Public Health Interventions and Mortality during the 1918 Influenza Pandemic: Evidence from Digitized Death Certificates

Kasey Buckles, Ph.D.
University of Notre Dame, NBER, & IZA

Carver Coleman
Brigham Young University

Joseph Price, Ph.D.
Brigham Young University, NBER, & IZA

Abstract

We use newly digitized individual-level death certificate data with detailed information on the location, date and cause of death to investigate the effects of city-level non-pharmaceutical interventions (NPIs) on mortality during the 1918 influenza pandemic. We collect information on the timing and nature of NPIs for cities in Ohio and Massachusetts with populations over 25,000 and focus on four cities that did not adopt any NPIs during the height of the pandemic. Using a synthetic control design to compare death rates in these cities with a composite of other similar cities who did implement NPIs, we find that the peak pneumonia and influenza (P&I) death rate was more than twice as high during the fall of 1918 in the no-intervention cities as in the comparison cities.

Keywords: Nonpharmaceutical Interventions, 1918 Pandemic, Synthetic Control Methods, Historical Records

Acknowledgements: We are grateful to Rebecca Bettinger and Kyle Andelin for excellent research assistance. This project was supported in part by the National Science Foundation under grant no. SMA-1852457.

Introduction

The 1918 influenza pandemic was the deadliest in human history, claiming the lives of 50 million people worldwide. Epidemiologists, historians, and social scientists have long sought to understand how public policy during the pandemic worked (or not) to reduce the loss of life from this terrible disease, in the hope that the answers might inform responses to modern pandemics like the one the world is currently experiencing as a result of the COVID-19 virus. Most prior work on this question has relied on the Center for Disease Control's (CDC) annual Mortality Statistics reports for the years surrounding the influenza pandemic (see for example Correia, Luck, and Verner 2020; Clay, Lewis, and Severnini 2018; Clay, Lewis, and Severnini 2019). These reports provide the monthly number of deaths due to leading causes for most states and for some large cities. Markel et al. (2007), Hatchett et al. (2007), and others use weekly data on deaths for cities with populations over 100,000.

Here, we introduce a new dataset we have created from millions of individual death certificates, with detailed information about the person and the cause, date, and location of their death. To create this dataset, we used machine learning and hand-writing recognition technology to read scanned death certificates from genealogy research organizations like Ancestry.com and FamilySearch.com (Price et al., 2021). These data are highly reliable, and we are able to use them to replicate perfectly the official monthly death rates from the CDC's Mortality Statistics reports for the years surrounding the influenza pandemic.

In this study, we use these data to identify the effects of city-level non-pharmaceutical interventions (NPIs) on pneumonia and influenza (P&I) mortality within two states during the 1918 influenza pandemic. With no vaccine available, the best weapons against the disease were non-pharmaceutical: quarantines, isolation, and social distancing. We collect information on the timing and nature of NPIs for all cities in Ohio and Massachusetts with populations over 25,000 and focus on four cities that did not adopt any NPIs during the height of the pandemic.

Our approach offers two key advantages. First, because we are not limited to the geographic categories available in the reports of the time, we are able to identify the effects of NPIs in smaller cities and towns on deaths, including deaths from P&I specifically. Second, with information on the exact date, location, and cause of death, we are able to document precisely the evolution of P&I deaths in the days before, during, and after the NPIs were implemented.

Results

To demonstrate the advantages of our data, we first show the trends in all-cause mortality for treatment cities (those that did not adopt any NPI) and their synthetic controls in 2018, with data aggregated to the monthly level as in the CDC Mortality Reports (Figure 1). There is a sharp spike in all-cause mortality for all series in October of 1918 that is larger in each of the treatment cities than in their synthetic control. In nearly all other months in the figure, all-cause mortality in treatment and synthetic control cities appears to be very similar, with the notable exception of a lower death rate in Hamilton than in its synthetic control in November of 2018.

In Figure 2, we use our dataset with digitized individual-level death certificates to examine more closely the days and weeks before and after October of 2018. To create these figures, we use the same treatment and synthetic control cities as in Figure 1, but we restrict the data to P&I deaths (measured as daily P&I deaths per 10,000 people). For the synthetic control cities, we identify the first date an NPI was implemented in each city, assign this date the value of 0, and then construct the daily P&I death rates relative to this date using the weights from Figure 1. For the treatment cities, where no NPI was implemented, the value of 0 corresponds to the median intervention date for the synthetic control cities. We smooth the data by calculating seven-day rolling averages, but our results are not sensitive to this choice.

