Sociological Perspectives
1–26

DOI: 10.1177/07311214211005486
journals.sagepub.com/home/spx
SAGE

Unequal Opportunity Spreaders: Higher COVID-19 Deaths with Later School Closure in the United States

Emily Rauscher[1] and Ailish Burns[1]

Abstract

Mixed evidence on the relationship between school closure and COVID-19 prevalence could reflect focus on large-scale levels of geography, limited ability to address endogeneity, and demographic variation. Using county-level Centers for Disease Control and Prevention (CDC) COVID-19 data through June 15, 2020, two matching strategies address potential heterogeneity: nearest geographic neighbor and propensity scores. Within nearest neighboring pairs in different states with different school closure timing, each additional day from a county's first case until state-ordered school closure is related to 1.5 to 2.4 percent higher cumulative COVID-19 deaths per capita (1,227–1,972 deaths for a county with median population and deaths/capita). Results are consistent using propensity score matching, COVID-19 data from two alternative sources, and additional sensitivity analyses. School closure is more strongly related to COVID-19 deaths in counties with a high concentration of Black or poor residents, suggesting schools play an unequal role in transmission and earlier school closure is related to fewer lives lost in disadvantaged counties.

Keywords

education, inequality, COVID-19, school closure, health, race, poverty

Introduction

Beginning in February 2020, K-12 schools across the United States began closing in an attempt to curb the spread of COVID-19. By March 25, every school district in the country had ended in-person instruction (Decker, Peele, and Riser-Kositsky 2020). However, evidence is mixed on the extent to which K-12 school closure slows the spread of coronavirus outbreaks (Viner et al. 2020; Zhang et al. 2020). Influenza transmission is lower when schools are closed for the summer or holidays (Chao, Halloran, and Longini 2010; Chowell et al. 2011; Earn et al. 2012; Huang et al. 2014; Litvinova et al. 2019; Wu et al. 2010) and school closures substantially reduce the number of social contacts among both students and workers (Cauchemez et al. 2008; Huang et al. 2014; Jackson et al. 2011). Reviews find early school closures can slow influenza transmission

[1]Brown University, Providence, RI, USA

Corresponding Author:
Emily Rauscher, Department of Sociology, Brown University, Box 1916, Providence, RI 02912, USA.
Email: emily_rauscher@brown.edu

when infection rates are higher among children than adults (Jackson, Mangtani, Hawker, et al. 2014; Jackson, Mangtani, and Vynnycky 2014).

However, unlike most previous influenza and novel virus outbreaks such as H1N1 (Cauchemez et al. 2009; Chao et al. 2010), COVID-19 causes higher symptomatic infection rates at older ages (Nogrady 2020; Rasmussen and Thompson 2020; Wu et al. 2020; Zhang et al. 2020) and transmission rates from young children are relatively low (Park et al. 2020). K-12 school closures may therefore be weakly related or unrelated to the spread of COVID-19. School closure has high costs for children's development and mental health, as well as for parents and communities (Coibion, Gorodnichenko, and Weber 2020; Orben, Tomova, and Blakemore 2020; Organisation for Economic Cooperation and Development 2020; UNESCO 2020). If school closures do little to prevent the spread of COVID-19, other public health measures that do not inhibit children's development may be a better approach to control the pandemic.

In addition to age, COVID-19 has unequal implications by race, ethnicity, and poverty. Black and Hispanic Americans are more likely to contract COVID-19 and experience severe symptoms than White Americans (Alcendor 2020; Centers for Disease Control and Prevention [CDC] 2020a; Zelner et al. 2020). Low-income individuals and communities also face higher risk of severe illness from COVID-19 (Koma et al. 2020; Wiemers et al. 2020), due in part to lower economic ability to practice social distancing (Jay et al. 2020). The relationship between school closure and COVID-19 spread may differ by race, ethnicity, or poverty due to segregation and unequal health risks and resources (Carratala and Maxwell 2020; de Brey et al. 2019; Egede 2006; Phelan and Link 2015; Phelan, Link, and Tehranifar 2010; Williams 2012; Williams, Lawrence, and Davis 2019). Because school closures are a universal intervention, they may be especially effective at curbing the spread of COVID-19 in Black, Hispanic, and low-income communities.

Country-level analyses of the relationship between school closure and COVID-19 incidence or mortality yield mixed results (Banholzer et al. 2020; Flaxman et al. 2020; Liu et al. 2020), but state-level analyses within the United States suggest school closure is related to lower COVID-19 mortality (Auger et al. 2020; Rauscher 2020). The different results could reflect the different geographic level of analysis. COVID-19 is transmitted interpersonally and smaller-scale analyses may provide a better estimate of the relationship between transmission and non-pharmaceutical interventions (NPIs) such as school closure. Existing work has limited ability to address potential endogeneity in the relationship: national or state political leadership, for example, could influence both NPI implementation and COVID-19 prevalence or mortality.

It remains unclear whether or to what extent school closure timing is related to COVID-19 spread or whether the relationship differs by race, ethnicity, or poverty. To help weigh the economic and social costs against the health benefits of closing schools (Cauchemez et al. 2009) during an outbreak with higher infection rates at older ages, this study:

1. Estimates the relationship between state K-12 school closure timing and COVID-19 deaths and cases within matched county pairs in different states and with different school closure timing. County pairs are identified using two matching strategies: nearest geographic neighbor and propensity score matching.
2. Estimates whether the relationship between state K-12 school closure timing and county COVID-19 deaths vary by county poverty, race, and ethnicity.

Results suggest later school closure is related to higher COVID-19 deaths per capita and that the relationship varies by poverty and race/ethnicity. Closing schools later is related to higher COVID-19 deaths in counties with high concentrations of poor and Black residents. Results have implications for our understanding of the economic and social costs of school closures.

Background

Schools and Public Health

Education became a stronger determinant of individual and social life in the United States throughout the 20th and 21st centuries (Fischer and Hout 2006). Institutionalization and expansion of formal education has shaped culture, the workplace, religion, economy, and family, among other aspects of life (D. P. Baker 2014; Fischer and Hout 2006). Educational expansion has incorporated a greater portion of the population for longer periods, which has independent effects on other social institutions. Institutional theories of education suggest schools are an independent force in society, instilling cultural, organizational, and economic changes through ideas (e.g., about efficiency, appropriateness) and socialization (e.g., national identity, civic duty; D. P. Baker 1999, 2009, 2014; Cremin 1951, 1961; Meyer, Ramirez, and Soysal 1992; Meyer and Rubinson 1975; Meyer et al. 1979; Ramirez and Boli 1987).

This institutional perspective makes clear the potentially important role of schools in public health efforts to control an infectious outbreak. However, while previous work emphasizes the importance of education through culture and ideas, schools also play a role through in-person social gatherings. For example, in addition to developing and disseminating knowledge, schools also develop social networks (Small 2009). Weeden and Cornwell (2020) illustrate the “small world” network at a medium-sized university in the United States. Using simulations, the authors found that most students are connected to one another through multiple transmission paths. Complex systems of social ties may cause schools to be particularly efficient spreaders of infectious disease.

K-12 schools similarly create social networks, with children, teachers, and staff interacting in classes, cafeterias, buses, and playgrounds. K-12 students and employees typically reside at home and travel daily to school, connecting school and family networks. By reducing in-person interactions and overlap of social networks, school closure could reduce opportunities for COVID-19 transmission. Alternatively, families could substitute other social gatherings for school (e.g., church school, play dates, or informal shared family childcare). When schools close, families may engage in alternative social activities, yielding a null or positive relationship between school closure and COVID-19 transmission. For example, household networks may expand during school closures to include older family members for childcare, which could theoretically increase symptomatic COVID-19 infections and deaths, due to higher susceptibility at older ages (Wu et al. 2020; Zhang et al. 2020).

Existing evidence about the relationship between school closure and COVID-19 transmission is mixed (Auger et al. 2020; Banholzer et al. 2020; Flaxman et al. 2020; Haug et al. 2020; Liu et al. 2020). The mixed results could reflect different geographic levels of analysis. For example, national-level analyses may be more likely to find a weak relationship because COVID-19 is transmitted locally through person-to-person interactions (Banholzer et al. 2020; Flaxman et al. 2020). However, a comparison of thousands of NPIs in 226 countries finds that school closure is strongly related to transmission (Haug et al. 2020). The mixed results could also reflect limited ability to address potential endogeneity in the relationship between school closure and COVID-19 transmission. Unobserved characteristics such as political leadership could influence both school closure timing and COVID-19 prevalence or mortality. County-level analyses that apply matching strategies to address potential endogeneity contribute to existing evidence about the relationship between transmission and school closure at a finer level than state or national analyses.

Schools and Inequality

Horace Mann (1849)—a 19th-century Massachusetts politician and champion of the common school—called education “the great equalizer of the conditions of men” (p. 59). However, this ideal role of education is far from reality. A common argument is that education could increase equality if children enjoyed equal access to education. Research examining labor market outcomes often finds greater equality of opportunity among those with higher levels of education (particularly, a college degree; Bernardi and Ballarino 2016; Breen and Jonsson 2007; Hout 1988; Torche 2011). However, when accounting for selection, recent work finds that higher education does not increase equality of opportunity (Fiel 2020; Zhou 2019). Even 19th century compulsory schooling laws did not increase equality of opportunity in the labor market (Rauscher 2016). This evidence raises questions about whether or in which contexts education increases equality.

Similar questions arise about the relationship between education and health (Cutler and Lleras-Muney 2008). Education is significantly related to multiple health outcomes for both adults and children (Abuya et al. 2012; Currie and Moretti 2003; Goldman and Smith 2011; Gunes 2015; Hahn and Truman 2015; Ross and Mirowsky 1999). However, those who are more likely to attain higher levels of education may also be healthier for a variety of other reasons, including social background, behavior, or neighborhood exposure to pollution. Evidence is mixed when accounting for selection into education. Extended compulsory schooling laws reduced mortality rates and improved health (Arendt 2005; Lleras-Muney 2005; Oreopoulos 2007) and greater access to college increased women's educational attainment and health of their children at birth (Currie and Moretti 2003). However, several rigorous studies that use natural experiments to account for unequal selection into education find no effect of education on health (Clark and Royer 2013; Dursun, Cesur, and Mocan 2018; Malamud, Mitrut, and Pop-Eleches 2018).

Mixed evidence of the relationship between education and health could partly reflect the focus on individual-level outcomes. Education has spillover effects, with social benefits beyond the individuals who gain more education. For example, educational expansion may spur state or national economic growth and occupational upgrading (Lutz, Cuaresma, and Sanderson 2008; Rauscher 2015). Similarly, education may have effects on population or public health, beyond its individual-level effects (Benjamin-Chung et al. 2018; Berniell, de la Mata, and Valdes 2013). For example, schools may play a role in transmission of infectious disease. Because schools gather students from diverse families and backgrounds in one place, schools could allow infectious diseases such as COVID-19 to spread more quickly.

Inequality and Health

Because of systemic race and income inequality, school closure could affect COVID-19 deaths differently across groups. The fundamental cause argument explains how social inequality produces health inequality. This theory suggests that those in economically and racially advantaged positions have greater access to flexible resources, which they use to maintain better health compared to those with fewer resources (Phelan and Link 2015; Phelan et al. 2010). Unequal resource distribution means that health inequality by race and income persists through multiple pathways (see e.g., Chetty et al. 2016), and cannot be ameliorated by individual interventions. The fundamental causes of racism and income inequality manifest in the unequal distribution and experiences of COVID-19.

