School Closures During the 1918 Flu Pandemic

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Abstract

COVID-19 has reignited interest in responses to the 1918-19 influenza pandemic, the last comparable U.S. public health emergency. During both pandemics, many local authorities made the controversial decision to close schools. Using newly collected data on local school closures during the 1918 pandemic, we find precise null effects of closures on children's school attendance in 1920, their educational attainment, and adult labor market outcomes in 1940. We highlight important differences between the 1918-19 flu pandemic and the COVID-19 pandemic that help explain our estimated null effects of 1918-19 school closures.

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1 Introduction

Students worldwide have been affected by school closures since the spring of 2020, when countries implemented a variety of non-pharmaceutical interventions (NPIs) to combat the spread of COVID-19. The decision to close schools is controversial; proponents of school closures argue that closures slow the spread of the virus, while opponents contend that the negative effect of closures on children's learning outweigh any public health benefits.[1] Numerous studies find that unplanned school closures and absenteeism negatively impact student achievement (Jaume and Willén, 2019; Gershenson et al., 2017; Aucejo and Romano, 2016; Goodman, 2014; Marcotte and Hemelt, 2008; Marcotte, 2007). Whether these findings predict the impact of COVID-19 related closures is unknown.[2] The extent and duration of COVID-19 related school closures is unprecedented, yet the effects of school closures on children may be mitigated by the ability of school districts to offer opportunities for remote and online learning (Clark et al., 2020).

We enrich the discussion about the consequences of school closures during pandemics by taking a historical perspective. During the 1918-19 influenza pandemic, many state and local authorities closed schools as the situation worsened while others kept their schools open—mirroring ongoing debates about the costs and benefits of closures. We evaluate the effect of school closures on both the short- and long-run outcomes of school-aged children affected by the 1918-19 pandemic. While our results are specific to the 1918-19 pandemic, we use our findings to highlight important differences between the 1918-19 pandemic and today, putting into perspective recent (and still ongoing) studies measuring the short-run effects of school closures during COVID-19.[3]

To study the effect of school closures in 1918-19, we construct novel data from newspaper archives on the duration of school closures for 167 of the largest U.S. cities in 1910. We combine this information with data on excess mortality in each city, and we merge this dataset with the

[1] Many papers provide overviews of the use of school closures as a pandemic mitigation strategy, including Ferguson et al. (2006) and Cauchemez et al. (2009).

[2] Kuhfeld et al. (2020) provide a detailed discussion on the literature and project the likely impact of COVID-19 learning interruptions using previous measures.

[3] For one discussion of the value of providing a historical perspective in understanding recent phenomena in social research, see Lawrence (1984).

1910 and 1920 full-count censuses to obtain data on individuals and city characteristics. To study the long-run effects of school closures on children, we link 0- to 25-year-old males from the 1920 census to their adult records in 1940 to obtain measures of adult outcomes.

Using these data, we first describe the geography of school closures and the city characteristics in 1910 that predict longer closures in 1918. The length of school closures was positively correlated with the number of city workers in medical fields and whether the city had a state order that mandated or recommended a closure, whereas it was negatively correlated with the share of immigrants in a city. One striking feature is a higher school attendance rate of 15- to 21-year-olds in cities that decided to close their schools for a longer period of time, indicating that stricter cities were positively selected on high school attendance.

Next, we estimate the short-run effects of school closures on attendance rates in the 1920 census. Our identification strategy uses the fact that some of the school-aged population were less likely to have their schooling interrupted because they were either too old or too young to be attending school during the pandemic. We find a precisely estimated null effect of closure length on attendance probabilities across different age groups. These null effects persist across groups based on paternal occupational prestige and nativity, as well as students' race and gender. We then show that these null effects on school attendance in the short run also carry over to the long run. Our long-run analysis reveals precisely estimated null effects of closures on adult educational attainment, wage income, non-wage income, and hours worked measured in 1940. Again, we observe no consistent heterogeneous impacts across family background or children's demographics. Overall, our results suggest that while the pandemic may have affected the academic performance of school-aged children in 1918-19, the closures themselves had no measurable effects on the outcomes we study.

To our knowledge, we are the first to study the effects of the 1918-19 school closures on children. In the historical context, our paper is most related to Meyers and Thomasson (2020), who study school closures during the 1916 U.S. polio epidemic. They find that children of legal working age living in areas with high numbers of polio cases had lower lifetime educational attainment than their peers in less affected locations. The polio epidemic was significantly smaller than the 1918-19 influenza pandemic, and primarily affected children. As a result, there was no widespread economic disruption, unlike in the 1918-19 influenza pandemic. While Meyers and Thomasson (2020)'s findings suggest that children of legal working age may have dropped out of school to work during closures and not returned, this may have been a less attractive option for teens during the influenza pandemic, since manufacturing and retail activity declined during the pandemic and employment became harder to find (e.g. Garrett, 2007; Bodenhorn, 2020; Velde, 2020). In addition, Meyers and Thomasson (2020) do not have direct data on school closures, and instead rely on geographic variation in polio morbidity rates to identify effects of the polio epidemic on outcomes. They focus on long-run effects using information on state of birth. We use direct measures of school closures at the city-level to measure the impacts of school closures on children's short-run and adult outcomes.

Our findings also contribute to an emerging literature on the impacts of the COVID-19 pandemic on children. While it is too soon to comprehensively measure the long-run impact of COVID-19 related school closures, early results suggest that student outcomes may suffer, at least in the short-run (Maldonado and De Witte, 2020; Chetty et al., 2020). Evidence also suggests that lower-income children may be more affected than those from higher-income families, thus increasing inequality across children from different backgrounds (e.g., Grewenig et al., 2020; Chetty et al., 2020; Bacher-Hicks et al., 2020).

However, there are important differences between the 1918-19 and 2020-21 pandemics and school closures which we think rationalize our null results. Mortality rates in 1918-19 followed an atypical curve, with death rates highest among young children (0–5) and workers (25–34). This contrasts with COVID-19, which has the highest mortality rate among older adults. These differences in mortality affect responses to school closures. Even when schools remained open in 1918-19, absentee rates were extremely high, dampening any potential effects of the closures: many people stayed home independent of local policies on school closures and re-openings.[4]

[4]For example, in Staten Island, half of students were not in school in mid-October 1918 even while schools were open (The Sun, 1918).

And ex-post, contemporary health officials regarded school closures and other NPIs aimed at preventing the spread of the pandemic as largely ineffective (e.g. Tomes, 2010; Byerly, 2010).Our results support the views of these contemporary observers.

Another important contrast is that school closures in the 1918-19 pandemic were substantially shorter than current COVID-19 related school closures, potentially limiting their effects. In our sample of 1918-19 school closures, the average closure length was 36 days, and some cities decided to make up for missing school days by extending the school year.[5] In 2020, many schools surpassed 30 days of closure in the spring, before closing again for much of the fall.

Finally, there are fewer reasons to suspect heterogeneous effects of missed schooling across socioeconomic groups from 1918-19 closures. The lack of effective remote learning platforms in 1918-19 may have put students on roughly equal footing when they missed school, unlike today, when there is substantial heterogeneity in access to online resources and parental support. Given these differences, it is plausible that the school closures of 1918-19 had fewer effects on the school-age population than the closures we observe today.

2 Background and Context

2.1 The 1918-19 Influenza Pandemic

The 1918-19 flu was the most severe pandemic in the 20th century. It was caused by the spread of an H1N1 virus and occurred in three waves: a first mild wave in spring 1918, a second severe wave in fall 1918, and a third less lethal wave in early 1919. Estimates reveal that about one-third of the world population suffered from influenza during this period (Taubenberger and Morens, 2006). The 1918-19 virus was extremely lethal compared to other influenza strains. The case fatality rates exceeded 2.5 percent and at least 50 million people died from the virus. Most influenza viruses have the largest negative effects on young children and the elderly. But a striking feature of the

[5] For example, in Atlanta the 1918-19 school year was extended to June 20 from June 1 because of closures (Influenza Archive, 2020a).

1918 pandemic was its high incidence and mortality for those aged 20-40 (Collins, 1931). In the United States, over one-quarter of the population was infected and about 675,000 individuals died from the virus between 1918 and 1920, 0.66 percent of the total population (Crosby, 2003; Johnson and Mueller, 2002; Taubenberger and Morens, 2006).

In the United States, the pandemic had its first noticeable but mild effect during spring 1918, when it was identified in military personnel (Crosby, 2003; Byerly, 2010; Barry, 2020).[6] Major outbreaks occurred across the country during the second wave, which first emerged in Boston's Commonwealth Pier on August 27, 1918 and, only two days later, the first severely ill soldiers were admitted to the U.S. Naval Hospital in Chelsea, Massachusetts (Byerly, 2010). The pandemic then spread along East Coast cities, including Boston, New York, and Philadelphia, and gradually diffused westward over the next two months. Some cities including Albany and Chicago experienced a substantial increase in excess mortality only during the fall of 1918, while other cities like San Francisco and New Orleans also experienced a second wave during the first two months of 1919.[7] The severity of the influenza pandemic during the second wave and the first months of the third wave is illustrated by Markel et al. (2007, Table 1), who report excess influenza and pneumonia mortality rates over the 24 weeks from September 8, 1918 through February 22, 1919 for 43 cities ranging from 210 excess deaths per 100,000 inhabitants (Grand Rapids, Michigan) to 710 excess deaths per 100,000 inhabitants (Boston, Massachusetts).[8]

2.2 School Closures

Local health authorities responded to increasing mortality numbers during the second wave of the 1918-19 influenza pandemic by imposing a wide range of NPIs. These measures included

[6] Contemporary accounts suggest the first identified cases in the United States occurred in Haskell County, Kansas, from which recruits brought the virus into Camp Funston, Kansas (Barry, 2020). Other military camps throughout the country recorded severe outbreaks during March and April 1918 (Crosby, 2003, p.19).

[7] An excellent description of the influenza pandemic in large U.S. cities is provided in Navarro and Markel's digital *Influenza Encyclopedia*; see http://www.influenzaarchive.org/about.html.

[8] Clay et al. (2018) show that air pollution elevated mortality rates in U.S. cities during the pandemic. Other factors such as distance to military camps, differences in pre-pandemic mortality, poverty rates and the population composition also contributed to the uneven distribution of excess pandemic deaths across the country (Crosby, 2003; Beach et al., 2020).

isolation/quarantine, bans on public gatherings, staggered business hours, ventilation of public venues and streetcars, mandated face masking, and school closures. There is now a large and growing literature on the effects of these NPIs on health and economic outcomes. Markel et al. (2007) and Hatchett et al. (2007) suggest that cities that enacted NPIs early delayed peak mortality and had lower mortality, while Bootsma and Ferguson (2007) find only modest effects on total mortality. Similarly, Barro (2020) finds that while NPIs slowed the initial acceleration of the pandemic, there is little evidence that the measures reduced overall mortality.[9]

We examine one particularly important NPI in this paper: school closures. In early October 1918, U.S. Surgeon General Rupert Blue issued a series of closure recommendations that included schools along with churches, theaters, and other public institutions. Blue noted that while "there was no way to put a nationwide closing order into effect," he hoped "that those having the proper authority will close all public gathering places if their community is threatened by the pandemic" (The Boston Globe, 1918). While the federal government did not have the power to close schools, some state governments did. New Jersey ordered all schools closed from October 10–26 and Louisiana ordered all schools closed from October 8 to November 16. But most states did not mandate closures. A few, such as New York and Illinois, made no closure recommendations at all. Others, such as North Carolina, advised communities to consider closing schools if influenza became prevalent in their community (Austin, 2018).

Local authorities had wide latitude in determining whether and when to close schools, with limited oversight from higher levels of government. The earliest school closures occurred around Boston in late September 1918. As the virus spread, other school districts followed. The decision to close schools was controversial, and not all agreed that it would help slow the virus. In Chicago, schools never closed despite heavy pandemic caseloads, though students who became ill were directed to stay home. In early October, the Chicago Heath Commissioner argued that keeping

[9] See Stern et al. (2009) for a list of NPIs by type and city. For greater discussion of the many papers related to the 1918 pandemic, see the recent surveys by Arthi and Parman (2020) and Beach et al. (2020). In addition, Almond and Currie (2011), Almond et al. (2018), and Beach et al. (2018) provide detailed surveys of the long-run effects of early childhood exposure to health shocks, including influenza. But none of these papers measure the causal effect of school closures on children.

schools open would reduce virus spread: “[T]he children are better off than they would be if we closed the schools and they were free to roam wherever they chose” (The Chicago Tribune, 1918a). After cases declined in November, Chicago-based public health officials were pleased with their decision to keep schools open. Dr. W.A. Evans, president of the American Public Health Association and a Chicago Tribune columnist, summarized this view in a late November column. He argued that the disease was not particularly dangerous for school-aged children; cities that closed schools did not seem to do any better at containing the virus than Chicago; and children were better off supervised in school, where learning could continue (The Chicago Tribune, 1918b). Similar justifications kept schools open in New York City.

In cities that did close their schools, similar pro-school opening views were common and affected decisions. There was immense pressure to keep schools open for as long as possible, and after closures, to reopen them quickly. For example, after a local health commissioner ordered schools to close in Minneapolis, Minnesota, the school board and superintendent defied the order, noting that “we shall not close the schools if they arrest us and fine us”(Influenza Archive, 2020c). These officials were supported by the State Board of Health, which praised nearby St. Paul for not closing its schools (Influenza Archive, 2020b). Under pressure, several cities opened their schools too soon, before the pandemic was contained. In Decatur, Illinois, schools opened on November 11. Only 17 days later, the schools were closed again until December 30.

Even when schools were open, many students did not attend. In Chicago and New York, students who were suspected of having the virus were told to stay home or sent to special quarantine facilities. Many families also appear to have kept children home, fearing infection. In Staten Island, New York, school attendance rates dropped by 50 percent (The Sun, 1918). In Sacramento, 2,237 children were absent on October 21, even as schools remained open and the city reported only 40 student cases. The school board attributed absences to “fear,” and noted that if absences continued to be high, the city would be forced to close the schools for financial reasons (The Sacramento Bee, 1918b). The next day, absences increased to 2,875 (“apparently due to fright”) and the city closed schools (The Sacramento Bee, 1918a). High levels of absenteeism were not limited to cities. At the peak of the pandemic in Davey, Nebraska (population 123 in 1920), over half of all students did not attend class (The Ceresco Courier, 1918).

