Original Research

Racial Residential Segregation and COVID-19 Health Outcomes: Evidence from the State of Georgia

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ABSTRACT

Background:According to the Georgia Department of Public Health (GDPH), the state of Georgia reported 563,658 cumulative COVID-19 cases and 9,845 total deaths in 2020. Decades of research on racial disparities in health outcomes suggest we should not be surprised with the disproportionate number of cases, hospital visits, and deaths of non-white and Black Georgia residents. Racial disparities in health are often defined by a Social Determinants of Health (SDOH) model. One understudied SDOH is racial residential segregation. In this study we explore the relationship between racial residential segregation and COVID-19 health outcomes. Our paper addresses critical challenges for racial health disparities research with guidance for legal and policy approaches to the reduction of racial health disparities.

Methods: The 2020 University of Wisconsin Population Health Institute and GDPH datasets were used to explore the relationship between segregation and COVID-19 health outcomes in Georgia. Independent variables included those SDOH most associated with racial health disparities. Dependent variables were COVID-19 case rate, hospitalization rate and death rate.

Results: Our findings suggest that racial residential segregation is directly associated with Black COVID-19 case rate and indirectly associated with Black hospitalization and death rate through its effect on Black case rate.

Conclusions: Racial residential segregation is an often-overlooked SDOH since it is secondary to more prominent social issues such as education and economic opportunities for reducing racial disparities in health. For the Black population, especially for public health issues like COVID-19, we make the case for a better focus on racial residential segregation policy, as a social and economic factor for disease transmission. The ultimate goal is to improve health outcomes for all. A focus on racial residential segregation policy can impact better prepared health services entities and ultimately improve population health.

Keywords: Racial disparities in health, Racial residential segregation, COVID-19, Social Determinants of Health

INTRODUCTION

In 2020, the Georgia Department of Public Health (GDPH), reported 563,658 cumulative COVID-19 cases and 9,845 total deaths. By May 2021, Blacks accounted for 25% of cases and 35% of deaths. The Georgia population is 33% Black. Recent research has shed some light on barriers to Black residents' ability to get tested including longer wait times because of the high demand and limit testing sites in predominantly Black areas (Kim, Vann, Bronner, and Manthey, 2020) and longer travel times to testing sites located in predominantly white areas (Rader et al. 2020). Once tested, Black residents face increased risk of hospitalization and death because as Seldan and Berhdal (2020, p. 1624) suggest "Black adults in every age group were more likely than White adults to have health risks associated with severe COVID-19 illness".

Our paper on racial disparities in health is based on this recent and related finding by Peek (2021):

Although not all African Americans live in racially segregated neighborhoods, all African Americans, to varying degrees, are affected by economic and sociopolitical burdens of racism that may increase their risk for COVID-19 morbidity and mortality.

Structural racism has led to inequities in education, employment, income, policing and incarceration, health care access, chronic stress, and multiple other factors that affect health. For example, African Americans are more likely to be employed as low wage essential workers, in areas such as mass transit and airport facilities, food production, and pharmacies (p. 286).

There is seminal literature on structural racism in the form of racial residential segregation and its impact on health outcomes (Kramer & Hogue, 2009, Williams & Collins, 2001, Williams & Purdie-Vaughan, 2016). Using a systematic review of relevant health literature, Kramer and Hogue (2009) found strong support for four interconnected pathways that racial residential segregation affects health. These include 1) by affecting individual socioeconomic status; 2) by perpetuating unhealthy neighborhood conditions; 3) by modifying access to social capital or healthy relationships within a community; and 4) by increasing exposure to stressful stimuli (p. 181). The health of minority community members differs in response to these four conditions (low socioeconomic status, poor neighborhood conditions, limited social capital, and stressful conditions) than that of majority community members. We are seeing increased attention to pernicious racial health disparities, with a growing interest in a broader spectrum of social conditions that determine health outcomes, as well as continued interest in disparate approaches to health care delivery.

Racial residential segregation has been deemed a modifiable risk factor in reducing racial health disparities, especially with geopolitical focused research to inform policy makers (Do et.al, 2008, Li et al, 2021, Slade et al, 2023). By geopolitical political research we mean county or state level research instead of focusing on individuals or groups of individuals and their decisions or health outcomes (Brown, 2014). Immediate issues, such as a pandemic, concern public health officials and policy makers but they must address the insidious racial health disparities that have been evident for decades and continue to this day (Williams, Wallace & Mendola, 2018).