Low-income, Black, and Hispanic Americans experience higher rates of COVID-19 infection than White and high-SES Americans (CDC 2020a; Centers for Medicare & Medicaid Services [CMS] 2020; Raine et al. 2020; Zelner et al. 2020). According to the CDC (2020a), Black Americans contract COVID-19 at 1.4 times the rate of Whites, while Hispanic or Latino individuals contract the virus at 1.7 times the rate of Whites. Evidence also suggests that low-income people are much more likely than wealthier people to contract COVID-19. Data from the Centers for Medicare and Medicaid Services (CMS) show that people on Medicare who are poor enough to qualify for Medicaid are four times more likely to test positive for the coronavirus or be hospitalized from it than their high-income peers (CMS 2020). Barriers to physical distancing might explain higher infection rates among poor, Black, and Hispanic individuals. These groups are more likely to be essential workers and live in more densely populated or crowded areas which puts them at higher risk for exposure to the virus (Arasteh 2020; Chen and Krieger 2020; Jay et al. 2020; Rogers et al. 2020).

In addition to being more likely to contract the virus, Black and Hispanic individuals are also more likely to experience severe symptoms or death (CDC 2020a). There are several explanations for this which stem from systemic and long-standing inequalities in employment opportunities and conditions, living conditions, health, and discrimination (Alcendor 2020; CDC 2020a; Williams 2012; Williams, Lawrence, and Davis 2019; Williams, Lawrence, Davis, et al., 2019). First, Black Americans have a higher incidence of chronic disease (e.g., obesity, hypertension, diabetes, asthma) than White Americans which makes them more susceptible to severe COVID-19 infections (Carratala and Maxwell 2020; Wiemers et al. 2020; Williams 2012). Second, Black and Hispanic Americans are more likely to be un- or under-insured, have less access to health care, and receive worse medical treatment, all of which likely make recovery from COVID-19 more difficult (Alsan, Garrick, and Graziani 2019; Bor, Cohen, and Galea 2017; Carratala and Maxwell 2020; Egede 2006).

Because school closures are a universal intervention and poor, Black, and Hispanic Americans are most affected by COVID-19, we expect school closures to be more strongly associated with COVID-19 deaths in counties with high percentages of poor, Black, or Hispanic residents. As argued by the theory of fundamental causes, health inequalities are likely to persist when interventions focus on individual risk factors because those with more resources use them to leverage new opportunities (Phelan et al. 2010). In contrast, an intervention that is not resource-dependent (such as closing schools) should yield universal benefits, because it has the ability to reduce mortality rates regardless of individual resources. Furthermore, current data suggest that poor, Black, and Hispanic individuals are at greater risk of contracting and dying from COVID-19, and that low-income neighborhoods and majority-nonwhite neighborhoods have a higher incidence of COVID-19 deaths. If school closures are an effective intervention to reduce COVID-19 mortality, we expect this to benefit areas that have been hit harder by the virus: areas with high concentrations of low-income, Black, or Hispanic residents.

Alternatively, since low-income Americans and Black and Hispanic individuals are more likely to be exposed to the coronavirus from other sources (such as employment and neighborhood factors), school closures could be more weakly related to COVID-19 for these groups. Following from fundamental cause theory, because it does not address the root cause of racial or income inequality, school closure may have similar implications regardless of demographics and may not be sufficient to reduce racial disparities in health outcomes.

Zajacova and Lawrence (2018) emphasize the importance of social context for understanding the relationship between education and health and leveraging it to improve population health and reduce health disparities. Using a finer level of geography than previous research and examining variation by county poverty and race/ethnicity, this paper quantifies the relationship between school closure timing and county-level COVID-19 deaths to provide more information when considering the high social costs of school closures (Coibion et al. 2020). At the same time, this paper provides a new analysis of the institutional theory of education (D. P. Baker 2014) by examining the relationship between schools and public health during a pandemic.

Data and Methods

Using daily cumulative data on COVID-19 deaths and cases by county from the Centers for Disease Control through June 15, 2020, this study examines dates after the first case in each county through the end of the academic year. June 15 includes dates through the end or within a few weeks of the end of the academic year in most states. June 15 also predates the publicized interventions into CDC data by the Trump administration, which began in July when they transferred COVID-19 data collection responsibility from the CDC to the Department of Health and Human Services (Stolberg 2020). COVID-19 prevalence measures are similar using county-level data from the CDC, *The New York Times* (NYT), and Johns Hopkins University (JHU). Mean values of deaths and cases per capita from NYT and JHU differ by less than 2 percent from CDC measures (see Table A1) and are highly correlated with CDC measures (0.995 or higher). Results are similar using NYT or JHU data (see Online Appendix Tables A12–A15).

Key Measures

COVID-19 prevalence is measured as the logged number of deaths (and cases) per 100,000 residents. Time to school closure is the number of days from the first case in each county until schools were closed based on state-ordered school closure dates from *EdWeek* (2020a). All states closed schools within 11 days after President Trump declared a national state of emergency on March 13. Variation in prevalence rates on March 13 (0–56.3 cases per 100,000 residents; 0–1.4 deaths per 100,000 residents) allows examination of the relationship between COVID-19 spread and school closure timing. Online Appendix Table A1 provides information about each measure used in the analyses.

Analytic Approach

State school closure decisions could partly reflect state COVID-19 prevalence, potentially biasing state estimates. State closures are not based on prevalence in each specific county and school closure timing is therefore less likely related to prevalence and more exogenous at the county level. (Correlations between state school closure date and COVID-19 cases and deaths per capita [log] on the date of school closure are 0.30 and -0.28 at the state level and 0.16 and -0.01 at the county level, respectively.)

Two matching strategies are used to address additional heterogeneity between counties: nearest geographic neighbor matching and propensity score matching. Matching is conducted using observed characteristics and unobserved characteristics may still differ after matching. These two strategies are complementary and results should be consistent using both approaches. First, National Weather Service geocode data for county centroid location is used to identify nearest neighboring county pairs in different states and the distance between those county pairs. Counties in close geographic proximity to each other have similar potential COVID-19 exposure and similar economic and demographic contexts. However, state school closure timing is more likely exogenous with respect to county COVID-19 prevalence among nearby counties in different states. Online Appendix Table A2 Panel A compares variation among all counties compared to within county pairs less than 100 miles apart in different states. Variation within pairs is lower on all measures than in the unmatched sample (by 37–138 percent, depending on the measure). Mean differences between paired counties are less 0.1 standard deviations on all measures.

Second, propensity score matching is used to identify county pairs with similar characteristics by school closure timing (Abadie et al. 2004; Rosenbaum and Rubin 1985). Specifically, we use psmatch2 (Leuven and Sianesi 2003) to identify the five nearest-neighbor matches between counties above and below the median of seven days from the first case in the county until states closed schools.

We estimate propensity scores using multiple county- and state-level measures (see Table A2 Panel B). Table A2 Panel B and Figure A1 show evidence of balance on observed characteristics between treatment and control counties within matched pairs (using pstest, Leuven and Sianesi 2003). The balance tests in Table A2 Panel B compare mean values, standardized percentage bias (difference in means divided by square root of the variance; Rosenbaum and Rubin 1985), and variance ratios (ratio of variance of residuals in treatment and control groups for each variable regressed on the propensity score; Rubin 2001). Tests of overall balance and for each variable are within the ranges recommended by Rubin (2001).

Using the propensity score from psmatch2, we use two approaches to estimate the relationship between late school closure and COVID-19 deaths: (1) we create strata (deciles) of propensity score and estimate the relationship within each strata (Long and Kurlaender 2009) and (2) we use the nearest neighbor match for each county with late school closure and estimate the relationship within county pairs. We limit the propensity score analyses to those in the range of common support on the propensity score (excluding 405 counties with propensity score>0.9628).

Statistical Analyses

As with other matching approaches, the geographic and propensity score matching techniques do not address unobserved variation, but they adjust for observed heterogeneity and allow us to compare counties with similar observed characteristics other than school closure timing (Dehejia and Wahba 2002; Morgan 2001). We use the matched counties in regressions with fixed effects for county pair or propensity score strata to estimate the relationship between the continuous measure of school closure timing and COVID-19 deaths within similar counties.

Equation 1 predicts log cumulative deaths per capita in county (*i*) in pair (*j*) as of June 15, 2020 with time to school closure and county pair fixed effects. Within pairs of matched counties, exp(β_1) estimates the percent increase in deaths for each additional day from a county's first case until the state closed schools. Standard errors are adjusted for county pair clustering.

$$ln(COVID19\ Deaths/100k)_{ij} = \alpha + \beta_1 Time\,to\,School\,Closure_{ij} + \beta_k X_{ij} + Pair_j + \varepsilon_{ij} \quad (1)$$

We estimate the relationship separately within geographic pairs and propensity score pairs. We use a similar approach to estimate the relationship within propensity score strata (*j*), adjusting standard errors for clustering within strata. When using geographic pairs, models are fit with and without the following controls (X_i) to address potential confounding: county-level population (log), population density (log), percent Black, percent Hispanic, percent Asian, percent urban, median income (log), poverty rate (from U.S. Census Bureau), percent of residents who frequently wear a mask in public, percent who always wear a mask, percent who rarely/never wear a mask (from *NYT* survey, July 2020); state-level number of public schools (log), public school enrollment (log), school closure date (from *EdWeek* 2020a); and median age, percent group quarters residence (from IPUMS; Ruggles et al. 2020), number of long-term care facilities with COVID-19 cases at the end of May (from Kaiser Family Foundation 2020; mean value assigned to seven non-reporting states). States implemented other physical distancing measures in addition to school closure. Controls therefore include dates of state: stay-at-home order, non-essential business closure, and restaurant closure (coded as last observed date for states without each policy; from Raifman et al. 2020; results are similar using stay-home dates from *Wall Street Journal* and *Aljazeera* as of April 21). In the propensity score analyses, we fit models with and without controlling for propensity score and controls from the geographic analyses not used to create the propensity score (X_i).

Heterogeneity by Poverty, Race, and Ethnicity

Based on U.S. Census Bureau data, we create indicators for whether counties are above the median values of percent poverty (14.1 percent), Black (2.0 percent), Hispanic (3.3 percent), American Indian (0.4 percent), Asian (0.5 percent), and white (85.8 percent) residents. We also create indicators for whether counties are above 70th percentile of poverty rate (17.3 percent) to distinguish counties with concentrated poverty. Equation 2 is similar to Equation 1, predicting log cumulative deaths per capita in county (*i*) in pair (*j*) with time to school closure and county pair fixed effects, but adds an interaction term between time to school closure and the indicator for high poverty rate (or high proportion of residents by race/ethnicity). Within pairs of matched counties, exp(β_1) estimates the percent increase in deaths for each additional day from a county's first case until the state closed schools in low-poverty counties. Exp(β_3) estimates the additional percent increase in deaths for each day until school closure in high-poverty counties and tests whether the relationship between school closure timing and COVID-19 deaths differs by county poverty rate. Standard errors are adjusted for county pair clustering.

$$\begin{aligned} &ln(COVID19\,Deaths/100k)_{ij} = \alpha + \beta_1 Time\ to\ School\ Closure_{ij} + \beta_2 High\ Poverty_{ij} + \\ &\beta_3 Time\ to\ School\ Closure_{ij} {*} High\ Poverty_{ij} + \beta_k X_{ij} + Pair_j + \varepsilon_{ij} \end{aligned} \tag{2}$$

As in the main analyses, we estimate the relationship separately within geographic pairs, propensity score pairs, and propensity score strata (standard errors adjusted for strata clustering). We fit models with and without the same controls (X_i) in the main analyses.