3 Data

3.1 School Closure Data

Our main treatment variable is the total number of days a city closed schools during the 1918-19 school year. We identify 229 cities with a 1910 population greater than 25,000 and search historical newspaper archives for mentions of school closures.[10] We located school closure and reopening dates for 165 of the 229 cities, as well as six additional cities mentioned in newspaper articles related to those 165 cities, leaving us with a sample of 171 cities.[11] Four of these 171 cities had incomplete school attendance information in the full-count decennial census data, so we focus on the remaining 167 cities. If a city closed schools multiple times, we use the total number of days closed across all closures.[12]

Figure 1 plots the distribution of school closures across areas. There is very little geographical clustering; cities in similar areas often made different closure choices. For example, Chicago and New York were the two largest cities in our sample not to close schools at any point while neighboring cities closed schools for many weeks.[13] Cities closed schools on average for 36 days, with a standard deviation of 21 days. In our main regression results we discuss changes in outcomes in response to a one standard deviation (21 day) increase in the number of days a city closed its school.

The length of time schools closed during the pandemic is correlated with several city demographic characteristics. Figure 2 presents the estimated coefficients from a regression of various

[10] We primarily rely on newspapers.com to search historical archives. 1910 population estimates are from the Bureau of Education's 1917 annual report.

[11] For an additional 34 cities, we found sources confirming that the city closed its schools, but could not confirm a closing and a reopening date. We do not use these 34 cities in our analysis.

[12] All dates were independently verified by at least two research assistants.

[13] Other cities in our sample that decided not to close schools are Bridgeport, C.T.; Hartford, C.T.; New Haven, C.T.; Lewiston, M.E.; and Troy, N.Y.

city characteristics in 1910 on days closed in the 1918-19 pandemic.[14] There is a strong, positive relationship between the fraction of children attending school in 1910 and the number of days schools in a city closed in 1918-19. An additional day of school closures is associated with a 0.01 standard deviation higher school attendance rate in the city in 1910. These effects are largest among teens aged 15–18, who were of legal working age in most states. Unsurprisingly, this pattern is not as strong for children aged 6–10 or 11–14, as school attendance rates for this group are comparably high. The share of individuals working in the medical field in 1910 is positively associated with longer school closures. On the other hand, cities with larger immigrant populations close their schools for shorter periods of time. Finally, state closure recommendations correlate with city-level decisions. In states with school closure recommendations, cities closed schools for slightly longer amounts of time.

Figure A1 plots the number of days closed versus excess 1918-19 flu mortality rates. We do not see any evidence that places with more excess flu deaths were any more likely to close down their schools for longer periods. In our baseline analysis, we do not control for excess mortality, since it could have been affected by school closures. But consistent with the weak relationship observed in Figure A1, we show that including mortality as a control does not change the estimated impact of school closures on the school-aged population.

3.2 Census Data

To measure short-run outcomes and city-level covariates, we use individual data from the full-count population censuses in 1910 and 1920.[15] The outcome variable for our short-run regressions is reported school attendance among individuals aged 0 to 25 in each census year.[16] We use other demographic variables to test for possible heterogeneous effects of closures, including the foreign-born status of the parents, the father's occupation, and the race and gender of the child.

[14] City characteristics are observed in the 1910 full-count census and standardized to have mean zero and standard deviation one.

[15] We use restricted access census data provided by IPUMS (Ruggles et al., 2020).

[16] The variable *school* is not perfectly comparable over time in these two censuses: In 1910, the question asked on April 15, 1910 whether a child had been in school since the previous September 1. In 1920, the question was asked on January 1 and also referred to the period since September 1.

We assign school closures to youth based on their city of residence.

To study the long-run impacts of school closures, we link male children in 1920 to their adult observations in the 1940 full-count population census, using the 1920-1940 links provided by the Census Linking Project (Abramitzky et al., 2020), which match records based on standardized name strings, birth state, and birth year.[17] We measure 1940 outcomes for this linked sample, including educational attainment, wage income, the existence of non-wage income, and hours worked.[18]

In Table A1, we report baseline summary statistics from the three analysis samples we use in this project: 0–25 year olds in the 1910 decennial census, 0–25 year olds in the 1920 decennial census, and 0–25 year olds in the 1920 decennial census who we link to the 1940 census. In all samples, we restrict our attention to children in our 167 city analysis sample. In our three samples, 38-41% of the 0–25 year olds report attending school and the average child lived in a city that closed schools for between 25 and 28 days. In our 1920–1940 matched sample, the average child obtained 10.3 years of education by 1940 and earned an average annual wage income of $1,151.

4 Results

4.1 School Attendance in the Short-Run

In this subsection, we show that school closures during the 1918-19 pandemic had precisely estimated null effects on school attendance. Figure 3 illustrates this point by plotting average attendance rates for cities with longer and shorter school closures by age and census year. Cities are grouped by those that closed schools for: (1) 0–21 days, (2) 22–35 days, and (3) 36 days or longer. Panel A shows that 1920 attendance rates are similar for children aged 0–13 across the three groups of cities, but that students aged 15–21 were more likely to be attending school in

[17] We use the Census Linking Project's standard links with phonetic string cleaning. More information on this linking method can be found in Abramitzky et al. (2019). Our results are robust to using the other linking methods provided by the Census Linking Project. We cannot link women due to name changes upon marriage.

[18] Non-wage income measures income from non-employer sources, including self-employment. In the 1940 decennial census, this indicator is the only collected measure of non-wage income.

cities that closed their schools for a longer time during the pandemic. This does not imply that school closures *increased* school attendance; instead, Panel B of Figure 3 shows that stricter cities were positively selected on high school attendance rates. Even in 1910 (before school closures could have affected children), youth in cities with longer school closures during the 1918-19 pandemic were more likely to attend school. Comparing Panels A and B, there is no change in that form of selection from 1920 to 1910 that would indicate a negative effect of school closures on attendance. If anything, cities with longer school closures in 1918-19 had higher relative levels of school attendance in 1920 than 1910.

To explore these results further, we use a standard regression analysis that estimates 1920 school attendance rates as a function of school closure length. We estimate versions of the following equation:

$$1(Attend\ School)_i = \beta_a DaysClosed_c \times AgeGroup_a + \gamma_c + \Pi \times X_i + \Delta \times V_{c,b} + \omega_{r,b} + \epsilon_i \qquad (1)$$

where the outcome variable $1(Attend\ School)_i$ is an indicator measuring whether child i was attending school in 1920. The variable $DaysClosed_c$ describes the number of days that schools were closed during the 1918-19 school year in child i's city c.[19] Age bins a group children into six groups (aged 0–5, 6–10, 11–14, 15–18, 19–21, and 22–25 in 1920) so we can separately estimate the effect of school closures on pupils of different ages. γ_c are city fixed effects. X_i is a vector of race-by-gender fixed effects. $V_{c,b}$ contains birth-year fixed effects linearly interacted with the following city characteristics measured in 1910: log population, the fraction of residents who are foreign-born, the average occupational score of 25–54 year-old men, and the school attendance rates of 6–10, 11–14, and 15–18 year-old children. In addition, we include census region-by-birth year fixed effects ($\omega_{r,b}$) to absorb time-varying investment in schooling at the region-level and region-level policy variation related to the 1918 pandemic that may have affected some children differently from others.Robust standard errors are clustered at the city level.

[19]The null effects that we present here are robust to a different choice of specification where we group the measure of school closures into three bins: cities that closed schools for a short period of time (at most 21 days), cities that closed schools for a moderate amount of time (22-35 days), and cities that closed schools for a significant amount of time: 36+ days. Our null short-run and long-run results are robust to our use of this variation.

In Panel A of Figure 4, we plot the estimated β_a coefficients for the above regression. The β_a coefficients are relative to children aged 0–5 (omitted category), who would not have been affected by school closures. Our estimates reveal no evidence that the number of days a school system closed during the 1918-19 pandemic affected attendance rates for school-aged children in 1920. For example, the estimated coefficient on school closures for the age group 11–14 is a precise zero. For each day that a city closed its school system during the pandemic, these children were no less likely to attend school in 1920 due to closures than the omitted category (children aged 0–5).[20] We find similar null results for other school-aged children in 1920, consistent with the raw school attendance rates plotted in Figure 3.

The confidence intervals in Panel A of Figure 4 are small enough for us to reject even modest differences in school attendance rates for affected cohorts. For example, the 95 percent confidence interval on the estimated $\beta_{age\in[11,14]}$ coefficient for 11–14 year-old children ranges from -0.0005 to 0.0012. Scaling this up by 21 days, our point estimate and 95% confidence interval imply that a city that closed its schools for 21 more days than a comparison city during the 1918-19 pandemic likely caused at most a one percentage point decline in the probability that 11–14 year-old children in that city attended school relative to the omitted category.[21] This bounding exercise leads to similar conclusions for the other age groups shown in Panel A.

In Panel B of Figure 4, we estimate Equation 1 using school attendance in 1910 as the outcome variable. This is a placebo test, since school closures in 1918 could not have affected school attendance in 1910. The results in Panels A (1920) and B (1910) are similar nulls. This suggests that the 1920 results are not driven by any time-invariant age-specific selection that our model fails to capture.[22] This regression-based analysis is consistent with the raw schooling patterns

[20]This interpretation is similar to a difference-in-difference model, since the $\beta_{age\in[11,14]}$ coefficient is measured relative to the $\beta_{age\in[0,5]}$ coefficient (which is zero by construction). To explain our result more explicitly, if every city in the U.S. closed schools for either zero or one day in 1918, our method would compare school attendance rates for 11–14 year-old children in places that closed schools for one day in 1918 vs. school attendance rates for 11–14 year-old children in places that did not close schools in 1918. We would then compare this difference to the same difference of children aged 0–5.

[21]21 days is a one standard deviation increase in the number of days that a city closed its schools in our sample.

[22]Potential concerns could include city-level availability of schooling for children of different ages, each city's school ventilation quality or other school inputs, or city-specific age-specific preferences for truancy.

displayed in Figure 3 across 1910 and 1920.

In Figures A3-A5, we show results from separately estimating Equation 1 on subsamples defined by: (1) race, (2) gender, (3) parental occupational prestige, and (4) parental nativity. Each figure shows similar null results as our baseline findings, suggesting that there were not heterogeneous effects on school closures on attendance across these dimensions.

We show that our results are robust to two modifications of our baseline specification. First, in Figure A6 we show results after conditioning on excess 1918-19 influenza mortality interacted with age-bin fixed effects. Mortality may be a bad control in this context, since prior work has shown that school closures may directly affect mortality (e.g., Markel et al., 2007). However, Figure A6 shows that our results are similar in both 1920 and 1910 if we control for excess mortality. In Figure A7, we show results from a specification that conditions on state-by-birth year fixed effects. These models absorb any state-level policies that may have differentially affected some children during this time period relative to others. The resulting estimates are similar to our baseline findings. In addition, Figure A8 shows that our results are similar if we cluster standard errors by state instead of city.

Finally, we use data on the total length of NPIs imposed by 50 cities compiled by Markel et al. (2007) and Berkes et al. (2020) to test whether our results are robust to conditioning on the length of non-schooling NPIs enacted during the pandemic. Figure A9 estimates our baseline model for this 50 cities subsample without (Panel A) and with (Panel B) controls for non-schooling NPI days interacted with age-bin fixed effects. Results for this subsample are similar to the main sample and are not affected by controlling for non-schooling NPI length.

4.2 Long-Run Outcomes

In this subsection, we estimate whether the school closures during the 1918-19 pandemic had any long-run consequences for affected youth's educational attainment and labor market outcomes based on the sample of linked men described in Section 3.2. We estimate regressions of the form:

$$Y_i = \beta_a DaysClosed_c \times AgeGroup_a + \gamma_c + \Pi \times X_i + \Delta \times V_{c,b} + \omega_{r,b} + \epsilon_i \quad (2)$$

where Y_i is a 1940 measure of educational attainment or a labor market outcome (log wage income, the probability that a respondent reports at least $50 of non-wage income, and log annual hours worked). We assign the city c as the city where we observe each child in the 1920 census, and all other variables are as defined in Equation 1.

Figure 5 shows that the 1918-19 school closures had little effect on years of educational attainment and labor market outcomes in 1940. Overall, these null long-run effects are precisely estimated. The 95 percent confidence intervals shown in Figure 5 imply that the effect of a school closure lasting an additional 20 days on long-run adult outcomes of affected children is bounded to +/- 0.09 years of educational attainment, a 4 percent change in wage income, a 0.2 percent chance of reporting at least $50 of non-wage income, and a 5 percent change in hours worked (annually).

As with the short-run results, we look for evidence of heterogeneous long-run effects by estimating our model on subsamples of the population (Figures A10-A15). Except for black men (Figure A11), where we find imprecisely estimated evidence that school closures could have mattered, point estimates are generally statistically insignificant and close to zero. Our null long-run effects are also robust to controlling for excess pandemic mortality (Figure A16) and state-by-birth year fixed effects (Figure A17). Finally, Figure A18 shows that our results are similar if we cluster standard errors by state.[23]

5 Conclusion

During the COVID-19 pandemic, governments implemented a variety of NPIs to combat the spread of the virus, including limiting the size of gatherings, curtailing business activities, mandating mask wearing and social distancing, and closing schools. These interventions have reignited interest in responses to the 1918-19 pandemic—the last comparable public health crisis.

In this paper, we analyze the NPI most likely to affect children during a pandemic: school closures. We estimate how school closures during the 1918-19 pandemic affected children's school

[23] As in the short-run results, our long-run findings are not affected by controlling for non-schooling NPI length for the subsample of 50 cities with available data.

attendance, long-run educational attainment, and adult labor market outcomes. Using newly collected data on the timing of 1918-19 school closures, we find precise null effects of school closure length on 1920 school attendance. Linking affected children to the 1940 census—where they are observed as adults—we also find little evidence of long-run schooling or labor market impacts; point estimates are close to zero with associated standard errors that rule out sizable effects. We also find no evidence that these null short- and long-run effects differ across student characteristics, including socioeconomic status, race, and parental nativity.

Our results highlight important differences between school closures in 1918-19 and 2020-21. An emerging literature finds plausible, negative effects of the COVID-19 pandemic on learning, particularly among lower-SES youth who may have been most negatively affected by school closures. However, while school closures in 2020 often lasted for months, the average school closed in 1918-19 for many fewer days. Moreover, the 1918 virus lead to high absentee rates—in some cases over 50 percent—in schools that stayed open, in part because the 1918-19 virus was a serious health risk to children and young parents. Finally, the lack of effective remote learning in 1918 may have *limited* the scope for heterogeneous effects to emerge. Unlike today, children in 1918 with more household resources did not necessarily have the ability to continue to learn at a higher rate. Given these differences, it may be unsurprising that we find little effects of 1918-19 school closures on the school-age population.