The literature on social determinants of health and health outcomes is still evolving but the Social Determinants of Health (SDOH) model (sometimes called the non-biological determinants of health) provides a framework for our paper (Fazili, 2017; Artiga & Hinton, 2018). The SDOH model recognizes that improving health outcomes will require more than looking at the healthcare system to focus on social, economic, and environmental factors that influence health (Artiga and Hinton, 2018). In other words, "social determinants of health are the conditions in which people are born, grow, live, work and age that shape health" (Artiga & Hinton, 2018 p. 1). The literature has identified five SDOH categories that include economic stability, neighborhood and physical environment, education, community and social context, and health care system. Overall, these six categories account for a large portion of health outcomes. Fazili (2017) states that "up to 50 percent of health outcomes are driven by socioeconomic factors… or the built environment" (p5) while Heiman and Artiga (2015), based on a meta-analysis of nearly 50 studies, found "that social factors, including education, racial segregation, social supports, and poverty accounted for over a third of total deaths in the United States in a year" (p2). Racial residential segregation is an important determinant of health outcomes in the community and social context category of the framework (Kramer & Hogue, 2009; Gee & Ford, 2011).

Racial residential segregation as a social determinant of health has been studied in many contexts but especially in terms of structural or systematic racism (Williams, Wallace & Mendola, 2018). Gee and Ford (2011) define structural racism "as the macrolevel systems, social forces, institutions, ideologies, and processes that interact with one another to generate and reinforce inequities among racial and ethnic groups" (p. 3) The article also defined current approaches to health services and health policy delivery. Williams and Collins (2001) have explored racial residential segregation and health policy for decades. Racial residential segregation, defined as the physical separation of the races, is a continuing social challenge. It was explored in a recent CBS 60 Minutes presentation that reinforces residence for Blacks as detrimental to their health (Whitaker, 2021; Williams & Collins, 2001). Williams and Collins (2001) have advocated for more research on the effects of segregation on health and segregated neighborhood environments. The authors suggest that racial residential segregation is a more relevant way to study the impact of SDOH community and neighborhood environments on health. A COVID-19 issue, social and economic inequities based on race, tracks back to prior literature on mortality and racial residential segregation. For example, Cooper et al. (2001) found that Blacks had a high premature mortality rate when there was low median household income. This was especially relevant when Blacks resided in highly segregated neighborhoods.

The spatial analysis approach to health disparities studies is relatively new (Brown, 2014) but considered important for policy making, especially in light of a pandemic. Prior studies show that racial residential segregation predicts overall COVID mortality (Li et al 2021, Medcalfe & Slade, 2023). Despite the relative newness of COVID-19 research findings, several studies have highlighted the disparate impact on health outcomes for racial groups in the U.S. (Weimers et al., 2020; Stokes et al., 2020). In Georgia, Moore et al. (2020) found that mortality rates in the first seven weeks of the pandemic were higher in counties with a higher proportion of non-Hispanic Black residents, older populations, less educated and poorer populations, fewer primary care physicians and were more rural. A follow up study by Porter et al. (2021) focusing on mortality after the

relaxing of "shelter-in-place" orders on April 24, 2020, found similar results: Counties in the highest quartile for mortality had a larger percentage of non-Hispanic Black residents and were poorer. Berman et al. (2021) describe in detail the ways that the COVID-19 pandemic affected residents of Georgia through the first five months of the pandemic. They found that COVID-19 incidence and fatality rates increased with rurality of county, adverse socioeconomic conditions, and income inequality (incidence rates only). However, they did not control for racial or ethnic populations. Moreover, few studies have looked at the complexity of racial health disparities in COVID mortality based on the categories and related set of variables in the SDOH framework that describe health outcomes.

Our paper builds on the SDOH framework by including racial residential segregation, a variable not included in previous studies of COVID-19, but which has been found to be a determinant of health outcomes in Georgia. Medcalfe et al., (2020) found that residential racial segregation was associated with self-reported health in Georgia but not measures of health status such as mortality of low birth weight in babies. We include a larger set of SDOH variables than previous studies and a longer timeline, including data from the onset of the disease through January 7, 2021. Our paper analyzes the relationship between racial residential segregation, a social context category for health outcomes in the SDOH, and COVID-19 in the state of Georgia. To our knowledge, this is the first study to explicitly examine this issue in Georgia, or the U.S.

METHODS

This study is an ecological study, with the unit of observation being the county. The 2020 University of Wisconsin Population Health Institute County Health Rankings dataset was used to select the SDOH and other independent variables for the 159 counties in Georgia. Variables were chosen to represent the six SDOH categories, economic stability, neighborhood and physical environment, education, community and social context, and health care system without incurring multicollinearity problems (see table 1 for correlation matrix). Other independent variables included county level demographics and the percentage of adults with obesity, which has been shown to be associated with COVID-19 outcomes (Weimers et al., 2020).

