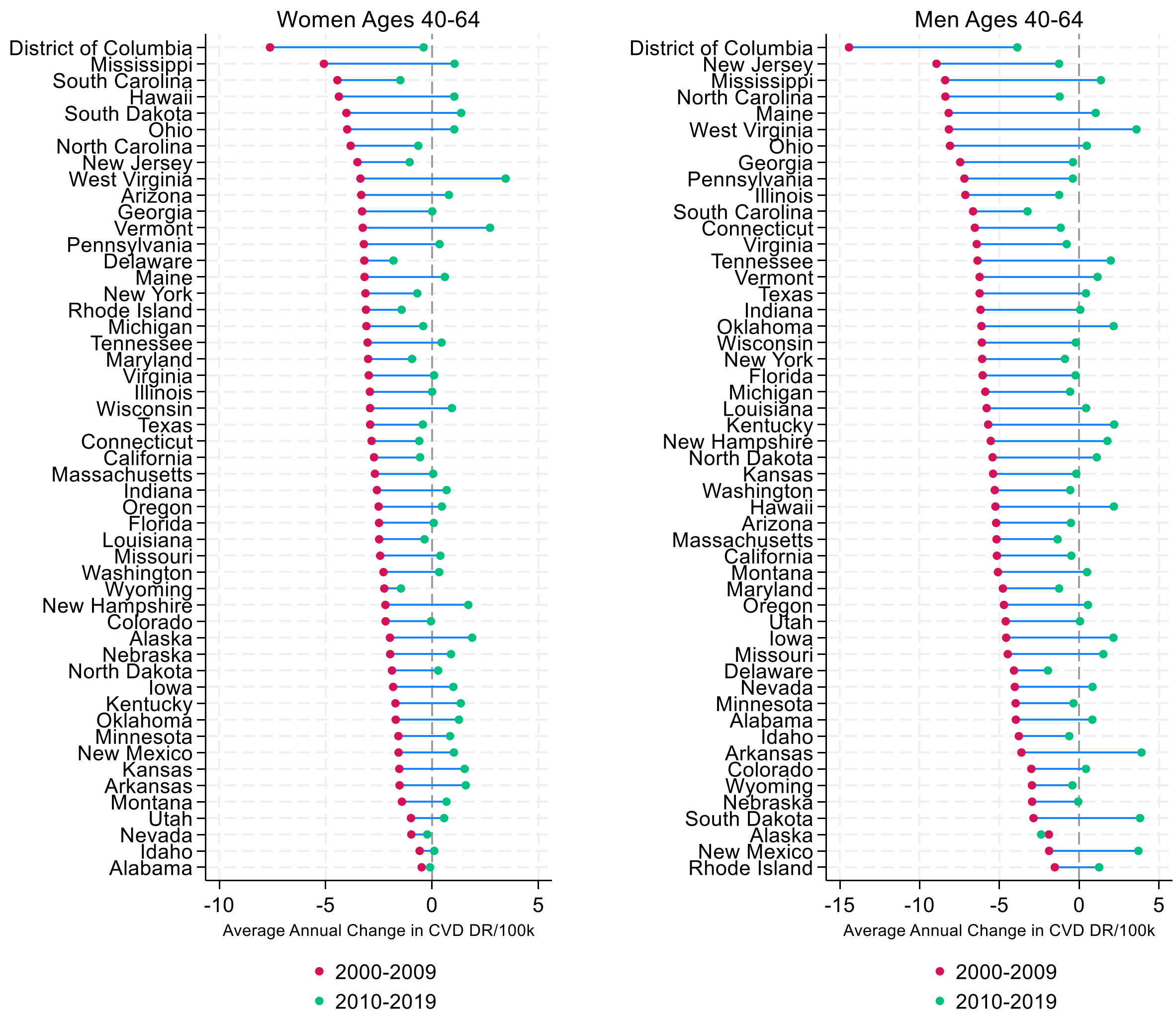


Figure 1 (Panels C and D)

