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Born on the wrong side of the tracks: Exploring the causal effects of segregation on infant health[☆]

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ABSTRACT

Prior research has found that a high level of residential racial segregation, or the degree to which racial/ethnic groups are isolated from one another, is associated with worsened infant health outcomes, particularly among non-Hispanic (NH) Black infant populations. However, because exposure to segregation is non-random, it is unclear whether and to what extent segregation is causally linked to infant health. To overcome this empirical limitation, we leverage exogenous variation in the placement of railroad tracks in the 19th century to predict contemporary segregation, an approach first introduced by Ananat (2011). In alignment with prior literature, we find that residential segregation has statistically significant associations with negative birth outcomes among Black infant populations in the area. Using OLS methods underestimates the negative impacts of segregation on infant health. We fail to detect comparable effects on health outcomes among NH White infant populations. Further, we identify several key mechanisms by which residential segregation could influence health outcomes among Black infant populations, including lower access to prenatal care during the first trimester, higher levels of anti-Black prejudice, greater transportation barriers, and increased food insecurity. Given that poor birth outcomes have adverse effects on adults' health and well-being, the findings suggest that in-utero exposure to residential segregation could have important implications for Black–White inequality over the life course.

1. Introduction

Researchers and policymakers have directed increasing attention and resources to addressing the longstanding Black–White disparities in infant health. Non-Hispanic (NH) Black infants experience the highest rates of low birthweight, preterm birth, and infant mortality of any racial/ethnic subgroup in the United States (Underwood et al., 2021; Culhane and Goldenberg, 2011; Green and Hamilton, 2019). These disparities persist even after accounting for birthing parents' individual-level characteristics and health behaviors, signaling the need to better understand how structural factors drive infant health. Identifying the most salient structural factors and assessing the magnitude of their impact is essential to reducing racial/ethnic disparities in early-life health and thus addressing the long-term consequences of these disparities on adult economic status and well-being.

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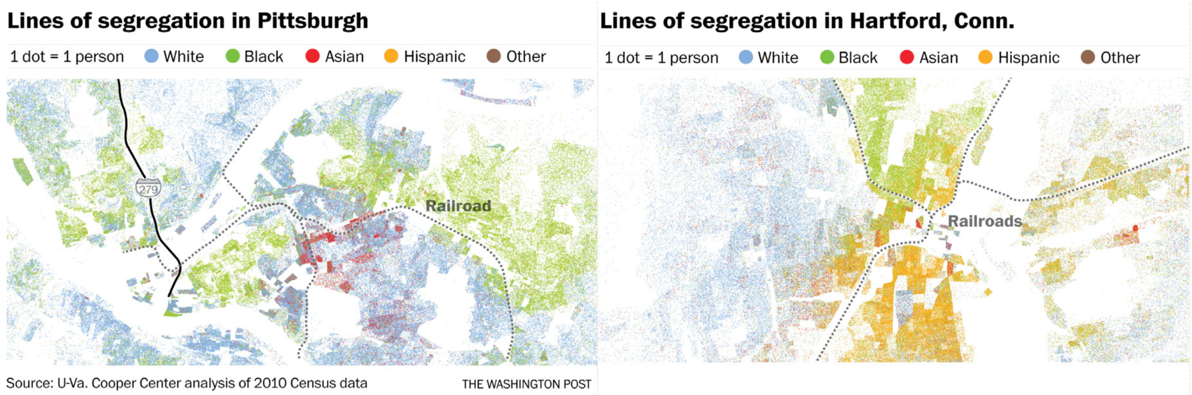

Fig. 1. Lines of segregation.

In the present study, we focus on one such structural factor: Black–White racial residential segregation (i.e., segregation). Segregation refers to the degree of spatial separation between racial/ethnic groups (see Table 1 for components of segregation). NH White and NH Black Americans comprise 60 percent and 12 percent of the U.S. population, respectively (2020 U.S. Census Bureau). Yet the typical White American lives in an area that is 71 percent White and the typical Black American lives in an area that is 45 percent Black (2014–2018 American Community Survey). These patterns did not occur by happenstance: both private and governmental discriminatory processes served to segregate Black and White Americans for more than a century. While average segregation levels have declined over the past several decades, this overall trend obscures extreme racial segregation levels in certain U.S. metropolitan areas (e.g., Detroit), as well as the increasing spatial isolation between poor and affluent communities. Due to segregation, Black Americans are more likely than White and Asian Americans to live in impoverished neighborhoods with reduced access to high-quality schooling and other important resources. In sum, Massey (2020) described segregation as "a kind of spatial glue that holds a [racial] stratification system together and intensifies its effects" (p. 1).

Segregation's negative impacts on a neighborhood's socioeconomic status and resources likely partially explain the strong association between segregation and health inequalities throughout the life course. For example, racial segregation is correlated with racial gaps in childhood asthma and early-life health outcomes such low birth weight (Alexander and Currie, 2017; Mehra et al., 2017). Further, one study found that Black children who consistently lived in segregated neighborhoods were more likely to experience worse adult health and more likely to smoke or drink than those who moved in and out of highly segregated neighborhoods (Schwartz et al., 2022). In contrast, studies have generally found no effects, or sometimes even positive effects, of segregation on health outcomes among White populations, including White infants (Kramer and Hogue, 2009).

Despite the large body of evidence linking residential segregation and infant and child health, very few studies have assessed whether these links are causal. Such assessments are difficult because unobserved area-level characteristics simultaneously affect both segregation and health outcomes for Black infant populations. For example, structural racism or racial animus may simultaneously influence the level of segregation within a region and the health outcomes of its infant population. Failing to account for these omitted variables produces biased estimates from OLS or even fixed effects models.

To address these potential biases, we use an instrumental variables (IV) identification strategy (Ananat, 2011), leveraging plausibly exogenous historical railroad divisions to estimate the causal impacts of residential segregation on the health of an area's NH Black and NH White infant populations. Specifically, we leverage the fact that, in the early 19th century, train companies laid thousands of miles of railroad tracks in metropolitan areas to transport goods and passengers between cities. The arrangement of these tracks created ready-made neighborhood subdivisions, which local policymakers used to establish and enforce racially segregated neighborhoods in response to large influxes of Black migrants from the U.S. South (Ananat, 2011). These patterns have persisted to the present day, and thus railroad lines often define the boundaries between Black and White communities (see Fig. 1). In other words, although train companies did not choose track configurations to facilitate racial segregation, they were a key technology that enabled segregation (Ananat, 2011). Importantly, we argue that the historical placement of railroad tracks is unrelated to contemporary birth outcomes and can serve as an exogenous instrument for estimating the causal effects of segregation on health.

