Early-Life Disease Exposure and Occupational Status: The Impact of Yellow Fever during the 19th Century *

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March 26, 2015

Abstract

Using city-of-birth data from the 100-percent sample of the 1880 Census merged to city-level fatality counts, I estimate the relationship between early-life yellow fever exposure and adult occupational status. I find that white males with immigrant mothers were less likely to become professional or skilled laborers and more likely to become unskilled laborers or report occupational nonresponse if they were born during yellow fever epidemics. They also reported occupations with lower 1900 occupational income scores and lower scores on the Duncan Socioeconomic Index. The children of US-born mothers (who were less susceptible to the disease) were relatively unaffected. Furthermore, I find no evidence that epidemics 3 to 4 years after birth affect adult occupational status and the results are robust to controlling for local trade during an individual's birth year.

JEL codes: N31, I130, I140
Keywords: fetal origins, early childhood, yellow fever, occupation, urban mortality penalty

*I want to thank Werner Troesken, Randall Walsh, Allison Shertzer, Seth Richards-Shubik and Greg Niemesh for helpful comments. I also want to thank participants at the Cliometric Society session of the 2015 ASSA and seminar partcipants at the University of Pittsburgh. Alokik Mishra and Emma Howe provided excellent research assistance. Comments are welcome at Martin.Saavedra@Oberlin.edu.

1 Introduction

During the nineteenth century, city dwellers carried a higher mortality risk than those in rural areas. Increased urbanization and transportation facilitated the spread of disease. Scientists had not yet discovered the vectors of many diseases, which prevented city official from investing in necessary sanitation. Diseases such as yellow fever, cholera, tuberculosis, dysentery, and typhoid fever increased the mortality rates in cities, a phenomenon described as the "urban mortality penalty." Once public health policies contained these diseases, the urban mortality penalty narrowed, eventually disappearing around 1940 (Haines 2001).

Health economists have linked early-life disease exposure to worse labor-market outcomes (Almond 2006; Barreca 2010; Almond and Currie 2011). This research argues that early-life health shocks have permanent effects on human capital development. Consequently, disparities in early-life disease exposure might cause economic disparities a generation later. This research has focused on mainly the effects of influenza, malaria, or famine-induced malnutrition.

This study considers how early-life environment affects adult occupational outcomes in the context of the urban mortality transition by focusing on an epidemic disease that plagued Southern port cities: yellow fever. Although yellow fever accounted for a small fraction of the urban mortality penalty, it was an exclusively urban disease. After the discovery of the yellow fever disease vector, the mosquito, public officials took measures to eradicate the disease. Yellow fever has not reached epidemic levels in the United States since 1905. In this paper, I ask whether yellow fever epidemics during early life decreased occupational status during adulthood, and if so, which demographic groups were most affected by these epidemics.

Yellow fever epidemics struck suddenly killing many city dwellers and infecting many others. These epidemics happened unpredictably, in some years killing thousands of citizens and in other years leaving cities untouched. For example, in New Orleans, LA, yellow fever killed 17 residents in 1851, 456 in 1852, and 7,849 in 1853 (Toner 1873). Consequently, New Orleanians born in 1851-1853 likely grew up in similar neighborhoods and in similar families, but they faced different disease environments during early life. The sporadic and unanticipated nature of yellow fever increases the likelihood that these epidemics were uncorrelated with unobservable variables that might affect human capital development, which would imply that the reduced form estimates take on a causal interpretation.

I identify white males in the 1880 Census who were born in one of four US cities: New Orleans, LA; Mobile, AL; Charleston, SC; and Washington, DC. I then merge this data with city/year level fatality counts. Using an ordered probit model, I find that whites who were born to immigrant mothers during yellow fever epidemics entered lower status occupations than whites with immigrant mothers born during non-epidemic years. For example, the results suggest that whites who were born to immigrant mothers during the 1853 yellow fever epidemic in New Orleans were 12 percentage points less likely to report a professional occupation (e.g. physician or lawyer). Furthermore, an epidemic during an individual's birth year does not predict occupational status for whites with US-born mothers. White immigrants were so much more susceptible to yellow fever that it earned the name "the strangers' disease" (Pritchett and Tulani 1995). Thus, this finding provides evidence that early-life disease exposure, as opposed to the wealthy fleeing cities or a stoppage of economic activity, drives the results. Additionally, I find some evidence that local yellow fever fatality rates not only during an individual's birth year, but also epidemics one to two years after birth predict lower occupational status, whereas epidemics three to four years after an individual's birth year do not. Additionally, I use linear models using 1900 occupational income and unemployment data. I find that early-life yellow fever exposure induced the children of immigrant mothers to enter lower-paying occupations, but they were no more likely to enter occupations with high unemployment rates. These results are robust to controlling for local trade levels during an individuals birth year.

Previous work on the effects of early-life disease exposure has examined influenza and malaria. In a seminal paper, Douglas Almond (2006) analyzed the 1918 influenza pandemic as an exogenous shock to fetal health. Almond compares cohorts who were *in utero* during the pandemic to those who were *in utero* the year before or the year after the pandemic. He uses cross-state variation in the severity of the epidemic and finds evidence that *in utero* influenza exposure reduced educational attainment and wages. Alan Barreca (2010) investigates the effect of early-life malaria exposure on adult labor market outcomes. Barreca uses historical temperature data as a source of exogenous variation in malaria death rates. Changes in temperature affect the population of mosquitoes, which are the vector for malaria. He finds that *in utero* and post-natal malaria exposure worsened labor market outcomes. Case and Paxson (2008) find that disease environment during age two has the most significant effects on cognition at elderly ages.

The paper proceeds as follows. Section 2 covers the historical background of yellow fever epidemics. Section 3 presents the historical mortality data and the 100-percent sample of the 1880 Census. Section 4 discusses the econometric model, and Section 5 presents the results. Section 7 presents robustness tests, and Section 8 concludes.

2 Historical Background

Yellow fever is an acute viral infection that spreads to humans through the *Aedes aegypti* mosquito. The mosquito contracts yellow fever after feeding on an infected primate and spreads the disease by later feeding on un-infected primates. Generally, human-to-human contact cannot spread yellow fever. Because mosquitoes are the yellow fever vector and are active mostly in summer, all yellow fever epidemics occurred during the summer months and ended by the first frost of the year. Symptoms of mild infections include fever, headaches, nausea, and vomiting. Some of the infected enter the toxic phase of the disease. Symptoms of the toxic phase include liver damage leading to jaundice, bloody vomit, and sometimes death.

Charles Finlay first hypothesized that mosquitoes were the yellow fever vector in 1881. Walter Reed confirmed Finlay's hypothesis, and in 1905, cities eradicated yellow fever by controlling the mosquito population. Yellow fever epidemics were limited to urban areas during the 19th century. The *Aedes aegypti* breed in standing freshwater located on hard surfaces, making urban cities an effective breeding ground. After acquiring the disease, survivors were generally immune for life. The *Aedes aegypti* needed to infect previously uninfected primates to spread the disease. Consequently, cities with strong immigration experiencing economic booms and robust trade were particularly susceptible to yellow fever. The disease rarely visited the countryside.

Yellow fever first appeared in the United States in 1693 in Boston, MA. Many port cities on the Atlantic experienced yellow fever epidemics. Boston, MA, New York, NY, Philadelphia, PA, Norfolk, VA, and Charleston, SC, experienced outbreaks during the early 1800s. These epidemics claimed hundreds or even thousands of victims. For example, yellow fever took the lives of 5,000 Philadelphians in 1793 (Toner 1873).

After 1835, trade ships from Latin America were more likely to stop in southern port cities such as New Orleans, LA, Mobile, AL, Charleston, SC, and Norfolk, VA, and less likely to continue to Philadelphia, PA, New York, NY, or Boston, MA. These trade ships brought mosquitoes and yellow fever with them. During the mid-nineteenth century, New Orleans was the worst affected by yellow fever. In 1853, nearly 8,000 New

Orleanians died of the disease.

Table 1 displays the number of outbreaks by city between 1668-1873, the number of outbreaks between 1835-1873, and the number of post-1835 outbreaks that killed at least one hundred inhabitants. It is clear from Table 1 that yellow fever plagued New Orleans the worst during the mid nineteenth century. New Orleans had twice as many outbreaks than any other city, and more than twice as many outbreaks resulting in at least 100 deaths.

White immigrants were at the greatest risk of contracting yellow fever, whereas blacks and native whites were relatively immune. For example, during the 1854 epidemic in Charleston, SC, 96.1 percent of fatalities were white and 72.9 percent were immigrants (Patterson 1992). Yellow fever took the lives of so many immigrants that it earned the name "the stranger's disease." In 1808 in St. Marys, GA, yellow fever took the lives of 42 of the town's 350 whites, while only taking three of the towns 150 blacks (Patterson 1992). Immigrants were more susceptible because natives would likely have gotten the disease during childhood, when cases tend to be mild, and acquired life-long immunity (Pritchett and Tulani 1995). Epidemic yellow fever during the nineteenth century had a fatality rate between 15 and 50 percent (Patterson 1992) implying that if 8 percent of a city died of yellow fever, then at least another 8 percent were infected and survived.

Because city officials did not know what caused yellow fever, cities tried various measures to stop the disease. American cities created Health Boards with the authority to quarantine ships from infected ports and order street cleanings (Duffy 1992). Physicians claimed that the disease only struck the "intemperate" and "imprudent." Public notices warned that excessive drinking or eating, and poor personal hygiene caused the disease. Believing that immoral behavior caused pestilence, politicians frequently called for prayer, repentance, and days of fasting. Although yellow fever could kill 10 percent of a city, Patricia Beeson and Werner Troesken (2006) find that yellow fever and small pox epidemics had little to no effect on long-term population growth or on trade, suggesting that any stoppage in economic activity was temporary.

