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Racial disparity in mortality from tuberculosis in the US between states with and without a history of Jim-Crow laws: an analysis of the Global Burden of Disease (GBD) and risk factors study, 1990 to 2019

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Abstract

Background While TB-related mortality in the US declined four-fold from 1990 to 2019, country-level estimates of TB burden obscure within-state racial heterogeneity and changes in TB burden over time. In sixteen US Southern States and Washington DC, the effects of health inequities engendered by Jim-Crow laws enacted from the late 1800s to the 1960s have not been evaluated for TB-related mortality. We, therefore, sought to compare TB mortality rates and annualized rate of change (AROC) between 1990 and 2019 in former Jim-Crow vs. non-Jim-Crow states to help guide response efforts and inform resource prioritization to improve racial equity.

Methods We evaluated whether TB-related mortality varied over time, from 1990 to 2019, between states that have a history of enacting Jim-Crow laws vs. states with no such history using estimates from the Global Burden of Diseases, Injuries, and Risk Factors Study 2019 (GBD 2019). TB mortality per 100,000 population and bootstrap 95% uncertainty intervals (UIs) were modeled using the Cause of Death Ensemble model (CODEm) framework with varying combinations of predictive covariates. For changes over time, we present age-standardized AROC as the percent difference in the natural logarithm of the rate in 1990 and 2019 divided by 30 (i.e., 100*[ln(2019 Rate/1990 Rate)/(30)) and the corresponding 95% UIs.

Results TB-related mortality in all US states declined between 1990 and 2019. From 1990 to 2019, most former Jim-Crow states had higher mortality rates than states that did not enact Jim-Crow laws. The most significant decline in TB mortality was in Washington DC, with a six-fold decline from 2.69 (2.46–2.96) per 100,000 population in 1990 to 0.45(0.37–0.55) in 2019, corresponding to an AROC of -0.83% (-0.86;-0.79). The lowest decline was in Iowa, from 0.30 (0.27–0.33) to 0.09 (0.07–0.11) (AROC: -0.70% (-0.76; -0.63)). Eleven of the 16 states and Washington DC in the third tertile of TB mortality rate in 1990 (range 0.81–2.69) had a history of Jim-Crow laws, whereas none of the 17 states

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in the first tertile (range 0.30–0.51) had such history. Conversely, mortality decreased relatively slowly in former Jim-Crow states than in non-Jim-Crow states.

Conclusions Even though the 1964 Civil Rights Act dismantled Jim-Crow statutes, racial inequities in TB burden experienced by past generations may still be felt in subsequent generations. Understanding the role of structural racism at the intersection of science and medicine shows the complex ways historical laws, such as Jim-Crow laws, continue to negatively impact health outcomes and warn of future dangers, such as COVID-19, to avoid.

Keywords Tuberculosis-related mortality in US States, Tuberculosis Epidemiology in US States, Changes in Tuberculosis mortality, Jim-Crow states

Background

Although preventable and treatable, tuberculosis (TB) causes over a million annual deaths worldwide [1–4]. A Global Burden of Disease (GBD) study estimated that the number of deaths due to TB in all ages in the US decreased four-fold from 2,271 (95% uncertainty interval [UI] 2,147–2,361) in 1990 to 978 (901–1,036) deaths in 2019. This resulted in an age-adjusted mortality per 100,000 of 0.72 (0.68–0.75) in 1990 to 0.18 (0.17–0.19) in 2019 or an annualized rate of change (AROC) of -0.75% (-0.76; -0.73) [1]. However, such national estimates of the burden of TB mask the heterogeneity in the changes in disease burden among subgroups of populations, regions, states, and local state counties and also conceal heterogeneity within racial minority subgroups known to experience elevated risks for many diseases [5–12].

Black communities and racially minoritized populations in the US have a disproportionately high burden of diseases, including TB and COVID-19 [13, 14]. For example, nationwide, Black individuals died of COVID-19 at 1.4 times the rate of White individuals [11, 12]. In addition, a burgeoning literature has reported a causal link between historical discriminatory practices and contemporary disease burden [15–18], from preterm births to stages of cancer at diagnosis [13, 14, 19]. The legacy of Jim-Crow may partly explain the inequities in contemporary health-related outcomes within the U.S. Southern States compared to states that did not implement such laws. Historical Jim-Crow laws and federally sponsored discrimination in housing are associated with contemporary adverse health outcomes. [20, 21] The GBD [1] findings underscore the persistence of the adverse effects even after the economic status has improved over time [9]. While it is known that racial minorities experience significant health disparities [5–12], the direct impact of structural racism has not been well described.

Structural racism refers to the system of public policies, institutional practices, cultural representations, and other norms that reinforce racial group inequity in housing, education, employment, earnings, health care, criminal justice, etc. Unlike systemic racism, which highlights interpersonal prejudice (e.g., a physician or healthcare provider having a judgmental way, with a superior and condescending attitude while caring for a patient of color), structural racism is broader and more widespread. It recognizes that throughout history and cultural institutions, "whiteness" has been associated with privileges denied to those of "color." Structural racism is not dependent on individual actors or institutions. Instead, it has been a feature of the US's social, economic, and political systems.

One example of such structural inequities was Jim Crow, a collection of laws enacted from the late 1800s to the 1960s that codified racial segregation in Mississippi (MS), Louisiana (LA), Georgia (GA), Maryland (MD), South Carolina (SC), Alabama, (AL) North Carolina (NC), Virginia (VA), Tennessee (TN), Florida (FL), Arkansas (AK), Texas (TX), Missouri (MO), Kentucky (KY), Oklahoma (OK), West Virginia (WV), and Washington District of Columbia (DC). These jurisdictions are home to 58% of all Black Americans, i.e., nearly 3 in every 5 Black Americans. [22–24] The discriminatory Jim-Crow laws segregated black and white populations in all spheres of life, including housing, healthcare, education, and social services. They were often enforced violently through the state or sanctioned groups [12].

While the US healthcare system provides care for some populations better than others, a causal link between historical discriminatory practices and contemporary disease burden has been reported [15, 18]. However, constructs for structural racism represent hidden exposures not amenable to direct observation or measurement. The Pathways to Health Equity framework [25–28] identifies structural inequities in US healthcare systems that place Black individuals at heightened risk for adverse health outcomes. Historically ingrained structural racism in the healthcare system, laws, and policies may partly explain the racial imbalance in TB outcomes. Even though the Civil Rights Act of 1964 dismantled the discriminatory statutes, inequities experienced by one generation may be felt across subsequent generations through what has been termed "intergenerational drag" [25–28], i.e., the long reach of past practices and the impact on contemporary practices of structural racism [15, 28]. The effect of inequities engendered decades ago by such discriminatory laws and other historical discriminatory practices, such as redlining, have been shown to continue to influence contemporary healthcare and outcomes such as cancer staging at diagnosis and birth outcomes [13, 14].

Several studies have shown that the abolition of Jim-Crow laws benefited black health by improving working and living conditions and the immediate impact of the desegregation of hospital facilities. This likely reduced black vs. white health inequities [5–9]. The effects of racial inequities and structural racism engendered by the relic of Jim Crowism in the U.S. Southern States have not been analyzed as a social determinant and risk factor in contemporary mortality and morbidity due to TB. Furthermore, the effects of historical structural racism on communicable and non-communicable diseases contrasting racial groups is essential to help understand and contextualize present-day racial health disparities and inform corrective interventions. We sought to elucidate the complicity in promoting racial discrimination as belonging to the past and dispel the myth that Jim-Crow laws are unrelated to modern-day health outcomes. Whether the observed dramatic decline in TB mortality between 1990 and 2019 [1] was evenly or differentially spread across or within states is unclear. Also unknown is the differential burden of TB outcomes (e.g., mortality and morbidity) by race and whether a state has a history of Jim-Crow laws. Confounding these questions is that estimation conducted by networks such as the GBD does not stratify data by race. In addition, local data at the county level is lagging by about five years, which necessitates creative strategies to help policymakers allocate resources or develop alternative interventions to help curtail future discriminatory health policies to create equity in healthcare.

Local-level data are crucial to address the root causes of poor health and early death among disadvantaged groups in the USA, eliminate health disparities, and increase longevity for all [29]. We, therefore, sought to compare TB mortality rates and annualized rate of change (AROC) between 1990 and 2019 in former Jim-Crow vs. non-Jim-Crow states to help guide response efforts and inform resource prioritization to improve racial equity. Furthermore, in each state, we assessed whether and how TB mortality between 1990 and 2014 (the latest period for which GBD county-level data is available) varied between the county with the highest proportion of the White population and the county with the highest proportion of the Black population. With emerging pandemics such as COVID-19 in mind, understanding the fundamental role of racism at the intersection of science, medicine, and politics over time shows the complex ways of discrimination mandated by laws (de jure) such as Jim-Crow laws and customs and practices (de facto) that continue to impact health and warns of dangers to avoid in the future.

Methods

Our conceptual model is informed by Krieger's ecosocial analysis as applied to the issue of racism and health [14, 28–31]. Ecosocial system theory, as encapsulated at the state level by Jim-Crow laws, posits that inequitable race relations can simultaneously [32, 33] (a) benefit the groups who claim racial superiority at the expense of those whom they deem intrinsically inferior, (b) racialize biology to produce and justify the same categories used to demarcate racial/ethnic groups, and (c) generate inequitable living and working conditions that, via embodiment, result in the biological expression of racism-and hence racial/ethnic health inequities [33]. A result is that there are many pathways, not just one, by which discrimination could harm health, i.e., they comprise economic and social deprivation, causing health-harming responses to discrimination and resulting in inadequate medical care [30, 31, 34, 35].

The GBD study is a systematic, scientific effort to quantify the comparative magnitude of health loss due to diseases, injuries, and risk factors by age, sex, and location. The conceptual and analytical framework for GBD and detailed methods have been published elsewhere. [3]. We used the GBD study data [1] to test hypotheses and compared states without a history of Jim-Crow laws. The comprehensive methodology, global approach, and systematic nature of the GBD modeling makes it ideal for testing our hypotheses. We also tested the hypotheses that compared with counties with the highest White population in an individual state, counties with the highest proportion of the Black population in the same state had a) higher mortality due to TB over the 1990 to 2014 period and b) less robust rate of decline from 1990 to 2014, more so than in former Jim-Crow states.

Since the GBD study does not segregate disease burden by race, we first created a proxy for racialized segregation by identifying in each state a county with the highest proportion of the Black population and a second county with the highest proportion of the White population using data from the annually updated US Census Bureau, Population Estimates Program (PEP) [22], the Mundi American Community Survey (ACS) website, https://www.indexmundi.com/facts/united-states/quick-facts/new-york/black-population-percentage#chart [23], and the American Community Survey (ACS) [24]. We then compared mortality rates and AROC between 1990 and 2014, the most recently available years for state-level GBD study data. Our objective was to mimic extremes in the proportion of the White and Black populations to help assess differences between the two races as a surrogate or imperfect proxy for racialized social segregation within each state. Age-standardized rates were made according to the new WHO World Standard Population to facilitate comparisons globally and remove the confounding effect of age [36]. In direct standardization, the rate is a weighted average of the age-specific rates, where the weights are the proportions of the World Standard Population in the corresponding age groups [37].