The main IV results show that plausibly exogenous exposure to residential segregation has significant negative impacts on the birth outcomes of NH Black infant populations in the area. Specifically, a 1 SD increase in racial segregation (equivalent to a 13.6% change) leads to a 49 g decrease in birth weight, a 1.2 percentage point increase in the likelihood of low birth weight, a 0.3 percentage point increase in the likelihood of very low birth weight, a 1.7 percentage point increase in being categorized as small for gestational age, a 0.16 week decrease in gestational length, a 1.9 percentage point increase in the likelihood of preterm birth, and a 0.95 gram per week decrease in fetal growth among Black infant populations. The OLS results were generally smaller in magnitude than the IV results. This pattern suggests that analyses that fail to account for the endogeneity of segregation likely underestimate its consequences for infant health. Importantly, we find few to no effects on White infant populations. Finally, we explore structural pathways through which segregation could potentially affect the health of infant populations in a given area. The analyses suggest that segregation is linked to lower access to prenatal care during the first trimester, higher levels of anti-Black prejudice, greater

Table 1
Components of segregation.
Source: Weinberg et al. (2002), Measurement of Segregation by the US Bureau of the Census, *Racial and Ethnic Residential Segregation in the United States: 1980–2000.*

Dimension of segregation	Definition	Measurement
Evenness	Unequal distribution of Black and White populations across areal units (e.g., neighborhoods) of an urban area	Dissimilarity index Theil's entropy index
Exposure	Degree to which Black and White populations have the potential contact	Isolation index Interaction index
Clustering	Degree to which minority (e.g., Black Americans) areas adjoin one another in space	White's index of spatial proximity
Centralization	Degree to which a group (Black or White) is located in close proximity of far away from the center urban area	Centralization index
Concentration	Relative amount of physical space taken up by a minority group (e.g., Black Americans) in an urban environment	Concentration index

transportation barriers, and increased area food insecurity (particularly among Black populations), findings consistent with those of prior studies linking each of these mechanisms to poor birth outcomes (Simonovich et al., 2020; Grilo et al., 2022; Orchard and Price, 2017). Taken together, the findings contribute to a growing literature documenting the causal impacts of racial segregation on the health and economic outcomes of Black American populations.

2. Background

2.1. Evolution of racial segregation outside the U.S. South

Residential segregation in the northern and western United States has a long and complex history. The large influx of Black migrants arriving from the U.S. South during the first half of the 20th century (i.e., the Great Migration) played a central role in this process (Massey and Denton, 1988). After the Civil War and the dissolution of legalized chattel slavery, Black Americans living in the former Confederacy made important strides in political participation, literacy, and economic advancement (Foner, 2002; Logan and Parman, 2017). However, the premature withdrawal of federal oversight allowed former Confederate states to impose a series of laws rolling back progressive reforms such as state-funded public school systems for all racial groups and anti-discrimination laws. In addition, state and local governments actively worked to disenfranchise Black Americans and implement state-sanctioned segregation. Coupled with an exploitative sharecropping system that kept Black Southerners in permanent servitude, increasing levels of anti-Black racism (e.g., threats, land theft, public lynching), and the post-World War I increase in demand for labor in the North, these developments prompted many Black families to leave the U.S. South in search of better economic opportunities and freedom from the constant specter of violence (Wilkerson, 2010). Between 1910 and 1960/70, millions of Black Southerners migrated to the North and West, settling in urban centers such as Chicago, New York, and Detroit.

The historical evidence suggests that relatively few of these Black Southern migrants were able to achieve the economic security and prosperity they hoped for. White residents did not welcome the large influx of new migrants; both governmental and private actors worked to segregate neighborhoods. Discriminatory practices such as redlining (the Federal Housing Administration's refusal to insure houses in or in close proximity to Black neighborhoods) (Aaronson et al., 2021), racial housing covenants that barred homeowners from selling to Black Americans, and interracial violence (i.e., lynching) (Massey and Denton, 1988; Cook et al., 2018) funneled Black residents into highly segregated, overcrowded inner city neighborhoods with substandard housing and limited access to education and job opportunities.

However, the problem of segregation is not relegated to the past. As Massey (2020) noted (p.1), "segregation…remains an important nexus in America's system of socioeconomic stratification". Although openly discriminatory practices such as redlining and racial housing covenants are now illegal and average segregation levels have declined since the 1980s (Massey and Denton, 1988), extreme racial segregation persists in certain U.S. metropolitan areas and the spatial isolation between poor and affluent communities is increasing. Further, even the most affluent Black Americans are more likely than the least affluent Hispanic or Asian Americans to be segregated from White Americans. Even today, banks are more likely to deny mortgages to Black prospective home buyers (Wheeler and Olson, 2015), and appraisers routinely undervalue owner-occupied homes in Black communities (Perry et al., 2018). As such, the average Black American lives in a census tract where over 33% of the residents have incomes below the federal poverty line, whereas the average White American lives in a tract where only 21% of the residents are poor.

2.2. Segregation and infant health

A large literature suggests that segregation is associated with early life morbidity and mortality, particularly among Black infants. First, pregnant people who live in more segregated areas are less likely to successfully carry a pregnancy to term. For example, using a sample of Georgia births, Brown et al. (2012) found that segregation was associated with a higher risk of stillbirth among Black birthing people, while the opposite was true for their White counterparts. More recent work from Williams et al. (2018) using national-level data found that low and declining segregation levels were associated with decreased stillbirth risks; further, Black pregnant people experienced disproportionate benefits from declines in segregation. In a 2017 systematic review, Mehra and colleagues reported that most of the focal studies found that Black infants born to parents living in more segregated neighborhoods were more likely to experience low birth weight, preterm birth, and infant mortality than those born to parents living in less segregated neighborhoods. In contrast, prior studies have found few to no associations between segregation and birth outcomes among NH White birthing people.

One important limitation of most extant studies on segregation and (infant) health is that they do not show that the estimated relationships are causal. Importantly, unmeasured area characteristics such as exposure to environmental toxins, lack of access to healthy food, and high levels of violence and crime could both increase segregation levels and worsen infant health outcomes. This empirical challenge often prevents researchers from fully understanding whether and to what extent segregation impacts early life health.

We are aware of only one prior study that attempted to estimate the causal impacts of segregation on infant health. Austin et al. (2016) estimated the links between MSA-level segregation and racial disparities in birth weight using the railroad division index as an instrument for segregation. Using two-stage least squares (2SLS) models, the authors found that every 1 percentage point increase in segregation lowered birth weight by 2.8 g. In contrast, the same increase had little impact on White infants' birth weight. Importantly, the authors found that failing to account for the endogeneity of segregation understated the impact of segregation on health and well-being. However, the study focused on only one birth outcome (birth weight for the full infant sample, restricted to infants born at or after 37 weeks gestation). This limitation may prevent the identification of important pathways through which segregation impacts infant health, such as through preterm birth. Finally, the study sample was restricted to a single year of data (2000), and thus does not allow an assessment of whether and to what extent the relationships between segregation and birth outcomes vary over time and across historical contexts (Logan and Parman, 2017).