Our variable of interest is racial residential segregation. Kramer and Hogue (2009) provide the basis for our racial residential segregation variable by describing five dimensions of segregation which are evenness, isolation, concentration, centralization, and clustering. The index of dissimilarity is a measure of unevenness segregation or the degree to which groups are evenly distributed across a county. "The index of dissimilarity can be interpreted as the proportion of the minority group that would have to move to another neighborhood to achieve complete integration" (Kramer and Hogue, 2009, p. 5). Low segregation is hypothesized to be associated with better population health because segregation lowers socioeconomic status; unhealthy neighborhoods rise from segregation; and more importantly, segregation changes the social capital and economic advantage of specific racial groups. Table 2 describes the variables used throughout the entire study.

The GDPH dataset provided the dependent variables, COVID-19 case rate, hospitalization rate, and death rate for each county in the state from the outbreak of the disease to January 7th, 2021. Case rates, death rates, and hospitalization rates were calculated per 100,000 and converted to logarithmic form because of non-normality. We follow the methodology of Medcalfe et al. (2020) which used ordinary least squares regression analysis and 18 variables across the five SDOH categories to analyze the relationship between racial residential segregation and health outcomes. We expand the number of variables as new data has become available (e.g. average grade performance in reading) and to include variables known to be related to COVID-19 health outcomes (e.g. air pollution and adult obesity). Since there is no consensus on the magnitude of each of the SDOH categories we use an unweighted methodology.

The regression equation to be estimated by ordinary least squares is:

$$\text{Log(COVID-19 outcome)}c = \alpha + \beta 1\text{SEGINDEX}c + \beta 2\text{ECONOMIC}c + \beta 3\text{EDUCATION}c + \beta 4\text{HEALTHCARE}c + \beta 5\text{SOCIAL}c + \beta 6\text{ENVIRONMENT}c + \beta 7\text{DEMOGRAPHICS}c + \beta 8\text{BEHAVIOR}c + \varepsilon$$

The COVID-19 outcomes are alternatively case rate, hospitalization rate and death rate for each county (c) in Georgia. The case rate was also used as an independent variable for hospitalization rate and both case rate and hospitalization rate were used as independent variables for death rate. The coefficient of interest is β1 on the segregation index. The next five categories represent vectors of control variables from the SDOH framework as described in table 3. The demographics of each county and adult obesity are represented by the final two categories, and ε is the error term.

RESULTS

The results are presented in Table 3 and show that segregation is not associated with COVID-19 cases, hospitalizations, or deaths. However, several other SDOH are associated with COVID-19 health outcomes although there is little consistency across COVID-19 outcomes. For example, higher median household income is associated with lower COVID-19 death rate but is not statistically significantly related to cases or hospitalizations. In the

education category, a one percentage-point increase in average grade performance in reading (equivalent to one month of improved reading level) is associated with a decrease in the case rate of 17.5% but is associated with a higher death rate. In healthcare system, a one-point increase in primary care physician rate is associated with an increase in the case rate by 0.3 but has no relationship with hospitalizations or death rates. In the demographic category, a one percentage-point increase in percent non-Hispanic Black is associated with a decrease in the case rate by 0.6% but an increase in the hospitalization rate by 0.9%. Overall, the SDOH that are most associated with COVID-19 health outcomes are economic and education reflecting previous research that has found socioeconomic status a fundamental cause of health outcomes (Artiga and Hinton, 2018; Fazilli, 2017).

Overall, across the three models, the major determinant of hospitalization and death is, unsurprisingly, having COVID-19 and being hospitalized respectively. The inclusion of these COVID-19 variables increases the R-squared from 45% to about 70% across the three models. A one percent increase in the case rate will increase hospitalizations by 0.7%. A one percent increase in hospitalizations will increase deaths by 0.6%.

COVID-19 Outcomes by Race and Ethnicity

Each of these COVID-19 health outcomes was also available by race (Black and White) and ethnicity (Hispanic and non-Hispanic) from the GDPH. The Black case rate was calculated by dividing the number of Black cases in a county by the number of Black residents of the county. Equivalent calculations were made to measure Black hospitalization rate, Black death rate, as well as the corresponding rates for White, Hispanic, and Non-Hispanic.

To further investigate if COVID-19 outcomes by race and ethnicity were affected by the segregation index, new regressions were run with case rate, hospitalization rate, and death rate measured by race and ethnicity. The results are presented in Table 4 for Black COVID-19 outcomes. Results are presented with log of rates and the rate because some counties had zero hospitalizations and/or deaths. The segregation index was never significant for White, Hispanic, or Non-Hispanic so those results are not presented but are available from the authors upon request.

