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Assessing Racial/Ethnic Differences in U.S. County-Level COVID-19 Mortality: Mediation by Socioeconomic Factors and Temporal Changes in the First Year

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Abstract

Extensive evidence shows that COVID-19 morbidity and mortality in the United States have been unevenly distributed across racial and ethnic groups, with minority populations experiencing disproportionately severe outcomes. This study revisits the role of race and ethnicity in shaping COVID-19 mortality during the first year of the pandemic. Using county-level data and an ecological regression design, the analysis contributes in two key ways. First, it quantifies the association between racial/ethnic composition and COVID-19 mortality for all major racial and ethnic groups at four distinct stages of the pandemic, allowing for an examination of how disparities changed over time. Second, it evaluates whether these associations persist after adjusting for basic socioeconomic factors (SEF), thereby shedding light on potential pathways underlying observed disparities. County racial and ethnic composition is measured using both continuous indicators (population shares) and categorical indicators capturing racial/ethnic plurality. The results demonstrate that counties with larger proportions of non-Hispanic Black, non-Hispanic American Indian and Alaska Native (AIAN), and Hispanic residents experienced higher COVID-19 mortality rates, though the magnitude and consistency of the associations varied across groups. The strongest and most persistent relationships were observed for Black and AIAN populations. Incorporating SEF into the models yielded divergent effects across groups. Among Hispanic populations, socioeconomic conditions largely explained the observed mortality differences. For Black populations, adjustment for SEF reduced but did not eliminate the association [a 1-standard deviation increase in Black population share corresponded to 62–6% higher mortality; mortality was 2.3–1.1 times greater in counties where Blacks constituted a plurality]. In contrast, the association for AIAN populations was minimally attenuated and, in some cases, strengthened [a 44–10% increase in mortality for a 1-standard deviation increase in AIAN share; mortality was 6.2–1.8 times higher in AIAN plurality counties]. Across all racial and ethnic groups, disparities in mortality generally narrowed as the pandemic progressed through its first year.

Keywords: COVID-19 Mortality, Socioeconomic factors, Temporal changes, Black populations

Introduction

From the outset of the COVID-19 pandemic, stark racial and ethnic disparities in health outcomes emerged in the United States. Early reporting highlighted that Black Americans were contracting and dying from COVID-19 at rates far exceeding those of White Americans [1]. By August 2020, data from the Centers for Disease Control and Prevention (CDC) indicated that American Indian or Alaska Native (AIAN) and Hispanic populations had infection rates nearly three times higher than those of non-Hispanic Whites, while Black or African American populations experienced infection rates approximately 2.6 times higher. Mortality disparities followed a similar pattern: deaths among Black Americans occurred at twice the rate observed among Whites, followed by AIANs and Hispanics [2].

These inequities remained evident one year into the pandemic. By March 2021, despite the introduction of COVID-19 vaccines, mortality rates per 100,000 population continued to be highest among Black populations, followed closely by AIANs and Hispanics, with Native Hawaiian or Other Pacific Islanders (NHPIs)

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also experiencing elevated mortality relative to Whites [3].

The persistence of these disparities has been widely interpreted as a reflection of entrenched structural inequalities affecting racial and ethnic minority communities. Longstanding disadvantages in education, employment opportunities, housing quality, access to healthcare, and exposure to the criminal justice system have shaped both vulnerability to infection and risk of severe disease [4-7]. During the pandemic, these inequalities manifested through several direct mechanisms. Racial and ethnic minorities are disproportionately represented in essential and frontline occupations that require in-person interaction, increasing exposure to SARS-CoV-2 [8, 9]. Housing conditions also played a critical role, as overcrowded and multi-unit residences—more common among minority populations—facilitated household transmission [10]. In addition, minority communities are more likely to be located in areas with higher levels of chronic air pollution, a factor associated with increased COVID-19 severity and mortality [11-13].

Structural disadvantage has also contributed to poorer underlying health among many minority populations, increasing susceptibility to severe COVID-19 outcomes. African Americans, in particular, experience elevated rates of chronic conditions such as obesity, hypertension, diabetes, and cardiovascular disease, all of which are known to exacerbate the clinical course of COVID-19 [11, 14, 15].

Initial empirical work on COVID-19 disparities primarily documented differences in infection rates, hospitalizations, and deaths across racial and ethnic groups (e.g. [16-18]). While valuable, much of this research relied on descriptive or bivariate analyses that did not control for socioeconomic or environmental factors, limiting insight into causal mechanisms. Subsequent studies expanded this work by examining whether disparities could be explained by social determinants of health [19-22] or broader forms of structural racism [4, 23]. However, many of these analyses focused on a single racial or ethnic group and assessed disparities at only one point in time, leaving important questions about heterogeneity and temporal change unanswered.

The present study addresses these gaps through a two-pronged approach. First, it evaluates racial and ethnic disparities in COVID-19 mortality across all groups recognized by the U.S. Census Bureau and examines how these disparities evolved over four points during the first 13 months of the pandemic. This responds to calls for more inclusive and temporally sensitive analyses of COVID-19 inequities [18, 19, 21, 24]. Second, the study explicitly examines whether racial and ethnic disparities persist after accounting for basic socioeconomic factors—poverty, employment, income, and educational attainment. Identifying the extent to which these factors mediate mortality disparities has direct policy implications, as it informs whether reducing socioeconomic inequalities could mitigate racial and ethnic inequities in future public health emergencies.

Ideally, analyses of this kind would rely on individual-level data linking COVID-19 outcomes to detailed clinical, demographic, and socioeconomic information [25]. In the United States, such datasets are rare and typically confined to specific healthcare systems, where socioeconomic measures are often limited [26]. Moreover, scholars have repeatedly highlighted the lack of consistent, nationwide reporting of COVID-19 outcomes disaggregated by race and ethnicity [27, 28]. With few exceptions, race-specific mortality data are available only at the state level rather than the county level [3]. Given these limitations, this study employs county-level data and an ecological regression framework [11, 13], modeling COVID-19 mortality as a function of racial and ethnic composition, socioeconomic conditions, and additional control variables.

Data

The empirical analysis relies exclusively on secondary data drawn from publicly available sources, all harmonized at the U.S. county level. COVID-19 mortality information is obtained from The New York Times, which compiles death counts reported by state and local public health agencies. This repository provides cumulative counts beginning on January 21, 2020, when the first COVID-19 case was confirmed in the United States; fatalities begin to appear in the dataset on February 29, 2020.

Information on county population size and racial/ethnic composition is taken from the U.S. Census Bureau's Annual County Resident Population Estimates covering the 2010–2018 period. These data are accessed through the curated dataset developed by Killeen *et al*. [29]. Measures describing counties' socioeconomic and demographic characteristics are drawn from the 2018 Social Vulnerability Index (SVI) produced by the Centers for Disease Control and Prevention and the

Agency for Toxic Substances and Disease Registry (CDC/ATSDR). The SVI indicators are constructed using data from the U.S. Census Bureau's five-year American Community Survey (ACS) for 2014–2018. County-level environmental exposure is represented by fine particulate matter concentrations (PM2.5), using estimates reported by Wu *et al*. [13].

To capture how racial and ethnic disparities in COVID-19 mortality shifted as the pandemic unfolded, the analysis evaluates outcomes at four separate points during approximately the first year of the crisis. Each observation date corresponds to a distinct stage of the pandemic. The first, May 15, 2020, falls near the end of the initial surge in cases and deaths. The second, August 15, 2020, reflects conditions following the summer wave. The third, December 15, 2020, coincides with the period immediately after the introduction of COVID-19 vaccines in the United States. The final date, March 15, 2021, occurs almost exactly one year after COVID-19 was declared both a global pandemic by the World Health Organization and a national emergency in the United States.