2.3. Contribution of the present study

This study builds on prior work examining the causal relationships between segregation and infant health (Austin et al., 2016) by examining several plausible structural pathways linking segregation and health. First, we measure infant health using an array of important birth outcomes, including low and very low birth weight, preterm and very preterm birth, gestational age, small for gestational age, and fetal growth. We examine preterm birth because experts have identified this outcome as the most important correlate of infant mortality. We also focus on intrauterine growth restriction (i.e., small for gestational age) because researchers consider it a potential pathway linking segregation and low birth weight. We use areas' birth outcomes from 121 non-Southern MSAs for a 10-year period (2010–2019), which allows us to estimate the impact of segregation on population-level health outcomes rather than individual health. This is a significant advancement as the IV estimates do not isolate the treatment effect of segregation from selection (e.g., the movement of unhealthy individuals into and healthy individuals out of segregated areas).

Second, in an effort to disentangle selection to segregated areas (unhealthy people move in and healthy people move out) from the treatment effect of segregation, we used a sample exclusively composed of individuals who were predicted to reside in the same location where they were born, referred to as 'stayers'.[1] By utilizing the 'stayers' sample, we aim to alleviate concerns surrounding the potential migration of unhealthy individuals into and healthy individuals out of segregated areas.

Third, and perhaps most significantly, we incorporate various supplementary datasets to explore potential mechanisms through which segregation might influence birth outcomes at the metro level. These include factors such as the educational and age structure within the birthing population, as well as the accessibility of prenatal healthcare in the area. Next, we present several checks on mechanisms that align with the impact of segregation on individual outcomes. Recent work suggests that segregation reduces intergenerational mobility for Black children, and potential mechanisms underlying this link are reductions in government expenditures, declines in support for anti-poverty policies, and increases in anti-Black racism (Chyn et al., 2022). We focus primarily on access to resources and measures of the social environment that prior work has linked to adverse birth outcomes. First, we capture access to resources and infrastructure via MSA-level measures of food insecurity, housing security, and barriers to transportation. Diminished access to these resources could adversely affect food intake, stress levels, and ability to access healthcare, which in turn could affect infant health outcomes. Second, we assess the links between segregation and MSA-level explicit and implicit prejudice, which prior work has linked to preterm birth among Black infants (Orchard and Price, 2017).

3. Data

The analyses use data from the American Community Survey (segregation and area characteristics), the 2010–2019 U.S. Vital Statistics Natality Files (area's infant health outcomes), Harvard's Project Implicit website (anti-Black prejudice measures), the Food Environment Atlas (food insecurity), and the Comprehensive Housing Affordability Strategy data (housing insecurity).

Segregation data. We use nationally representative population samples from the American Community Survey (ACS) Integrated Public Use Microdata Series data (Ruggles et al., 2022) and data from Cutler et al. (1999) to capture residential segregation (via the dissimilarity index). The ACS is a nationally representative survey administered to three million households annually by the U.S. Census Bureau. The ACS data provide population estimates by race and Hispanic origin in each census tract, which we used to calculate a measure of segregation: the dissimilarity index. This index is a statistical measure used to assess the level of segregation

[1] We extend our appreciation to the editor for this valuable recommendation.

within a given geographic area. It is based on the principle that segregation is defined as the unequal distribution of a particular population group across a geographic area. While this measure can be calculated for many social groups, we focus here on NH Black and NH White populations because they are the focus of the present study. (Throughout the remainder of the article, we use "Black" to refer to NH Black populations and "White" to refer to NH White populations.) The dissimilarity index was calculated as follows:

$$\text{Dissimilarity index} = \frac{1}{2}\sum_{i=1}^{N}\left|\frac{Black_i}{Black} - \frac{White_i}{White}\right| \tag{1}$$

where i is an index for a census tract within a city,[2] $Black_i$ is the total number of Black residents in tract i, $White_i$ is the total number of White residents in tract i, Black is the total number of Black residents in the city, and White is the total number of White residents in the city.[3]

The index of dissimilarity measures the fraction of one group that would have to move to another neighborhood in order to equalize the population distribution in the metropolitan statistical area. In other words, this index measures how evenly Black residents are spread across census tracts within a city. The index of dissimilarity ranges from 0 to 1, with higher values indicating a greater degree of segregation (Massey and Denton, 1988). For example, a value of 0.5 indicates that 50% of the members of a specific population group would need to move to a different area in order for the two groups to be equally distributed. In general, values above 0.6 are considered to represent a high level of segregation, while values below 0.3 are considered to represent a low level of segregation (Massey and Denton, 1988).

We choose the dissimilarity index because it is a widely recognized measure for quantifying residential segregation. It is commonly used in research on the effects of segregation on social and health outcomes, including infant health (Cutler et al., 1999; Ananat and Washington, 2009; Ananat, 2011; Austin et al., 2016; Chyn et al., 2022; Cox et al., 2022, and others). Additionally, we test the robustness of our results by using the isolation index as an alternative measure of segregation in Table A.6.

We focus on the 1990 dissimilarity index due to changes in Metropolitan Statistical Areas (MSAs) delineation over time. Regrettably, data constraints prevent us from calculating the dissimilarity index for 14 out of 121 cities in 2000 and 24 out of 121 cities in 2010. Over time, there have been notable changes such as "formerly separate areas have been merged, components of an area have been transferred from one area to another, or components have been dropped from an area".[4] For instance, in the case of Salem, MA, it was an independent MSA in 1990, but in subsequent years (2000 and 2010), it merged into the Boston–Cambridge–Newton, MA-NH MSA. Consequently, we opted to use the 1990 segregation data to encompass all 121 cities which Ananat (2011) constructed the railroad division index (RDI), because having the RDI data is essential to our study. Furthermore, we include a table in our analysis to demonstrate the robustness of our results using 2000 or 2010 segregation data (Table A.7). Our findings remain robust to using segregation data from 2000 or 2010.

Area's infant health data. The main data source for measuring area's infant health outcomes is a version of the 2010–2019 Vital Statistics Natality Files (VSNF). The VSNF comprises a yearly, individual-level record of all U.S. births and contains information on parental characteristics, including the birthing person's age, race, education, and marital status. The data also contain information on the child's health at birth, such as gestational weeks and birth weight. We used this information to construct other infant health measures based on generally accepted cutoffs in the literature: preterm birth (gestational weeks <37), very preterm birth (gestational weeks <34), low birth weight (birth weight <2500 g), very low birth weight (birth weight <1500 g), and fetal growth (birth weight divided by gestational weeks; this measure was used in Noghanibehambari, 2022). We also created a dummy outcome measure of small for gestational age that equals 1 if birth weight is below the 10th percentile of the birth weight distribution for the same gestational age (Talge et al., 2014). We collapsed the data using metro-level population weights to get the infant health statistics at the metro-level. These statistics were then merged with segregation data using the MSA FIPS code.

