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Philipp Ager
Katherine Eriksson
Ezra Karger
Peter Nencka
Melissa A. Thomasson

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ABSTRACT

The COVID-19 pandemic has reignited interest in responses to the 1918-19 influenza pandemic, the last comparable U.S. public health emergency. During both pandemics, many state and local governments made the controversial decision to close schools. We study the short- and long-run effects of 1918-19 pandemic-related school closures on children. We find precise null effects of school closures in 1918 on school attendance in 1919-20 using newly collected data on the exact timing of school closures for 168 cities in 1918-19. Linking affected children to their adult outcomes in the 1940 census, we also find precise null effects of school closures on adult educational attainment, wage income, non-wage income, and hours worked in 1940. Our results are not inconsistent with an emerging literature that finds negative short-run effects of COVID-19-related school closures on learning. The situation in 1918 was starkly different from today: (1) schools closed in 1918 for many fewer days on average, (2) the 1918 virus was much deadlier to young adults and children, boosting absenteeism even in schools that stayed open, and (3) the lack of effective remote learning platforms in 1918 may have reduced the scope for school closures to increase socioeconomic inequality.

Philipp Ager
Department of Business and Economics
University of Southern Denmark
Campusvej 55
5230 Odense M, Denmark
and CEPR
phag@sam.sdu.dk

Katherine Eriksson
Department of Economics
University of California, Davis
One Shields Avenue
Davis, CA 95616
and NBER
kaeriksson@ucdavis.edu

Ezra Karger
University of Chicago
1126 E. 59th Street
Chicago, IL 60637
karger@uchicago.edu

Peter Nencka
Department of Economics
Miami University
800 E. High Street
Oxford, OH 45056
nenckap@miamioh.edu

Melissa A. Thomasson
Miami University/FSB
Department of Economics MSC 1035
800 E. High Street, Rm. #2054
Oxford, OH 45056
and NBER
thomasma@miamioh.edu

1 Introduction

Hundreds of millions of students worldwide have been affected by school closures since the spring of 2020, when nations 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 they slow the spread of the virus, while opponents contend that the negative effect of closures on children's learning will 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).

This paper's goal is to 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 governments decided to close schools as the situation worsened while others controversially kept their schools open—mirroring ongoing debates about the costs and benefits of closures. Compared to recent studies on the impact of COVID-19 related school closures (which are ongoing at the time this paper was written), we evaluate the effect of school closures on both the short- and long-run outcomes of students 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 recent short-run studies measuring the effects of school closures during COVID-19 into perspective.[3]

To study the effect of school closures in 1918-19, we construct novel data from newspaper

[1]Papers that overview the use of school closures as a pandemic mitigation strategy include 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).

archives on the duration of school closures for 168 of the largest U.S. cities with populations exceeding 25,000 in 1910. We combine this information with data on excess mortality in each city, and we merge this dataset of local school closures with the 1910 and 1920 full-count censuses to obtain data on individuals and city characteristics. To study the long-run effects of these school closures on children, we link 0- to 25-year-old males in these cities 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 is 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 leverages the fact that some age groups within a city are 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 age groups. These null effects persist across heterogeneous 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. We link male students in 1920 to their adult outcomes in the 1940 census and find precisely estimated null effects of closures on adult educational attainment, wage income, non-wage income, and hours worked 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 students in 1918-19, school closures themselves had no measurable effects on the outcomes we study.

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. In this paper, we use direct measures of school closures at the city-level to measure the city-specific impacts of school closures on children's short-run and adult outcomes.

Our findings are also related 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, the the 1918-19 pandemic and school closures followed a different pattern than the 2020 pandemic and school closures. 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 the response to school closures. Even when schools remained open, absentee rates were extremely high in 1918-19, dampening any potential effects of the closures: many people stayed home independent of local policies on school closures and reopenings.[4] And ex post, contemporary health officials regarded school closures and other NPIs to prevent the spread of the pandemic as largely ineffective (e.g. Tomes, 2010; Byerly, 2010).[5]

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.[6] 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.

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. In some countries, such as Denmark and Sweden, the virus reemerged in 1920. Estimates reveal that about one-third of the world population suffered from influenza during this period (Taubenberger and Morens, 2006). The

[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).

[5] For example, Navy Surgeon General William Braisted wrote in the Annual Reports of the Navy Department in 1919 "[...] the history of influenza in the autumn of 1918 shows that the disease spread rapidly and progressively, attacking communities of all sizes regardless of preventive measures put into effect" (United States Navy Department, 1920). The report of the Connecticut state department of health in 1920 concluded about the epidemic that "[...] the closing of schools, theaters, churches and other public places had apparently no effect on diminishing the spread of the disease" (State of Connecticut, 1921).

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

1918-19 H1N1 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 H1N1 virus.[7] In the United States, estimates indicate that over one-quarter of the population was infected and about 675,000 individuals died from the influenza pandemic between 1918 and 1920, or 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 first identified in military personnel (Crosby, 2003; Byerly, 2010; Barry, 2020).[8] 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 the cities of the East Coast, 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 experienced a second wave of the 1918 pandemic during the first two months of 1919.[9] 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 reported 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).[10]

[7]Most influenza viruses have the largest negative effects on young children and the elderly. But a striking feature of the 1918 pandemic was its high incidence and mortality rates among 20 to 40-years-old (Collins, 1931).

[8]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). Besides Camp Funston, other military camps throughout the country recorded severe outbreaks during March and April 1918 (Crosby, 2003, p.19).

[9]An excellent description of the influenza pandemic in 50 large U.S. cities is provided in Navarro and Markel's digital *Influenza Encyclopedia*; see http://www.influenzaarchive.org/about.html.

[10]Clay et al. (2018) show that air pollution (measured by the intensity of burning coal) 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 the pandemic severity across the country (Crosby, 2003; Beach et al., 2020).

2.2 School closures

Local health authorities responded to the increasing mortality numbers during the second wave of the 1918-19 influenza pandemic by imposing a wide range of NPIs. These measures included isolation or quarantine, bans on public gatherings, staggered business hours, ventilation of public venues and streetcars, the use of face masks, 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 ('flattening the curve'), there is little evidence that the measures reduced overall mortality.[11]

We focus on 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, soon after the first outbreaks in the second wave of the pandemic.

[11] 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 (2006), 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.

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 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 much better off supervised in school, where learning could continue uninterrupted (The Chicago Tribune, 1918b).

Similar justifications kept schools open in New York City. In late September, reacting to growing caseloads in the city and Boston’s recent decision to close, health officials argued that it was important to keep schools open to help reduce virus spread among children, since at school, “educational propaganda against influenza can be kept constantly before them [students]” (The New York Tribune, 1918b). As cases continued to rise and the Surgeon General suggested schools should be closed in “stricken” areas, New York City officials reiterated the claim that schools were the "safest places for the children of the city" (The New York Tribune, 1918a). After cases subsided in November, the New York City health commissioner credited the decision to keep schools open with helping to slow the virus, since students spent less time in crowded tenements and more time in regulated classrooms: “I know that in our city one of the most important methods of disease control is the public school system” (The New York Times, 1918).

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 rebellious 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 prematurely 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 Richmond (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 followed through on their warning and 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 first identify 229 cities with a 1910 population greater than 25,000, and then search historical newspaper archives for mentions of school closures.[12] Our search revealed school

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

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.[13] Four of these 171 cities had incomplete school attendance information for children 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.[14]

Figure 1 plots the distribution of school closures across areas. Chicago and New York were the two largest cities in our sample not to close schools at any point.[15] Cities closed schools on average for 36 days, with a standard deviation of 21 days. There is very little geographical clustering; cities in similar areas often made different closure choices.

The length of time schools closed in a city during the pandemic is correlated with several of its demographic characteristics. Figure 2 presents the estimated coefficients from a regression of various city characteristics in 1910 on days closed in the 1918-19 pandemic.[16] 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. Specifically, an additional day of school closures during the 1918 pandemic is associated with a 0.01 standard deviation higher school attendance rate in the city in 1910, particularly among teens between the ages of 15 and 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. Similarly, 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 on the y-axis versus excess 1918-19 flu mortality

[13] For an additional 34 cities, we found archival sources confirming that the city closed its schools, but we were not able to confirm a closing and a reopening date, so we do not use these 34 cities in our analysis.

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

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

[16] City characteristics are observed in the 1910 full count census and standardized to have a mean of zero and a standard deviation equal to one.

rates on the x-axis. Weighting the dots by population, 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 youth.

3.2 Census Data

To analyze the causal effect of school closures on children, we use individual data from the full count population censuses in 1910 and 1920.[17] The outcome variable for our short-run regressions is reported school attendance among individuals aged 0 to 25 in each census year.[18] 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. We assign school closures to youth based on their city of residence.[19] 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.[20] We measure 1940 outcomes for this linked sample, including educational attainment, wage income, the existence of non-wage income, and hours worked.[21]

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 match forward to the 1940 census.

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

[18]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. Therefore, a child had 3.5 more months to attend school and report as such in 1910 than 1920.

[19]We clean the raw town and place names in the 1910 and 1920 decennial censuses and extract standardized place names that correct for punctuation differences. We impute missing place names within enumeration district with the modal non-missing place name of residents of that enumeration district.

[20]We cannot link women due to frequent name changes.

[21]In particular, 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.

In all samples, we restrict our attention to children who resided in one of the 168 cities that comprise our final 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, depending on the sample. In our 1920–1940 matched sample, we see that the average child obtained 10.3 years of education by the 1940 census and earned average annual wage income of $1,151.