The study sample consists of all U.S. counties for which cumulative COVID-19 mortality was reported on at least one of the four selected dates and for which complete information on all explanatory variables was available. Puerto Rico is excluded from the analysis because COVID-19 deaths are not reported at the county (municipio) level. Alaska is also omitted due to the lack of county-level air quality measures. Additionally, because The New York Times reports COVID-19 statistics for New York City as a single aggregated unit encompassing all five boroughs, county-level mortality figures for New York City are instead taken from the New York City Department of Health and Mental Hygiene. **Figure 1** illustrates the distribution of cumulative COVID-19 deaths across counties over the study period.

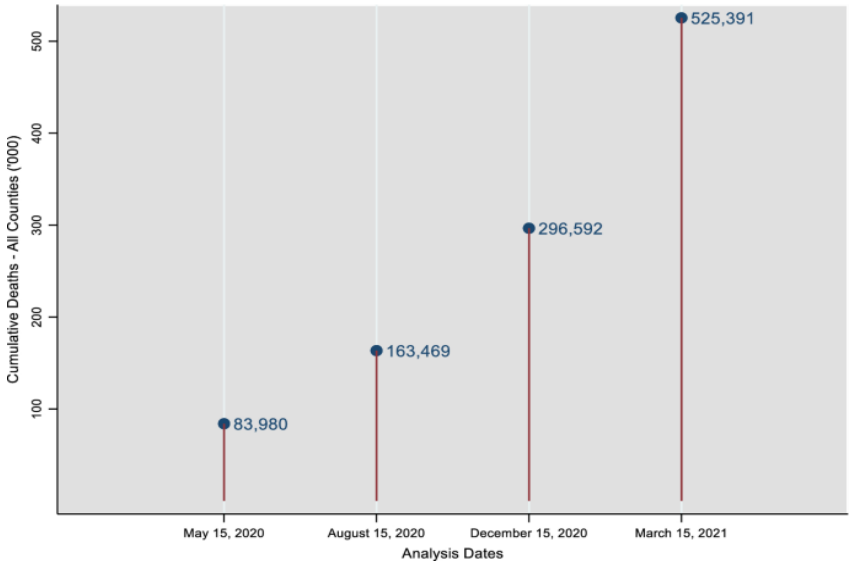


Figure 1. Displays the cumulative COVID-19 deaths across all counties throughout the study period.

Table 1 provides descriptive statistics for the key county-level variables employed in the regression analyses. On May 15, 2020, the average county-level COVID-19 mortality rate—expressed as deaths per 100,000 population—stood at 10.7. This figure increased to 28.9 by August 15, 2020, roughly six months after the pandemic's onset. By the start of the vaccination program, the mean county mortality rate had climbed to nearly 100 (98.6 deaths per 100,000). One year after the declaration of a national emergency in the United States, as of March 15, 2021, the average county-level mortality rate reached 180.5 deaths per 100,000.

The distribution of mortality rates was markedly skewed during the early phase of the pandemic, with the mean exceeding the median by a factor of five. As the virus spread nationwide, this skewness diminished substantially; by one year into the pandemic, the mean was only approximately 1.1 times the median. Nevertheless, considerable heterogeneity persisted across counties in mortality outcomes, and roughly 2

percent of counties reported no COVID-19 deaths throughout the period.

Table 1. Descriptive statistics for key study variables

Variable	Mean	N	Min	Std. Dev.	Max	75th Perc.	Median	25th Perc.
Deaths (per 100,000 population)								
May 15, 2020	10.69	2900	0	24.21	307.3	9.738	2.046	0
December 15, 2020	98.59	3136	0	79.93	765.7	131.8	81.12	43.35
August 15, 2020	28.87	3116	0	42.24	420.4	38.07	13.58	2.000
March 15, 2021	180.5	3136	0	110.0	842.3	235.0	165.8	103.9
Population aged 17 and younger (%)	22.36	3136	5.300	3.492	40.50	24.10	22.30	20.30
Population aged 65 and older (%)	18.37	3136	3.800	4.582	55.60	20.80	18	15.50
Poverty rate (%)	15.61	3136	2.300	6.475	55.10	19.10	14.70	11
Uninsured population (%)	10.06	3136	1.700	5.077	45.60	12.60	9.200	6.200
Unemployment rate (%)	5.767	3136	0	2.845	28.90	7.100	5.400	4
Per capita income (dollars)	27,029	3136	10,148	6,506	72,832	30,103	26,244	22,764
No high school diploma (%)	13.41	3136	1.200	6.340	66.30	17.20	12.10	8.800
Air pollution (PM2.5 concentration)	8.406	3091	2.060	2.520	15.79	10.49	8.793	6.341
Racial/ethnic composition (% share)								
Black	9.008	3136	0	14.31	85.41	10.28	2.240	0.708
White	76.08	3136	2.691	20.11	97.89	92.31	83.39	64.40
American Indian/Alaska Native	1.891	3136	0	7.267	90.51	0.776	0.385	0.243
Asian	1.493	3136	0	2.886	42.79	1.339	0.674	0.425
Native Hawaiian/Pacific Islander	0.105	3136	0	0.955	48.86	0.0684	0.0362	0.0182
Two or more races	1.804	3136	0	1.304	23.77	2.023	1.521	1.162
Hispanic/Latino (any race)	9.620	3136	0.610	13.77	96.36	9.998	4.390	2.399
Largest racial/ethnic group (indicator)								
Black	0.0408	3136	0	0.198	1	0	0	0
White	0.908	3136	0	0.289	1	1	1	1
Asian/Native Hawaiian/Pacific Islander	0.00223	3136	0	0.0472	1	0	0	0
American Indian/Alaska Native	0.0105	3136	0	0.102	1	0	0	0
Hispanic/Latino	0.0386	3136	0	0.193	1	0	0	0

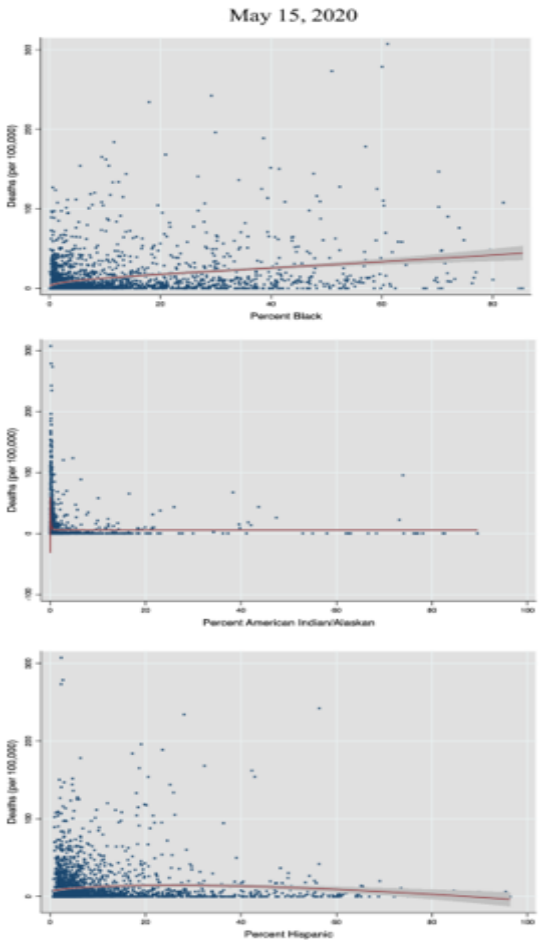
The racial and ethnic categories included in the analysis comprise individuals identifying as Black or African American alone (Black); non-Hispanic White alone (White); Asian alone (Asian); Alaska Native alone or American Indian (AIAN); individuals reporting two or more races (mixed); Native Hawaiian or Other Pacific Islander alone (NHPI); and those identifying as Hispanic. In this analysis, county racial and ethnic composition is operationalized using two distinct approaches. The first approach captures composition continuously, measuring the share of the county population accounted for by each racial or ethnic group. Consistent with U.S. Census Bureau conventions, the full set of racial and ethnic categories is included: individuals identifying as non-Hispanic White alone (White); non-Hispanic Black or African American alone (Black); non-Hispanic American Indian or Alaska Native alone (AIAN); non-Hispanic Asian alone (Asian); non-Hispanic Native Hawaiian or Other Pacific Islander alone (NHPI); non-Hispanic individuals reporting two or more races (mixed); and those identifying as Hispanic.