Implicit and explicit prejudice data. We used data collected from Harvard's Project Implicit website, which has been gathering information on implicit and explicit prejudice toward various social groups, including Black Americans, since 1998. Specifically, we utilized data collected between 2010 and 2019 from individuals who voluntarily accessed the website and completed the anti-Black implicit association test. Although the Project Implicit website relies on a convenience sample of voluntary participants, it is currently the most extensive and inclusive source of data on implicit and explicit prejudice in the United States. The use of this dataset allowed us to examine the associations between racial segregation and the prevalence of implicit and explicit racial biases.

Food insecurity data. To measure food insecurity, we used data from the United States Department of Agriculture (USDA) Economic Research Service (ERS) Food Environment Atlas 2020. The Food Environment Atlas is a publicly available dataset that provides information on various measures of food access and availability across the United States. Specifically, we used data on food insecurity rates, which are based on the percentage of households that were categorized as having low or very low food security. These data were used to examine the relationship between the prevalence and distribution of food insecurity and segregation at the city level.

[2] We use the term "city" and metropolitan statistical area (MSA) interchangeably. Our unit of measurement in the empirical analysis is metropolitan statistical areas.

[3] The census tract is selected for its ability to meet two primary objectives. Firstly, our aim is to analyze segregation at the metro-level. Census tracts strike a balance between granularity and generalization, enabling us to effectively measure segregation without excessively fragmenting the data. Secondly, the use of census tract data to calculate the metro-level dissimilarity index is a standard practice within the literature. Its widespread adoption as a standard unit facilitates comparability across different studies and ensures consistency in evaluating segregation patterns at the metropolitan level.

[4] https://www.census.gov/programs-surveys/metro-micro/about.html.

Housing insecurity data. To measure housing insecurity, we used the U.S. Department of Housing and Urban Development's Comprehensive Housing Affordability Strategy (CHAS) data,2015–2019. Specifically, we used CHAS data to identify the percentage of households that had at least one of four housing problems: high housing costs, overcrowding, lack of kitchen facilities, or lack of plumbing facilities. CHAS includes a range of data related to housing, including data on housing insecurity, such as the percentage of households that are severely or moderately cost-burdened. The use of this dataset allowed us to investigate the relationship between segregation and housing insecurity at the city level.

We derived the main estimation sample (i.e., the integrated segregation and birth data samples) using the following criteria: First, we included only singleton births of either Black or White birthing people because health at birth is consistently worse for multiple births than for singleton births for reasons other than the health environment during the intrauterine period (Almond and Mazumder, 2011). Second, we restricted the sample to births occurring in the 121 U.S. cities outside the South for which Ananat (2011) constructed the railroad division index (RDI), because having the RDI data is essential to the instrumental variables estimation strategy.[5] Next, we only included cases with comprehensive information on all variables (see Table A.11 for details on sample derivation). Finally, we collapsed the data using population weights at the metropolitan level to derive infant health statistics for each metro.

Table A.1 presents summary statistics for the sample. In alignment with prior empirical evidence, adverse birth outcomes occurred significantly more frequently among Black infant populations than among their White counterparts. For example, the average rate of low birth weight among Black populations is 10.7%, while the same rate among White populations is significantly lower at 5.0%. A similar pattern is observed for the rate of premature births, with 13.6% of Black infants born prematurely compared to 8.0% of White infants.

4. Empirical strategy

4.1. Ordinary Least Squares (OLS)

We began the empirical analysis by examining the cross-sectional relationship between segregation and the health of Black and White infant populations within a given area, as is standard in much of the literature on segregation and infant health. Specifically, we estimated equations of the following form:

$$Y_c = \alpha + \beta Segregation_c + \epsilon_c \tag{3}$$

where Y_c is the birth outcomes of infant populations in city c. $Segregation_c$ is the segregation level in city c. The parameter of interest in this model is β, which represents the correlation between segregation and the health of infant populations in city c.

4.2. Instrumental Variables (IV)

The OLS estimates of Eq. (3) might be biased due to omitted variables. For instance, the presence of unobservable factors like racial animus can concurrently impact both the segregation levels within an area and the health outcomes of its infant population. To address these potential sources of bias, we employed an instrumental variables estimation strategy. We ran equations (second stage) similar to those above, but in the first stage, we used railroad division as an instrument for segregation. Because railroad tracks act as dividers, impeding the flow of pedestrian and vehicle traffic and thus creating geographic areas that are relatively isolated from one another, we expect areas with more railroad-created subunits to have more segregation. The use of railroad division as an instrument follows the approach developed by Ananat (2011). The specification for the first stage is:

$$Segregation_c = \delta RDI_c + \mu \tag{4}$$

where RDI is the railroad division index as defined in Eq. (2). The specification for the second stage is:

$$Y_c = \beta \widehat{Segregation}_c + \epsilon_c \tag{5}$$

where $\widehat{Segregation}_c$ is the predicted changes in city c's residential segregation obtained through the first-stage estimates.

The IV framework requires the exclusion restrictions to hold in order to interpret the estimates as the causal effect of segregation. The exclusion restriction of RDI for segregation requires railroad placement to affect the health of an area's infant populations through changes in segregation and not directly in any way. It is useful to consider the causes of U.S. railroad placement to assess whether any of these factors directly affect contemporary infant health. In the early days of railroads, railroad company executives and investors often decided where to lay the tracks. They considered factors such as the availability of land, the potential for business along the proposed route, and the potential to connect with other railroads. They also took into account the terrain and any natural obstacles that might make construction more difficult or expensive (Atack and Passell, 1994). Ultimately, the goal was to build

[5] Ananat (2011) defined the railroad division index (RDI) as:

$$RDI = 1 - \sum_i \left(\frac{area_{neighborhood_i}}{area_{total}}\right)^2 \tag{2}$$

The RDI measures the extent to which the city's land is divided into subunits by railroads, with a higher value indicating a city is more divided.

a profitable railroad that would connect important population centers and economic hubs. Thus, the factors that determined the placement of railroads were not necessarily related to the characteristics of a city that affect infant health. Below, we summarize regression results that support the assumption that railroad placement affects infant health through racial segregation.

We replicated a falsification check used by Ananat (2011) to test for correlations between RDI and city characteristics in 1910–1920, just after the period of major railroad construction; results are shown in Appendix Table A.2. Column 1 replicates the first-stage estimate in Table 4. Columns 2–7 demonstrate that there appears to be no significant correlation between RDI and population characteristics in 1910–1915. Among the 12 coefficients estimated, only the association between track length and the percentage of the Black population in 1910 is significant at the 5% level. Columns 8–13 reveal a similar lack of association between RDI and population characteristics in 1920. Out of the 12 coefficients examined, only two, the association between track length and the percentage of Black population in 1920, as well as labor force participation are significant at the 5% level. In summary, the lack of significant results across all 12 RDI coefficients indicates an absence of correlation between RDI and city characteristics during 1910–1920.

The IV framework also requires a relevant first stage.[6] Table 4 reports the first-stage estimates of Eq. (4). We began by analyzing the first-stage results without controlling for track length per square kilometer; results are shown in Column (1). The coefficient for this specification is positive and significant at the 1% level, meaning that higher values of RDI are associated with higher residential segregation in 1990. The first-stage estimate is similar in the specification controlling for track length, shown in Column (2). In both cases, the F-statistics are all greater than 10 (Stock and Yogo, 2005).