Case definition

The TB definition used in the GBD study includes all forms of TB, including pulmonary and extrapulmonary, which are bacteriologically confirmed or clinically diagnosed before death or at autopsy. The GBD study definition, paraphrased below, is in greater detail in the Supplement to GBD Tuberculosis Collaborators, pages 3–4 [4]. For TB, the ICD 10 codes are A10-A19.9, B90-B90.9, K67.3, K93.0, M49.0, P37.0, and ICD 9 codes are 010–019.9, 137–137.9, 138.0, 138.9, 139.9, 320.4, 730.4–730.6. For HIV-TB, the ICD 10 code is B20.0. Latent TB infection is defined as an infection with Mycobacterium TB without any symptoms or signs of active TB disease, as described below. The ICD 10 codes for TB included the following:

- Multidrug-resistant (MDR) TB without extensive drug resistance: a form of TB (among HIV-negative individuals) that is resistant to the two most effective first-line anti-TB drugs (isoniazid and rifampicin) but is not resistant to any fluoroquinolone and any second-line injectable drugs (amikacin, kanamycin, or capreomycin).
- Extensively drug-resistant (XDR) TB is a form of TB (among HIV-negative individuals) resistant to isoniazid and rifampicin, plus any fluoroquinolone and any second-line injectable drugs.
- Drug-susceptible TB: TB (among HIV-negative individuals) is susceptible to isoniazid and rifampicin.
- Multidrug-resistant HIV-TB without extensive drug resistance is a form of TB (among HIV-positive individuals) resistant to the two most effective first-line anti-TB drugs (isoniazid and rifampicin) but not resistant to any fluoroquinolone and second-line injectable drugs (amikacin, kanamycin, or capreomycin).
- Extensively drug-resistant HIV-TB: a form of TB (among HIV-positive individuals) resistant to isoniazid and rifampicin, plus any fluoroquinolone and any second-line injectable drugs.
- Drug-susceptible HIV-TB: TB (among HIV-positive individuals) is susceptible to isoniazid and rifampicin.

TB mortality among HIV-negative individuals was modeled for each sex using the Cause of Death Ensemble model (CODEm) framework with varying combinations of predictive covariates [36–39]. CODEm is a highly systematized tool to analyze cause of death data using an ensemble of different modelling methods for rates or cause fractions with varying choices of covariates that perform best with out-of-sample predictive validity testing [38–42]. Covariates used in the CODEm framework can be found in the appendix ((see: http://ghdx.healthdata.org/gbd-2017/code (Global Burden of Disease Study 2017 (GBD 2017)—Causes of Death 5)). TB mortality among HIV-positive individuals was estimated using a population-attributable fraction approach consistent with previous GBD cycles [43, 44]

Input data

The description of input data is in the Supplement to GBD TB Collaborators,

Page 37 [4]. Briefly, input data for latent TB infection included population-based tuberculin surveys and cohort studies examining the risk of developing active TB disease as a function of induration size. TB-related deaths in the GBD study are defined as the number of deaths caused by TB in people who are either HIV-negative or HIV-positive. Input data is obtained from vital registration, autopsy, and other sources of mortality information. This data is used to estimate the outcome measure described below.

Outcome measures

The GBD results tool extracted sex-pooled age-standardized morbidity and mortality from 1990 to 2019 (http://ghdx.healthdata.org/gbd-results-tool).

Deaths, YLLs, YLDs, and DALYs

The duration people live with TB is assessed using TB-specific mortality rates and TB-specific years of lives lost (YLLs). TB deaths were multiplied by standard life expectancy at each age to calculate YLLs. How long people have been sick with TB is assessed using years of healthy life lost due to the disability (YLDs). Adding together YLLs and YLDs yields disability-adjusted life years (DALYs). The three metrics are weighted for disease severity and age-standardized for comparison over time and across geographic locations (GBD 2019 Diseases and Injuries Collaborators, Supplementary Appendix 1). [41]

Change in mortality rates over time

For changes over time, we present annualized age-standardized rates of change (AROC) as the percent difference in the natural logarithm of the rate in 1990 and 2019 divided by 30 (i.e., 100*[ln(2019 Rate/1990 Rate)/(30)].

AROC (%) is a crude measure of a trend over 30 years. A positive AROC indicates an increasing trend/slope or acceleration of mortality over the 30 years of TB, and a negative AROC indicates a decreasing trend/slope or deceleration of mortality. To put negative AROC into perspective, two locations with different negative AROCs (e.g., -1.0% and -2.0%) indicate that the decline in mortality rate is less robust in the location with the lesser absolute AROC (-1.0%) than the decline in the location with the larger absolute AROC (-2.0%) (see Fig. 1).

Uncertainty analysis

Uncertainty for each outcome was quantified using uncertainty intervals (UIs) based on 1000 bootstrap draws from the posterior distribution. [38, 43]. UIs were determined by the 25th and 975th ordered values of the posterior distribution of the 1000 draws, and point estimates were computed from the mean. Changes over time were considered statistically significant when the 95% UI of the percentage change did not include zero.

Statistical, analytical, processing, and estimation codes used to generate the GBD results are available on their website: http://ghdx.healthdata.org/gbd-2017/code (Global Burden of Disease Study 2017 [40]. Data for individual states' counties are available up to 2014 at https://vizhub.healthdata.org/subnational/usa.

Reporting guidelines

The study did not require an Institutional Review Board ethical review or informed consent as it used public GBD results. The GBD study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines [43]. In addition, all GBD estimates adhere to the 14 Guidelines on Accurate and Transparent Health Estimate Reporting (GATHER). [44]. GATHER recommends making available statistical code, details of why some sources are used, and others are not, and how primary data are statistically adjusted.

Results

The presentation of results is arranged in the following sequence: a) mortality rates due to TB by state between 1990 and 2019; b) Comparison of mortality rates, rate ratios (RRs), and AROCs in former Jim-Crow states vs.

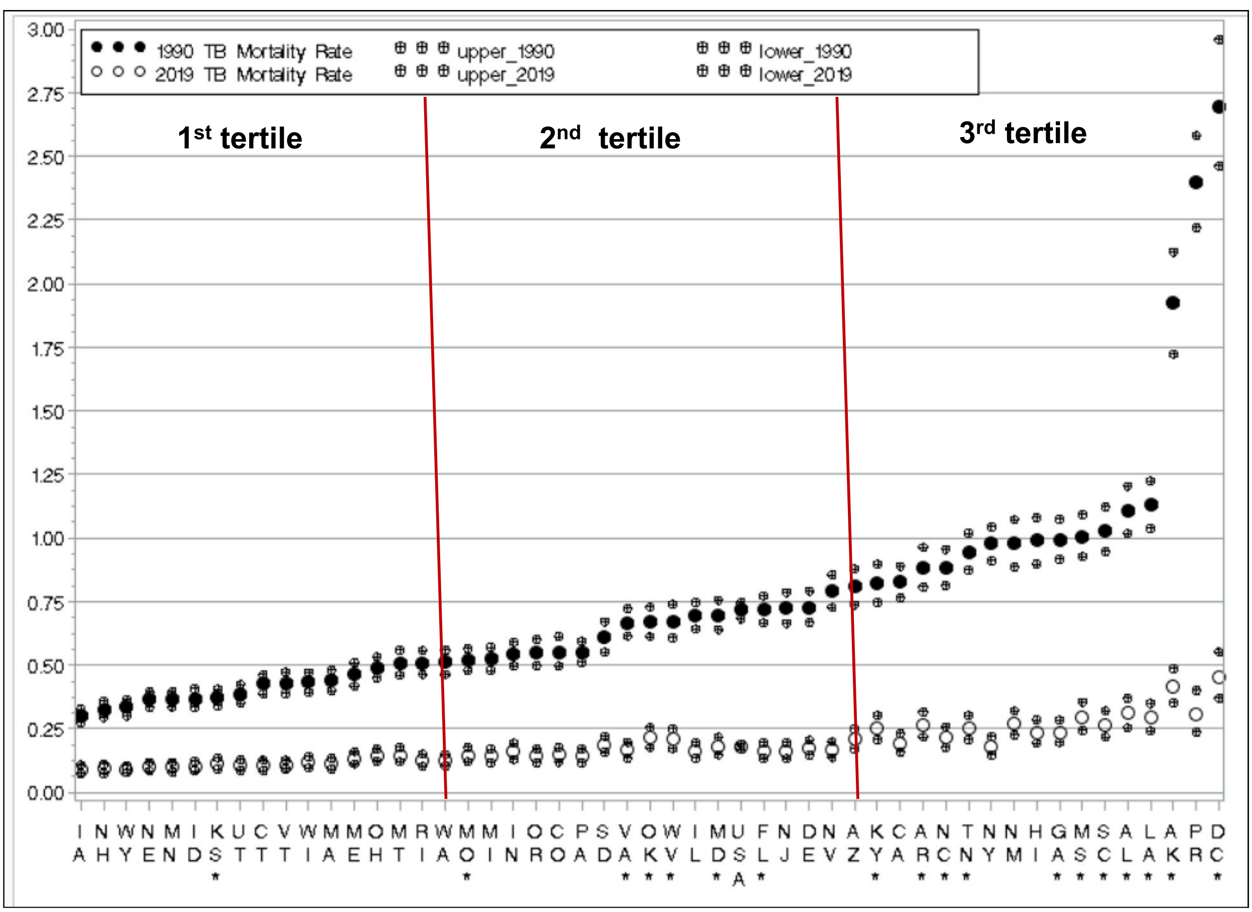

Fig. 1 Age-standardized TB mortality rate per 100,1000 population by U.S. State, 1990 and 2019

states that did not enact Jim-Crow laws; c) mortality rates and RRs in 1990 and 2014 in each state comparing pairs of counties with the highest Black and White populations.

TB Mortality rates and DALYs rates by state between 1990 and 2019;

Table 1 shows tuberculosis mortality rates and DALYs rate per 100,000 population and annualized rate of change, 1990 to 2019. Compared to 1990, mortality due to TB declined substantially in all states in 2019. The greatest decline was in Washington DC, with mortality in 1990 of 2.69 (2.46–2.96), which declined nearly six-fold to 0.45 (0.37–0.55) in 2019, corresponding to an AROC (%) of -0.83% (-0.86; -0.79). The smallest decline was observed in Iowa, with 0.30 (0.27–0.33) mortality declining to 0.09 (0.07–0.11) in 2019, corresponding to an AROC of -0.70% (-0.76; -0.63). In addition, most former Jim-Crow states had the highest burden of TB mortality in 1990 and 2019, whereas most non-Jim-Crow states had the lowest burden. Of the 17 states with the highest tertile of TB mortality in both 1990 and 2019, eleven (KY, AR, NC, TN, TX, GA, MS, SC, AL, LA, AK, and DC) had a history of Jim-Crow laws. In contrast, none of the 17 states in the lowest tertile had a history of such laws. DALY rates ranged from 15.37(14.02–16.85) to 84.90(77.88–92.43) in 1990 and 4.49(3.76–5.34) to 13.57(11.47–16.21) in 2019 former Jim-Crow states the compared with 9.10 (8.17–10.12) to 71.0 (64.4–76.5) in 1990 and 2.76 (2.32–3.29) to 11.90 (10.29–13.63) in 2019 for non-Jim-Crow states. In former Jim-Crow States, the AROC for YLDs ranged from -0.76 (-0.81; -0.71) for Texas to -0.56(-0.64; -0.45) for Oklahoma; whereas in non-Jim-Crow states the AROC for YLDs ranged from -0.73 (-0.78; -0.67) for New Mexico to -0.54(-0.62; -0.44) for Hawaii. AROC for YLLs in former Jim-Crow States, the ranged from -0.85(-0.81; -0.88) for Washington DC to -0.55 to (-0.64; -0.44) for Texas; whereas in non-Jim-Crow states the AROC for YLLs ranged from -0.85(-0.81; -0.88) for New York to -0.62 (-0.69; -0.52) for New Mexico. (Table 2).