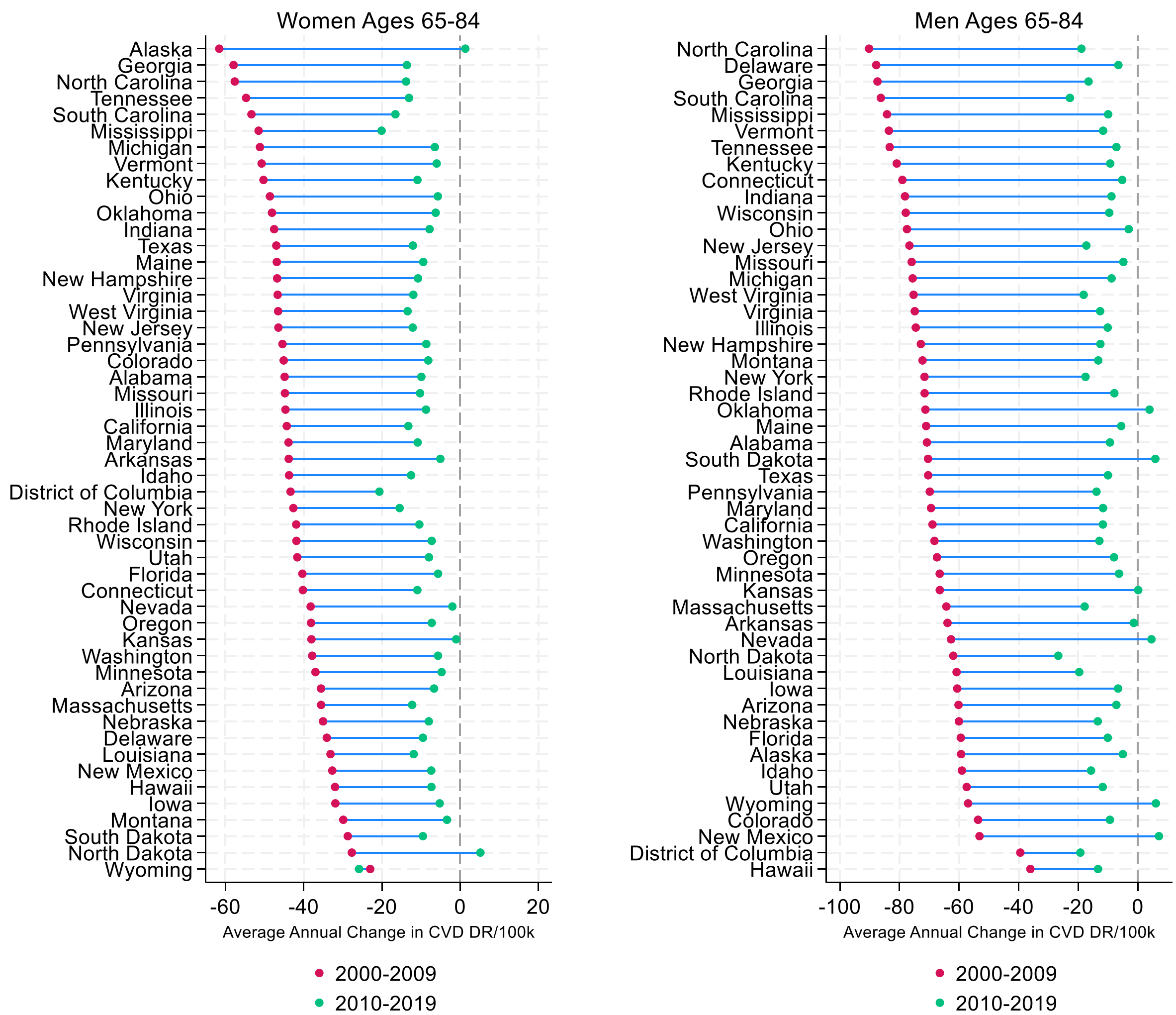


Figure 2 (Panels A, B, C, and D)