4.3. Separate treatment/causation from selection

As highlighted in Ananat (2011), the IV framework fails to disentangle two critical factors: (1) selection—determining who opts in and out of an area due to quasi-random segregation, and (2) treatment/causation—examining how this quasi-random segregation affects the residents. To mitigate this issue, we employed a sample consisting exclusively of individuals who were both born and currently reside in the same location, referred to as ‘stayers’. To identify these individuals, we employed two predictive modeling techniques Decision Trees and Support Vector Machines (SVM), using the data from the American Community Survey (ACS). Subsequently, we utilized these trained models to predict ‘stayers’ within the Vital Statistics data.

Our prediction models used ACS data from 2010 to 2019, leveraging information on state birthplace and current state residence. This has the advantage that the boundaries are stable over time. However, this method has its limitations, particularly in capturing between-city migration within a state, which might not be accounted for in inter-state migration statistics. To offset the potential underestimation of between-city migration, in our interpretation of the results, we emphasize algorithms that tend to over-predict individuals who have moved between states.

We used only women identified in the algorithm training process. Individuals were classified as ‘stayers’ if they currently reside in the same state they were born in. Subsequently, the labeled data was split into 25% for training and 75% for testing the algorithms. Training these models – Decision Tree and SVM – on the training data, we evaluated their performance using precision, recall, and accuracy metrics on the test data. Table A.3 highlights that the SVM algorithm achieved a higher precision score (74.4%) while the Decision Tree algorithm achieved a higher recall score (85.9%). Both Decision Tree and SVM algorithms demonstrated an accuracy score of 71.9%. These results indicate the efficacy of our prediction models in identifying ‘stayers’, aligning within the realistic accuracy range of 70%–90% and consistent with industry benchmarks (Brink et al., 2016).

Employing these trained algorithms on Vital Statistics data, the Decision Tree and SVM models predicted 81.8% and 85.7%, respectively, of individuals as ‘stayers.’ Subsequently, we estimated our IV specification using only the ‘stayers’ sample and presented the results in Table 6. As mentioned above, we put more weight on SVM since this model predicted a higher number of inter-state movers. Results for these models show that our estimates remain robust to using only the ‘stayers’ sample. To a certain extent, this approach helps mitigate the concern that unhealthy birthing individuals relocated to or healthy ones departed from segregated metropolitan areas. It is important to note that there could be selection bias from the earlier generations. However, if we try to model selection across multiple generations, we find ourselves in the position of disentangling place from people in a manner that appears forced.

5. Results

Concern regarding changes in the endogenous fertility rate. Endogenous sample selection is a significant concern. Specifically, if segregation has an impact on the fertility rate of an area’s Black populations, it may lead to biased estimates. To address this issue, we conducted tests to assess the impact of segregation on fertility rates (births per 1000 birthing people aged 15–44) and birth rates (births per 1000 people in the general population) of Black populations, and the results are presented in Table 2. We also used the share of male birth as a proxy for miscarriages, as male fetuses are more vulnerable to the negative effects of maternal stress in utero, and a reduction in male births may indicate an increase in miscarriages (Sanders and Stoecker, 2015). Our analysis revealed no significant impact of segregation on fertility rates for Black populations (Columns 1 and 2). Additionally, we observed small and insignificant impacts of segregation on the share of male births for Black populations (Column 3). These findings indicate that endogenous sample selection does not bias our results.

[6] Figure A.1 shows the relation between segregation and the Railroads Division Index. As predicted, segregation is positively related to the Railroads Division Index.

Table 2
Racial segregation and fertility of black populations.

	Births per 1000 women aged 15–44 (1)	Births per 1000 population (2)	Probability of a male birth (3)
1990 Dissimilarity index	−0.0666 (2.3685)	−0.0533 (0.4478)	−0.0321 (0.0321)
Effect of 1 SD increase	−0.009	−0.007	−0.004
Mean dep. var.	4.91	1.01	0.51
Observations	90	90	121

Notes: Data are from Vital Statistics Natality and Surveillance, Epidemiology, and End Results (SEER) 2010–2019. Fertility rate is defined as births per 1000 birthing people aged 15–44, birth rate is defined as births per 1000 population, and male birth is a dummy for male birth. Heteroskedasticity robust standard errors are reported in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 3
OLS estimates.

Outcomes	Birth weight (1)	Low birth weight (2)	Very low birth weight (3)	Small for gestational age (4)	Gestational weeks (5)	Preterm birth (6)	Very preterm birth (7)	Fetal growth (8)
Panel A: Blacks								
1990 Dissimilarity index	−187.1615*** (58.6020)	0.0672*** (0.0127)	0.0197*** (0.0041)	0.0568*** (0.0150)	−0.5671** (0.2227)	0.0836*** (0.0182)	0.0419*** (0.0073)	−3.8805*** (1.1433)
Effect of 1 SD increase	−25.495	0.009	0.003	0.008	−0.077	0.011	0.006	−0.529
Mean dep. var.	3171.01	0.10	0.02	0.16	38.51	0.13	0.04	82.00
Observations	121	121	121	121	121	121	121	121
Panel B: Whites								
1990 Dissimilarity index	−0.0587 (32.8972)	0.0113* (0.0057)	0.0036** (0.0017)	0.0017 (0.0096)	−0.0991 (0.1233)	0.0239** (0.0097)	0.0104*** (0.0037)	0.2061 (0.6403)
Effect of 1 SD increase	−0.008	0.002	0.000	0.000	−0.013	0.003	0.001	0.028
Mean dep. var.	3387.87	0.05	0.01	0.09	38.98	0.08	0.02	86.75
Observations	121	121	121	121	121	121	121	121

Notes: The table shows OLS estimation results from Eq. (3). Data are from Vital Statistics Natality 2010–2019. Heteroskedasticity robust standard errors are reported in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 4
Instrumental variables estimates: First-stage.

Outcome	1990 Segregation	
	(1)	(2)
RDI	0.40*** (0.08)	0.36*** (0.09)
Observations	121	121
R-squared	0.17	0.20
Control for railroad track length	No	Yes
F-test	21.57	13.46

Notes: The table shows estimation results from Eq. (4). Data are from Vital Statistics Natality 2010–2019. Columns (1) and (3) show results without controlling for track length per square kilometer. Columns (2) and (4) show results controlling for track length. Heteroskedasticity robust standard errors are reported in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

OLS results. We began the econometric analysis by conducting an OLS regression, separately estimating Eq. (3) for the health of Black and White infant populations at the metro level; results are presented in Table 3. As shown in Panel A, among Black infant populations, a 1 SD increase in residential segregation is associated with roughly a 25 g decrease in birth weight (Column 1), a 0.9 percentage point increase in low birth weight (Column 2), a 0.3 percentage point increase in very low birth weight (Column 3), and a 0.8 percentage point increase in being categorized as small for gestational age (Column 4). In addition, this increase in segregation is associated with a 0.08 week decrease in gestational length (Column 5), a 1.1 percentage point increase in the likelihood of preterm birth (Column 6), a 0.6 percentage point increase in the likelihood of very preterm birth, and a 0.53 gram per week decrease in fetal growth (Column 8) for Black infant populations. Panel B of Table 3 shows the results for White infant populations. Relative to the results for Black infant populations, estimates are much smaller (Columns 1–7) or indicate relationships in the opposite direction (Column 8). Though robust, the OLS results might still be affected by omitted variable bias as discussed in Section 4. To correct this bias, we employ an instrumental variables strategy.

