

# The 1918 Influenza Pandemic and its Lessons for COVID-19\*

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## Abstract

This article reviews the global health and economic consequences of the 1918 influenza pandemic, with a particular focus on topics that have seen a renewed interest because of COVID-19. We begin by providing an overview of key contextual and epidemiological details as well as the data that are available to researchers. We then examine the effects on mortality, fertility, and the economy in the short and medium run. The role of non-pharmaceutical interventions in shaping those outcomes is discussed throughout. We then examine longer-lasting health consequences and their impact on human capital accumulation and socioeconomic status. Throughout the paper we highlight important areas for future work.

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# 1 Introduction

The COVID-19 pandemic took the world by surprise. While the first documented case was in December of 2019, it would take just three months before the World Health Organization would declare that COVID-19 was a pandemic. At the end of its seventh month, official estimates indicate that 17.3 million have been infected. Of those 17.3 million cases, COVID-19 is officially responsible for nearly 700,000 deaths. These statistics are despite much of the global economy shutting down in hopes of controlling the spread. As of July 2020 the pandemic continues with no clear end in sight, and so these statistics also underestimate the pandemic's ultimate health toll.

As the COVID-19 pandemic has unfolded, many are drawn to the parallels with the 1918 influenza pandemic. Both are respiratory diseases caused by a virus, could spread from casual close contact, and reached most parts of the globe within months. The case mortality rates for both pandemics are higher than a typical seasonal influenza, with the 1918 influenza pandemic killing tens of millions worldwide. In both pandemics, non-pharmaceutical interventions like social distancing and mask wearing were used to control the spread, though in 1918 the restrictions were far less stringent. These parallels have renewed interest in understanding the health and economic effects of the 1918 pandemic as a way of inferring something about the future.

This article surveys the literature on the 1918 influenza pandemic, with a particular focus on understanding its health and economic effects.<sup>1</sup> We review the evidence on the following questions: How many people did it kill? What were the determinants of pandemic severity? How did the pandemic affect the economy? How did it affect fertility? Were there long-lasting effects on health and human capital development?

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<sup>1</sup>We do not review other global pandemics, such as the black death, cholera, or HIV/AIDS. For reviews on these topics, see the other review articles in this issue. We also do not review the literature on other influenza pandemics, such as the influenza pandemics of 1890-1891, 1957-1958, 1968, or 2009. While these pandemics have the potential to enhance our understanding COVID-19, they are beyond the scope of this review.

Throughout the article, we highlight where papers disagree, perhaps because of differing methodologies, data sources, or geographic focus.

COVID-19 has renewed interest in the economics of the 1918 influenza pandemic, and consequently, many papers we review are working papers. We include these papers in this review, as they now make up a substantial portion of the economics literature on the 1918 pandemic and some already have over 100 citations. While some of the papers may evolve, the working papers that appear in this article were selected because of their potential to aid our understanding of the economics of COVID-19.

The first lesson from 1918 is that the health effects were large and diffuse. We may never know the true mortality consequences of 1918 because of incomplete or inaccurate record keeping, issues that also undermine our ability to quantify the impact of COVID-19. The 1918 pandemic likely killed 50 million people, with some estimates suggesting the death toll could be as high as 100 million. There was substantial variation in the intensity of the pandemic with population density, air pollution, and non-pharmaceutical interventions playing an important role in determining pandemic severity. While 1918 was deadly, most that contracted the virus survived. But survival does not mean that individuals fully recovered. The evidence suggests that in 1918, those that survived the initial infection faced an elevated mortality risk and some physiological conditions never fully healed. The range of lingering health effects for those that contract COVID-19 and survive remains to be seen. The cohort in utero during 1918 grew up to be in worse health and of lower socioeconomic status. This finding is consistent with the broader literature on the fetal origins hypothesis (Almond and Currie, 2011).<sup>2</sup> This literature suggests that the in utero effects of COVID-19 warrant attention by future researchers.

The second lesson from 1918 is that it caused an economic contraction, reducing

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<sup>2</sup>The fetal origins hypothesis is the idea that environmental shocks that occur while in utero impair biological development, generating a wide range of latent effects.

both GDP and employment. Businesses and schools temporarily shut down in many places, although those shutdowns were less stringent than what occurred in the spring of 2020. Many studies disagree on the size of the contraction and how long the effects lasted. Some suggest the economy recovered by the time the pandemic was over, whereas others argue that the economy recovered in 2 to 3 years. The literature points to an underlying mechanism of a negative labor supply shock, as working-age adults had unusually high mortality rates. With COVID-19, working-age adults are among the most likely to survive. It is thus unlikely that COVID-19 will generate a similarly sized negative labor supply shock.

The biggest challenge in estimating the effects of the 1918 pandemic are poor data quality as well as the existence of concurrent events. While many important data sets exist, many modern data sets begin shortly after the pandemic and others were collected at irregular intervals. The 1918 influenza pandemic also coincided with the end of WWI. The war disrupted economies across the globe. Even neutral countries were affected, either because of increased demand for their goods or because of the disruption in trade networks. The deployment of millions of young men, as well as widespread death and dismemberment of both civilians and service-members, has its own effects on the economy. These issues, at times, hinder making conclusive inferences.

The paper proceeds as follows. Section 2 discusses the origins of the 1918 pandemic, as well as its spread, attempts to limit the spread, and its duration. That section also highlights important contextual details, such as the independent effects of WWI as well as the prevalence of infectious disease at the time. In Section 3 we review what data are available during this period and the challenges of working with these data. We also present some preliminary evidence from data sources that we believe are underutilized. Section 4 explores the health effects as well as the leading evidence for why some regions were hit so much harder than others. The literature on economic effects is discussed in

Section 5. Section 6 explores the impact on fertility. Section 7 reviews the long-lasting health consequences of the pandemic, with a particular emphasis on understanding whether in utero exposure permanently impaired health and labor market outcomes. Section 8 discusses issues that are of modern importance but for which there is limited historical evidence or limited historical parallels. Section 9 concludes.

## **2 Background**

There is a substantial amount of uncertainty surrounding the COVID-19 pandemic. How long will it last? What is the true mortality rate? Will there be lingering health or economic effects? When faced with this level of uncertainty it is tempting to look to history for guidance. Among the set of historical pandemics and epidemics to consider, the 1918 influenza pandemic is appealing for two reasons. First, the 1918 influenza pandemic is the most recent historical event to match or exceed the scale of the COVID-19 pandemic. Second, the 1918 pandemic occurred after a series of improvements in data collection and preservation. Because of these improvements, the 1918 pandemic offers a unique opportunity for comprehensive and systematic analysis across a wide range of countries. While the COVID-19 pandemic has many important parallels with the 1918 pandemic, there are also important differences. The remainder of this section provides an overview of similarities and differences in the context, the severity and duration of the pandemics, and specifics of the two viruses.

### **2.1 Context**

One key difference between the two pandemics is that quality of life and overall life expectancy were much lower in 1918 than today. Cities in the 19th and early 20th century were polluted and the risk of contracting and dying from an infectious

disease was high (Costa, 2015).<sup>3</sup> Throughout the 20th century, a series of innovations brought about dramatic improvements in health and longevity that many have come to expect. Cities discovered and invested in new technologies to eliminate waterborne diseases like cholera and typhoid fever (Alsan and Goldin, 2019; Ferrie and Troesken, 2008; Beach et al., 2016). Sulfa drugs were discovered in 1930, providing the first effective treatment for infectious diseases (Jayachandran, Lleras-Muney and Smith, 2010). Many cities would adopt pasteurization standards and other milk ordinances to improve the quality of milk supplies. Life expectancy conditional on surviving to age 10 increased from 47 in 1900 to 57 in 1940. By the year 2000, that figure would increase to 67 (Costa, 2015).<sup>4</sup> The value of a statistical life in the United States was between 600,000 and 800,000 dollars (1990 U.S. dollars) in 1920, but by the year 2000 the value would increase to somewhere between 6 and 8.7 million dollars (Costa and Kahn, 2004).

The experience of New York illustrates that epidemics were not out of the ordinary during the early 1900s. Figure 1 plots death rates in New York City from 1804 to 1930. Between 1917 and 1918 New York City’s crude mortality rate increased by 3.173 deaths per 1000 persons. While tragic, the hollow circles in Figure 1 depict 12 other years where the year-over-year increase in mortality exceeded the magnitude of the 1917 to 1918 change. During the cholera epidemics of 1832, 1834, 1849, and 1854 the year-over-year increase in mortality was 3 to 5 times larger in magnitude than what occurred in 1918.<sup>5</sup> As another comparison, the mortality rate in New York City was higher in nearly every year between 1800 and 1905 than the mortality rate in

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<sup>3</sup>Costa (2015) provides an excellent survey on this literature. One literature that has emerged since that article assesses the role of coal-fired air pollution. See, for instance, Clay and Troesken (2011), Beach and Hanlon (2018), Hanlon (2018), and Clay, Lewis and Severnini (2019a)

<sup>4</sup>While the patterns are striking, researchers continue to debate how much these innovations contributed to the gains in life expectancy. Perhaps the most intense debate is over the role of water purification. See for instance, Cutler and Miller (2005), Ferrie and Troesken (2008), Alsan and Goldin (2019) and Anderson, Charles and Rees (2020).

<sup>5</sup>The notable epidemics in Figure 1 come from (Bolduan, 1935).

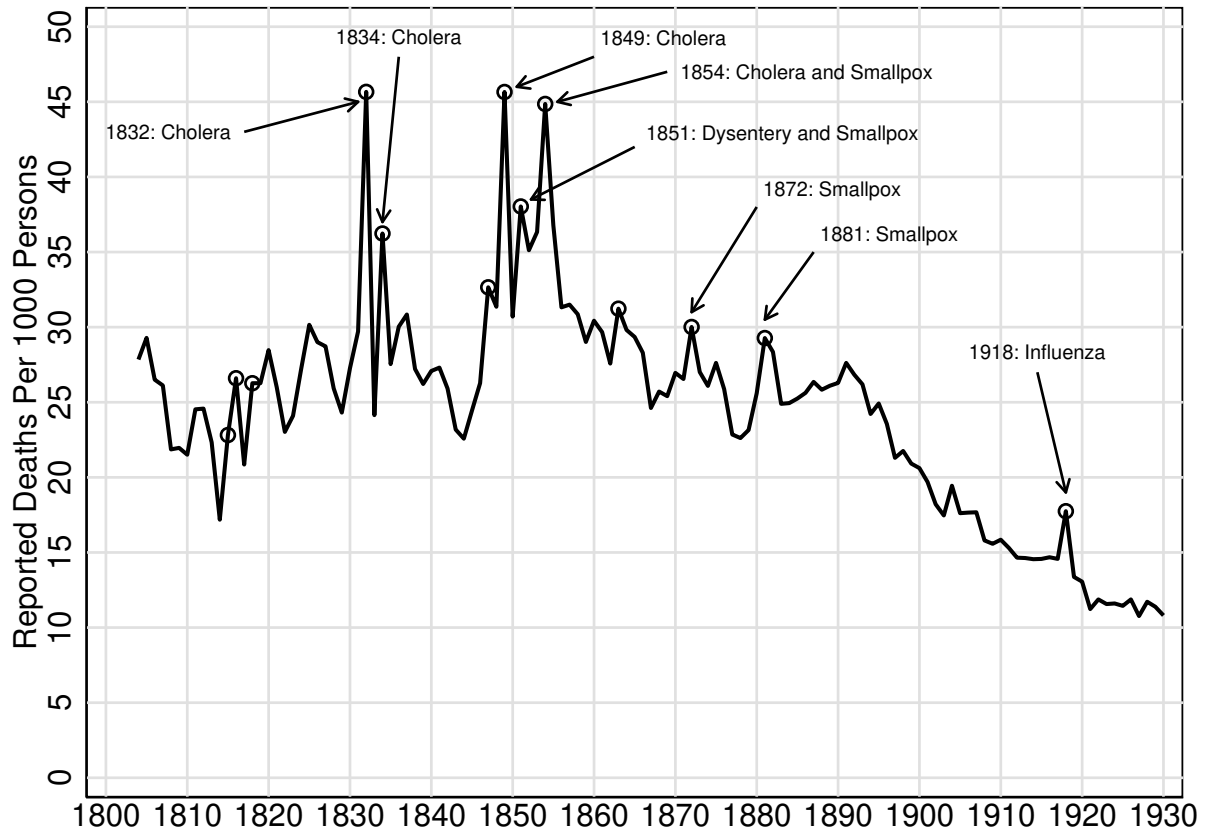
1918. The experience of New York City is not unique. Many cities throughout history were ravaged by the black death, yellow fever, smallpox, and cholera. During the first half of the 20th century, Black Americans in urban areas died from infectious disease at a rate that was greater than what urban whites experienced during the 1918 flu pandemic every single year (Feigenbaum, Muller and Wrigley-Field, 2019). In the year 1900 the leading causes of death in the United States were pneumonia, tuberculosis, and diarrhea/enteritis, together accounting for 30% of all deaths. By the year 2000 the leading causes of death in the United States would be heart disease (31%), cancer (24%), and stroke (7%). The only infectious disease to appear in the top 10 causes of death in 2000 is pneumonia/influenza, which accounted for less than 5% of all deaths.<sup>6</sup> What was perhaps most unique about 1918 was that it was global and that it occurred following substantial improvements in our understanding of the causes of infectious disease.

A second key difference between the two pandemics is that the 1918 pandemic arrived just as World War I (WWI) was coming to an end. WWI spanned from July of 1914 to November of 1918. The war led to the mobilization of 70 million military personnel, 9 million combatant deaths, and an additional 13 million civilian deaths. The war disrupted most economies, due both to destruction as well as the diversion of resources to help the war effort. Many countries saw production of key crops and livestock fall by 50 to 75% relative to prewar levels (Nourse, 1924). The United States, which remained neutral for most of the war, experienced a boom as the country tried to meet wartime demand and a bust as the war ended. Many commodities saw prices increase by a factor of 2 to 3 relative to prewar levels (Rajan and Ramcharan, 2015). Labor demand increased in both cities, for manufacturing, and in rural areas, as 30 million acres of land were suddenly put into production. As Kitchens and Rodgers

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<sup>6</sup>These figures come from Cole (1999)

Figure 1: New York City Death Rates and Notable Epidemics, 1804-1930



*Notes:* Mortality data from 1804 to 1899 come from Rosenwaike (1972). Mortality data from 1900 to 1930 come from the annual reports on Mortality Statistics in the death registration area. Population comes from the census and is linearly interpolated between census years. Note that data from 1804 to 1865 correspond to Manhattan only, data from 1866 to 1899 correspond to Manhattan and Brooklyn, and data from 1900 to 1930 correspond to the all five boroughs. The hollow circles denote a year over year increase in mortality that was greater than or equal to 3.173 deaths per 1000 persons, which is what occurred between 1917 and 1918. The notable epidemics come from Bolduan (1935).



(2020) show, marriages were delayed and fertility fell as women were brought into the labor force. The United States entered the war just one year before the pandemic, and in doing so the labor market was further strained as nearly 3 million men, or 7% of the labor force, was mobilized (Rockoff, 2004; Kendrick et al., 1961). In short, the pandemic arrived at a time of widespread disruption because of a worldwide war. The existence of the war is important to keep in mind as it is often difficult to disentangle the impact of the war from the impact of the pandemic.