We aim with this paper to inspire more discussions about how the *differences* between the 1918-19 and COVID-19 pandemics can help inform policymakers. Much of the recent literature on the 1918-19 pandemic motivates its analysis by suggesting direct links to today. While the situations are in some ways comparable, this paper provides a concrete counterexample: school closures in 1918-19 were a different policy in a different context from today. While our findings may be more applicable in some modern circumstances than others (e.g., when a virus is particularly deadly for younger adults and children or when remote learning opportunities are limited), we caution against over-extrapolating from the 1918-19 experience when making decisions about optimal policies during the COVID-19 pandemic.

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The Sacramento Bee (October 22th, 1918a). Everyone with a cold must wear a mask.

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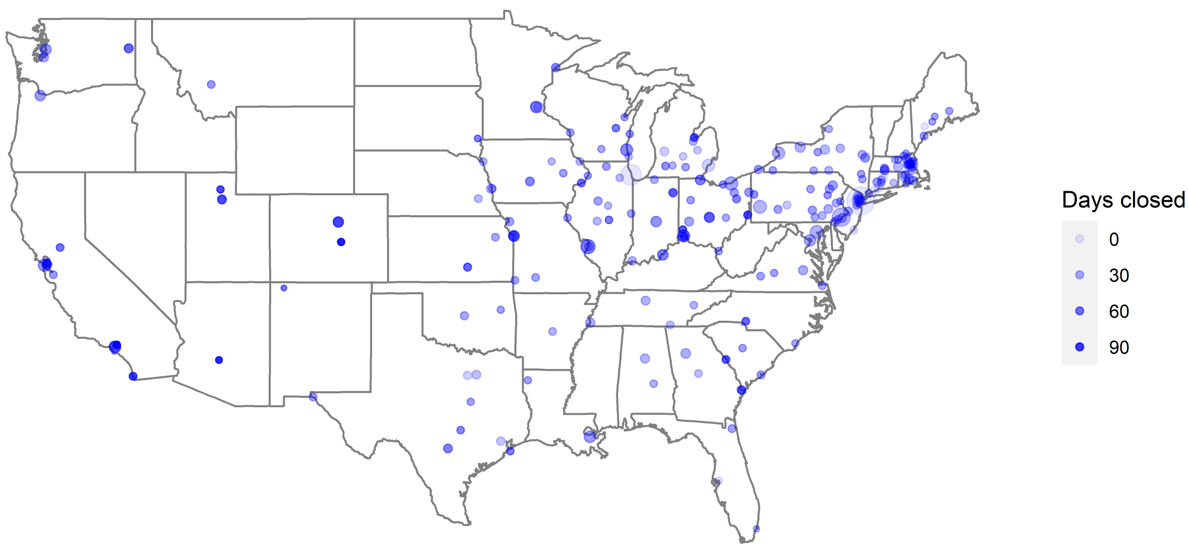
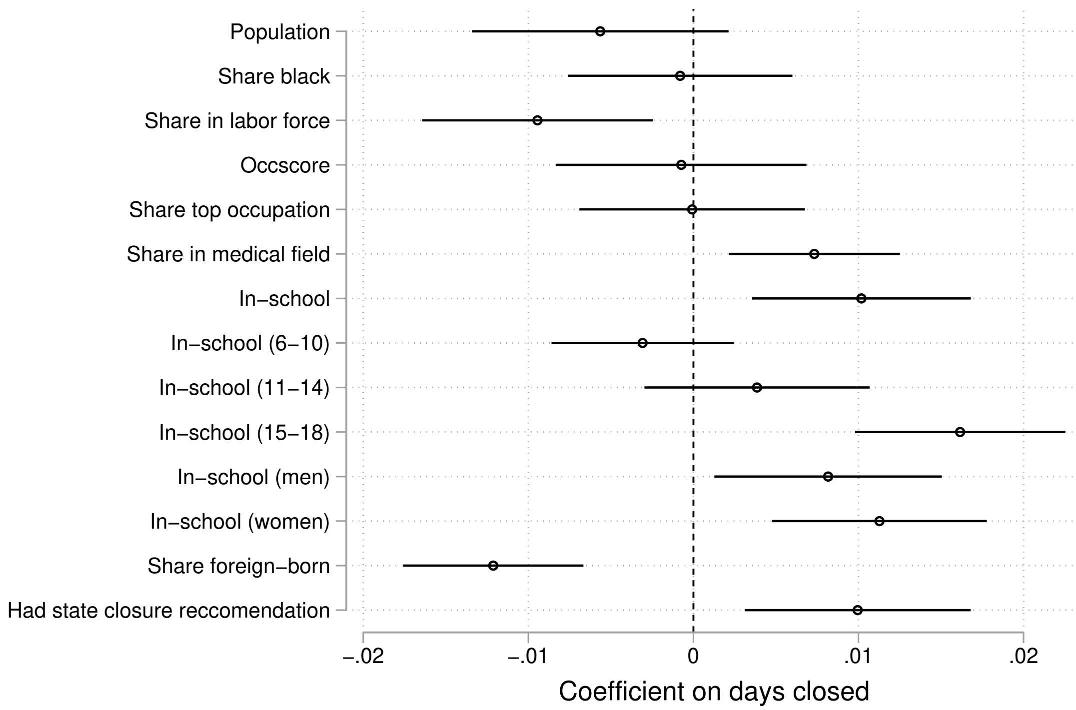
Figure 1: Map of cities by 1918-19 school closure length



This map plots the location of cities in our sample. Dots are colored by the length of school closures during the 1918-19 pandemic. Darker dots correspond to more days closed. Dot size is weighted by 1910 population, as calculated in the 1910 census.

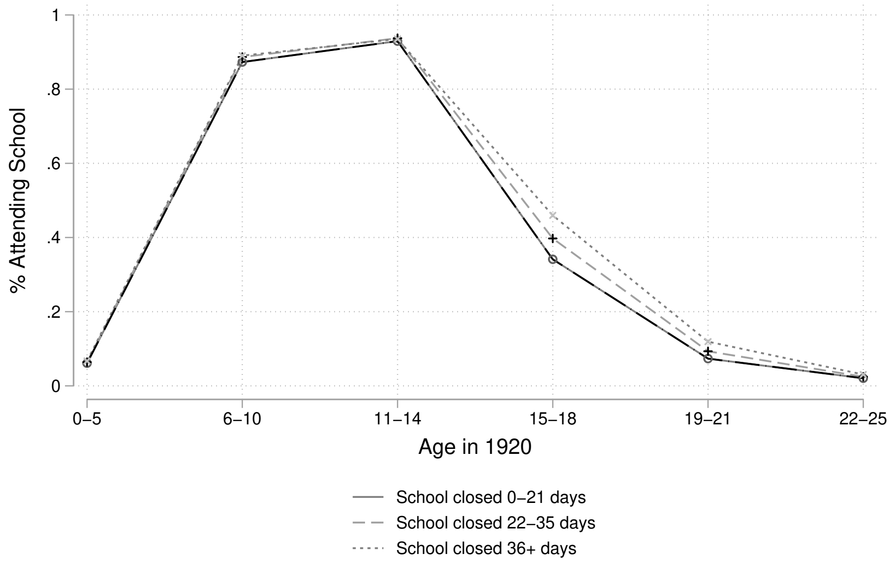
Figure 2: Relationship between 1918-19 school closure length, 1910 city demographics, and state closure orders



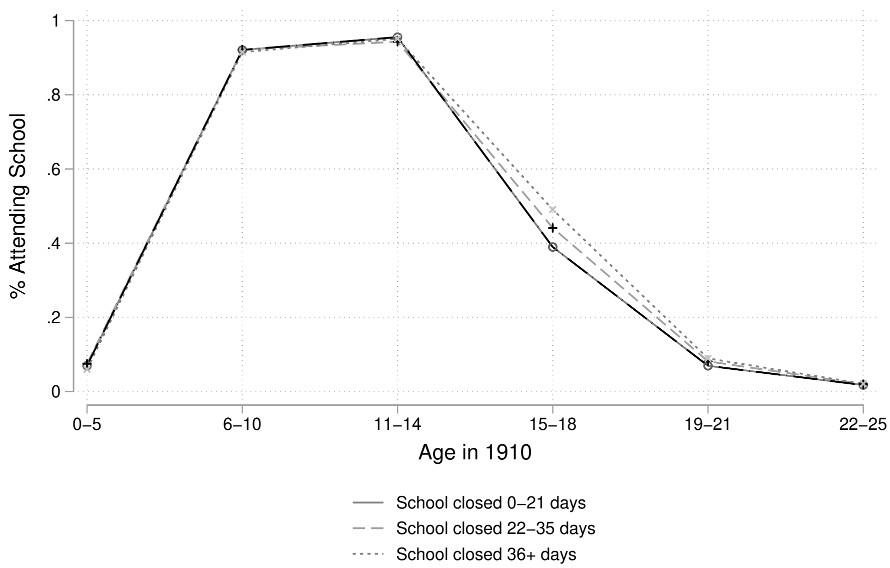
This figure plots coefficients from separate regressions with the indicated variable as the outcome and days schools closed in 1918 and 1919 as the independent variable. Each outcome variable is standardized to have mean zero, standard deviation one. All demographics and individual characteristics are calculated from the 1910 full-count decennial census and each observation is a city. State closure recommendations indicate states that had a direct order or a recommendation for schools to close at some point during the 1918-19 pandemic. Overall school attendance rates are calculated for 6-18 year-olds. 95 percent confidence intervals calculated with robust standard errors.

Figure 3: Average school attendance rates, by age group and 1918-19 school closure length

(a) School attendance in 1920, by 1918-19 closure length



(b) School attendance in 1910, by 1918-19 closure length (placebo)

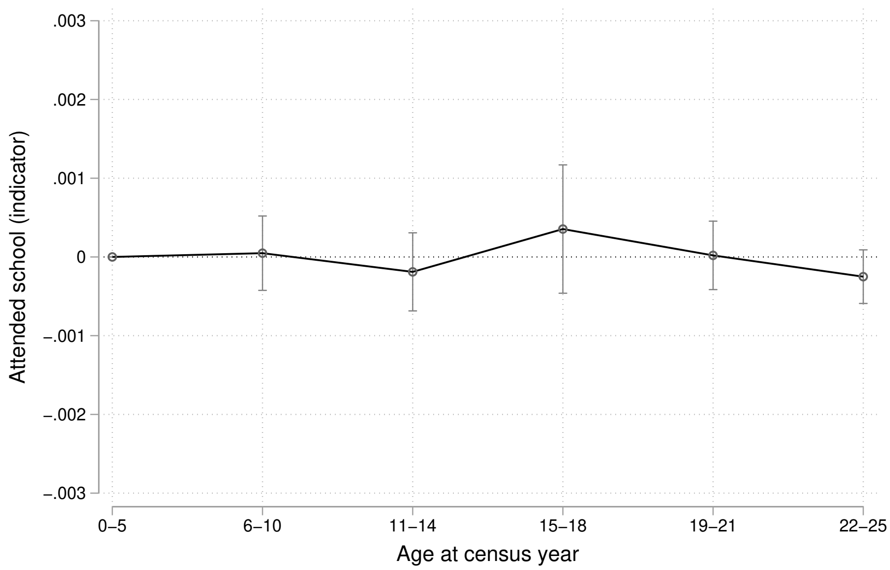


These figures show the fraction of respondents who report school attendance by reported age group in the census. Each sub-figure has three lines, separately plotting average school attendance among children who lived in cities that closed schools for 0–21, 22–35, and 36+ days in 1918-19. Panel (a) shows average school attendance as reported in the 1920 census; Panel (b) shows average school attendance from the 1910 census. Panel (b) is a placebo because city closures in 1918-19 could not have affected school attendance in 1910.

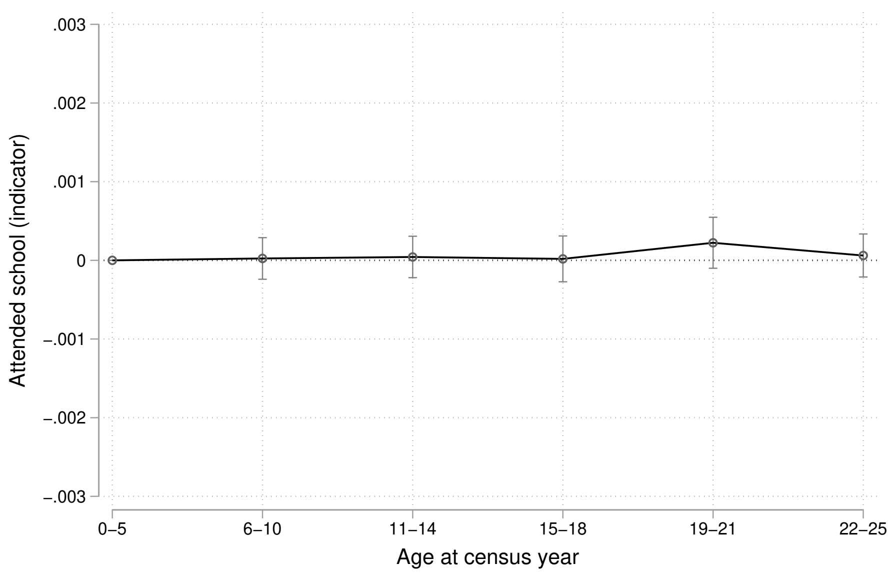
The figures show that cities that closed their schools for longer periods of time had higher rates of school attendance at age 15–21. But the magnitude of that difference is similar in 1910 and 1920.

Figure 4: Relationship between days schools closed during 1918 influenza pandemic and school attendance, by age group and census year

(a) 1920



(b) 1910 (placebo)



These figures plot the β_a coefficients from Equation 1 estimated separately for 1920 (Panel a) and 1910 (Panel b) full-count decennial census data. The estimating equation is:

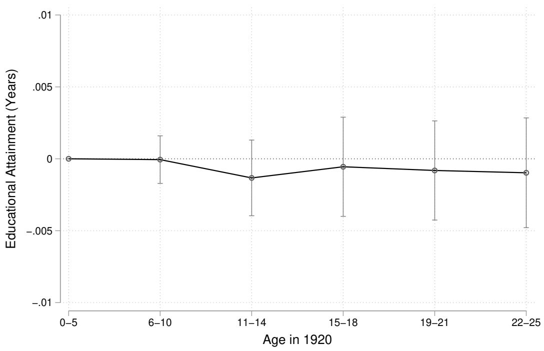
$1(Attend\ School)_i = \beta_a DaysClosed_c \times AgeGroup_a + \gamma_c + \Pi \times X_i + \Delta \times V_{c,b} + \omega_{r,b} + \epsilon_i$

where $1(Attend\ School)_i$ is an indicator measuring whether each child i was attending school. $DaysClosed_c$ describes the number of days that schools were closed during the 1918–1919 school year in child i's city c. Age bins a group children into six age bins in the census (aged 0-5, 6-10, 11-14, 15-18, 19-21, and 22-25). X_i is a vector of personal characteristics, $V_{c,b}$ a matrix of controls containing birth-year fixed effects linearly interacted with characteristics of each city in 1910, and $\omega_{r,b}$ are census-by-region fixed effects. 0-5 year-olds are the omitted category and robust standard errors are clustered by city.