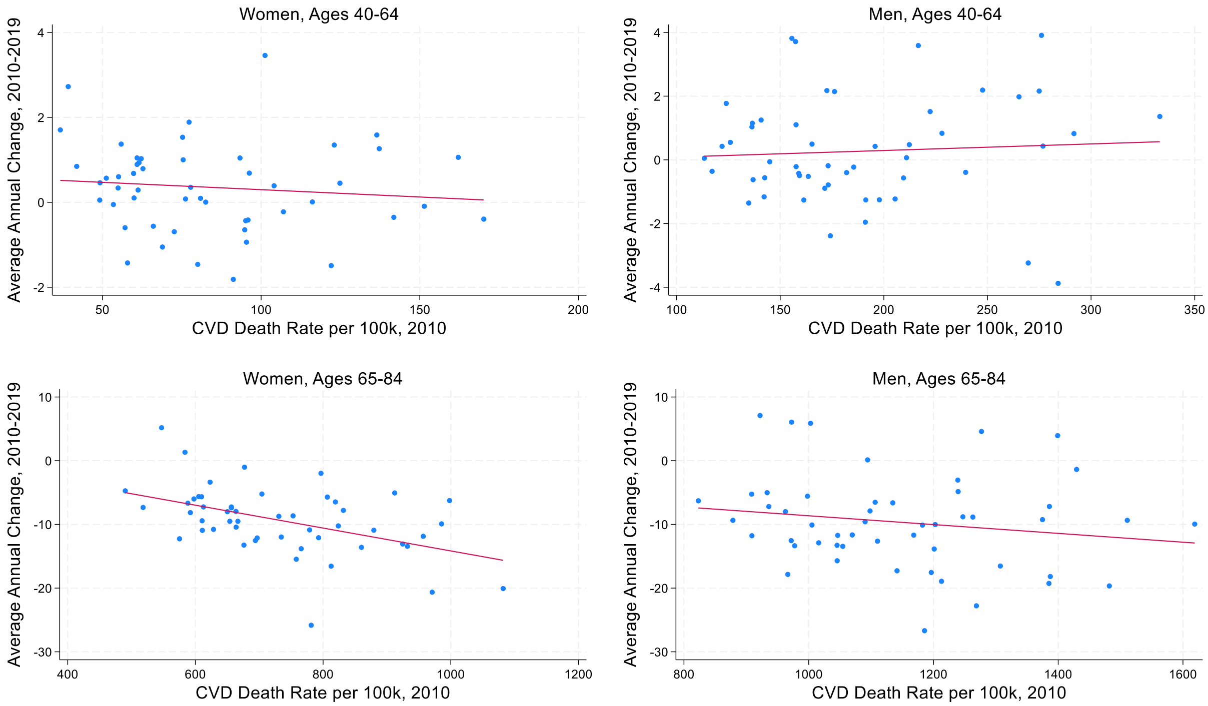


Figure 3 (Panels A and B)