## 2.2 Severity and Duration of the Pandemics

The influenza pandemic of 1918-1919 was brief but severe. Estimates of the number of worldwide excess deaths during the pandemic range from 20-100 million (Taubenberger, Kash and Morens, 2019). Barro, Ursúa and Weng (2020) estimate worldwide deaths over 1918-1920 at 39 million, with a mean death rate of 2%. The range of estimates is a function of incomplete records and differing opinions about how to define counterfactual mortality. Nevertheless, even the lowest estimate (20 million) is about 2.5 times the number of combat-induced deaths from World War I (Royde-Smith and Showalter, 2020). The origins of the 1918 virus are also unclear, with studies suggesting that the virus may have originated in France, China, or Kansas. Despite its uncertain origins, the pandemic is generally described as having a number of waves. The first less lethal wave was in the spring and summer of 1918. A second more lethal wave hit many countries in September-November of 1918. Two-thirds of the mortality occurred in 1918. A third wave hit in the spring of 1919. A fourth wave hit a few countries in 1920.

The precise severity and duration of the COVID-19 pandemic are not yet clear. One way to draw comparisons is to examine trends in cumulative mortality rates. Lin and Meissner (2020) use total weekly deaths per 100,000 from influenza and pneumonia

in 46 U.S. cities as a benchmark, since these are among the best high frequency data available for the period. Cumulative death rates in 1918 went from 1.3 deaths per 100,000 persons to 100 deaths per 100,000 in about 30 days, growing at a constant rate. As Lin and Meissner (2020) show, many countries saw a similar trend with COVID-19 over the first 15 days, at which point the COVID-19 death rates have since flattened and are lower than the 1918 cumulative mortality rates. Whether the COVID-19 cumulative mortality rates remain lower than 1918 remains to be seen. At the U.S. state level, COVID-19 death rates were fairly similar to 1918 death rates over the first 20 days or so in the hardest hit states – New York, New Jersey, Massachusetts, Michigan, and Louisiana. At the U.S. city level, where comparisons can be made for the same city in both periods, cumulative mortality rates in the first 35 days in a subset of cities, including New York City, Detroit, Indianapolis, and Newark are surprisingly similar across the two pandemics.

Lin and Meissner (2020) find that country COVID-19 mortality rates in the 42 days since the first death are positively related to mortality in 1918 and negatively related to the mortality rate from the 2002-2003 SARS pandemic.<sup>7</sup> Some governments have had experience with infectious disease such as SARS. Many governments, however, have not had experience with outbreaks of infectious disease of this magnitude in decades. This may have implications for public response and resistance to efforts to reduce the spread of COVID-19. Recent governmental experience with infectious disease appears to have led to a more effective initial response, at least for the first 42 days that the authors study.

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<sup>7</sup>Le Bert et al. (2020) find that exposure to the 2002-2003 SARS-CoV-1 virus provides some cross-immunity to SARS-CoV-2.

## 2.3 Novel Highly Contagious Viruses

Both pandemics involve the spread of a novel, highly contagious virus that induces respiratory distress. With a novel virus, the consequences of infection are not fully understood and the scope for medical intervention is limited. Both pandemics involve viruses that attack the respiratory system, with the H1N1 strain of avian influenza causing the 1918 pandemic and SARS-CoV-2 strain from the coronavirus family causing the COVID-19 pandemic. Transmission is also similar, with a typical transmission occurring by inhaling droplets generated from the coughs or sneezes of an infected individual. H1N1 turned out to be a “founder virus” with variations of that strain still circulating today.<sup>8</sup> Whether SARS-CoV-2 will also become a “founder virus” remains to be seen.

Barry (2005), particularly in chapters 20 and 21, provides a detailed summary of the pathology of the 1918 virus. As with other strains of influenza, symptoms in 1918 included inflammation of membranes in the throat, pharynx, and nose, as well as fever, cough, headache, body aches, and exhaustion. Most victims would recover within 10 days. But influenza is transmitted so effectively that there were easily 100 million cases with severe complications, and the complications were extreme. Some that survived the initial infection would ultimately die after developing bacterial pneumonia. Today, antibiotics would be used to fight bacterial pneumonia, but in 1918 antibiotics were still in the future. Others would suffer from acute respiratory distress syndrome (ARDS). In both 1918 and today, the only care for ARDS is to provide relief for the symptoms.

Both viruses are highly contagious. The baseline reproduction rate in 1918 is estimated to be between 2 and 3, meaning that in normal circumstances each infected

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<sup>8</sup>In a 2019 review article Taubenberger, Kash and Morens (2019) state (p 1): “The founding 1918 pandemic virus is truly the “mother” of all subsequent influenza pandemics, and we are still in its “pandemic era” today. Its descendants are still evolving, still killing tens of thousands of people every year, with no end in sight.”

person is expected to infect 2 to 3 other individuals (Mills, Robins and Lipsitch, 2004). Early estimates for SARS-CoV-2 suggest a similar level of contagiousness.

Both SARS-CoV-2 and H1N1 induce respiratory distress. The viruses invade the lungs, attaching themselves to epithelial cells. Once attached to those cells the viruses begin to replicate. With H1N1, those cells would burst roughly ten hours later releasing an additional 1,000 to 10,000 viruses, each capable of infecting other cells. The rapidity of replication is so great that many victims in 1918 would die somewhere between the 5th or 6th generation. Barry (2005) writes of one healthy person that showed their first symptom at 4:00pm and was dead by 10:00am the next day. With coronaviruses the speed of replication is much slower, and so death often comes several weeks after the first symptoms appear, as we have seen with COVID-19.

As the viruses replicate they induce a commensurate immune system response. It was the response of the immune system that was so deadly in 1918. The immune system followed the virus to the lungs, and in an attempt to eliminate the virus, the victim's lungs filled with fluid and debris, limiting the exchange of oxygen. Death took many forms. Oxygen deprived organs would begin to fail, the heart, strained from trying to pump blood out of the lungs, might give out, or the victim could die when muscles overworked from trying to breathe finally become exhausted and stop.

The populations most vulnerable to COVID-19 differs sharply from 1918. The 1918 pandemic is known for the distinct W-shaped pattern that appears when plotting age-specific mortality rates. As with many other infectious diseases, mortality rates were high for the young and the old. Unusually, in 1918 mortality rates were also high for young adults. Figure 2 plots the median difference in age-specific all-cause mortality rates during the pandemic (1918-1920) relative to the average of the three years immediately preceding and following the pandemic. The underlying data set includes information from 13 countries, and the figure originally appeared in Murray

et al. (2006). The high mortality that peaked at 25-29 was particularly notable and tragic for individuals losing parents, spouses, and breadwinners. Males appear to have had higher excess mortality than women. The reasons for the disproportionate effect on prime-age workers and men continue to be debated (Taubenberger, Kash and Morens, 2019). The two leading explanations relate to the strength of an individual's immunological response and cohort-level differences in exposure to other strains of influenza. With COVID-19, the elderly are the most vulnerable population.<sup>9</sup> The differing mortality patterns of the viruses is an important caveat to keep in mind, as the economic impact of a virus that disproportionately kills individuals that are still in the workforce or still caring for children is likely to differ from a virus that disproportionately kills the elderly.<sup>10</sup>

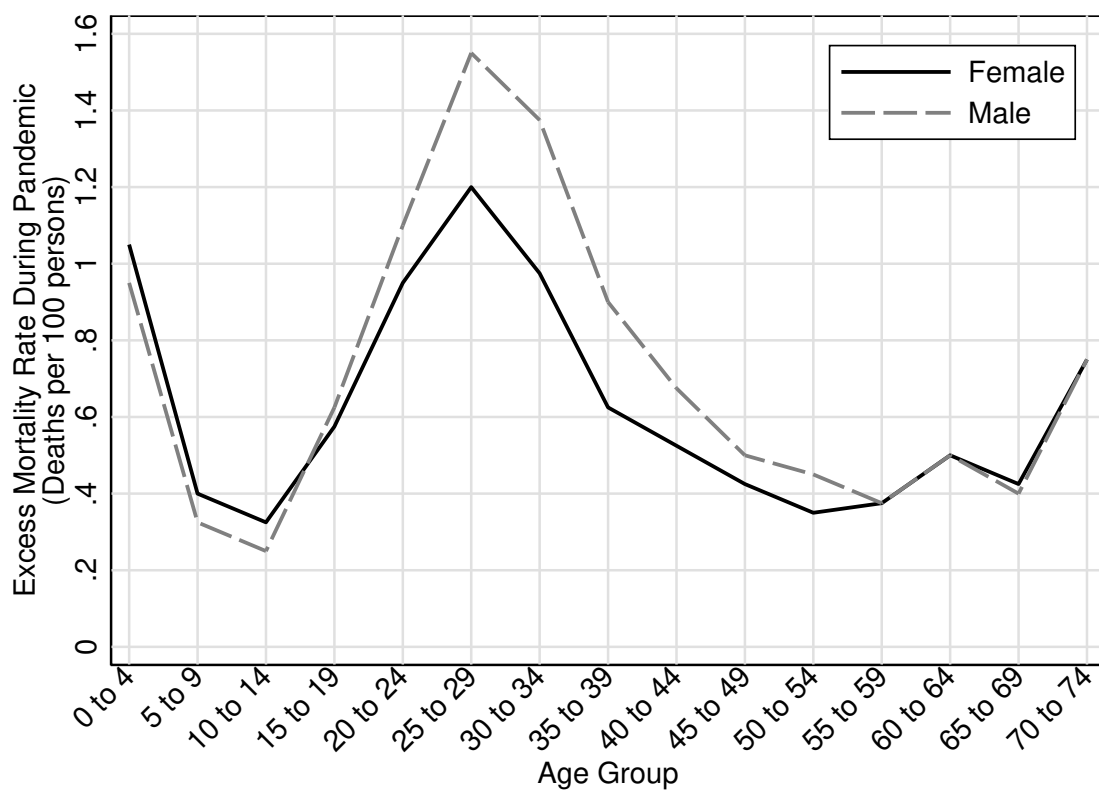
Both viruses are characterized by limited scope for medical intervention and overwhelming demands on medical resources. In 1918, medical responses were limited by a lack of knowledge about the virus, existing medical technology, and doctor and hospital capacity (Jester et al., 2019). The main approach was to provide care that targets the symptoms while the person recovered. In 1918, hospitals were overwhelmed. This appears to have been a universal experience from Brazil to India to the United States to U.S. military hospitals (Guimbeau, Menon and Musacchio, 2020; Ojo, 2020; Crosby, 2003; Byerly, 2010). As the death toll rose, morgues became overwhelmed and many victims were buried in mass graves (Scanlon and McMahon, 2011). Although our ability to provide symptomatic care today is greater than it was during 1918, many hospitals have nevertheless found themselves with a shortage of doctors, hospital beds, and ventilators. Hospitals and morgues were hard hit in locations like Italy and New York City. As of this writing antivirals and vaccines are in development but are not

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<sup>9</sup>For early estimates of the age gradient of COVID-19 mortality, see Verity et al. (2020)

<sup>10</sup>This is not to say that the older adults do not contribute to the economy. Bloom et al. (2020) finds that the market and non-market activities of older adults in the U.S. and Europe are on the order of 7% of GDP.

Figure 2: Median Excess Mortality Rate by Age and Sex in 13 Countries



*Notes:* Data reprinted from Murray et al. (2006). Excess mortality is calculated by taking the average age-specific mortality rate over the pandemic period (1918, 1919, and 1920) and subtracting the average age-specific mortality rate in 1915, 1916, 1917, 1921, 1922, and 1923. Mortality rates are deaths per 100 people.

widely available. It takes time to develop vaccines for novel viruses, and it is worth noting that vaccines were not developed in time to combat either the 1957-1958 or the 1968-1969 influenza pandemics (WHO, 2009).

With limited scope for medical intervention, officials in both pandemics encouraged the use of non-pharmaceutical interventions to help control the spread. These interventions include the closing of schools, churches, and restaurants, as well as encouraging mask wearing and hand washing.<sup>11</sup>

The non-pharmaceutical restrictions in 1918 and 2020 differ in two important ways. First, the restriction in 1918 were much less strict than the “shelter in place” restrictions enacted in response to COVID-19. The second difference is that the use of these interventions was likely more familiar in 1918 than today. Pandemics, epidemics, and outbreaks of infectious disease were common, intermittent features of life prior to the twentieth century, and so were attempts to control their spread. In towns with trade connections, quarantine of ships, sailors, and goods was common after the 14th century, although it was often incompletely enforced. Thus, the basic principles of quarantine had been around for centuries (McDonald, 1951; Gensini, Yacoub and Conti, 2004). The germ theory of disease was established and became widely known in the second half of the 19th century (Mokyr and Stein, 1996). The germ theory helped public health officials and many members of the public understand the importance of hand washing and covering the mouth and nose to reduce transmission of tuberculosis, a lesson that translated readily to influenza (Tomes, 1999, 2010).

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<sup>11</sup>Collier (1974, p.148) writes of church closings in Winnipeg, Budapest, and Dunedin, New Zealand. Many churches adopted precautionary measures, with Zurich’s ban on singing and oral responses representing an extreme version of those measures. See also, Collier (1974, p.192-196) for a discussion of mask policies from several different countries.

### 3 Data on the Pandemic

Before turning to the health and economic effects of the 1918 influenza pandemic, it is perhaps useful to discuss issues related to data quality and data availability. This section describes three main sources of data: data on mortality, which are used to identify the severity of the pandemic, data on non-pharmaceutical interventions, which are often used for assessing the efficacy of government intervention, and data on economic activity, which are used to assess the impact of the pandemic on the economy in the short- and long-run.

#### 3.1 Mortality Data

A fundamental issue in understanding mortality from both the COVID-19 pandemic and the 1918 influenza pandemic is the lack of reliable mortality data.<sup>12</sup> In 1918, some countries had reporting systems in place for mortality for some or all geographic units, but other countries did not. For example, India, the hardest hit country, had reporting for many British-controlled areas. China, which is believed to have the second most fatalities, had very little reporting (Cheng and Leung, 2007). The overwhelming rate of deaths and limited capacity for testing and autopsies made classification difficult. For instance, deaths from pneumonia in 1918 may have been incorrectly classified as deaths from influenza or the converse. Political pressures can make it difficult to provide accurate information in a timely manner. During the 1918 pandemic, many European countries sought to protect morale among soldiers by suppressing information on the spread of influenza, both throughout the country and on the front lines (Barry, 2005). Spain did not face the same incentive to suppress coverage as they remained neutral throughout WWI. Spain's lack of information suppression likely contributed to the

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<sup>12</sup>Reliable case data is also of interest. Prior to 1918, in the United States at least, influenza was not deemed important enough to collect morbidity data. This, of course, changed after 1918.



coinage of the term “Spanish Flu.”

Because of the difficulty in accurately identifying deaths due to influenza and pneumonia, many scholars have turned to all cause mortality to quantify the effects in 1918. Table 1 presents estimates of excess all cause mortality rates for 43 countries from Johnson and Mueller (2002), Murray et al. (2006), and Barro, Ursúa and Weng (2020). The estimates differ substantially across sources, reflecting uncertainty in the effects and differences in approaches to construction of the estimates.