As reported in **Table 1**, the typical U.S. county during the study period was predominantly White, with this group accounting for approximately 75 percent of the population. Hispanics and Blacks represented the next largest shares, averaging 9.6 percent and 9.0 percent, respectively. AIAN populations comprised roughly 1.9 percent of county residents on average, a proportion closely aligned with that of individuals identifying with two or more races (1.8 percent).

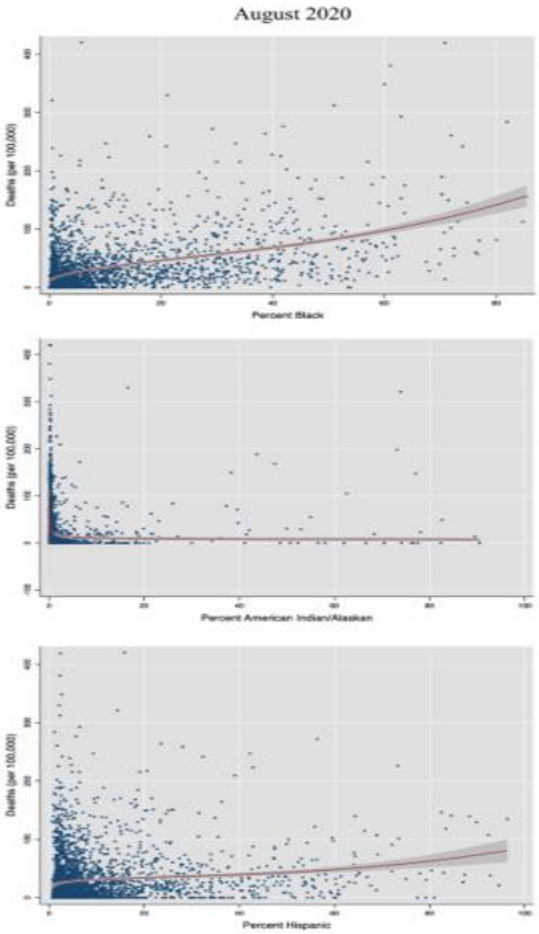
The second approach categorizes counties based on the racial or ethnic group with the largest population share,

using a set of indicator variables. Each indicator takes a value of one if a given group constitutes the plurality population within a county and zero otherwise. For instance, the variable Largest_Black equals one in counties where Black residents form the largest racial group. Parallel indicators are constructed for counties in which AIANs (Largest_AIAN) or Hispanics (Largest_Hispanic) represent the largest population share. Because very few counties have Asian or NHPI populations that individually exceed all other groups, these two categories are combined into a single indicator (Largest_ANHPI). No U.S. county has individuals identifying as two or more races as the largest racial or ethnic group. Summary statistics in **Table 1** indicate that White populations are the largest group in the vast majority of counties (91 percent). Blacks and Hispanics are each the plurality group in a similar proportion of counties, accounting for 4.1 percent and 3.9 percent, respectively, while AIANs constitute the largest group in only 1.1 percent of counties.

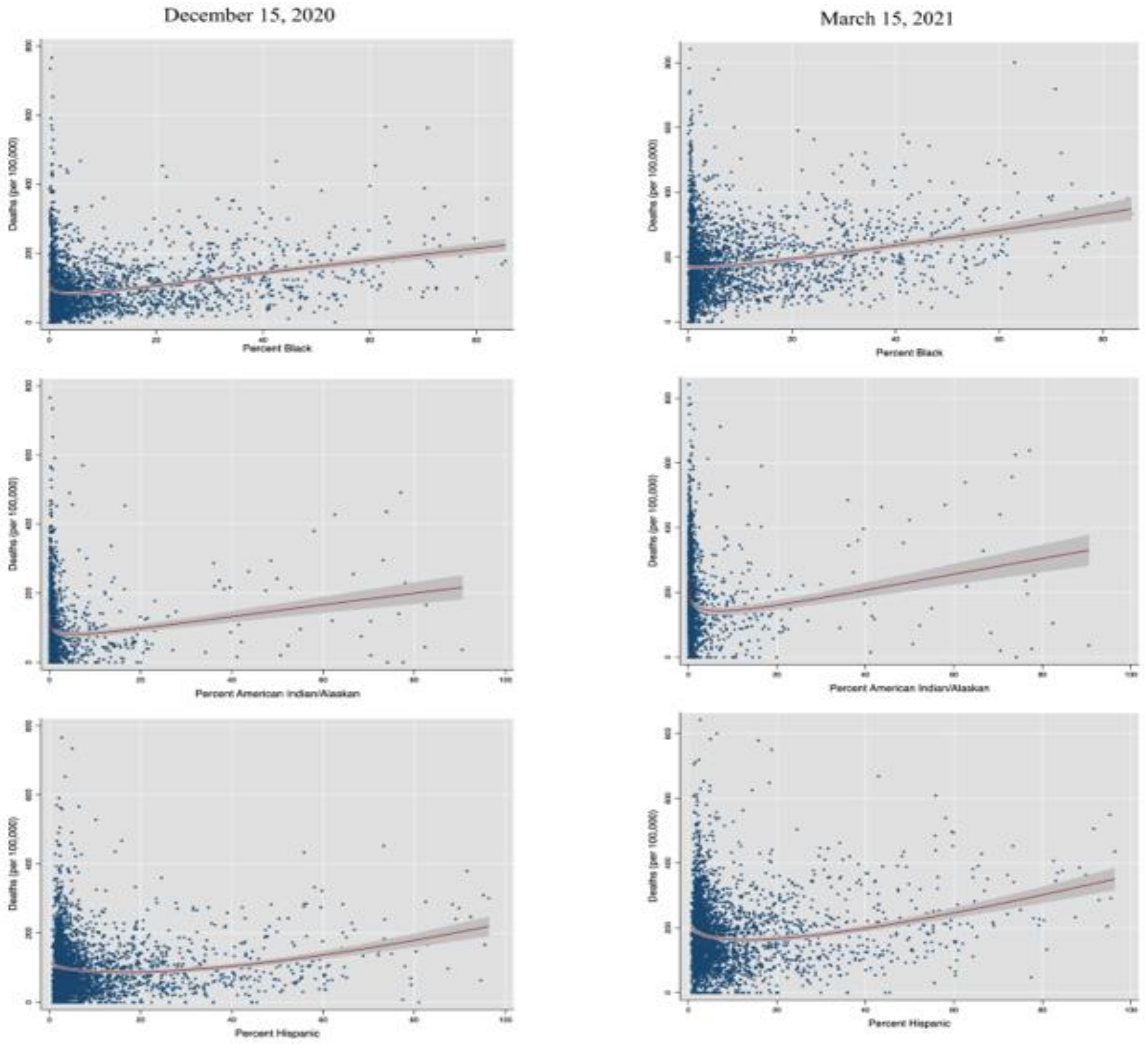
To provide context for the subsequent multivariate analysis, **Figures 2 and 3** illustrate how county racial and ethnic composition is related to COVID-19 mortality over time in a bivariate setting. Specifically, **Figures 2a–2d** depict cumulative COVID-19 deaths per 100,000 residents plotted against county population shares of Blacks, AIANs, and Hispanics at four points during the pandemic (May 15, August 15, and December 15, 2020, and March 15, 2021). Early in the pandemic, approximately three months after onset, only the share of Black residents exhibited a clear positive association with county-level mortality. By mid-August 2020, a positive relationship was also evident for Hispanic population share, while the slope relating mortality to the Black population share became steeper. By December 2020, the three groups displayed broadly similar patterns, each showing a positive association between population share and cumulative deaths. By March 2021, as overall mortality increased substantially, the relationship between deaths and population share intensified for all three groups, resulting in noticeably steeper gradients.