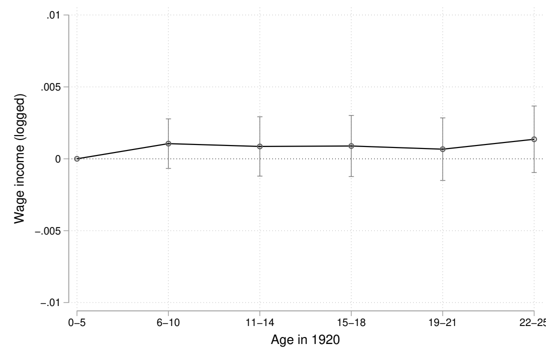
The figures show the similar relationships between school closure length during the 1918-19 pandemic and school attendance rates by age group in 1910 (a placebo year) and 1920 (a post-pandemic year).

Figure 5: Relationship between days schools closed during 1918 influenza pandemic and 1940 outcomes

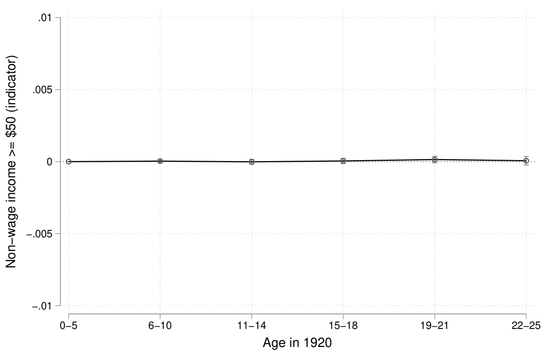
(a) Educational Attainment (Years)



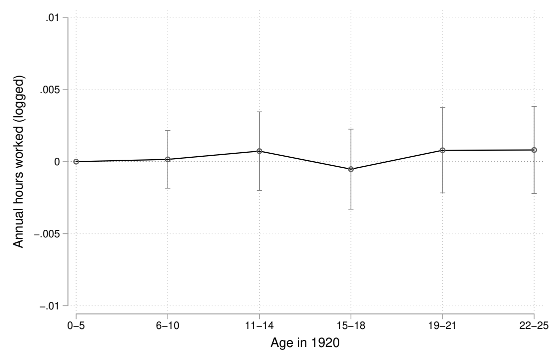
(b) Wage Income (logged)



(c) 1(Non-Wage Income ≥ \$50)



(d) Hours Worked (annual)



These figures plot the β_a coefficients from Equation 2. Outcomes are each measured in the 1940 census. The estimating equation is:

$Y_i = \beta_a DaysClosed_c \times AgeGroup_a + \gamma_c + \Pi \times X_i + \Delta \times V_{c,b} + \omega_{r,b} + \epsilon_i$

where $1(Attend\ School)_i$ is the indicated outcome, $DaysClosed_c$ describes the number of days that schools were closed during the 1918-19 school year in child i's city c. Age bins a groups children into six age bins (aged 0-5, 6-10, 11-14, 15-18, 19-21, and 22-25). X_i is a vector of personal characteristics, $V_{c,b}$ a matrix of controls containing birth-year fixed effects linearly interacted with characteristics of each city in 1910, and $\omega_{r,b}$ are census-by-region fixed effects. 0-5 year-olds are the omitted category and robust standard errors are clustered by city.

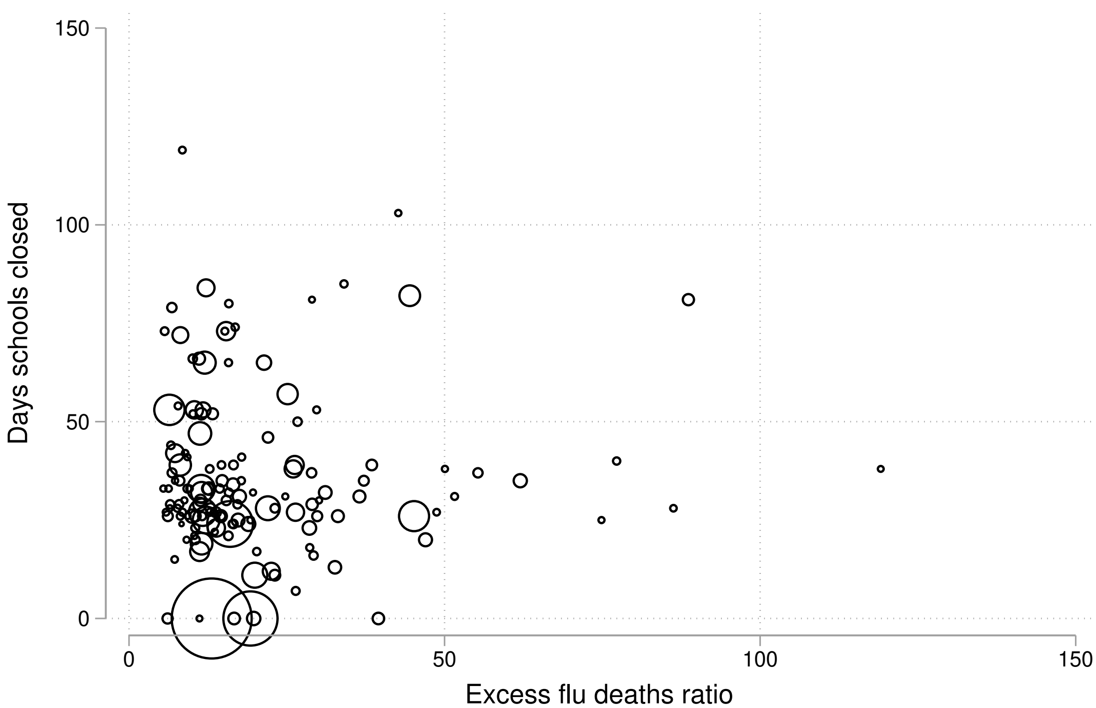
The figures show null effects of school closures in 1918-19 on 1940 human capital and labor market outcomes.

Table A1: Summary statistics: decennial census samples

	Short-Run 1910 Sample		***Short-Run 1920 Sample***		***Matched Sample***	
	Mean	Obs	Mean	Obs	Mean	Obs
Variables from 1910 and 1920						
Male (%)	0.50	12,792,818	0.49	15,139,633	1.00	2,310,153
White (%)	0.95	12,792,818	0.94	15,139,633	0.96	2,310,153
Age (in Childhood Census)	12.97	12,792,818	12.53	15,139,633	12.22	2,310,150
Attending School (%)	0.38	12,792,818	0.38	15,139,633	0.41	2,310,150
Attending School Age 0–5 (%)	0.07	2,987,915	0.06	3,727,892	0.07	571,017
Attending School Age 6–10 (%)	0.92	2,197,021	0.88	2,872,808	0.87	468,592
Attending School Age 11–14 (%)	0.95	1,722,623	0.93	2,120,506	0.94	339,291
Attending School Age 15–18 (%)	0.43	1,900,596	0.39	2,034,975	0.45	316,478
Attending School Age 19–21 (%)	0.08	1,629,753	0.09	1,703,654	0.13	250,092
Attending School Age 22–25 (%)	0.02	2,354,910	0.02	2,679,798	0.04	364,680
Number of Days Closed	25.17	12,792,818	25.66	15,139,633	27.71	2,094,082
Variables from 1940						
Educational Attainment (years)					10.33	2,266,496
Wage Income ($)					1,150.87	2,214,413
1(Non-Wage Income $\geq$ $50)					0.19	2,238,024
Hours Worked (Annual)					1,576.75	2,310,150
Weeks Worked (Annually)					39.80	2,310,150
Hours Worked (Weekly)					34.40	2,310,150

Notes: This table shows summary statistics describing the three samples of decennial census data that we use in our analysis: (a) the set of all 0–25 year olds in the 1910 decennial census, (b) the set of all 0–25 year olds in the 1920 decennial census, and (c) the set of all male 0–25 year olds in the 1920 decennial census who we match forward to adult records in the 1940 decennial census. Samples are restricted to children who resided in one of the 167 cities that comprise our final analysis sample.

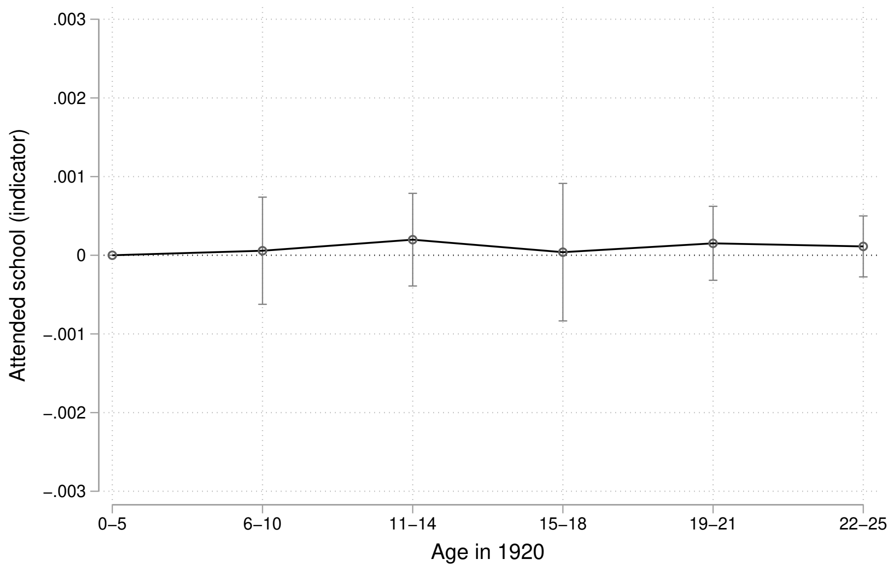
Figure A1: Scatterplot of school closure length against excess pandemic flu death ratios



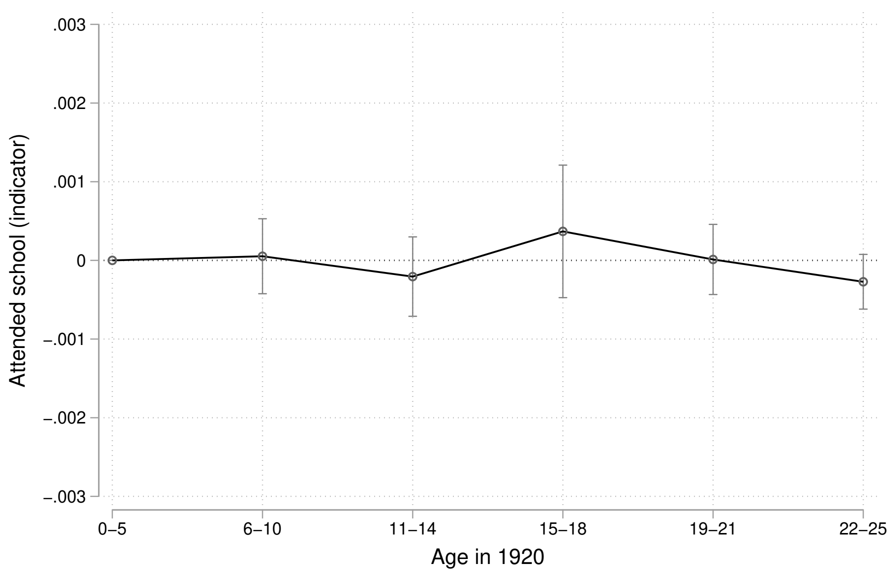
This figure shows the relationship between 1918-19 school closures and excess 1918-19 pandemic flu deaths ratios. Each dot is a city and dot sizes are weighted by population.

Figure A2: Relationship between days schools closed during 1918 influenza pandemic and 1920 school attendance, by race

(a) Black



(b) Non-black



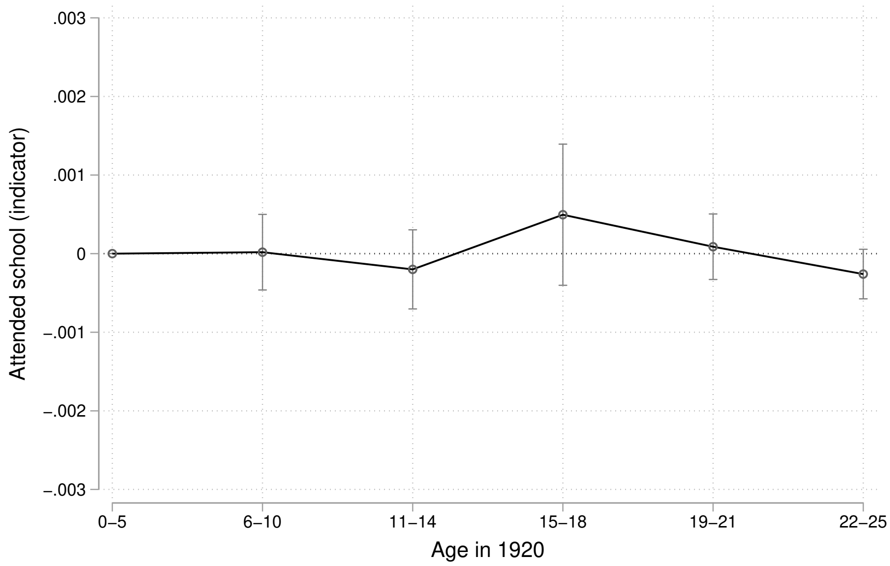
These figures plot the β_a coefficients from Equation 1 estimated separately for Black (Panel a) and Non-black (Panel b) youth. The estimating equation is:

$1(Attend\ School)_i = \beta_a DaysClosed_c \times AgeGroup_a + \gamma_c + \Pi \times X_i + \Delta \times V_{c,b} + \omega_{r,b} + \epsilon_i$

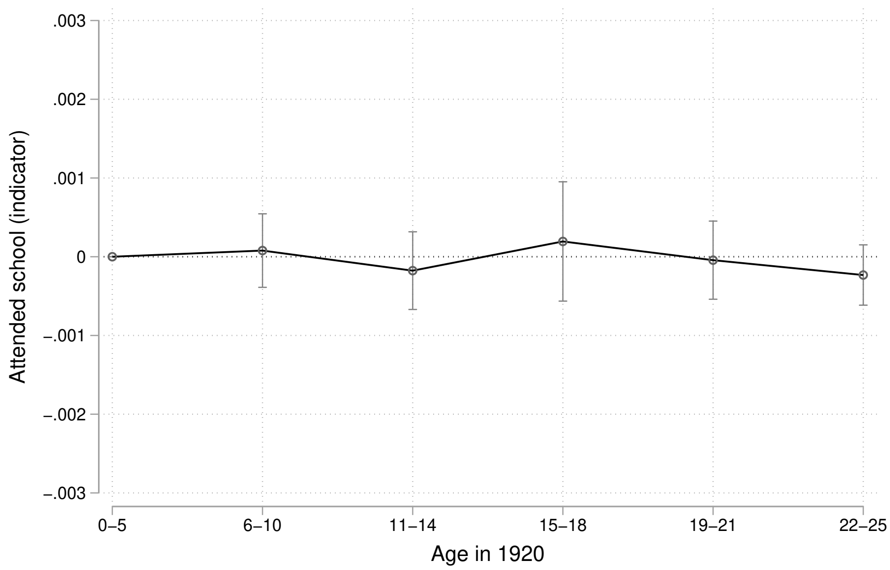
where $1(Attend\ School)_i$ is an indicator measuring whether each child i was attending school. $DaysClosed_c$ describes the number of days that schools were closed during the 1918−1919 school year in child i's city c. Age bins a group children into six age bins in the census (aged 0-5, 6-10, 11-14, 15-18, 19-21, and 22-25). X_i is a vector of personal characteristics, $V_{c,b}$ a matrix of controls containing birth-year fixed effects linearly interacted with characteristics of each city in 1910, and $\omega_{r,b}$ are census-by-region fixed effects. 0-5 year-olds are the omitted category and robust standard errors are clustered by city.