Although most countries have mortality reporting systems in place today, issues around determining cause of death and political pressures around reporting are still salient. One early factor in determining cause of death was the limited testing capacity in many countries. Not every person suspected of having COVID-19 was tested before or after death (Leon et al., 2020). Retrospective analyses of all cause deaths suggest that many countries experienced excess mortality that was substantially higher than reported COVID-19 deaths.<sup>13</sup> This likely reflects two factors – under identification of COVID-19 deaths and the failure of patients to seek treatment or hospitals to provide treatment during the crisis for other health emergencies. Politicians may have reasons for wanting to minimize the severity of the outbreak, whether measured in deaths, hospitalizations, or positive tests for COVID-19.

## 3.2 Non-pharmaceutical Interventions

While social distancing laws and guidelines are well documented during COVID-19, they are not as well documented for the 1918 influenza pandemic. Many localities banned public gatherings, closed schools, or required masks, but researchers have had to aggregate this information from several sources to generate databases on non-pharmaceutical interventions (NPIs). Another issue is that of compliance with social

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<sup>13</sup>The U.S. CDC now has a dashboard that reports weekly excess mortality.

Table 1: Excess All-Cause Mortality Rates (Deaths per 1000 persons)

Country	Johnson and Mueller (2002)	Murray et al. (2006)	Barro et al. (2020)
Argentina	1.2	5.4	3.3
Australia	2.7	2.9	2.8
Austria	3.3	16.1	9.7
Belgium		8.3	8.3
Brazil	6.9		6.9
Canada	6.1	6.3	6.2
Chile	11	5.2	8.6*
China			14.3
Columbia			4.6
Denmark	4.1	2	3.1
Egypt	10.7		10.7
Finland	5.8	8.5	7.1
France	7.3	7.5	7.4
Germany	3.8	7.6	7.8
Greece			4.5
Hungary	12.7		12.7
Iceland	5.4		8
India	60.5	43.9	52.2
Indonesia	30.4		30.4
Italy	10.7	13.8	12.3
Japan	7	9.4	9.6
Korea			13.8
Malaysia			12.9
Mexico	20.6		20.6
Netherlands	7.1	7	7.1
New Zealand	7.4	6.3	6.9
Norway	5.7	5.7	5.7
Peru			3.9
Philippines	*	28.4	18.8
Portugal	9.8	26.4	18.1
Russia	2.4		18.7
Singapore			12.9
South Africa	44.3		33.6
Spain	12.3	14.9	13.6
Sri Lanka	17.9	16.8	17.4
Sweden	5.9	6.6	6.3
Switzerland	6.1	9.2	7.6
Taiwan	6.9	14.4	10.7
Turkey			10.8
United Kingdom	5.8	3.4	4.6
	(England/Wales)	(England)	
United States	6.5	3.9	5.2
Uruguay	1.4	2.9	2.2
Venezuela		4	12.5

distancing guidelines. Whereas researchers of the COVID-19 pandemic have made novel use of cell-phone data to measure compliance, research on the 1918 compliance with NPIs rarely goes beyond anecdotal evidence.<sup>14</sup>

In 1918, many countries implemented quarantines of incoming ships, including Australia, New Zealand, and South Africa (World Health Organization Writing Group, 2006). During the second and third wave of the pandemic, approximately one-third of the ships arriving in Australia were determined to be “infected,” yet Australia only had one-half the influenza death rate as the United States. Remote islands with quarantines may have been one of the few places on earth to escape the pandemic. Quarantines of ports may have been ineffective if influenza could still arrive by land. Quarantines in African ports may have slowed, but did not prevent the arrival of the disease (Patterson, 1983; World Health Organization Writing Group, 2006). While there are many case studies of non-pharmaceutical interventions outside of the U.S., we are unaware of any papers that aggregate these data into one data set, allowing for cross-country regressions. This is a promising area for future research.

The most commonly used data set on non-pharmaceutical interventions (NPIs) in the United States comes from Markel et al. (2007). They collected weekly mortality data from 43 cities and then combined newspapers and government reports to obtain non-pharmaceutical intervention dates for those cities. The NPI data in Markel et al. (2007) have since been used by Barro (2020), Correia, Luck and Verner (2020), and Lilley, Lilley and Rinaldi (2020). The NPIs include school closures, quarantines, and bans on public assemblies.<sup>15</sup> The authors then generate “total number of days” of NPIs, where if a single calendar day had, for example, three NPIs implemented, that day would count as three. Thus, a city that implemented one NPI for 30 days would be

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<sup>14</sup>One exception is Velde (2020) which uses street car revenue to measure social distancing.

<sup>15</sup>Barry (2007) argues that Markel et al. (2007) incorrectly categorized New York City as having implemented a quarantine. While the New York City Health Board announced its intention to quarantine the sick, it is possible that such a quarantine never went into effect.

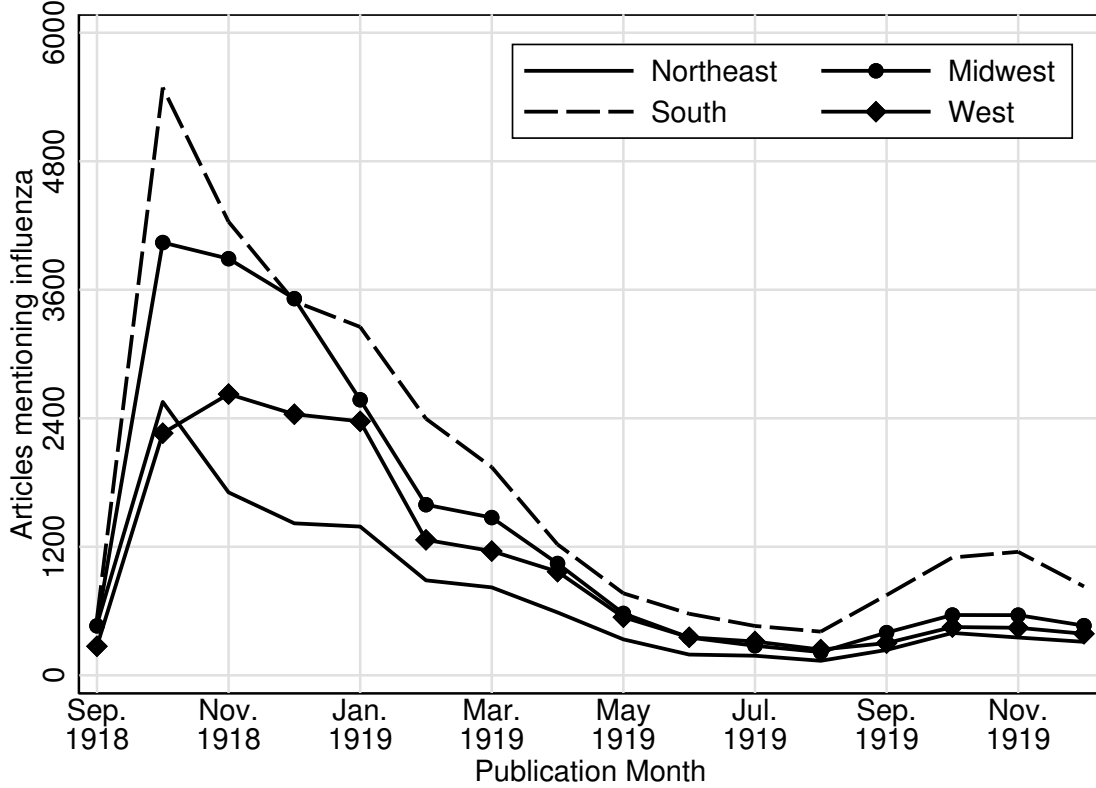
recorded as having the same amount of social distancing as a city that had three NPIs for 10 days, although it is likely that the two policies would have different effects on the spread of influenza. Hatchett, Mecher and Lipsitch (2007) use data for a broader set of NPIs, but for a small number of cities. It is worth noting that Markel et al. (2007) limit their collection of NPI data to the 43 cities with weekly influenza data. For many research questions about the medium and long-run effects of NPIs, annual influenza data would be sufficient and it should be possible to collect NPI data for the larger set of cities that have annual influenza data.

Text mining analysis of newspaper archives may provide an opportunity to increase the Markel et al. (2007) sample to include other cities. As a proof of concept, we examined the set of newspapers from the Chronicling America newspaper archive published by the Library of Congress (LOC). In coordination with the National Endowment of Humanities, the LOC supports state-level institutions to digitize regional newspapers. Most states are currently represented in the sample. The archive focuses on newspapers without active ownership that have ceased publication, which are papers that are unlikely to be digitized in the absence of the LOC initiative. Thus, the sample of newspapers available in the archive is not random and likely skews toward smaller and more localized newspaper coverage.

Figure 3 shows the number of newspaper pages that mention the word “influenza” by month and region between September of 1918 and December of 1919. There are more mentions of influenza in the South and Midwest than the West and Northeast, but this likely reflects some regions having more digitized newspapers in the LOC archive. Discussion of influenza mirrors the course of the pandemic. In all four regions there are effectively no mentions of influenza in September of 1918 and then there is a peak in coverage in October of 1918, the height of the pandemic. The number of articles mentioning influenza declined throughout the spring and then we see a

moderate resurgence during the return of influenza season in the fall of 1919.

Figure 3: Regional Patterns of Influenza Newspaper Coverage

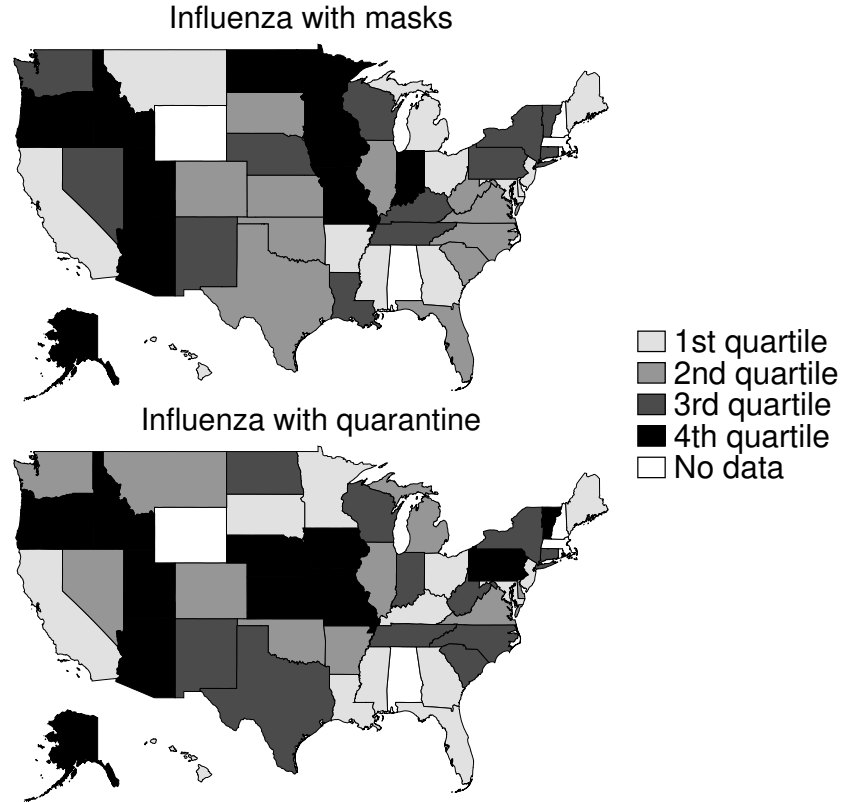


*Notes:* The data are from newspaper pages from the Chronicling America newspaper archive published by the Library of Congress. The data are restricted to newspapers published between September 1st, 1918 to December 31st, 1919.

Figure 4 displays a map of the proportion of times an NPI-related word appears within 50 words of the word “influenza.” Two words measuring NPIs are considered: “mask” and “quarantine.” Each color represents a quartile, with darker shades representing states in which the word “mask” or “quarantine” appears near “influenza” more often. The sample suggests that states west of the Mississippi River were more likely to mention masks or quarantines whenever “influenza” appears. Whether this reflects greater promotion of NPI adoption or criticisms of those policies is an open

question.<sup>16</sup> The western United States did experience relatively lower mortality rates, which would be consistent with the efficacy of NPIs, but we hesitate to draw strong conclusions from that correlation.

Figure 4: Proportion of influenza articles in which an NPI appears within 50 words



*Notes:* The data are from newspaper pages from the Chronicling America newspaper archive published by the Library of Congress. The data are restricted to newspapers published between September 1st, 1918 to December 31st, 1919. The share of influenza articles is the number of pages for which “influenza” appears within 50 words of the NPI divided by the total number of pages in which “influenza” appears.

A similar technique could be applied using data from the British Newspaper Archive ([www.britishnewspaperarchive.co.uk](http://www.britishnewspaperarchive.co.uk)). This website represents an ongoing joint effort by the British Library and findmypast to digitize 40 million newspaper pages from the

<sup>16</sup>While the archive digitization is useful for identifying keywords, the search algorithm only identifies the page in which the word appears not the specific article. Thus, analyzing the context of specific articles would require substantial data cleaning and is beyond the scope of this exercise.

British Library’s extensive collection. Similar to the Library of Congress, the sample of digitized newspapers tends to emphasize content from local newspapers. Despite this, the resource is quite comprehensive. A search for “influenza” returns 23,039 articles in 1918, 19,579 articles in 1919, and 8,549 articles in 1920. Interestingly, the coverage of non-pharmaceutical interventions appears to lag the United States. The data from the Library of Congress indicate that the share of articles mentioning “influenza” and “mask” was 3.5% in 1918 and 0.9% in 1919. Among the articles appearing in the British Newspaper Archive, just 0.77% of the influenza articles published in 1918 mention the word “mask,” whereas 2% of the articles published in 1919 mention mask. A similar trend appears with influenza and “ban” or “quarantine.”

In summary, trends in the digitization of historical print sources present new opportunities for researchers to assess the role of NPIs in 1918. We have shown that, at least for the United States and England and Wales, it is possible to construct a measure of NPI for a large set of cities. These exercises illustrate that our understanding of the role of NPI does not need to be informed entirely by the 43 U.S. cities that appeared in the pioneering work of Markel et al. (2007).

### **3.3 Economic Data**

Economic data collected today are generally more reliable than in the past. However, the abrupt nature of the COVID-19 outbreak has presented several challenges to data collection. Shutdowns have suspended in-person interviews in many places, and there has been some recent controversy of whether to classify individuals who work for temporarily shutdown businesses as unemployed. The data issues faced by researchers interested in analyzing the 1918 pandemic are typically much more challenging.