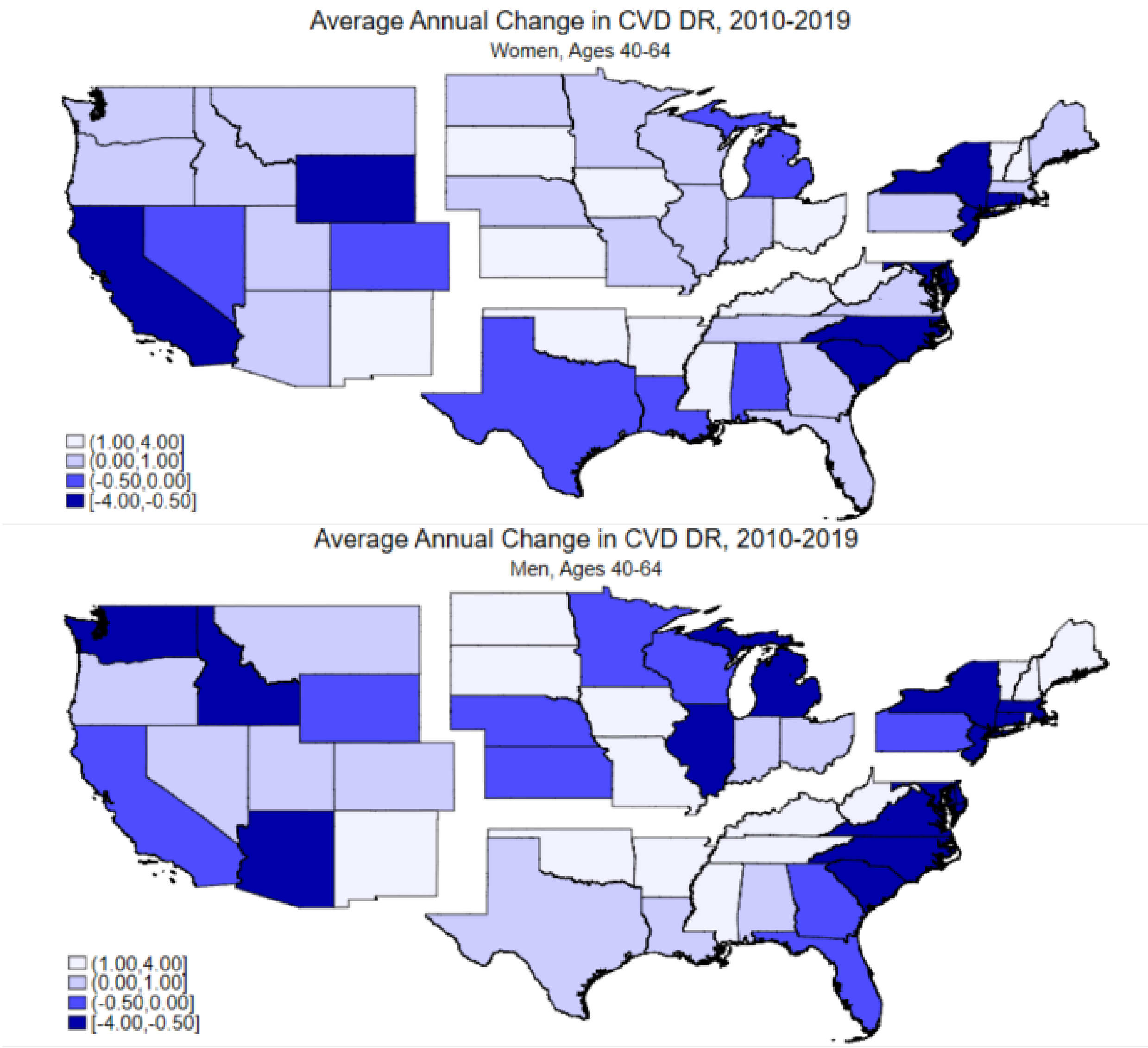


Figure 3 (Panels C and D)