Mortality rate ratios in former Jim-Crow states vs. states that did not enact Jim-Crow laws

The race-pooled state-level estimates shown in Table 1, Figs. 1 and 2 can potentially mask county-level disparities and racial (Black vs. White) disparities in the burden of TB. While the GBD study does not estimate disease burden by race, county-level data is available only up to 2014. (https://vizhub.healthdata.org/subnational/usa). As described above, for each state, we identified proxies for racial segregation by selecting the county with the highest proportion of the Black population and the county with the highest proportion of the White population (https://www.indexmundi.com/facts/united-states/quick-facts/new-york/black-population-percentage#chart) as established by the US Census Bureau's Population Estimates Program (PEP) [22], Mundi American Community Survey (ACS).[23], and American Community Survey (ACS), [23]. For example, in Mississippi, as shown in Table 3, Claiborne County has an 86.1% Black population, the highest in the state. In contrast, in the same state, Tishomingo County has a 95.8% White population, the highest.

Figure 3 shows 1990 vs. 2014 TB Mortality Rate Ratios of the pair of counties in each state, i.e., one county in the with the highest proportion of Black over the TB Mortality Rate for the county with the highest White population in the state. The black dots represent the Black/White TB mortality rate ratios for 1990, whereas the black circles represent the Black/White rate ratios for 2014. The gap between these 1990 vs the 2014 rate ratios represent the widening relative disparity for each state in the Black vs. White burden of TB mortality between 1990 and 2014.We calculated the corresponding AROC shown in Table 3 and Fig. 3. The Black/White RRs are an imperfect proxy for racial disproportionality in mortality. Under the null, i.e., in the absence of racial disparity, the RR should be approximately equal to 1.0; an RR substantially greater (lower) than 1.0 indicates a greater (lesser) burden in the county with a predominantly Black population.

Tuberculosis mortality rates and Black/White rate ratios comparing former Jim-Crow states vs. states that did not enact Jim-Crow laws

Table 3 shows the overall mortality and race (Black, White), AROC, and Black/White RR for each period for the selected county pairs for each state in 1990 and 2014. We clarify and emphasize here that the comparison of mortality in pairs of counties in each state with the highest proportion of the Black and White population does not represent a perfect or direct comparison. Instead, an attempt to reasonably approximate differences in the TB burden in racialized segregation settings whereby the county with the highest Black population serves as a proxy for "the location where the Black population is most concentrated" and similarly "the location where the White population is most concentrated" without insinuating that either county has an exclusively Black or exclusively White population.

The gap in Fig. 3 between the two curves represents the Black vs. White disproportionality in mortality for each state. Notably, for the most part, in Fig. 3, the RRs in 2014 (black circles) were above the 1990 RRs (black dots), implying that Black vs. White disparities, in general, worsened in 2014. The Black vs. White RRs between 1990 and 2014 were more prominent in former

Table 1 Age-standardized tuberculosis mortality rates and DALYs rate per 100,000 population and annualized rate of change, 1990 to 2019

Former Jim Crow	1990 Death Rate (95% UIs)	2019 Deaths Rate (95% UIs)	AROC (%)	1990 DALYs Rate (95% UIs)	2019 DALYs Rate (95% UIs)	AROC (%)
Alabama	1.11 (1.02–1.20)	0.31 (0.25–0.37)	-0.72 (-0.77; -0.65)	32.28(29.81–35.07)	9.33(7.76–11.02)	-0.71 (-0.76; -0.65)
Arkansas	0.88 (0.81–0.96)	0.26 (0.22–0.32)	-0.70(-0.76; -0.63)	26.45(24.37–28.82)	8.03 (6.71–9.57)	-0.70(-0.75; -0.63)
Washington DC	2.69 (2.46–2.96)	0.45 (0.37–0.55)	-0.83(-0.86;-0.79)	84.90(77.88–92.43)	13.57(11.47–16.21)	-0.84(-0.87;-0.80)
Florida	0.72(0.67–0.77)	0.16 (0.13–0.20)	-0.77(-0.82; -0.73)	22.64(20.97–24.39)	5.36 (4.42–6.36)	-0.76 (-0.80; -0.72)
Georgia	0.99 (0.92–1.07)	0.24 (0.20–0.28)	-0.76(-0.81) -0.71)	29.48(27.22–31.89)	7.08 (5.89–8.40)	-0.76 (-0.80; -0.72)
Kentucky	0.82 (0.75–0.90)	0.25 (0.21–0.30)	-0.69(-0.75; -0.62)	23.25(21.46–25.17)	7.33(6.14–8.84)	-0.68 (-0.74; -0.62)
Louisiana	1.13 (1.04–1.22)	0.29 (0.24–0.35)	-0.74(-0.79; -0.69)	33.50(31.04–36.31)	8.92(7.4–10.65)	-0.73(-0.78; -0.68)
Maryland	0.70 (0.64–0.76)	0.18 (0.15–0.22)	-0.74(-0.79; -0.69)	19.89(18.34–21.54)	5.43(4.51–6.41)	-0.73(-0.77; -0.68)
Mississippi	1.01 (0.93–1.09)	0.30 (0.24–0.35)	-0.71(-0.76; -0.64)	30.34(27.91–33.00)	8.98(7.53–10.75	-0.70(-0.75; -0.65)
Missouri	0.52 (0.48–0.57)	0.15 (0.12–0.18)	-0.72(-0.77; -0.66)	15.37(14.02–16.85)	4.49(3.76–5.34)	-0.71(-0.76;- 0.65)
North Carolia	0.88 (0.81–0.96)	0.21 (0.18–0.26)	-0.76(-0.80; -0.71)	25.49(23.52–27.42)	6.25(5.26–7.36)	-0.75(-0.79; -0.71)
Oklahoma	0.67 (0.61–0.73)	0.21 (0.18–0.26)	-0.68(-0.74;-0.61)	19.82(18.23–21.60)	6.49 (5.39–7.69)	-0.67(-0.73; -0.61)
South Carolina	1.03 (0.95–1.12)	0.26 (0.22–0.32)	-0.74(-0.79; -0.69)	31.09(28.77–33.75)	7.85 (6.52–9.34)	-0.75(-0.79; -0.70)
Tennessee	0.95 (0.87–1.02)	0.25(0.21–0.30)	-0.73(-0.78; -0.67)	26.87(24.87–28.99)	7.46(6.25–8.92)	-0.72(-0.77; -0.67)
Texas	0.96 (0.90–1.03)	0.24(0.19–0.29)	-0.75(-0.80; -0.69)	27.76(26.02–29.72)	7.12(5.88–8.56)	-0.74(-0.79; -0.69)
Virginia	0.67(0.62–0.72)	0.17(0.14–0.20)	-0.75(-0.80; -0.70)	18.70(17.28–20.27)	4.82(4.06–5.74)	-0.74(-0.78; -0.70)
West Virginia	0.67(0.61–0.74)	0.21(0.17–0.25)	-0.69(-0.75; -0.61)	19.76(18.10–21.61)	6.21(5.15–7.25)	-0.69(-0.74; -0.62)
Non-Jim Crow						
Connecticut	0.43(0.39–0.46)	0.10(0.09–0.13)	-0.75(-0.80;-0.70)	12.60(11.54–13.75)	3.19(2.65–3.79)	-0.75(-0.79; -0.70)
Massachusetts	0.44(0.40–0.48)	0.11(0.09–0.13)	-0.75(-0.80; -0.69)	12.80(11.73–14.00)	3.48(2.87–4.19)	-0.73(-0.77; -0.68)
New Jersey	0.72(0.66–0.79)	0.16(0.13–0.19)	-0.78(-0.82; -0.73)	21.23(19.58–22.87)	4.94 (4.18–5.88)	-0.77(-0.80; -0.72)
New York	0.98(0.91–1.04)	0.18(0.15–0.22)	-0.81(-0.85; -0.77)	32.75(30.46–35.13)	5.62(4.68–6.63)	-0.83(-0.86; -0.80)
Pennsylvania	0.55 (0.51–0.59)	0.14(0.12–0.17)	-0.74(-0.79; -0.69)	15.91(14.71–17.31)	4.29(3.60–5.13)	-0.73(-0.77; -0.68)
Alaska	1.93(1.72–2.13)	0.41 (0.35–0.49)	-0.78 (-0.82; -0.74)	49.12 (44.81–53.42)	11.90(10.29–13.63)	-0.76 (-0.80; -0.72)
Arizona	0.81 (0.74–0.88)	0.21 (0.17–0.25)	-0.74 (-0.79; -0.68)	23.58 (21.68–25.67)	6.29(5.23–7.46)	-0.73(-0.78; -0.68)
California	0.83 (0.76–0.89)	0.19 (0.16–0.23)	-0.77(-0.81; -0.72)	24.48 (22.60–26.37)	5.73 (4.84–6.72)	-0.77(-0.80; -0.72)
Colorad	0.55 (0.50–0.61)	0.15 (0.12–0.18)	-0.73(-0.79; -0.68)	15.54 (14.20–17.06)	4.21 (3.49–4.98)	-0.73 (-0.78; -0.68)
Delaware	0.73 (0.67–0.79)	0.17 (0.15–0.20)	-0.76(-0.80;-0.72)	20.65 (18.99–22.51)	5.15 (4.40–5.98)	-0.75(-0.79; -0.71)
Hawaii	0.99 (0.90–1.08)	0.24 (0.19–0.28)	-0.76(-0.81; -0.71)	28.20 (25.79–30.62)	7.20 (6.00–8.53)	-0.74 (-0.79; -0.69)
Idaho	0.37(0.33–0.41)	0.10 (0.09–0.12)	-0.72(-0.77; -0.66)	11.04 (9.93–12.18)	3.00 (2.56–3.57)	-0.73 (-0.77; -0.68)
Illinois	0.70(0.64–0.75)	0.16 (0.13–0.20)	-0.76(0.81; -0.71)	21.18 (19.56–22.79)	4.97 (4.12–5.93)	-0.77 (-0.80; -0.72)
Indiana	0.54 (0.50–0.59)	0.16 (0.13–0.19)	-0.71(-0.76; -0.64)	15.66 (14.29–17.02)	4.74 (3.95–5.63)	-0.70 (-0.75; -0.64)
Iowa	0.30 (0.27–0.33)	0.09 (0.07–0.11)	-0.70(-0.76; -0.63)	9.10 (8.17–10.12)	2.82 (2.31–3.39)	-0.69 (-0.74; -0.63)
Kansas	0.37 (0.34–0.40)	0.11 (0.09–0.14)	-0.70(-0.76; -0.63)	11.31(10.31–12.37)	3.48 (2.88–4.19)	-0.69(-0.75; -0.64)
Maine	0.46 (0.42–0.51)	0.13 (0.11–0.16)	-0.71(-0.76; -0.65)	13.05 (11.84–14.38)	3.80 (3.21–4.49)	-0.71 (-0.75; -0.66)
Michigan	0.52(0.48–0.57)	0.14 (0.12–0.17)	-0.73(-0.78; -0.67)	15.72 (14.42–17.28)	4.28 (3.58–5.08)	-0.73(-0.78; -0.67)
Minnesota	0.37 (0.34–0.40)	0.10(0.08–0.12)	-0.73(-0.78; -0.67)	10.46 (9.51–11.48)	3.07 (2.54–3.62)	-0.71(-0.75; -0.66
Montana	0.51(0.46–0.56)	0.15 (0.12–0.18)	-0.71 (-0.77; -0.64)	14.81 (13.53–16.33)	4.31 (3.58–5.22)	-0.71 (-0.76; -0.65)
Nebraska	0.37(0.34–0.40)	0.10 (0.08–0.12)	-0.73(-0.78; -0.67)	10.96 (10.04–12.09)	3.01 (2.54–3.56)	-0.72(-0.77; -0.68)
Nevada	0.79(0.73–0.85)	0.17(0.14–0.20)	-0.79(-0.83; -0.75)	21.32 (19.59–23.09)	4.91 (4.08–5.83)	-0.77(-0.81; -0.72)
NH	0.33(0.29–0.36)	0.09 (0.07–0.11)	-0.72(-0.78; -0.65)	9.53 (8.65–10.59)	2.76 (2.32–3.29)	-0.71(-0.76; -0.66)
New Mexico	0.98(0.89–1.07)	0.27(0.23–0.32)	-0.72 (-0.77; -0.67)	28.55 (26.10–31.00	8.14 (6.86–9.50)	-0.71 (-0.76; -0.66)
North Dakota	0.44(0.40–0.48)	0.13 (0.11–0.16)	-0.70(-0.75; -0.63)	12.68 (11.40–13.98	4.07 (3.49–4.77)	-0.68(-0.73; -0.62)
Ohio	0.49(0.45–0.53)	0.15 (0.12–0.17)	-0.70(-0.76; -0.65)	14.23 (13.05–15.45)	4.35 (3.68–5.09)	-0.69(-0.74; -0.64)
Oregon	0.55(0.50–0.60)	0.14 (0.12–0.17)	-0.74 (-0.79;-0.68)	15.58 (14.1–16.98)	4.15 (3.51–4.89)	-0.73(-0.78; -0.68))
Rhode Island	0.51 (0.46–0.56)	0.13 (0.10–0.15)	-0.75(-0.80; -0.70)	14.84 (13.62–16.20)	3.80 (3.20–4.46)	-0.74(-0.78; -0.70)
South Dakota	0.61 (0.55–0.67)	0.19(0.16–0.22)	-0.70(-0.75; -0.63)	7.71 (16.04–19.56)	5.57 (4.80–6.57)	-0.69(-0.74; -0.63)
Utah	0.39(0.35–0.42)	0.11 (0.09–0.13)	-0.73 (-0.78; -0.66)	11.48 (10.40–12.65)	3.13 (2.59–3.77)	-0.73(-0.77;-0.67)