4 Results

4.1 Short-run Schooling Attendance

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 length of school closure: (1) those that closed schools for 0–21 days; (2) those that closed for 22–35 days; and (3) those that closed for 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 cities that closed their schools for a longer time during the pandemic. This, however, 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. In particular, we estimate versions of the following equation:

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

where the outcome variable $1(Attend\ School)_i$ is an indicator measuring whether each child i was attending school in 1920. The variable $DaysClosed_c$ describes the number of days that schools were closed during the 1918–1919 school year in child i's city c.[22] Age bins a group children into six age bins (aged 0–5, 6–10, 11–14, 15–18, 19–21, and 22–25 in 1920) so that we can separately estimate the effect of school closures on pupils of different ages. X_i is a vector of race-by-gender fixed effects. The matrix of controls $V_{c,b}$ contains birth-year fixed effects linearly interacted with characteristics of each city in 1910. These city characteristics, calculated using the 1910 decennial census, are: 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.[23] Robust standard errors are clustered at the city level.

In Panel A of Figure 4, we plot the estimated β_a coefficients for the above regression using 1920 school attendance as the outcome variable. 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

[22] The null effects that we present here are robust to a different choice of specification where we discretize 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, instead of the linear measure of days closed that we use in this paper. So, the results we present in this project are not a function of the linearity assumption embedded in Equation 1.

[23] In Appendix Figure A7, we show that results are robust to including state-by-birth year fixed effects, which absorb the effects of state-level policies that affected some birth cohorts more than others.

than the omitted category (children aged 0–5).[24] 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 20 days, our point estimate and 95% confidence interval imply that a city that closed its schools for 20 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. 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 null attendance results are not driven by any time-invariant selection that our model fails to capture. This regression-based analysis is consistent with the raw schooling patterns 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

[24]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.

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.

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. This long-run analysis is based on the sample of linked men described in Section 3.2. We estimate regressions of the form:

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

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.[25] 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 A8-A13). Except for black men

[25]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. Many respondents in entrepreneurial professions reported minimal wage income but answered the question about non-wage income affirmatively.

(Figure A9), where we find imprecisely estimated evidence that school closures could have mattered, point estimates are generally statistically insignificant and close to zero. Finally, we show that the null long-run effects are robust to controlling for excess pandemic mortality (Figure A14) and state-by-birth year fixed effects (Figure A15).

5 Conclusion

Over the past year, governments have implemented a variety of NPIs to combat the spread of the COVID-19 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. A series of recent papers use the historical nature of the 1918-19 pandemic to measure the causal effects of different NPIs on the short- and long-run economic outcomes of cities during that time period.

In this paper, we focus our attention on the NPI most likely to affect children: school closures. We estimate how school closures during the 1918-19 pandemic affected children's school 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 already 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. 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, when schools closed in 1918, children with more household resources did not necessarily have the ability to continue to learn at a high rate. Given these differences, it may be unsurprising that we find little effects of 1918-19 school closures on youth.

More broadly, we hope that this paper inspires more discussions about how the *differences* between the 1918-19 and COVID-19 pandemics can help inform policy and sharpens the discussion of the current crisis. 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), our paper cautions against over-extrapolating from the 1918-19 pandemic when making decisions about optimal policies during the COVID-19 pandemic.

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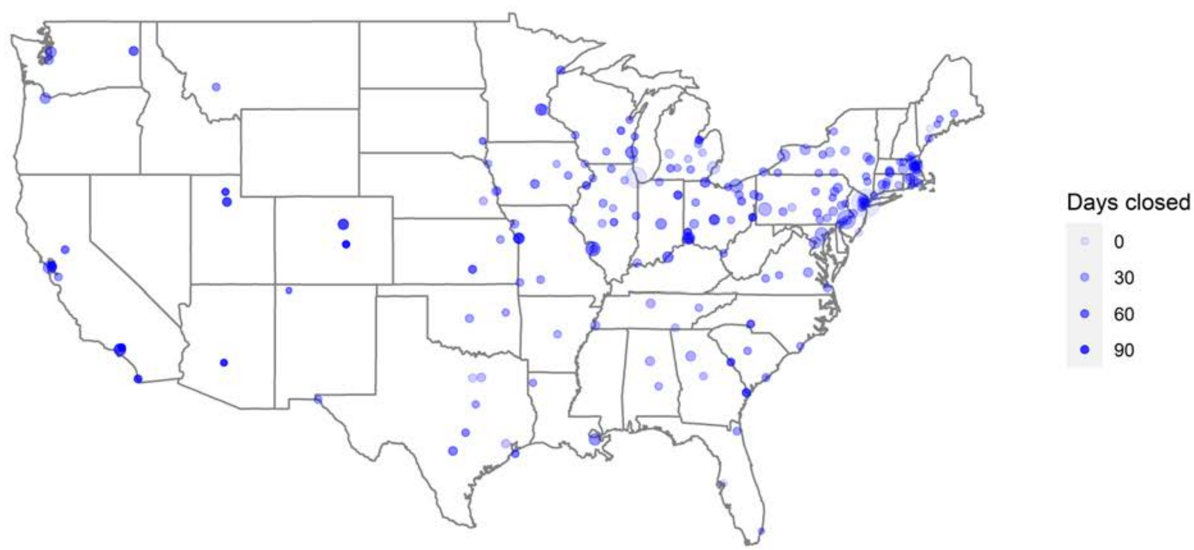
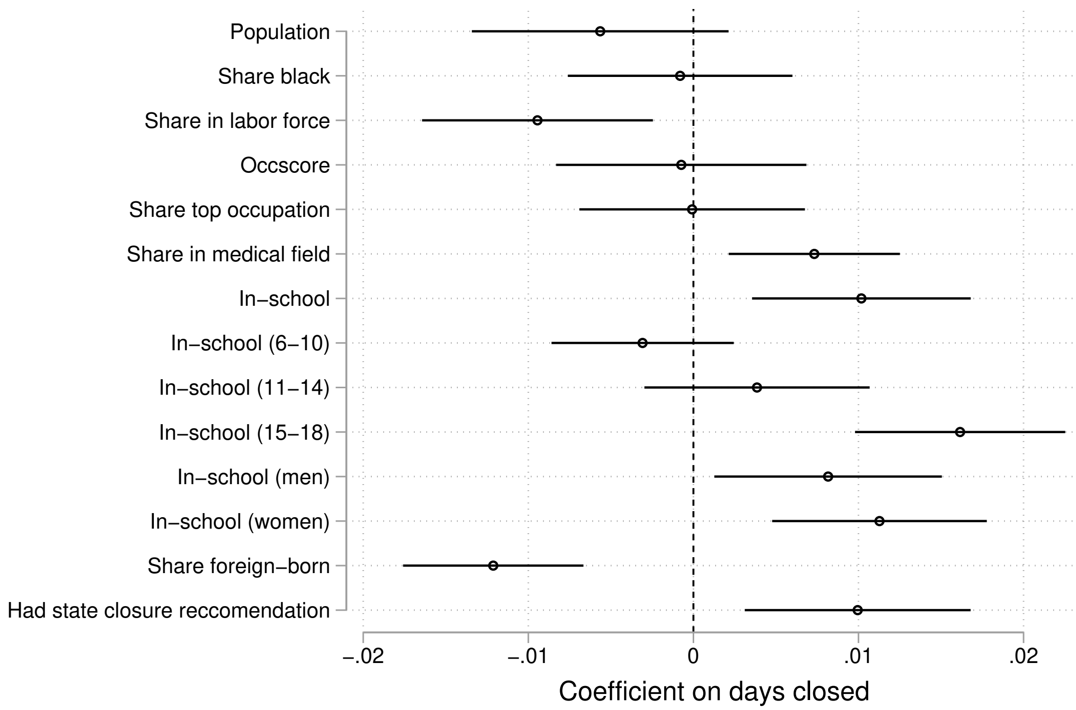
Figure 1: Map of cities by 1918-19 school closure length



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.

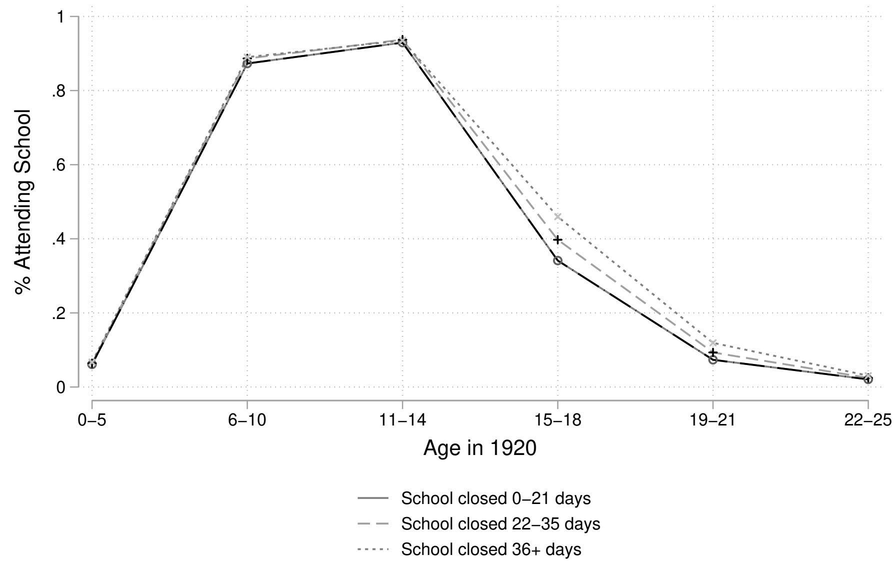
Figure 2: Relationship between 1918-19 school closure length, 1910 city demographics, and state closure orders