Annual GDP and consumption data are available for 42 countries from 1911 onward from Barro and Ursúa (2010), although the data go back even further for many

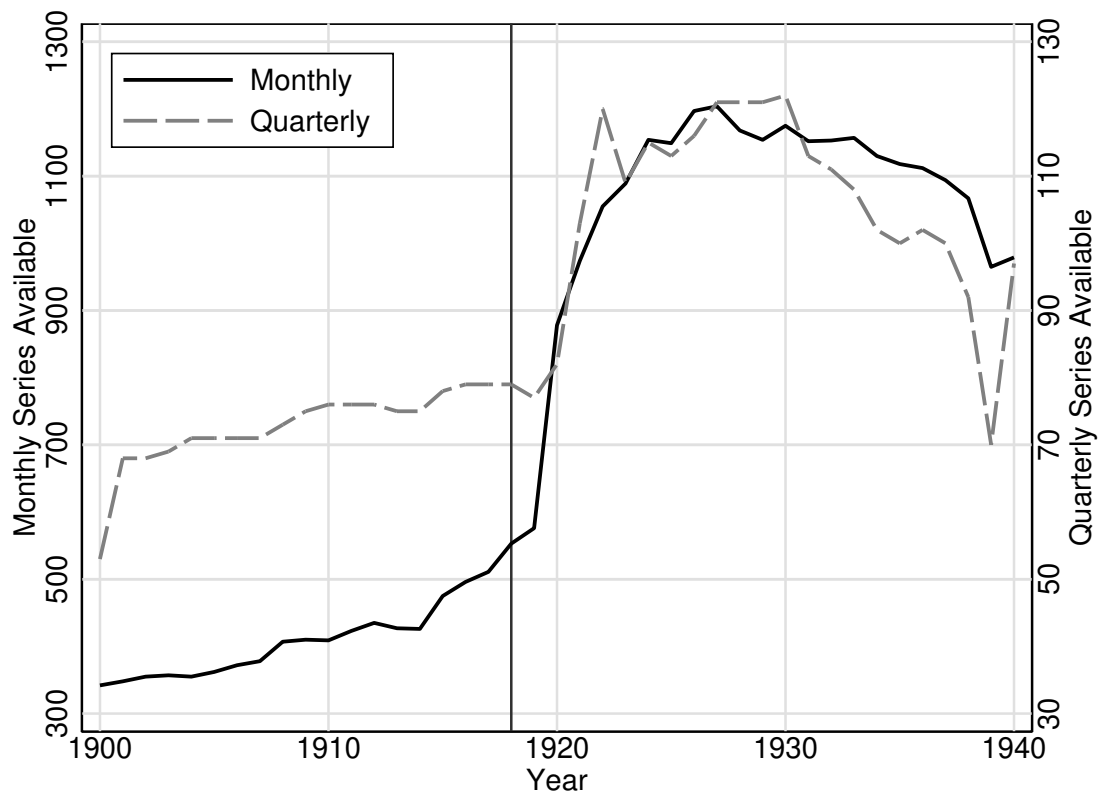
of those countries. Barro, Ursúa and Weng (2020) use these data to estimate cross-country panel data regressions that we discuss in more detail in Section 5. Additionally, many European countries have annual regional or district-level data on economic activity, including Sweden, Denmark, and Italy (Karlsson, Nilsson and Pichler, 2014; Dahl, Hansen and Jense, 2020; Carillo and Jappelli, 2020). Most worldwide data sources are at the annual level. The lack of monthly and quarterly data presents challenges to estimating the effects of the pandemic, given that the pandemic was largely concentrated in the last quarter of 1918.

There are several U.S. macroeconomic time series spanning the pandemic including real GNP, industrial production, and various employment indices. These time series are analyzed by Velde (2020) and are discussed in Section 5. Unfortunately, many macroeconomic time series begin shortly after the pandemic. Figure 5 displays the number of monthly and quarterly time series that are digitized in the NBER Macroeconomic Time Series Database. This database is also the source of many of the historical series that appear in the FRED database published by the Federal Reserve Bank of St. Louis. While there are a number of series that span the time of the pandemic, the number of both monthly and quarterly series doubles between 1918 and 1921. Much of this increase likely reflects the founding of NBER in 1920.

Cross-sectional economic data during the pandemic are often lacking in the United States. The most commonly used panel data set is the Census of Manufacturers, which was taken every 5 years from 1899-1919, and every 2 years thereafter. The Census of Manufacturers includes total manufacturing employment for U.S. states and major cities, as well as total wages. That the data are only observed from 1914-1919 presents several challenges in making conclusive inferences. Any difference in employment observed between 1914 and 1919 may have occurred before, during, or after the pandemic. It is uncertain whether the timing of employment changes is more



Figure 5: Number of Series in the NBER Macrohistory Database



*Notes:* Data are from the NBER Macrohistory Database. The graph shows the number of series that include a given year. Often the quarterly series ends and a monthly series of the same variable begins immediately afterwards.

consistent with the pandemic, WWI, or something else. See the debate in Correia, Luck and Verner (2020) and Lilley, Lilley and Rinaldi (2020).

Although common measures of city-level economic activity are not available annually during this period, some annual city-level economic data do exist. For example, building permit and cost data are available annually for most major cities from the Statistical Abstracts of the United States. Figure 6 shows estimated costs and the number of building permits for cities with below- and above-median pandemic intensity from 1914-1925. The data are limited to a balanced sample of 93 cities for which building permit data are available for all 12 years. We measure pandemic intensity as the number deaths in 1918 relative to the predicted number of deaths in 1918. The predicted number of 1918 deaths comes from a regression of the log of deaths on a linear time trend, using data from 1900 to 1917.<sup>17</sup>

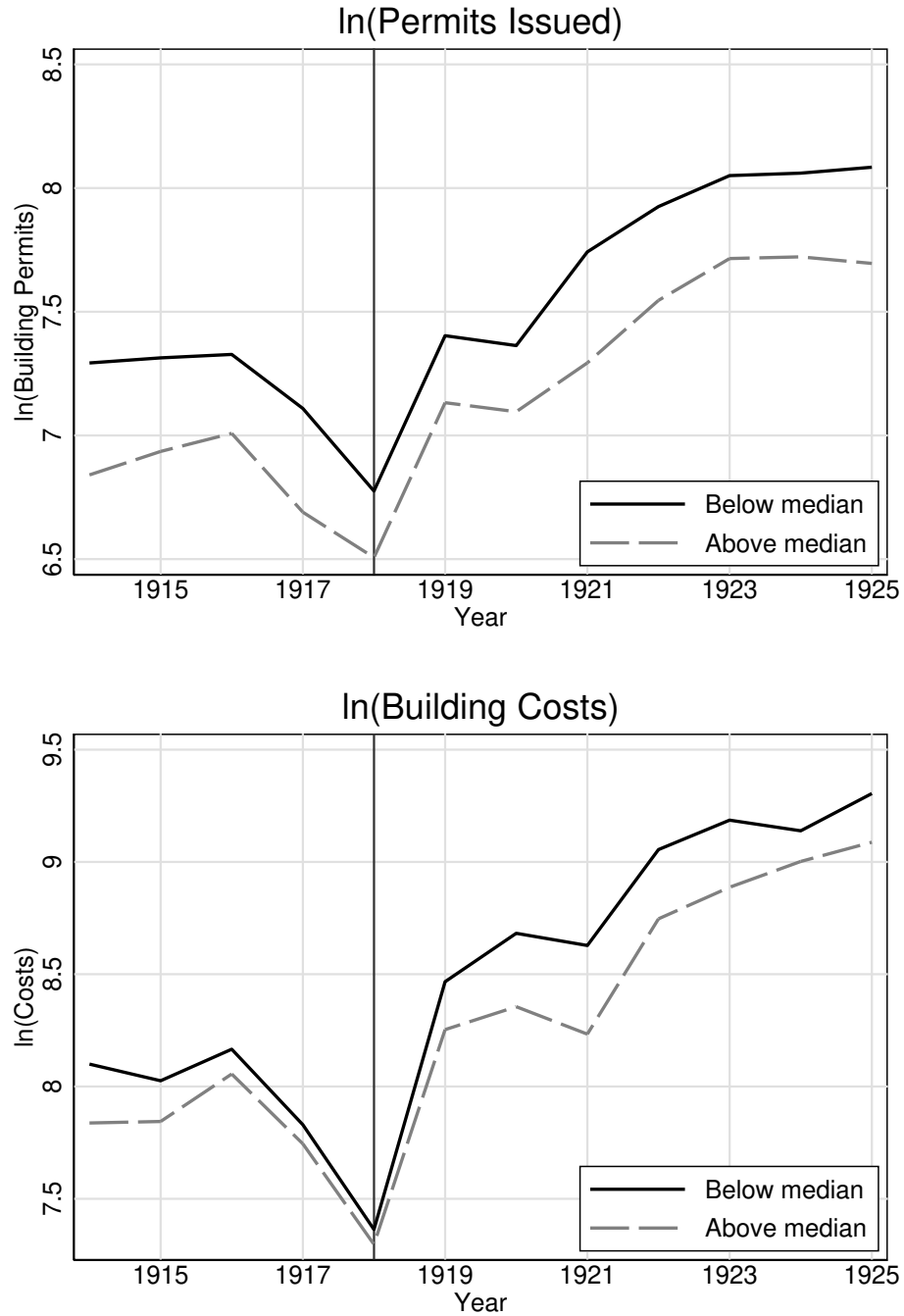
Figure 6 shows that permits declined starting in 1917 for all cities, reaching a trough in 1918, and returning to 1916 levels by 1919. The timing of this downturn is consistent with resources being shifted away from construction toward war production and might be unrelated to the pandemic. There is weak evidence that construction costs and the number of permits issued were higher in below-median intensity cities relative to above-median intensity cities, though the evidence is not compelling. Construction is only one industry and may not be representative of the whole economy. However, the graph does highlight how economic shocks can be missed with irregularly spaced data. More research would need to be done to see if these preliminary results represent robust causal estimates.

As with NPIs, newspapers may provide an additional source for economic data. Garrett (2009) reviewed two newspapers, *The Arkansas Gazette* in Little Rock and

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<sup>17</sup>This approach follows from Beach, Ferrie and Saavedra (2018). One could apply a similar technique to influenza deaths or deaths from influenza and pneumonia. Measuring pandemic intensity with this variable yields similar qualitative conclusions.

Figure 6: Building permits and costs by pandemic intensity



*Notes:* The data are from various years of the Statistical Abstracts of the United States. The data report the number of permits from 1914 to 1919 and the number of buildings from 1921 to 1925. Both are available in 1920, during which the correlation between the number of permits and buildings is over 0.99. The number of permits does not always equal the number of buildings because sometimes a single permit may cover multiple structures.

*The Commercial Appeal* in Memphis, for examples of how businesses coped with the pandemic. Garrett documents that the newspapers reported that retail business declined, often by one-third to one-half of usual sales. Industrial plants, railway service, telephone companies, and coal mines were all operating below capacity as workers were out sick. Of course, there is likely selection bias in which industries receive coverage in newspapers.

Newspapers may also be a useful source for explaining macroeconomic data. Baker et al. (2020) examine next-day newspaper explanations for stock market jumps. They identify 23 stock market jumps between March of 1918 (the first wave of the pandemic) and June of 1920. In no single jump observation was the influenza pandemic cited as the source for stock market volatility. Similarly, Bodenhorn (2020) uses ratings of retail and manufacturing activity as reported in the business journals *Bradstreet's* and *Dun's Review*. He finds that the pandemic decreased the rating of both retail sales and manufacturing activity.

## 4 Health Effects

This section begins by reviewing mortality worldwide, patterns of differences in severity, and reasons for these differences, notably poverty. The analysis then examines the United States. Its experience is well documented, and fighting during World War I did not occur on U.S. soil.

### 4.1 Worldwide

COVID-19 has infected millions worldwide and killed hundreds of thousands within the first six months of the pandemic. As with influenza, pandemic severity has varied across geographic units for reasons that are not fully understood. Thus far, the

countries with the highest reported death rates per 100,000 have included high income countries (Belgium, Spain, the UK, Italy, France, Sweden and the United States) as well as middle income countries from Latin America (Brazil, Peru, and Chile).<sup>18</sup> Although mortality is positively related to per capita income at the country level, within those countries, mortality appears to be negatively related to per-capita income once the effects of population density are accounted for (Jung et al., 2020). That is, the poor are experiencing higher mortality rates.

The 1918 pandemic killed millions worldwide.<sup>19</sup> The largest numbers were in India, where the high fatality rate and large population combined to generate between 10 and 20 million deaths. Recent estimates suggests the number was 11-14 million (Chandra, Kuljanin and Wray, 2012; Hill, 2011). China was next with between 4 and 9.5 million deaths. In total, Asia accounted for 26-36 million deaths. Africa and Europe accounted for 2.4 million and 2.3-2.6 million deaths, respectively.<sup>20</sup> The Americas accounted for about 1.5 million deaths. Oceania accounted for 85,000. Johnson and Mueller (2002) estimate that there were 49 million deaths and that the total number could be as high as 100 million. Other estimates such as Barro, Ursúa and Weng (2020) are somewhat lower at 39 million. Given the limited evidence on mortality for important countries, the total mortality will remain uncertain.

Pandemic severity varied significantly across countries.<sup>21</sup> For example, 4.4 to 6.1% of the population in India died, while in Denmark fatality rates were between 0.2 and 0.4%. One way to visualize the scale of the effect is to examine the impact on life expectancy. Period life expectancy is a statistic that reports how long we would expect

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<sup>18</sup>These rankings come from <https://coronavirus.jhu.edu/data/mortality>. It is possible that an excess mortality model, which would ignore official cause of death classifications, would generate a different pattern.

<sup>19</sup>The numbers, unless otherwise indicated, are from Johnson and Mueller (2002).

<sup>20</sup>Ansart et al. (2009) estimates that there were 2.64 million excess European deaths.

<sup>21</sup>Pandemic severity also varied within countries, an issue that we discuss further in the following section.

someone would live if they were exposed to the mortality rate every single year. Figure 7 plots period life expectancy for 14 countries from 1900 to 1940.<sup>22</sup> We highlight the patterns for the countries that experienced the smallest and largest percentage change in life expectancy between 1918 and 1919. Denmark experienced a 1.7% decline in life expectancy whereas Italy experienced a 38.9% decline. Among these 14 countries, average life expectancy declined by 17.6% between 1918 and 1919. This is depicted in the figure with a black dashed line.