The first person to my knowledge to argue that pregnant women might spread yellow fever to their fetuses was Dr. Joseph Jones in an 1894 JAMA article. Dr. Jones' evidence came from the case of a yellow fever patient at Charity Hospital in New Orleans in which a woman presented symptoms of yellow fever (nausea, vomiting, and jaundice). Shortly afterward, she gave birth to a jaundiced (the symptom for which yellow fever got its name) still-born fetus. A few days later, the woman died of yellow fever. Dr. Jones also noted many similar cases with smallpox, and argued that a mother could transmit yellow fever to the fetus in a similar way.

Recent case studies have suggested that the virus might spread to children during lactation as well. In 2009, a Brazilian woman received the yellow fever vaccine postpartum. Fifteen days after giving birth to a healthy infant, the woman received a yellow fever vaccination because yellow fever was spreading to a non-endemic region of Brazil. Eight days later, the infant refused to nurse and had a fever. The infant was admitted to the hospital, and an investigation determined that the infant received the yellow fever vaccine virus from breastfeeding (CDC 2010). Kuhn et al (2011) discuss a similar case study from a Canadian woman who received the vaccination to travel to Venezuela. More research is needed in this area, and where historical records are lacking, researchers could turn to the modern yellow fever epidemics in Latin America and Africa.

3 Data

3.1 Fatality Data

Yellow fever fatality count data are from J.M Toner (1878). Toner pooled several sources from his medical library to document every yellow fever epidemic in the United States for which data was available. Toner's data appears to be complete after 1820, and there are few subsequent epidemics with missing fatality counts. Beeson and Troesken (2006) use Toner's data to analyze the effect of yellow fever epidemics on city population growth.

I convert fatality counts to fatality rates under the assumption that cities grow linearly between Census years. Figure 1 displays time-series yellow fever fatality rate data for New Orleans, LA, Charleston, SC, Mobile, AL, and Norfolk, VA. The data from Figure 1 suggest that yellow fever appeared unexpectedly. The yellow fever fatality rate in one year does not predict the absence or presence of an epidemic in the next year. Furthermore, an epidemic in one port city did not necessarily spread to others. For example, the worst yellow fever epidemic in New Orleans, LA, was in 1853, whereas Norfolk, VA, was not struck by yellow fever until 1855.

3.2 1880 Census

The micro occupational data are from the 100-percent sample of the 1880 Census available in the Integrated Public Use Microdata Series (Ruggles et al 2010). I restrict attention to white males born between 1835 and 1864, because labor force participation is nearly universal for this group in 1880. Normally, only state of birth is available in the IPUMS. However, in the 1880 Census the alphabetic birthplace string is available. While Census enumerators were instructed to record state of birth or territory of birth if an individual was born outside of the U.S., not all enumerators followed these instructions exactly. A subset of enumerators recorded city of birth. In the 100-percent sample of the U.S. Census, enough enumerators made this mistake to create a data set that includes birth city. For the main analysis, I searched Census records in which the enumerator included the individual's city of birth, allowing for misspellings and variations in punctuation. I include individuals born in one of four US cities: New Orleans, LA; Charleston, SC; Mobile, AL; and Washington, D.C. I refer to this sample as Sample 1. No other Southern city had enough individuals with city of birth mistakenly recorded to meaningfully affect the analysis.

Although a subset of enumerators may have mistakenly included city of birth, these mistakes were not limited to a narrow geographical region. To see this, Figure 2 maps the geographic distribution of white males born between 1835-1864 who reported being born in New Orleans. Most individuals still reside in Louisiana. However, many moved to New York, Pennsylvania, Missouri, and California. Additionally, most states are represented, but in smaller numbers. For comparison, Figure 3 maps the geographic distribution of individuals who reported being born in Washington, DC. Since Washington, DC is both the city of birth and state of birth, the DC distribution is what ideal city of birth data would resemble. For the DC data, most individuals stayed within the region (DC, Maryland, and Virginia). Significant numbers moved to New York, Illinois, Pennsylvania, Missouri, and California. Additionally, most states are represented. An alternative to exploiting the mistakes of enumerators would be linking individuals across Censuses. However, merging the 1850-1880, 1860-1880, and 1870-1880 samples from the IPUMS do not yield enough observations born during yellow fever epidemics.

Yellow fever visited New Orleans, Charleston, and Mobile. I include Washington, DC, in the sample for various reasons. Including a city free of yellow fever allows me to estimate birth year fixed effects during years in which the three other cities experienced the disease. To make the birth year fixed effects as representative as possible of what would have happened in other cities in the absence of epidemics, we would like to include a city as similar as possible to those struck by yellow fever. Cities struck by yellow fever had warm summers, were on coasts or rivers, and were below an elevation of 500 feet (Toner 1873). Cities as far north as Baltimore and Philadelphia had smaller outbreaks of yellow fever during the time period, and Washington is the southernmost major city that was not struck by yellow fever. Furthermore, Washington is on the Potomac River and has an elevation of only 23 feet. Another reason to include Washington, DC, in the sample is that Washington is the only city in which birth city corresponds with "state of birth." This feature of DC dramatically increases the sample size and allows my to precisely estimate the birth year fixed effects.

These sample restrictions result in 15,273 observations for Sample 1. Sample 1 includes 13,303 individuals born in Washington D.C., which comprise 87 percent of sample. Washington is highly represented in Sample 1 because even enumerators who followed instructions recorded birth city. The sample includes 1,631 individuals born in New Orleans, LA; 196 born in Charleston, SC; and 139 born in Mobile, AL. The top panel of Table 2 presents summary statistics for Sample 1. The average birth year is 1853.8. Individuals with a foreign-born mother and foreign-born fathers comprise 32 percent and 35 percent of the sample, respectively. The occupational categories include occupational nonresponse (12 percent), unskilled laborers (18 percent), skilled laborers (39 percent), and professionals (31 percent). Because income is not available in the 1880 Census, in the analysis I use an ordered probit model treating occupational nonresponse as the lowest category, and professional as the highest. Although this approach is not perfect, it should capture socioeconomic status on average. Additionally, I analyze linear models in which I merge this data with occupational income and occupational unemployment data from 1900 compiled in Appendix A from Preston and Haines

(1991).

Because only Census records with city of birth are included in the sample, this sample is not necessarily representative of individuals born in cities. However, for this to bias the estimates of the effects of early-life disease exposure, occupational status would have to be biased in opposite direction for those born during epidemic years and for those born during non-epidemic years. This kind of bias seems unlikely. To address this concern further, I construct an alternative sample without this problem. Sample 2 includes the universe of white males living in New Orleans, LA, Mobile, AL, Charleston, SC, or Washington, DC, who were also born in the same state. This sample is not perfect either. Sample 2 does not include those born in cities affected by yellow fever who then left the city. Sample 2 also includes those from the countryside of the same state that migrated to the city. Since those from the countryside would not have been exposed to yellow fever, this problem should attenuate the results. However, if the results from using Sample 2 align closely with those from using Sample 1, we can be more confident in the results.

Summary statistics for Sample 2 are in the bottom panel of Table 2. Those in Sample 2 are more likely to have foreign-born parents than those in Sample 1. This feature of Sample 2 is because immigrants are more likely to remain in the city. Sample 2 also contains fewer farm workers, because those who reside in the city are unlikely to work in farming. There is little overlap in the two samples. For example, Sample 2 is twice the size of Sample 1.

4 Econometric Model

Because neither income nor educational attainment are available in the 100-percent sample of the 1880 Census, I focus on the effect of early-life disease exposure on occupational choice. Occupational data is categorical; consequently, I use an ordered probit model. Suppose occupational categories are ordered from lowest to highest as follows: occupational nonresponse, unskilled laborers, skilled laborers, and professionals. Furthermore, suppose that o^*_{ibc} is a latent occupational index variable for individual i born during birth year b in city c, and is defined by

$$o^*_{ibc} = \alpha_b + \beta_c + \gamma Y_{bc} + X_i'\theta + \epsilon_i \tag{1}$$

where α_b is a set of dummy variables for each birth year, β_c is a set of dummy variables for each birth city, and Y_{bc} is the yellow fever fatality rate in individual i's birth year b and birth city c. The vector X_i is a set of control variables containing dummy variables for each birthplace of individual i's mother. The term ϵ_i is distributed according to the standard normal. Because yellow fever epidemics occurred unpredictably, I assume that Y_{bc} is independent of ϵ_i.

Individual i enters occupational category j (which is to say $o_{ibc} = j$) if $\mu_{j-1} < o^*_{ibc} \leq \mu_j$. It follows that

$$\begin{aligned} Pr\left[o_{ibc} = j\right] \;&=\; \Phi\left(\mu_j - \alpha_b - \beta_c - \gamma Y_{bc} - X_i'\theta\right) \\ &\quad -\Phi\left(\mu_{j-1} - \alpha_b - \beta_c - \gamma Y_{bc} - X_i'\theta\right) \end{aligned} \tag{2}$$

where Φ is the CDF of the standard normal distribution.

One interpretation of this model is to view o^*_{ibc} as unobservable ability. Higher ability individuals enter high-income occupations. Early-life disease exposure reduces ability, and consequently moves the marginal individual into lower earning occupational categories.

I also estimate two variations of equation (1). The first variation allows the effect of yellow fever for individuals with foreign-born mothers, who were more susceptible to yellow fever, to be different from those with US-born mothers. The latent index variable becomes

$$
\begin{aligned}
o^*_{ibc} \quad = \quad & \alpha_b + \beta_c + \gamma_0 Y_{bc} \times \mathbf{1}\,[\text{Foreign-born mother}] \\
& + \gamma_1 Y_{bc} \times \mathbf{1}\,[\text{US-born mother}] + X_i'\theta + \epsilon_i
\end{aligned}
\tag{3}
$$

where $\mathbf{1}\,[\text{Foreign-born mother}]$ is an indicator variable that is equal to 1 if the individual's mother was born outside of the United States. Because all observations were born in one of four US cities, there are no immigrants in the sample. However, some were born into immigrant families. The parameters γ_0 and γ_1 represent the effects of early-life yellow fever for individuals born into immigrant families and for individuals born into native families, respectively, on the latent occupation index.