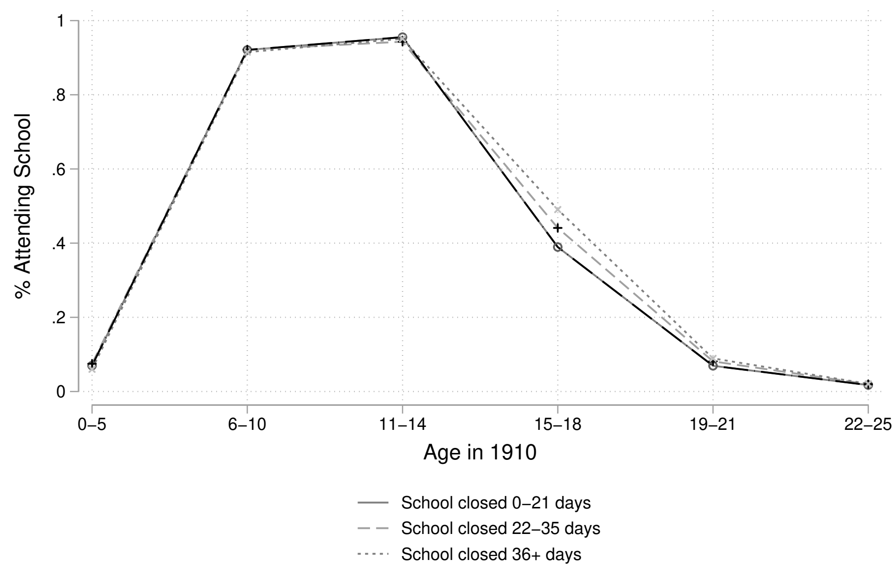
This figure plots coefficients from separate regressions with the indicated variable as the outcome and days schools closed in 1918 and 1919 as the independent variable. Each outcome variable is standardized to have mean zero, standard deviation one. All demographics and individual characteristics are 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)

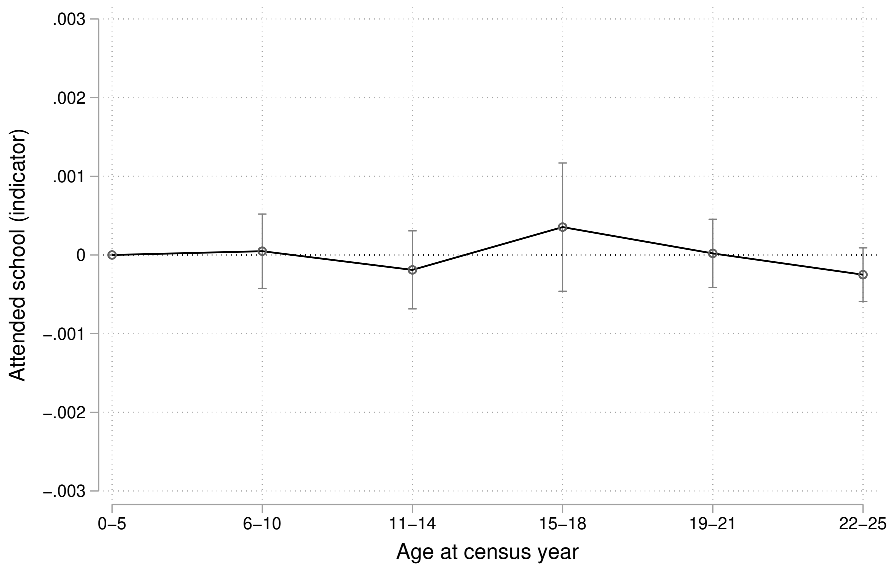


These figures show the fraction of respondents who report school attendance by reported age group in the census. Each sub-figure has three lines, separately plotting average school attendance among children who lived in cities that closed schools for 0–21, 22–35, and 36+ days in 1918-19. Panel (a) shows 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.

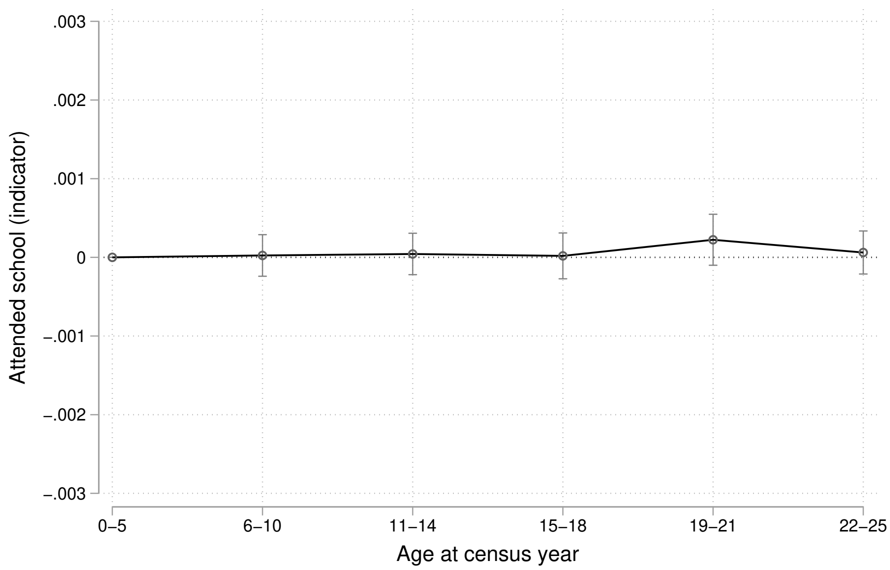
The figures show that cities that closed their schools for longer periods of time had higher rates of school attendance at age 15–21. But the magnitude of that difference is similar in 1910 and 1920.

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:

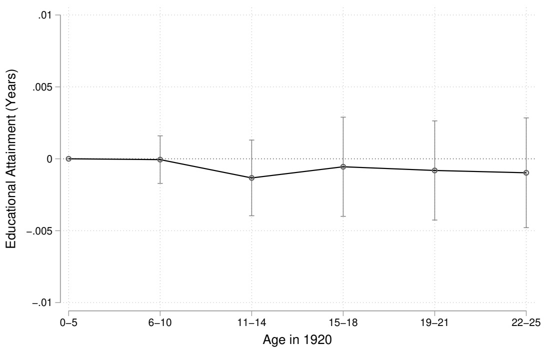
$1(Attend\ School)_i = \beta_a DaysClosed_c \times AgeGroup_a + \gamma_c + \Pi \times X_i + \Delta \times V_{c,b} + \omega_{r,b} + \epsilon_i$

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.

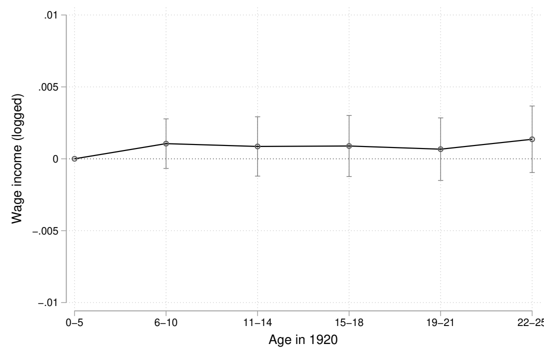
The figures show the similar relationships between school closure length during the 1918-19 pandemic and school attendance rates by age group in 1910 (a placebo year) and 1920 (a post-pandemic year).

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

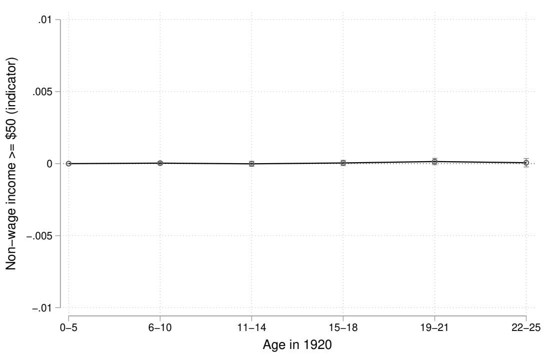
(a) Educational Attainment (Years)



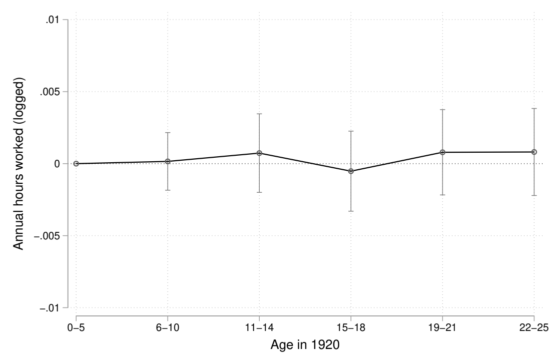
(b) Wage Income (logged)



(c) 1(Non-Wage Income $\geq$ \$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.

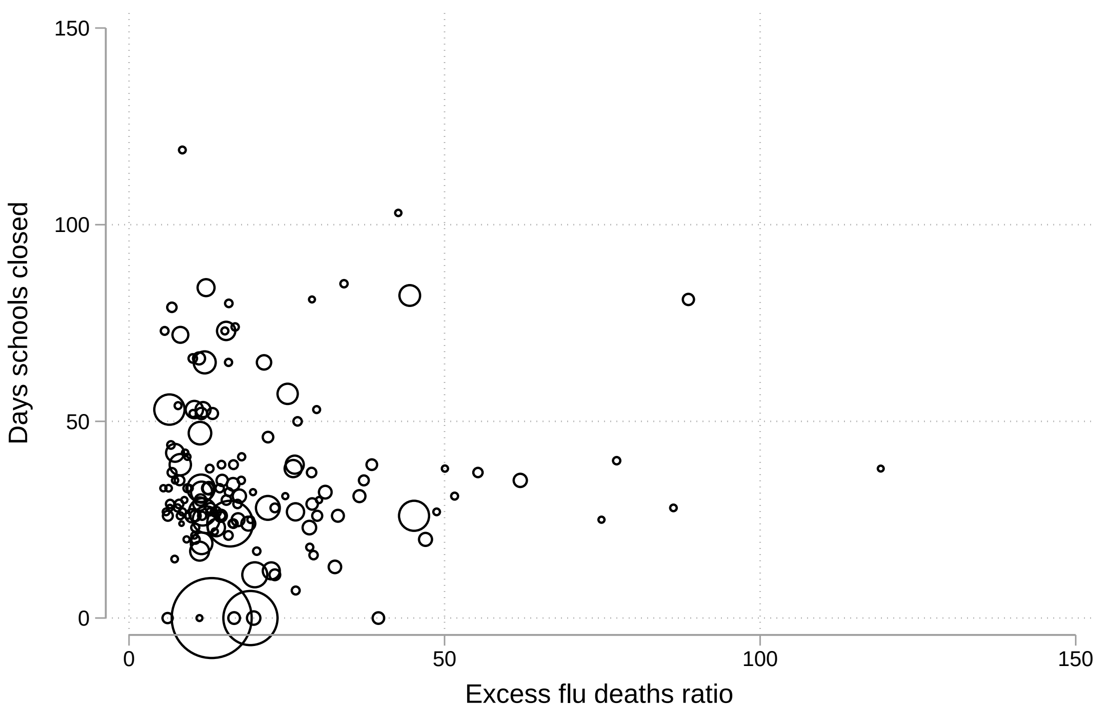
The figures show null effects of school closures in 1918-19 on 1940 human capital and labor market outcomes.