Sensitivity Analyses

Geographic matched pair estimates shown (in Figure 2) are limited to county pairs less than 100 miles and less than 40 miles apart, but other distance thresholds yield consistent results. Counties can be matched multiple times, resulting in multiple observations per county (mean is 2 observations; range 1–10 in geographic pairs). Results are consistent when weighted by the inverse of the number of observations for each county (i.e. weighting each county to represent one observation) or when adjusting standard errors for county rather than pair clustering.

Estimates within county pairs could be biased if states closed schools based on the number of cases in all of its counties or if cases were evenly distributed throughout states and states closed schools based on state prevalence. Estimates could be downwardly biased if counties or districts closed schools at dates other than the state-mandated closure date. Because of potential bias, estimates are associational and interpreted using associational language throughout the paper. However, Oster (2019) bounds are used to identify the degree of selection on unobservables required to explain the estimates (i.e. required to make coefficients zero).

We replicate analyses using COVID-19 data from *NYT* and from JHU (2020; New York Times 2020). We use alternative measures of the dependent variable, including number deaths or cases (log) unadjusted for population size, when excluding the 7 states that recommended rather than ordered schools closed, when excluding the 5 counties in New York City (see Online Appendix Tables A1–A3), and when including counties with zero deaths (by adding one death per one hundred thousand residents), which are excluded when log-transforming deaths per capita.

We repeat the propensity score analyses when matching on additional variables: % Black, median income (log), and state median age and restaurant closure date. Overall balance statistics did not meet recommended levels when including these measures, so the main analyses control for them in regressions rather than in propensity score calculation. Propensity score analyses are unweighted, but results are consistent when weighting by the frequency a county is matched divided by five (to normalize weights across the five potential matched counties).

States implemented several other physical distancing measures during the COVID-19 pandemic. Controls include dates of these measures, but it is difficult to isolate the role of school closures alone. A step in this direction is to limit analyses to county pairs with the same dates of other NPIs.

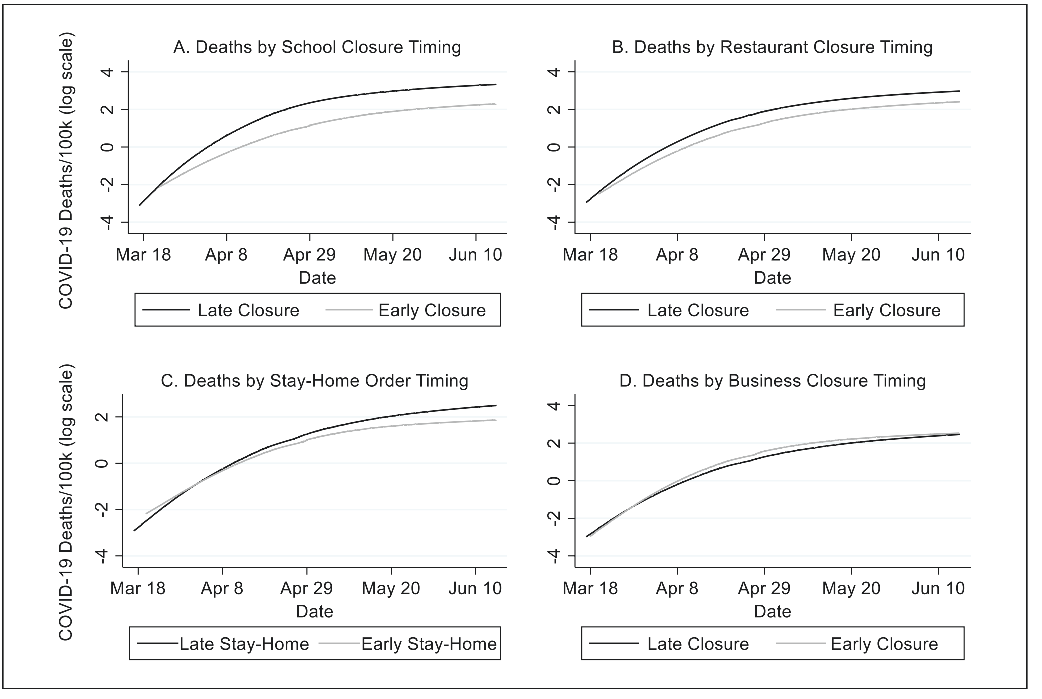

Figure 1. Lowess graphs of (log) daily cumulative state COVID-19 deaths per 100,000 residents over time by timing of state non-pharmaceutical interventions.

Note. Late Closure includes states in the top tercile of days from 100 cases until each measure. Early Closure includes states in the bottom tercile of days from 100 cases until each measure. Panel A: Late School Closure—on or after the day a state reached 100 cases. Early School Closure—5 or more days before reaching 100 cases. Panel B: Late Restaurant Closure—2 or more days after reaching 100 cases. Early Restaurant Closure—4 or more days before reaching 100 cases. Panel C: Late Stay-Home Order—16 or more days after reaching 100 cases. Early Stay-Home Order—less than 7 days after reaching 100 cases. Alternative stay-home order dates from *Wall Street Journal* and *Aljazeera* show consistent results. Panel D: Late Business Closure—13 or more days after reaching 100 cases. Early Business Closure—less than 5 days after reaching 100 cases. Quadratic graphs with confidence intervals indicate significant differences in Panels A and B and overlap in Panels C and D.

COVID-19 prevalence and its relationship to school closure could change over time. Sensitivity analyses predict daily cumulative county COVID-19 deaths per capita with daily observations from the first case in each county. These analyses add date and county fixed effects in Equation 1 to account for stable differences between counties and national changes over time. Models are fit with and without controlling for a 1-day lagged measure of deaths per capita.

We predict COVID-19 deaths and deaths due to all causes separately by race/ethnicity. However, the distribution of deaths by race/ethnicity are suppressed by the CDC in many counties due to small numbers to protect privacy and data are only available for approximately 400 counties. Significant differences (Paternoster et al. 1998) between β_1 coefficients in Equation 1 predicting Black and Hispanic deaths compared to those predicting white deaths would indicate that the relationship between school closure timing and death rates differs by race or ethnicity. Due to the small number of counties with mortality data by race/ethnicity, this approach is provided as a sensitivity check.

Results

Figure 1 compares cumulative state COVID-19 deaths per capita over time by timing of school closure, restaurant closure, business closure, and stay-home orders. States that closed schools late have substantially higher deaths per capita than states that closed schools early. In contrast, there is little difference in deaths per capita by stay-home order or business closure timing. Restaurant closure timing is related to differences in deaths per capita. Based on these preliminary analyses, we use dates of these NPIs (in addition to other measures) as controls or to match counties in statistical analyses.

Table 1 shows estimates using geographic nearest-neighbor county pairs in different states with variation in school closure timing. Within nearby county pairs, one additional day before school closure is related to 1.5 to 2.4 percent higher county COVID-19 deaths per capita (an additional 1,227–1,972 deaths for a county with median deaths per capita and median population). Figure 2 shows estimates limited to counties less than 100 miles apart, less than 40 miles apart, and with and without controls, which include county- and state-level characteristics. Results are consistent when predicting COVID-19 cases and when limited to counties at other maximum distances.

Table 2 shows estimates when matching counties based on propensity score, with similar observed characteristics but with different school closure timing. Within the same propensity score strata, one additional day before school closure is related to 1.2 to 1.6 percent higher county COVID-19 deaths per capita (an additional 980–1,310 deaths for a county with median deaths per capita and median population). Within propensity score pairs, there is no relationship between school closure timing and deaths when not including controls, but the estimate is similar to other analyses when including controls: an additional day before school closure is related to 1.7 percent higher county COVID-19 deaths per capita (an additional 1,392 deaths for a county with median deaths per capita and median population). Propensity score models predicting COVID-19 cases add further support for a relationship to school closure timing.

Table 3 shows results examining variation in COVID-19 deaths by county poverty, race, and ethnicity. Coefficients for the interaction between school closure timing and high proportions of poor or Black residents suggest variation by poverty and race, but not by ethnicity. For example, Models 5 and 6 in Panel A (within geographic county pairs) suggest minimal relationship between school closure and COVID-19 deaths in counties below median percent Black residents. However, in counties with a high proportion of Black residents, an additional day before school closure is related to 1.9 to 2.3 percent higher county COVID-19 deaths per capita. Propensity score analyses similarly find a significantly stronger relationship between school closure and deaths in counties with a high concentration of Black residents (marginal estimates illustrated in Figure 3). Poverty interaction terms are not statistically significant within geographic pairs. However, propensity score analyses suggest school closure is more strongly related to COVID-19 deaths in high poverty counties (above the 70th percentile of poverty rate). Specifically, each additional day before school closure is related to approximately 1 percent higher COVID-19 deaths in low-poverty counties, but this relationship is significantly higher (1–3 percent) in high poverty counties. Interaction terms are not significant for counties above the median poverty rate, suggesting the relationship emerges in counties with high poverty rates. Interaction terms are also not significant for counties with a high proportion of Hispanic residents. Thus, results indicate variation in the relationship between COVID-19 deaths and school closure by poverty and race, but not by ethnicity.

Sensitivity Analyses

Sensitivity analyses find consistent results when predicting the number of deaths or cases (log) unadjusted for population size, when excluding the 7 states that recommended rather than ordered schools closed, or when excluding the 5 counties in New York City (see Online Appendix Tables A3–A5).

Table 1. Predicted County COVID-19 Deaths/Cases per 100,000 Residents within Geographic County Pairs.

Panel A: County Pairs <100 Miles Apart.

	(1)	(2)	(3)	(4)
	Deaths/100k (log)		Cases/100k (log)	
Variables	Baseline	+Controls	Baseline	+Controls
Days from first case until school closure	0.018**	0.015*	0.022**	0.016**
	(0.005)	(0.006)	(0.002)	(0.002)
Constant	2.817**	1,670.333**	5.608**	361.738
	(0.019)	(482.489)	(0.018)	(220.399)
Observations	1,452	1,452	3,322	3,320
Number of county pairs	726	726	1,661	1,660
R-squared	.710	.768	.774	.820
County pair fixed effects	Y	Y	Y	Y
Controls		Y		Y

Panel B: County Pairs <40 Miles Apart.