The second variation modifies equation (1) to include yellow fever fatality rates during an individuals year of birth, as well as the year before birth and the four years after birth. As in equation (2), for this specification, I interact the variables with an indicator variable equal to one if an individual is white with an immigrant mother. The coefficients in an ordered probit model do not have an easy interpretation beyond sign and significance, so I also report the marginal effect on the probability of entering specific occupational categories $\frac{\partial Pr[o_{ibc}=j]}{\partial Y_{bc}}$.

In section 5.2, I will also analyze linear models in which the dependent variable in the average income or average months unemployed for each occupation in 1900. The linear models use the same set of regressors but with non-categorical dependent variables.

5 Results

5.1 Ordered Occupational Category Results

Estimates from equations (1) and (3) appear in the top panel of Table 3 for Sample 1 (the main sample). The first column displays the estimated coefficients from equation (1) and the second column displays the marginal effect on the probability of entering a professional occupation. The main effect of early-life yellow fever exposure is negative and significant at five percent level, suggesting yellow fever during an individual's birth year decreased occupational status. The associated marginal effect implies that being born during a yellow fever epidemic that killed one percent of the city decreased the probability of entering a professional occupation by approximately 1.6 percentage points. This implies that those born during the 1853 yellow fever epidemic were 9.6 percentage points less likely to become professionals than they would have in the absence of the epidemic.

The third and fourth column display the estimates and marginal effects from equation (2), which allows for the effect of early-life yellow fever exposure to be different for those born to immigrant mothers and for those born to US-born mothers. The results suggest that the children of US-born mothers were relatively unaffected. The estimated coefficient for those with US-born mothers is close to zero and statistically insignificant. However, the effect of early-life yellow fever exposure is negative and significant at the one percent level for those born to immigrant mothers. The marginal effect predicts that the children of immigrant mothers who were born during epidemics that killed one percent of a city were 2.3 percentage points less likely to become professionals. Because immigrants were far more susceptible to the disease than natives, this provides evidence that the mechanism is disease exposure and not a temporary stoppage of economic activity.

Figure 4 displays the predictive margins from this specification, holding all other covariates at their sample means. Children born during yellow fever epidemics to immigrant mothers are less likely to be professional, and more likely to be unskilled laborers or to not report an occupation. As the size of the epidemic increases, both the lower and upper bounds of the 95 percent confidence intervals are strictly decreasing for professional occupations and strictly increasing for unskilled laborers and occupational nonresponse. However, children born during yellow fever epidemics to US-born mothers are unaffected. The point estimate of the predictive margins hardly change with exposure to yellow fever during early life. Furthermore, for the children of US-born mothers, the point estimate for each occupational category when their is no epidemic (a 0 percent fatality rate) is contained in the 95 percent confidence interval for an epidemic that takes 6 percent of the city. The same cannot be said for the children of immigrant mothers.

The results from the previous regressions are from individuals who reported a city of birth in the 100 percent sample of the 1880 Census (Sample 1). It is possible, even if unlikely, that this could bias the results. To see if this result is driven by the sample selection, I repeat the analysis for Sample 2 in the bottom panel of Table 3: all individuals who live in New Orleans, LA, Mobile, AL, Charleston, SC, or Washington, DC, in 1880 and were born in the same state. This sample is not perfect either, because it will contain individuals who were born in the countryside and then moved to the city. However, since these individuals were not exposed to yellow fever, if anything, this should only attenuate the results.

The results are strikingly similar. For example, the estimated marginal effect for the whole population is -1.67 in the first sample (significant at the five percent level), and -1.21 (significant at the one percent level) in the second sample. Similarly, the estimated marginal effect of yellow fever for those born to immigrant mothers is -2.28 in the first sample, and -1.88 percent in the second sample, both of which are significant at the one percent level. The estimated marginal effects from those born to US-born mothers is statistically insignificant in both samples. The results are remarkably similar given that there is little overlap between these two samples (the second sample is twice the size of the first).

Figure 5 is analogous to Figure 4, but uses Sample 2 instead of Sample 1. The results are nearly identical, expect that the confidence intervals are smaller. The children of immigrant mothers are negatively affected by yellow fever epidemics during early-life. Yellow fever epidemics decrease the probability that they enter a professional occupation and increase the probability that they become unskilled laborers or report occupational nonresponse. The children of US-born mothers are still unaffected, even at high levels of yellow fever, the predictive margins are indistinguishable from the predictive margins in the absence of an epidemic.

5.2 1900 Occupational Income Index Results

In the previous subsection, I assumed occupations are ordered. Although this should measure socioeconomic status on average, it has some problems. The highest paid skilled laborers probably earn more than the lowest paid professionals. Unfortunately, occupation is the only meaningful labor-market outcome in the 100-percent sample of the 1880 Census. Occupational income scores do not exist for the time period. However, Appendix A of Preston and Haines (1991) presents average income and average months unemployed by occupation in 1900. Since these variables are equivalent to the 1950 occupational income scores available in the IPUMS (just from smaller samples), I will refer to these variables as 1900 occupational income scores and occupational unemployment scores. In this section, I merge this data to the 1880 Census microdata, and use a linear model to analyze the effects of early-life yellow fever exposure on the log of

1900 occupational income scores and on occupational unemployment scores (which is a proxy for average job security by occupation). As an additional dependent variable, I include the Duncan Socioeconomic Index, which is a measure of occupational prestige.

The results are in Table 4. The top panel uses data from Sample 1 (individuals who reported being born in New Orleans, Mobile, Charleston, or DC), and the bottom panel uses data from Sample 2 (individuals living in New Orleans, Mobile, Charleston, or DC, and were born in the same state). As in the previous subsection the results from the two samples are remarkably similar.

The results suggests that being born during a yellow fever epidemic that killed one percent of the city decreased occupational earnings by between 0.7 percent (Sample 2) and 1.7 percent (Sample 1). These estimates are both significant at the five percent level. Epidemics affected those born to immigrant mothers and did not affect those born to native mothers. A yellow fever epidemic that killed one percent of the city decreased occupational earnings by between 1 percent (Sample 2) and 2.3 percent (Sample 1). These estimates are significant at one and five percent levels, respectively. There is no evidence that early-life yellow fever exposure increased the likelihood of individuals entering occupations with a high risk of unemployment. Lastly, yellow during early-life decreased Duncan SEI scores, but this result is only significant for the children of immigrant mothers.

Figures 6 and 7 present these results visually. These figures present the residuals of a regression of the log of 1900 occupational income scores on a set of birth year fixed effects, birthplace fixed effects, and mother's birthplace fixed effects. I then plot these residuals against the yellow fever fatality rate during an individual's birth year for those with immigrant mothers and for those with native mothers. Each point is the average residual for a birth year/birth city combination. The size of each circle is proportional to the number of observations in that birth year/birth city cell. The residuals are downward sloping for those with immigrant mothers, but the lines are flatter for those with US-born mothers, suggesting that yellow fever epidemics do not explain residual income for this group.

6 Robustness tests

6.1 Local Trade

The estimates from the previous sections are unbiased under the assumption of random sampling and if early-life yellow fever exposure is uncorrelated with other unobservable characteristics affecting human capital development. Yellow fever exposure was primarily correlated with nativity, race, urban status, trade, and weather. Nativity is observable in the sample and I control for it using a set of dummy variables for the birthplace of the mother. Race is uncorrelated with the error term, because the sample is restricted to whites. The preferred sample is also restricted to individuals born in cities. This leaves trade and weather. Yellow fever was associated with robust trade and booming economic times. Trade ships from the Caribbean would bring the *Aedes aegypti* mosquito and yellow fever with them, and a growing economy would then attract previously uninfected immigrants. These two forces together could result in an epidemic. If local trade and economic conditions also affects nutrition or other human capital investments, it is possible that this is confounding the effect of yellow fever on adult occupational outcomes. Similarly, for the *Aedes aegypti* to spread the disease, local weather patterns would have to be conducive to mosquito activity. Unfortunately, I am unaware of any temperature or precipitation data at the city level dating back to 1840s and 1850s. However, several sources for local trade data exist.

In this subsection, I test whether the results remain when controling for local trade data. Trade data come from Albion (1985), the 1879 Statistical Abstract of the United

States, and the DeBow (1854). These sources include nominal exports, nominal imports, and total tonnage entering a city port for most years in the sample. Although Washington, D.C. is on a river, most of the trade to the area arrived through Baltimore. The lack of trade activity in Washington, D.C. is absorbed through the birth city fixed effect. Figure 8 graphs the time series for entering tonnage for Charleston, Mobile, and New Orleans. All three time series are trending upward, however, there is substantial year-to-year variation. I convert nominal trade data into real terms, and add these three variables as controls to the original specifications: real exports, real imports, and entering tonnage.

The results from this exercise are in Tables 5 and 6. The ordered probit results are similar to those in Table 3. The only noticeable distinction is that the main effect of yellow fever in Sample 1 is no longer statistically significant. However, the effect of yellow fever for those with immigrant mothers is still significant at the five percent level. The children of US-born mothers are still unaffected by the disease. The results for Sample 2 are hardly changed at all after controlling for local trade during an individual's birth year. Table 6 presents the linear regression results. These results are similar to Table 4, but less precise. Yellow fever during an individual's birth year still decreases 1900 occupational income score for the children of immigrant mothers, but the main effect (before interacting with nativity) is no longer significant for Sample 2. The results for Duncan SEI are similar in magnitude but no longer significant for Sample 1, however, when interacted with an indicator for foreign-born mother, it remains significant for Sample 2. It is slightly concerning that there is marginal significance on the interaction between yellow fever and an indicator for having a US-born mother when looking at occupational unemployment scores, however, this is only at the 10-percent level.