Table 1 (continued)

Former Jim Crow	1990 Death Rate (95% UIs)	2019 Deaths Rate (95% UIs)	AROC (%)	1990 DALYs Rate (95% UIs)	2019 DALYs Rate (95% UIs)	AROC (%)
Vermont	0.43(0.39–0.47)	0.11 (0.09–0.13)	-0.75(-0.79; -0.70)	12.39 (11.21–13.76)	3.15 (2.69–3.63)	-0.75(-0.78; -0.71)
Washington	0.51(0.46–0.56)	0.13 (0.10–0.15)	-0.75(-0.80; -0.70)	14.62 (13.35–15.89)	3.79 (3.20–4.47)	-0.74(-0.78; -0.69)
Wisconsin	0.43(0.39–0.47)	0.12(0.10–0.14)	-0.73(-0.78; -0.67)	12.46 (11.33–13.60)	3.40 (2.82–4.02)	-0.73(-0.77; -0.68)
Wyoming	0.33 (0.30–0.37)	0.09(0.08–0.10)	-0.73(-0.77; -0.68)	10.21 (9.13–11.37)	2.84 (2.44–3.25)	0.72(-0.76; -0.68)
USA	0.72 (0.68–0.75)	0.18 (0.17–0.19)	-0.75(-0.76; -0.73)	21.60(20.44–22.75)	5.48 (5.03–5.96)	-0.75(0.76; -0.73)

Source: https://vizhub.healthdata.org/subnational/usa and http://ghdx.healthdata.org/gbd-results-tool

ALYs Disability-Adjusted Life Years, *UI* Uncertainty Interval, *AROC* Annualized rate of change (%) in rate per 100,000 population from 1990 to 2019

Jim-Crow states than in non-Jim-Crow states. For example, between 1990 and 2014, the RRs increased 3.58 times (1.25 to 4.47) for Georgia, 2.86 (0.85 to 2.43) for Tennessee, 2.07 (1.35 to 2.80) for Arkansas, 1.52 to 1.72 times for five other states (West Virginia, South Carolina, Florida, Mississippi and Maryland); i.e. 8 of the 16 (50%) former Jim-Crow states. In contrast 7 of the 34 (i.e., approximately 1 in 5) non-Jim-Crow states (Minnesota, Alaska, Nebraska, Wisconsin, Idaho, New Mexico, and South Dakota) had RRs ranging from 1.53 to 1.83.

AROCs in counties with the highest Black and White proportions in each state

Figure 4 and Table 3 show that from 1990 to 2014, the counties with the largest proportion of Black population. The absolute values for AROCs for counties with the highest White population generally larger, i.e., more robust (black dots) than the absolute values for AROCs for counties with a predominantly Black population (black circles). For example, Georgia's Clayton County, a county with a 72.1% black population in a former Jim-Crow states, had a mortality of 0.96 (0.75–1.17) in 1990, which modestly declined to 0.67 (0.50–0.87) in 2014, yielding an AROC of -1.44%. In Contrast, Fannin County, also in Georgia with a 96.8% White population, had a mortality of 0.77 (0.56–1.05) in 1990; the rate declined more than five-fold to 0.15 (0.09–0.22) in 2014, corresponding to a robust AROC of -6.54%. Arizona's Maricopa County, with a tiny but highest proportion of the Black population of 6.3%, had a mortality of 1.51(1.08–2.05) in 1990, which drastically declined to 0.21(0.13–0.32) in 2014, yielding a dramatic and highest AROC of -7.89%. In sharp contrast, however, still, in Arizona, Santa Cruz County, with a 95.7% White population, had a mortality of 1.06 (0.95–1.18) in 1990, which declined four-fold to 0.26 (0.23–0.30) in 2014, had an AROC of -5.62%, i.e., over two percentage points lower than Maricopa County in the same state. Similar flipped AROCs favorable to the county with the largest Black population were observed between pairs of counties, i.e., Wyandotte County (-4.39%) vs. Greeley County (-3.71%) in Kansas, Jefferson County (6.16%) vs. Starr (-3.42%) in Texas, and Arapahoe County (-6.44%) vs. Yuma County (-5.23%) in Colorado. Flipped AROCs tend to happen when the proportion of the Black population in the selected county is small to moderate and the proportion of the White population in the selected county is greater than 90%. This suggests that by the complement rule, the two counties are "approximately homogenous," i.e., counties being compared are not divergent in their racial makeup, suggesting that our approach to approximate racialized segregation is not without limitations.

Discussion

We studied the association between historical structural racism and health disparities in TB's burden in US states and counties. What has been missing from the medical and public health discourse is the link between the disproportionality in adverse health outcomes affecting racial minorities with structural racism and other historical conditions that create poor health, such as residential segregation [10, 13, 14, 19, 26]. We sought to describe mortality rate differences and changes over 30 years between states with vs. without a history of Jim-Crow laws. Given that states have different racial demographics, we compared counties with the highest proportion of white population in each state vs. counties with the highest proportion of black population.

Our main finding is that mortality due to TB declined substantially in all states between 1990 and 2019. However, most former Jim-Crow states had higher TB mortality rates than non-former Jim-Crow states. The rate of decline was generally sluggish in former Jim-Crow states than in states that did not implement such laws. In the analysis of pairs of counties in each state, the county with the highest Black population had higher mortality than the county with the highest proportion of the White population. We found that in the counties with the highest proportion of the Black population, the rates of mortality decline were modest compared

Table 2 Age-standardized tuberculosis YLDs and YLLs rate per 100,000 population and annualized rate of change, 1990 to 2019