When examining the Black case rate in log form as a dependent variable, the segregation index is now significant. A one-percentage point increase in the segregation index is associated with an increase in the Black case rate by 0.2% (p=0.9). When the dependent variable is Black case rate the coefficient is marginally insignificant (p=.102). A one-percentage point increase in the segregation index is associated with an increase in the Black case rate of 21.2.

When examining the Black hospitalization rate the segregation variable is not significant, however, the Black case rate as an independent variable is significant in both the log and normal form models. For example, a one-percent increase in the Black case rate is associated with an increase in the Black hospitalization rate of 0.69%. Even though segregation does not directly impact Black hospitalization rate, it indirectly affects it through its effect on Black case rate of COVID-19. In addition, log of Black Hospitalization rate as an independent variable was significant when log of Black death rate was the dependent variable. A one-percent increase in Black hospitalization rate is associated with an increase in the Black death rate of 0.429%. Even though segregation does not directly impact Black death rate, it indirectly affects it through its effect on Black hospitalization rate, which is itself affected by Black case rate and segregation.

In contrast to the results for the whole population presented in Table 3, economic and education characteristics are much less associated with Black COVID-19 health outcomes. For the Black population the community and social context, including segregation, are important and suggest strong evidence that where people live is a major determinant of their health.

DISCUSSION

Racial residential segregation was not significant when looking at overall case rate, hospitalization rate, and death rate for the counties in Georgia. However, looking specifically at race it was found that racial residential segregation was positively associated with Black case rate. Racial residential segregation was not found to be associated with Black hospitalization rate and Black death rate. Although there was no direct association between racial residential segregation with Black hospitalization rate and Black death rate, it was found that Black case rate was positively associated with Black hospitalization rate. Further, Black hospitalization rate was positively associated with Black death rate. This association suggests that there is a direct and an indirect relationship between racial residential segregation and COVID-19 health outcomes.

The variable percent non-Hispanic Black was rarely significant for Black COVID-19 rates. Given the positive and significant coefficient on the segregation variable, these results together suggest it is not the number of Blacks in a county that is an important determinant of health outcomes, but how they are distributed. It is important to understanding the relationship between racial residential segregation beyond simple demographics. For example, consider two counties, A and B, that are 50% Black and 50% White (Figure 1). County B is a segregated county with all the White residents living on the West side of town and all the Black residents living on the East side of town. County A is more integrated with roughly half of all Whites

and Blacks living on the West side and half living on the East side. Our results suggest that county B will have worse COVID-19 health outcomes because it is more segregated even though the percent Black is the same in both counties.

Looking at overall data, economic stability was an important category that influenced COVID-19 health outcomes. To reduce the health disparities, public health policy can be created to look more deeply at the economic variables. However, in a more specific context, economic stability variables were less important for the Black health outcomes for COVID-19. For the Black population it is where they live in terms of social context and segregation is associated with COVID-19 outcomes and demands a different public health policy.

CONCLUSIONS

This study focuses on the relationship between racial residential segregation and COVID-19 health outcomes in the state of Georgia. We found that racial residential segregation is an important component in COVID-19 health outcomes for Black residents. Racial residential segregation was significant for Black case rate, and Black case rate was significant for Black hospitalization rate and Black death rate. This leads to a direct and an indirect relationship between racial residential segregation and COVID-19 health outcomes. Our study concludes that public health policy can be constructed looking at the economic and social conditions that affect racial disparities in health.

As authors of this paper we agree that it is tragic that a pandemic is needed to again raise awareness of the ongoing impact of racial residential segregation on racial health disparities in disease transmission and death. Disparities in pre-existing conditions have been recognized for decades and COVID-19 is not a great equalizer (Wiemers, 2020) especially when social determinants of health such as racial residential segregation are considered.

Racial residential segregation is a social determinant of health that can be impacted by policy concerning economic development and allocation of scarce public resources (Williams and Collins 2001; Williams & Purdie-Vaughn, 2016, Williams, Wallace & Mendola, 2018, Peek 2021, Slade et al, 2023). This has been a longstanding issue. Epidemics and similar disease transmission bring it to the forefront of policy discussion and public program evaluation again. We have shown that racial residential segregation affects disease transmission and controlling disease transmission is fundamental to improved population health (Van Seventer 2017; 2021).

Beyond population health we note that much more research is needed on spatiotemporal transmission of disease based on where we as individuals live (segregated or less segregated communities) and the impact on health services and allocation of scarce resources in specific geopolitical areas like counties within states (Bobo & Zubrinsky, 1996, Cuardos, 2021). The resource allocation decisions that affect structural racism are made by policy makers at the geopolitical level. We use this study to demonstrate that there is more than adequate publicly available data to support better policy decision-making.