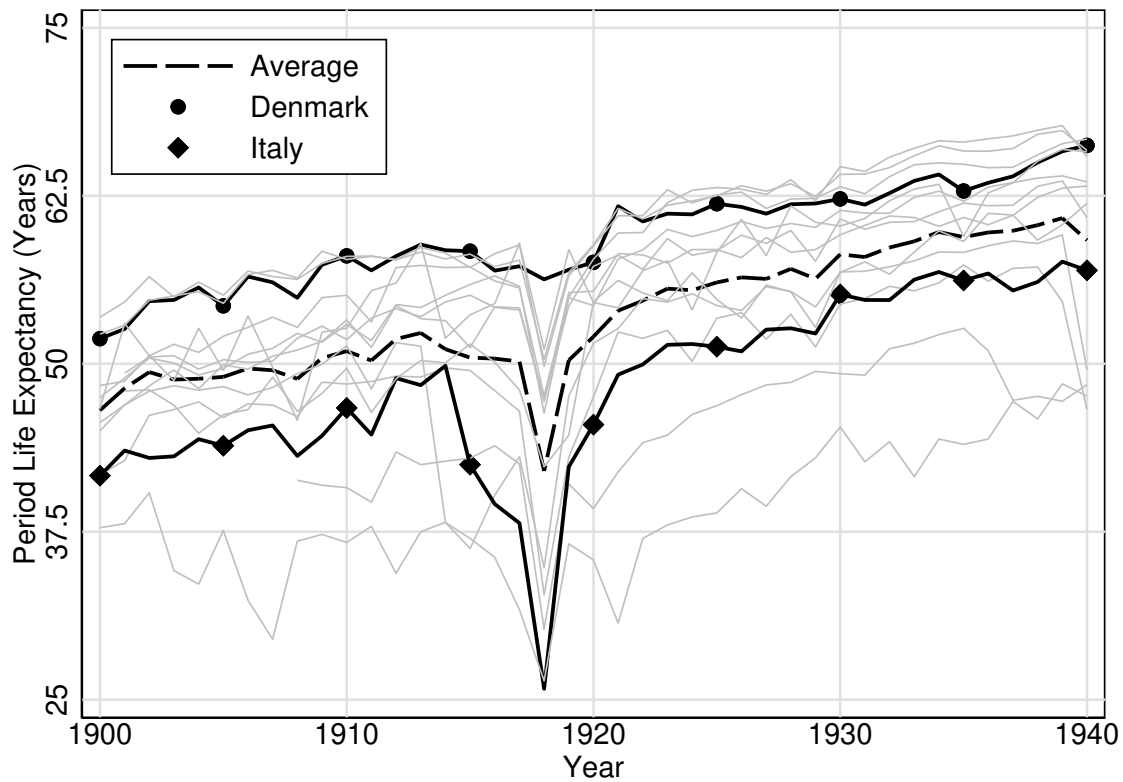
An important question is why pandemic severity varied across countries. A leading explanation is income or poverty. Using data for 27 countries, Murray et al. (2006) regress country level severity on country income per head in 1918. They find that income was negatively and significantly related to severity. A 10% increase in income was associated with a 9-10% decrease in mortality. In the next section, which examines evidence from the United States, city-level measures of poverty are positively related to mortality.

A related strand of the literature has used individual level data to examine mortality by economic status and so provides insight into the pandemic's effect on inequality. Sydenstricker (1931) did pioneering work using detailed data for 100,000 individuals in nine urban localities in the United States. Individuals of well-to-do and moderate economic status experienced a mortality rate of 0.38%. Those of poor economic status experienced a mortality rate of 0.52%, while the very poor experienced a mortality rate of 1.00%. Mills (1986) finds that low-caste Hindus in Bombay City (modern day Mumbai) had mortality that was 3 times higher than other Hindus and 8 times higher than Europeans. More recent work by Mamelund (2006) using individual and household level data has shown that controlling for other factors, apartment size, a

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<sup>22</sup>The underlying data are from ourworldindata.org. Sample is restricted to the set of countries with annual data from at least 1915-1920. The sample includes: Denmark, Finland, France, Iceland, Italy, Jamaica, Luxembourg, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom, and the United States.

Figure 7: Period Life Expectancy by Year in 14 Countries



*Notes:* Data from ourworldindata.org. Sample is restricted to the set of countries with annual data from at least 1915-1920. The sample includes: Denmark, Finland, France, Iceland, Italy, Jamaica, Luxembourg, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom, and the United States. Denmark and Italy are highlighted because they experienced the smallest and largest change in life expectancy between 1917 and 1918, 1.7% and 38.9% respectively. The dashed line corresponds to the average life expectancy. The average decline in life expectancy between 1917 and 1918 was 17.6%.

proxy for socioeconomic status, was related to mortality in Kristiania (modern day Oslo). Compared to individuals who lived in one-room apartments, individuals who lived in two-room, three-room, and four-room apartments had 34, 41, and 56% lower mortality, respectively. We discuss inequality further in section 8.4.

## 4.2 United States

As of June 28, 2020, official numbers for the United States indicate that COVID-19 has infected over 2.5 million and has killed 125,000. Because of its large geographic area, COVID-19 arrived in different locations at different times. The cities and states that were the hardest hit early on have been experiencing declining infections and death rates going into the summer. Other areas that were not as hard hit initially are in some cases now experiencing rising infection and death rates. Poorer zip codes are seeing disproportionately higher infection and death rates as compared to richer nearby zip codes.

Even in the United States, where historical data are more complete than many countries, estimates of mortality during the 1918 pandemic vary from 550,000 to 850,000. The 550,000 appears to have originated with Collins (1945) and been reported by Crosby (2003) as a conservative estimate. It is used by Patterson and Pyle (1991) and more recently by Barro, Ursúa and Weng (2020). If the estimate for cities in Clay, Lewis and Severnini (2019*b*) is scaled up to the United States, total mortality is estimated to be about 615,000.<sup>23</sup> Crosby’s main estimate is 675,000, which accounts for the fact that the registration area did not cover the entire United States in 1918. This number is used by Johnson and Mueller (2002). The 850,000 estimate appears to have

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<sup>23</sup>Whether rural areas were affected more or less than urban areas remains an open question. There is suggestive evidence in Clay, Lewis and Severnini (2019*b*) and Acuna-Soto, Viboud and Chowell (2011) that mortality rates may have been higher in rural areas. Paynter, Ware and Shanks (2011) also finds soldiers from rural areas died at higher rates than soldiers from urban areas.



originated with Dauer (1957).

Early observers noted that there was substantial variation in pandemic severity across the U.S. and this led to many hypotheses regarding the causes of the variation. These hypotheses focus on four determinants of excess pandemic mortality across cities: i) measures of pre-pandemic health and poverty, ii) the use of non-pharmaceutical interventions, iii) the timing of onset and proximity to military bases, and iv) air pollution.

A number of authors have used measures of population health, poverty, and public health to predict mortality in 1918. Acuna-Soto, Viboud and Chowell (2011) examine the relationship between pre-pandemic influenza and pneumonia mortality and pandemic influenza and pneumonia mortality, finding that pre-pandemic and pandemic pneumonia mortality are highly correlated. Bootsma and Ferguson (2007) show that 1918 mortality is correlated with 1917 mortality. Other researchers have explored the relationship between poverty markers and pandemic severity. Grantz et al. (2016) examine the ability of percent illiterate, percent homeowners, percent unemployed and population density to predict pandemic influenza mortality across census tracts in Chicago. Tuckel et al. (2006) explore the relationship between the percent foreign born and ward-level influenza mortality in Hartford. While the analysis is at the level of the geographic unit and not the individual level, the results provide additional evidence that the pandemic had unequal effects.

Bootsma and Ferguson (2007), Markel et al. (2007), Clay, Lewis and Severini (2018), Barro, Ursúa and Weng (2020), and Correia, Luck and Verner (2020) examine the effects of public health measures, often referred to as nonpharmaceutical interventions, on influenza and pneumonia mortality drawing on data for 43 cities for which weekly data is available. Nonpharmaceutical interventions included school closures, bans on public gatherings, and quarantine or isolation of suspected cases. Correia,

Luck and Verner (2020) find that cities with above median days of nonpharmaceutical interventions had lower peak mortality and lower cumulative mortality. Using data at the annual level, neither Clay, Lewis and Severnini (2018) nor Barro (2020) find that nonpharmaceutical interventions had statistically significant effects, although the signs appear to be correct. Barro (2020) suggests that one issue is that the closures were of relatively short duration.

The timing of pandemic onset in the fall is thought to be an important predictor of mortality, because the virulence may have declined over time (Crosby, 2003; Barry, 2005). The most serious wave originated in Camp Devens near Boston in the first week of September 1918. The pandemic had surfaced in most East Coast cities by mid-September and then moved westward, diffusing nationwide by early October. The movement of military personnel is also believed to have influenced severity through its role in spreading the virus across the country. Kolata (2001), Crosby (2003), Barry (2005), and Byerly (2010) provide detailed accounts of the pandemic in the military, and the role of the Navy and Army in its spread.

Although pre-pandemic health and poverty and the timing of onset and proximity to military bases have been discussed in the historical and medical literatures, air pollution has received far less attention. There is growing biological (Jakab, 1993; Jaspers et al., 2005), animal (Hahon et al., 1985; Harrod et al., 2003; Lee et al., 2014), and epidemiological evidence that air pollution can increase susceptibility to influenza (Ciencewicki and Jaspers, 2007). Recent empirical evidence suggests that air pollution interacts with infectious disease. Hanlon (2018) finds that higher underlying rates of measles, tuberculosis (TB), and other respiratory diseases increased the mortality effects of pollution episodes in London from 1866 to 1965. Similarly, Clay, Lewis and Severnini (2019a) show that coal-fired generating capacity, a proxy for air pollution, led to significantly higher mortality rates during the pandemic.

Because Clay, Lewis and Severnini (2019*b*) is the most comprehensive analysis of variation in mortality, we discuss it in more detail. Their study draws on a new data set of annual mortality in 438 U.S. cities that represent two-thirds of the urban population for the period 1915 to 1925. The panel structure of the data set facilitates construction of a measure of pandemic severity for a large sample of cities. The empirical analysis involves two steps. First, they estimate excess pandemic mortality in every city as the difference between observed and predicted mortality in 1918. The interquartile range in excess mortality is 0.39 to 0.78%. Second, they estimate cross-sectional regressions to assess the importance of: i) measures of pre-pandemic health and poverty, ii) the timing of onset and proximity to military bases, and iii) air pollution.<sup>24</sup>

Clay, Lewis and Severnini (2019*b*) find that pre-pandemic infant mortality, percent illiterate, air pollution from coal plants, and rural share are positively and statistically significantly related to excess mortality.<sup>25</sup> To facilitate interpretation control variables are included as terciles. High and middle terciles are then compared to the lowest tercile. Figure 8 reports the corresponding magnitudes for the main explanatory variables. Proximity to World War I bases are statistically significant when percent urban is included as a control. When all of the covariates are included, however, the coefficients on proximity to World War I bases are statistically insignificant.

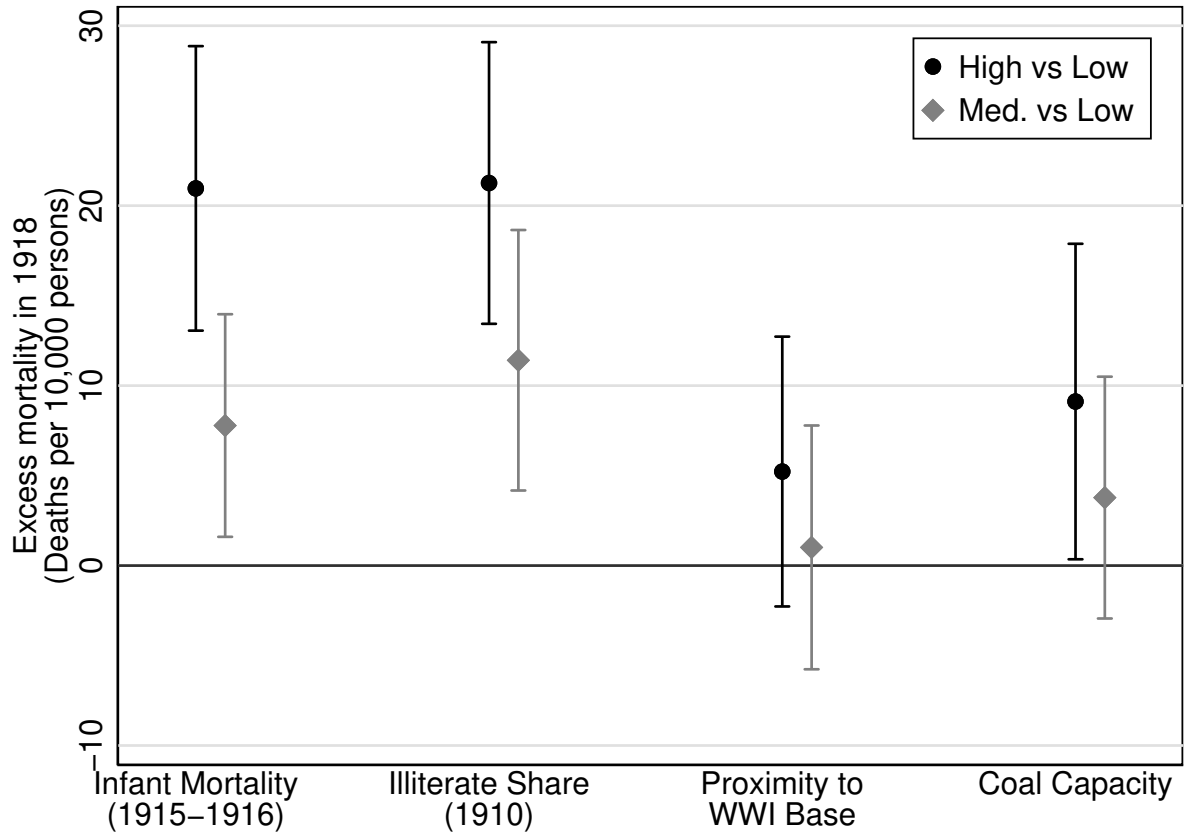
The results shown in Figure 8 are robust to other measures of excess mortality and to including a number of additional controls such as measures of religiosity and

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<sup>24</sup>Clay, Lewis and Severnini (2019*b*) controls for percent urban in the county. Like Acuna-Soto, Viboud and Chowell (2011), they find that cities in more urban counties had statistically significantly lower mortality rates. This may have occurred for a number of reasons. More urban areas may have greater exposure to the milder spring wave of influenza and so have greater immunity. More urban areas also may have been more able to implement non-pharmaceutical interventions such as isolation and quarantine of victims, school closure, and cancellation of public gatherings (Bootsma and Ferguson, 2007; Markel et al., 2007).

<sup>25</sup>The infant mortality rate is widely used as a measure of population health, since the link between infant deaths and contemporaneous health conditions – including disease, pollution, and nutrition – is immediate, whereas adult mortality reflects an accumulation of lifetime exposure (Chay and Greenstone, 2003; Currie and Neidell, 2005).

Figure 8: Drivers of Excess Mortality in 1918



*Notes:* Coefficients and confidence intervals from Table 1 column 5 of Clay, Lewis and Severnini (2019b). The estimates are obtained by regressing excess mortality in 1918 on indicators for whether the city has high, medium, or low intensity with respect to each of the explanatory variables: pre-existing infant mortality rates, illiterate share, proximity to a WWI base, coal-fired electricity capacity (a proxy for air pollution), and urban share. The “low” classification is the omitted category. Excess mortality is the difference between observed mortality and predicted mortality in 1918, where predicted mortality is calculated based on a linear city-specific trend.

religious fractionalization, city public health infrastructure, and access to trade (Clay, Lewis and Severnini, 2019*b*). There is some evidence that greater religious fractionalization is associated with higher pandemic mortality. Pre-pandemic local public health infrastructure appears to be unrelated to pandemic mortality, consistent with local public health response having been overwhelmed by the magnitude of the pandemic (Crosby, 2003). Finally, greater access to trade, as measured by total miles of railway in 1911, is associated with increased pandemic severity, consistent with recent evidence on the role of transportation in accelerating the spread of influenza (Adda, 2016). Including these variables does not alter the results in Figure 8.

## 5 Economic Effects

In this section, we discuss how the 1918 influenza pandemic affected the economy. We start by discussing the short-run economic effects, which we define as the period when the pandemic was still ongoing. This literature is most consistent with a negative labor supply shock, most likely because the pandemic disproportionately killed or incapacitated working-age adults. We then turn to what we refer to as the medium-run economic effects, or the effects on the economy after the pandemic had ended, generally from 1920 to 1930. In the medium-run, there is some evidence that the pandemic reduced economic growth, but much of this evidence comes from countries involved in WWI, making conclusive inference challenging.