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 168 cities that comprise our final analysis sample.

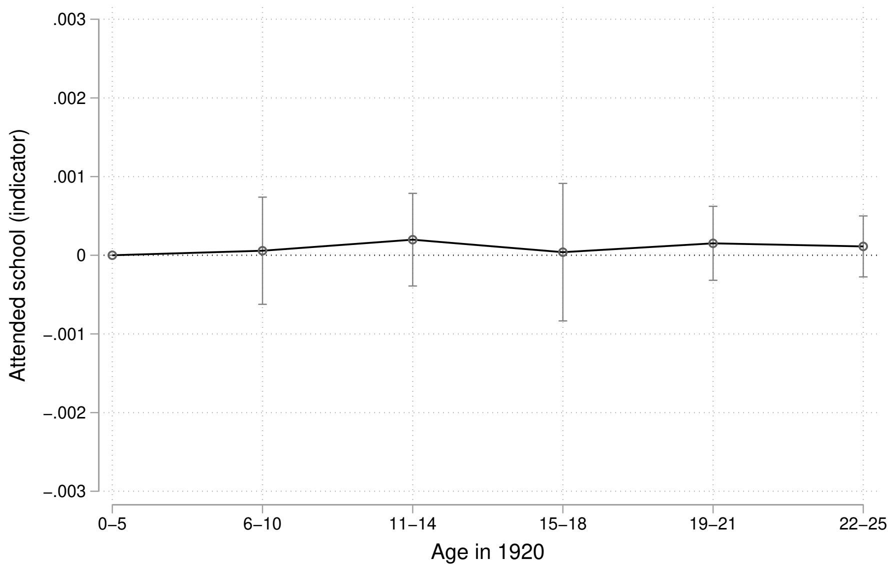
Figure A1: Scatterplot of school closure length against excess pandemic flu death ratios



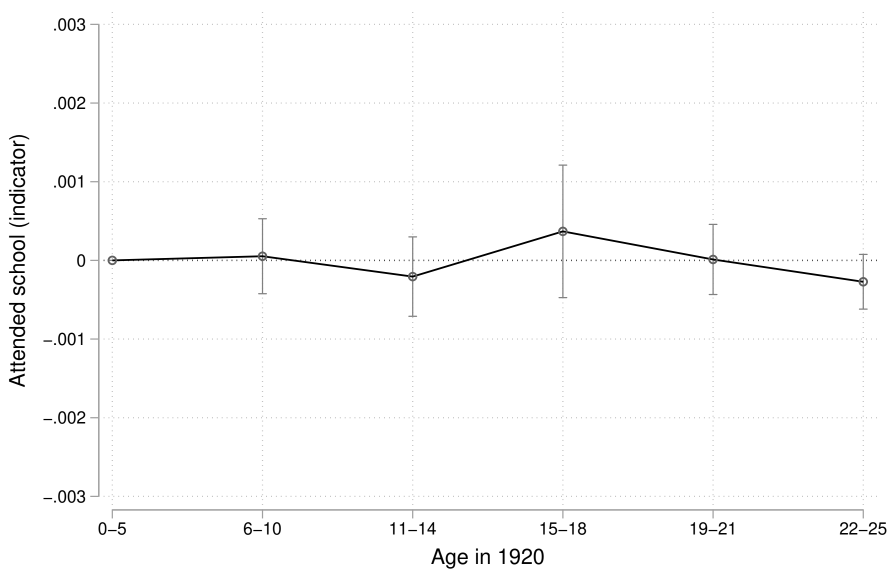
This figure shows the relationship between 1918-19 school closures and excess 1918-19 pandemic flu deaths ratios. Each dot is a city and dot sizes are weighted by population.

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

(a) Black



(b) Non-black



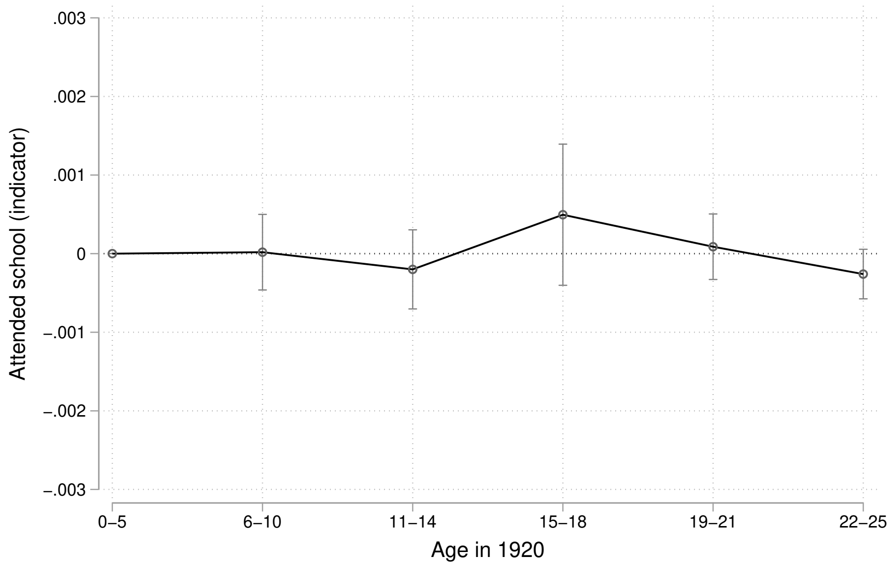
These figures plot the β_a coefficients from Equation 1 estimated separately for Black (Panel a) and Non-black (Panel b) youth. The estimating equation is:

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

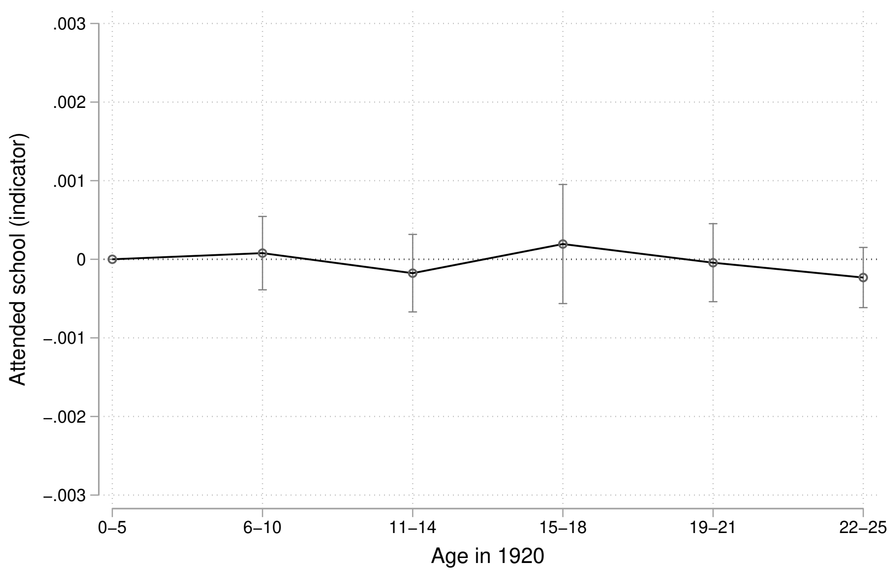
where $1(Attend\ School)_i$ is an indicator measuring whether each child i was attending school. $DaysClosed_c$ describes the number of days that schools were closed during the 1918–1919 school year in child i's city c. Age bins a group children into six age bins in the census (aged 0-5, 6-10, 11-14, 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



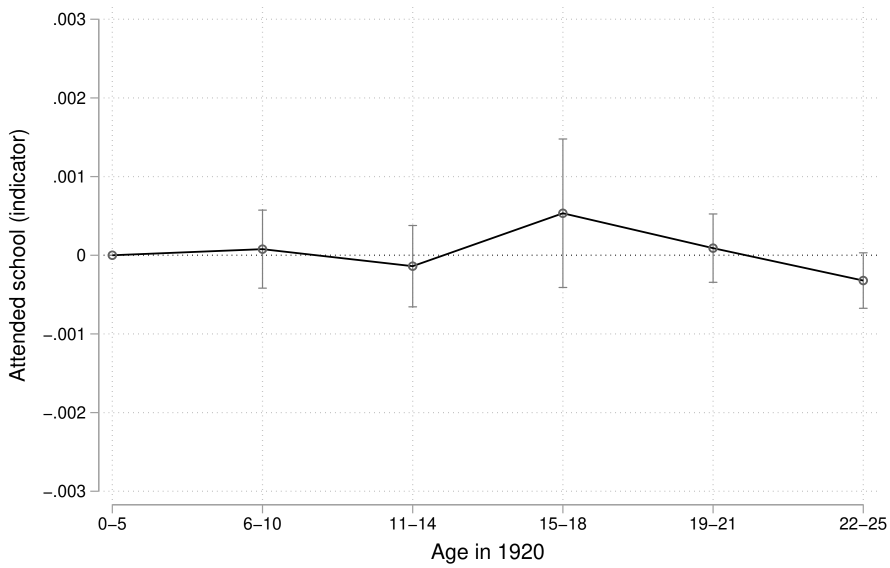
These figures plot the β_a coefficients from Equation 1 estimated separately for women (Panel a) and men (Panel b). The estimating equation is:

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

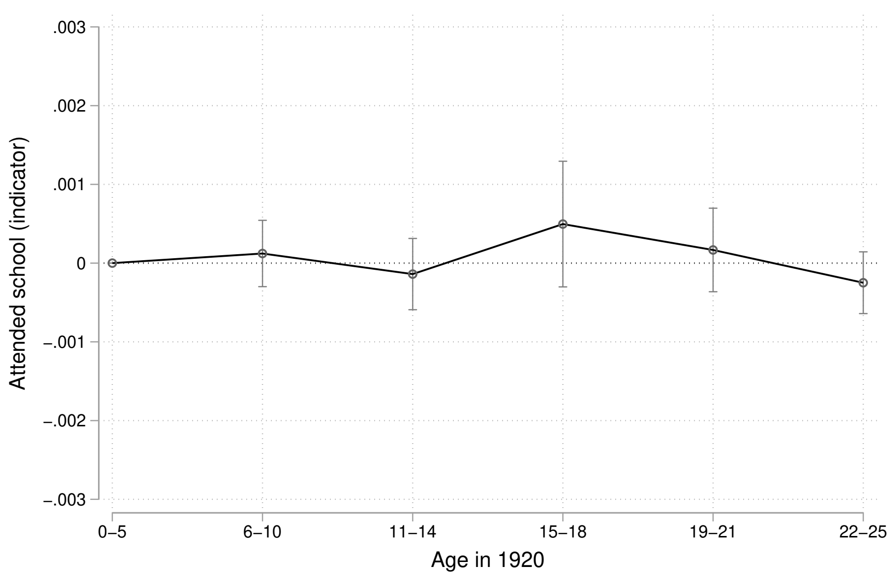
where $1(Attend\ School)_i$ is an indicator measuring whether each child i was attending school. $DaysClosed_c$ describes the number of days that schools were closed during the 1918–1919 school year in child i's city c. Age bins a group children into six age bins in the census (aged 0-5, 6-10, 11-14, 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



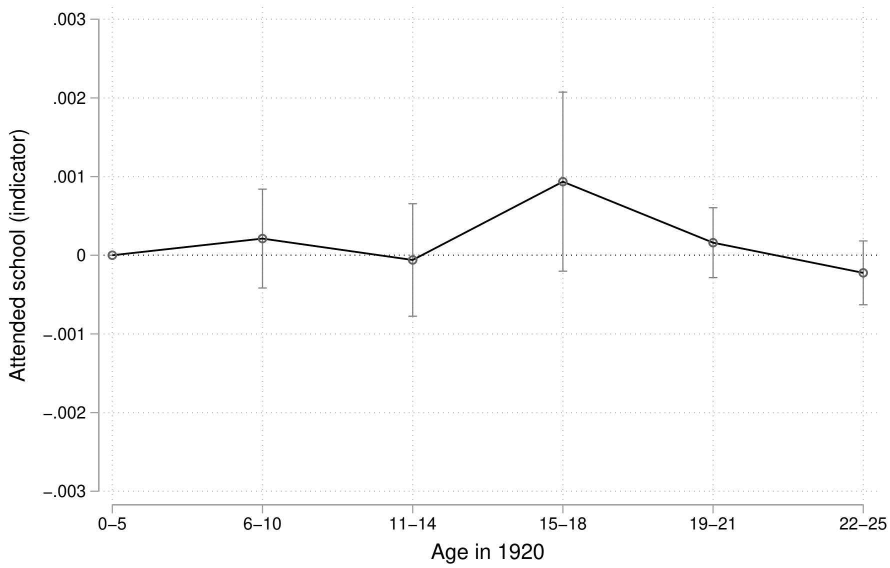
These figures plot the β_a coefficients from Equation 1 estimated separately for youth with lower (Panel a) and higher (Panel b) occupational prestige fathers. The estimating equation is:

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

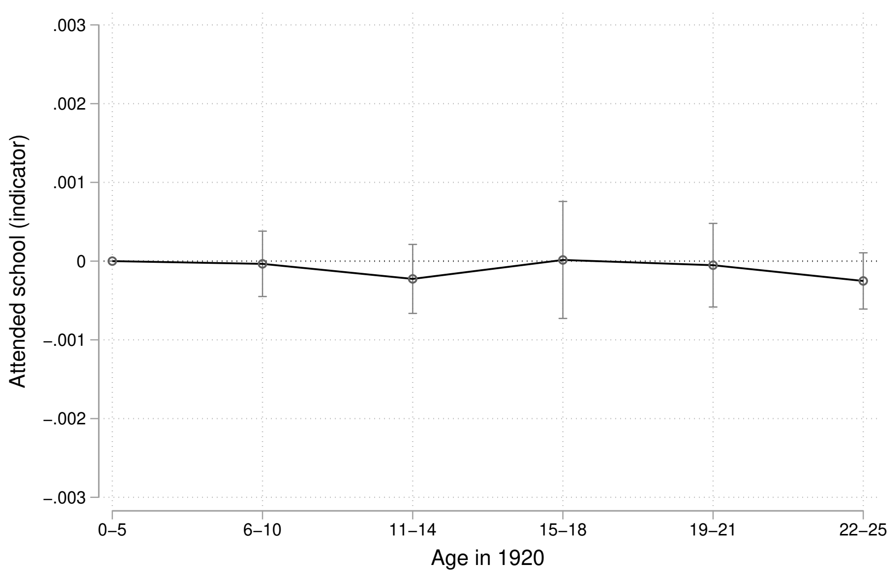
where $1(Attend\ School)_i$ is an indicator measuring whether each child i was attending school. $DaysClosed_c$ describes the number of days that schools were closed during the 1918–1919 school year in child i's city c. Age bins a group children into six age bins in the census (aged 0-5, 6-10, 11-14, 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



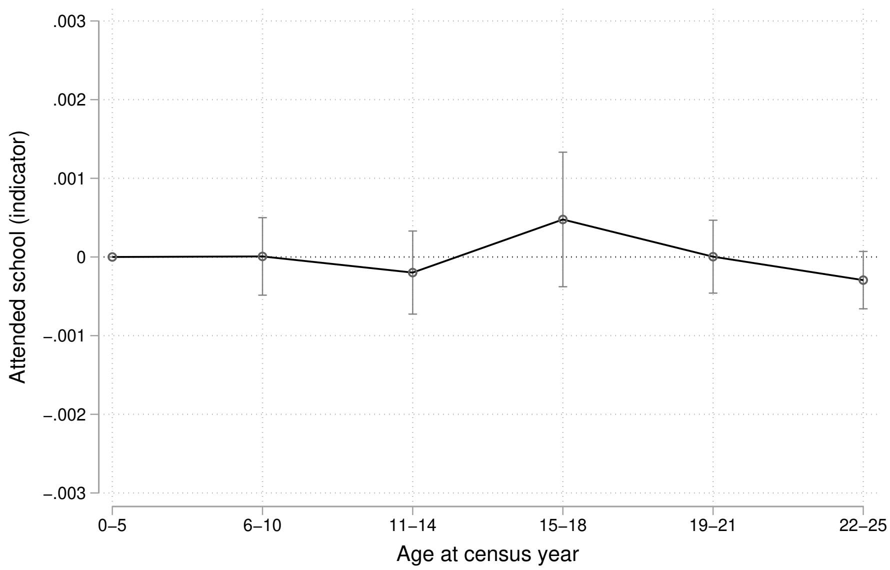
These figures plot the β_a coefficients from Equation 1 estimated separately for youth with foreign (Panel a) and U.S.-born (Panel b) fathers. The estimating equation is:

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

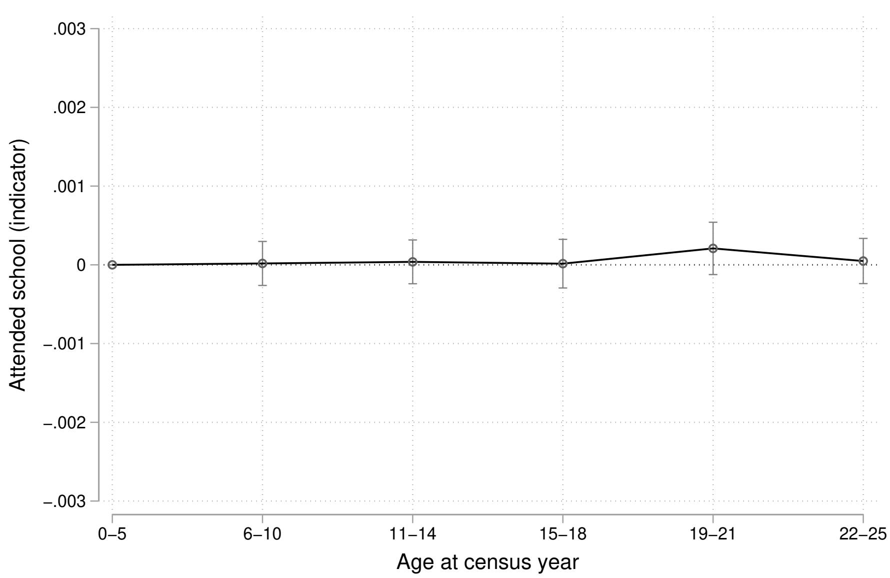
where $1(Attend\ School)_i$ is an indicator measuring whether each child i was attending school. $DaysClosed_c$ describes the number of days that schools were closed during the 1918–1919 school year in child i's city c. Age bins a group children into six age bins in the census (aged 0-5, 6-10, 11-14, 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