Our study is not without its limitations. It is an ecological study and therefore does not imply anything about individual behavior. We acknowledge that there is longstanding literature that describes the in-group and out-group impact of living among people of the same race and ethnicity (Bobo & Zubrinsky, 1996) and we hope that this paper will encourage policy makers and researchers to pursue further studies at the individual and group level. The study is based solely on data from the state of Georgia, and it is not obvious that the results can be generalized to other states of the U.S. as a whole. The study methodology design is cross sectional, and although we find strong associations between segregation and COVID-19 outcomes, the results do not imply causality. Our models R-Squared suggest a large amount of the variation in COVID-19 outcomes is still unexplained. Although we control for many SDOH variable, we may still have omitted important correlates. For example, although we control for urban and rural counties, a better measure of population density may add valuable information given the changing relationship between density and COVID-19 deaths over time (Carozzi, Provenzano, and Roth, 2022). Despite the limitations, we believe that studying COVID outcomes at the county level can be informative for future research on the impact of racial residential segregation on individuals, especially those with disparate health outcomes. Our focus is on the attention of policy makers to challenges in their purview based on analysis of publicly available data using basic statistical analysis techniques.

Table 1

Correlations

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Percent Unemployed	1.0																					
2	Log of Median Household Income	-.66	1.0																				
3	Single Parent Household	.60	-.71	1.0																			
4	Income Ratio	.30	-.49	.52	1.0																		
5	Percent Homeowners	-.33	.33	-.41	-.19	1.0																	
6	High School Graduation Rate	-.20	.11	-.20	.10	.42	1.0																
7	Percent Some College	-.40	.70	-.39	-.22	-.11	.01	1.0															
8	Average Grade Performance in Reading	-.49	.69	-.69	-.40	.28	.19	.46	1.0														
9	Primary Care Physician Rate	-.10	.25	-.01	-.01	-.31	.01	.46	.19	1.0													
10	Preventable Hospitalization Stay Rate	.09	-.34	.24	.28	-.08	-.09	-.31	-.24	-.18	1.0												
11	Flu Vaccinations	-.43	.55	-.46	-.23	.22	.21	.39	.40	.22	-.19	1.0											
12	Segregation Index Non-White-White	-.06	.08	.05	.07	-.28	-.10	.23	.04	.36	-.08	.17	1.0										
13	Social Association Rate	.02	-.17	.21	.38	-.01	.20	-.06	-.07	.28	.14	.07	.18	1.0									
14	Severe Housing Problems	.30	-.42	.61	.31	-.61	-.34	-.06	-.54	.13	.07	.19	.14	.16	1.0								

15	Air Pollution- Particulate Matter	.11	.14	.12	-.08	-.17	-.28	.18	-.11	.04	-.03	.01	.06	-.22	.14	1.0						
16	Access to Exercise Opportunities	-.25	.47	-.32	-.30	-.19	-.14	.43	.35	.47	-.19	.35	.27	.06	.02	-.14	1.0					
17	Percent Non-Hispanic Black	.56	-.73	.77	.32	-.47	-.37	-.11	-.56	.07	.06	-.46	.10	.01	.57	.38	-.22	1.0				
18	Percent Hispanic	-.10	.10	-.12	-.17	-.22	-.12	-.05	-.01	.06	.02	.14	.05	-.19	.11	.04	.20	-.16	1.0			
19	Percent 65 and older	.14	-.31	.20	.12	.44	.31	-.40	-.18	-.06	-.07	.02	-.06	.38	-.06	-.39	-.15	-.12	-.37	1.0		
20	Percent Rural	-.42	.42	-.45	-.33	.17	.12	.18	.32	.03	-.08	.32	.09	-.02	-.21	.07	.17	-.44	.14	-.17	1.0	
21	Log of Population	-.37	.61	-.31	-.30	-.31	-.24	.59	.30	.39	-.18	.33	.37	-.13	.09	.24	.54	-.01	.35	-.61	.41	1.0
22	Adult Obesity	.11	-.22	.27	.21	-.09	.02	-.16	-.20	-.09	.21	-.21	-.10	-.03	.08	.13	-.25	.19	-.09	-.10	-.11	-.18	1.0