IV results. Table 5 reports second-stage estimates. Panel A presents estimates for Black infant populations. As shown in Columns 1–8, a 1 SD increase in residential segregation leads to a 49 g decrease in birth weight, a 1.2 percentage point increase in the likelihood of low birth weight, a 0.3 percentage point increase in the likelihood of very low birth weight, a 1.7 percentage point

Table 5
Instrumental variables estimates: Second-stage.

Outcomes	Birth weight	Low birth weight	Very low birth weight	Small for gestational age	Gestational weeks	Preterm birth	Very preterm birth	Fetal growth
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Blacks								
1990 Dissimilarity index	−362.2536**	0.0881*	0.0216**	0.1244**	−1.1467**	0.1408***	0.0569***	−6.9670*
	(181.8590)	(0.0460)	(0.0089)	(0.0570)	(0.5821)	(0.0509)	(0.0185)	(3.5575)
Effect of 1 SD increase	−49.346	0.012	0.003	0.017	−0.156	0.019	0.008	−0.949
Mean dep. var.	3171.01	0.10	0.02	0.16	38.51	0.13	0.04	82.00
Observations	121	121	121	121	121	121	121	121
Panel B: Whites								
1990 Dissimilarity index	−131.5157	0.0489	0.0094*	0.0366	−0.8953	0.1012	0.0317	−1.3614
	(116.0599)	(0.0311)	(0.0055)	(0.0342)	(0.5869)	(0.0637)	(0.0199)	(1.9214)
Effect of 1 SD increase	−17.915	0.007	0.001	0.005	−0.122	0.014	0.004	−0.185
Mean dep. var.	3387.87	0.05	0.01	0.09	38.98	0.08	0.02	86.75
Observations	121	121	121	121	121	121	121	121

Notes: Data are from Vital Statistics Natality 2010–2019. Heteroskedasticity robust standard errors are reported in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

increase in being categorized as small for gestational age, a 0.156 week decrease in gestational length, a 1.9 percentage point increase in the likelihood of preterm birth, a 0.8 percentage point increase in the likelihood of very preterm birth, and a 0.95 gram per week decrease in fetal growth among Black infant populations. Among White infant populations (Panel B), the coefficients are either not statistically significant (Columns 1, 2, 4, 5, 6, 7, and 8) or smaller in magnitude (Column 3). Collectively, the IV results indicate a detrimental effect of residential segregation on birth outcomes within the Black infant population while demonstrating no impact on the White infant population. Nevertheless, these results do not conclusively establish whether segregation directly induces adverse birth outcomes among Black infants.

We ran multiple robustness tests for the IV estimates. First, following Ananat (2011), we controlled for city characteristics in 1910 and 1920, as these historical city characteristics might affect cities today. The results, shown in Tables A.4 and A.5, indicate that the estimates remain robust even after controlling for these historical city characteristics, which may have affected cities in ways that persist today. Second, the results are robust when we use the isolation index instead of the dissimilarity index to measure segregation; results are shown in Table A.6.[7] This robustness check confirms that the results are not reliant on a single measure and provides a more robust and accurate representation of the effects of segregation patterns in a given city. Third, our results remain robust when accounting for routine flooding at the city-level in Table A.8. Given the likely correlation between flood risk, residential segregation, and infant health, any alteration in the relationship between segregation and infant health by controlling for this factor would suggest the exclusion restriction assumption might not hold. However, our IV estimates for segregation's impact on city-level infant health remain robust after including flood risk controls. Although the point estimates show a tendency to decrease slightly, these results together with results in Table A.4 reinforce our confidence that RDI impacts infant health primarily through segregation, rather than other factors.

IV estimates and OLS estimates. A comparison of the OLS results in Table 3 and the IV results in Table 5 indicates that the OLS analysis underestimates the impact of segregation on the health of an area's Black infant populations. The observed difference in model results might stem from potential omitted variable bias in the OLS model. Omitted variables such as structural racism/racial animus influence both segregation and directly affect the health of local infant populations. The IV estimates assist in estimating the effect of segregation on infant health while excluding the influence of structural racism or racial animus on infant health outcomes.

6. Mechanisms

A limited number of studies have established that segregation is associated with lower public spending because areas with a high level of segregation generate fewer revenues (Chyn et al., 2022; Cox et al., 2022). In addition, a larger body of literature has documented the association between racial resentment and lukewarm support for welfare programs and redistributive policies (Metzl, 2019; Westbrook, 2020). Because government spending and redistributive policies can directly or indirectly impact infants' health outcomes in various ways, including by providing better nutrition or a healthier environment, these policies could act as potential mechanisms driving the relationships between segregation and infant health. Using government finances data from the U.S. Census Bureau, we replicated the findings of Chyn et al. (2022) on the relationship between segregation and government spending, and extended their study by including additional data and conducting further analyses. Specifically, in addition to the data used by Chyn et al. (2022), we used data from 1985–1986 and 1993–1995 to increase power and test the robustness of the Chyn et al. (2022)'s

[7] The isolation index is a widely used measure of segregation that gauges the probability of minority residents being surrounded by others within their group. A higher isolation index value suggests more pronounced levels of segregation (Massey and Denton, 1988).

Table 6
Robustness to predicted 'Stayers' sample.

Outcomes	Birth weight	Low birth weight	Very low birth weight	Small for gestational age	Gestational weeks	Preterm birth	Very preterm birth	Fetal growth
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Stayers prediction using decision tree models								
1990 Dissimilarity index	−265.6673**	0.0769***	0.0193**	0.0717	−1.3310**	0.1478***	0.0508***	−4.1066*
	(119.9550)	(0.0271)	(0.0081)	(0.0687)	(0.5461)	(0.0525)	(0.0175)	(2.2990)
Effect of 1 SD increase	−36.189	0.010	0.003	0.010	−0.181	0.020	0.007	−0.559
Mean dep. var.	3137.64	0.11	0.02	0.18	38.49	0.13	0.04	81.18
Observations	121	121	121	121	121	121	121	121
Panel B: Stayers prediction using support vector machine models								
1990 Dissimilarity index	−318.1333**	0.0797***	0.0235***	0.0741	−1.5295***	0.1667***	0.0674***	−5.1267
	(158.8059)	(0.0272)	(0.0080)	(0.0925)	(0.5894)	(0.0573)	(0.0210)	(3.2372)
Effect of 1 SD increase	−43.336	0.011	0.003	0.010	−0.208	0.023	0.009	−0.698
Mean dep. var.	3134.88	0.11	0.02	0.18	38.50	0.13	0.04	81.09
Observations	119	119	119	119	119	119	119	119

Notes: The sample is limited to predicted 'stayers' sample. Data are from Vital Statistics Natality 2010–2019. Heteroskedasticity robust standard errors are reported in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

results. We analyzed both government spending and revenue categories to gain a more complete understanding of the impact of segregation on government finances. The analysis confirmed the conclusion of Chyn et al. (2022) that segregation has a substantial negative impact on government spending (Table A.9). Additionally, we found that segregation leads to lower government revenue. This implies that segregation not only reduces the funds available for government expenditure, but also has an impact on the overall size of the government's budget. It should be noted that this reduction in revenue cannot solely be attributed to the impoverishment of segregated communities, as it may also be a result of intentional disinvestment in these areas.