6.2 Yellow Fever Exposure at Other Ages

So far, I have only considered the effect of yellow fever epidemics during an individual's year of birth. Table 7 includes the yellow fever fatality rate in an individual's year of birth, as well as the year before birth, and the four years following birth. As in equation (3), I interact these variables with a dummy variable indicating if an individual was born to a immigrant mother. I include these years individually (as has been done in the previous sections for the individual's year of birth) and altogether. The results suggest that yellow fever during an individual's year of birth, the following year, and two years after birth predict lower occupational status for individuals born to a immigrant mother when estimating the model one year at a time. When estimating the model with all years together, only year of birth is significant, but only at a ten percent level. Notice that yellow fever exposure during any age is not significant for the children of US-born mothers, and only the children of immigrant mothers are negatively affected. These results are generally consistent with the extant literature. For example, Almond (2006) finds that the long-run effects of the 1918 influenza pandemic were mostly for individuals who were *in utero*. However, Barreca (2010) finds that malaria during the *in utero*, neonatal, and postnatal periods had long run negative effects on labor market outcomes. On the other hand, Case and Paxson (2008) find that disease environment during age two has the most significant effects on cognition. Consistent with all of these studies, I find no effect at ages 3 and 4.

6.3 Selection from Fleeing the City

During yellow fever epidemics, many fled to the countryside. These reactions could potentially be problematic for giving the association between early-life yellow fever and occupational status a causal interpretation. If only the wealthy could afford to leave the city, those left behind would be relatively poor. Consequently, even if yellow fever had no long run effects on human capital formation, it is possible that those born during the epidemic would enter lower paying occupations than those born during non-epidemic years. Historically, there is no doubt that many responded to the news of a yellow fever epidemic in this way. However, it is another question of whether enough people and whether the right subset of people responded this way to explain the results documented in the previous sections.

For residents fleeing the city to explain the previous results, immigrants would have had to flee is larger numbers than those with US-born mothers. This seems unlikely, because the wealthiest citizen would typically leave the city. Individuals with US-born parents would have been more likely to have family living in the countryside with whom they could reside until the epidemic had passed. However, I find that the children of immigrants were more negatively affected by yellow fever epidemics–a group of people for whom we have strong biological evidence that they were more susceptible to the disease and for whom we have no reason to believe they would flee in larger numbers than natives.

Nonetheless, we can examine whether enough people fled the city during epidemic years by observing the number of individuals that show up in the sample. A drop of 10 percent of less could be explained by the disease itself. However, if the number of births dropped significantly more during epidemic years, this could be reason to suspect that the number of pregnant women who fled the city were large enough to affect the regression results. Figure 9 displays the number of individuals for Sample 1 and Sample 2 for each birth cohort and birth city cell. I also display a nonparametric smoothed regression line through cohorts born during non-epidemic years. Large deviations from that line during epidemic years are a sign that a substantial portion of the population fled for the countryside. Figure 9 shows that any deviation from the trend during epidemic years was small.

6.4 Choice of Control Cities

In the previous analysis, Washingtonians act as a control group. Because yellow fever did not visit Washington, DC, during the sample period, including Washingtonians enables estimation of birth cohort effects even during years in which New Orleans, Charleston, and Mobile all experienced yellow fever. Furthermore, because Washington, DC, is the only city for which "state of birth" corresponds with city of birth, including DC in the sample drastically increases the sample size and allows for precise estimation of other control variables as well (such as the dummies for the mother's birthplace). Washington also has the advantage of being Southern, at least relative to most U.S. cities at the time, having a low elevation, and being on a river, all of which were common features of cities plagued by yellow fever.

As a robustness check, I add the following cities: Richmond, VA; St. Louis, MO; Cincinnati, OH; Louisville, KY; Pittsburgh, PA, Baltimore, MD; Philadelphia, PA; and Norfolk, VA. The first six did not experience outbreaks of yellow fever during the sample period, although St. Louis, Cincinnati, and Baltimore experienced outbreaks in other periods. Philadelphia experienced a couple of minor outbreaks, but no major yellow fever epidemics during the sample period. The 1855 epidemic of Norfolk, VA, took about 10 percent of the city, but I previously excluded Norfolk because it contributed little to the sample size. White males born between 1835-1864 in these cities as well as the original four produce a sample of 22,796 from the 100-percent sample of the 1880 Census.

Table 8 reproduces the main ordered probit estimates for this new sample. The estimates are qualitatively similar. Yellow fever during an individual's year of birth negatively predicts occupational status, but is not significant at the ten percent level.

Yellow fever during early life interacted with a dummy for having an immigrant mother is negative and significant at the five percent level. The results suggest that being born during a yellow fever epidemic that took one percent of the city would have decreased the probability of becoming a professional by 1.9 percent for the children of immigrant women. Yellow fever exposure during early life does not meaningful affect the adult occupational outcomes of the children of U.S.-born mothers.

6.5 African Americans and Yellow Fever

Yellow fever primarily affected white immigrants. Native whites and blacks were relatively immune from the disease, and when they did contract yellow fever, cases tended to be mild. I exclude blacks from the previous analysis because few blacks lived in cities during the 1835-1864 period. The blacks that were born in cities rarely had the opportunity to enter professional occupations by 1880. Here I add blacks to the sample, and consider how yellow fever may have affected them. Because blacks were relatively immune, in some ways this acts as a placebo test. If there is strong evidence that yellow fever epidemics during early life are correlated with adult occupations for blacks and immigrants, but not native whites, we might be concerned that the cities' responses to yellow fever in ways that only affected low-income communities.

Table 9 repeats the estimates from Table 8, but includes controls for race. Because relatively few blacks lived in New Orleans, Mobile, and Charleston, I also individuals from the additional control cities mentioned in the previous subsection. The results indicate that yellow fever negatively predicted occupational status for the children of white immigrants, but not for the children of white U.S.-born mothers or the children of blacks. The point estimates for early life yellow fever exposure for blacks and whites with U.S.-born mothers are small, statistically insignificant, and of the wrong sign. Yellow fever exposure during early life still negatively predicts occupational status for the children of white immigrants and is statistically significant.

7 Conclusion and Discussion

The results of this paper suggest that yellow fever epidemics had profound impacts on the distribution of occupations a generation later. This implies that the economic benefit of eradicating the disease may be higher than previously thought. Furthermore, if the effects from other urban diseases such as cholera, tuberculosis, dysentery, and typhoid fever had similar effects, then the benefits from the urban mortality transitions would be even larger.

There are several caveats to this study. First, city-of-birth data is only available for a small subset of the 100-percent sample of the 1880 Census, and this sample may or may not be random. However, even if the sample is biased, so long as that bias is not correlated with early life year fever exposure, it should not affect the results. Furthermore, using individuals currently living in these cities and who were born in the same state in 1880 yields remarkably similar results. Linear models using 1900 occupational data suggest that early-life yellow fever exposure induced the children of immigrant mothers to enter lower paying occupations, however, they were no more likely to enter occupations with high unemployment rates.

Another limitation is that only year of birth, and not quarter or month of birth, is available in the 1880 Census. Without at least quarter of birth, it is impossible to say whether an individual would have been *in utero* or not during an epidemic. Yellow fever epidemics struck during the summer months, implying that many individuals who were *in utero* during the epidemic would have been born during the same year. However, the results are at least suggestive that yellow fever may have been transmitted to children during gestation and lactation. I only find strong evidence that exposure during the year of birth matters; I find weak evidence that exposure during ages 1 and 2 matters; and I find no evidence that epidemics during ages 3 or 4 have long-run effects. This timing is consistent with the *in utero*, neonatal, and postnatal stages of life. Second, although yellow fever infected many adults (including mothers), children were less likely to become infected. Cases in which children became infected were typically mild.

Another possibility that I have not ruled out is that these results are driven by the fact that the children of immigrant mothers were more likely to be orphaned. This was indeed the case since immigrants were more susceptible to the disease. However, by living in a city that was regularly visit by yellow fever, children who were not in early-life would also be at risk of being orphaned, and this risk would be absorbed by the birth city fixed effects and by controls for the mother's nativity. Furthermore, I find no evidence that a yellow fever epidemic at age 3 or age 4 decreased adult occupational status. If orphaned children are driving this result, it would have to have disproportionally affected children who were orphaned during early life more so than children who were orphaned during later in childhood.

References

Albion, Robert. "The Rise of the New York Port." *Charles Scribner's and Sons*, 1935.

Almond, Douglas. "Is the 1918 Influenza Pandemic Over? Long-Term Effects of In Utero Influenza Exposure in the Post-1940 U.S. Population." *Journal of Political Economy*, Vol 114, No. 4, 2006, pp 672-712.

Almond, Douglas, and Janet Currie. "Human Capital Development Before Age Five" *Handbook of Labor Economics*, Vol. 4, Chap. 15, 2011, pp 1315-1486.

Almond, Douglas, and Janet Currie. "Killing Me Softly: The Fetal Origins Hypothesis." *Journal of Economic Perspectives*, Vol. 25, No. 3, 2011, pp 153-172.

Barecca, Alan. "The Long-Term Economic Impact of In Utero and Postnatal Exposure to Malaria." *Journal of Human Resources*, Vol. 45, No. 4, 2010, pp 865-892

Barker, David. "The Fetal Origins of Coronary Heart Disease." *British Medical Journal*, Vol. 311, No. 6998, 1995, pp 171-174.

Beeson, Patricia and Werner Troesken. "When Bioterrorism Was No Big Deal." *NBER Working Paper Series*, 2006.

Bleakley, Hoyt. "Disease and Development: Evidence from Hookworm Eradication in the American South." *The Quarterly Journal of Economics*, Vol. 122, No. 1, 2007.

Case, Anne, and Christina Paxson. "Early Life Health and Cognition Funcation in Old Age." *American Economic Review: Papers and Proceedings*, Vol. 99, No. 2, 2008.

Case, Anne, Angela Fertig, and Christina Paxson. "The Lasting Impact of Childhood Health and Circumstances." *Journal of Health Economics*, Vol. 24, No. 2, 2005, pp 365-389.

CDC. "Transmission of Yellow Fever Vaccine Virus Through Breast-Feeding – Brazil, 2009" *Morbidity and Mortality Weekly Report*, Center of Disease Control, 2010.

DeBow, J.D.B. "Statistical Views of the United States." *United States Census Bureau*, 1854.

Duffy, John. "The Sanitarians: A History of American Public Health." *University of Illinois Press*, 1992.