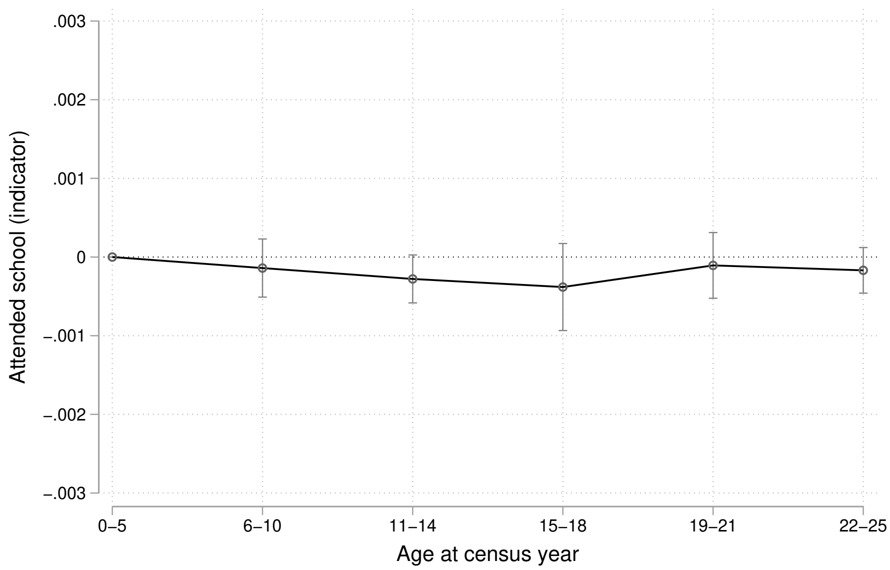
(b) 1910 (placebo)



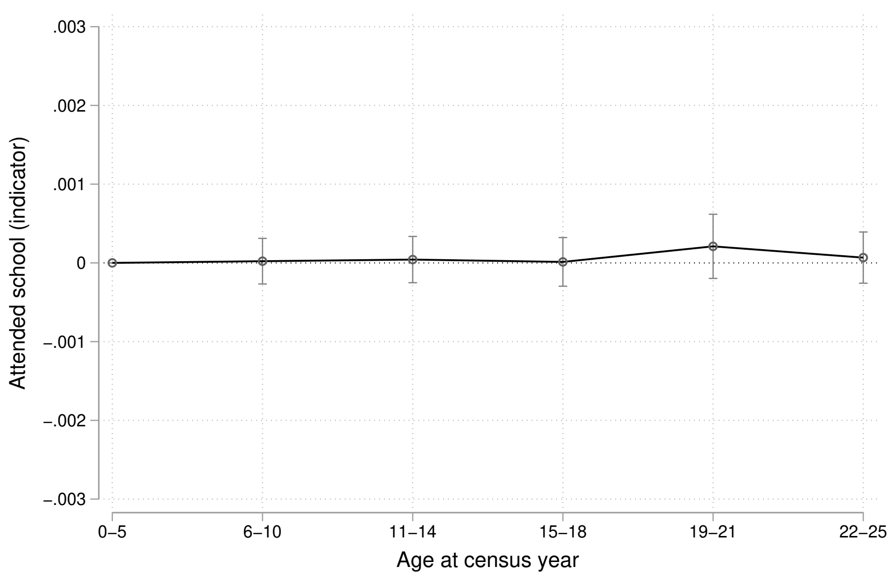
These figures plot the β_a coefficients from Equation 1 estimated separately for 1920 (Panel a) and 1910 (Panel b). These models also include include controls for excess mortality ratios interacted with age at census year fixed effects.

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



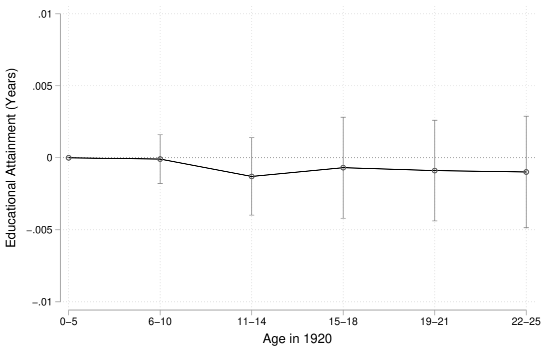
(b) 1910 (placebo)



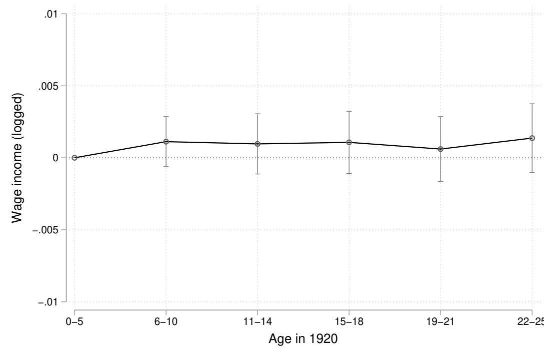
These figures plot the β_a coefficients from equation 1 estimated separately for 1920 (Panel a) and 1910 (Panel b). These models also include include state-by-birth year fixed effects.

Figure A8: Relationship between days schools closed during 1918 influenza pandemic and 1940 outcomes, non-black children

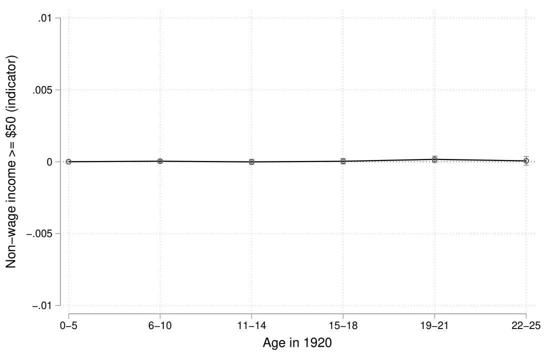
(a) Educational Attainment (Years)



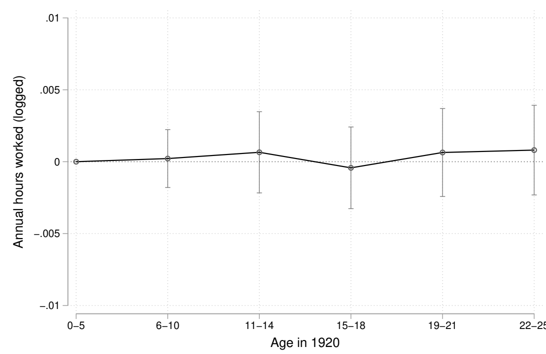
(b) Wage Income (logged)



(c) 1(Non-Wage Income ≥ \$50)



(d) Annual Hours Worked (logged)



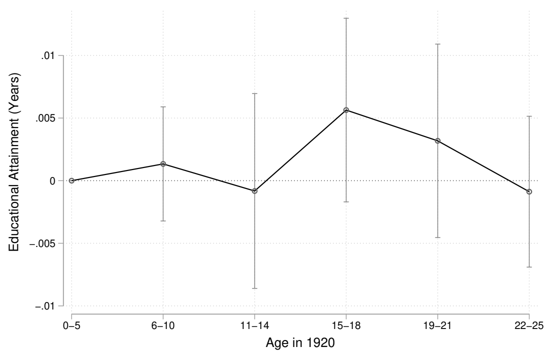
These figures plot the β_a coefficients from Equation 2 estimated on the sample of non-black children. Outcomes are each measured in the 1940 census. The estimating equation is:

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

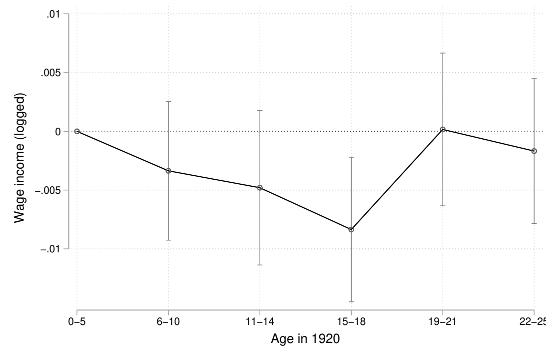
where $1(Attend\ School)_i$ is the indicated outcome, $DaysClosed_c$ describes the number of days that schools were closed during the 1918-19 school year in child i's city c. Age bins a groups children into six age bins (aged 0-5, 6-10, 11-14, 15-18, 19-21, and 22-25). X_i is a vector of personal characteristics, $V_{c,b}$ 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 A9: Relationship between days schools closed during 1918 influenza pandemic and 1940 outcomes, black children

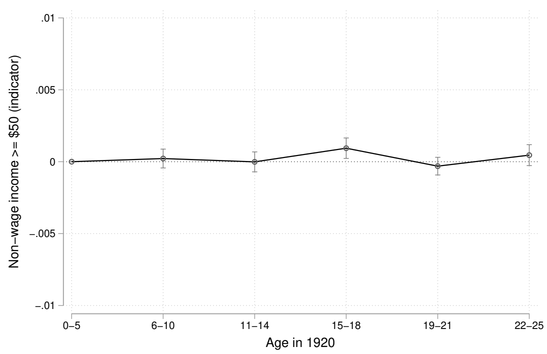
(a) Educational Attainment (Years)



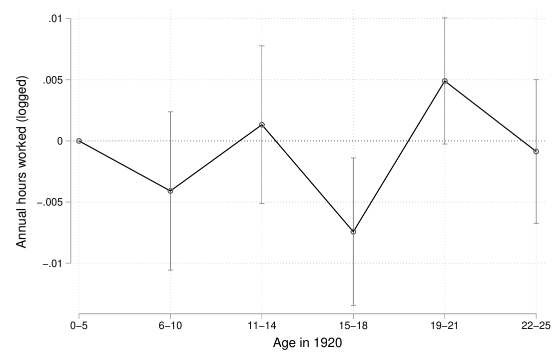
(b) Wage Income (logged)



(c) 1(Non-Wage Income ≥ \$50)



(d) Annual Hours Worked (logged)