	(1)	(2)	(3)	(4)
	Deaths/100k (log)		Cases/100k (log)	
Variables	Baseline	+Controls	Baseline	+Controls
Days from first case until school closure	0.024**	0.024*	0.017**	0.011**
	(0.008)	(0.012)	(0.002)	(0.003)
Constant	2.944**	2,332.964**	5.677**	589.500
	(0.032)	(843.829)	(0.022)	(405.333)
Observations	492	492	1,040	1,040
Number of county pairs	246	246	520	520
R-squared	.775	.842	.832	.868
County pair fixed effects	Y	Y	Y	Y
Controls		Y		Y

Note. Predicted CDC COVID-19 data by county as of June 15, 2020 using *EdWeek* school closure data. Limited to county pairs in different states with unequal school closure timing. Counties are matched 1-10 times with mean of 2 matches. Even numbered models include controls for county population (log), population density (log), percent Black, percent Hispanic, percent Asian, percent urban, median income (log), poverty rate (from U.S. Census Bureau), percent of residents who frequently wear a mask in public, percent who always wear a mask, percent who rarely/never wear a mask (from *NYT* survey, July 2020); state number of public schools (log), public school enrollment (log), school closure date (from *EdWeek*); median age, percent group quarters residence (from IPUMS), number of long-term care facilities with COVID-19 cases at the end of May (from Kaiser Family Foundation; mean value assigned to seven non-reporting states), stay-at-home order, non-essential business closure, and restaurant closure (coded as last observed date for states without each policy; from Raifman et al. 2020; similar results using stay-home dates from *Wall Street Journal* and *Aljazeera* as of April 21). Robust standard errors adjusted for county pair clustering in parentheses. CDC = Centers for Disease Control and Prevention; IPUMS = Integrated Public Use Microdata Series.
$^+p < .1$. $^*p < .05$. $^{**}p < .01$.

Results are also consistent when including counties with zero deaths, which are excluded when log-transforming deaths per capita. Table A6 shows results when assigning a value of

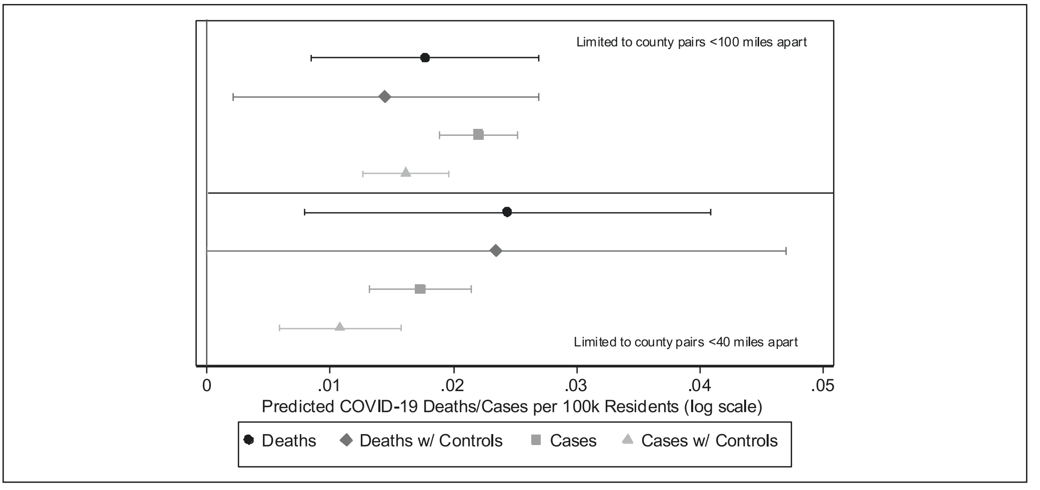

Figure 2. Predicted COVID-19 deaths and cases per 100,000 residents within geographic county pairs.
Note. Estimates based on models in Table 1. Within nearest neighboring county pairs in different states with different school closure timing, each additional day from a county's first case until state-ordered school closure is related to 1.5 to 2.4 percent higher cumulative county COVID-19 deaths per capita as of June 15, 2020 (an additional 1,227–1,972 deaths for a county with median deaths per capita and median population). Estimates are β_1 coefficients from Table 1 with 95 percent confidence intervals (standard errors adjusted for county pair clustering). Analyses are limited to counties <100 miles or <40 miles apart (alternative distance thresholds yield consistent results).

one death per 100,000 residents to counties before the first death occurred to include all matched counties.

On the whole, results shown in Tables A7–A9 are consistent when limited to county pairs with the same dates of restaurant closure, stay-home order, or business closure. The main analyses control for the timing of other physical distancing measures and these sensitivity analyses add further confidence that school closure is independently related to COVID-19 spread. However, small samples sizes among propensity score pair analyses (Table A9) indicate the limitations of this approach.

As a robustness check, Table A10 shows results examining the relationship between COVID-19 prevalence as of December 15, 2020 and state Fall 2020 school opening policies (from *EdWeek* 2020b). Compared to counties in states that began Fall 2020 K-12 schooling in-person, those in states that began at least partially closed had 20 to 53 percent lower cumulative COVID-19 deaths as of December 15, 2020.

Table A11 shows results from models predicting daily cumulative county COVID-19 deaths per capita with date and county fixed effects, weighted by the inverse of the number of observations for each county to prevent counties where the first case emerged earlier from driving results. Controlling for lagged COVID-19 deaths, results suggest each additional day before school closure is related to 0.1 percent faster daily growth in COVID-19 deaths.

Tables A12–A15 show results when using COVID-19 data from the *NYT* and JHU. Results are consistent with the main analyses. We repeat propensity score analyses when matching on four additional variables: % Black, median income (log), and state median age and restaurant closure date. Results are similar to the main analyses (shown in Online Appendix Tables A16–A17). The main analyses control rather than match on those measures to achieve the recommended balance levels (Rubin 2001).

A concern in interpreting results is that school closure timing may be endogenous. Unobserved characteristics could influence both school closure and COVID-19 deaths. Using Oster (2019)

Table 2. Predicted County COVID-19 Deaths/Cases per 100,000 Residents within Counties Matched Based on Propensity Scores.

Panel A: Propensity Score Strata.

	(1)	(2)	(3)	(4)
	Deaths/100k (log)		Cases/100k (log)	
Variables	Baseline	+Controls	Baseline	+Controls
Days from first case until school closure	0.016*	0.012*	0.019**	0.013*
	(0.006)	(0.004)	(0.006)	(0.005)
Constant	2.548**	75.627	5.865**	−108.024*
	(0.041)	(48.831)	(0.042)	(42.790)
Observations	1,446	1,446	1,446	1,446
number of strata	10	10	10	10
R-squared	.046	.164	.025	.211
County strata fixed effects	Y	Y	Y	Y
Controls		Y		Y

Panel B: Propensity Score Pairs.

	(1)	(2)	(3)	(4)
	Deaths/100k (log)		Cases/100k (log)	
Variables	Baseline	+Controls	Baseline	+Controls
Days from first case until school closure	0.000	0.017**	0.016**	0.017**
	(0.004)	(0.005)	(0.004)	(0.005)
Constant	2.468**	31.294	5.855**	−146.624
	(0.035)	(95.456)	(0.034)	(107.435)
Observations	1,226	1,226	1,226	1,226
number of county pairs	613	613	613	613
R-squared	.479	.580	.493	.610
County pair fixed effects	Y	Y	Y	Y
Controls		Y		Y

Note. Predicted CDC COVID-19 data by county as of June 15, 2020 using *EdWeek* school closure data. Limited to counties within range of propensity score support. Even numbered models include controls for county propensity score, percent Black, median income (log), state median age, and date of restaurant closure (coded as last observed date for states without; from Raifman et al. 2020). Robust standard errors adjusted for county strata (Panel A) or county pair (Panel B) clustering in parentheses. CDC = Centers for Disease Control and Prevention.
$^{+}p < .1$. $^{*}p < .05$. $^{**}p < .01$.

bounds, estimates for school closure timing predicting deaths per capita remain positive when assuming potential selection on unobservables is 13 percent higher than selection on observables within county pairs less than 100 miles apart ($\delta = 1.13$) and over seven times selection on observables within pairs less than 40 miles apart ($\delta = 7.22$). Within propensity score strata, estimates remain positive when assuming selection on unobservables is nearly eight times selection on observables within strata ($\delta = 7.97$). Bounds are calculated by assigning a maximum r-squared value of 1.3*estimated r-squared (the value at which 90 percent of randomized estimates survive; Oster 2019). Bounds are appropriate for coefficients that decrease when adding controls and therefore are not calculated for estimates based on propensity score pairs.

Table 3. Predicted County COVID-19 Deaths per 100,000 Residents by County Poverty and Race/Ethnicity.
Panel A: Geographic County Pairs <100 Miles Apart.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	Deaths/100k (log)							
Days from first case until school closure	0.016**	0.016*	0.015**	0.013+	0.001	0.003	0.018*	0.017*
	(0.006)	(0.008)	(0.005)	(0.008)	(0.009)	(0.010)	(0.008)	(0.008)
High poverty (>median)	0.400**	0.121						
	(0.093)	(0.106)						
High poverty (>70th percentile)			0.399**	0.106				
			(0.110)	(0.133)				
High pov × days to school closure	0.006	–0.002	0.009	0.003				
	(0.008)	(0.009)	(0.008)	(0.008)				
High Black (>median)					0.142	–0.013		
					(0.149)	(0.150)		
High Black × days to school closure					0.023*	0.019+		
					(0.010)	(0.010)		
High Hispanic (>median)							–0.123	–0.197
							(0.113)	(0.123)
High Hispanic × days to school closure							0.002	–0.005
							(0.009)	(0.010)
Constant	2.611**	1,635.548**	2.681**	1,655.274**	2.697**	1,706.476**	2.884**	1,578.232**
	(0.055)	(483.258)	(0.044)	(484.560)	(0.125)	(485.127)	(0.077)	(479.596)
Observations	1,452	1,452	1,452	1,452	1,452	1,452	1,452	1,452
Number of county pairs	726	726	726	726	726	726	726	726
R-squared	.717	.768	.716	.768	.713	.769	.711	.769
County pair fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
Controls		Y		Y		Y		Y

Note. Predicted CDC COVID-19 data by county as of June 15, 2020 using EdWeek school closure data. Limited to county pairs in different states with unequal school closure timing. Counties are matched 1-10 times with mean of 2 matches. Even numbered models include controls for county population (log), population density (log), percent Black, percent Hispanic, percent Asian, percent urban, median income (log), poverty rate (from U.S. Census Bureau), percent of residents who frequently wear a mask in public, percent who always wear a mask, percent who rarely/never wear a mask (from New York Times survey, July 2020); state number of public schools (log), public school enrollment (log), school closure date (from EdWeek); median age, percent group quarters residence (from IPUMS), number of long-term care facilities with COVID-19 cases at the end of May (from Kaiser Family Foundation; mean value assigned to seven non-reporting states), stay-at-home order, non-essential business closure, and restaurant closure (coded as last observed date for states without each policy; from Raifman et al. 2020; similar results using stay-home dates from Wall Street Journal and Aljazeera as of April 21). Robust standard errors adjusted for county pair clustering in parentheses. CDC = Centers for Disease Control and Prevention.
$^{+}p < .1$. $^{*}p < .05$. $^{**}p < .01$.