Table 2

Summary Statistics

	Dependent Variables	Definition	Mean	SD	Min	Max
COVID-19	Log of Case Rate	Logarithm of COVID-19 Case Rate in the counties of Georgia	8.583	0.299	7.763	9.917
	Log of Hospitalization Rate	Logarithm of COVID-19 Hospitalization Rate in the counties of Georgia	6.079	0.484	4.808	7.528
	Log of Death Rate	Logarithm of COVID-19 Death Rate in the counties of Georgia	4.730	0.628	2.230	6.352
	Independent Variables	Definition	Mean	SD	Min	Max
Economic Stability	Percent Unemployed	Percentage of population ages 16+ unemployed and looking for work	4.435	0.918	2.956	7.692
	Log of Median Household Income	The income where half of households in a county earn more and half of households earn less. (Log form)	10.735	0.251	10.251	11.570
	Single Parent Household	Percentage of children that live in single-parent households	40.766	12.398	13.286	80
	Income Ratio	Ratio of household income at the	4.967	0.935	3.450	11.971

	Dependent Variables	Definition	Mean	SD	Min	Max
		80th percentile to income at the 20th percentile				
	Percent Homeowners	Percentage of occupied housing units that are owned	67.974	8.952	26.0	86.0
Education	High School Graduation Rate	Graduation rate	87.845	5.352	72.088	98.864
	Percent Some College	Percentage of adults ages 25-44 with some post-secondary education	50.725	11.959	20.746	81.566
	Average Grade Performance in Reading	Average grade level performance for 3rd graders on English Language Arts standardized tests	2.938	0.276	2.059	3.849
Health Care System	Primary Care Physician Rate	Primary Care Physicians per 100,000 population	46.472	28.139	0	139.371
	Preventable Hospitalization Stay Rate	Discharges for Ambulatory Care Sensitive Conditions per 100,000 Medicare Enrollees	5327.968	1337.435	1246.0	10012.0
	Flu Vaccinations	Percentage of annual Medicare	41.126	5.620	25.0	53.0

	Dependent Variables	Definition	Mean	SD	Min	Max
		enrollees having an annual flu vaccination				
Community and Social Context	Segregation Index Non-White White	Index of dissimilarity where higher values indicate greater residential segregation between Non-White and White county residents.	26.980	12.277	1.755	64.053
	Social Association Rate	Associations per 10,000 population	8.981	3.465	0	17.586
Neighborhood and Physical Environment	Severe Housing Problems	Percentage of households with at least 1 of 4 housing problems: overcrowding, high housing costs, lack of kitchen facilities, or lack of plumbing facilities	15.967	3.264	9.444	25.824
	Air Pollution-Particulate Matter	Average daily amount of fine particulate matter in micrograms per cubic meter	10.737	0.621	8.7	12.0
	Access to Exercise Opportunities	Percentage of the population with access	54.168	26.786	0	100

	Dependent Variables	Definition	Mean	SD	Min	Max
		to places for physical activity				
Demographics	Percent Non-Hispanic Black	Percentage of population that is non-Hispanic Black or African American	27.951	17.319	0.633	70.843
	Percent Hispanic	Percentage of population that is Hispanic	6.842	5.763	1.589	35.928
	Percent 65 and older	Percentage of population ages 65 and older	17.519	4.553	4.830	34.534
	Percent Rural	Percentage of population living in a rural area	60.489	28.967	0.246	100
	Log of Population	Resident population (Log form)	8.789	1.254	6.061	12.670
Health Behavior	Adult Obesity	Percentage of adults that report BMI >= 30	34.448	5.885	23.4	57.7

Note: Variables from University of Wisconsin Population Health Institute and GDPH. Definitions of variables directly from data source.

Table 3

Regression Results for COVID-19 Health Outcomes

Category	Independent Variables	Log of Case Rate	Log of HR	Log of Death Rate
COVID-19	Log of Case Rate		0.703*** (0.000)	-0.075 (0.714)
	Log of Hospitalization Rate			0.596*** (0.000)
Economic Stability	Percent Unemployed	0.027 (0.422)	.008 (0.847)	0.089 (0.170)
	Log of Median Household Income	0.064 (0.774)	-0.343 (0.218)	-1.240*** (0.001)
	Percent Single Parent Household	-0.00073 (0.837)	0.012*** (0.004)	0.006 (0.344)
	Income Ratio	0.032 (0.161)	-0.052* (0.075)	0.024 (0.521)
	Percent Homeowners	-0.005 (0.533)	0.019*** (0.001)	0.024*** (0.009)
Education	High School Graduation Rate	0.006 (0.161)	0.004 (0.530)	0.010 (0.161)
	Percent Some College	-0.004 (0.296)	-0.002 (0.615)	-0.010* (0.091)
	Average Grade Performance Reading	-0.192* (0.061)	0.005 (0.971)	0.340** (0.041)
Health Care System	Primary Care Physician Rate	0.003*** (0.001)	0.001 (0.400)	0.002 (0.257)
	Preventable Hospitalization Rate	0.000 (0.822)	0.000 (0.113)	-1.47e-07 (0.996)
	Flu Vaccinated	-0.0007 (0.883)	0.007 (0.182)	-0.006 (0.442)
Community and Social Context	Segregation Index Non-White White	0.001 (0.637)	0.000 (0.959)	0.0003 (0.901)
	Social Association Rate	0.003 (0.768)	0.023** (0.014)	0.008 (0.482)
Neighborhood and Physical Environment	Severe Housing Problems	0.011 (0.305)	0.010 (0.394)	-0.010 (0.513)
	Air Pollution- Particulate Matter	-0.037 (0.342)	-0.076 (0.136)	0.128** (0.023)