May 15, 2020
Deaths (per 100,000)
Percent Black
Deaths (per 100,000)
Percent American Indian/Alaskan
Deaths (per 100,000)
Percent Hispanic

a)


August 2020
Deaths (per 100,000)
Percent Black
Deaths (per 100,000)
Percent American Indian/Alaskan
Deaths (per 100,000)
Percent Hispanic

b)



c) d)

Figure 2. Share of ethnic/racial and Deaths group in county.

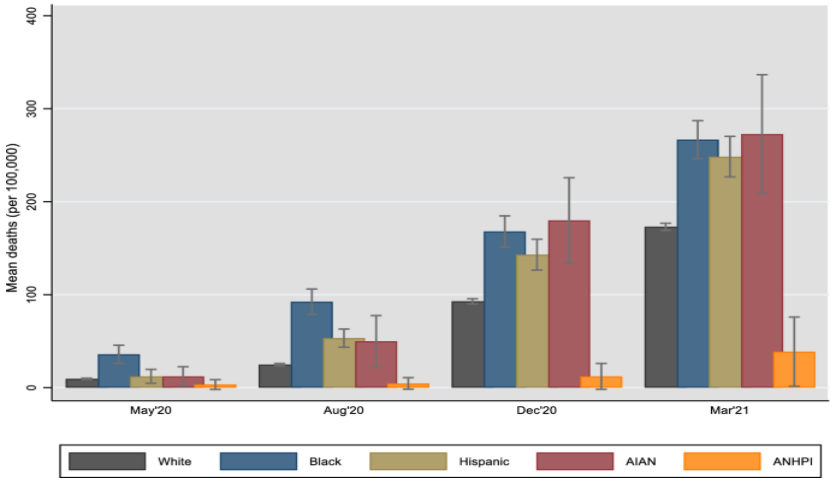


Figure 3. Average COVID-19 mortality by county classification based on plurality racial/ethnic group

Figure 3 provides additional support for the observed pattern by displaying average COVID-19 death rates across counties grouped according to their plurality racial or ethnic population. During the early phase of the pandemic, counties in which Black residents constituted the largest population group experienced the highest mortality levels. By August 2020, these counties recorded an average of 92 deaths per 100,000 residents, nearly double the mortality observed in counties where Hispanic or AIAN populations formed the plurality.

By December 2020, this ranking shifted slightly, with AIAN-plurality counties registering marginally higher average mortality than Black-plurality counties. This pattern persisted into March 15, 2021, approximately one year after the onset of the pandemic. At that point, counties with AIANs as the largest racial/ethnic group exhibited the highest average death rate (273 per 100,000), followed closely by Black-plurality counties (267), Hispanic-plurality counties (248), and White-plurality counties (173). Counties in which Asians or NHPIs constituted the largest population group—though relatively few in number—experienced substantially lower mortality, averaging only 39 deaths per 100,000 residents.

Taken together, these descriptive comparisons reinforce the broader finding that, over the first year of the COVID-19 pandemic, counties with larger minority populations tended to experience higher mortality rates than counties dominated by White populations.

Regression methodology

The multivariate analysis employs two alternative regression specifications, each corresponding to a different operationalization of county racial and ethnic composition. The first specification treats racial/ethnic composition as a continuous measure, using population shares for each group. Under this approach, cumulative COVID-19 mortality in county i is modeled as:

$$D_i = \beta_0 + \beta_1 \text{ Percent\_Black}_i + \beta_2 \text{ Percent\_AIAN}_i + \beta_3 \text{ Percent\_Asian}_i + \beta_4 \text{ Percent}_i \text{ NHPI}_i + \beta_5 \text{ Percent\_Mixed}_i + \beta_6 \text{ Percent\_Hispanic}_i + SEF * \gamma + X * \Theta + \varepsilon_i \quad (1)$$

(1) where Di denotes cumulative COVID-19 deaths in county i. The racial/ethnic variables represent each group's share of the county population. The vector **SEF** captures basic socioeconomic factors, with associated parameter vector γ, while **X** represents additional control variables with coefficients Θ. The error term is given by εi.

The socioeconomic factors include two income-related indicators (the county poverty rate and median per capita income), a measure of labor market conditions (the unemployment rate), and an education variable (the proportion of residents without a high school diploma). The covariate set incorporates demographic structure (shares of the population aged 65 and older and 17 and younger), access to health insurance (the uninsured rate), and environmental conditions (average fine particulate matter concentration, PM2.5). Descriptive statistics for all socioeconomic and control variables are reported in **Table 1.**

Within this framework, the coefficient on a given racial or ethnic group reflects the marginal change in mortality associated with a one–percentage point increase in that group's population share, holding all other factors constant. Because population shares sum to one, this effect is interpreted relative to a corresponding reduction in the share of non-Hispanic White residents. The specification imposes a linear relationship, implying that each additional percentage point carries the same average effect regardless of baseline group size. If population composition is unrelated to COVID-19 mortality, the estimated coefficient for that group would not differ statistically from zero. Separate regressions are estimated for each of the four time points examined during the first year of the pandemic.

The second specification captures racial and ethnic composition using categorical indicators based on the plurality group within each county. In this case, the estimating equation is:

$$D_i = \beta_0 + \beta_1 \text{ Largest\_Black}_i + \beta_2 \text{ Largest\_AIAN}_i + \beta_3 \text{ Largest\_ANHPI}_i + \beta_4 \text{ Largest\_Hispanic}_i + SEF * \gamma + X * \Theta + \varepsilon_i \quad (2)$$

All notation remains consistent with the first model. Each indicator variable equals one if the specified racial or ethnic group constitutes the largest share of the county population and zero otherwise. Counties in which non-Hispanic Whites form the plurality serve as the reference category. As with the first specification, regressions are

estimated separately for each of the four observation dates. In this setup, the race/ethnicity coefficients capture differences in mortality rates between the average county where a given group is the plurality and the average White-plurality county.

Because cumulative deaths are nonnegative integers and exhibit substantial overdispersion, both models are estimated using negative binomial regression. County population is included as an offset term to model death rates rather than raw counts. Robust standard errors clustered at the state level are reported to account for potential correlation in unobserved factors across counties within the same state, such as shared policy environments. All explanatory variables are standardized prior to estimation. For ease of interpretation, results are presented as incidence rate ratios (IRRs), which express the estimated effects as multiplicative changes in the COVID-19 mortality rate.

Results and Discussion

Racial and ethnic composition measured as population share

The first set of empirical findings is based on regressions that operationalize county racial and ethnic composition using each group's proportion of the county population (model 1). These estimates are reported in **Table 2.** Results for the earlier stages of the pandemic—May 15 and August 15, 2020—are presented in Panel A, while Panel B reports estimates for December 15, 2020, and March 15, 2021.

For each observation date, four alternative model specifications are estimated. The baseline specification includes only the racial and ethnic population share variables, providing a descriptive estimate of the association between racial/ethnic composition and COVID-19 mortality for each group. The second specification expands the model by incorporating county-level covariates—specifically age structure, health insurance coverage, and air quality—along with the set of basic socioeconomic factors (SEF). The third specification further augments the model by including state fixed effects to control for unobserved state-level differences that may influence mortality outcomes.

The final specification evaluates the robustness of the results to the exclusion of potential outliers. In this case, the five counties comprising New York City are omitted from the sample due to the unusually severe outbreak experienced there during the early months of the pandemic. Apart from this exclusion, the model retains the full set of regressors included in the third specification.