Table 3. (continued)

Panel B: Propensity Score Strata.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables				Deaths/100k (log)				
Days from first case until school closure	0.011	0.010	0.010	0.009$^+$	0.006	0.004	0.022*	0.014**
	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)	(0.003)	(0.007)	(0.004)
High poverty (>median)	0.296*	–0.209*						
	(0.120)	(0.088)						
High poverty (>70th percentile)			0.662**	0.217*				
			(0.110)	(0.093)				
High pov × days to school closure	0.011	0.005	0.019*	0.009$^+$				
	(0.010)	(0.009)	(0.006)	(0.004)				
High Black (>median)					0.544**	0.124*		
					(0.039)	(0.054)		
High Black × days to school closure					0.019**	0.020**		
					(0.004)	(0.004)		
High Hispanic (>median)							–0.108	–0.035
							(0.084)	(0.071)
High Hispanic × days to school closure							–0.012$^+$	–0.004
							(0.006)	(0.005)
Constant	2.396**	77.579	2.326**	74.156	2.219**	77.417	2.606**	75.960
	(0.068)	(51.423)	(0.049)	(50.367)	(0.029)	(51.607)	(0.079)	(48.971)
Observations	1,446	1,446	1,446	1,446	1,446	1,446	1,446	1,446
Number of strata	10	10	10	10	10	10	10	10
R-squared	.057	.169	.093	.166	.079	.169	.049	.164
County pair fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
Controls		Y		Y		Y		Y

Note. Predicted CDC COVID-19 data by county as of June 15, 2020 using *EdWeek* school closure data. Limited to counties within range of propensity score support. Even numbered models include controls for county propensity score, percent Black, median income (log), state median age, and date of restaurant closure (coded as last observed date for states without; from Raifman et al. 2020). Robust standard errors adjusted for county strata clustering in parentheses. CDC = Centers for Disease Control and Prevention.
$^+p < .1$. $^*p < .05$. $^{**}p < .01$.

Table 3. (continued)

Panel C: Propensity Score Pairs.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	Deaths/100k (log)							
Days from first case until school closure	–0.008	0.013^{+}	–0.008	0.011^{+}	–0.013*	0.005	0.007	0.018*
	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)
High poverty (>median)	0.500**	–0.275^{+}						
	(0.135)	(0.165)						
High poverty (>70th percentile)			0.866**	0.110				
			(0.143)	(0.173)				
High pov × days to school closure	0.018	0.007	0.030*	0.018				
	(0.012)	(0.011)	(0.013)	(0.012)				
High Black (>median)					0.483**	–0.069		
					(0.131)	(0.141)		
High Black × days to school closure					0.024*	0.027*		
					(0.012)	(0.011)		
High Hispanic (>median)							–0.321*	–0.079
							(0.132)	(0.124)
High Hispanic × days to school closure							–0.012	–0.001
							(0.011)	(0.010)
Constant	2.206**	43.612	2.171**	42.305	2.177**	29.096	2.633**	28.301
	(0.074)	(96.109)	(0.056)	(94.787)	(0.080)	(94.686)	(0.079)	(97.109)
Observations	1,226	1,226	1,226	1,226	1,226	1,226	1,226	1,226
Number of county pairs	613	613	613	613	613	613	613	613
R-squared	.493	.585	.517	.582	.491	.589	.485	.580
County pair fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
Controls		Y		Y		Y		Y

Note. Predicted CDC COVID-19 data by county as of June 15, 2020 using EdWeek school closure data. Limited to counties within range of propensity score support. Even numbered models include controls for county propensity score, percent Black, median income (log), state median age, and date of restaurant closure (coded as last observed date for states without; from Raifman et al. 2020). Robust standard errors adjusted for county pair clustering in parentheses.

In Panels A-C, counties with high poverty, Black, or Hispanic concentration are above the median value among all counties (U.S. Census Bureau 2011, 2018). Models 3 and 4 examine counties above the 70th percentile for poverty rate. CDC = Centers for Disease Control and Prevention.

$^{+}p < .1$. $^{*}p < .05$. $^{**}p < .01$.

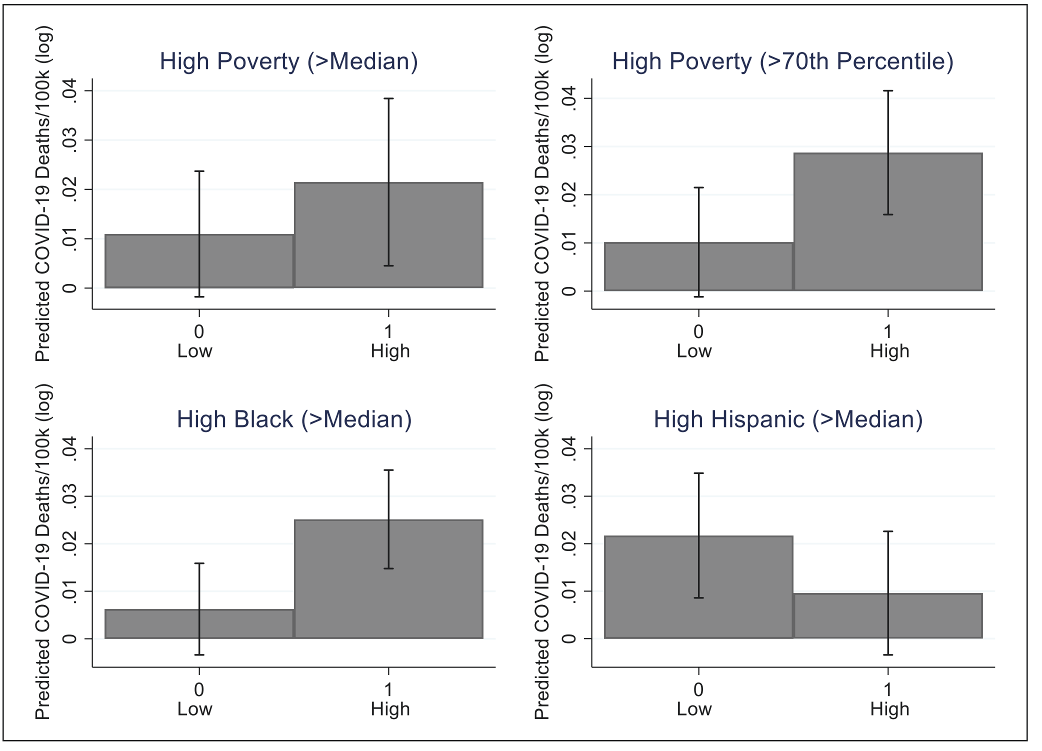

Figure 3. Predicted COVID-19 deaths per 100,000 residents within propensity score strata.
Note. Marginal estimates at sample mean values based on odd-numbered models in Table 3, Panel B. Within propensity score strata, the relationship between school closure timing and predicted county COVID-19 deaths per 100,000 residents is higher in counties with high poverty rate and high proportion Black residents.

Conclusion

Although children do not appear to be the primary spreaders of COVID-19 (Lee and Raszka 2020; Park et al. 2020), earlier school closure is related to lower deaths and cases per capita in U.S. counties. Previous inconsistent evidence on the relationship between school closure and COVID-19 prevalence could reflect a focus on large-scale levels of geography, limited ability to address endogeneity, and variation by poverty, race, or ethnicity. We build on previous work by examining county-level data and applying two matching strategies to address potential heterogeneity: nearest geographic neighbor and propensity score matching. Within nearest neighboring county pairs in different states with different school closure timing, each additional day from a county's first case until state-ordered school closure is related to 1.5 to 2.4 percent higher cumulative county COVID-19 deaths per capita. Propensity score analyses suggest that one additional day before school closure is related to 1.2 to 1.7 percent higher county COVID-19 deaths per capita. For a hypothetical county with median population and deaths per capita, this amounts to 980 to 1,972 deaths for each day before school closure.

We find that school closure is more strongly related to COVID-19 deaths in counties with a high concentration of Black or poor residents. Schools may therefore be unequal opportunity spreaders, playing an unequal role in transmission. The stronger relationship could reflect unequal school resources (if schools in advantaged counties can leverage resources to prevent spread during in-person schooling; B. D. Baker et al. 2018; Sosina and Weathers 2019), unequal family or individual socioeconomic resources, and higher risk of COVID-19 exposure and severe symptoms due to economic and social inequality and preexisting health conditions (Alcendor 2020; CDC 2020b; Wiemers et al. 2020; Williams 2012; Williams, Lawrence, and Davis 2019; Zelner et al. 2020).

School closure creates a larger burden for families—especially those with few resources, but it is a relatively universal intervention which does not require family resources to access or adopt. The universal nature of school closure may account for its stronger link to COVID-19 deaths among Black and low-income Americans (Phelan and Link 2015; Phelan et al. 2010). Results do not differ in counties with high concentrations of Hispanic residents, which could reflect the lower rate of preexisting health conditions related to severe COVID-19 symptoms (Wiemers et al. 2020) and the Hispanic health paradox, which yields better health than expected for both individuals and communities (Hummer et al. 2007; Markides and Coreil 1986; Shaw and Pickett 2013).

School closure has social, economic, psychological, and cognitive costs for individuals and societies (Coibion et al. 2020), with potentially long-term implications, which is why states rarely close schools. In the context of the first wave of COVID-19; however, results suggest school closure is related to lower death rates. Estimates are robust to multiple sensitivity analyses and remain positive when assuming potential selection on unobservables is larger than selection on observables—in some analyses over 7 times larger (Oster 2019). The costs are high, but in the absence of a robust test and trace containment strategy, earlier school closure was related to lower COVID-19 deaths during the first outbreak in the United States.

Although other physical distancing policies are not the focus of this study, descriptive results echo existing work (Friedson et al. 2020; Lin and Meissner 2020), which provides mixed evidence for a relationship between COVID-19 spread and stay-at-home orders and non-essential business closures. This may be because those measures were generally implemented later than school closures. Restaurant closure shows some relationship with COVID-19 deaths. Future research could directly examine restaurant closure compared to other physical distancing measures.

An important limitation of this study is that it cannot establish a causal relationship. Two county matching strategies are used to reduce the possibility that unobserved heterogeneity could account for the results. However, matching is necessarily based on observed characteristics. Similar results using both geographic and propensity score matching strategies reduce the possibility that random variation or selection explain the findings, but additional research is required to establish a causal relationship.

Evidence from the above analyses supports institutional theories of education, which suggest schools are an independent force in society (D. P. Baker 2009, 2014). While work in this area has focused on the importance of education in shaping culture and the economy, results of this study add to evidence that schools can also play a role in public health through in-person social gatherings (Weeden and Cornwell 2020). The role of schools likely differs by the specific disease examined, but results suggest public health implications of schools can spillover and extend beyond those who enter schools to include other community members (Benjamin-Chung et al. 2018; Berniell et al. 2013), including older individuals.

Furthermore, this study contributes to our understanding of the relationship between education and inequality. Recent work finds that education does not increase equality of opportunity in the labor market (Fiel 2020; Rauscher 2016; Zhou 2019) and has no effect on health (Clark and Royer 2013; Dursun et al. 2018; Malamud et al. 2018). However, the majority of studies focus on individual-level outcomes, omitting important spillover effects and social benefits of education. Results of this study add to evidence of the link between education and population or public health (Benjamin-Chung et al. 2018; Berniell et al. 2013). Results suggest schools may play a role in transmission of infectious diseases. In the case of COVID-19, schools are more strongly related to death rates in counties with a high proportion of Black or low-income residents. This evidence is consistent with a recent finding that school closure is unrelated to COVID-19 prevalence in areas with low infection rates, but may help reduce spread in areas with high infection rates (Harris et al. 2021). Our results suggest school closure may be related to lower COVID-19 deaths in disadvantaged areas. Balancing the unequal learning opportunities created by closing schools (Aucejo et al. 2020; Bacher-Hicks, Goodman, and Mulhern 2021; Chetty et al. 2020; Kuhfeld et al. 2020; Lancker and Parolin 2020) with the potential for lower mortality among disadvantaged populations poses an ethical challenge.