Former Jim Crow	1990 YLDs Rate (95% UI)	2019 YLDs Rate (95% UI)	AROC (%)	1990 YLLs Rate (95% UI)	2019 YLLs Rate (95% UI)	AROC (%)
Alabama	2.88(1.85–4.08)	1.19 (0.78–1.70)	-0.59(-0.67; -0.49)	29.40(27.10–31.87)	8.14 (6.66–9.75)	-0.72(-0.66; -0.78)
Arkansas	2.72(1.73–4.00)	1.17(0.76–1.66)	-0.57(-0.65;-0.47)	23.73 (21.96–25.80)	6.86 (5.62–8.27)	-0.71(-0.64; -0.76)
Washington DC	4.35 (2.78–6.18)	1.55(1.01–2.18)	-0.64(-0.71; -0.56)	80.56(73.96–88.02)	12.02 (9.90–14.55)	-0.85(-0.81; -0.88)
Florida	2.33(1.47–3.35)	0.99 (0.63–1.43)	-0.58(-0.66; -0.48)	20.31(18.96–21.72)	4.38 (3.57–5.26)	-0.78(-0.73; -0.83)
Georgia	2.88 (1.81–4.12)	1.16 (0.76–1.66)	-0.60(-0.67; -0.50)	26.60 (24.68–28.66)	5.91 (4.82–7.16)	-0.78(-0.73; -0.82)
Kansas	1.91 (1.24–2.71)	0.74 (0.48–1.06)	-0.61(-0.68; -0.53)	9.40(8.68–10.14)	2.74 (2.20–3.29)	-0.71(-0.65; -0.77)
Kentucky	2.46(1.55–3.63)	0.98(0.63–1.40)	-0.60(-0.68; -0.50)	20.79(19.22–22.49)	6.35(5.18–7.66)	-0.69(-0.62; -0.76)
Louisiana	2.89(1.85–4.16)	1.19(0.77–1.70)	-0.59(-0.67; -0.48)	30.61(28.28–33.13)	7.72(6.37–9.28)	-0.75(-0.69; -0.80)
Maryland	2.38(1.51–3.44)	0.97(0.62–1.40)	-0.59(-0.67; -0.50)	17.51(16.24–18.88)	4.47(3.64–5.37)	-0.75(-0.69; -0.80)
Mississippi	2.90(1.85–4.24)	1.20(0.77–1.72)	-0.59(-0.67; -0.48)	27.45(24.45–29.72)	7.78(6.40–9.47)	-0.72(-0.65; -0.77)
Missouri	2.14(1.33–3.12)	0.81 (0.52–1.16)	-0.62(-0.69;- 0.54)	13.23 (12.25–14.33)	3.68 (3.04–4.49)	-0.72(-0.65; -0.77)
North Carolina	2.65(1.72–3.85)	0.97(0.62–1.40)	-0.63(-0.71; -0.53)	22.84(21.18–24.45)	5.28(4.36–6.34)	-0.77(-0.72; -0.81)
Oklahoma	2.28(1.45–3.22)	1.01(0.65–1.43)	-0.56(-0.64; -0.45)	17.54(16.12–18.88)	5.49 (4.46–6.57)	-0.69(-0.62; -0.75)
South Carolina	2.89(1.85–4.21)	1.10(0.71–1.61)	-0.62(-0.69; -0.53)	28.20(26.08–30.57)	6.74(5.49–8.21)	-0.76(-0.70; -0.81)
Tennessee	2.67(1.70–3.89)	1.08(0.71–1.54)	-0.60(-0.67; -0.50)	24.20(22.51–26.01)	6.38(5.24–7.71)	-0.74(-0.68; -0.79)
Texas	2.65(1.69–3.83)	1.19(0.77–1.69)	-0.76 (-0.81; -0.71)	25.11(23.63–26.65)	5.94 (4.77–7.17)	-0.55 (-0.64; -0.44)
Virginia	2.29(1.42–3.34)	0.88 (0.58–1.29)	-0.61(-0.69; -0.52)	16.42(15.23–17.63)	3.94 (3.26–4.76)	-0.76(-0.71; -0.80)
West Virginia	2.42(1.54–3.49)	0.84(0.53–1.22)	-0.65(-0.72; -0.56)	17.35(15.96–18.90)	5.37(4.38–6.44)	-0.69(-0.62; -0.75)
Non-Jim Crow						
Connecticut	1.99(1.29–2.83)	0.73(0.47–1.05)	-0.63(-0.69; -0.56)	10.62 (9.83–11.42)	2.46 (1.99–2.96)	-0.77(-0.72; -0.81)
Massachusetts	1.94(1.24–2.74)	0.85(0.55–1.23)	-0.56(-0.63; -0.49)	10.87(10.06–11.71)	2.63(2.14–3.19)	-0.76(-0.70; -0.81)
New Jersey	2.37(1.50–3.50)	1.00(0.65–1.44)	-0.58(-0.66; -0.47)	18.86(17.43–20.27)	3.94(3.25–4.73)	-0.79(-0.74; -0.83)
New York	2.77(1.81–4.05)	1.10(0.71–1.58)	-0.60(-0.68; -0.51)	29.98 (27.98–32.02)	4.52(3.69–5.47)	-0.85(-0.81; -0.88)
Pennsylvania	2.15(1.41–3.12)	0.79(0.52–1.13)	-0.63(-0.70; -0.54)	13.76(12.89–14.71)	3.50(2.90–4.28)	-0.75(-0.68; -0.79)
Alaska	3.74 (2.45–5.40)	1.59 (1.02–2.27)	-0.57(-0.65;-0.46)	45.38 (41.36–49.67)	10.30 (8.88–11.96)	-0.77(-0.73; -0.81)
Arizona	2.41 (1.53–3.46)	1.00 (0.65–1.44)	-0.58(-0.67; -0.47)	21.17 (19.50–22.85)	5.29 (4.28–6.42)	-0.75 (-0.80; -0.69)
California	2.66 (1.68–3.92)	1.17 (0.75–1.68)	-0.56(-0.64; -0.46)	21.82 (20.29–23.33)	4.56 (3.75–5.46)	-0.79(-0.74; -0.83)
Colorado	2.12 (1.38–3.10)	0.71 (0.46–1.03)	-0.66(-0.72; -0.60)	13.42 (12.30–14.66)	3.50 (2.83–4.20)	-0.74(-0.68; -0.79)
Delaware	2.39 (1.51–3.40)	0.91 (0.58–1.31)	-0.62(-0.69; -0.52)	18.26 (16.85–19.80)	4.24 (3.59–5.04)	-0.77(-0.72; -0.81)
Hawaii	2.96 (1.89–4.24)	1.36 (0.89–1.93)	-0.54(-0.62; -0.44)	25.25 (23.13–27.43)	5.84 (4.77–7.06)	-0.77(-0.71; -0.81)
Idaho	2.02 (1.29–2.93)	0.63 (0.40–0.93)	-0.69(-0.74; -0.62)	9.03 (8.30–9.83)	2.37 (1.98–2.85)	-0.74(-0.68; -0.78)
Illinois	2.41 (1.51–3.52)	0.94 (0.61–1.35)	-0.61(-0.69; -0.50)	18.77 (17.54–20.13)	4.03 (3.31–4.86)	-0.79(-0.74; -0.83)
Indiana	2.17 (1.38–3.14)	0.78 (0.50–1.13)	-0.64(-0.70; -0.56)	13.49 (12.45–14.61)	3.95 (3.22–4.81)	-0.71(-0.64; -0.76)
Iowa	1.85 (1.17–2.69)	0.67 (0.43–0.97)	-0.64(-0.70; -0.57)	7.25 (6.66–7.91)	2.15 (1.75–2.59)	-0.70(-0.63; -0.76)
Maine	2.07 (1.33–2.95)	0.70 (0.45–1.02)	-0.66(-0.72; -0.60)	10.99 (10.10–11.90)	3.10 (2.60–3.72)	-0.72(-0.65; -0.77)
Michigan	2.19 (1.35–3.19)	0.80 (0.51–1.14)	-0.64(-0.70; -0.55)	13.52 (12.57–14.60)	3.48 (2.86–4.18)	-0.74(-0.68; -0.79)
Minnesota	1.80 (1.18–2.59)	0.80 (0.53–1.15)	-0.55(-0.62; -0.48)	8.65 (8.00–9.31)	2.27 (1.87–2.72)	-0.74(-0.68; -0.79)
Montana	2.16 (1.36–3.10)	0.72 (0.46–1.03)	-0.72 (-0.77; -0.64)	12.65 (11.51–13.74)	3.60 (2.96–4.45)	-0.67 (-0.73; -0.59)
Nebraska	1.94 (1.27–2.81)	0.65 (0.42–0.94)	-0.67(-0.72; -0.61)	9.02 (8.32–9.80)	2.37 (1.97–2.83)	-0.74(-0.68; -0.79)
Nevada	2.38 (1.49–3.46)	0.97 (0.62–1.38)	-0.59(-0.67; -0.48)	18.94 (17.54–20.36)	3.94 (3.23–4.76)	-0.79(-0.74; -0.83)
NH	1.92 (1.23–2.83)	0.63 (0.40–0.92)	-0.67(-0.72; -0.62)	7.61 (7.0–8.27)	2.13 (1.73–2.59)	-0.72(-0.66; -0.78)
New Mexico	2.73 (1.77–3.96)	1.05 (0.68–1.47)	-0.73 (-0.78; -0.67)	25.81 (23.74–28.05)	7.09 (5.92–8.42)	-0.62 (-0.69; -0.52)
North Dakota	2.06 (1.35–3.05)	0.74 (0.48–1.09)	-0.64(-0.70; -0.56)	10.61 (9.72–11.56)	3.33 (2.79–3.96)	-0.69(-0.61; -0.74)
Ohio	2.10 (1.35–3.01)	0.75 (0.48–1.08)	-0.64(-0.70; -0.57)	12.12 (11.28–13.00)	3.60 (3.01–4.28)	-0.70(-0.64; -0.76)
Oregon	2.07 (1.34–2.96)	0.79 (0.51–1.14)	-0.62(-0.68; -0.54)	13.50 (12.42–14.65)	3.36 (2.74–4.05)	-0.75(-0.69; -0.80)
Rhode Island	2.13 (1.35–3.06)	0.85 (0.55–1.21)	-0.60(-0.67; -0.51)	12.71 (11.82–13.75)	2.95 (2.43–3.53)	-0.77(-0.72; -0.81)
South Dakota	2.27 (1.46–3.30)	0.84 (0.53–1.21)	-0.63(-0.69; -0.54)	15.44 (14.11–16.91)	4.73 (4.01–5.65)	-0.69(-0.63; -0.75)
Utah	2.01 (1.28–2.90)	0.66 (0.42–0.96)	-0.67(-0.73; -0.61)	9.47 (8.69–10.25)	2.46 (2.00–3.02)	-0.74(-0.68; -0.79)
Vermont	2.17 (1.36–3.18)	0.64 (0.40–0.91)	-0.71(-0.76; -0.64)	10.22 (9.33–11.09)	2.51 (2.16–2.92)	-0.75(-0.71; -0.79)

Table 2 (continued)

Former Jim Crow	1990 YLDs Rate (95% UI)	2019 YLDs Rate (95% UI)	AROC (%)	1990 YLLs Rate (95% UI)	2019 YLLs Rate (95% UI)	AROC (%)
Washington	2.02 (1.32–2.92)	0.88 (0.57–1.25)	-0.57(-0.63; -0.48)	12.60 (11.62–13.73)	2.92 (2.41–3.49)	-0.77 (-0.72; -0.81)
Wisconsin	1.97 (1.24–2.87)	0.61 (0.39–0.88)	-0.69(-0.74; -0.63)	10.49 (9.69–11.33)	2.79 (2.28–3.35)	-0.73(-0.68; -0.79)
Wyoming	2.01 (1.29–3.00)	0.69 (0.44–1.01)	-0.66(-0.72;-0.58)	8.19 (7.49–8.86)	2.15 (1.86–2.47)	-0.74 (-0.69; -0.77)
USA	2.41 (1.62–3.41	0.98 (0.64–1.40)	-0.59(-0.63; -0.56)	19.19 (18.50–19.82)	4.51 (4.26–4.73)	-0.77(-0.75; -0.78)

Source: https://vizhub.healthdata.org/subnational/usa and http://ghdx.healthdata.org/gbd-results-tool

YLLs Years of life lost due to premature mortality, *YLDs* Years lived with disability, *AROC* Annualized rate of change (%) in rate per 100,000 population from 1990 to 2019, *UI* Uncertainty Interval

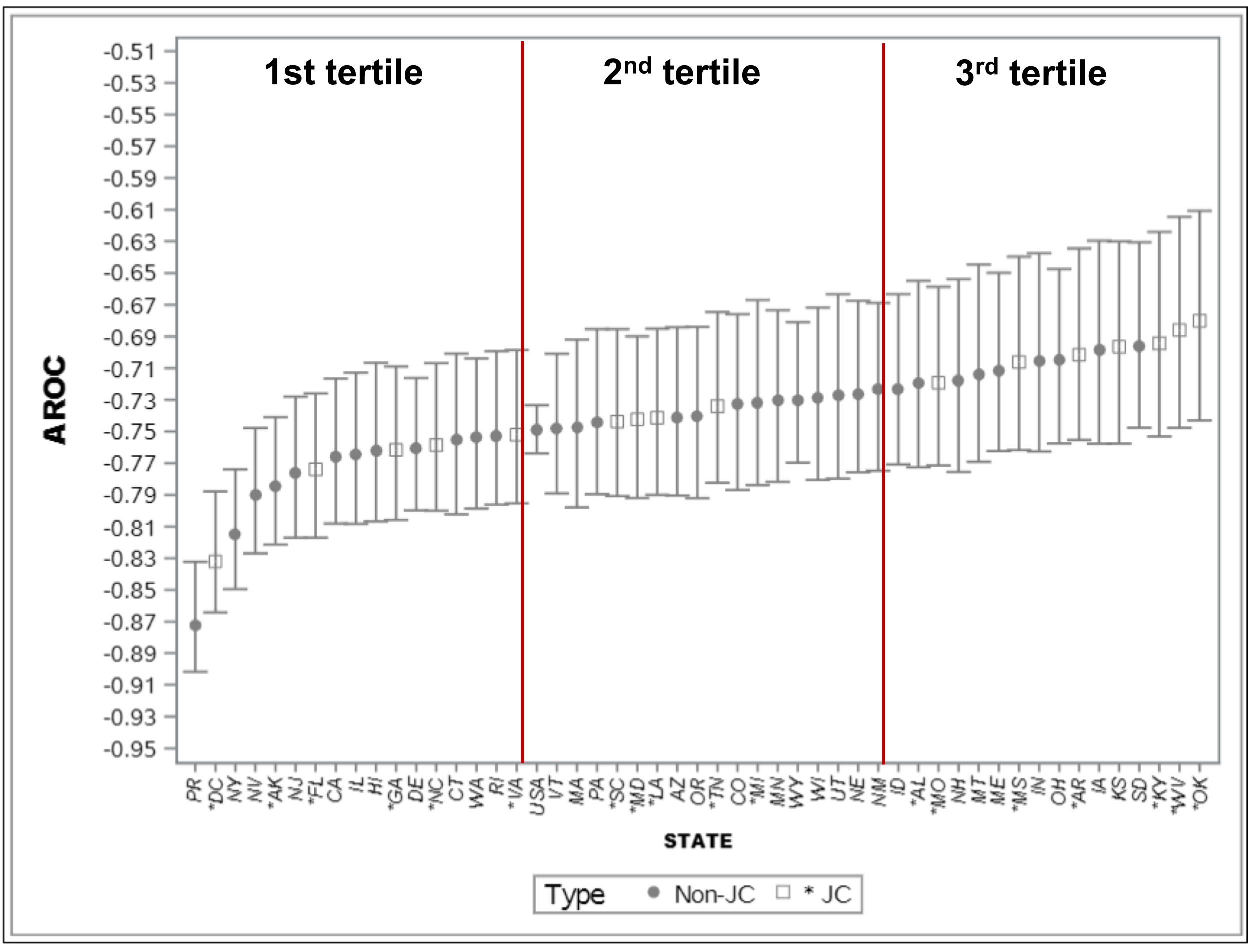

Fig. 2 Age-standardized 1990–2019 AROC(%) for for Tuberculosis-related mortality in all U.S. States