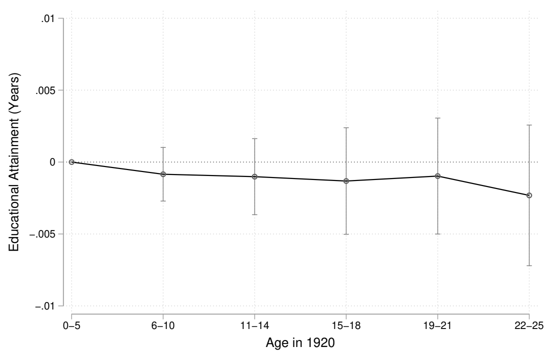
These figures plot the β_a coefficients from Equation 2 estimated on the sample of black children. Outcomes are each measured in the 1940 census. The estimating equation is:

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

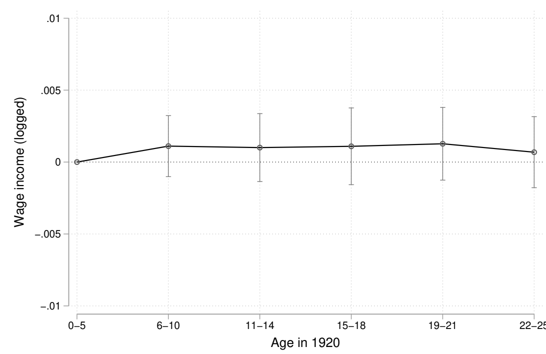
where $1(Attend\ School)_i$ is the indicated outcome, $DaysClosed_c$ describes the number of days that schools were closed during the 1918-19 school year in child i's city c. Age bins a groups children into six age bins (aged 0-5, 6-10, 11-14, 15-18, 19-21, and 22-25). X_i is a vector of personal characteristics, $V_{c,b}$ 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 A10: Relationship between days schools closed during 1918 influenza pandemic and 1940 outcomes, children with lower occupational prestige fathers

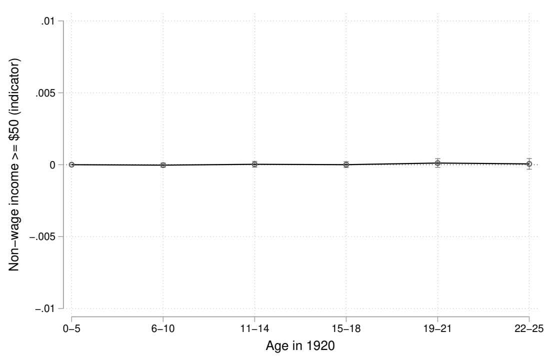
(a) Educational Attainment (Years)



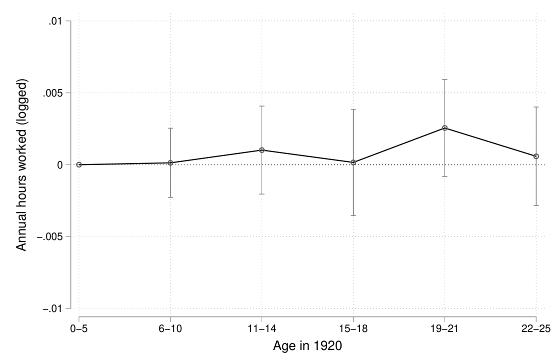
(b) Wage Income (logged)



(c) 1(Non-Wage Income ≥ $50)



(d) Annual Hours Worked (logged)



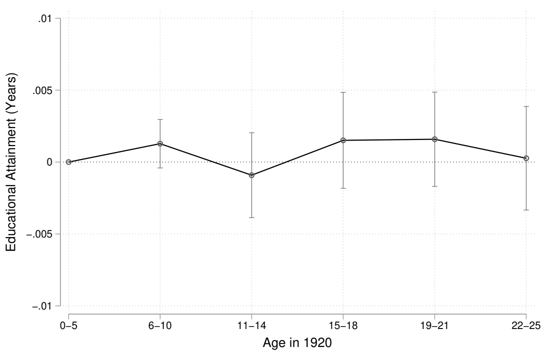
These figures plot the β_a coefficients from Equation 2 estimated on a sample of children with lower occupational prestige fathers. Outcomes are each measured in the 1940 census. The estimating equation is:

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

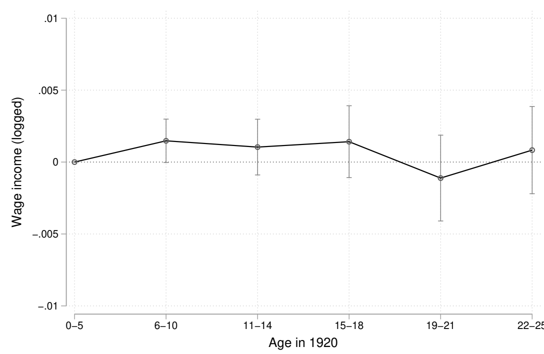
where $1(Attend\ School)_i$ is the indicated outcome, $DaysClosed_c$ describes the number of days that schools were closed during the 1918-19 school year in child i's city c. Age bins a groups children into six age bins (aged 0-5, 6-10, 11-14, 15-18, 19-21, and 22-25). X_i is a vector of personal characteristics, $V_{c,b}$ 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 A11: Relationship between days schools closed during 1918 influenza pandemic and 1940 outcomes, children with higher occupational prestige fathers

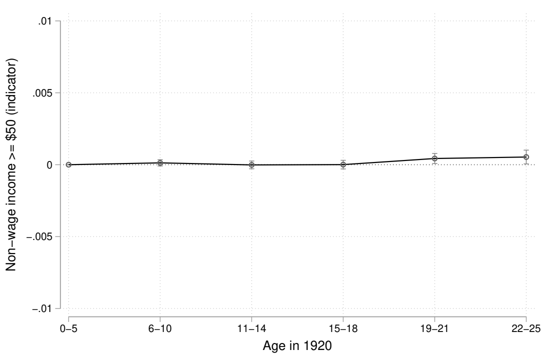
(a) Educational Attainment (Years)



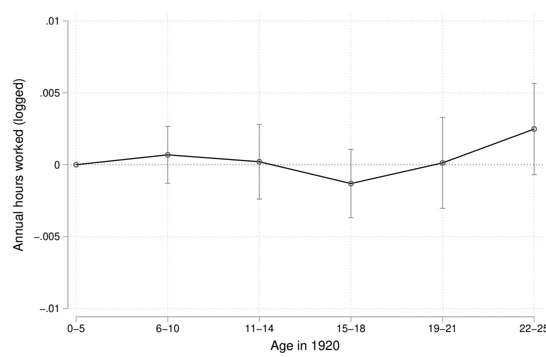
(b) Wage Income (logged)



(c) 1(Non-Wage Income ≥ \$50)



(d) Annual Hours Worked (logged)



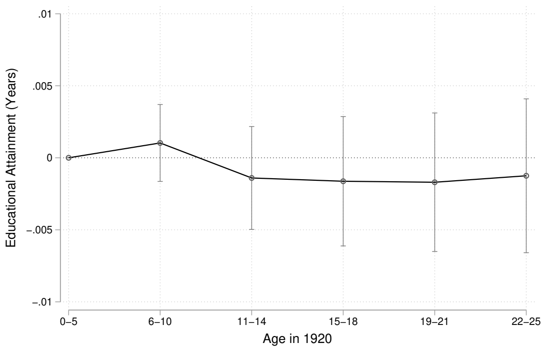
These figures plot the β_a coefficients from Equation 2 estimated on a sample of children with higher occupational prestige fathers. Outcomes are each measured in the 1940 census. The estimating equation is:

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

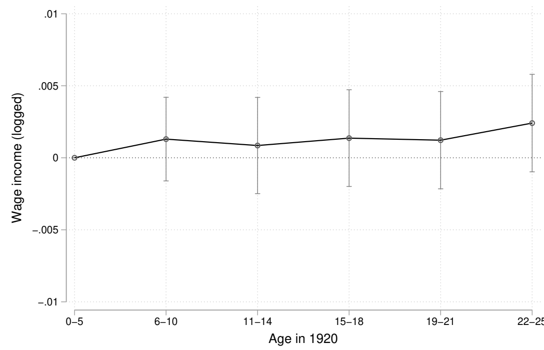
where $1(Attend\ School)_i$ is the indicated outcome, $DaysClosed_c$ describes the number of days that schools were closed during the 1918-19 school year in child i's city c. Age bins a groups children into six age bins (aged 0-5, 6-10, 11-14, 15-18, 19-21, and 22-25). X_i is a vector of personal characteristics, $V_{c,b}$ 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 A12: Relationship between days schools closed during 1918 influenza pandemic and 1940 outcomes, children with foreign-born fathers

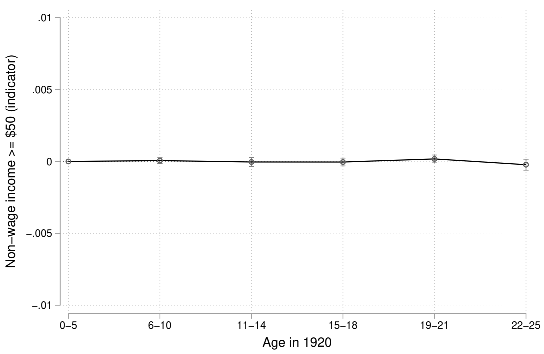
(a) Educational Attainment (Years)



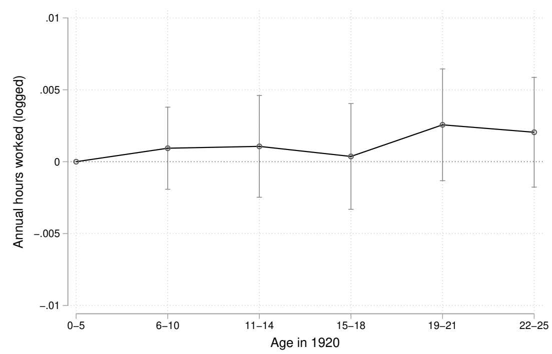
(b) Wage Income (logged)