Haines, Michael. "The Urban Mortality Transition in the United States, 1800-1940." *NBER Working Paper Series*, 2001.

Jones, Joseph. "Communication of Yellow Fever from the Mother to the Fetus in Utero" *The Journal of the American Medical Association*, Volume 23, 1894.

Kuhn, Susan, Loreto Twele-Montecinos, Judy MacDonald, Patricia Webster and Barbara Law. "Case report: probable transmission of vaccine strain of yellow fever virus to an infant via breast milk." *Canadian Medical Association Journal*, 2011.

Patterson, KD. "Yellow Fever Epidemics and Mortality in the United States, 1693-1905." *Social Sciences and Medicine*, Vol. 34, No. 8, pp 855-865.

Preston, Samuel, and Michael Haines. "Fatal Years: Child Mortality in Late Nineteenth-Century America." *Princeton University Press*, 1991.

Pritchett, Jonathan, and Insan Tunali. "Strangers' Disease: Determinants of Yellow Fever Mortality during the New Orleans Epidemic of 1853." *Explorations in Economic History*, Vol. 32, No. 4, 1995, pp 517-539.

Ruggles, Steven, J. Trent Alexander, Katie Genadek, Ronald Goeken, Matthew Sobek, and Matthew B. Schroeder. *Integrated Public Use Microdata Series*, Version 5.0, Machine-readable database. Minneapolis: University of Minnesota, 2010.

Toner, J.M. "The Distribution and Natural History of Yellow Fever as it has Occurred at Different Times in the United States." *Public Health Pap Rep*, 1873, 359-384.

Table 1: Yellow fever outbreaks by city

city	state	1668-1873	post-1835	
		number of outbreaks	number of outbreaks	outbreaks with more than 100 victims
Mobile	AL	28	16	6
New Haven	CT	6	0	0
Wilmington	DE	2	0	0
Pensacola	FL	22	15	0
Savannah	GA	9	4	1
New Orleans	LA	66	32	21
Baltimore	MD	14	1	0
Boston	MA	10	1	0
Natchez	MS	13	7	2
St Louis	MO	2	2	0
New York City	NY	62	14	0
Wilmington	NC	3	1	1
Cincinnati	OH	2	2	0
Philadelphia	PA	34	3	1
Providence	RI	5	0	0
Charleston	SC	52	15	7
Memphis	TN	4	4	1
Galveston	TX	10	10	9
Norfolk	VA	18	4	1

Source: J.M. Toner (1873)

United States Department of the Treasury, "Statistical Abstract of the United States" *Government Printing Office*, 1879.

Table 2: Summary statistics

Sample 1					
Variable	Mean	Std. Dev.	Min.	Max.	N
immigrant mother	0.32	0.466	0	1	15273
immigrant father	0.353	0.478	0	1	15273
birth year	1853.822	7.849	1835	1864	15273
urban	0.869	0.337	0	1	15269
professional	0.312	0.463	0	1	15273
skilled laborer	0.388	0.487	0	1	15273
unskilled laborer	0.176	0.381	0	1	15273
occupational nonresponse	0.124	0.329	0	1	15273
Duncan SEI	29.08	23.162	0	96	15269
yellow fever fatality rate	0.083	0.515	0	6.035	15273

Sample 2					
Variable	Mean	Std. Dev.	Min.	Max.	N
immigrant mother	0.481	0.5	0	1	34604
immigrant father	0.522	0.5	0	1	34604
birth year	1854.493	7.482	1835	1864	34604
urban	1	0	1	1	34604
professional	0.378	0.485	0	1	34604
skilled laborer	0.315	0.465	0	1	34604
unskilled laborer	0.197	0.398	0	1	34604
occupational nonresponse	0.109	0.312	0	1	34604
Duncan SEI	30.168	22.293	0	96	34604
yellow fever fatality rate	0.444	1.107	0	6.035	34604

Notes: Sample 1 includes white males in the 100-percent sample of the 1880 Census who reported being born in either New Orleans, LA, Mobile, AL, Charleston, SC, or Washington, DC, allowing for misspellings and variations in punctuation. Sample 2 includes white males in the 100-percent sample of the 1880 Census that lived in New Orleans, LA, Mobile, AL, Charleston, SC, or Washington, DC, and were born in the same state.

Table 3: Order probit results

Sample 1

	(1) coefficient	(2) marginal effect	(3) coefficient	(4) marginal effect
Y_b	-0.0497**	-0.0167**		
	(0.0207)	(0.00694)		
$Y_b \times \mathbf{1}$ [Immigrant mother]			-0.0680***	-0.0228***
			(0.0241)	(0.00810)
$Y_b \times \mathbf{1}$ [US-born mother]			-0.0204	-0.00684
			(0.0338)	(0.0114)
Pseudo R^2	0.0439		0.0439	
N	15269	15269	15269	15269

Sample 2

	(1) coefficient	(2) marginal effect	(3) coefficient	(4) marginal effect
Y_b	-0.0335***	-0.0121***		
	(0.00874)	(0.00316)		
$Y_b \times \mathbf{1}$ [Immigrant mother]			-0.0520***	-0.0188***
			(0.00942)	(0.00341)
$Y_b \times \mathbf{1}$ [US-born mother]			-0.00400	-0.00145
			(0.0116)	(0.00420)
Pseudo R^2	0.0339		0.0340	
N	34604	34604	34604	34604

Notes: Sample 1 includes white males in the 100-percent sample of the 1880 Census who reported being born in either New Orleans, LA, Mobile, AL, Charleston, SC, or Washington, DC, allowing for misspellings and variations in punctuation. Sample 2 includes white males in the 100-percent sample of the 1880 Census that lived in New Orleans, LA, Mobile, AL, Charleston, SC, or Washington, DC, and were born in the same state. Columns (1) and (3) are coefficients from ordered probit regressions and Columns (2) and (4) are the associated marginal effects on the probability of entering a professional occupation. Each regression contains a set of dummy for each birth year, birth city, and birth state/country of the mother. Robust standard errors are in parenthesis.

$*$ 10 percent significance; $**$ 5 percent significance; $***$ 1 percent significance

Table 4: Linear occupational score results

Sample 1

	(1)	(2)	(3)	(4)	(5)	(6)
	log of occ. income score		occ. unemployment score		Duncan SEI	
Y_b	-0.0176**		0.0209		-0.982**	
	(0.00734)		(0.0191)		(0.406)	
$Y_b \times \mathbf{1}$ [Immigrant mother]		-0.0228**		0.0231		-1.033**
		(0.00947)		(0.0217)		(0.509)
$Y_b \times \mathbf{1}$ [US-born mother]		-0.00835		0.0173		-0.907
		(0.00960)		(0.0314)		(0.589)
R^2	0.0563	0.0564	0.0461	0.0461	0.0919	0.0919
N	10918	10918	14351	14351	15269	15269

Sample 2

	(1)	(2)	(3)	(4)	(5)	(6)
	log of occ. income score		occ. unemployment score		Duncan SEI	
Y_b	-0.00728**		-0.00251		-0.594***	
	(0.00303)		(0.00954)		(0.189)	
$Y_b \times \mathbf{1}$ [Immigrant mother]		-0.0107***		0.0107		-0.946***
		(0.00343)		(0.0103)		(0.205)
$Y_b \times \mathbf{1}$ [US-born mother]		-0.00204		-0.0218*		-0.0808
		(0.00383)		(0.0118)		(0.234)
R^2	0.0813	0.0815	0.0399	0.0401	0.0941	0.0945
N	26321	26321	32593	32593	34604	34604

Notes: Sample 1 includes white males in the 100-percent sample of the 1880 Census who reported being born in either New Orleans, LA, Mobile, AL, Charleston, SC, or Washington, DC, allowing for misspellings and variations in punctuation. Sample 2 includes white males in the 100-percent sample of the 1880 Census that lived in New Orleans, LA, Mobile, AL, Charleston, SC, or Washington, DC, and were born in the same state. Occupational income score is the 1900 average earnings of an occupation and occupational unemployment score is average months unemployed for an occupation. Both of these scores are national averages for each occupation in 1900 as reported in Appendix A of Preston and Haines (1991). Each regression include birth year and birthplace fixed effects, as well as dummies for the mother's birthplace. Robust standard errors are in parenthesis.

$*$ 10 percent significance; $**$ 5 percent significance; $***$ 1 percent significance

Table 5: Ordered probit results controlling for early-life trade

Sample 1

	(1) coefficient	(2) marginal effect	(3) coefficient	(4) marginal effect
Y_b	-0.0347	-0.0117		
	(0.0222)	(0.00745)		
$Y_b \times \mathbf{1}$ [Immigrant mother]			-0.0529**	-0.0178**
			(0.0254)	(0.00853)
$Y_b \times \mathbf{1}$ [US-born mother]			-0.00485	-0.00163
			(0.0361)	(0.0121)
Pseudo R^2	0.0450		0.0450	
N	14990	14990	14990	14990

Sample 2

	(1) coefficient	(2) marginal effect	(3) coefficient	(4) marginal effect
Y_b	-0.0206**	-0.00749**		
	(0.00936)	(0.00340)		
$Y_b \times \mathbf{1}$ [Immigrant mother]			-0.0356***	-0.0130***
			(0.0101)	(0.00366)
$Y_b \times \mathbf{1}$ [US-born mother]			0.00357	0.00130
			(0.0125)	(0.00453)
Pseudo R^2	0.0356		0.0358	
N	30553	30553	30553	30553

Notes: Sample 1 includes white males in the 100-percent sample of the 1880 Census who reported being born in either New Orleans, LA, Mobile, AL, Charleston, SC, or Washington, DC, allowing for misspellings and variations in punctuation. Sample 2 includes white males in the 100-percent sample of the 1880 Census that lived in New Orleans, LA, Mobile, AL, Charleston, SC, or Washington, DC, and were born in the same state. Trade data is from Albion (1935), *The Statistical Abstract of the United States* (1879), and DeBow (1854).Columns (1) and (3) are coefficients from ordered probit regressions and Columns (2) and (4) are the associated marginal effects on the probability of entering a professional occupation. Each regression contains a set of dummy for each birth year, birth city, and birth state/country of the mother. Robust standard errors are in parenthesis.