Acknowledgments

The authors are grateful for feedback from colleagues at the Annenberg Institute for School Reform and the Population Studies and Training Center (PSTC) at Brown University.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for research, authorship, and/or publication of this article: This research was supported by PSTC, which receives funding from the NIH for training support (T32 HD007338) and for general support (P2C HD041020), and by a grant from the American Educational Research Association which receives funds for its “AERA Grants Program” from the National Science Foundation under NSF Grant #DRL-1749275. Opinions reflect those of the authors and do not necessarily reflect those of the granting agencies.

Supplemental Material

Supplemental material for this article is available online.

References

Abadie, Alberto, David Drukker, Jane Leber Herr, and Guido W. Imbens. 2004. “Implementing Matching Estimators for Average Treatment Effects in Stata.” *The Stata Journal* 4(3):290–311. doi:10.1177/1536867X0400400307.

Abuya, Benta A., James Ciera, and Elizabeth Kimani-Murage. 2012. “Effect of Mother’s Education on Child’s Nutritional Status in the Slums of Nairobi.” *BMC Pediatrics* 12:80. doi: 10.1186/1471-2431-12-80.

Alcendor, Donald J. 2020. “Racial Disparities-associated COVID-19 Mortality among Minority Populations in the US.” *Journal of Clinical Medicine* 9(8):2442. doi:10.3390/jcm9082442.

Alsan, Marcella, Owen Garrick, and Grant Graziani. 2019. “Does Diversity Matter for Health? Experimental Evidence from Oakland.” *American Economic Review* 109(12):4071–4111. doi:10.1257/aer.20181446.

Arasteh, Kamyar. 2020. “Prevalence of Comorbidities and Risks Associated with COVID-19 Among Black and Hispanic Populations in New York City: An Examination of the 2018 New York City Community Health Survey.” *Journal of Racial and Ethnic Health Disparities*. Published electronically August 13. doi:10.1007/s40615-020-00844-1.

Arendt, Jacob Nielsen. 2005. “Does Education Cause Better Health? A Panel Data Analysis Using School Reforms for Identification.” *Economics of Education Review* 24:149–60. doi:10.1016/j.econedurev.2004.04.008.

Aucejo, Esteban M., Jacob F. French, Maria Paola Ugalde Araya, and Basit Zafar. 2020. “The Impact of COVID-19 on Student Experiences and Expectations: Evidence from a Survey.” *Journal of Public Economics* 191:104271.

Auger, Katherine A., Samir S. Shah, Troy Richardson, David Hartley, Matthew Hall, Amanda Warniment, Kristen Timmons, Dianna Bosse, Sarah A. Ferris, Patrick W. Brady, Amanda C. Schondelmeyer, and Joanna E. Thomson. 2020. “Association Between Statewide School Closure and COVID-19 Incidence and Mortality in the US.” *Journal of the American Medical Association* 324(9):859–70. doi:10.1001/jama.2020.14348.

Bacher-Hicks, Andrew, Joshua Goodman, and Christine Mulhern. 2021. "Inequality in Household Adaptation to Schooling Shocks: Covid-Induced Online Learning Engagement in Real Time." *Journal of Public Economics* 193:104345. doi:10.1016/j.jpubeco.2020.104345.

Baker, Bruce D., Danielle Farrie, and David Sciarra. 2018. *Is School Funding Fair? A National Report Card*. Newark, NJ: Education Law Center. Retrieved December 18, 2020 (https://edlawcenter.org/assets/files/pdfs/publications/Is_School_Funding_Fair_7th_Editi.pdf).

Baker, David P. 1999. "Schooling All the Masses: Reconsidering the Origins of American Schooling in the Postbellum Era." *Sociology of Education* 72(4):197215. doi:10.2307/2673153.

Baker, David P. 2009. "The Educational Transformation of Work: Towards a New Synthesis." *Journal of Education and Work* 22(3):163–91. doi:10.1080/13639080902957822.

Baker, David P. 2014. *The Schooled Society: The Educational Transformation of Global Culture*. Palo Alto, CA: Stanford University Press.

Banholzer, Nicolas, Eva van Weenen, Bernhard Kratzwald, Arne Seeliger, Daniel Tschernutter, Pierluigi Bottrighi, Alberto Cenedese, Joan Puig Salles, Werner Vach, and Stefan Feuerriegel. 2020. "Impact of Non-Pharmaceutical Interventions on Documented Cases of COVID-19." medRxiv. doi:10.1101/2020.04.16.20062141.

Benjamin-Chung, Jade, Benjamin F. Arnold, David Berger, Stephen P. Luby, Edward Miguel, John M. Colford, Jr., and Alan E. Hubbard. 2018. "Spillover Effects in Epidemiology: Parameters, Study Designs and Methodological Considerations." *International Journal of Epidemiology* 47(1):332–47. doi:10.1093/ije/dyx201.

Bernardi, Fabrizio, and Gabriele Ballarino, eds. 2016. *Education, Occupation and Social Origin: A Comparative Analysis of the Transmission of Socio-economic Inequalities*. Northampton, MA: Edward Elgar.

Berniell, Lucila, Dolores de la Mata, and Nieves Valdes. 2013. "Spillovers of Health Education at School on Parents' Physical Activity." *Health Economics* 22(9):1004–20.

Bor, Jacob, Gregory H. Cohen, and Sandro Galea. 2017. "Population Health in an Era of Rising Income Inequality: USA, 1980–2015." *The Lancet* 389:1475–90. doi:10.1016/S0140-6736(17)30571-8.

Breen, Richard and Jan O. Jonsson. 2007. "Explaining Change in Social Fluidity: Educational Equalization and Educational Expansion in Twentieth-century Sweden." *American Journal of Sociology* 112(6):1775–1810. doi:10.1086/508790.

Carratala, Sofia and Connor Maxwell. 2020. "Health Disparities by Race and Ethnicity." *Center for American Progress*, May 7. Retrieved July 20, 2020 (https://www.americanprogress.org/issues/race/reports/2020/05/07/484742/health-disparities-race-ethnicity/).

Cauchemez, Simon, Neil M. Ferguson, Claude Wachtel, Anders Tegnell, Guillaume Saour, Ben Duncan, and Angus Nicoll. 2009. "Closure of Schools during an Influenza Pandemic." *The Lancet Infectious Diseases* 9:473–81. doi:10.1016/S1473-3099(09)70176-8.

Cauchemez, Simon, Alain-Jacques Valleron, Pierre-Yves Boëlle, Antoine Flahault, and Neil M. Ferguson. 2008. "Estimating the Impact of School Closure on Influenza Transmission from Sentinel Data." *Nature* 452:750–54. doi:10.1038/nature06732.

Centers for Disease Control and Prevention. 2020a. "COVID-19 Cases, Hospitalization, and Deaths, by Race/Ethnicity." Retrieved December 28, 2020 (https://www.cdc.gov/coronavirus/2019-ncov/downloads/covid-data/hospitalization-death-by-race-ethnicity.pdf).

Centers for Disease Control and Prevention. 2020b. "Health Equity Considerations and Racial and Ethnic Minority Groups." Retrieved July 20, 2020 (https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/racial-ethnic-minorities.html).

Centers for Medicare & Medicaid Services. 2020. "Preliminary Medicare COVID-19 Data Snapshot." Retrieved December 29, 2020 (https://www.cms.gov/files/document/medicare-covid-19-data-snapshot-fact-sheet.pdf).

Chao, Dennis L., M. Elizabeth Halloran, and Ira M. Longini, Jr. 2010. "School Opening Dates Predict Pandemic Influenza A(H1N1) Outbreaks in the United States." *The Journal of Infectious Diseases* 202:877–80. doi:10.1086/655810.

Chen, Jarvis T. and Nancy Krieger. 2020. "Revealing the Unequal Burden of COVID-19 by Income, Race/Ethnicity, and Household Crowding: US County versus Zip Code Analyses." *Journal of Public Health Management and Practice* 27(1):S43–56. doi:10.1097/PHH.0000000000001263.

Chetty, Raj, John Friedman, Nathaniel Hendren, and Michael Stepner, and The Opportunity Insights Team. 2020. "The Economic Impacts of COVID-19: Evidence from a New Public Database Built Using Private Sector Data." NBER Working Paper No. 27431. Retrieved (https://www.nber.org/papers/w27431).

Chetty, Raj, Michael Stepner, Sarah Abraham, Shelby Lin, Benjamin Scuderi, Nicholas Turner, Augustin Bergeron, and David Cutler. 2016. "The Association Between Income and Life Expectancy in the United States, 2001-2014." *Journal of the American Medical Association* 315(16):1750–66. doi:10.1001/jama.2016.4226.

Chowell, Gerardo, Santiago Echevarría-Zuno, Cécile Viboud, Lone Simonsen, James Tamerius, Mark A. Miller, and Víctor H. Borja-Aburto. 2011. "Characterizing the Epidemiology of the 2009 Influenza A/H1N1 Pandemic in Mexico." *PLoS Medicine* 8(5):e1000436. doi:10.1371/journal.pmed.1000436.

Clark, Damon and Heather Royer. 2013. "The Effect of Education on Adult Mortality and Health: Evidence from Britain." *American Economic Review* 103(6):2087–120. doi:10.1257/aer.103.6.2087.

Coibion, Olivier, Yuriy Gorodnichenko, and Michael Weber. 2020. *The Cost of the COVID-19 Crisis: Lockdowns, Macroeconomic Expectations, and Consumer Spending*. IZA DP No. 13224. IZA Institute of Labor Economics. Retrieved March 13, 2021 (https://www.iza.org/publications/dp/13224/the-cost-of-the-covid-19-crisis-lockdowns-macroeconomic-expectations-and-consumer-spending).

Cremin, Lawrence A. 1951. *The American Common School: An Historic Conception*. New York: Teachers College Press.

Cremin, Lawrence A. 1961. *The Transformation of the School: Progressivism in American Education, 1876-1957*. New York: Knopf.

Currie, Janet and Enrico Moretti. 2003. "Mother's Education and the Intergenerational Transmission of Human Capital: Evidence from College Openings." *The Quarterly Journal of Economics* 118(4):1495–532. doi:10.1162/003355303322552856.

Cutler, David and Adriana Lleras-Muney. 2008. "Education and Health: Evaluating Theories and Evidence." Pp. 29–60 in *Making Americans Healthier: Social and Economic Policy as Health Policy*, edited by J. House, R. Schoeni, G. Kaplan, and H. Pollack. New York: Russell Sage Foundation.

de Brey, Cristobal, Lauren Musu, Joel McFarland, Sidney Wilkinson-Flicker, Melissa Diliberti, Anlan Zhang, Claire Branstetter, and Xiaolei Wang. 2019. "Status and Trends in the Education of Racial and Ethnic Groups." NCES 2019-038. Washington, DC: National Center for Education Statistics, U.S. Department of Education. Retrieved July 20, 2020 (https://nces.ed.gov/pubsearch/).

Decker, Stacey, Holly Peele, and Maya Riser-Kositsky. 2020. "The Coronavirus Spring: The Historic Closing of U.S. Schools (A Timeline)." *Education Week*, July 1. Retrieved December 29, 2020 (https://www.edweek.org/leadership/the-coronavirus-spring-the-historic-closing-of-u-s-schools-a-timeline/2020/07).

Dehejia, Rajeev H. and Sadek Wahba. 2002. "Propensity Score-matching Methods for Nonexperimental Causal Studies." *The Review of Economics and Statistics* 84(1):151–61.