(c) 1(Non-Wage Income ≥ \$50)



(d) Annual Hours Worked (logged)



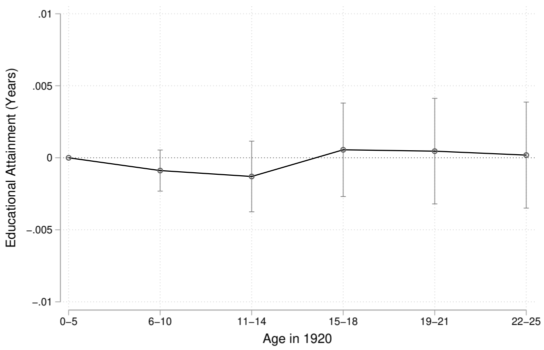
These figures plot the β_a coefficients from Equation 2 estimated on a sample of children with foreign-born fathers. Outcomes are each measured in the 1940 census. The estimating equation is:

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

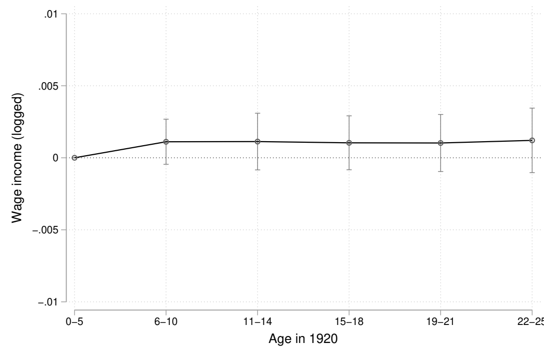
where $1(Attend\ School)_i$ is the indicated outcome, $DaysClosed_c$ describes the number of days that schools were closed during the 1918-19 school year in child i's city c. Age bins a groups children into six age bins (aged 0-5, 6-10, 11-14, 15-18, 19-21, and 22-25). X_i is a vector of personal characteristics, $V_{c,b}$ 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 A13: Relationship between days schools closed during 1918 influenza pandemic and 1940 outcomes, children with U.S. born fathers

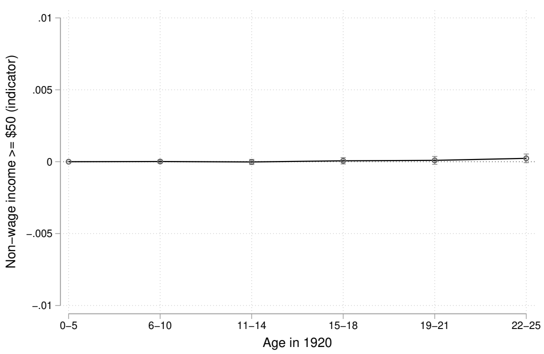
(a) Educational Attainment (Years)



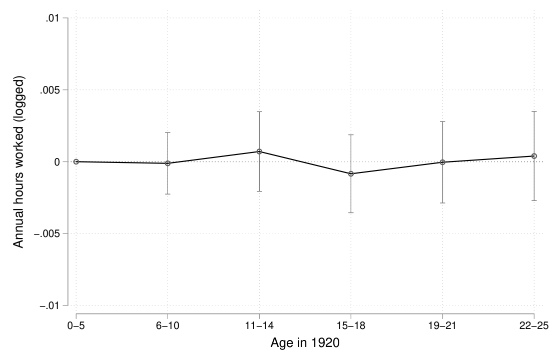
(b) Wage Income (logged)



(c) 1(Non-Wage Income ≥ \$50)



(d) Annual Hours Worked (logged)



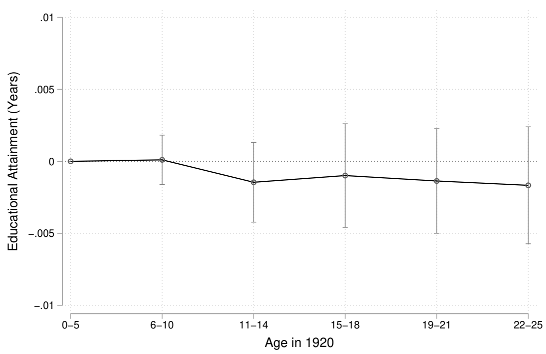
These figures plot the β_a coefficients from Equation 2 estimated on a sample of children with U.S.-born fathers. Outcomes are each measured in the 1940 census. The estimating equation is:

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

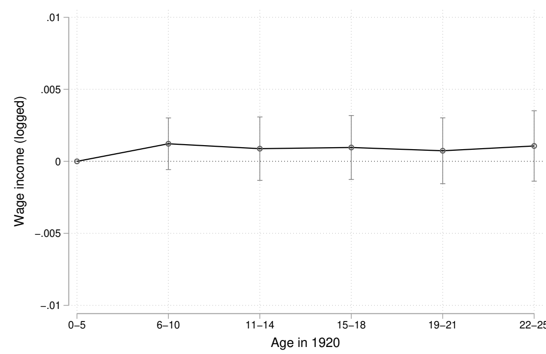
where $1(Attend\ School)_i$ is the indicated outcome, $DaysClosed_c$ describes the number of days that schools were closed during the 1918-19 school year in child i's city c. Age bins a groups children into six age bins (aged 0-5, 6-10, 11-14, 15-18, 19-21, and 22-25). X_i is a vector of personal characteristics, $V_{c,b}$ 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 A14: Relationship between days schools closed during 1918 influenza pandemic and 1940 outcomes, with mortality controls

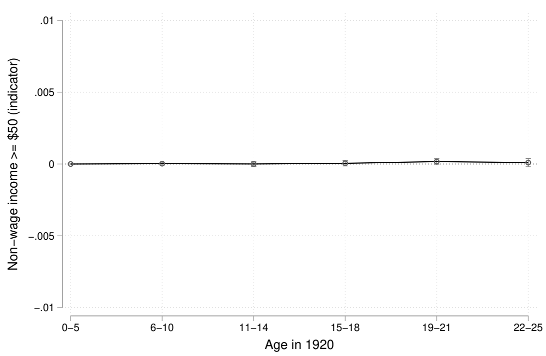
(a) Educational Attainment (Years)



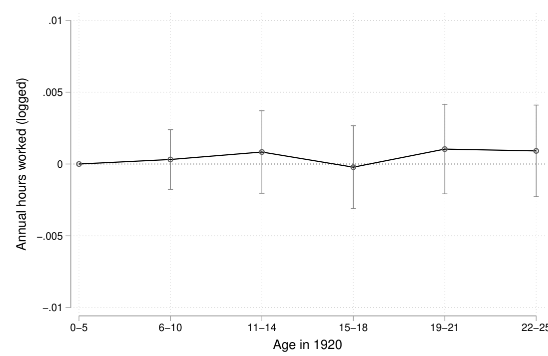
(b) Wage Income (logged)



(c) 1(Non-Wage Income ≥ \$50)



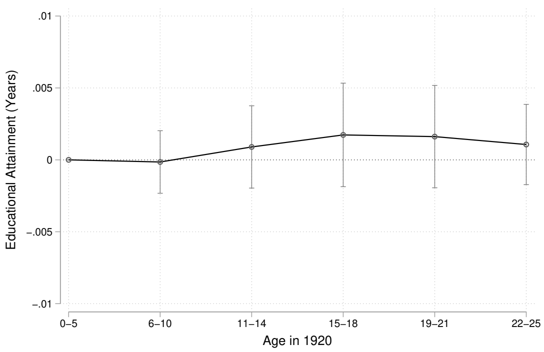
(d) Annual Hours Worked (logged)



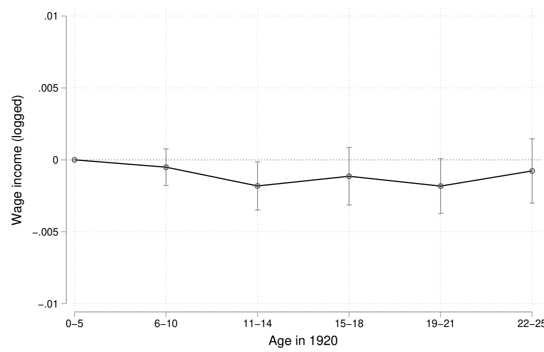
These figures plot the β_a coefficients from a version of Equation 2 that also controls for excess influenza mortality ratios interacted with age bin fixed effects.

Figure A15: Relationship between days schools closed during 1918 influenza pandemic and 1940 outcomes, controlling for state-by-birth year fixed effects

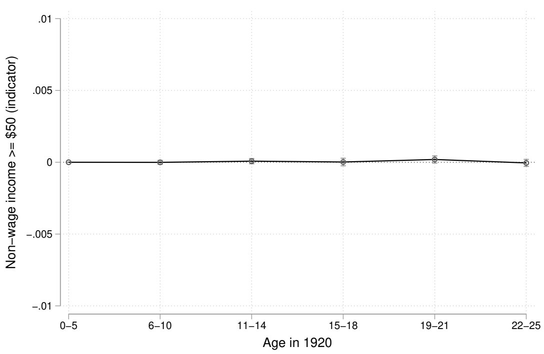
(a) Educational Attainment (Years)



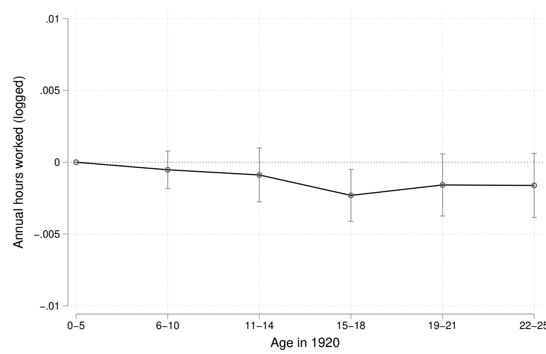
(b) Wage Income (logged)



(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.