$*$ 10 percent significance; $**$ 5 percent significance; $***$ 1 percent significance

Table 6: Linear results controlling for early-life trade

Sample 1

	(1)	(2)	(3)	(4)	(5)	(6)
	log of occ. income score		occ. unemployment score		Duncan SEI	
Y_b	-0.0183**		0.00295		-0.708	
	(0.00776)		(0.0203)		(0.433)	
$Y_b \times \mathbf{1}$ [Immigrant mother]		-0.0231**		0.00879		-0.738
		(0.00990)		(0.0229)		(0.533)
$Y_b \times \mathbf{1}$ [US-born mother]		-0.00965		-0.00640		-0.662
		(0.00996)		(0.0324)		(0.621)
R^2	0.0562	0.0563	0.0468	0.0468	0.0928	0.0928
N	10726	10726	14099	14099	14990	14990

Sample 2

	(1)	(2)	(3)	(4)	(5)	(6)
	log of occ. income score		occ. unemployment score		Duncan SEI	
Y_b	-0.00468		-0.00630		-0.301	
	(0.00320)		(0.0101)		(0.200)	
$Y_b \times \mathbf{1}$ [Immigrant mother]		-0.00861**		0.00559		-0.597***
		(0.00360)		(0.0109)		(0.216)
$Y_b \times \mathbf{1}$ [US-born mother]		0.00136		-0.0239*		0.132
		(0.00406)		(0.0125)		(0.249)
R^2	0.0791	0.0794	0.0379	0.0381	0.0925	0.0928
N	23698	23698	28876	28876	30553	30553

Notes: Sample 1 includes white males in the 100-percent sample of the 1880 Census who reported being born in either New Orleans, LA, Mobile, AL, Charleston, SC, or Washington, DC, allowing for misspellings and variations in punctuation. Sample 2 includes white males in the 100-percent sample of the 1880 Census that lived in New Orleans, LA, Mobile, AL, Charleston, SC, or Washington, DC, and were born in the same state. Trade data is from Albion (1935), *The Statistical Abstract of the United States* (1879), and DeBow (1854). Occupational income score is the 1900 average earnings of an occupation and occupational unemployment score is average months unemployed for an occupation. Both of these scores are national averages for each occupation in 1900 as reported in Appendix A of Preston and Haines (1991). Each regression include birth year and birthplace fixed effects, as well as dummies for the mother's birthplace. Robust standard errors are in parenthesis.
$*$ 10 percent significance; $**$ 5 percent significance; $***$ 1 percent significance

Table 7: The effect of yellow fever at different ages

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$Y_{b-1} \times \mathbf{1}$ [Immigrant mother]	-0.000551						0.00318
	(0.00810)						(0.00912)
$Y_{b} \times \mathbf{1}$ [Immigrant mother]		-0.0178**					-0.0153*
		(0.00853)					(0.00876)
$Y_{b+1} \times \mathbf{1}$ [Immigrant mother]			-0.0181*				-0.0138
			(0.00959)				(0.00996)
$Y_{b+2} \times \mathbf{1}$ [Immigrant mother]				-0.0178**			-0.0138
				(0.00811)			(0.00862)
$Y_{b+3} \times \mathbf{1}$ [Immigrant mother]					-0.0000672		0.00272
					(0.00899)		(0.00954)
$Y_{b+4} \times \mathbf{1}$ [Immigrant mother]						-0.0114	-0.0123
						(0.0114)	(0.0132)
$Y_{b-1} \times \mathbf{1}$ [US-born mother]	-0.00997						-0.0186
	(0.0121)						(0.0129)
$Y_{b} \times \mathbf{1}$ [US-born mother]		-0.00163					-0.00131
		(0.0121)					(0.0126)
$Y_{b+1} \times \mathbf{1}$ [US-born mother]			-0.00495				-0.00325
			(0.0115)				(0.0119)
$Y_{b+2} \times \mathbf{1}$ [US-born mother]				0.00141			-0.00245
				(0.0136)			(0.0144)
$Y_{b+3} \times \mathbf{1}$ [US-born mother]					-0.00287		-0.00787
					(0.0112)		(0.0116)
$Y_{b+4} \times \mathbf{1}$ [US-born mother]						0.00912	0.0178
						(0.0143)	(0.0158)
N	14990	14990	14990	14990	14990	14990	14990

Notes: Sample 1 includes white males in the 100-percent sample of the 1880 Census who reported being born in either New Orleans, LA, Mobile, AL, Charleston, SC, or Washington, DC, allowing for misspellings and variations in punctuation. Sample 2 includes white males in the 100-percent sample of the 1880 Census that lived in New Orleans, LA, Mobile, AL, Charleston, SC, or Washington, DC, and were born in the same state. Trade data is from Albion (1935), *The Statistical Abstract of the United States* (1879), and DeBow (1854).Columns (1) and (3) are coefficients from ordered probit regressions and Columns (2) and (4) are the associated marginal effects on the probability of entering a professional occupation. Each regression contains a set of dummy for each birth year, birth city, and birth state/country of the mother. Robust standard errors are in parenthesis.
$*$ 10 percent significance; $**$ 5 percent significance; $***$ 1 percent significance

Table 8: Main Estimates with Additional Control Cities

	(1) coefficient	(2) marginal effect	(3) coefficient	(4) marginal effect
Y_b	-0.0332	-0.0110		
	(0.0212)	(0.00704)		
$Y_b \times \mathbf{1}$ [US-born mother]			0.00140	0.000463
			(0.0337)	(0.0112)
$Y_b \times \mathbf{1}$ [Immigrant mother]			-0.0573**	-0.0190**
			(0.0249)	(0.00824)
Pseudo R^2	0.0345		0.0345	
N	22796	22796	22796	22796

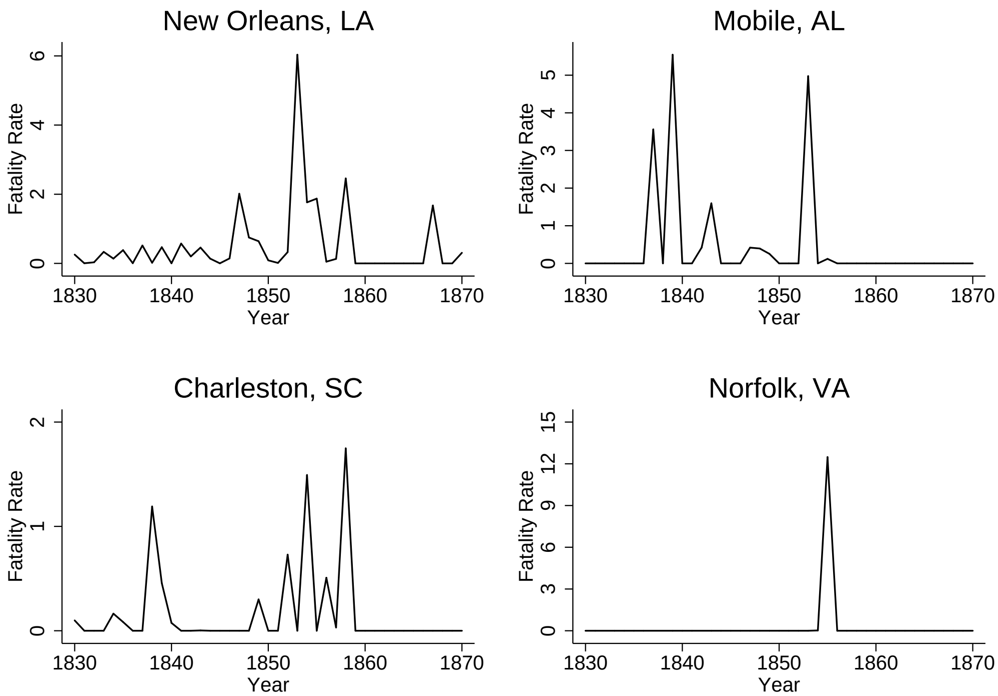
Notes: The data comes from males from the 100-percent sample of the 1880 Census who reported being born in New Orleans, Mobile, Charleston, Washington, Norfolk, Baltimore, Pittsburgh, Philadelphia, Cincinnati, St. Louis, Richmond, and Louisville. Columns 1 and 3 present ordered probit coefficients; Columns 2 and 4 present the marginal effect on the probability of becoming a professional. Each regression includes dummies for birth city, birth year, mother's and birthplace.
$*$ 10 percent significance; $**$ 5 percent significance; $***$ 1 percent significance

Table 9: The Effects of Yellow Fever on Including Blacks

	(1) coefficient	(2) marginal effect	(3) coefficient	(4) marginal effect
Y_b	-0.0225	-0.00668		
	(0.0185)	(0.00550)		
$Y_b \times \mathbf{1}$ [Black]			0.00638	0.00189
			(0.0255)	(0.00756)
$Y_b \times \mathbf{1}$ [White and immigrant mother]			-0.0576**	-0.0171**
			(0.0255)	(0.00758)
$Y_b \times \mathbf{1}$ [White and US-born mother]			0.0109	0.00324
			(0.0335)	(0.00994)
Pseudo R^2	0.0630		0.0631	
N	27717	27717	27717	27717