Table 2. COVID-19 mortality and racial/ethnic population shares at the county level

	Panel A							
	May 15, 2020				**August 15, 2020**			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
AIAN	1.461	5.361***	6.227***	6.036***	2.070*	3.983***	5.578***	5.521***
	(0.748)	(3.242)	(3.169)	(3.157)	(1.869)	(3.566)	(3.764)	(3.764)
Black	3.547***	2.690***	2.307***	2.325***	3.521***	1.888***	1.561***	1.565***
	(6.165)	(4.962)	(5.745)	(5.837)	(13.28)	(3.980)	(4.975)	(4.992)
Hispanic	1.329	0.833	0.934	0.845	2.063***	1.157	1.147	1.113
	(0.589)	(−0.548)	(−0.332)	(−0.844)	(4.521)	(0.756)	(1.084)	(0.790)
ANHPI	0.340*	0.123***	1.153	1.102	0.240***	0.190***	0.714***	0.708***
	(−1.881)	(−6.039)	(1.019)	(0.625)	(−2.868)	(−6.567)	(−3.280)	(−3.154)
Unemp. Rate		1.040	0.924	0.924		1.076	0.964	0.965
		(0.597)	(−1.288)	(−1.281)		(1.223)	(−0.817)	(−0.797)
Poverty		1.357**	1.218**	1.217**		1.236**	1.169**	1.170**
		(2.398)	(2.117)	(2.093)		(2.533)	(2.294)	(2.289)
Per Capita Inc		1.896***	1.463***	1.469***		1.544***	1.250***	1.252***
		(4.993)	(4.520)	(4.428)		(5.068)	(4.001)	(3.912)
Age ≥ 65		0.838***	0.953	0.952		0.958	1.016	1.015

		(−2.763)	(−0.724)	(−0.753)		(−1.018)	(0.401)	(0.383)
No HS Diploma		1.484***	1.442***	1.440***		1.489***	1.399***	1.398***
		(3.410)	(5.167)	(5.147)		(4.859)	(6.163)	(6.088)
Uninsured Rate		0.896	0.932	0.930		1.050	0.959	0.957
		(−0.813)	(−0.808)	(−0.834)		(0.541)	(−0.749)	(−0.788)
Pollution		1.155***	1.229***	1.216***		1.158***	1.196***	1.190***
		(3.804)	(4.185)	(4.149)		(6.471)	(6.661)	(6.902)
Age ≤ 17		0.889	0.961	0.966		1.017	1.077**	1.079**
		(−1.509)	(−0.624)	(−0.531)		(0.336)	(2.138)	(2.192)
Observations	2,900	2,866	2,866	2,861	3,116	3,073	3,073	3,068
State effects	No	No	Yes	Yes	No	No	Yes	Yes
Panel B								
		December 15, 2020				**March 15, 2021**		
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
AIAN	1.968***	2.419***	2.061***	2.020***	1.598**	2.234***	1.750***	1.726***
	(3.034)	(3.681)	(2.636)	(2.588)	(2.139)	(3.984)	(2.838)	(2.777)
Black	1.815***	1.554***	1.231***	1.240***	1.538***	1.272***	1.101**	1.106***
	(9.589)	(3.817)	(4.045)	(4.233)	(7.784)	(2.892)	(2.505)	(2.647)
Hispanic	1.535**	1.166	1.198***	1.165**	1.430***	1.170*	1.084	1.068
	(2.505)	(1.021)	(2.637)	(1.983)	(3.052)	(1.901)	(1.603)	(1.250)
ANHPI	0.209***	0.448***	1.190***	1.201***	0.289***	0.769**	1.422***	1.433***
	(−4.834)	(−4.563)	(3.037)	(3.254)	(−3.044)	(−2.110)	(11.22)	(12.67)
Poverty		1.091*	1.067*	1.059		1.018	1.019	1.014
		(1.782)	(1.675)	(1.500)		(0.477)	(0.688)	(0.514)
Per Capita Inc		0.994	0.938*	0.927**		0.928*	0.889***	0.881***
		(−0.104)	(−1.724)	(−2.384)		(−1.704)	(−4.670)	(−6.023)
Unemp. Rate		0.900***	0.946***	0.947**		0.929**	0.962**	0.962**
		(−2.648)	(−2.592)	(−2.554)		(−2.414)	(−2.325)	(−2.314)
Age ≥ 65		1.200***	1.175***	1.175***		1.213***	1.184***	1.184***
		(6.708)	(6.663)	(6.681)		(8.276)	(9.479)	(9.516)
Age ≤ 17		1.177***	1.125***	1.134***		1.124***	1.098***	1.103***
		(4.108)	(6.050)	(6.064)		(3.565)	(6.199)	(6.206)
No HS Diploma		1.156**	1.199***	1.188***		1.132***	1.141***	1.133***
		(2.466)	(5.847)	(6.189)		(2.850)	(6.314)	(6.606)
Pollution		1.035	1.058**	1.050**		1.056***	1.049**	1.044*
		(1.493)	(2.015)	(1.977)		(3.046)	(2.041)	(1.910)
Uninsured Rate		0.974	0.931***	0.929***		1.002	0.943***	0.942***
		(−0.400)	(−2.848)	(−2.962)		(0.0335)	(−2.653)	(−2.704)
Observations	3,136	3,091	3,091	3,086	3,136	3,091	3,091	3,086
State effects	No	No	Yes	Yes	No	No	Yes	Yes

The table reports incidence rate ratios (IRRs), with t-statistics calculated using robust standard errors clustered at the state level and shown in parentheses. The indicator for Asian or Native Hawaiian/Pacific Islander (ANHPI) equals one when this group constitutes the largest racial or ethnic population in a county and zero otherwise. All explanatory variables, except for the racial and ethnic indicators, are standardized prior to estimation, and each model includes a constant term. Specification (4) excludes New York City from the sample. Statistical

significance is denoted by *** ($p < 0.01$), ** ($p < 0.05$), and * ($p < 0.10$).

Based on the estimates in Panel A, three months after the onset of the COVID-19 pandemic, counties in which Black or American Indian/Alaska Native (AIAN) populations constitute the largest racial or ethnic group experienced substantially higher mortality rates. The estimated effects for these groups are particularly large. In the fully specified model (Specification 3), which controls for socioeconomic characteristics, basic spatial epidemic factors, and state fixed effects, counties where Blacks are the largest group had mortality rates approximately 2.3 times those of counties with a White plurality—equivalent to about a 130 percent increase. The estimated effect for AIAN-majority counties is even larger, corresponding to a mortality rate more than five times higher than that of White plurality counties.

The inclusion of covariates has a meaningful but distinct impact across groups. For Black-plurality counties, the estimated effect in the full specification is roughly one-third smaller than in the simple bivariate model, suggesting that omitting relevant controls leads to an overstatement of the disparity. In contrast, the AIAN effect only becomes statistically significant once confounding factors are accounted for, indicating that unadjusted comparisons mask the true magnitude of the disparity. These findings highlight the importance of adequately controlling for socioeconomic and demographic characteristics when evaluating racial and ethnic differences in COVID-19 mortality. Consistent with earlier results based on population shares, counties in which Hispanics represented the largest group did not exhibit statistically significant mortality differences as of May 2020.

Six months into the pandemic, racial and ethnic disparities in mortality remained broadly similar. Counties with Black or AIAN pluralities continued to experience higher death rates than White plurality counties, while counties dominated by Asian or NHPI populations showed lower mortality. Compared with earlier months, however, the estimated effect for Black plurality counties declined by roughly one-third, whereas the AIAN effect remained markedly elevated. By August 2020, counties where AIANs were the largest group experienced mortality rates roughly 460 percent higher than those in White plurality counties. In contrast, counties where Asians or NHPIs were the largest group had mortality rates about 30 percent lower on average. As before, the response of the estimates to the inclusion of covariates differs sharply by group: failing to control for confounders biases the Black estimate upward but biases the AIAN estimate downward. This divergence underscores the limitations of simple bivariate analyses in assessing racial and ethnic disparities in COVID-19 outcomes.