### 5.1 Short-run economic effects

The COVID-19 pandemic has led to a historic downturn in the global economy. The OECD has projected that global GDP will drop between 6 and 7.6% and unemployment will increase by 3.8 to 4.6% in 2020, depending on whether there is a second wave of

COVID-19 later in the year (OECD, 2020). While these are projections, they do highlight that the pandemic has caused a contraction of historic size and abrupt onset, as well as a high degree of economic uncertainty. The current pandemic raises the question of whether global pandemics always cause economic crises, or whether the reaction to COVID-19 is unique. To answer this question, many economists are turning their attention toward 1918.

In 1918, countries with higher influenza mortality had deeper recessions.<sup>26</sup> Barro, Ursúa and Weng (2020) use annual panel-data from 43 countries during the 1901 to 1929 period to estimate the macroeconomic effects of the pandemic. Holding WWI combat-fatalities per capita fixed, an additional percentage point of influenza mortality is associated with a 3 and 4% decline in real GDP per capita and real consumption per capita, respectively. The 1918 influenza pandemic killed approximately 2% of the population for the average country in the sample, suggesting that the pandemic resulted in a 6% decline in real GDP per capita and an 8% decline in real consumption per capita on average. These estimates are remarkably close to the OECD projections for the real GDP decline in 2020 (OECD, 2020).

Countries with higher pandemic mortality had higher rates of inflation, lower short-term government bill returns, and may have had lower stock returns as well (Barro, Ursúa and Weng, 2020). The panel data regression suggests that a country with a 2% influenza mortality rate experienced a 20 percentage point increase in the inflation rate, although the effect on prices is temporary. Similarly, average pandemic mortality is associated with a 14 percentage point decrease in real returns on government bills and a 26 percentage point decrease in real returns for stocks, however the latter estimate is

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<sup>26</sup>There is a related literature in economics that asks how recessions affect health. See the seminal paper of Ruhm (2000), which finds that recessions can lead to improvements in health. Evidence from historical settings is less consistent with that idea. See Arthi, Beach and Hanlon (2019) as well as the recent review by Arthi and Parman (2020).

noisy and statistically insignificant.<sup>27</sup> An increase in prices accompanied by a decrease in output is consistent with a negative supply shock.

In the United States, a brief V-shaped recession coincided with the pandemic. Velde (2020) uses high-frequency time series data (often weekly or monthly) to examine the immediate economic impacts of the pandemic. Industrial production dropped 20% from July 1918 to January 1919 but rebounded quickly. Relative to August of 1918, ten-cent stores and dry goods/clothing stores saw a decrease in sales.<sup>28</sup> Drug stores showed a modest increase in sales in October and larger decreases as the pandemic ended. Mail-order catalogs saw an increase in sales, an increase Velde attributed to an “early Amazon effect.” Employment indices from Ohio, Massachusetts, Wisconsin, and New York show that employment fell between 7 and 15% during the pandemic, but all recovered by the end of 1919. Bodenhorn (2020) finds that influenza mortality decreased ratings of retail sales and manufacturing activity as reported in trade journals.

Coal production fell during the pandemic, largely due to labor shortages. Every week, the U.S. Fuel Administration reported the percent below capacity coal mines were operating, along with whether the shortfall in production was due to labor shortages or strikes. Labor shortages increased in October 1918, peaking in November, and returned to pre-pandemic levels by January of 1919 (Velde, 2020). Cumulative lost production due to labor shortages was higher in states with more excess influenza and pneumonia mortality. There were similar production declines in the textile and lumber industry (Bodenhorn, 2020).

At least in the U.S., the stock market did not decline during the pandemic (Velde,

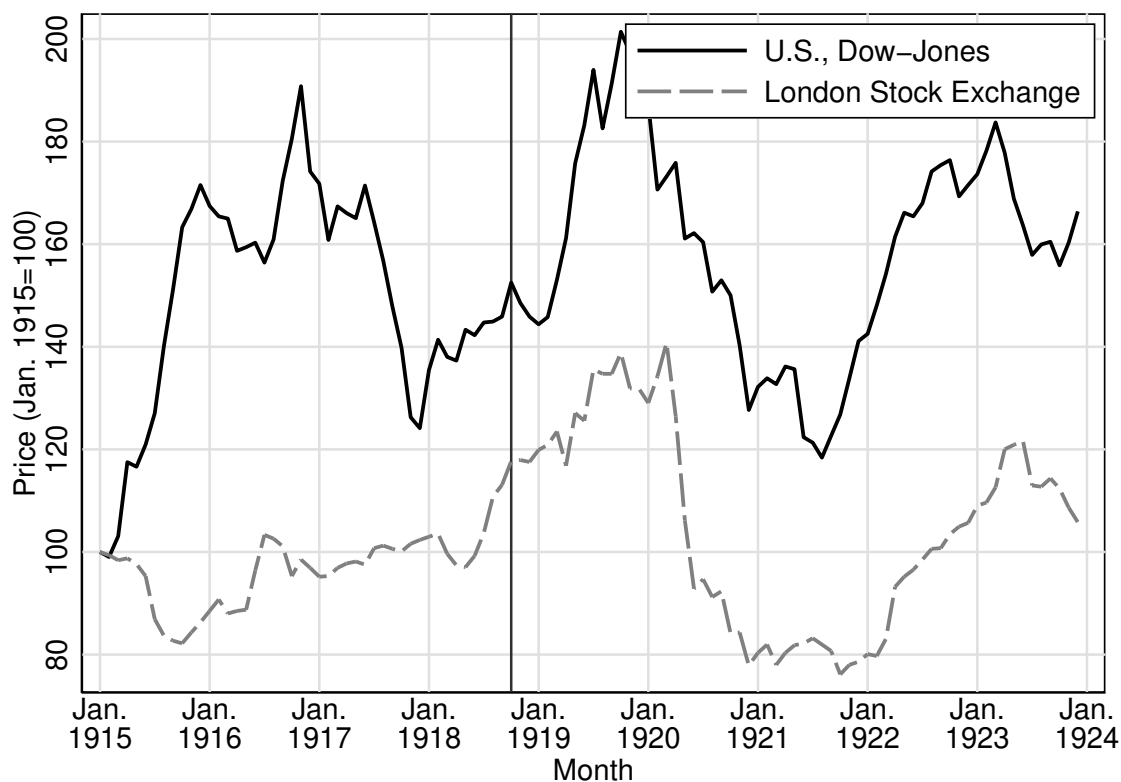
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<sup>27</sup>Jordà, Singh and Taylor (2020) study the macroeconomic effects of 15 pandemics that killed at least 100,000 people, starting with the black death in the 14th century to the 2009 H1N1 influenza pandemic. They find that real rates of return are lower following pandemics for a 40 year period. They show that their results are robust to excluding the 1918 pandemic.

<sup>28</sup>The retail sales data come from a 1929 article in the *Harvard Business Review*.

2020). This was also true for the United Kingdom. Figure 9 displays monthly data for the Dow Jones Industrial Average and the London Security Price Index. Both indices are normalized to have a value of 100 as of January of 1915. There was not significant movement in either index during the pandemic, although U.S. stocks did briefly peak in October of 1918. By contrast, the Dow Jones Industrial Average lost more than a third of its value during both 1917 and 1920. Newspapers during 1918 did not identify the pandemic as being the source of any major stock jumps (Baker et al., 2020). Taken together, the evidence suggests that the 1918 pandemic was not a major determinant of U.S. stock market volatility.

Figure 9: Stock Market Indices



*Notes:* The data are from NBER Macrohistory database. The vertical line represents October of 1918.

The brevity of the recession and the lack of stock market volatility raises the ques-



tion: why were the concurrent effects of the influenza pandemic on the U.S. economy so modest in 1918 and so large during the 2020 COVID-19 pandemic? First, the U.S. had a lower mortality rate in 1918 than most of the world. For example, the estimated mortality rate was only one-quarter of the average of the Barro, Ursúa and Weng (2020) sample. Second, the pandemic in 1918 occurred in a time when infectious disease was a common cause of death (see Figure 1). Americans in 1918 may have become accustomed to the risk of dying from infectious disease in a similar way that many modern-day Americans are accustomed to the risk of dying from heart disease. Third, although there were non-pharmaceutical interventions during the 1918 pandemic, they were not as severe as the social distancing laws that were implemented in the spring of 2020. Many businesses and schools in 1918 either did not close, or did so only briefly. Fourth, the demand for munitions for the war may have prevented the closing of businesses and factories.

## 5.2 Medium-Run Economic Effects

The medium-run consequences of the COVID-19 pandemic remain highly uncertain. The answer will likely depend on if and when a vaccine is discovered and if there are multiple waves of the disease. We will not know the lasting economic consequences of COVID-19 until it is too late for policymakers to intervene. Economic historians, however, have measured the medium- and long-run economic effects for the 1918 influenza pandemic.

There is recent within-country evidence that the influenza pandemic stunted economic growth, but the economy recovered after approximately 3 years. Carillo and Jappelli (2020) find that Italian regions that were hit hardest by the pandemic experienced a 6.5% decline in real GDP compared to the least affected Italian regions. The effect is largest the year after the pandemic and fades out by 1922. Dahl, Hansen and

Jense (2020) find similar results using a panel of 76 Danish municipalities. They find that income growth fell for 2 to 3 years after the pandemic, after which there is some evidence of a medium-run effect in 1922 to 1925, although the estimates are noisy. They do not find evidence that the pandemic had long-run effects on income growth.

Using annual panel data, Karlsson, Nilsson and Pichler (2014) find that Swedish regions with worse pandemic mortality had lower capital earnings in the short-run (1918-1920) and the medium-run (1921-1930). While the pandemic had no effects on poorhouse rates in the short-run, poorhouse rates increased in the medium-run. To put the effect into perspective, the authors find that increasing excess mortality from the 25th to the 75th percentile resulted in a 10 percentage point increase in poorhouse rates. Although the estimates for earnings are negative, the effect sizes are small and statistically insignificant in both the short-run and long-run.

Turning to the United States, Correia, Luck and Verner (2020) use city-level data to test whether there exists a trade off between non-pharmaceutical interventions and economic activity. They show that high- and low-NPI cities had similar levels of economic disruptions during the pandemic, as measured by wholesale, retail, and manufacturing disruptions reported in *Bradstreet Trade*. The authors then use data from the 1904 to 1927 Census of Manufactures<sup>29</sup> as well as annual banking data and show that NPI intensity either increased economic activity or had no effect on economic activity in the medium-run.<sup>30</sup>

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<sup>29</sup>The Census of Manufacturers was not done annually and is only available every five years from 1904 to 1919 and every two years after 1919.

<sup>30</sup>Lilley, Lilley and Rinaldi (2020) critiqued an earlier version of Correia, Luck and Verner (2020). They show that while NPIs during the pandemic predict employment growth from 1914-1919, most of the correlation goes away after control for 1910-1917 population growth, suggesting that the faster growing cities were more likely to implement NPIs. It should be noted that the 1917 population number is an interpolation from the 1910 and 1920 Census and not an actual count. Lilley, Lilley and Rinaldi (2020) then show that cities that adopted NPIs had different preexisting trends and after accounting for pre-trends in the regression, the effect of NPIs on employment has large confidence intervals. Correia, Luck and Verner have responded to the critique challenging whether the interpolated data are reliable. This debate highlights the difficulty in making inferences when population data are not collected annually.

The pandemic and WWI reduced the size of the labor force and increased wages (Garrett, 2009). The servicemen killed in WWI would have almost exclusively been working age males, and because the influenza pandemic had a W-shaped mortality curve, the pandemic killed a higher percentage of prime-aged adults than a typical influenza. Similarly, researchers have argued that the black death resulted in a negative labor supply shock and increased wages (see discussion in Jedwab, Johnson and Koyama (2020)). For 30 states with influenza data, Garrett regresses manufacturing wage growth on 1918 influenza deaths per capita and WWI combat deaths per capita. Both WWI mortality per capita and influenza deaths per capita predict 1914-1919 wage growth and are statistically significant. Increasing WWI combat fatalities by 10% from its mean increased wage growth by 1.9 percentage points. A similar increase for influenza fatalities would have increased wage growth by 0.9 percentage points. While data on the WWI combat fatalities do not exist at the city level, Garrett repeats the influenza exercise for a sample of 50 cities and finds similar results.

Wartime production may have affected economic growth in U.S. cities, potentially confounding estimates of the effect of the pandemic. Rockoff (2004) documents how the U.S. economy changed leading up to and during the war. The economy experienced an economic boom starting in 1914, three years before the U.S. entered the war, and the manufacturing sector expanded as the U.S. produced munitions for its allies. In which direction this would bias estimates of influenza’s effect is unclear. On the one hand, proximity to railways and ports may have meant that cities experiencing production booms may have been harder hit by the flu. Additionally, city officials may have hesitated to implement social distancing laws that would have hindered war production. In this case, we would expect that the estimates of influenza on employment growth would be underestimated. On the other hand, cities far from Boston tended to be less affected by influenza and West Coast cities had numerous shipyards which may have

expanded production after 1914 due to the war. It is possible that West Coast cities grew because of the boom in war production, rather than from escaping the worst of the pandemic.

Brainerd and Siegler (2003) examine whether the pandemic affected economic growth of U.S. states from shortly after the pandemic (1919-1921) to 1930. The authors measure economic growth as the growth rate in real personal per capita income, as reported in Lindert (1978). The authors estimate that influenza and pneumonia mortality predicts higher economic growth conditional on control variables. States with higher death rates among prime-aged workers had more business failures between 1919 and 1921. This suggests states more affected by the pandemic were not operating at full capacity. Thus, the effect may reflect that the pandemic caused a recession and growth rates increased afterwards as the economy returned to the natural rate of output.

The medium-run economic consequences of the pandemic are complicated by the 1920 to 1921 recession in the U.S. Wholesale prices more than doubled between 1915 and 1920, and in response the Federal Reserve raised the discount rate (Friedman and Schwartz, 2008). Wholesale prices then collapsed, dropping more than 50% between 1920 and 1921, contributing to the forces leading to a recession. A lack of European production increased crop prices during the war, which in turn increased agricultural land values in the United States (Jaremski and Wheelock, 2018). When prices fell after European production resumed, many local banks failed. Between WWI production and the 1920 to 1921 recession, identifying the impact on the pandemic on U.S. economic growth remains challenging.

## 6 Fertility

Pandemics may affect population growth either directly by killing inhabitants or indirectly by affecting fertility and migration. Unlike the 1918 influenza pandemic, COVID-19 kills women of childbearing age at relatively low rates. Despite the absence of a mortality channel, COVID-19 may still impact fertility, as women may delay childbearing in response to economic and public health uncertainty.

There is a significant literature on the effects of the 1918 influenza pandemic on fertility that spans several countries (Japan, India, Norway, Sweden, Taiwan, and the United States). The literature has consistently found a drop in fertility during the pandemic, as the disease killed potential parents, increased miscarriages, and may have decreased coital frequency. After the pandemic, a baby boom occurred in most countries, perhaps representing births that were delayed until the pandemic was over or parents attempting to “replace” a child who died of influenza.