Figure A3: Relationship between days schools closed during 1918 influenza pandemic and 1920 school attendance, by gender

(a) Women



(b) Men



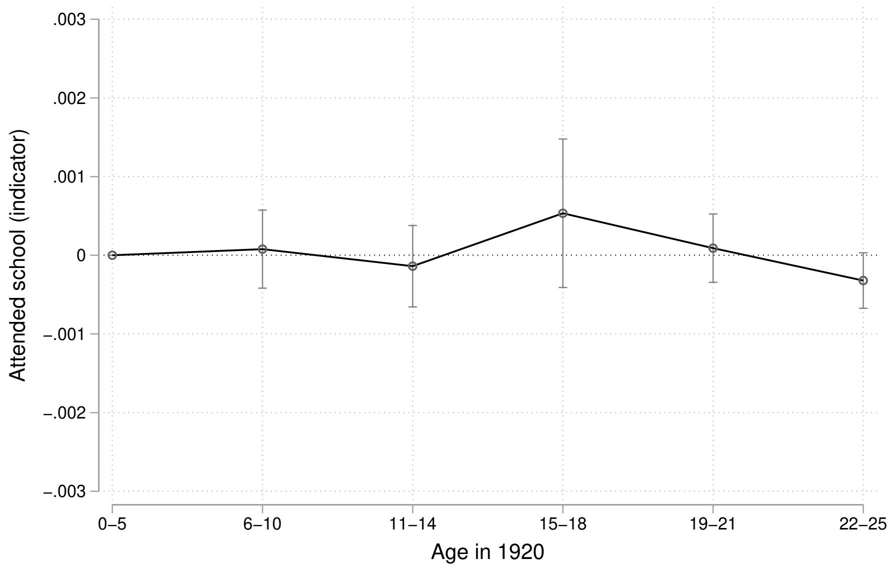
These figures plot the β_a coefficients from Equation 1 estimated separately for women (Panel a) and men (Panel b). The estimating equation is:

$$1(Attend\ School)_i = \beta_a DaysClosed_c \times AgeGroup_a + \gamma_c + \Pi \times X_i + \Delta \times V_{c,b} + \omega_{r,b} + \epsilon_i$$

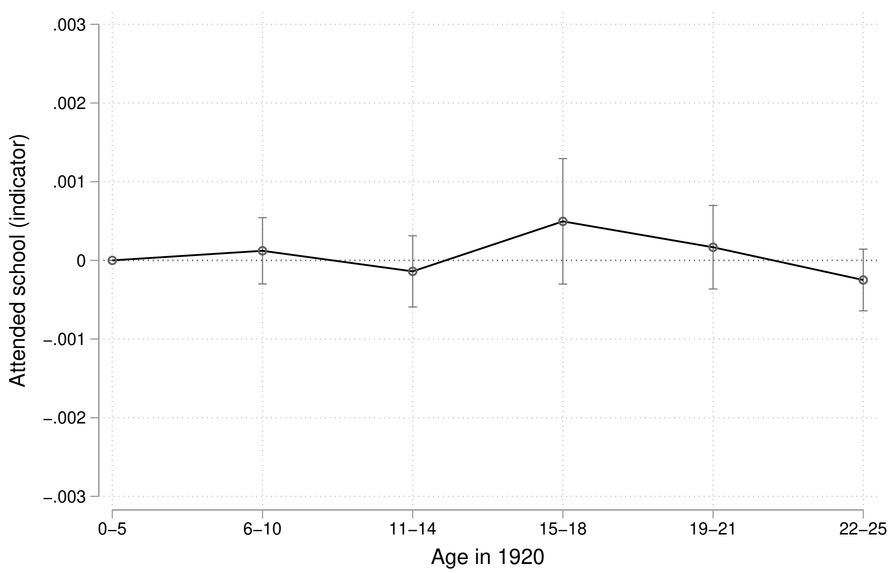
where $1(Attend\ School)_i$ is an indicator measuring whether each child i was attending school. $DaysClosed_c$ describes the number of days that schools were closed during the 1918–1919 school year in child i's city c. Age bins a group children into six age bins in the census (aged 0-5, 6-10, 11-14, 15-18, 19-21, and 22-25). X_i is a vector of personal characteristics, $V_{c,b}$ a matrix of controls containing birth-year fixed effects linearly interacted with characteristics of each city in 1910, and $\omega_{r,b}$ are census-by-region fixed effects. 0-5 year-olds are the omitted category and robust standard errors are clustered by city.

Figure A4: Relationship between days schools closed during 1918 influenza pandemic and 1920 school attendance, by parental occupation prestige

(a) Lower-prestige father occupation



(b) Higher-prestige father occupation



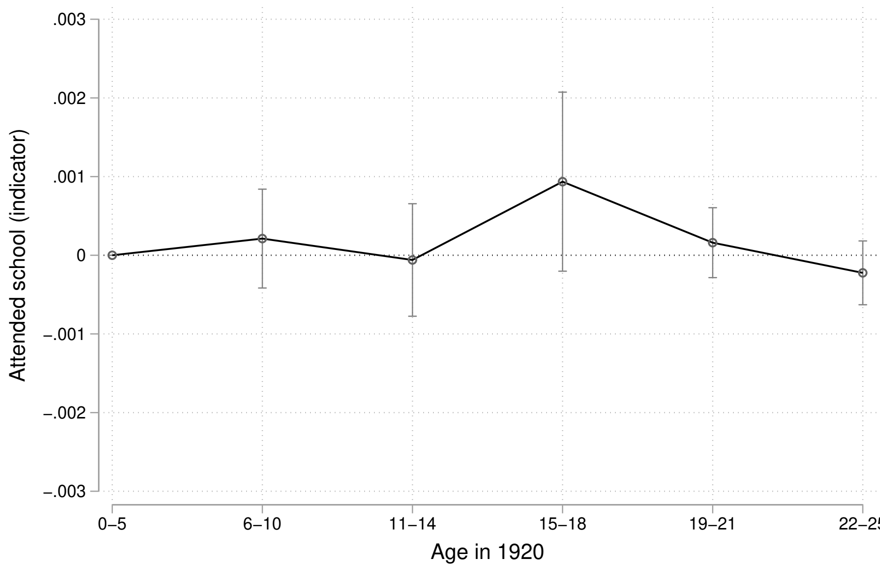
These figures plot the β_a coefficients from Equation 1 estimated separately for youth with lower (Panel a) and higher (Panel b) occupational prestige fathers. The estimating equation is:

$$1(Attend\ School)_i = \beta_a DaysClosed_c \times AgeGroup_a + \gamma_c + \Pi \times X_i + \Delta \times V_{c,b} + \omega_{r,b} + \epsilon_i$$

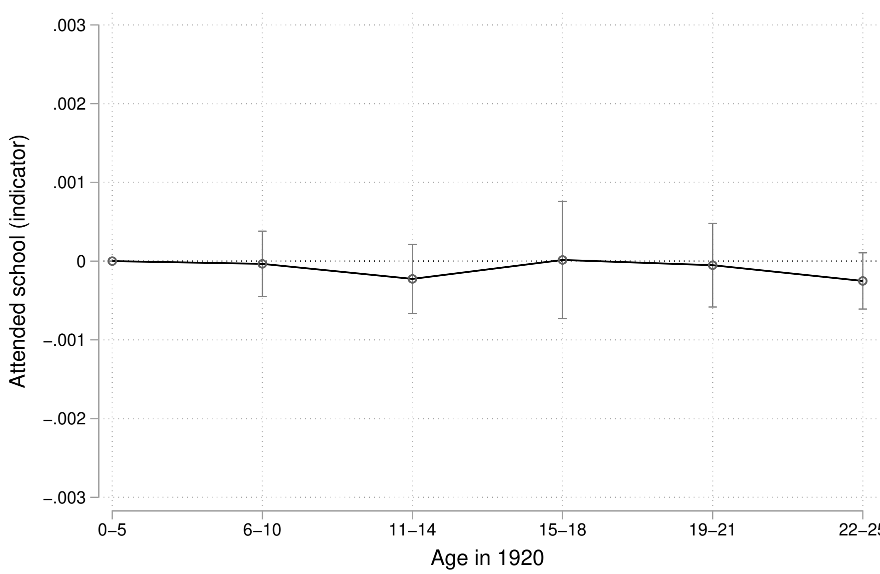
where $1(Attend\ School)_i$ is an indicator measuring whether each child i was attending school. $DaysClosed_c$ describes the number of days that schools were closed during the 1918−1919 school year in child i's city c. Age bins a group children into six age bins in the census (aged 0-5, 6-10, 11-14, 15-18, 19-21, and 22-25). X_i is a vector of personal characteristics, $V_{c,b}$ a matrix of controls containing birth-year fixed effects linearly interacted with characteristics of each city in 1910, and $\omega_{r,b}$ are census-by-region fixed effects. 0-5 year-olds are the omitted category and robust standard errors are clustered by city.

Figure A5: Relationship between days schools closed during 1918 influenza pandemic and 1920 school attendance, by parental nativity

(a) Foreign-born father



(b) Native-born father



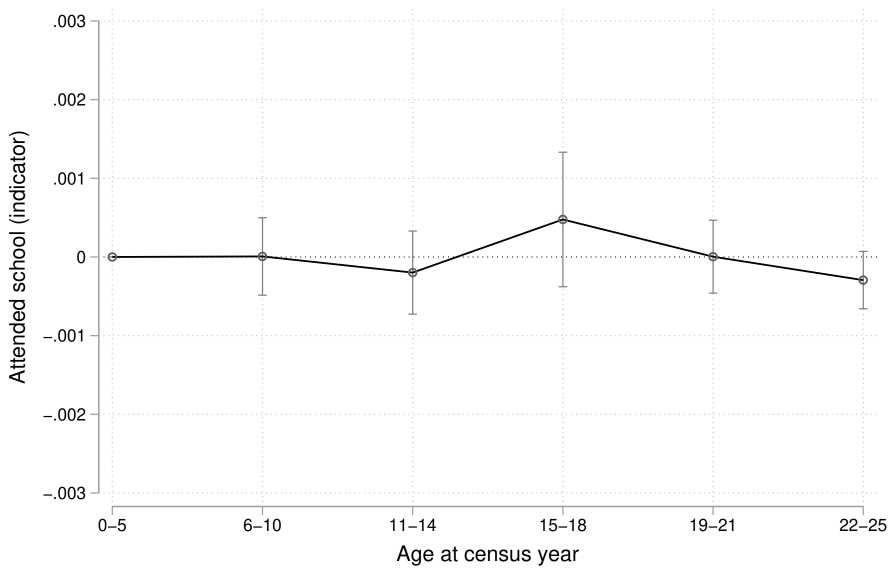
These figures plot the β_a coefficients from Equation 1 estimated separately for youth with foreign (Panel a) and U.S.-born (Panel b) fathers. The estimating equation is:

$1(Attend\ School)_i = \beta_a DaysClosed_c \times AgeGroup_a + \gamma_c + \Pi \times X_i + \Delta \times V_{c,b} + \omega_{r,b} + \epsilon_i$

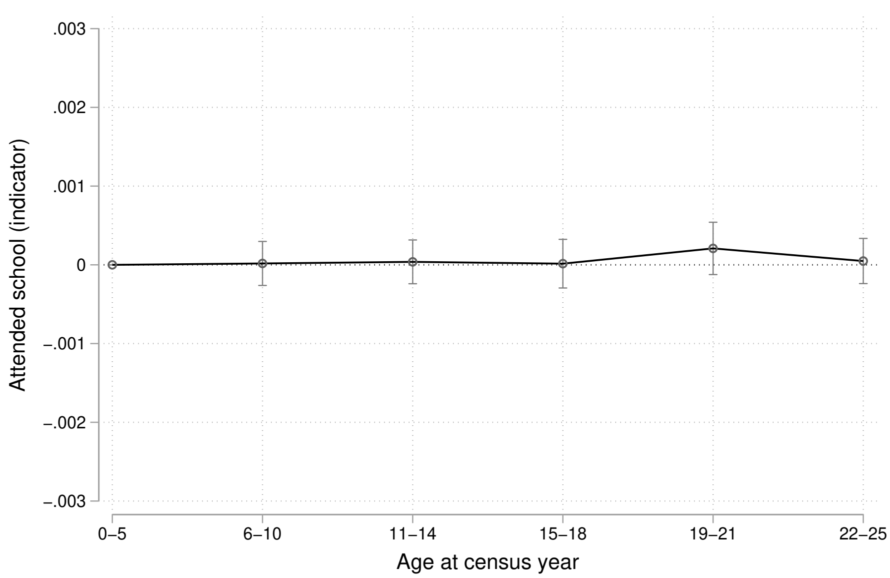
where $1(Attend\ School)_i$ is an indicator measuring whether each child i was attending school. $DaysClosed_c$ describes the number of days that schools were closed during the 1918–1919 school year in child i's city c. Age bins a group children into six age bins in the census (aged 0-5, 6-10, 11-14, 15-18, 19-21, and 22-25). X_i is a vector of personal characteristics, $V_{c,b}$ a matrix of controls containing birth-year fixed effects linearly interacted with characteristics of each city in 1910, and $\omega_{r,b}$ are census-by-region fixed effects. 0-5 year-olds are the omitted category and robust standard errors are clustered by city.