By December 2020, racial and ethnic effects remained statistically significant for Black and AIAN counties, although their magnitudes were substantially reduced, as shown in Panel B. Relative to White plurality counties, mortality was approximately 23 percent higher in Black plurality counties and about 106 percent higher in AIAN plurality counties, based on the fully specified model. Counties in which Hispanics were the largest group also exhibited elevated mortality, with death rates roughly 20 percent higher than those in White plurality counties. These disparities continued to diminish by March 15, 2021, though they did not disappear entirely. At that point, AIAN plurality counties still experienced mortality rates about 1.75 times higher than those of White plurality counties, while the corresponding estimate for Black plurality counties was approximately 1.1. Notably, counties dominated by Asian or NHPI populations exhibited higher mortality only in the fully specified and robustness models, and only during the later stages of the period examined.

Turning to the covariates and spatial epidemic factors, counties with larger shares of both older adults and children experienced higher mortality rates, particularly during the latter half of 2020 and early 2021. Higher poverty levels were generally associated with increased mortality throughout much of the year. In contrast, higher unemployment rates and higher shares of uninsured residents were linked to modest but statistically significant reductions in mortality during the latter part of the year. Counties with higher per capita income saw elevated mortality early in the pandemic, but this relationship reversed later on. Lower educational attainment, however, consistently emerged as a strong and persistent predictor of higher mortality across all four time points examined.

Racial/Ethnic composition measured by county plurality group

The second set of findings, presented in **Table 3,** examines county racial and ethnic composition using indicator variables that identify which racial or ethnic group constitutes the largest share of the county population (Model 2). Estimates are provided for the

same four time points considered throughout the analysis. For each date, the table reports results from a sequence of model specifications that start with race and ethnicity indicators alone and then progressively incorporate socioeconomic controls, basic spatial epidemic factors, and state fixed effects. A final robustness specification removes New York City from the sample.

In all models, counties in which Whites represent the largest racial or ethnic group serve as the baseline category against which the effects for other groups are measured.

Table 3. Reports the association between COVID-19 mortality and county racial/ethnic plurality.

Panel A								
	May 15, 2020				**August 15, 2020**			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
AIAN	1.461	5.361***	6.227***	6.036***	2.070*	3.983***	5.578***	5.521***
	(0.748)	(3.242)	(3.169)	(3.157)	(1.869)	(3.566)	(3.764)	(3.764)
Black	3.547***	2.690***	2.307***	2.325***	3.521***	1.888***	1.561***	1.565***
	(6.165)	(4.962)	(5.745)	(5.837)	(13.28)	(3.980)	(4.975)	(4.992)
Hispanic	1.329	0.833	0.934	0.845	2.063***	1.157	1.147	1.113
	(0.589)	(−0.548)	(−0.332)	(−0.844)	(4.521)	(0.756)	(1.084)	(0.790)
ANHPI	0.340*	0.123***	1.153	1.102	0.240***	0.190***	0.714***	0.708***
	(−1.881)	(−6.039)	(1.019)	(0.625)	(−2.868)	(−6.567)	(−3.280)	(−3.154)
Unemp. Rate		1.040	0.924	0.924		1.076	0.964	0.965
		(0.597)	(−1.288)	(−1.281)		(1.223)	(−0.817)	(−0.797)
Poverty		1.357**	1.218**	1.217**		1.236**	1.169**	1.170**
		(2.398)	(2.117)	(2.093)		(2.533)	(2.294)	(2.289)
Per Capita Inc		1.896***	1.463***	1.469***		1.544***	1.250***	1.252***
		(4.993)	(4.520)	(4.428)		(5.068)	(4.001)	(3.912)
No HS Diploma		1.484***	1.442***	1.440***		1.489***	1.399***	1.398***
		(3.410)	(5.167)	(5.147)		(4.859)	(6.163)	(6.088)
Age ≥ 65		0.838***	0.953	0.952		0.958	1.016	1.015
		(−2.763)	(−0.724)	(−0.753)		(−1.018)	(0.401)	(0.383)
Age ≤ 17		0.889	0.961	0.966		1.017	1.077**	1.079**
		(−1.509)	(−0.624)	(−0.531)		(0.336)	(2.138)	(2.192)
Pollution		1.155***	1.229***	1.216***		1.158***	1.196***	1.190***
		(3.804)	(4.185)	(4.149)		(6.471)	(6.661)	(6.902)
Uninsured Rate		0.896	0.932	0.930		1.050	0.959	0.957
		(−0.813)	(−0.808)	(−0.834)		(0.541)	(−0.749)	(−0.788)
Observations	2,900	2,866	2,866	2,861	3,116	3,073	3,073	3,068
State effects	No	No	Yes	Yes	No	No	Yes	Yes
Panel B								
	December 15, 2020				**March 15, 2021**			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
AIAN	1.968***	2.419***	2.061***	2.020***	1.598**	2.234***	1.750***	1.726***
	(3.034)	(3.681)	(2.636)	(2.588)	(2.139)	(3.984)	(2.838)	(2.777)
ANHPI	0.209***	0.448***	1.190***	1.201***	0.289***	0.769**	1.422***	1.433***
	(−4.834)	(−4.563)	(3.037)	(3.254)	(−3.044)	(−2.110)	(11.22)	(12.67)
Black	1.815***	1.554***	1.231***	1.240***	1.538***	1.272***	1.101**	1.106***
	(9.589)	(3.817)	(4.045)	(4.233)	(7.784)	(2.892)	(2.505)	(2.647)
Poverty		1.091*	1.067*	1.059		1.018	1.019	1.014

		(1.782)	(1.675)	(1.500)		(0.477)	(0.688)	(0.514)
Hispanic	1.535**	1.166	1.198***	1.165**	1.430***	1.170*	1.084	1.068
	(2.505)	(1.021)	(2.637)	(1.983)	(3.052)	(1.901)	(1.603)	(1.250)
Unemp. Rate		0.900***	0.946***	0.947**		0.929**	0.962**	0.962**
		(−2.648)	(−2.592)	(−2.554)		(−2.414)	(−2.325)	(−2.314)
No HS Diploma		1.156**	1.199***	1.188***		1.132***	1.141***	1.133***
		(2.466)	(5.847)	(6.189)		(2.850)	(6.314)	(6.606)
Per Capita Inc		0.994	0.938*	0.927**		0.928*	0.889***	0.881***
		(−0.104)	(−1.724)	(−2.384)		(−1.704)	(−4.670)	(−6.023)
Age ≥ 65		1.200***	1.175***	1.175***		1.213***	1.184***	1.184***
		(6.708)	(6.663)	(6.681)		(8.276)	(9.479)	(9.516)
Age ≤ 17		1.177***	1.125***	1.134***		1.124***	1.098***	1.103***
		(4.108)	(6.050)	(6.064)		(3.565)	(6.199)	(6.206)
Pollution		1.035	1.058**	1.050**		1.056***	1.049**	1.044*
		(1.493)	(2.015)	(1.977)		(3.046)	(2.041)	(1.910)
Uninsured Rate		0.974	0.931***	0.929***		1.002	0.943***	0.942***
		(−0.400)	(−2.848)	(−2.962)		(0.0335)	(−2.653)	(−2.704)
Observations	3,136	3,091	3,091	3,086	3,136	3,091	3,091	3,086
State effects	No	No	Yes	Yes	No	No	Yes	Yes

Incidence rate ratios (IRRs) are presented, with t-statistics reported in parentheses and computed using robust standard errors clustered at the state level. The ANHPI indicator takes a value of one when Asian or Native Hawaiian/Pacific Islander individuals constitute the largest racial or ethnic group in a county and zero otherwise. All explanatory variables—except the racial and ethnic indicators—are standardized prior to estimation, and each regression includes a constant term. The fourth specification omits New York City from the sample. Statistical significance is denoted by *** ($p < 0.01$), ** ($p < 0.05$), and * ($p < 0.10$).