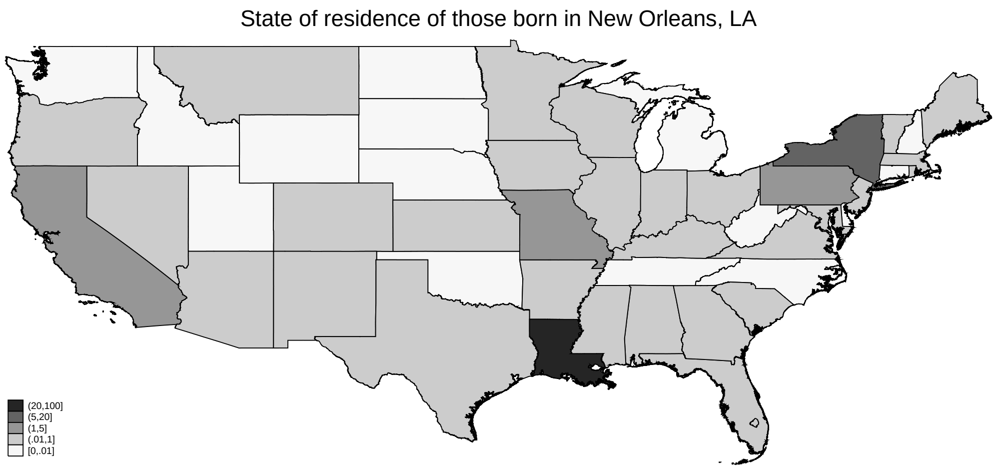
Notes: The data comes from males from the 100-percent sample of the 1880 Census who reported being born in New Orleans, Mobile, Charleston, Washington, Norfolk, Baltimore, Pittsburgh, Philadelphia, Cincinnati, St. Louis, Richmond, and Louisville. Columns 1 and 3 present ordered probit coefficients; Columns 2 and 4 present the marginal effect on the probability of becoming a professional. Each regression includes dummies for birth city, birth year, mother's birthplace and race.
$*$ 10 percent significance; $**$ 5 percent significance; $***$ 1 percent significance

Figure 1: Yellow fever fatality rates



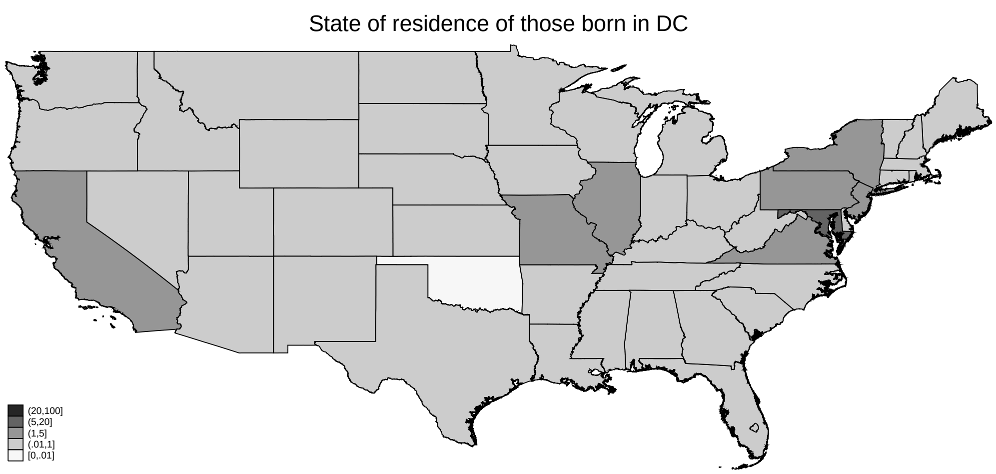
Notes: Data are from Toner (1873). I convert fatality counts into fatality rates by assuming city population grows linearly between Census years.

Figure 2: State of residence (in percents) for Sample 1 individuals born in New Orleans, LA



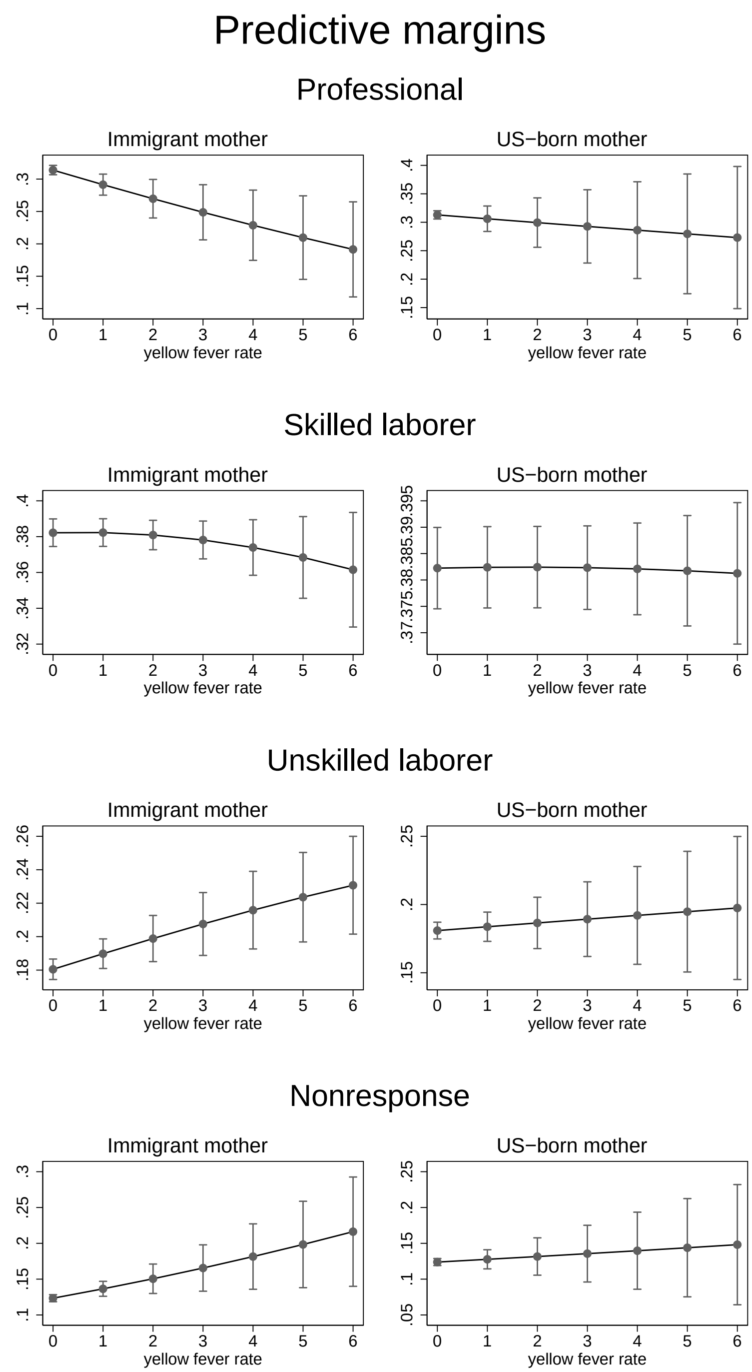
Notes: Data are from the 100 percent sample of the US Census and includes all white males born between 1835 to 1864 who reported being born in New Orleans, LA.

Figure 3: State of residence (in percents) for Sample 1 individuals born in Washington, DC



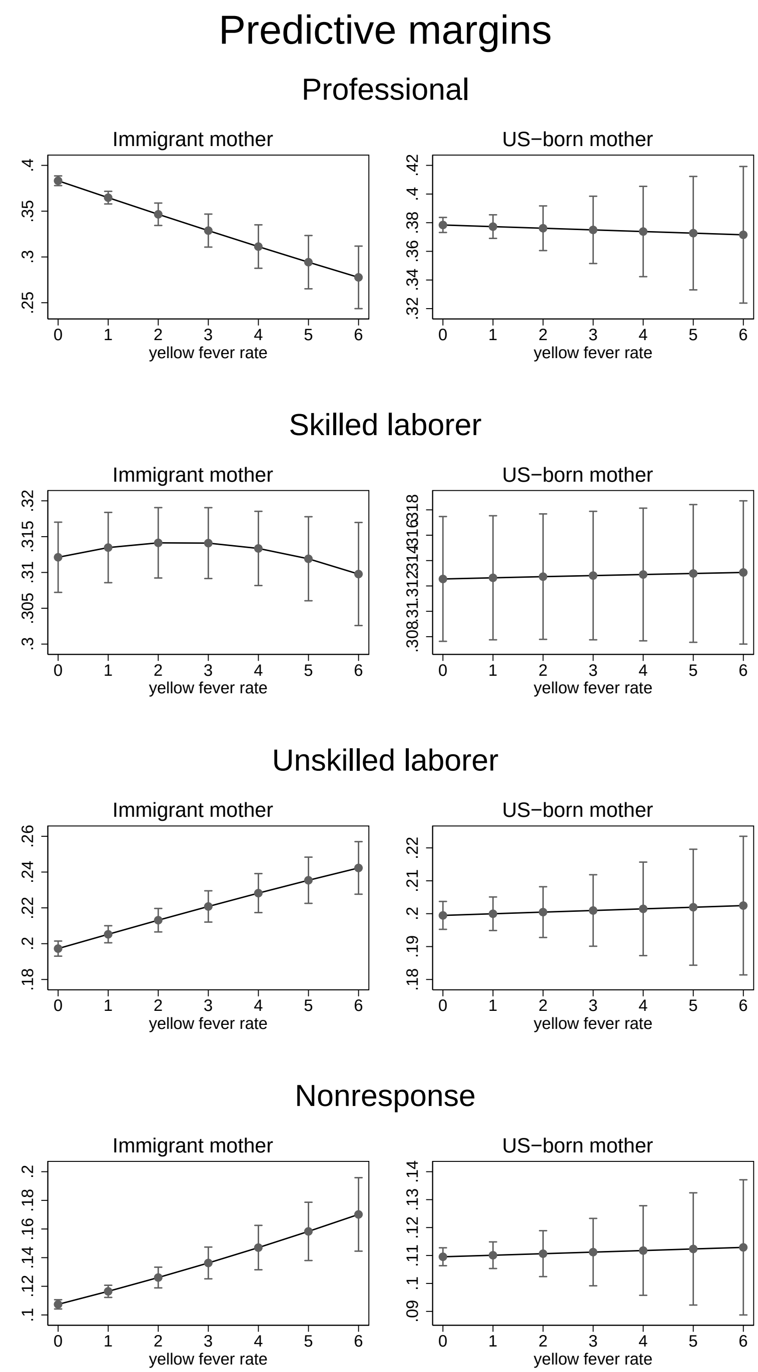
Notes: Data are from the 100 percent sample of the US Census and includes all white males born between 1835 to 1864 who reported being born in Washington, DC.