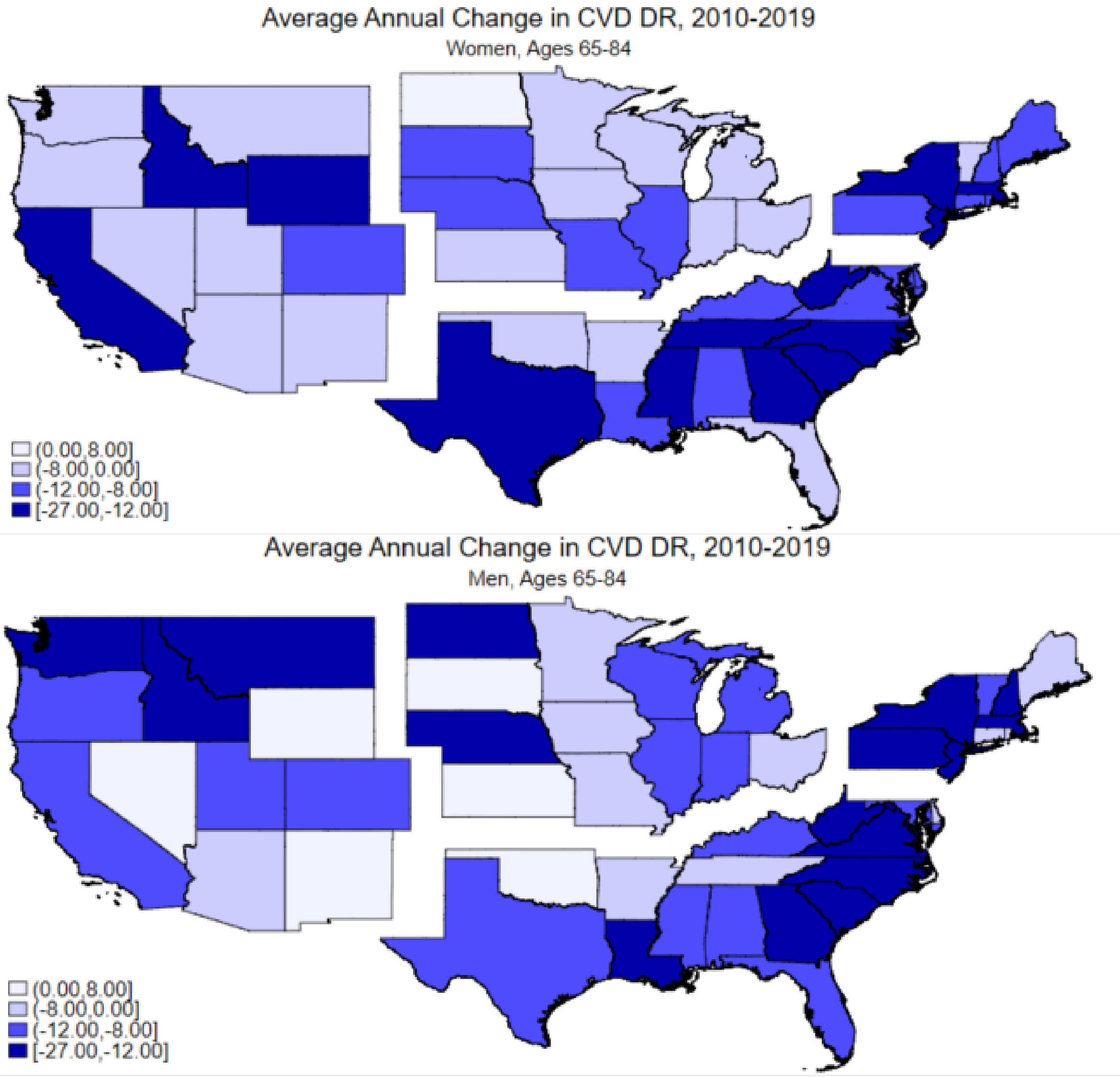
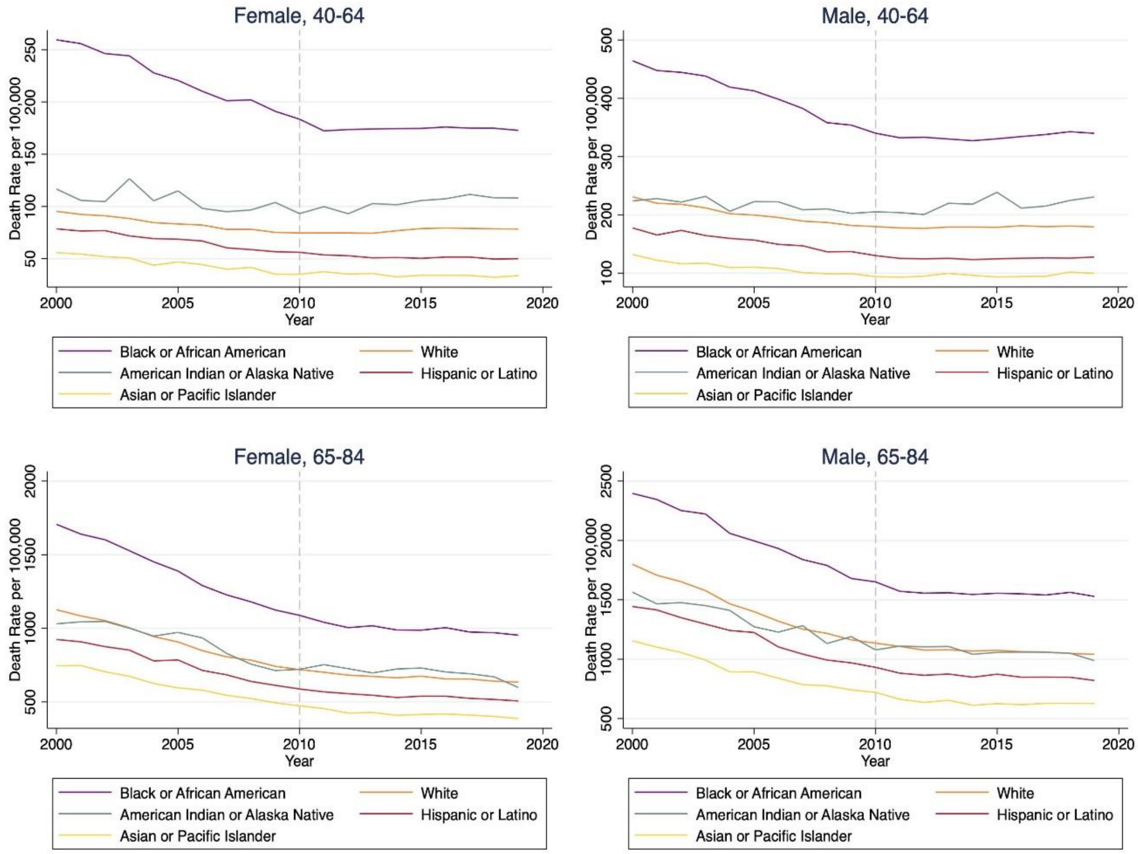