Results from Panel A show that, by approximately three months after the start of the COVID-19 pandemic, counties dominated by Black or American Indian/Alaska Native (AIAN) populations experienced markedly higher mortality than counties where Whites were the largest group. The magnitude of these racial and ethnic disparities is substantial. In the fully adjusted model (Specification 3), which controls for socioeconomic characteristics, spatial epidemic factors, and state fixed effects, counties with a Black plurality exhibited mortality rates more than double those of White plurality counties—corresponding to an increase of roughly 130 percent. The estimated disparity for AIAN plurality counties is even larger, implying mortality levels more than five times higher.

As with earlier analyses, progressively introducing controls has a pronounced but asymmetric impact across groups. For Black plurality counties, the estimated association is notably smaller—by roughly one-third—in the fully specified model compared with the simple bivariate specification. In contrast, the AIAN effect only becomes statistically meaningful once confounding variables are incorporated, indicating that unadjusted comparisons substantially understate the disparity for this group. Together, these patterns emphasize the necessity of adequately accounting for sociodemographic and contextual factors when evaluating racial and ethnic differences in COVID-19 mortality. Consistent with results based on population shares, counties where Hispanics represented the largest racial or ethnic group did not show a statistically distinguishable mortality difference as of May 2020.

By six months into the pandemic, the overall pattern across racial and ethnic groups remained largely unchanged. Mortality continued to be higher in counties with Black or AIAN pluralities relative to White plurality counties, while counties dominated by Asian or NHPI populations experienced lower death rates. Compared with earlier in the pandemic, however, the estimated effect for Black plurality counties declined substantially—by about one-third—whereas the AIAN effect remained pronounced. In August 2020, counties in which AIANs were the largest group faced mortality

rates approximately 460 percent higher than those of White plurality counties. In contrast, counties with Asian or NHPI pluralities recorded death rates that were roughly 30 percent lower on average. Importantly, the direction of bias introduced by omitting covariates differs sharply across groups: failing to control for confounders appears to inflate the estimated Black effect while suppressing the estimated AIAN effect. As a result, simple bivariate analyses can lead to misleading conclusions about the role of race and ethnicity in COVID-19 mortality.

By December 2020, the estimated racial and ethnic disparities for Black and AIAN plurality counties remained statistically significant but were considerably smaller, as shown in Panel B. Relative to White plurality counties, mortality was approximately 23 percent higher in counties with Black pluralities and about 106 percent higher in those with AIAN pluralities, based on the fully adjusted specification. Counties in which Hispanics constituted the largest group also experienced elevated mortality, with death rates around 20 percent higher. These disparities diminished further by March 15, 2021. Nonetheless, AIAN plurality counties continued to face mortality rates roughly 1.75 times higher than those of White plurality counties, while the corresponding estimate for Black plurality counties was approximately 1.1. Elevated mortality among Asian or NHPI plurality counties emerged only in the fully specified and robustness models and only at the final two time points examined.

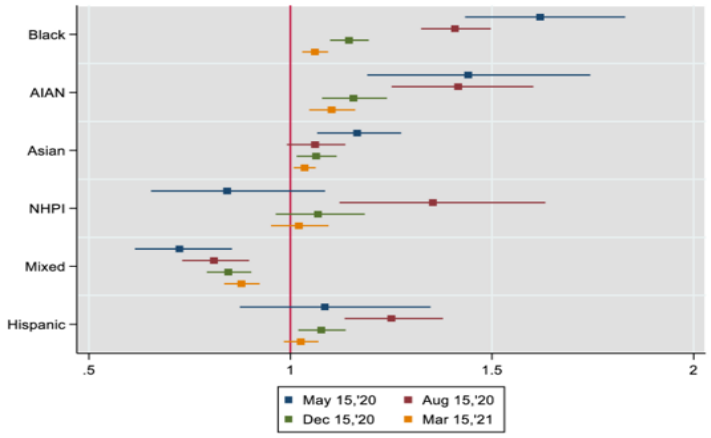
Turning to the role of control variables and spatial epidemic factors, counties with larger proportions of both elderly residents and children experienced higher mortality, particularly during the latter half of the first pandemic year. Higher poverty levels were generally associated with increased mortality over most of the study period. In contrast, higher unemployment rates and greater shares of uninsured residents were linked to modest but statistically significant reductions in mortality during the final two observation dates. Counties with higher per capita income experienced higher death rates early in the pandemic, but this relationship reversed later in the year. Educational attainment stands out as a consistent predictor throughout: counties with lower levels of education experienced substantially higher mortality at all four time points.

Summary of regression results

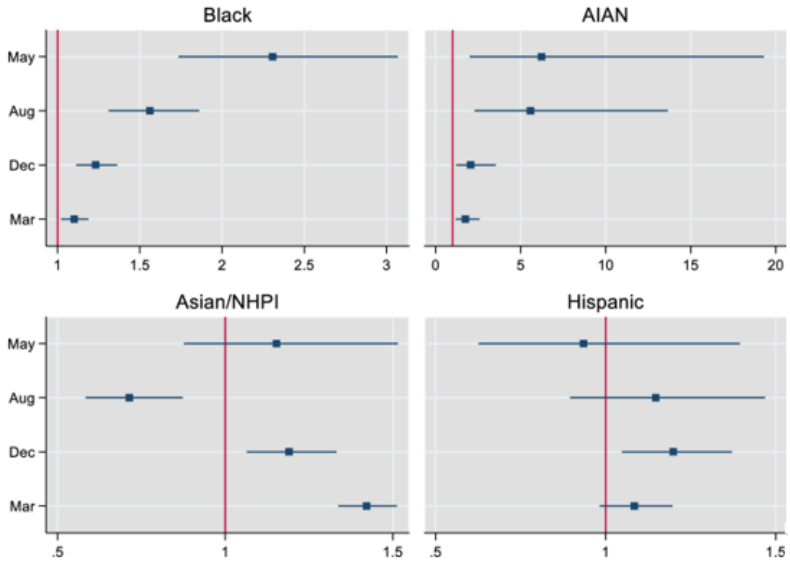
Figure 4a brings together the estimated race and ethnicity coefficients, along with their confidence intervals, for the four time points using regressions based on county population shares **(Table 2)**. All estimates are drawn from the fully specified model (Specification 3). The figure highlights two key patterns discussed previously.

First, across all racial and ethnic groups, the magnitude of the race/ethnicity effect—capturing the relationship between a group's population share and county-level COVID-19 mortality—declined steadily over the course of the first year of the pandemic.

Second, despite this attenuation over time, the estimated effects remained highly statistically significant ($p < 0.01$) at all four dates for only three groups: Black, American Indian/Alaska Native (AIAN), and individuals identifying with two or more races. Counties with larger Black or AIAN population shares consistently experienced higher mortality rates, whereas counties with higher proportions of multiracial residents exhibited persistently lower mortality.



a)



b)

Figure 4a. Illustrates how race and ethnicity influenced COVID-19 mortality during the first year of the pandemic, using estimated incidence rate ratios based on each group's share of the county population. The figure reports IRRs together with 95 percent confidence intervals for four time points: August 15, May 15, and December 15, 2020, as well as March 15, 2021.

Figure 4b presents corresponding estimates based on indicator variables identifying the largest racial or ethnic group within a county. As in **Figure 4a**, the reported IRRs and 95 percent confidence intervals are drawn from the fully specified model (Specification 3 in **Table 3**).