Figure A6: Relationship between days schools closed during 1918 influenza pandemic and school attendance by census year, with mortality controls

(a) 1920



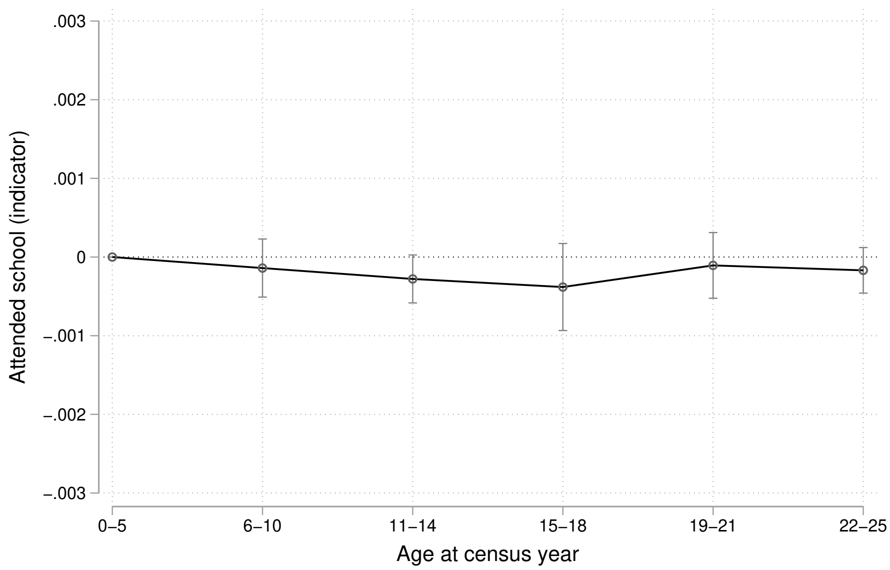
(b) 1910 (placebo)



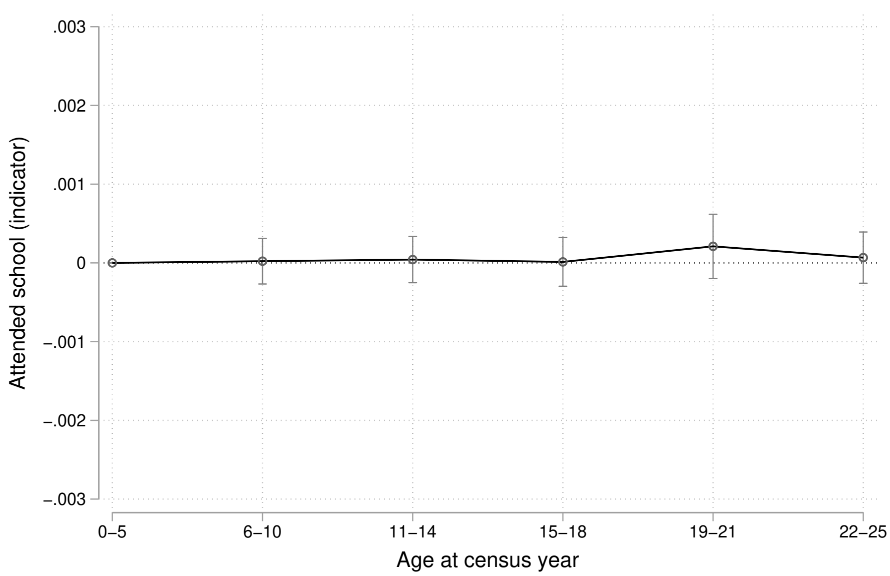
These figures plot the β_a coefficients from Equation 1 estimated separately for 1920 (Panel a) and 1910 (Panel b). These models also include include controls for excess mortality ratios interacted with age at census year fixed effects.

Figure A7: Relationship between days schools closed during 1918 influenza pandemic and school attendance by census year, with state-by-birth year fixed effects

(a) 1920



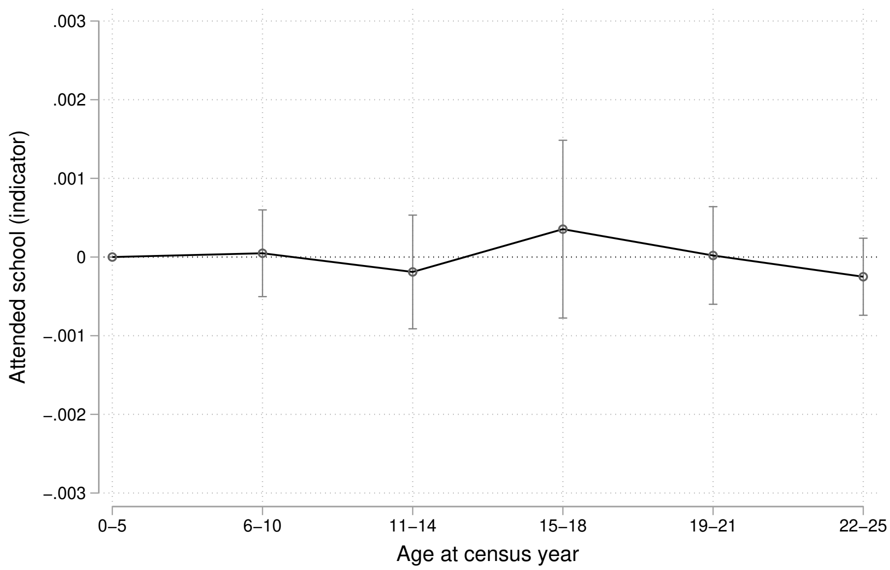
(b) 1910 (placebo)



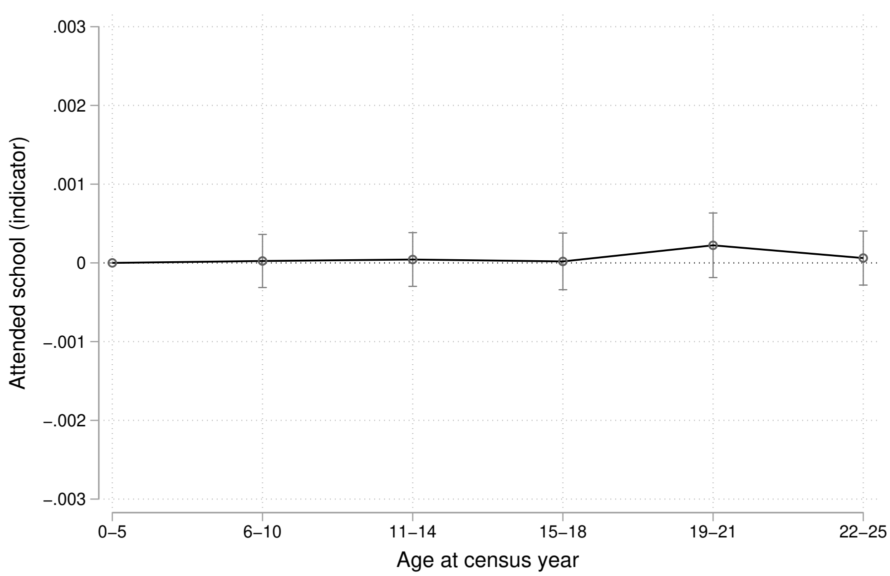
These figures plot the β_a coefficients from equation 1 estimated separately for 1920 (Panel a) and 1910 (Panel b). These models also include include state-by-birth year fixed effects.

Figure A8: Relationship between days schools closed during 1918 influenza pandemic and school attendance by census year, state-clustered errors

(a) 1920



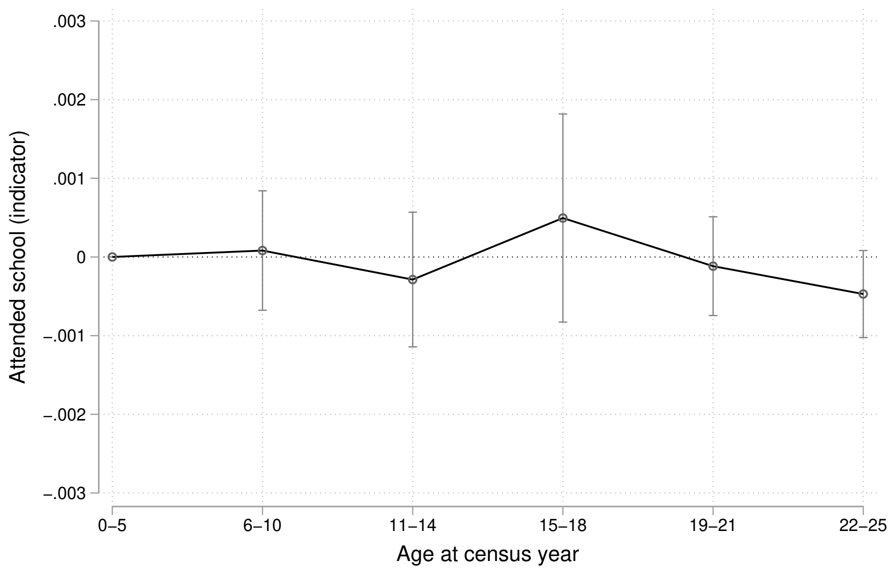
(b) 1910 (placebo)



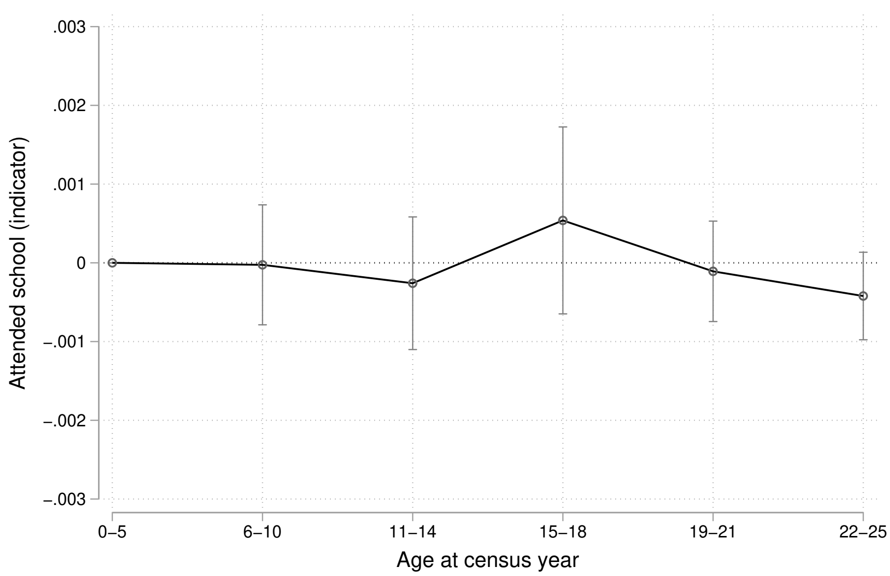
These figures plot the β_a coefficients from Equation 1 estimated separately for 1920 (Panel a) and 1910 (Panel b). Standard errors are clustered by state.

Figure A9: Relationship between days schools closed during 1918 influenza pandemic and school attendance in 1920, with and without other NPI controls

(a) 1920, sub-sample of cities with other NPI info



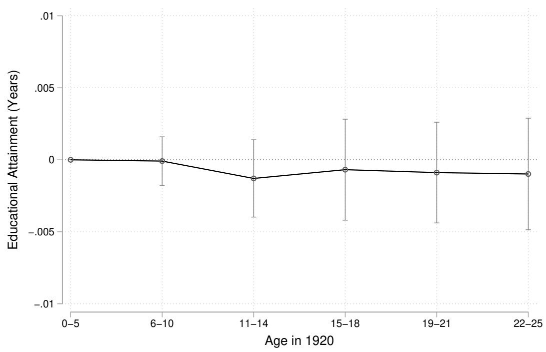
(b) 1920, controlling for other NPI days



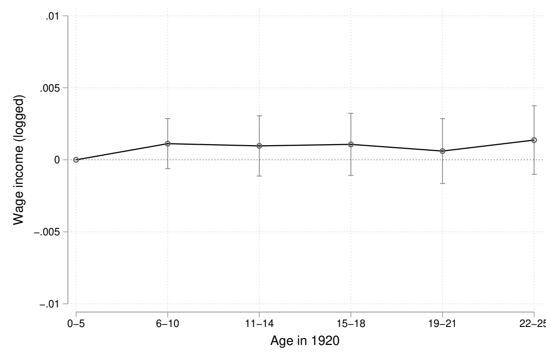
These figures plot the β_a coefficients from equation 1 estimated separately on a subset of cities with data on other NPIs beyond school closures. Panel A shows the baseline results for this sample; Panel B shows the results after conditioning on additional NPI days interacted with age bins.