We also explored potential mechanisms in several additional ways. First, access to prenatal care during the first trimester of pregnancy is crucial as it allows healthcare providers to monitor the health of both the pregnant person and the developing fetus early on. Early prenatal care helps in identifying and addressing any potential health risks or complications that may arise during pregnancy. Early prenatal care might be linked to segregation due to the unequal distribution of healthcare resources in segregated areas. In many cases, neighborhoods facing segregation lack proper healthcare facilities, including prenatal clinics, which makes it challenging for pregnant individuals to access essential healthcare services promptly and effectively. Table 7 indicates that heightened levels of segregation correspond to a decreased share of Black individuals accessing prenatal care during the first trimester within metropolitan areas (Column 1). A similar correlation is not observed within the White population (Column 4). We also explore the relationship between segregation and two additional prenatal healthcare access outcomes: the metropolitan area's average number of prenatal visits (Columns 2 and 5) and the percentage of individuals having any prenatal care (Columns 3 and 6). However, we find no statistically significant associations for these outcomes.

Second, segregation is likely intertwined with the education and age structure of the birthing population due to historical and systemic inequities in access to opportunity. Prior research finds that neighborhood segregation is associated with diminished access to quality education among Black students (Quillian, 2014). In turn, this could directly impact educational attainment among birthing people within affected communities. Similarly, researchers have linked segregation to teenage childbearing, which can have adverse downstream effects on health and wellbeing due to the relative lack of social supports for this population (Hans and White, 2019).

The findings presented in Table 8 demonstrate a significant correlation between higher levels of segregation and the composition of the birthing population. Specifically, areas with increased segregation tend to have a higher proportion of younger individuals giving birth (Columns 1–4) and a greater concentration of individuals with lower levels of education (Columns 5–7). Weathering due to segregation, which moves up optimal childbearing timing, might explain the earlier birthing patterns observed in more segregated areas (Geronimus, 1992). Additionally, there is a noticeable decrease in the proportion of married individuals giving birth among Black populations in metropolitan areas with higher segregation levels. Notably, higher segregation levels are associated with a higher percentage of teenage births, especially among Black individuals (Column 1).

Third, anti-Black prejudice can shape the experiences and opportunities of Black birthing populations and can have significant impacts on access to education, employment, healthcare, and other resources, which could in turn adversely influence the health of infant populations. For example, if a health care provider holds conscious or unconscious biases against Black birthing populations, they may be less likely to provide the same level of care to Black birthing populations as they do to others, which can generate disparities in both access to health care and the quality of care received and thus may have negative impacts on infant health. Table 9 presents results concerning the relationship between segregation and racial prejudice. Specifically, the results in Columns (1) and (2) show that when segregation increases by 1 standard deviation, there is a corresponding 1.7 percentage point increase in anti-Black implicit prejudice and a 8.3 percentage point increase in anti-Black explicit prejudice among non-Black test takers.

Table 7
Racial segregation and prenatal care access.

	Share of the Black birthing people with:			Share of the White birthing people with:		
	First trimester visit (1)	*Prenatal visits* (2)	*Any prenatal visit* (3)	*First trimester visit* (4)	*Prenatal visits* (5)	*Any prenatal visit* (6)
1990 Dissimilarity index	−0.2396**	−0.9438	−0.0292	−0.1475	0.7505	−0.0039
	(0.1146)	(1.5261)	(0.0234)	(0.1181)	(1.3775)	(0.0095)
Effect of 1 SD increase	−0.033	−0.129	−0.004	−0.020	0.102	−0.001
Mean dep. var.	0.67	10.80	0.98	0.81	11.85	0.99
Observations	121	121	121	121	121	121

Notes: Data are from Vital Statistics Natality 2010–2019. Heteroskedasticity robust standard errors are reported in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 8
Racial segregation and the education and age structure of the birthing population.

Outcomes	Share of birthing people:							
	Age < 20 (1)	Age 20–24 (2)	Age 25–34 (3)	Age 35–44 (4)	Educ < HS (5)	Educ = HS (6)	Educ > HS (7)	Are married (8)
Panel A: Blacks								
1990 Dissimilarity index	0.2966***	0.4696***	−0.3820***	−0.3742***	0.2944**	0.3108***	−0.1312	−0.8751***
	(0.0715)	(0.1342)	(0.0934)	(0.1127)	(0.1204)	(0.1196)	(0.0899)	(0.1992)
Effect of 1 SD increase	0.040	0.064	−0.052	−0.051	0.040	0.042	−0.018	−0.119
Mean dep. var.	0.10	0.29	0.48	0.12	0.18	0.33	0.35	0.32
Observations	121	121	121	121	121	121	121	121
Panel B: Whites								
1990 Dissimilarity index	0.1143***	0.3238**	−0.0556	−0.3749**	0.2071**	0.2787**	0.1865	−0.2504
	(0.0403)	(0.1292)	(0.0579)	(0.1534)	(0.0819)	(0.1369)	(0.1453)	(0.1903)
Effect of 1 SD increase	0.016	0.044	−0.008	−0.051	0.028	0.038	0.025	−0.034
Mean dep. var.	0.04	0.19	0.61	0.16	0.08	0.22	0.32	0.66
Observations	121	121	121	121	121	121	121	121

Notes: Data are from Vital Statistics Natality 2010–2019. Heteroskedasticity robust standard errors are reported in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 9
Racial segregation and anti-black prejudice.

	Non-Black test takers		Black test takers	
	Implicit prejudice (1)	*Explicit prejudice* (2)	*Implicit prejudice* (3)	*Explicit prejudice* (4)
1990 Dissimilarity index	0.126**	0.610***	−0.159*	−0.425
	(0.056)	(0.137)	(0.096)	(0.333)
Effect of 1 SD increase	0.017	0.083	−0.022	−0.058
Mean of dep. var.	0.34	0.31	−0.01	−0.88
Observations	120	120	120	120
Year fixed effects	Yes	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: Data are from the Harvard Implicit Association Test 2010–2019. Heteroskedasticity robust standard errors are reported in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

The results in Columns (3) and (4) of Table 9, which show a negative association between higher levels of segregation and implicit prejudice, as well as no association with explicit prejudice among Black test takers, serve as a placebo test.