Examining the time patterns in **Figure 4b**, only the coefficients for Black and American Indian/Alaska Native (AIAN) counties display clear and systematic trends. For both groups, the estimated effects declined over the course of the year but remained statistically significant at every date. The estimated impact for AIAN counties is notably larger than that for Black counties, particularly early in the pandemic, although it is also accompanied by substantially wider confidence intervals, as reflected by the different scales used in the figure.

In contrast, the remaining groups show less consistent patterns. After accounting for basic spatial epidemic factors, the estimated effect for Hispanic plurality counties is generally not statistically different from zero for most of the period examined. The coefficient for Asian or Native Hawaiian/Pacific Islander counties fluctuates in sign over time, alternating between negative and positive values, and does not exhibit a stable trend.

Conclusion

This paper reexamines racial and ethnic disparities in COVID-19 outcomes in the United States, with a particular focus on mortality during the first year of the pandemic. The study pursues two primary objectives: first, to present a more comprehensive account of how disparities across racial and ethnic groups evolved over time; and second, to assess the degree to which these disparities can be explained by preexisting differences in basic socioeconomic conditions. Because much of the existing literature relies on analyses conducted early in the pandemic and therefore offers only a cross-sectional snapshot, a retrospective and longitudinal approach such as the one employed here provides important additional insight.

The empirical analysis is based on an ecological regression framework using county-level data. The study estimates the relationship between county racial and ethnic composition and COVID-19 mortality at four points during the first 13 months of the pandemic. All major racial and ethnic groups recognized by the U.S. Census Bureau are included. County racial composition is measured flexibly in two ways: by each group's share of the county population and by indicator variables identifying the largest racial or ethnic group in the county.

Preliminary bivariate analyses show positive correlations between COVID-19 mortality and the size of Black, Hispanic, and American Indian/Alaska Native (AIAN) populations. However, results from multivariate ecological regressions reveal two overarching patterns. First, once basic covariates and socioeconomic characteristics are taken into account, the estimated race and ethnicity effects differ markedly across these groups. For Hispanic populations, the estimated effect is largely mediated by covariates and frequently becomes statistically insignificant. For Black populations, the estimated effect declines—by between 4 and 56 percent depending on the date and specification, particularly in models using group plurality—but remains statistically significant throughout. In contrast, the AIAN effect either remains largely unchanged (when racial composition is measured by population shares) or becomes larger (when measured by plurality indicators). Second, for all three groups, the association between race/ethnicity and mortality generally diminishes over the latter part of the first pandemic year.

At a fundamental level, these findings raise the question of what underlies racial and ethnic differences in COVID-19 mortality risk. In the absence of genetic or biological explanations, the answer lies largely in the historical and ongoing consequences of structural racism—the multiple and interconnected ways in which racial discrimination contributes to poorer health outcomes in minority communities [4, 23, 28, 30]. Many of these effects operate indirectly through social, economic, and institutional pathways, including education, employment, housing, healthcare access, and the justice system. There are also direct mechanisms, such as when experiences or perceptions of discrimination themselves act as stressors or amplify the health impacts of environmental exposures [28, 31]. Collectively, these forces contribute to a higher prevalence of comorbid conditions in affected communities, increasing their vulnerability to severe outcomes during the COVID-19 pandemic.

From this perspective, the near-complete mediation of the Hispanic mortality effect by basic socioeconomic factors is particularly noteworthy. From a policy standpoint, this suggests that reducing inequities in education, labor market opportunities, and income could be effective in preventing similarly adverse outcomes for Hispanic populations in future public health crises, as well as in improving overall health outcomes more broadly. For Black and AIAN populations, however, the persistence of a statistically significant race effect after controlling for socioeconomic variables indicates that addressing disparities requires confronting additional dimensions and expressions of structural racism within the health system and beyond.

For Black Americans, many of these mechanisms have already been documented in the context of COVID-19. In healthcare settings, they include limited access, lower quality of care, and reduced utilization [31, 32]. For instance, higher mortality has been linked to inadequate internet access, which is crucial for obtaining timely health information and for participating in remote work and education [19, 33]. Medical mistrust—rooted in historical healthcare discrimination, scientific racism, and everyday experiences of bias—is associated with reluctance to seek care, lower adherence to protective behaviors, and greater susceptibility to conspiracy beliefs [24, 30, 34, 35]. Correspondingly, African Americans exhibited significantly lower COVID-19 vaccination rates, especially during the initial phases of vaccine rollout [36, 37]. More broadly, social and institutional structures such as concentrated disadvantage [23] and residential segregation [4] have been shown to elevate mortality risks within Black communities.

AIAN communities have likewise faced a long history of discrimination [38, 39]. Although the empirical evidence on the specific mechanisms driving their disproportionate COVID-19 mortality is more limited, many of the same channels affecting Black communities are likely relevant. For example, surveys conducted during the pandemic indicate that AIAN individuals reported levels of medical mistrust comparable to those of Black respondents [24]. The findings of this study emphasize that AIAN populations must be central to discussions of the pandemic's unequal impacts. Given that their elevated mortality risk appears to be only weakly mediated by socioeconomic factors, preventing similarly severe outcomes in future pandemics will require targeted, evidence-based policy interventions specifically designed to address their unique circumstances [40].

Overall, the results suggest that effective policy responses for both Black and AIAN communities must be multifaceted and sustained over the long term. Such efforts must address broader structural inequities across education, employment, housing, healthcare, and wealth distribution, as well as power imbalances that have entrenched health disparities. At the same time, policies must be sensitive to the historical and cultural factors that have contributed to lower levels of healthcare access and

utilization in these communities [27, 39, 40]. Developing such responses requires careful research, strategic planning, broad public engagement, and substantial resource commitment. Only through a deliberate and comprehensive approach can racial and ethnic health inequities be eliminated in the long run.

Several limitations should be noted. First, because the analysis relies on county-level data and an ecological regression framework, the results cannot be interpreted as reflecting individual-level relationships between race/ethnicity and COVID-19 outcomes. Ideally, analyses of this kind would use person-level data on health outcomes, race/ethnicity, and relevant covariates, with appropriate age adjustments; however, such data are not available at scale in the United States. Second, county-level mortality data may contain measurement error due to inconsistencies in reporting practices and definitions. Third, given the complexity of the issue, the estimated race and ethnicity coefficients represent reduced-form associations rather than causal effects. The interpretation of these estimates is further complicated by issues related to covariate selection, model specification, and unobserved confounding. For example, if comorbidities are not adequately captured by the included socioeconomic and environmental controls, incorporating community-level disease prevalence measures—where available [19]—could further explain observed disparities by capturing more direct pathways to mortality. Future research could also adopt more flexible modeling strategies to explore nonlinearities and interaction effects among racial and ethnic groups. Despite these limitations, the study's comprehensive scope—covering all major minority groups, multiple time points, and alternative measures of racial composition, while maintaining internal consistency in methods—makes it a valuable contribution and a useful resource for informing public policy.

Notes

1. The classification of the first two observation dates as corresponding to specific COVID-19 waves in the United States should be viewed as indicative rather than definitive [41]. There is no single, universally accepted method for identifying pandemic waves, and existing approaches vary considerably in both criteria and interpretation [42, 43]. The U.S. government formally declared a national emergency on March 13, 2020 [44], while the first COVID-19 vaccine dose administered outside of clinical trials occurred on December 14, 2020 [45].
2. For each time point analyzed, the complete empirical framework includes additional regression variants beyond those presented in the main tables. These comprise an intermediate model that incorporates covariates but omits the basic spatial epidemic factors, as well as a sensitivity analysis that removes counties reporting zero COVID-19 deaths. These results are excluded from the paper for conciseness. By way of example, as of May 15, 2020, one-third of the counties with the highest recorded COVID-19 mortality (34 out of the top 100) were concentrated in four states: New York, New Jersey, Massachusetts, and Connecticut. In these counties, the proportion of Asian residents averaged 8.4 percent—more than five times the corresponding average across the full sample.

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