Dursun, Bahadır, Resul Cesur, and Naci Mocan. 2018. "The Impact of Education on Health Outcomes and Behaviors in a Middle-income, Low-education Country." *Economics & Human Biology* 31:94–114. doi:10.1016/j.ehb.2018.07.004.

Earn, David J. D., Daihai He, Mark B. Loeb, Kevin Fonseca, Bonita E. Lee, and Jonathan Dushoff. 2012. "Effects of School Closure on Incidence of Pandemic Influenza in Alberta, Canada." *Annals of Internal Medicine* 156(3):173–81.

EdWeek. 2020a. "Map: Coronavirus and School Closures in 2019-2020." *Education Week*, March 6. Retrieved May 22, 2020 (https://www.edweek.org/ew/section/multimedia/map-coronavirus-and-school-closures.html).

EdWeek. 2020b. "Map: Where Are Schools Closed?" *Education Week*, July 28. Retrieved November 30, 2020 (https://www.edweek.org/ew/section/multimedia/map-covid-19-schools-open-closed.html).

Egede, Leonard E. 2006. "Race, Ethnicity, Culture, and Disparities in Health Care." *Journal of General Internal Medicine* 21(6):667–69. doi:10.1111/j.1525-1497.2006.0512.x.

Fiel, Jeremy E. 2020. "Great Equalizer or Great Selector? Reconsidering Education as a Moderator of Intergenerational Transmissions." *Sociology of Education* 93(4):353–71. doi:10.1177/0038040720927886.

Fischer, C. S. and M. Hout. 2006. *Century of Difference: How America Changed in the Last One Hundred Years*. New York: Russell Sage Foundation.

Flaxman, Seth, Swapnil Mishra, Axel Gandy, H. Juliette T Unwin, Thomas A. Mellan, Helen Coupland, Charles Whittaker, Harrison Zhu, Tresnia Berah, Jeffrey W. Eaton, Mélodie Monod, Azra C. Ghani, Christl A. Donnelly, Steven Riley, Michaela A. C. Vollmer, Neil M. Ferguson, Lucy C. Okell, and Samir Bhatt. 2020. "Estimating the Effects of Non-pharmaceutical Interventions on COVID-19 in Europe." *Nature* 584:257–61. doi:10.1038/s41586-020-2405-7.

Friedson, Andrew I., Drew McNichols, Joseph J. Sabia, and Dhaval Dave. 2020. "Did California's Shelter-in-place Order Work? Early Coronavirus-related Public Health Effects." NBER Working Paper No. 26992. Retrieved December 10, 2020 (https://www.nber.org/papers/w26992).

Goldman, Dana and James P. Smith. 2011. "The Increasing Value of Education to Health." *Social Science & Medicine* 72:1728–37. doi:10.1016/j.socscimed.2011.02.047.

Gunes, Pinar Mine. 2015. "The Role of Maternal Education in Child Health: Evidence from a Compulsory Schooling Law." *Economics of Education Review* 47:1–16.

Hahn, Robert A. and Benedict I. Truman. 2015. "Education Improves Public Health and Promotes Health Equity." *International Journal of Health Services* 45(4):657–78. doi:10.1177/0020731415585986.

Harris, Douglas N., Engy Ziedan, and Susan Hassig. 2021. "The Effects of School Reopenings on COVID-19 Hospitalizations." New Orleans, LA: National Center for Research on Education Access and Choice. Retrieved January 4, 2021 (https://www.reachcentered.org/publications/the-effects-of-school-reopenings-on-covid-19-hospitalizations).

Haug, Nils, Lukas Geyrhofer, Alessandro Londei, Elma Dervic, Amélie Desvars-Larrive, Vittorio Loreto, Beate Pinior, Stefan Thurner, and Peter Klimek. 2020. "Ranking the Effectiveness of Worldwide COVID-19 Government Interventions." *Nature Human Behaviour* 4(12):1303–12. doi:10.1038/s41562-020-01009-0.

Hout, Michael. 1988. "More Universalism, Less Structural Mobility: The American Occupational Structure in the 1980s." *American Journal of Sociology* 93(6):1358–1400. doi:10.1086/228904.

Huang, Karen E., Marc Lipsitch, Jeffrey Shaman, and Edward Goldstein. 2014. "The US 2009 A(H1N1) Influenza Epidemic: Quantifying the Impact of School Openings on the Reproductive Number." *Epidemiology* 25(2):203–206. doi:10.1097/EDE.0000000000000055.

Hummer, R. A., D. A. Powers, S. G. Pullum, G. L. Gossman, and W. P. Frisbie. 2007. "Paradox Found (Again): Infant Mortality among the Mexican-origin Population in the United States." *Demography* 44(3):441–57.

Jackson, Charlotte, Punam Mangtani, Jeremy Hawker, Babatunde Olowokure, and Emilia Vynnycky. 2014. "The Effects of School Closures on Influenza Outbreaks and Pandemics: Systematic Review of Simulation Studies." *PLoS ONE* 9(5):e97297. doi:10.1371/journal.pone.0097297.

Jackson, Charlotte, Punam Mangtani, and Emilia Vynnycky. 2014. "Impact of School Closures on an Influenza Pandemic: Scientific Evidence Base Review." Department of Health, London. Retrieved July 20, 2020 (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/316203/School_Closures_Evidence_review.pdf).

Jackson, Charlotte, Punam Mangtani, Emilia Vynnycky, Katherine Fielding, Aileen Kitching, Huda Mohamed, Anita Roche, and Helen Maguire. 2011. "School Closures and Student Contact Patterns." *Emerging Infectious Diseases* 17(2):245–47. doi:10.3201/eid1702.100458.

Jay, Jonathan, Jacob Bor, Elaine O. Nsoesie, Sarah K. Lipson, David K. Jones, Sandro Galea, and Julia Raifman. 2020. "Neighbourhood Income and Physical Distancing during the COVID-19 Pandemic in the United States." *Nature Human Behaviour* 4(12):1294–302. doi:10.1038/s41562-020-00998-2.

Johns Hopkins University. 2020. "Johns Hopkins COVID-19 Case Tracker: Cases and Deaths by County Timeseries." Retrieved December 15, 2020 (https://data.world/associatedpress/johns-hopkins-coronavirus-case-tracker).

Kaiser Family Foundation. 2020. "State Reporting of Cases and Deaths Due to COVID-19 in Long-term Care Facilities." Retrieved May 29, 2020 (https://www.kff.org/coronavirus-covid-19/issue-brief/state-reporting-of-cases-and-deaths-due-to-covid-19-in-long-term-care-facilities/).

Koma, Wyatt, Samantha Artiga, Tricia Neuman, Gary Claxton, Matthew Rae, Jennifer Kates, and Josh Michaud. 2020. "Low-income and Communities of Color at Higher Risk of Serious Illness if Infected with Coronavirus." Kaiser Family Foundation. Retrieved December 10, 2020 (https://www.kff.org/coronavirus-covid-19/issue-brief/low-income-and-communities-of-color-at-higher-risk-of-serious-illness-if-infected-with-coronavirus/).

Kuhfeld, Megan, James Soland, Beth Tarasawa, Angela Johnson, Erik Ruzek, and Jing Liu. 2020. "Projecting the Potential Impact of COVID-19 School Closures on Academic Achievement." *Educational Researcher* 49(8):549–65. doi:10.3102/0013189X20965918.

Lancker, Wim Van and Zachary Parolin. 2020. "COVID-19, School Closures, and Child Poverty: A Social Crisis in the Making." *The Lancet* 5(5):243–44.

Lee, Benjamin and William V. Raszka. 2020. "COVID-19 Transmission and Children: The Child Is Not to Blame." *Pediatrics* 146(2):e2020004879. doi:10.1542/peds.2020-004879.

Leuven, Edwin and Barbara Sianesi. 2003. "PSMATCH2: Stata Module to Perform Full Mahalanobis and Propensity Score Matching, Common Support Graphing, and Covariate Imbalance Testing." Version 4.0.12. Retrieved December 10, 2020 (http://ideas.repec.org/c/boc/bocode/s432001.html).

Lin, Zhixian and Christopher M. Meissner. 2020. "Health vs. Wealth? Public Health Policies and the Economy During Covid-19." NBER Working Paper No. 27099. Retrieved December 10, 2020 (https://www.nber.org/papers/w27099).

Litvinova, Maria, Quan-Hui Liu, Evgeny S. Kulikov, and Marco Ajelli. 2019. "Reactive School Closure Weakens the Network of Social Interactions and Reduces the Spread of Influenza." *Proceedings of the National Academy of Sciences of the United States of America* 116(27):13174–81. doi:10.1073/pnas.1821298116.

Liu, Yang, Christian Morgenstern, James Kelly, Rachel Lowe, CMMID COVID-19 Working Group, and Mark Jit. 2020. "The Impact of Non-pharmaceutical Interventions on SARS-CoV-2 Transmission across 130 Countries and Territories." medRxiv. doi:10.1101/2020.08.11.20172643.

Lleras-Muney, Adriana. 2005. "The Relationship between Education and Adult Mortality in the United States." *The Review of Economic Studies* 72(1):189–221.

Long, Bridget Terry and Michal Kurlaender. 2009. "Do Community Colleges Provide a Viable Pathway to a Baccalaureate Degree?." *Educational Evaluation and Policy Analysis* 31(1):30–53. doi:10.3102/0162373708327756.

Lutz, Wolfgang, Jesus Crespo Cuaresma, and Warren Sanderson. 2008. "The Demography of Educational Attainment and Economic Growth." *Science* 319(5866):1047–48.

Malamud, Ofer, Andreea Mitrut, and Cristian Pop-Eleches. 2018. "The Effect of Education on Mortality and Health: Evidence from a Schooling Expansion in Romania." NBER Working Paper 24341. Retrieved December 10, 2020 (https://www.nber.org/papers/w24341).

Mann, Horace. 1849. *Twelfth Annual Report of the Board of Education*. Boston, MA: Dutton and Wentworth.

Markides, Kyriakos S. and Jeannine Coreil. 1986. "The Health of Hispanics in the Southwestern United States: An Epidemiologic Paradox." *Public Health Reports* 101(3):253–65.

Meyer, John W., Francisco O. Ramirez, and Yasemin Nuhoglu Soysal. 1992. "World Expansion of Mass Education, 1870-1980." *Sociology of Education* 65(2):128–49. doi:10.2307/2112679.

Meyer, John W. and Richard Rubinson. 1975. "Education and Political Development." *Review of Research in Education* 3(1):134–62.

Meyer, John W., David Tyack, Joane Nagel, and Audri Gordon. 1979. "Public Education as Nation-building in America: Enrollments and Bureaucratization in the American States, 1870-1930." *American Journal of Sociology* 85(3):591–613. doi:10.1086/227051.

Morgan, Stephen L. 2001. "Counterfactuals, Causal Effect Heterogeneity, and the Catholic School Effect on Learning." *Sociology of Education* 74(October):341–74.

New York Times. 2020. "COVID-19 Data: County-level Data." Retrieved December 15, 2020 (https://github.com/nytimes/covid-19-data).

Nogrady, Bianca. 2020. "How Kids' Immune Systems Can Evade COVID." *Nature* 588:382.

Orben, Amy, Livia Tomova, and Sarah-Jayne Blakemore. 2020. "The Effects of Social Deprivation on Adolescent Development and Mental Health." *The Lancet Child & Adolescent Health* 4(8):634–40. doi:10.1016/S2352-4642(20)30186-3.