with counties with a predominantly White population. If these divergent trends continue unabated, the significant disparities across states will only increase. Even though the Jim-Crow laws have since been repealed, their effect persists; we attribute the state-level and county-level disproportionality in TB mortality rate to the lingering effects of structural racism. Our findings are discussed concerning various socioeconomic risk factors, political and healthcare financing, mistrust, and historical factors that may be expected to influence the burden of TB. Notably, latent factors such as mistrust, and historical factors that influence the burden of TB are not directly observable, therefore are not easy to quantify or to account for in statistical analysis. We also

Table 3 Age-standardized tuberculosis mortality rate per 100,000 population and annualized rate of change in mortality rate in state county with highest proportion of Black population vs. county with highest White population, 1990 and 2014

Jim Crow States	% Black	% White	County with most Black population (%)	1990 Mortality (95% UI)	2014 Mortality (95% UI)	AROC (%)	County with most White population (%)	1990 Mortality (95% UI)	2014 Mortality (95% UI)	AROC (%)	1990 RR (B/W)	2014 RR (B/W)
Mississippi	38.7	59.1	Claiborne (86.1)	2.07 (1.53–2.72)	0.70 (0.47–1.00)	-4.34	Tishomingo (95.8)	1.22 (0.90–1.68)	0.27 (0.17–0.42)	-6.03	1.70	2.59
Louisiana	32.7	62.9	East Carroll (68.7)	2.27 (1.72–2.96)	0.73 (0.50–1.05)	-4.54	Cameron (93.2)	0.62 (0.45–0.84)	0.17 (0.11–0.24)	-5.18	3.66	4.29
Georgia	32.4	60.5	Clayton (72.1)	0.96 (0.75–1.17)	0.67 (0.50–0.87)	-1.44	Fannin (96.8)	0.77 (0.56–1.05)	0.15 (0.09–0.22)	-6.54	1.25	4.47
Maryland	30.9	58.8	Prince George's (64.4)	0.98 (0.85–1.11)	0.28 (0.23–0.34)	-5.01	Garrett (97.5)	0.64 (0.45–0.86)	0.12 (0.07–0.17)	-6.70	1.53	2.33
South Carolina	27.1	68.5	Allendale (73.1)	3.16 (2.42–4.18)	1.15 (0.76–1.66)	-4.04	Oconee (89.2)	0.80 (0.60–1.03)	0.18 (0.12–0.26)	-5.97	3.95	6.39
Alabama	26.8	69.1	Macon (80.7)	2.89 (2.22–3.61)	0.54 (0.38–0.75)	-6.71	Winston, 96.2	1.17 (0.85–1.62)	0.26 (0.15–0.42)	-6.02	2.47	2.08
North Carolina	22.2	70.6	Bertie (61.2)	2.67 (2.08–3.39)	0.66 (0.48–0.91)	-5.59	Ashe (96.9)	0.61 (0.43–0.85)	0.11 (0.07–0.17)	-6.85	4.38	6.00
Virginia	19.9	69.5	Petersburg City (77.2)	2.39 (1.76–3.18)	0.51 (0.33–0.78)	-6.18	Dickenson (98.3)	1.19 (0.78–1.70)	0.18 (0.10–0.32)	-7.56	2.01	2.83
Tennessee	17.1	78.5	Shelby (54.2)	1.12 (0.98–1.28)	0.56 (0.46–0.68)	-2.77	Picket (98.4)	1.32 (0.90–1.90)	0.23 (0.12–0.38)	-6.99	0.85	2.43
Florida	16.9	77.3	Gadsden (55.8)	2.10 (1.15–2.60)	0.67 (0.48–0.93)	-5.57	Citrus (93.0)	0.69 (0.53–0.87)	0.14 (0.10–0.21)	-6.38	3.04	4.79
Arkansas	15.7	79.1	Phillips (62.0)	1.15 (1.15–1.92)	0.42 (0.29–0.57)	-4.03	Clay (97.1)	0.85 (0.58–1.21)	0.15 (0.09–0.24)	-6.94	1.35	2.80
Texas	12.8	78.8	Jefferson (34.1)	1.68 (1.27–2.14)	0.36 (0.24–0.51)	-6.16	Starr (98.7)	1.27 (1.07–1.50)	0.54 (0.42–0.67)	-3.42	1.32	0.67
Missouri	11.8	83.0	St Louis City (46.9)	1.40 (1.18–1.66)	0.29 (0.22–0.38)	-6.30	Schuyler (98.2)	0.54 (0.36–0.76)	0.11 (0.08–0.18)	-6.36	2.59	2.64
Kentucky	7.8	87.6	Fulton (24.2)	1.20 (0.87–1.66)	0.17 (0.11–0.25)	-7.82	Jackson (98.7)	1.15 (0.81–1.61)	0.26 (0.16–0.41)	-5.95	1.04	0.65
Oklahoma	7.8	74.2	Comanche (17.6)	1.08 (0.82–1.38)	0.30 (0.22–0.41)	-5.12	Harper (95.0)	0.43 (0.28–0.61)	0.12 (0.07–0.19)	-5.11	2.51	2.50
West Virginia	3.6	93.5	Gilmer (11.0)	0.81 (0.54–1.18)	0.22 (0.12–0.37)	-5.21	Lincoln (98.3)	1.08 (0.80–1.43)	0.17 (0.11–0.25)	-7.40	0.75	1.29
Non-Jim Crow States												
Connecticut	12.0	80.0	Hartford (15.7)	0.67 (0.57–0.79)	0.18 (0.14–0.23)	-5.23	Litchfield (93.6)	0.54 (0.42–0.69)	0.10 (0.07–0.14)	-6.75	1.24	1.80
Massachusetts	8.9	80.8	Suffolk (24.7)	1.46 (1.24–1.69)	0.29 (0.23–0.37)	-6.47	Franklin (93.8)	0.52 (0.37–0.72)	0.11 (0.07–0.16)	-6.21	2.81	2.64

Table 3 (continued)

Jim Crow States	% Black	% White	County with most Black population (%)	1990 Mortality (95% UI)	2014 Mortality (95% UI)	AROC (%)	County with most White population (%)	1990 Mortality (95% UI)	2014 Mortality (95% UI)	AROC (%)	1990 RR (B/W)	2014 RR (B/W)
New Jersey	15.0	72.0	Essex (41.9)	2.50 (2.23–2.78)	0.38 (0.32–0.46)	-7.54	Sussex (93.5)	0.67 (0.50–0.88)	0.12 (0.08–0.17)	-6.88	3.73	3.17
New York	17.6	69.7	Westchester (16.6)	0.88 (0.75–1.02)	0.18 (0.14–0.23)	-6.35	Lewis (97.1)	0.45 (0.30–0.64)	0.10 (0.06–0.16)	-6.02	1.96	1.80
Penn	12.0	81.8	Philadelphia (43.7)	1.72 (1.56–1.90)	0.34 (0.28–0.40)	-6.71	Elk (98.0)	0.46 (0.33–0.65)	0.09 (0.05–0.13)	-6.53	3.74	3.78
Alaska	3.8	65.3	Aleutians E (11.6)	2.36 (1.56–3.86)	0.73 (0.37–1.27)	-4.69	Skagway (86.0)	2.33 (1.59–3.36)	0.42 (0.24–0.69)	-6.85	1.01	1.74
Arizona	5.1	82.8	Maricopa (6.3)	1.51 (1.08–2.05)	0.21 (0.13–0.32)	-7.89	Santa Cruz (95.7)	1.06 (0.95–1.18)	0.26 (0.23–0.30)	-5.62	1.42	0.81
California	6.5	72.1	Solano (14.8)	1.21 (1.08–1.46)	0.34 (0.26–0.42)	-5.08	Nevada (93.4)	0.57 (0.43–0.76)	0.12 (0.08–0.17)	-6.23	2.12	2.83
Colorado	4.6	87.1	Arapahoe (11.4)	1.15 (1.01–1.30)	0.23 (0.19–0.27)	-6.44	Yuma (96.6)	0.48 (0.34–0.65)	0.13 (0.08–0.20)	-5.23	2.40	1.77
Delaware	23.0	69.5	Kent (26.8)	1.08 (0.85–1.37)	0.31 (0.23–0.42)	-4.99	Sussex (82.9)	1.06 (0.85–1.30)	0.25 (0.19–0.34)	-5.78	1.02	1.24
Idaho	0.9	93.0	Elmore (3.4)	0.45 (0.33–0.60)	0.12 (0.08–0.17)	-5.29	Oneida (97.5)	0.36 (0.25–0.51)	0.06 (0.04–0.10)	-7.17	1.25	2.00
Illinois	14.6	76.9	Alexander (32.3)	1.46 (1.05–1.99)	0.30 (0.18–0.46)	-6.33	Calhoun (98.5)	0.46 (0.33–0.61)	0.08 (0.05–0.12)	-7.00	3.17	3.75
Indiana	9.8	85.1	Marion (28.9)	1.07 (0.92–1.24)	0.32 (0.26–0.39)	-4.83	Greene (97.9)	0.67 (0.50–0.90)	0.16 (0.11–0.22)	-5.73	1.60	2.00
Iowa	4.0	90.7	Black Hawk (9.7)	0.57 (0.45–0.74)	0.14 (0.10–0.20)	-5.62	Grundy (98.1)	0.38 (0.26–0.52)	0.08 (0.05–0.12)	-6.23	1.50	1.75
Maine	1.6	94.6	Androscoggin (4.4)	0.71 (0.52–0.94)	0.13 (0.09–0.20)	-6.79	Franklin (96.8)	0.55 (0.36–0.79)	0.10 (0.06–0.16)	-6.82	1.29	1.30
Michigan	14.1	79.3	Wayne (38.8)	1.45 (1.32–1.60)	0.34 (0.29–0.40)	-5.80	Keweenaw (97.8)	0.54 (0.37–0.76)	0.09 (0.06–0.14)	-7.17	2.69	3.78
Minnesota	6.8	84.1	Hennepin (13.6)	0.77 (0.65–0.89)	0.25 (0.20–0.30)	-4.50	Lincoln (97.9)	0.45 (0.32–0.64)	0.08 (0.05–0.13)	-6.91	1.71	3.13
Montana	0.6	89.0	Cascade (1.6)	0.70 (0.52–0.94)	0.15 (0.10–0.21)	-6.16	Garfield (98.3)	0.43 (0.29–0.63)	0.07 (0.04–0.11)	-7.26	1.63	2.14
Nebraska	5.1	88.3	Douglas (11.4)	0.73 (0.60–0.89)	0.26 (0.20–0.33)	-4.13	Garfield (99.0)	0.46 (0.30–0.69)	0.10 (0.06–0.16)	-6.10	1.59	2.60
Nevada	10.1	74.3	Clark (12.8)	0.92 (0.78–1.06)	0.31 (0.26–0.38)	-4.35	Eureka (91.8)	0.46 (0.31–0.67)	0.11 (0.06–0.16)	-5.72	2.00	2.82