Figure 4: The effect of yellow fever for Sample 1



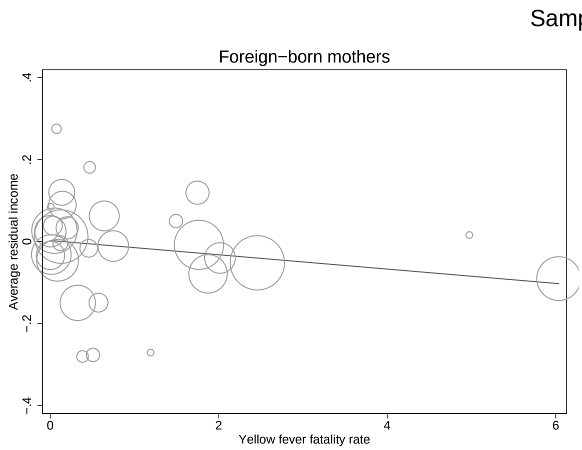
Notes: Predictive margins are from the estimates in the top panel of Table 3. The sample includes white males in the 100-percent sample of the 1880 Census who reported being born in either New Orleans, LA, Mobile, AL, Charleston, SC, or Washington, DC, allowing for misspellings and variations in punctuation. Yellow fever fatality rates are deaths per 100 people. The confidence intervals are at the 95 percent level.

Figure 5: The effect of yellow fever for Sample 2



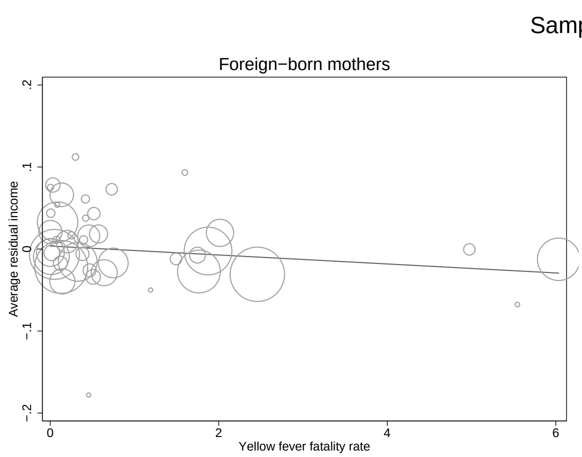
Notes: Predictive margins are from the estimates in the bottom panel of Table 3. The sample white males in the 100-percent sample of the 1880 Census that lived in New Orleans, LA, Mobile, AL, Charleston, SC, or Washington, DC, and were born in the same state. Yellow fever fatality rates are deaths per 100 people. The confidence intervals are at the 95 percent level.

Figure 6: Residual log 1900 occupational income score for Sample 1



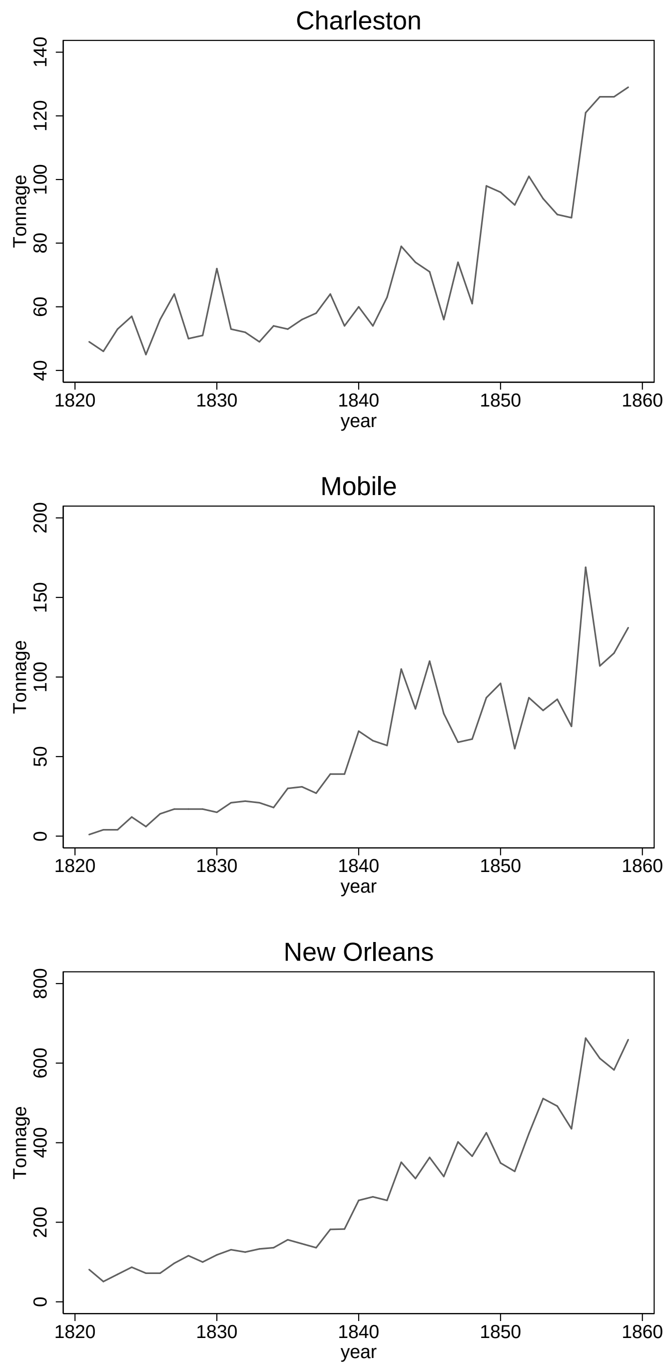
Notes: Sample 1 includes white males in the 100-percent sample of the 1880 Census who reported being born in either New Orleans, LA, Mobile, AL, Charleston, SC, or Washington, DC, allowing for misspellings and variations in punctuation. The dependent variable is the residual log of occupational income score from a regression including a set of birth year, birthplace, and mother's birthplace fixed effects. Each circle is a birthplace/birth year cell and is proportional to sample size.

Figure 7: Residual log 1900 occupational income score for Sample 2



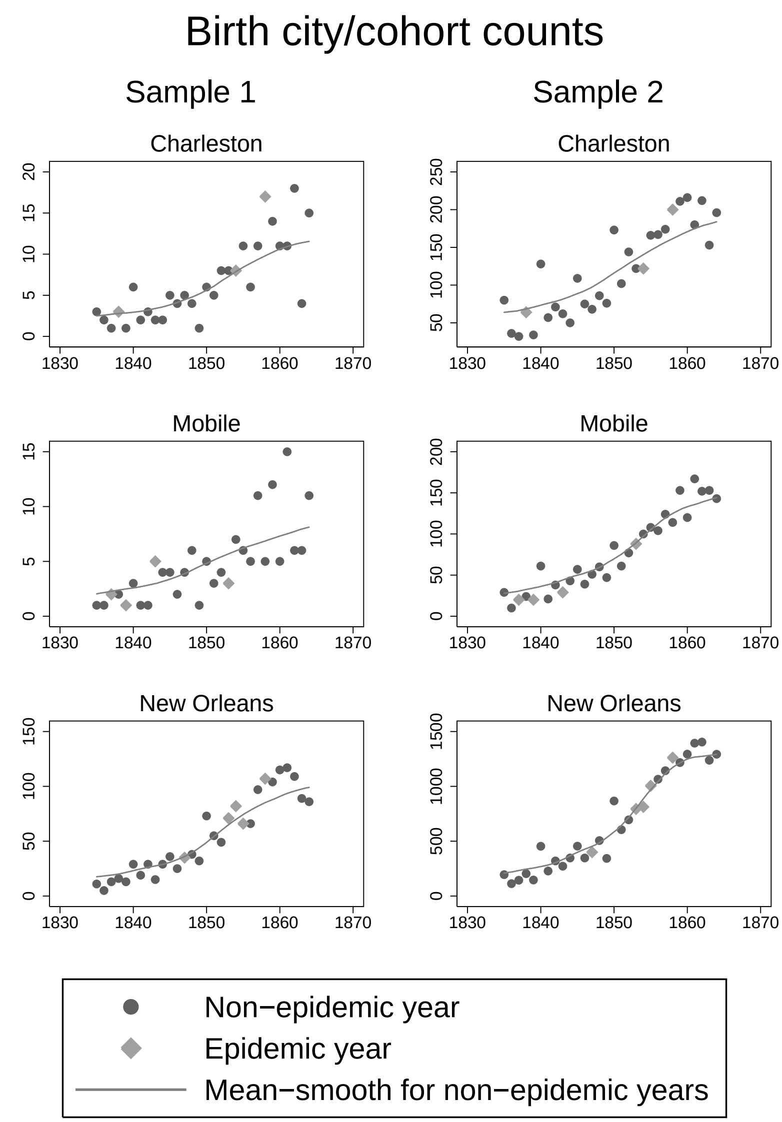
Notes: Sample 2 includes white males in the 100-percent sample of the 1880 Census that lived in New Orleans, LA, Mobile, AL, Charleston, SC, or Washington, DC, and were born in the same state. The dependent variable is the residual log of occupational income score from a regression including a set of birth year, birthplace, and mother's birthplace fixed effects. Each circle is a birthplace/birth year cell and is proportional to sample size.

Figure 8: Entering tonnage (in thousands) by city and year



Notes: Trade data is from Albion (1935), *The Statistical Abstract of the United States* (1879), and DeBow (1854). Tonnage is thousands of tons.

Figure 9: The number of observations for each sample in each birth city/year cell



Notes: Sample 1 includes white males in the 100-percent sample of the 1880 Census who reported being born in either New Orleans, LA, Mobile, AL, Charleston, SC, or Washington, DC, allowing for misspellings and variations in punctuation. Sample 2 includes white males in the 100-percent sample of the 1880 Census that lived in New Orleans, LA, Mobile, AL, Charleston, SC, or Washington, DC, and were born in the same state.