Figure A10: Relationship between days schools closed during 1918 influenza pandemic and 1940 outcomes, non-black children

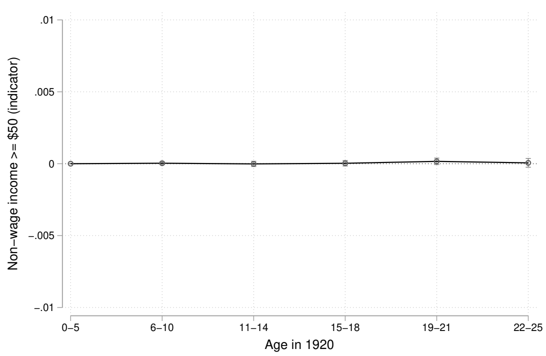
(a) Educational Attainment (Years)



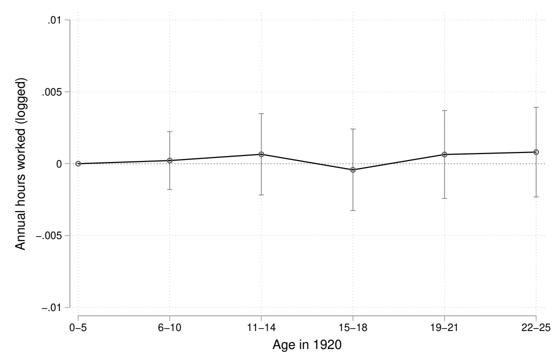
(b) Wage Income (logged)



(c) 1(Non-Wage Income ≥ \$50)



(d) Annual Hours Worked (logged)

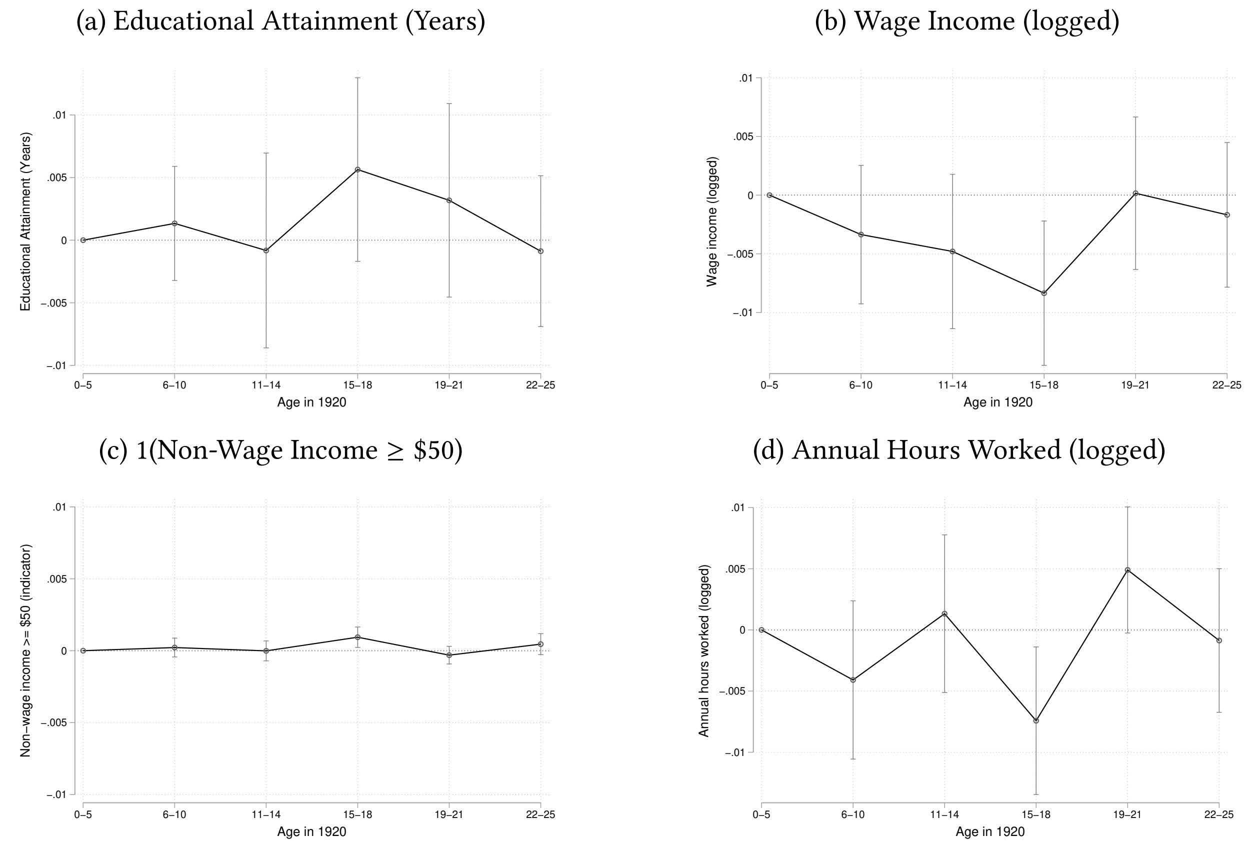


These figures plot the β_a coefficients from Equation 2 estimated on the sample of non-black children. Outcomes are each measured in the 1940 census. The estimating equation is:

$$Y_i = \beta_a DaysClosed_c \times AgeGroup_a + \gamma_c + \Pi \times X_i + \Delta \times V_{c,b} + \omega_{r,b} + \epsilon_i$$

where $1(Attend\ School)_i$ is the indicated outcome, $DaysClosed_c$ describes the number of days that schools were closed during the 1918-19 school year in child i's city c. Age bins a groups children into six age bins (aged 0-5, 6-10, 11-14, 15-18, 19-21, and 22-25). X_i is a vector of personal characteristics, $V_{c,b}$ a matrix of controls containing birth-year fixed effects linearly interacted with characteristics of each city in 1910, and $\omega_{r,b}$ are census-by-region fixed effects. 0-5 year-olds are the omitted category and robust standard errors are clustered by city.

Figure A11: Relationship between days schools closed during 1918 influenza pandemic and 1940 outcomes, black children



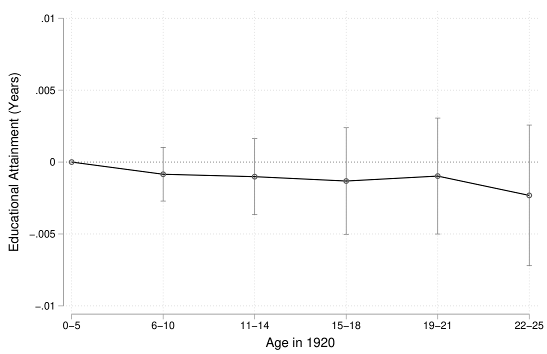
These figures plot the β_a coefficients from Equation 2 estimated on the sample of black children. Outcomes are each measured in the 1940 census. The estimating equation is:

$$Y_i = \beta_a DaysClosed_c \times AgeGroup_a + \gamma_c + \Pi \times X_i + \Delta \times V_{c,b} + \omega_{r,b} + \epsilon_i$$

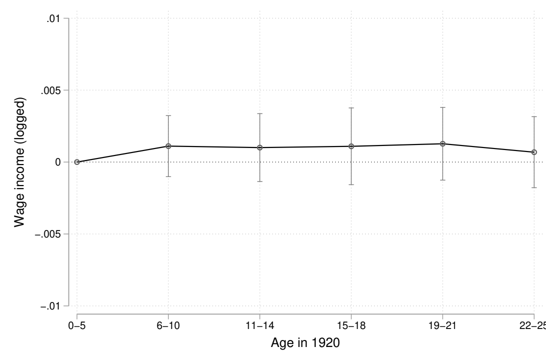
where $1(Attend\ School)_i$ is the indicated outcome, $DaysClosed_c$ describes the number of days that schools were closed during the 1918-19 school year in child i's city c. Age bins a groups children into six age bins (aged 0-5, 6-10, 11-14, 15-18, 19-21, and 22-25). X_i is a vector of personal characteristics, $V_{c,b}$ a matrix of controls containing birth-year fixed effects linearly interacted with characteristics of each city in 1910, and $\omega_{r,b}$ are census-by-region fixed effects. 0-5 year-olds are the omitted category and robust standard errors are clustered by city.

Figure A12: Relationship between days schools closed during 1918 influenza pandemic and 1940 outcomes, children with lower occupational prestige fathers

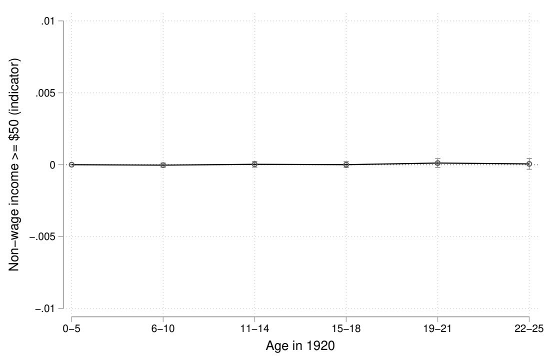
(a) Educational Attainment (Years)



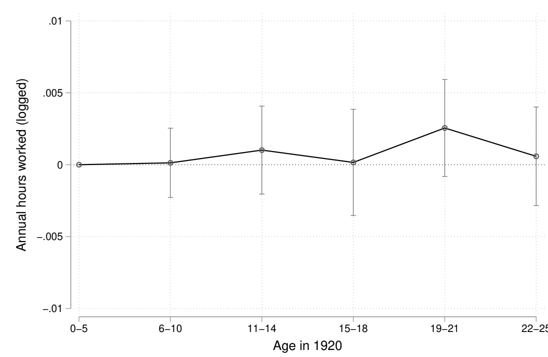
(b) Wage Income (logged)



(c) 1(Non-Wage Income ≥ \$50)



(d) Annual Hours Worked (logged)



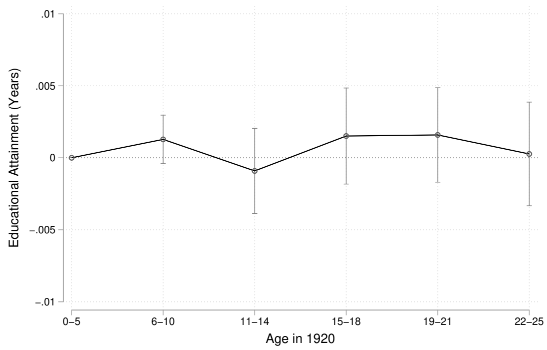
These figures plot the β_a coefficients from Equation 2 estimated on a sample of children with lower occupational prestige fathers. Outcomes are each measured in the 1940 census. The estimating equation is:

$Y_i = \beta_a DaysClosed_c \times AgeGroup_a + \gamma_c + \Pi \times X_i + \Delta \times V_{c,b} + \omega_{r,b} + \epsilon_i$

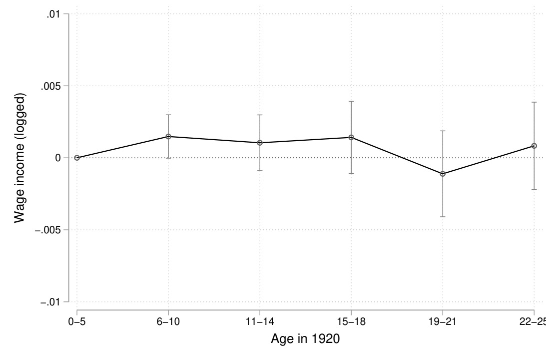
where $1(Attend\ School)_i$ is the indicated outcome, $DaysClosed_c$ describes the number of days that schools were closed during the 1918-19 school year in child i's city c. Age bins a groups children into six age bins (aged 0-5, 6-10, 11-14, 15-18, 19-21, and 22-25). X_i is a vector of personal characteristics, $V_{c,b}$ a matrix of controls containing birth-year fixed effects linearly interacted with characteristics of each city in 1910, and $\omega_{r,b}$ are census-by-region fixed effects. 0-5 year-olds are the omitted category and robust standard errors are clustered by city.

Figure A13: Relationship between days schools closed during 1918 influenza pandemic and 1940 outcomes, children with higher occupational prestige fathers

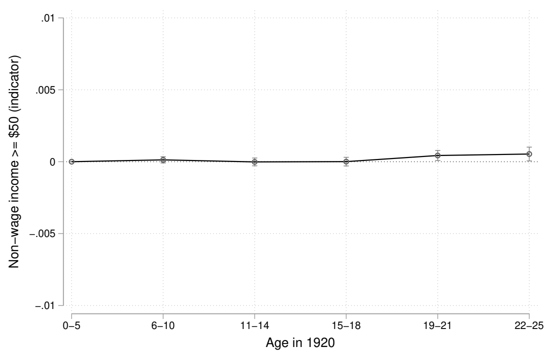
(a) Educational Attainment (Years)



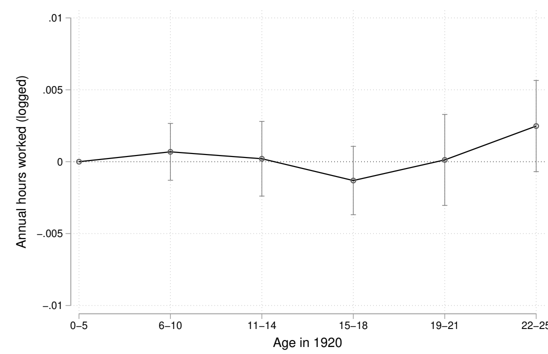
(b) Wage Income (logged)



(c) 1(Non-Wage Income ≥ $50)



(d) Annual Hours Worked (logged)



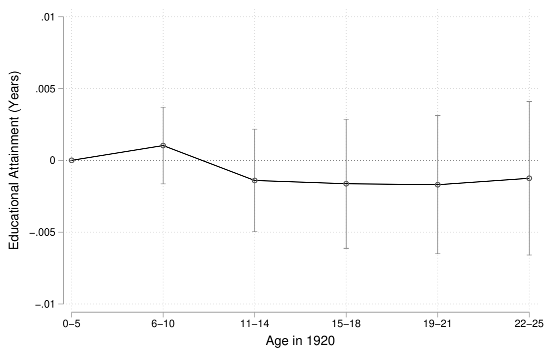
These figures plot the β_a coefficients from Equation 2 estimated on a sample of children with higher occupational prestige fathers. Outcomes are each measured in the 1940 census. The estimating equation is:

$Y_i = \beta_a DaysClosed_c \times AgeGroup_a + \gamma_c + \Pi \times X_i + \Delta \times V_{c,b} + \omega_{r,b} + \epsilon_i$

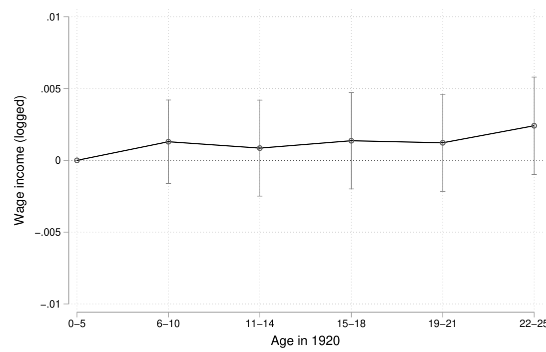
where $1(Attend\ School)_i$ is the indicated outcome, $DaysClosed_c$ describes the number of days that schools were closed during the 1918-19 school year in child i's city c. Age bins a groups children into six age bins (aged 0-5, 6-10, 11-14, 15-18, 19-21, and 22-25). X_i is a vector of personal characteristics, $V_{c,b}$ a matrix of controls containing birth-year fixed effects linearly interacted with characteristics of each city in 1910, and $\omega_{r,b}$ are census-by-region fixed effects. 0-5 year-olds are the omitted category and robust standard errors are clustered by city.