Category	Independent Variables	Log of Case Rate	Log of HR	Log of Death Rate
	Access to Exercise Opportunities	-0.0006 (0.631)	0.001 (0.437)	0.0003 (0.860)
Demographics	Percent Non-Hispanic Black	-0.006** (0.015)	0.009*** (0.006)	-0.002 (0.625)
	Percent Hispanic	0.015*** (0.002)	0.013** (0.020)	-0.011 (0.117)
	Percent 65 and over	-0.013 (0.120)	0.002 (0.843)	0.009 (0.516)
	Percent Rural	-0.002 (0.397)	0.004** (0.033)	-0.006** (0.019)
	Log of Population	-0.093 (0.142)	0.064 (0.217)	0.077 (0.314)
Health Behavior	Adult Obesity	-0.005 (0.157)	0.005 (0.240)	0.003 (0.684)
	Number of Observations (N)	143	143	143
	R^2	0.451	0.684	0.728

Note: Robust Standard Error p-values in parenthesis ***p<0.01, **p<0.05, and *p<0.1 parenthesis

Table 4

Regression Results for the Black Case, Hospitalization, and Death Rate

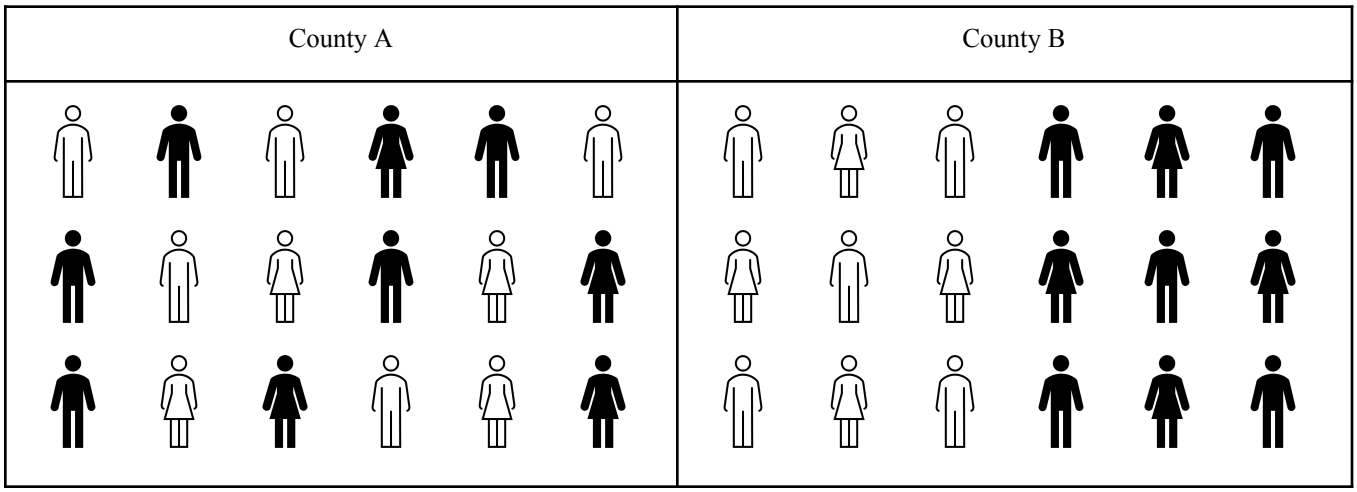
	Independent Variables	Log of Black Case Rate	Black Case Rate	Log of Black HR	Black HR	Log of Black Death Rate	Black Death Rate
COVID-19	Log of Black Case Rate			.690*** (0.000)		.223 (0.344)	
	Log of Black Hospitalization Rate					.429*** (0.001)	
	Black Case Rate				.098*** (0.000)		-.002 (0.750)
	Black Hospitalization Rate						.124*** (0.000)
Economic Stability	Percent Unemployed	-.014 (0.460)	-69.524 (0.773)	-.006 (0.836)	-38.111 (0.413)	.062* (0.092)	14.43 (0.324)
	Log of Median Household Income	.140 (0.326)	2110.0 (0.218)	-.012 (0.947)	-156.66 (0.554)	-.077 (0.741)	46.10 (0.616)
	Percent Single Parent Household	.002 (0.489)	5.615 (0.840)	.006** (0.035)	11.989*** (0.005)	.002 (0.732)	1.768 (0.251)
	Income Ratio	.008 (0.496)	177.85 (0.339)	-.027 (0.178)	-38.032 (0.186)	.049*** (0.009)	19.14** (0.041)
	Percent Homeowners	-.002 (0.588)	-49.95 (0.308)	.003 (0.301)	9.351* (0.060)	-.001 (0.777)	1.982 (0.331)
Education	High School Graduation Rate	-.002 (0.410)	-26.75 (0.368)	-.001 (0.841)	-.347 (0.948)	.005 (0.272)	1.872 (0.291)
	Percent Some College	.000 (0.994)	12.36 (0.608)	.001 (0.629)	-1.802 (0.626)	-.003 (0.326)	-1.212 (0.357)
	Average Grade Performance Reading	-.088 (0.154)	-1193.1 (0.111)	-.095 (0.424)	10.903 (0.952)	.153 (0.232)	41.09 (0.361)
Healthcare System	Primary Care Physician Rate	.001** (0.028)	11.315** (0.044)	.001 (0.330)	-.145 (0.900)	.001 (0.427)	-.008 (0.979)
	Preventable Hospitalization Rate	.000 (0.268)	.104 (0.463)	.000 (0.439)	-.006 (0.768)	-.000 (0.262)	-.004 (0.554)
	Flu Vaccinated	.000 (1.00)	-23.849 (0.513)	.005 (0.114)	10.586** (0.027)	-.010** (0.035)	-5.187** (0.018)