Table 3 (continued)

Jim Crow States	% Black	% White	County with most Black population (%)	1990 Mortality (95% UI)	2014 Mortality (95% UI)	AROC (%)	County with most White population (%)	1990 Mortality (95% UI)	2014 Mortality (95% UI)	AROC (%)	1990 RR (B/W)	2014 RR (B/W)
New Hampshire	1.7	93.2	Hillsborogh (3.0)	0.47 (0.37–0.58)	0.12 (0.09–0.16)	-5.46	Carroll (97.0)	0.49 (0.34–0.69)	0.10 (0.06–0.15)	-6.36	0.96	1.20
New Mexico	2.6	82.0	Curry (7.1)	0.75 (0.55–1.00)	0.21 (0.14–0.31)	-5.09	Harding (96.0)	0.61 (0.44–0.83)	0.11 (0.07–0.17)	-6.85	1.23	1.91
North Dakota	3.5	87.0	Cass (6.3)	0.55 (0.41–0.73)	0.14 (0.10–0.20)	-5.47	Griggs (98.3)	0.51 (0.35–0.72)	0.10 (0.06–0.15)	-6.52	1.08	1.40
Ohio	13.0	81.9	Cuyahoga (30.5)	0.91 (0.80–1.04)	0.25 (0.20–0.31)	-5.17	Holms ((98.6)	0.53 (0.37–0.75)	0.12 (0.07–0.18)	-5.94	1.72	2.08
Oregon	2.2	86.8	Multnomah (6.1)	1.13 (0.96–1.32)	0.26 (0.21–0.32)	-5.88	Wallowa (95.7)	0.43 (0.31–0.58)	0.09 (0.06–0.14)	-6.26	2.63	2.89
Rhode Island	8.4	83.9	Providence (12.3)	0.74 (0.62–0.89)	0.20 (0.15–0.25)	-5.23	Bristrol (94.1)	0.55 (0.38–0.77)	0.11 (0.07–0.18)	-6.44	1.35	1.82
South Dakota	2.4	84.4	Minnehaha (6.6)	0.49 (0.37–0.64)	0.15 (0.10–0.20)	-4.74	Hand (97.9)	0.45 (0.31–0.62)	0.09 (0.06–0.14)	-6.44	1.09	1.67
Utah	1.4	90.7	Salt Lake (2.2)	0.76 (0.64–0.92)	0.17 (0.14–0.22)	-5.99	Morgan (97.3)	0.34 (0.24–0.49)	0.06 (0.04–0.09)	-6.94	2.24	2.83
Vermont	1.4	94.2	Chittenden (2.6)	0.56 (0.40–0.75)	0.12 (0.08–0.18)	-6.16	Orange (96.8)	0.47 (0.31–0.69)	0.09 (0.05–0.14)	-6.61	1.19	1.33
Washington	4.3	78.9	Pierce (7.6)	0.75 (0.62–0.89)	0.19 (0.15–0.24)	-5.49	Lincoln (94.0)	0.35 (0.25–0.49)	0.08 (0.05–0.12)	-5.90	2.14	2.38
Wisconsin	6.7	87.1	Milwaukee (27.2)	1.04 (0.91–1.19)	0.33 (0.27–0.40)	-4.59	Pepin (97.9)	0.41 (0.29–0.56)	0.08 (0.05–0.12)	-6.54	2.54	4.13
Wyoming	1.3	92.6	Laramie (2.7)	0.66 (0.49–0.87)	0.14 (0.09–0.20)	-6.20	Crook (96.4)	0.41 (0.29–0.57)	0.08 (0.05–0.12)	-6.54	1.61	1.75
Kansas	6.1	86.4	Wyardotte (23.0)	1.08 (0.89–1.33)	0.36 (0.26–0.14)	-4.39	Greeley (97.6)	0.43 (0.29–0.62)	0.17 (0.07–0.17)	-3.71	2.51	2.12
Hawaii	2.2	25.6	Honolulu (2.8)	1.40 (1.14–1.69)	0.32 (0.23–0.42)	-5.90	Maui (34.9)	1.21 (0.89–1.68)	0.25 (0.15–0.39)	-6.31	1.16	1.28

Source: https://vizhub.healthdata.org/subnational/usa, 2014 is the latest GBD US county-level mortality data

UI ncertainty Interval, *1990 RR (B/W)* Risk ratio [mortality rate for county with highest proportion of Black population / mortality rate for county with highest proportion of White population

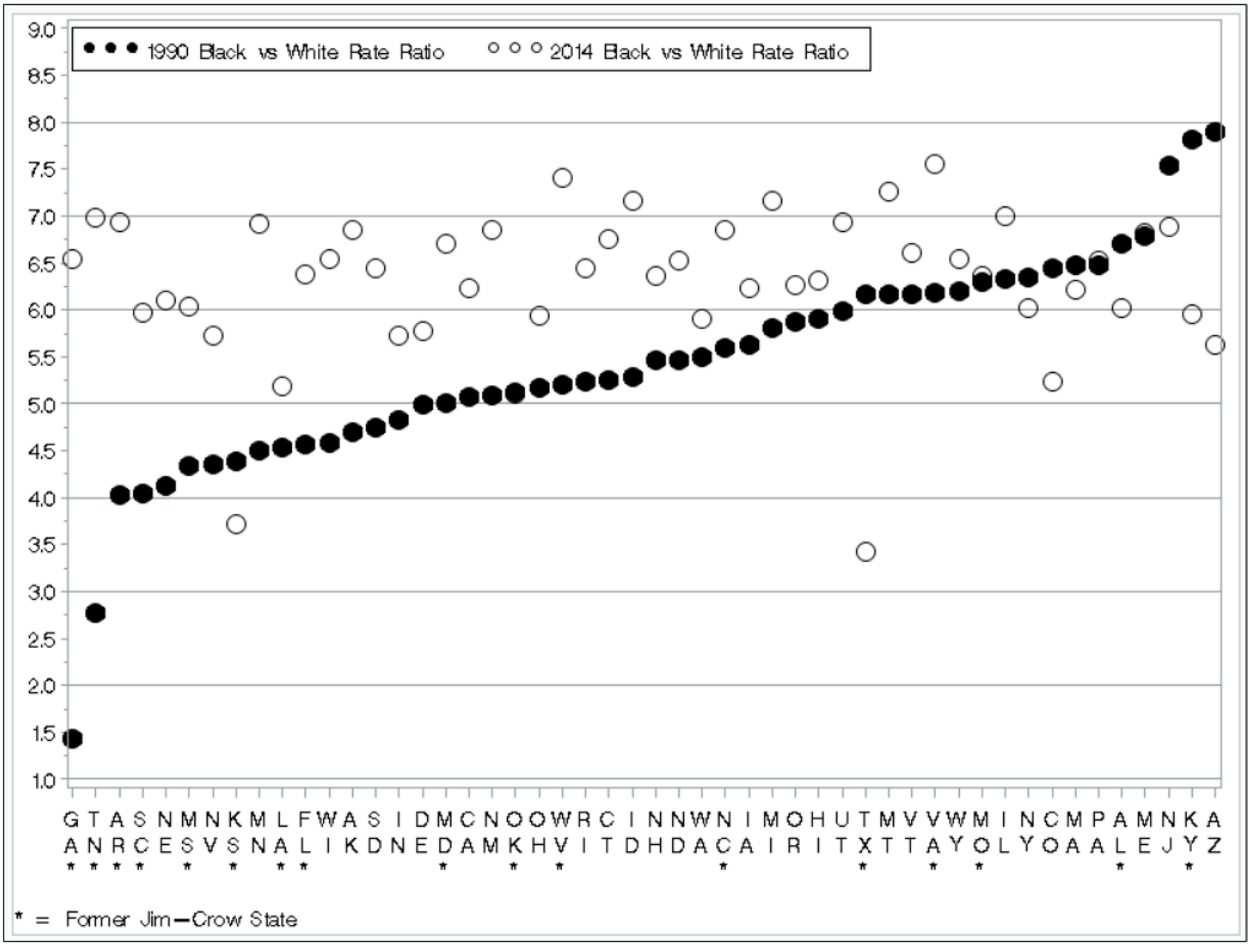

Fig. 3 1990 vs. 2014 TB Mortality Rate Ratios of the pair of counties in each state: one county in the with the highest proportion of Black over the TB Mortality Rate for the county with the highest White population in the state

discuss opportunities, strategies, and policy recommendations to encourage an equitable response. Leveraging on similarities between TB and COVID-19, our findings are also discussed in the context of COVID-19.

Health divides in the US unfold along racial and ethnic lines are well known. [10, 13, 14, 19]. Nationally, a 2019 small-area estimation revealed that life expectancies for Black Americans, 75.3 years [95% uncertainty interval [UIs]: 75.2 to 75.4] and American Indian or Alaska Native people, 73.1 years [71.5 to 74.8]) were shorter, whereas Asian and Pacific Island people, 85.7 years [85.3 to 86.0]), and Latino populations, 82.2 years [82.0 to 82.5]) were longer, compared with their White counterparts, 78·9 years [78·9 to 79·0]) [29]. Structural racism in healthcare manifests at the individual level before it becomes pervasive in the community. During the Jim-Crow era, when Black people showed up at a white-only hospital, the staff was likely to send them away, even if it meant they might die in the parking lot [45].