Oreopoulos, Philip. 2007. "Do Dropouts Drop out Too Soon? Wealth, Health and Happiness from Compulsory Schooling." *Journal of Public Economics* 91:2213–29. doi:10.1016/j.jpubeco.2007.02.002.

Organisation for Economic Cooperation and Development. 2020. "Education and COVID-19: Focusing on the Long-term Impact of School Closures. OECD Policy Responses to Coronavirus (COVID-19)." Retrieved January 5, 2021 (https://www.oecd-ilibrary.org/education/education-and-covid-19-focusing-on-the-long-term-impact-of-school-closures_2cea926e-en).

Oster, Emily. 2019. "Unobservable Selection and Coefficient Stability: Theory and Evidence." *Journal of Business & Economic Statistics* 37(2):187–204. doi:10.1080/07350015.2016.1227711.

Park, Young Joon, Young June Choe, Ok Park, Shin Young Park, Young-Man Kim, Jieun Kim, Sanghui Kweon, Yeonhee Woo, Jin Gwack, Seong Sun Kim, Jin Lee, Junghee Hyun, Boyeong Ryu, Yoon Suk Jang, Hwami Kim, Seung Hwan Shin, Seonju Yi, Sangeun Lee, Hee Kyoung Kim, Hyeyoung Lee, Yeowon Jin, Eunmi Park, Seung Woo Choi, Miyoung Kim, Jeongsuk Song, Si Won Choi, Dongwook Kim, Byoung-Hak Jeon, Hyosoon Yoo, and Eun Kyeong Jeong, and on behalf of the COVID-19 National Emergency Response Center, Epidemiology and Case Management Team. 2020. "Contact Tracing during Coronavirus Disease Outbreak, South Korea, 2020." *Emerging Infectious Diseases* 26(10):2465–68. doi:10.3201/eid2610.201315.

Paternoster, Raymond, Robert Brame, Paul Mazerolle, and Alex Piquero. 1998. "Using the Correct Statistical Test for the Equality of Regression Coefficients." *Criminology* 36(4):859–66. doi:10.1111/j.1745-9125.1998.tb01268.x.

Phelan, Jo C. and Bruce G. Link. 2015. "Is Racism a Fundamental Cause of Inequalities in Health?" *Annual Review of Sociology* 41:311–30. doi:10.1146/annurev-soc-073014-112305.

Phelan, Jo C., Bruce G. Link, and Parisa Tehranifar. 2010. "Social Conditions as Fundamental Causes of Health Inequalities: Theory, Evidence, and Policy Implications." *Journal of Health and Social Behavior* 51(S):28–40. doi:10.1177/0022146510383498.

Raifman, Julia, Kristen Nocka, David Jones, Jacob Bor, Sarah Lipson, Jonathan Jay, and Philip Chan. 2020. "COVID-19 US State Policy Database." Retrieved June 6, 2020 (www.tinyurl.Com/statepolicies).

Raine, Samuel, Amy Liu, Joel Mintz, Waseem Wahood, Kyle Huntley, and Farzanna Haffizulla. 2020. "Racial and Ethnic Disparities in COVID-19 Outcomes: Social Determination of Health." *International Journal of Environmental Research and Public Health* 17(21):8115. doi:10.3390/ijerph17218115.

Ramirez, Francisco O. and John Boli. 1987. "The Political Construction of Mass Schooling: European Origins and Worldwide Institutionalization." *Sociology of Education* 60(1):2–17. doi:10.2307/2112615.

Rasmussen, Sonja A. and Lindsay A. Thompson. 2020. "Coronavirus Disease 2019 and Children: What Pediatric Health Care Clinicians Need to Know." *JAMA Pediatrics* 174(8):743–44. doi:10.1001/jamapediatrics.2020.1224.

Rauscher, Emily. 2015. "Educational Expansion and Occupational Change: US Compulsory Schooling Laws and the Occupational Structure 1850–1930." *Social Forces* 93(4):1397–1422. doi:10.1093/sf/sou127.

Rauscher, Emily. 2016. "Does Educational Equality Increase Mobility? Exploiting Nineteenth-century U.S. Compulsory Schooling Laws." *American Journal of Sociology* 121(6):1697–1761. doi:10.1086/685443.

Rauscher, Emily. 2020. "Lower State COVID-19 Deaths and Cases with Earlier School Closure in the U.S." medRxiv. doi:10.1101/2020.05.09.20096594.

Rogers, Tiana N., Charles R. Rogers, Elizabeth VanSant-Webb, Lily Y. Gu, Bin Yan, and Fares Qeadan. 2020. "Racial Disparities in COVID-19 Mortality among Essential Workers in the United States." *World Medical & Health Policy* 12(3):311–27. doi:10.1002/wmh3.358.

Rosenbaum, Paul R. and Donald B. Rubin. 1985. "Constructing a Control Group Using Multivariate Matched Sampling Methods That Incorporate the Propensity Score." *The American Statistician* 39(1):33–38.

Ross, Catherine E. and John Mirowsky. 1999. "Refining the Association between Education and Health: The Effects of Quantity, Credential, and Selectivity." *Demography* 36(4):445–60. doi:10.2307/2648083.

Rubin, Donald B. 2001. "Using Propensity Scores to Help Design Observational Studies: Application to the Tobacco Litigation." *Health Services and Outcomes Research Methodology* 2:169–88. doi:10.1017/CBO9780511810725.

Ruggles, Steven, Sarah Flood, Ronald Goeken, Josiah Grover, Erin Meyer, Jose Pacas, and Matthew Sobek. 2020. "IPUMS USA: Version 10.0." Minneapolis, MN: Integrated Public Use Microdata Series. doi:10.18128/D010.V10.0.

Shaw, Richard John and Kate E. Pickett. 2013. "The Health Benefits of Hispanic Communities for Non-Hispanic Mothers and Infants: Another Hispanic Paradox." *American Journal of Public Health* 103:1052–57.

Small, Mario Luis. 2009. *Unanticipated Gains: Origins of Network Inequality in Everyday Life*. New York: Oxford University Press.

Sosina, Victoria E. and Ericka S. Weathers. 2019. "Pathways to Inequality: Between-district Segregation and Racial Disparities in School District Expenditures." *AERA Open* 5(3):1–15. doi:10.1177/2332858419872445.

Stolberg, Sheryl Gay. 2020. "Trump Administration Strips C.D.C. of Control of Coronavirus Data." *The New York Times*, July 14. Retrieved December 22, 2020 (https://www.nytimes.com/2020/07/14/us/politics/trump-cdc-coronavirus.html).

Torche, Florencia. 2011. "Is a College Degree Still the Great Equalizer? Intergenerational Mobility across Levels of Schooling in the United States." *American Journal of Sociology* 117(3):763–807. doi:10.1086/661904.

UNESCO. 2020. "Adverse Consequences of School Closures." Retrieved January 5, 2021 (https://en.unesco.org/covid19/educationresponse/consequences).

U.S. Census Bureau. 2011. "USA Countries." Retrieved December 15, 2020 (https://www.census.gov/library/publications/2011/compendia/usa-counties-2011.html#POP).

U.S. Census Bureau. 2018. "SAIPE State and County Estimates for 2018." Retrieved June 17, 2020 (https://www.census.gov/data/datasets/2018/demo/saipe/2018-state-and-county.html).

Viner, Russell M., Simon J. Russell, Helen Croker, Jessica Packer, Joseph Ward, Claire Stansfield, Oliver Mytton, Chris Bonell, and Robert Booy. 2020. "School Closure and Management Practices during Coronavirus Outbreaks Including COVID-19: A Rapid Systematic Review." *The Lancet Child & Adolescent Health* 4(5):397–404. doi:10.1016/S2352-4642(20)30095-X.

Weeden, Kim and Benjamin Cornwell. 2020. "The Small-world Network of College Classes: Implications for Epidemic Spread on a University Campus." *Sociological Science* 7:222–41. doi:10.15195/v7.a9.

Wiemers, Emily E., Scott Abrahams, Marwa AlFakhri, V. Joseph Hotz, Robert F. Schoeni, and Judith A. Seltzer. 2020. "Disparities in Vulnerability to Complications from COVID-19 Arising from Disparities in Preexisting Conditions in the United States." *Research in Social Stratification and Mobility* 69:100553. doi:10.1016/j.rssm.2020.100553.

Williams, David R. 2012. "Miles to Go before We Sleep: Racial Inequities in Health." *Journal of Health and Social Behavior* 53(3):279–95. doi:10.1177/0022146512455804.

Williams, David R., Jourdyn A. Lawrence, and Brigette A. Davis. 2019a. "Racism and Health: Evidence and Needed Research." *Annual Review of Public Health* 40:105–25. doi:10.1146/annurev-publhealth-040218-043750.

Williams, David R., Jourdyn A. Lawrence, Brigette A. Davis, and Cecilia Vu. 2019b. "Understanding How Discrimination Can Affect Health." *Health Services Research* 54:1374–88. doi:10.1111/1475-6773.13222.

Wu, Joseph T., Benjamin J. Cowling, Eric H. Y. Lau, Dennis K. M. Ip, Lai-Ming Ho, Thomas Tsang, Shuk-Kwan Chuang, Pak-Yin Leung, Su-Vui Lo, Shao-Haei Liu, and Steven Riley. 2010. "School Closure and Mitigation of Pandemic (H1N1) 2009, Hong Kong." *Emerging Infectious Diseases* 16(3):538–41. doi:10.3201/eid1603.091216.

Wu, Joseph T., Kathy Leung, Mary Bushman, Nishant Kishore, Rene Niehus, Pablo M. de Salazar, Benjamin J. Cowling, Marc Lipsitch, and Gabriel M. Leung. 2020. "Estimating Clinical Severity of COVID-19 from the Transmission Dynamics in Wuhan, China." *Nature Medicine* 26:506–10. doi:10.1038/s41591-020-0822-7.

Zajacova, Anna and Elizabeth M. Lawrence. 2018. "The Relationship Between Education and Health: Reducing Disparities Through a Contextual Approach." *Annual Review of Public Health* 39:273–89. doi:10.1146/annurev-publhealth-031816-044628.

Zelner, Jon, Rob Trangucci, Ramya Naraharisetti, Alex Cao, Ryan Malosh, Kelly Broen, Nina Masters, and Paul Delamater. 2020. "Racial Disparities in COVID-19 Mortality Are Driven by Unequal Infection Risks." *Clinical Infectious Diseases* 72:e88–e95.

Zhang, Juanjuan, Maria Litvinova, Yuxia Liang, Yan Wang, Wei Wang, Shanlu Zhao, Qianhui Wu, Stefano Merler, Cécile Viboud, Alessandro Vespignani, Marco Ajelli, and Hongjie Yu. 2020. "Changes in Contact Patterns Shape the Dynamics of the COVID-19 Outbreak in China." *Science* 368:1481–86. doi:10.1126/science.abb8001.

Zhou, Xiang. 2019. "Equalization or Selection? Reassessing the 'Meritocratic Power' of a College Degree in Intergenerational Income Mobility." *American Sociological Review* 84(3):459–85. doi:10.1177/0003122419844992.

Author Biographies

Emily Rauscher is associate professor of Sociology at Brown University. Rauscher studies the relationship between education and inequality.

Ailish Burns is a PhD student in Sociology at Brown University. Her work focuses on medical sociology and inequality.