A confounding event is that World War I may have affected fertility by changing the marriage market, income, and women’s labor force participation. As men disproportionately died in the war, the male-to-female sex ratio declined, improving the marriage market for men and worsening the marriage market for women. For example, Abramitzky, Delavande and Vasconcelos (2011) show that war fatalities increased the probability that men married and decreased the probability women married and that men were less likely to marry women from lower socioeconomic classes. As some women were left without husbands and less income, labor force participation for women increased (Boehnke and Gay, 2020; Vandenbroucke, 2014). Countries that fought in WWI saw a decline in fertility during the war years followed by a baby boom (Mamelund, 2004).

For these reasons, it’s important to examine evidence from neutral countries. Neu-

tral Sweden, Norway, and the Netherlands saw declining fertility rates from 1905 to 1930, with an upward blip in 1920 (Mamelund, 2004). Mamelund (2004) examines whether the 1918 influenza pandemic can explain the 1920 increase in births in Norway. He documents that relative to pre-pandemic years, there was a deficit in conceptions during the pandemic and a surplus of conceptions in 1919 as the pandemic was ending, leading to an increase in fertility in 1920. In Sweden, Boberg-Fazlic et al. (2017) find that districts with higher levels of influenza had lower fertility rates during the pandemic (August to November 1918). Child quantity increased in rural districts shortly after the pandemic (December 1918 to December 1920). A similar baby boom was not observed in urban districts. Both urban and rural districts observed lower fertility in the long run (January 1921 to December 1927).

Several studies have documented a decline in births approximately nine months after the pandemic. Time series data from Japan (Chandra and Yu, 2015*a*) and Taiwan (Chandra and Yu, 2015*b*) show that influenza deaths were followed by a decline in births nine months later, implying that the pandemic resulted in either fewer conceptions or increased miscarriages during the first weeks of pregnancy. Similarly, Chandra et al. (2018) use panel data from 19 U.S. states and find that excess influenza deaths result in a drop in births 3 to 7 months later (likely reflecting an increase in miscarriages) and 9 to 10 months later (likely reflecting a decrease in conceptions). Bloom-Feshbach et al. (2011) use monthly data from Denmark, Norway, Sweden, and the United States. They find that the birth rate dropped approximately six months after the peak of the pandemic. The number of “missing births” exceeds the number of women of childbearing age who died in the pandemic, implying that the pandemic decreased the birth rate, at least in part, by increasing miscarriages during the first trimester.

The selection induced by altering fertility decisions may have also affected average “investments” or “child quality” for post-pandemic birth cohorts. Boberg-Fazlic et al.

(2017) find that births to married mothers increased after the pandemic in rural areas of Sweden. In urban districts, births to high socioeconomic status mothers, as proxied by surnames, increased following the pandemic. These findings suggest that high socioeconomic status mothers may have delayed pregnancy until after the pandemic. In India, Donaldson and Keniston (2016) argue that rural districts were in a Malthusian equilibrium. Population and income were relatively stagnant. Influenza was particularly virulent in India and some districts lost over 10% of their population. Donaldson and Keniston (2016) show that despite the population loss, agricultural output remained unchanged, resulting in higher per capita income.<sup>31</sup> As in Sweden, Donaldson and Keniston (2016) find that births during the pandemic declined and there was an increase in child quantity after the pandemic. The baby boom lasted longer, however, from 1921 to at least 1931. There was also an increase in child quality, as children ages 10-15 from high influenza districts were more literate, taller, and less likely to be married in 1931.

## 7 The Pandemic’s Lasting Health Legacy

This section reviews the long-term health consequences of infection. We begin with an overview of post-infection complications and the interaction of influenza with pre-existing conditions. We then assess whether those who were exposed to the pandemic during key periods of fetal development were left permanently scarred by that exposure.

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<sup>31</sup>These findings relate to an earlier debate over the issue of whether there was surplus labor in India’s agricultural sector. Schultz et al. (1964) tested this hypothesis using the 1918 influenza epidemic as a shock to the labor force. Schultz et al. finds that agricultural output declined between the 1916-1917 season and the 1919-1920 season (two seasons with similar weather), suggesting there was not a surplus of labor. This led to a debate between Sen (1967) and Schultz (1967) on using the influenza pandemic to test the theory of surplus labor.

## 7.1 The Sequelae of Influenza Infection

With many diseases, those that survive the initial infection may still be left with chronic health conditions. These sequelae can range from something as mild as aches and pains to a range of life-threatening complications. For instance, some young and otherwise healthy individuals have recovered from a seemingly mild case of COVID-19 only to show up at a hospital several weeks later after experiencing a severe stroke. For the 1918 flu, Collier (1974) writes of complications like deafness that persisted for up to one year, debilitating physical weakness, and breathing difficulties. More serious complications include cardiac disorders, pulmonary tuberculosis, encephalitis, and early-onset Parkinson's disease.<sup>32</sup>

A 1920 supplemental report on the pandemic written by England's registrar general provides some of the earliest estimates of influenza infection and subsequent mortality risk. The estimates are derived from excess mortality models, which means they are sensitive to how counterfactual mortality is defined. This is not a trivial issue for England or other countries engaged in World War I. One approach is to compare mortality rates for women in 1918 with the average mortality rate from 1914-1917. This comparison suggests that while influenza mortality rates in England increased by a factor of 20, pneumonia mortality rates increased by 68%, bronchitis mortality rates increased by 10%, and pulmonary tuberculosis increased by about 16%. While some of these deaths may have been misclassified influenza deaths (e.g., pneumonia), there is nevertheless some evidence that the pandemic may have elevated the mortality risk from certain underlying conditions.

Given the pandemic's widespread infection rates, many have wondered if other 20th century patterns in mortality and morbidity can be traced back to the pandemic. One

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<sup>32</sup>On the issue of deafness, Heider (1934) plots the distribution of birth years among those enrolled in deaf schools, which indicates a sharp increase in enrollment for those born in the second half of 1918.



such pattern is the rapid decline in tuberculosis rates. Contemporary observers and public health reports discuss a relative peak in tuberculosis mortality in 1918 and 1919 followed by a permanent decline that brought mortality rates down to about 50% of the pre-pandemic average.<sup>33</sup> Noymer and Garenne (2000) and Noymer (2011) provide evidence to support the idea that those with tuberculosis may have been particularly susceptible to the 1918 flu, and by disproportionately killing those infected with tuberculosis, the pandemic may have helped stop the spread and accelerated the elimination of tuberculosis in the United States.<sup>34</sup> Another broad pattern that may have been influenced by the pandemic is the wave of encephalitis lethargica (commonly known as sleeping sickness) that emerged worldwide, killing an estimated 500,000 and leading to an additional million cases of severe neurological disease between 1919 and 1928 (Ravenholt, Foege et al., 1982). The precise role of influenza is unclear, since scientists have not been able to find evidence of influenza spreading to the brain. Nevertheless, it is still possible that influenza may increase susceptibility to encephalitis lethargica, as generating compelling empirical evidence in either direction has proven difficult (McCall et al., 2008).

## 7.2 In Utero Scarring

Those in utero during a pandemic will likely suffer from worse health and cognitive performance, but the extent of those damages will not be observed for decades. The evidence in support of this claim comes from the literature on the “fetal origins hypothesis.” According to that literature, insults that occur during key periods of fetal development can generate a wide set of latent effects leading to chronic health

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<sup>33</sup>See Abbott (1922) as well as reports on trends in tuberculosis that appear in England’s registrar general reports and the United States mortality statistics from 1920-1922.

<sup>34</sup>This hypothesis is not universally accepted, see for instance the Bradshaw, Smith and Blanchard (2008) critique of Noymer and Garenne (2000), and the response by Noymer (2008).

conditions and worse cognitive performance, which together undermine human capital accumulation and lower socioeconomic status in adulthood (Almond, Currie and Duque, 2018; Almond and Currie, 2011; Currie and Almond, 2011). While the precise biological mechanisms are difficult to identify, economists have generated substantial empirical support for this hypothesis through the use of “natural experiments” that leverage variation in exposure to disease and deprivation to recover a causal effect. Key drivers of these insults during a pandemic could include the biological stress induced if the mother becomes infected, maternal stress from coping with the pandemic, nutritional deficiencies, or worse medical care. On the other hand, decreased pollution because of shutting down economic activity could work in the opposite direction.

Almond (2006), which leverages variation in in utero exposure to the 1918 influenza pandemic, is among the most influential papers in this literature. Before Almond (2006), most empirical evidence in support of the fetal origins hypothesis came from randomized experiments with animals. While those experiments speak to lasting health consequences, they cannot speak to socioeconomic differences or the ability of social programs to mitigate those harmful effects. As Almond argued, the pandemic provides a unique opportunity to explore this relationship for humans because it was severe, unexpected, and widespread, but also temporary. These features, in turn, generate sharp exogenous variation in the health environment for those born before, during, and after the pandemic. Much of the literature following Almond (2006) has leveraged similar types of variation to further our understanding of the importance of the fetal environment.

Figure 10 reproduces Almond’s main results. The figure draws on data from the 1970 Census, as made available from IPUMS.org. That Census asked individuals about their quarter of birth, and so we define a birth cohort as the set of individuals born between the fourth quarter of year  $T$  to the third quarter of year  $T+1$ . Since the 1918

pandemic emerged in the fall of 1918, this ensures those with any in utero exposure are categorized as the same birth cohort. We then plot cohort by sex averages for three outcome variables: whether the individual graduated high school, whether their household income was below the poverty line, and whether the individual was disabled.<sup>35</sup> As in Almond (2006), we also plot a quadratic fit between 1912 and 1926 (omitting the year of the pandemic). For all three outcomes we see that the cohort with in utero exposure performed relatively worse than what would have been predicted by trend. The tables in Almond (2006) indicate that these deviations are statistically significant at conventional levels.

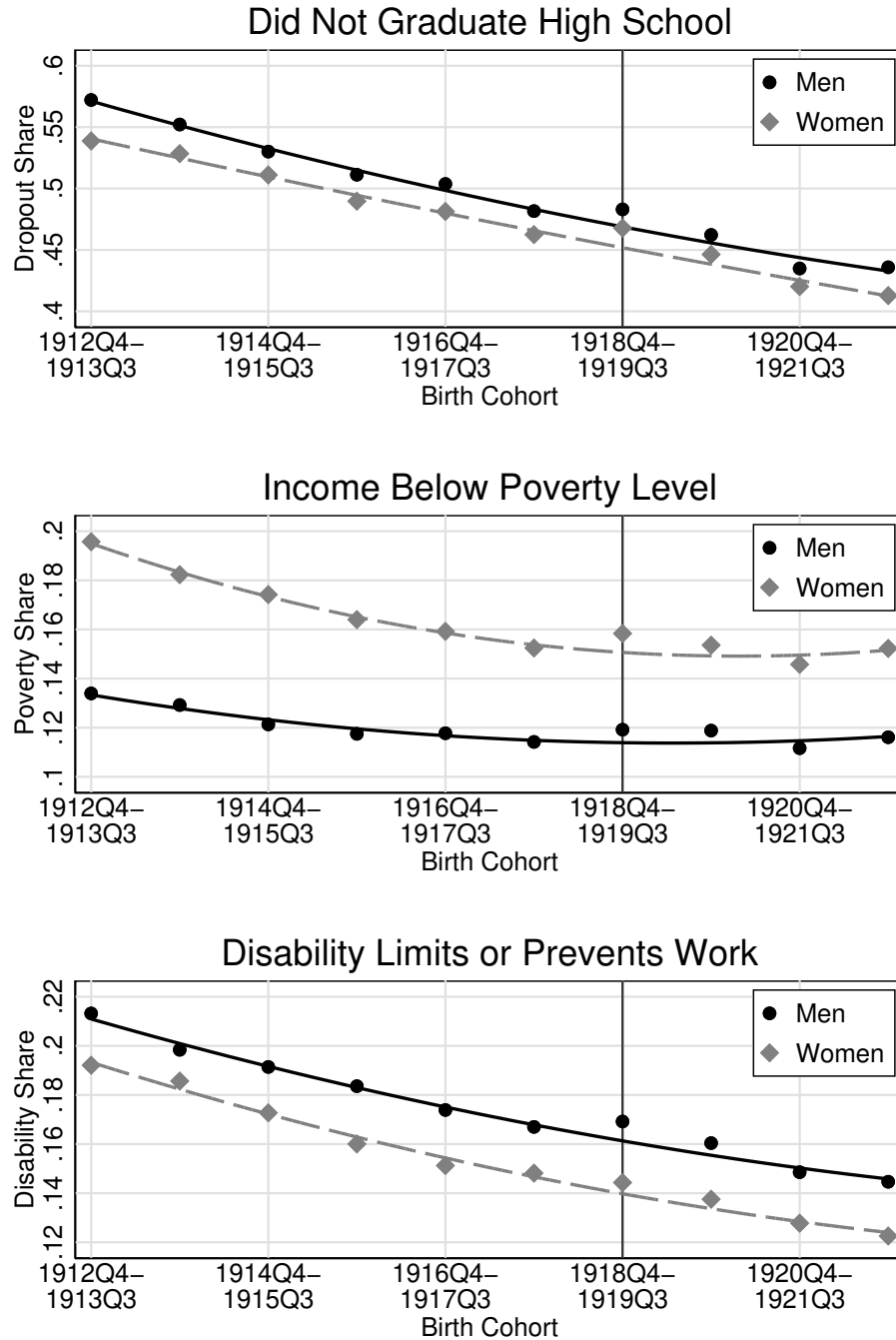
While the above results are often cited as the purely biological consequences of in utero exposure to the pandemic, there are reasons to be skeptical of that interpretation. Parman (2015), for instance, provides evidence that households in the United States may have reinforced the in utero shock by reallocating resources towards healthier siblings.<sup>36</sup> Brown and Thomas (2011) note that parents of the in utero cohort may have been selected, since the pandemic coincided with the height of World War I enlistment. Importantly, Brown and Thomas (2011) argue that WWI veterans were positively selected from the population, raising the possibility that the 1919 birth cohort was more likely to be born into a lower socioeconomic status household. Unfortunately, Almond (2006), Almond and Mazumder (2005), and Mazumder et al. (2010) lack comprehensive data on parental characteristics to assess whether the results are driven

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<sup>35</sup>The causes of disability are not reported in the Census, but Almond and Mazumder (2005) examine an alternative data set and find that those with in utero exposure suffered from a range of functional limitations, including trouble hearing, speaking, lifting, and walking. The magnitudes of these effects are meaningful at roughly 17% of the sample mean and as high as 35% for trouble speaking. Mazumder et al. (2010) show that in utero exposure is associated with a roughly 20% increase in cardiovascular disease.

<sup>36</sup>As Royer (2009) notes, whether behavioral responses should be thought of as a confounder depends on whether the goal is to identify the net consequences of early life health shocks or if we are only interested in isolating the biological effect. Decomposing the behavioral and biological components remains an important avenue for future research.

Figure 10: Cohort Outcomes as Observed in 1970 Census



*Notes:* The data are from IPUMS. Solid lines correspond to a quadratic fit. Cohorts span from September to September. Since the U.S. pandemic was primarily from October to December, this ensures that those with any in utero exposure all appear in the same cohort.

by negative parental selection.<sup>37</sup> Brown and Thomas (2011) do construct proxies for parental controls from historical census data and find that many of the results in Almond (2006) are sensitive to the inclusion of those proxies, suggesting that parental selection may be an important confounder.