To qualitatively illustrate and provide context beyond quantitative data, the 1951 medical record of Henrietta Lacks [45], the Black woman whose peculiar cancer tumor gave rise to a perpetual cell line referred to as HeLa, sheds light on mistrust of the healthcare system [46]. In a chapter titled "The Exam" in Skloot R (2011) [45]. the medical record states, "Breathing difficult since childhood due to recurrent throat infection… Physician recommended surgical repair… *Patient declined.* Patient had unexplained vaginal bleeding, and blood in urine, physician recommended sickle cell test… *Patient declined.* Patient has asymptomatic neurosyphilis but cancelled syphilis treatment, said *she felt fine*…Tests showed areas of increased cellular activity in the cervix, Physician recommended diagnostics… *Patient cancelled appointment.* Patient tested positive for gonorrhea… Patient recalled to clinic… *No response*". The medical notes reveal the doctors' attitudes that bred non-cooperation. Doctors refused to acknowledge Lacks' pain in a chapter titled "A miserable Specimen" in Skloot R (2011)

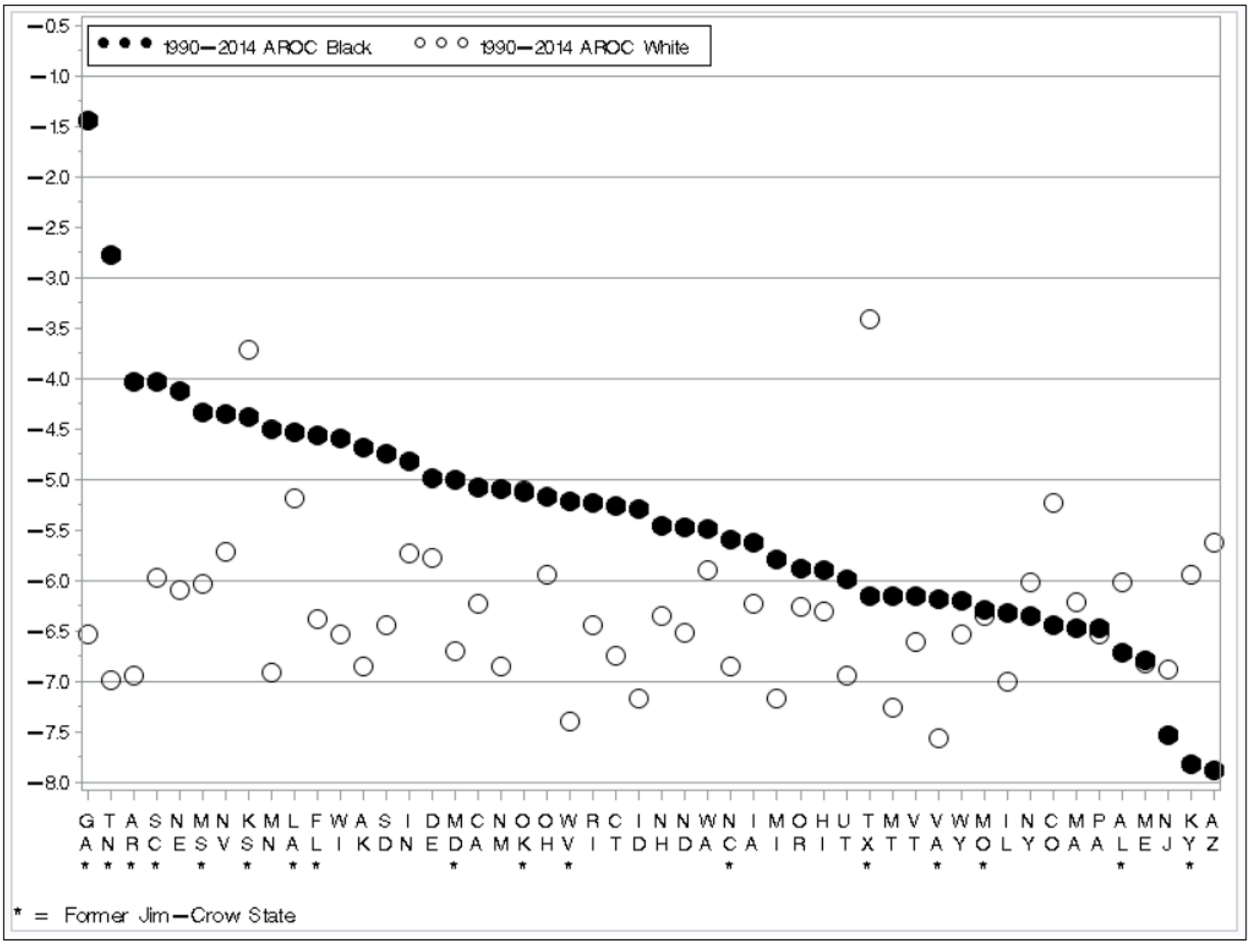

Fig. 4 AROC (%) in TB Mortality for the state county with highest proportion of Black and the state county with the highest white Population for 1990 and 2014

[45]., "Henrietta told her doctors that she thought her cancer was spreading, she could feel it moving through her, but they found nothing wrong with her, noting *the patient states that she feels fairly well, however, she continues to complain of some vague lower abdominal discomfort...., no evidence of recurrence. Return in one month.* After she returned complaining again of pain, the doctor pressed on her abdomen and felt a "stony hard mass." Doctors looked at the X-ray and concluded: *Inoperable. The patient looks chronically ill; she is obviously in pain…* He sent her home to bed. A month later, one doctor wrote: *In view of the rapid extension of the disease process, the outlook is pretty poor. … Patient has been complaining bitterly about pain, and she seems miserable, and it is felt that she deserves to be in the hospital where she can be better cared for*. Her terminal illness did not stop doctors from taking more cells from her cervix *to see if a second batch would grow like the first*. Her doctors stopped any radiation treatment and noted *Henrietta is still a miserable specimen, she groans, …, patient is acutely upset…, as far as I can see, we are doing all that can be done.*

A range of health inequalities has been especially apparent during the COVID-19 pandemic, which has had a disproportionately harmful effect on racial-ethnic groups [36, 47, 48] owing to the underlying social, structural, and environmental factors that have historically driven disparities across a broad range of health outcomes [29].

COVID-19 death rates were higher among blacks, and higher mortality occurred in working age groups, with a disproportionate number of deaths also occurring in essential workers who are racial minorities [49]. Mistrust in the US healthcare system is not unfounded. It reflects decades of medical mistreatment that continues today, as seen in the case of Dr. Susan Moore, a clinician in Indiana who died from COVID-19 after reporting racist treatment by healthcare workers. https://www.thinkglobalhealth.org/article/reducing-inequity-united-states-vaccine-rollout Black Americans are underrepresented among COVID-19 vaccine recipients despite relatively low rates of vaccine hesitancy [50]. Similar to our findings, the Institute for Health Metrics and Evaluation (IHME) confirmed that non-Hispanic Black Americans are more likely to die from COVID-19 than non-Hispanic whites (IHME, 2020 https://www.healthdata.org/acting-data/prevent-covid-19-deaths-prioritizing-interventions-hispanic-latino-and-black-populations). Hispanic/Latino and non-Hispanic Black Americans had higher exposure to the virus and increased risk of COVID-19 death, in part because of their labor market and limited ability to work from home. [49]. These findings could be used in designing and implementing preventive programs to reduce exposure through protective measures.

Our results provide the groundwork for future research to address policy strategies to improve access to primary care providers, public health professionals, community organizers, and health system strategies to increase awareness of the differential disease burden stemming from Jim's relic Crow. Our findings complement the US Department of Health and Human Services public education efforts, which recently launched its "Closing the Health Gap" campaign to heighten awareness of health disparities. The Institute of Medicine's "Unequal Treatment" [51, 52] also provides a detailed systematic examination of racial/ethnic disparities in healthcare and a blueprint for addressing them.

Professional societies should have explicit language for their membership about the harm caused by structural racism and promote restorative justice approaches as part of their professional ethics. Beyond issuing statements identifying structural racism as a scourge in today's healthcare landscape [51–58], professional organizations should advance to include the historical nature of structural racism and associated restorative justice issues in pre-licensure education, professional development through continuing medical education for license renewal and continued certification. Similarly, states and healthcare networks should create an ombudsperson to address complaints of barriers to care on racial grounds and implement punitive measures in direct contrast with Jim-Crow laws whereby violators who provided care to black patients at non-designated facilities could be appropriately disciplined.

Strengths

We presented age-standardized estimates of the burden of TB-related mortality, DALYs, YLDs, and YLLs. Such standardized rates facilitate direct comparison of TB burden across locations. GBD estimates follow GATHER and STROBE guidelines for reporting [43, 44]. Our methodology, defining structural racism based on the history of Jim-Crow laws, adds to the toolkit for studying and explaining contemporary social disadvantage in health outcomes, advancing research on minority health disparities associated with structural racism beyond the individual lived experience.

Limitations

Although imperfect, our approach reasonably assesses the problem. First, our method has not previously been used for this purpose; therefore, it has not been validated for use in health disparities-related constructs. Second, our analysis did not account for urban vs. rural settings. Health facilities in rural areas are less accessible than facilities in urban areas. Third, considering that the spread and transmission of TB are accentuated among people living in close quarters, our analysis did not account for population density or the population per square mile in the counties that we compared. Historically, predominantly Black neighborhoods are more likely to be densely populated or overcrowded than neighborhoods with predominantly white populations. Fourth, while GBD methods account for a composite social demographic index (SDI) [41], our analysis did not account for transient changes socioeconomic status, income, education, or medical insurance coverage, factors that are individually associated with TB care and disease outcomes. However, it has been reported that counties with a predominantly Black than White population have adverse socioeconomic indicators—lower median income and a higher proportion of the less educated, uninsured population. Undoubtedly, we may not have captured other factors that may also affect mortality rates. Fifth, our analysis is unable to disentangle individual-, social-, and environmental-level factors that influence the transmission of TB. Further research is needed to disentangle the effects of structural racism on the burden of TB. Another limitation is that the relationships we observed in comparing states and counties within states with and without the history of Jim-Crow laws and the burden of TB are only associative rather than causal. Finaly, the nature of GBD Study data does not allow end-uses to pool states or locations, i.e., it is not possible to conduct additional modelling outside the estimates provided in the results database.

Conclusions

Despite the limitations, filling the gap in understanding and knowledge will provide avenues for intervention on current health policies and help curtail future discriminatory policies such as those focused on housing, training a new generation of healthcare providers in cultural competency (how to think about race beyond interpersonal), cultural humility (reflective learning from others and being able to assess the role of structural racism) [14]. A recent cohort of 1618 US counties revealed that greater Black primary care physician (PCP) workforce representation is associated with better population health measures such as life expectancy for Black individuals. The study recommended that investments to build a more representative PCP workforce nationally may be necessary for improving population health [58]. Even though the 1964 Civil Rights Act dismantled Jim-Crow statutes, racial inequities in TB burden experienced by past generations may still be felt in subsequent generations. Understanding the role of historical structural racism at the intersection of science, medicine, and politics over time shows the complex ways Jim-Crow laws may continue to impact health negatively. The Civil Rights Act did not necessarily end segregation and other forms of racial discrimination, but the Act gave way to other forms of racialized economic exploitation such as predatory lending effects of which extended beyond states with a history of Jim-Crow laws [13, 14, 19]. Our study utilized the case for TB burden across US states to help elucidate the complicity in promoting racial discrimination as belonging to the past and dispel the myth that Jim-Crow laws are not related to modern-day health outcomes. Our study, therefore, helps contextualize the continuing role of ostensibly color-blind laws and policies and thus presents an opportunity to incorporate values like health, equity, and racial justice into public health ecosystems and infrastructures [12]. An understanding of the effects over time of structural racism engendered by historical segregation laws on the contemporary burden of TB allows for the more targeted allocation of resources in treating and preventing not just TB but other diseases as well. Further research will be needed to gain a more nuanced understanding of the health effects of structural racism.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-024-20522-9.

Below is the link to the electronic supplementary material.Supplementary Material 1.

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Authors' contributions
Contributions PNG conceptualized the study, had access to raw data, analyzed data, wrote the first draft of the manuscript, and interpreted the data. Lorena M. Estrada-Martinez, Lingling Zhang, Clara M Gona, Aaloke Mody, Ping Chen, Sowmya R Rao, Kibibi Mack-Shelton, Joseph N. Cooper, Suzanne G. Leveille, contributed to the clinical, epidemiological, policy implications sections, and strengthened the intellectual content and recommendations of the study. SRR co-wrote the first draft of the paper strengthened the intellectual content of the study. Ali H. Mokdad supervised the development of the study, critiqued earlier drafts, and shaped the overall interpretation in relation to previous related studies. The authors read and approved the final manuscript. Please note: We are publishing under the banner GBD 2019 TB Racial Disparity. We will provide a full author list upon acceptance of the paper.

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Data availability
GBD data is publicly available for anyone who registers at http://ghdx.healthdata.org/gbd-results-tool.

Declarations

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Competing interests
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