	Independent Variables	Log of Black Case Rate	Black Case Rate	Log of Black HR	Black HR	Log of Black Death Rate	Black Death Rate
Community and Social Context	Segregation Index Non-White White	.002* (0.093)	21.20 (0.102)	-.002 (0.169)	-2.082 (0.369)	.001 (0.397)	.425 (0.546)
	Social Association Rate	.005 (0.290)	70.04 (0.246)	.015** (0.018)	21.698*** (0.006)	-.007 (0.313)	-.500 (0.884)
Neighborhood and Physical Environment	Severe Housing Problems	.002 (0.677)	5.169 (0.936)	-.003 (0.602)	-8.066 (0.447)	-.003 (0.762)	4.892 (0.185)
	Air Pollution-Particulate Matter	.015 (0.410)	208.1 (0.362)	-.031 (0.206)	-33.378 (0.367)	.073* (0.059)	37.880** (0.010)
	Access To Exercise Opportunities	-.001 (0.230)	-9.850 (0.200)	-.000 (0.750)	-1.310 (0.317)	-.000 (0.863)	-.644 (0.209)
Demographics	Percent Non-Hispanic Black	-.002 (0.238)	-27.627 (0.124)	.002 (0.126)	3.920* (0.092)	-.004 (0.209)	-1.126 (0.276)
	Percent Hispanic	.004 (0.245)	66.04* (0.095)	.004 (0.209)	-1.222 (0.791)	.000 (0.964)	-.158 (0.921)
	Percent 65 and over	-.010 (0.120)	-81.52 (0.208)	.004 (0.656)	-10.243 (0.387)	.013 (0.209)	2.501 (0.508)
	Percent Rural	-.000 (0.776)	-2.195 (0.837)	.002* (0.054)	1.711 (0.314)	-.001 (0.637)	-1.606** (0.022)
	Log of Population	-.079*** (0.008)	-1091.1** (0.012)	.016 (0.590)	49.415 (0.346)	-.038 (0.462)	-31.184* (0.058)
Health Behavior	Adult Obesity	.001 (0.512)	11.22 (0.687)	.001 (0.785)	1.768 (0.628)	.004 (0.368)	1.080 (0.530)
	Constant	3.20*** (.009)	-1324.4 (0.925)	-.057 (0.973)	556.36 (0.825)	-.405 (0.853)	-903.13 (0.277)
	Number of observations	143	143	138	143	131	143
	R^2	0.31	0.35	0.55	0.52	0.58	0.59

Note: Robust Standard Error p-values in parenthesis ***p<0.01, **p<0.05, and *p<0.1

Figure 1

Racial Residential Segregation, An Example.



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