Figure A14: Relationship between days schools closed during 1918 influenza pandemic and 1940 outcomes, children with foreign-born fathers

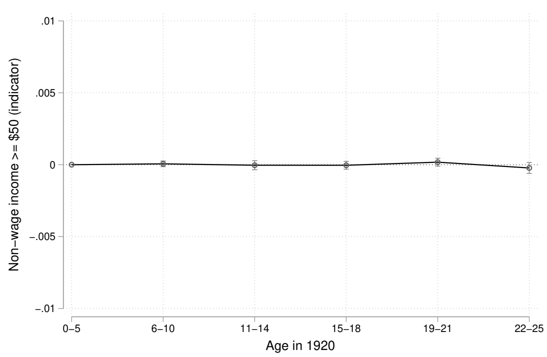
(a) Educational Attainment (Years)



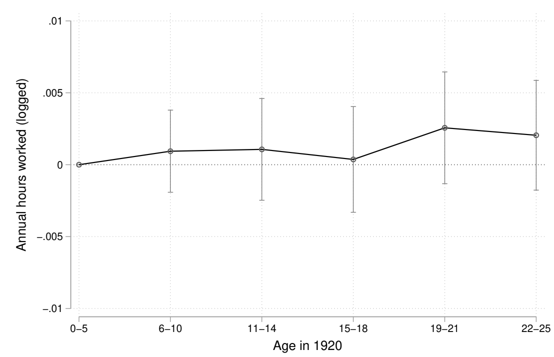
(b) Wage Income (logged)



(c) 1(Non-Wage Income ≥ \$50)



(d) Annual Hours Worked (logged)



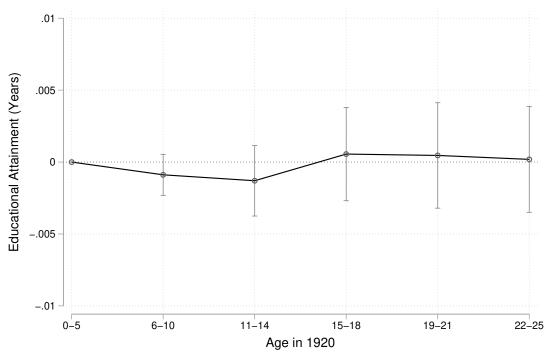
These figures plot the β_a coefficients from Equation 2 estimated on a sample of children with foreign-born fathers. Outcomes are each measured in the 1940 census. The estimating equation is:

$Y_i = \beta_a DaysClosed_c \times AgeGroup_a + \gamma_c + \Pi \times X_i + \Delta \times V_{c,b} + \omega_{r,b} + \epsilon_i$

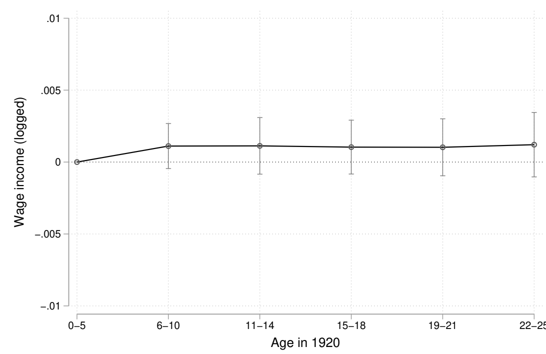
where $1(Attend\ School)_i$ is the indicated outcome, $DaysClosed_c$ describes the number of days that schools were closed during the 1918-19 school year in child i's city c. Age bins a groups children into six age bins (aged 0-5, 6-10, 11-14, 15-18, 19-21, and 22-25). X_i is a vector of personal characteristics, $V_{c,b}$ a matrix of controls containing birth-year fixed effects linearly interacted with characteristics of each city in 1910, and $\omega_{r,b}$ are census-by-region fixed effects. 0-5 year-olds are the omitted category and robust standard errors are clustered by city.

Figure A15: Relationship between days schools closed during 1918 influenza pandemic and 1940 outcomes, children with U.S. born fathers

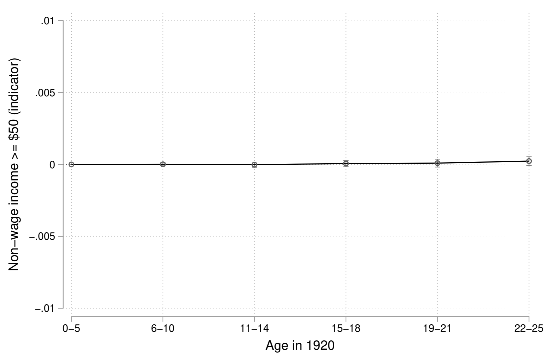
(a) Educational Attainment (Years)



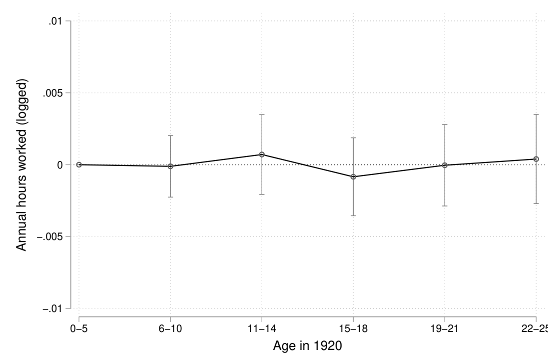
(b) Wage Income (logged)



(c) 1(Non-Wage Income ≥ \$50)



(d) Annual Hours Worked (logged)

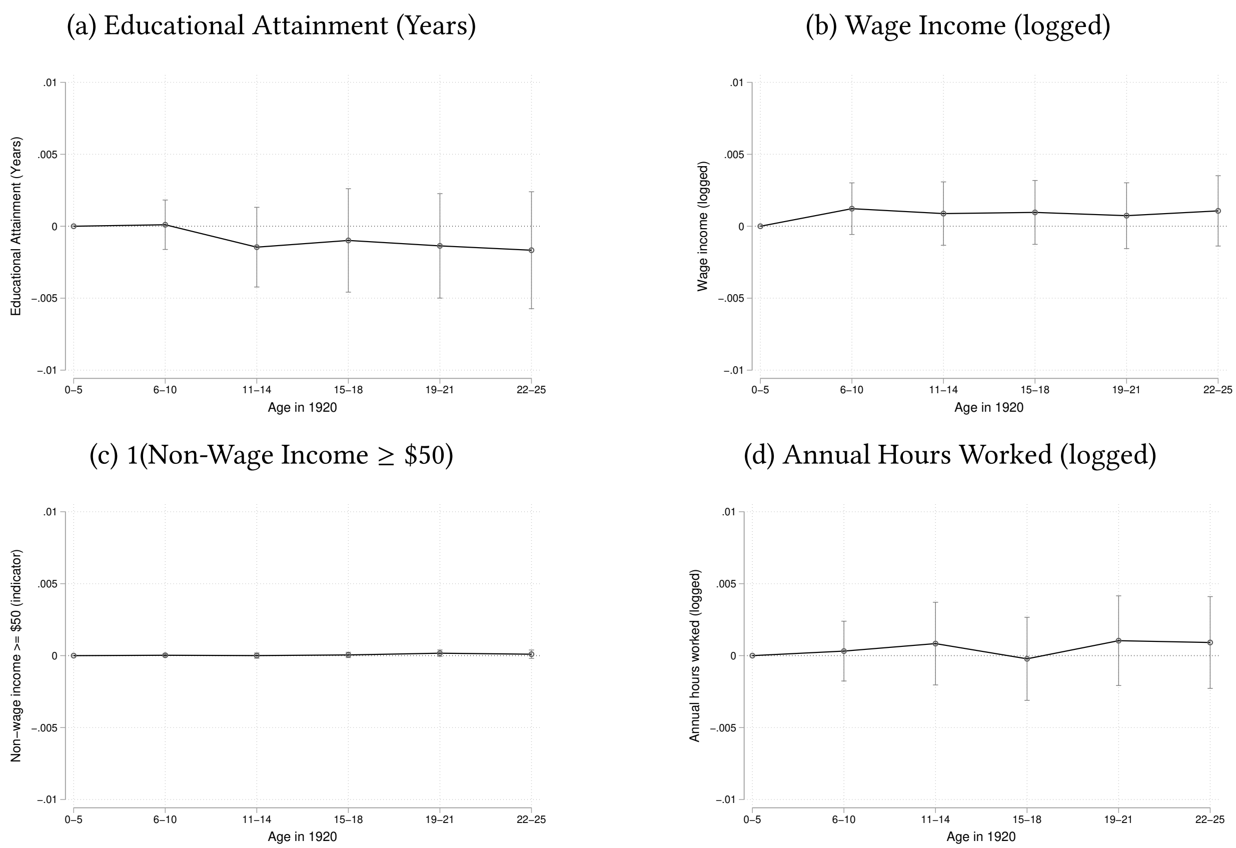


These figures plot the β_a coefficients from Equation 2 estimated on a sample of children with U.S.-born fathers. Outcomes are each measured in the 1940 census. The estimating equation is:

$Y_i = \beta_a DaysClosed_c \times AgeGroup_a + \gamma_c + \Pi \times X_i + \Delta \times V_{c,b} + \omega_{r,b} + \epsilon_i$

where $1(Attend\ School)_i$ is the indicated outcome, $DaysClosed_c$ describes the number of days that schools were closed during the 1918-19 school year in child i's city c. Age bins a groups children into six age bins (aged 0-5, 6-10, 11-14, 15-18, 19-21, and 22-25). X_i is a vector of personal characteristics, $V_{c,b}$ a matrix of controls containing birth-year fixed effects linearly interacted with characteristics of each city in 1910, and $\omega_{r,b}$ are census-by-region fixed effects. 0-5 year-olds are the omitted category and robust standard errors are clustered by city.

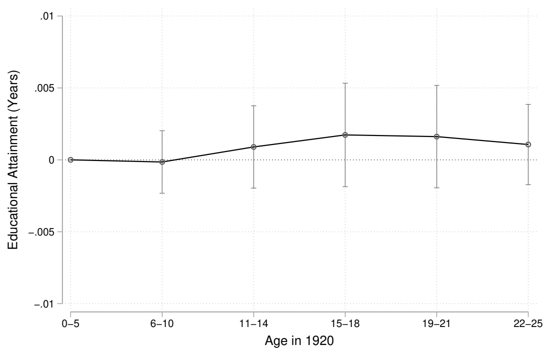
Figure A16: Relationship between days schools closed during 1918 influenza pandemic and 1940 outcomes, with mortality controls



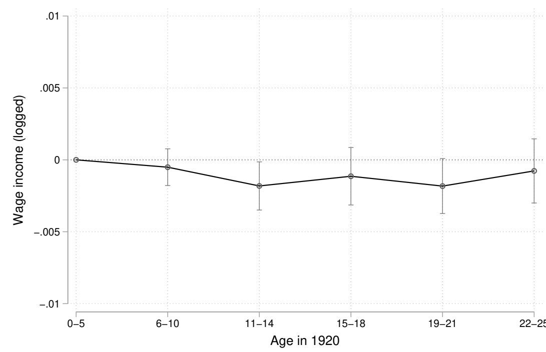
These figures plot the β_a coefficients from a version of Equation 2 that also controls for excess influenza mortality ratios interacted with age bin fixed effects.

Figure A17: Relationship between days schools closed during 1918 influenza pandemic and 1940 outcomes, controlling for state-by-birth year fixed effects

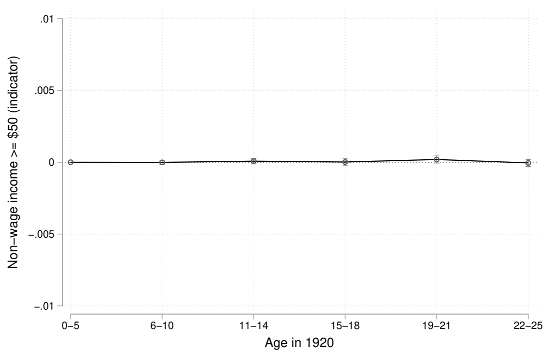
(a) Educational Attainment (Years)



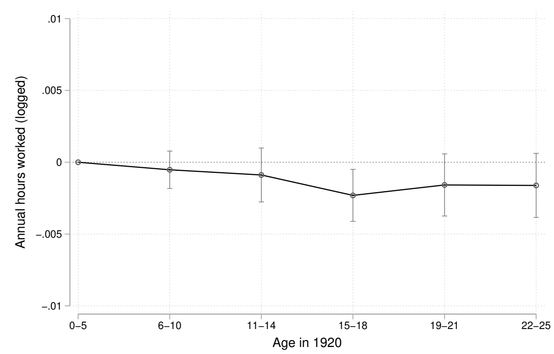
(b) Wage Income (logged)



(c) 1(Non-Wage Income ≥ \$50)



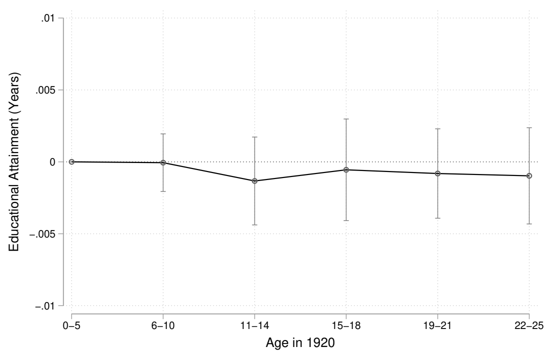
(d) Annual Hours Worked (logged)



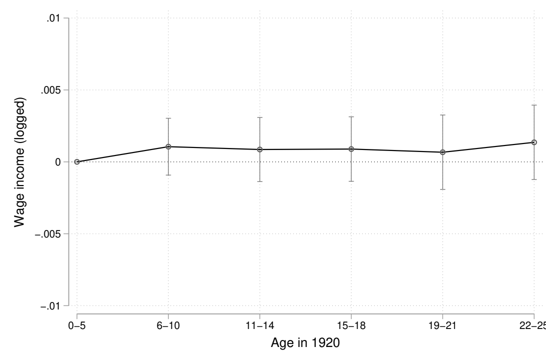
These figures plot the β_a coefficients from a version of Equation 2 that also controls for state-by-birth year fixed effects.

Figure A18: Relationship between days schools closed during 1918 influenza pandemic and 1940 outcomes, with state-clustered standard errors

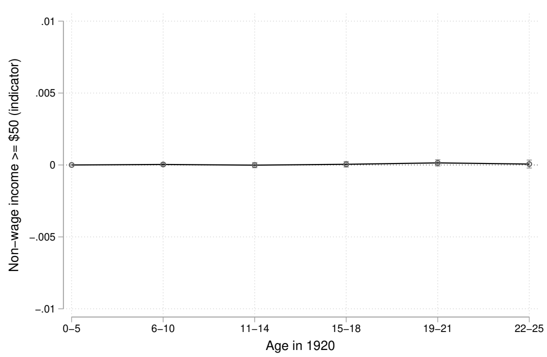
(a) Educational Attainment (Years)



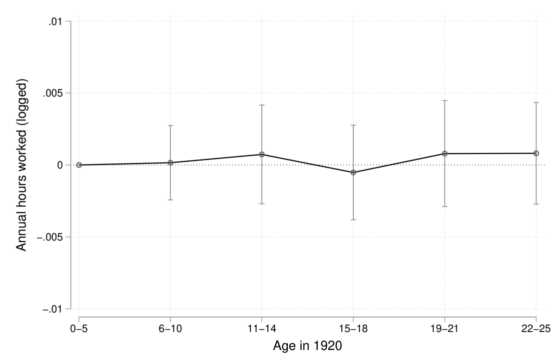
(b) Wage Income (logged)



(c) 1(Non-Wage Income ≥ $50)



(d) Annual Hours Worked (logged)



These figures plot the β_a coefficients from from Equation 2. Standard errors are clustered by state.