Figure 4 (Panels A, B, C, D)



References

Abrams, L. R., Myrskylä, M., & Mehta, N. K. (2021). The growing rural–urban divide in US life expectancy: contribution of cardiovascular disease and other major causes of death. *International Journal of Epidemiology*. https://doi.org/10.1093/IJE/DYAB158

Ahmad, F. B., Cisewski, J. A., & Anderson, R. N. (2022). Provisional Mortality Data—United States, 2021. *Morbidity and Mortality Weekly Report*, *71*(17), 597.

Bell, F.C., Miller, M. L. (2002) "Life Tables for the United States Social Security Area 1900-2100 Actuarial Study No. 116".

Ho, J. Y. (2022). Causes of America's Lagging Life Expectancy: An International Comparative Perspective. *The Journals of Gerontology: Series B*, *77*(Supplement_2), S117–S126. https://doi.org/10.1093/geronb/gbab129

Liao, Y., Greenlund, K. J., Croft, J. B., Keenan, N. L., & Giles, W. H. (2009). Factors Explaining Excess Stroke Prevalence in the US Stroke Belt. *Stroke*, *40*(10), 3336–3341. https://doi.org/10.1161/STROKEAHA.109.561688

Mehta, N. K., Abrams, L. R., & Myrskylä, M. (2020). US life expectancy stalls due to cardiovascular disease, not drug deaths. *Proceedings of the National Academy of Sciences*, 201920391. https://doi.org/10.1073/pnas.1920391117

Mujib, M., Zhang, Y., Feller, M. A., & Ahmed, A. (2011). Evidence of a "Heart Failure Belt" in the Southeastern United States. *The American Journal of Cardiology*, *107*(6), 935–937. https://doi.org/https://doi.org/10.1016/j.amjcard.2010.11.012

National Center for Health Statistics, Vital Statistics of the United States, Volume II: Mortality, Part A. (Data obtained through the Human Mortality Database, www.mortality.org or www.humanmortality.de).

Vaughan, A. S., Coronado, F., Casper, M., Loustalot, F., & Wright, J. S. (2022). County-Level Trends in Hypertension-Related Cardiovascular Disease Mortality—United States, 2000 to 2019. *Journal of the American Heart Association*, *11*(7), e024785. https://doi.org/10.1161/JAHA.121.024785

Vaughan, A. S., Ritchey, M. D., Hannan, J., Kramer, M. R., & Casper, M. (2017). Widespread recent increases in county-level heart disease mortality across age groups. *Annals of Epidemiology*, *27*(12), 796–800. https://doi.org/https://doi.org/10.1016/j.annepidem.2017.10.012