Fourth, food insecurity, or a lack of access to sufficient, safe, and nutritious food, may also be a critical mechanism by which segregation worsens the health of an area's Black infant populations. Poor nutrition during pregnancy can lead to low birth weight (Bergner and Susser, 1970), which is associated with an increased risk of complications during childbirth, such as preterm delivery, and an increased risk of long-term health problems for the infant, such as developmental delays and chronic conditions (Desta, 2019). Food insecurity can also lead to maternal malnutrition, which can weaken the immune system and increase the risk of infections, complications, and adverse outcomes for both the pregnant person and the infant (Black et al., 2008). Additionally, food insecurity can contribute to stress and mental health issues, which can have negative impacts on pregnancy and childbirth (Pourmotabbed et al., 2020).

Segregation can lead to food insecurity by limiting the resources and opportunities available to individuals and communities, including access to nutritious and healthy food options. For example, segregated neighborhoods may have fewer supermarkets and grocery stores, and thus limited access to fresh and healthy food options (Bower et al., 2014). The results in Table 10 show that

Table 10
Racial segregation and food insecurity.

Outcomes	Black, percent low access to store (1)	White, percent low access to store (2)	2015–17 Household food insecurity (%, three-year average) (3)	2015–17 Household very low food security (%, three-year average) (4)	2016 Grocery stores (5)
1990 Dissimilarity index	5.419***	−8.208	3.747	2.229	−0.205**
	(2.004)	(13.323)	(3.335)	(1.687)	(0.100)
Effect of 1 SD increase	0.738	−1.118	0.510	0.304	−0.028
Mean of dep. var.	1.26	19.21	12.76	5.03	0.18
Observations	121	121	121	121	121
Outcomes	2016 Supercenters & club stores (6)	2011 Convenience stores (7)	2016 Specialized food stores (8)	2016 WIC-authorized stores (9)	2017 SNAP-authorized stores (10)
1990 Dissimilarity index	0.094	0.021	−0.074	0.090	0.491**
	(0.191)	(0.018)	(0.047)	(0.067)	(0.241)
Effect of 1 SD increase	0.013	0.003	−0.010	0.012	0.067
Mean of dep. var.	0.37	0.02	0.08	0.14	0.70
Observations	121	121	121	121	121

Notes: Data are from USDA ERS Food Environment Atlas 2020. USDA defines “food insecurity” as a household-level economic and social condition of limited or uncertain access to adequate food. USDA defines “very low food security” as at times during the year food intake of household members is reduced and their normal eating patterns are disrupted because the household lacks money and other resources for food. Heteroskedasticity robust standard errors are reported in parentheses. The number of stores are per 1000 population. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 11
Racial segregation and transportation barriers.

	Blacks		Whites	
	Travel time to work > median	Percent of households without a vehicle	Travel time to work > median	Percent of households without a vehicle
	(1)	(2)	(3)	(4)
1990 Dissimilarity index	0.114**	−0.014	−0.019	−0.047
	(0.047)	(0.177)	(0.073)	(0.038)
Effect of 1 SD increase	0.016	−0.002	−0.003	−0.006
Mean of dep. var.	0.75	0.23	0.72	0.07
Observations	93	93	93	93

Notes: Data are from American Community Survey 2010–2019. Heteroskedasticity robust standard errors are reported in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

higher levels of segregation are associated with lower access to stores for Black individuals (Column 1), but not for White individuals (Column 2). In addition, neighborhoods with higher levels of segregation tend to have fewer grocery stores (Column 5) and SNAP-authorized stores (Column 10), providing further evidence of the ways in which segregation can restrict access to essential resources and opportunities, leading to food insecurity and other negative outcomes.

Fifth, transportation barriers such as long commutes, unreliable transportation options, and obstacles to using public transportation can lead to stress and limit pregnant people’s ability to obtain healthcare services and otherwise engage in activities that promote their mental and physical well-being (Broussard, 2010). This limitation, in turn, can affect maternal stress levels and parenting practices, resulting in impacts on infant health. Using American Community Survey data, we tested whether transportation barriers are higher in areas with higher levels of segregation; results are presented in Table 11. We found that higher segregation levels are associated with a greater likelihood of travel times exceeding the median for Black populations (Column 1), while this correlation is not observed for White populations (Column 3).

Finally, we used the Comprehensive Housing Affordability Strategy (CHAS) data to examine the relationship between segregation and housing insecurity (results in Table A.10). We did not observe a significant association between segregation and housing insecurity for Black owners or renters. In contrast, White owners and renters gain an advantage from segregation because higher segregation levels are linked to fewer housing issues for Whites.

7. Conclusion

In the United States, NH Black infants experience dramatically worse birth outcomes than infants in other racial/ethnic groups. Racial segregation, which has served as a tool of discrimination and oppression against Black Americans, resulting in unequal access to resources, opportunities, and services, and thus perpetuating and exacerbating existing inequalities, is one possible driver of these differences in birth outcomes. Indeed, there is robust evidence that racial segregation is associated with worsened health outcomes for NH Black infants, which suggests that eliminating racial segregation could play a crucial role in reducing health disparities.

However, the presence of a causal link between segregation and infant health, as well as the magnitude of this link, remains largely uncertain, partly due to non-random exposure to segregation.

In this paper, we leverage administrative birth data and plausibly exogenous variations driven by railroad division to provide evidence on the causal effect of racial residential segregation on the health of an area's NH Black infant populations. Instrumental variable results reveal that higher levels of racial segregation lead to multiple adverse health outcomes for Black infant populations, including decreased birth weight, shorter gestational length, and higher likelihood of low birth weight and preterm birth. We found no comparable impacts among White infant populations.

This research highlights the need for policymakers and community leaders to address segregation as a root cause of health disparities and to implement measures that promote more equitable and integrated communities. Given that poor birth outcomes can have harmful impacts on adults' health and well-being, alleviating these disparities can also address their long-term consequences for adults' economic status and well-being. The current results also provide suggestive evidence that lower access to first-trimester prenatal care, greater anti-Black prejudice, higher transportation barriers, increased food insecurity, and lower government spending and weaker redistributive policies are significant mechanisms contributing to the link between residential segregation and poor health outcomes among Black infant populations. By understanding these mechanisms, policymakers and community leaders can develop targeted interventions to address the specific challenges faced by communities affected by segregation and can work toward a more equitable and just society.

CRediT authorship contribution statement

Hoa Vu: Conceptualization, Data curation, Formal analysis, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Tiffany L. Green:** Conceptualization, Formal analysis, Supervision, Validation, Writing – original draft, Writing – review & editing. **Laura E.T. Swan:** Validation, Writing – original draft, Writing – review & editing.

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Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.jhealeco.2024.102876.

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