Beach, Ferrie and Saavedra (2018) re-assess the idea that parental selection is a potential confounder with linked data. Their linked data set allows them to observe individuals twice: first as a child with their parents and again as an adult. Information on parents is available from either the 1920 or 1930 Census (when the relevant birth cohort is between the ages of 0 and 1 or 10 and 11). Because of data restrictions, the latest publicly available adult outcome data are from World War II enlistment records, roughly 20 years before Almond begins his analysis. While this sample is clearly selected, it is notable that their baseline estimates not only point to lower high school completion rates and educational attainment but that the magnitudes are comparable to Almond (2006). When using a sample and empirical framework closest to Almond (2006), the authors find evidence that the cohort with in utero exposure to the pandemic was also born into slightly lower SES households. Controlling for observable parental characteristics attenuates results, but even with a large set of controls there is still evidence that the 1919 birth cohort experienced a meaningful decline in human capital accumulation.

To provide evidence that in utero exposure affected human capital accumulation, Beach, Ferrie and Saavedra (2018) adopt a differences-in-differences framework that exploits variation in both the timing and the intensity of the 1918 pandemic. This strategy was first introduced by Almond (2006), although since Almond did not use linked data, state-of-birth was the finest geography available, and historical mortality statistics are only available for 22 states for the time of the pandemic. Beach, Ferrie

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<sup>37</sup>Almond (2006) does observe whether the individual's parents were foreign born in the 1970 census and finds no departure from trend.

and Saavedra (2018), make the assumption that city of enumeration, in April of 1920, was also the city in which the child spent the in utero period. This allows the authors to incorporate information on the intensity of flu exposure from local health reports of over 200 cities. The authors then ask whether individuals born in the same year but in areas with greater pandemic exposure had lower socioeconomic status as adults. Within that specification, the authors find no evidence of parental selection and continue to find strong evidence supporting Almond’s conclusion that in utero exposure to the pandemic had lasting effects on educational attainment.

While Almond (2006) receives a substantial amount of attention because it was the first paper in this area, there is no reason to expect the elasticities in that paper to translate to other settings. For instance, when baseline mortality rates are high, it may be the case that those affected the most by their exposure do not survive early childhood, working against a finding of persistent scarring effects. Alternatively, where the returns to human capital are low, the cognitive impairment induced by in utero exposure might not be large enough to translate into an appreciable loss of education or income. Even in the United States we might expect the effects to be different for groups whose labor market opportunities were hindered by widespread discrimination.

A large literature has emerged examining the relationship between in utero exposure and long-run outcomes across a range of settings.<sup>38</sup> One notable example is Lin and Liu (2014), which provides a comprehensive assessment of the Taiwanese experience. Taiwan offers an interesting point of comparison because baseline health and educational attainment were much lower than in the United States. Taiwan was also not involved in WWI and is thus not subject to the critique raised in Brown and Thomas

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<sup>38</sup>Vollmer and Wójcik (2017) draw on 117 census samples from IPUMS.org and compare the adult outcomes for the in utero cohort to the outcomes of adjacent cohorts. The findings in this study are generally imprecise. However, this meta-analysis approach only leverages variation across birth cohorts, rather than variation in both the intensity and the timing of the pandemic. We focus our discussion on studies that incorporate both types of variation, as that is a more convincing empirical design.

(2011). Taiwan experienced two waves of the pandemic, and the authors find strong evidence that affected cohorts were less educated and in worse health as adults. Ogasawara (2017, 2018) document a link between in utero exposure and stunting in Japan. In Sweden, we continue to see strong health consequences from in utero exposure, but the evidence for socioeconomic status is less conclusive (Helgertz and Bengtsson, 2019). Neelsen and Stratmann (2012) find a negative education effect in Switzerland, although the effects are about one fifth of the magnitude of Almond (2006). Nelson (2010) and Guimbeau, Menon and Musacchio (2020) find strong evidence that the 1918 pandemic had lasting effects on human capital development in Brazil.

## 8 Issues with Limited Historical Evidence

This section briefly describes issues that are relevant to COVID-19 but that have limited historical evidence and, in some cases, limited historical parallels. These include the impact of COVID-19 on human capital accumulation, political economy, migration, and inequality. We summarize the evidence and discuss the parallels for each of these below.

### 8.1 Human Capital Accumulation

What is the effect of pandemics on human capital accumulation? COVID-19 has disrupted primary, secondary, and post-secondary education worldwide. The extent of the impact on educational attainment and long-run outcomes remains to be seen, but it is likely to be an active area of future research.

The literature on the human capital effects of the 1918 influenza pandemic offers little guidance on this issue. As we discussed in section 7.2, there is a large literature examining whether in utero exposure to the disease impairs cognitive ability. There

is very little research on the impact of the 1918 pandemic for children that were born before the pandemic. One important exception is Parman (2015), which finds that households appear to have shifted resources to older siblings in response to the pandemic. Compared to siblings born during the pandemic and younger siblings, older siblings had higher educational attainment and high school graduation rates.

Schools were closed for weeks in many locations in 1918 and in some cases during 1919, but it is not clear what those closures can tell us about today. In the United States at least, the 1918 pandemic struck while states were still strengthening—or in a few cases, adopting—compulsory schooling laws. Because of this, primary and secondary education attendance was much more sparse, and so, compared to today, school closures were likely less disruptive.<sup>39</sup> Older students may have decided not to return once schools reopened, as was the case during the widespread U.S. polio epidemic of 1916 (Meyers and Thomasson, 2017). But, those that were of schooling age during the pandemic would ultimately grow up to enter a labor market where the returns to education were by some estimates lower than today (Feigenbaum and Tan, Forthcoming; Goldin and Katz, 2009), and so dropping out of school may not have affected long-run occupational standing. Moreover, the returns to education during this period appear to be driven by schooling at lower grade levels (Clay, Lingwall and Stephens Jr, 2016), and younger children probably didn’t drop out because of temporary school closures.

## 8.2 Political Economy

What is the effect of pandemics on political economy? COVID-19 has the potential to affect politics, as voters respond to political leaders’ actions with respect to the

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<sup>39</sup>Today, technological advances allow for online instruction, which might mitigate the harmful effects of school closings for some students. One concern with online instruction is that students without reliable access to high speed internet or computers may be left behind.



virus. Also some issues around masks and social distancing in some countries, notably the U.S., have become highly politicized. An obvious question is whether there are similar historical parallels to 1918. The short answer is largely no. Individuals in 1918 had experienced a number of epidemics, particularly if they lived in cities. The response of political leaders was certainly relevant. At the same time, expectations around the ability of politicians to control the epidemic, particularly in wartime, were likely limited. There were some anti-mask rallies, but generally the 1918 pandemic appears to have been less heavily politicized than the current one.

What is the effect of political economy on pandemics? This question is likely to attract substantial scholarly attention in light of the substantial heterogeneity of political responses to COVID-19. Troesken (2015) offers some guidance on this question, although that book does not explicitly consider the influenza pandemic. Troesken's hypothesis is that institutions that promote economic activity, e.g., secure property rights and limited government, also shape the state's approach to public health. The book then examines how institutions affected responses to three types of epidemics: smallpox, yellow fever, and waterborne diseases like cholera and typhoid fever. One of the central conclusions is that, countries with institutions that promote economic liberty have a mixed effect on public health. For instance, in the U.S., secure property rights benefited municipalities because they were able to finance water and sewer infrastructure at low interest rates. But the U.S. also suffered with smallpox because of its unwillingness to adopt universal mandatory vaccination laws. Thus far, the U.S. response to COVID-19 seems to conform to this hypothesis, as shutdown decisions and mask wearing mandates have been adopted at the state and local level rather than the federal level.

Although the 1918 pandemic was less politicized, it may have affected political economy by changing the demographic composition of electorates. Preliminary work

by Blickle (2020) finds that in German municipalities, influenza deaths were negatively correlated with later per capita public spending and argues this might be driven by the 1918 pandemic disproportionately affecting young adults. He also shows that influenza mortality was associated with higher vote share for extremist political parties. He finds that a one-standard deviation increase in influenza mortality increased the vote share for the National Socialist Party by 3%.

There is also evidence that the 1918 pandemic influenced voting behavior. In the United States, the pandemic coincided with the fourth and final liberty loan campaign. The liberty loan campaigns were a widespread effort to fund the Allied cause. Over 23 million Americans purchased liberty bonds, and for many Americans, liberty bonds were their first experience with owning a financial instrument. In turn, the performance of those bonds was suddenly relevant for many potential voters. Hilt and Rahn (forthcoming) find that sales of liberty bonds during the fourth campaign were lower in places with greater influenza intensity. Liberty bonds had depreciated in value during president Wilson’s 1916-1920 Democratic administration and appreciated in value during 1920-1924 Harding/Coolidge Republican administration. Hilt and Rahn (forthcoming) go on to show that the variation in ownership of bonds induced by the pandemic influenced vote shares in both the 1920 and 1924 presidential elections.

While epidemics can influence voting behavior through economic or demographic/selective mortality channels, they may also influence voting behavior by affecting trust in politicians and leaders. Survey evidence presented in Brück et al. (2020) suggests that COVID-19 has lowered trust in institutions and in general, particularly among those that have had contact with someone that is sick or those that have lost their job. Aksoy et al. (2020) show that exposure to epidemics since 1970 permanently lowers trust in institutions and political leaders. Those beliefs may also be transmitted across generations. Aassve et al. (2020), for instance, shows that, among

descendants that migrated to the United States, trust is negatively correlated with the severity of the 1918 pandemic. While the above papers highlight a general distrust, if the epidemic is politicized then it is possible that one party may be disproportionately punished/rewarded. Mansour, Rees and Reeves (2020), for instance, show that U.S. congressional districts that experienced greater mortality during the HIV/AIDS epidemic were more likely to turn out and vote for Democratic candidates.

### 8.3 Migration

Do pandemics induce or impede migration in the short and medium run? In response to COVID-19, many nations have closed their borders and imposed immigration restrictions. Additionally, COVID-19 has hit urban areas especially hard, which has caused some temporary and perhaps permanent migration to less densely populated areas. The virus may also change the composition of goods demanded by consumers, and workers may migrate away from localities in which economic activity has shut down, such as tourist destinations.

There has been considerably less research on the effect of the 1918 pandemic on migration. If the pandemic led to a negative labor supply shock and increased wages, it is possible that laborers would migrate to the areas hardest hit by the pandemic, thus offsetting the effects of the pandemic on population. Using data from India, where mortality rates were very high, Donaldson and Keniston (2016) measure migration by examining the proportion of individuals in each district who were born in a different province. Their point estimates are all positive, suggesting that districts with higher levels of influenza may have had experienced more immigration, but only one of four specifications is statistically significant and the magnitude of the estimates are relatively small.

We are unaware of any research on the effect of the pandemic on either internal

or external migration in the United States, and there are a variety of data sources that could be used to answer this question. The Census microdata contain state or country of birth. In some Censuses, year of immigration is available. Recent advances in Census linking have made it significantly easier to link individuals from the 1910 and 1920 Censuses (Bailey et al., Forthcoming; Abramitzky et al., Forthcoming). One challenge with answering this question is that two shocks to immigration occurred in the U.S. around the same time. The U.S. entered WWI the year before the pandemic, and starting in 1917 and continuing into the 1920s, the U.S. passed a series of immigration restrictions, both of which reduce immigration (Greenaway and Gushulak, 2017).

## 8.4 Inequality and disparities

How do pandemics affect economic and health inequality? Pandemics may exacerbate health disparities by disproportionately affecting groups who are more likely to suffer from risk factors, such as pre-existing chronic conditions. Gross et al. (2020) find that COVID-19 age-adjusted mortality rates for blacks are 3.5 times higher than for whites. It is unlikely that socioeconomic status alone can explain the disparity, as McLaren (2020) finds that counties with higher black shares have higher COVID-19 mortality rates even after controlling for socioeconomic status. Similarly, inequality may have recently increased as some occupations can be done remotely, whereas other industries have shut down. For example, females who are disproportionately represented in sectors that require face-to-face interactions have been more affected by the current recession than in previous recessions (Alon et al., 2020; Montenovo et al., 2020).

Økland and Mamelund (2019) reviews the literature on how the 1918 influenza pandemic affected mortality and morbidity for blacks and whites in the United States. Using data from military, insurance, and death records, they show that blacks had lower morbidity, lower mortality rates, but higher case-mortality rates than whites during

the second wave of the pandemic. This finding is striking given the evidence from other contexts that lower socioeconomic groups were more affected by the pandemic (see Section 4). The reasons for the lower morbidity for blacks are unclear, but it is possible that blacks may have had greater exposure to the milder spring wave and thus some immunity to the more deadly second wave (Crosby, 2003).

There has been less evidence on how the 1918 influenza pandemic affected economic inequality. In theory, the pandemic may have reduced economic inequality. If the poor were more likely to die, then the surviving population may have been a more equal one. In India, Mills (1986) finds that low-caste Hindus had mortality rates that were three times higher than high-caste Hindus. Most estimates suggest that the mortality rate in India was approximately 10 times higher than that of the United States, suggesting that the mortality differential between low- and high-caste Hindus may have been sufficient to affect standard measures of inequality. On the other hand, if the pandemic lowered the incomes of those who were sick, and mortality rates were sufficiently low to not change the composition of the population, then the pandemic may have increased economic inequality. Galletta and Giommoni (2020) find that the 1918 influenza pandemic increased economic inequality in Italian municipalities, and the effect is driven by reducing incomes of the bottom half of the distribution. It seems unlikely that the 1918 pandemic significantly affected gender equality, as few married women participated in the labor force during 1918. On the other hand, a man who lost their spouse to influenza likely would be less economically affected than a widowed woman.

## 9 Conclusion

The 1918 influenza pandemic is the most recent pandemic to share a number of important parallels with COVID-19. Both pandemics involve novel, highly contagious, respiratory diseases that were caused by a virus. Both pandemics spread across the globe in a matter of months. As of July 2020, both pandemics lack medical treatment, and so both pandemics saw the adoption of non-pharmaceutical interventions to slow the spread.

In this article we surveyed the literature on the health and economic effects of the 1918 influenza pandemic in order to distill lessons for COVID-19. The pandemic was severe, although there was substantial variation in the intensity of the pandemic. While NPIs were somewhat effective at reducing mortality in 1918, they were also far less stringent, and the extent to which more restrictive NPIs would have further reduced pandemic mortality remains debated. Variation in pandemic severity has proven to be a useful tool for understanding the health consequences of 1918. That literature suggests that the health effects were large and diffuse, extending well beyond the binary outcome of survived or not. The 1918 influenza pandemic, however, has less to say about the impact of COVID-19 on the economy. There is evidence that the 1918 pandemic caused an economic contraction, although there is disagreement on the size and duration of the contraction. Regardless, it seems that the contraction may have been driven by a negative labor supply shock, as many prime-aged workers died during the pandemic. With COVID-19, working-age adults are among the most likely to survive. It is thus unlikely that COVID-19 will generate a similarly sized negative labor supply shock.

There are many questions about 1918 that we still don't know how to answer. What role did WWI censorship play in spreading the disease? How did the pandemic affect public finance, political economy, and cultural norms? What were the impacts of the

pandemic in Africa, Asia, and Latin America? These questions may not have direct implications for COVID-19, but are nevertheless important for our understanding of the 1918 influenza pandemic.

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