There are three key takeaways from Figure 2. First, the synthetic control cities appear to have implemented their NPIs within days after P&I mortality began to increase. Second, this quick action appears to have lessened the deadly toll of the disease. In all four cities, we see that P&I deaths reached a peak within the two weeks after the first NPIs were implemented, but that deaths accelerated more quickly and reached a higher peak in the no-NPI cities. Peak P&I deaths were 126, 107, 97, and 19% higher than the synthetic control in Waltham, Fitchburg, Pittsfield, and Hamilton, respectively. Our results for these smaller cities are comparable to the results of Hatchett et al. (2007), who use weekly data for 17 large cities and show that those that failed to implement any NPI during the fall of 2018 experienced peak P&I death rates that were almost double that of otherwise similar cities. In the Massachusetts treatment cities, P&I deaths remained higher throughout the first thirty days after NPI implementation began in the synthetic control cities, while the protective effect of the NPIs appears to have eroded more quickly in the synthetic controls for Hamilton. Third, the cities' experience after the initial thirty-day period varied. Pittsfield and Waltham have daily death rates at or slightly above those in their synthetic control cities throughout the first 90 days after the NPIs were implemented. However, in Fitchburg and Hamilton, there is evidence that

some of the deaths their synthetic control cities avoided immediately after implementing NPIs were realized later.

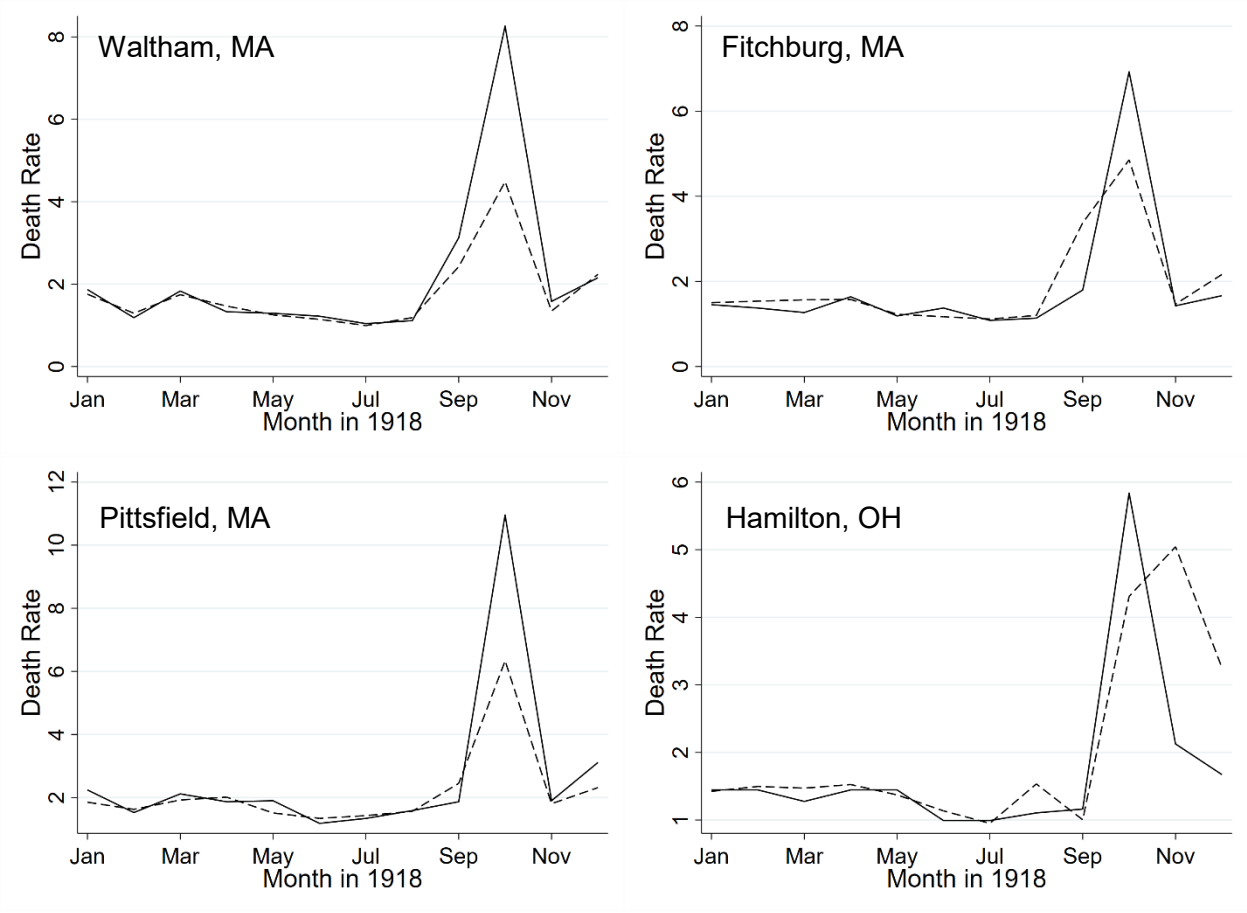
Discussion

Beach et al. (2019) recently wrote that "a fundamental issue in understanding mortality from both the COVID-19 pandemic and the 1918 influenza pandemic is the lack of reliable mortality data" (p. 15). We overcome this obstacle with a newly-created dataset with rich information from individual death certificates. In doing so, we reveal novel insights into the consequences of failing to implement any NPIs during a pandemic. We show that cities that did not implement NPIs during the 1918 influenza pandemic experienced *immediate* increases in P&I death rates that were much more acute than those in similar cities that did take such action. In two of the four cities that did not implement an NPI, daily death rates remained at or above those in the comparison cities for at least ninety days; in the other two, there is evidence that some (though not all) of the deaths averted by NPIs occurred later.

Methods

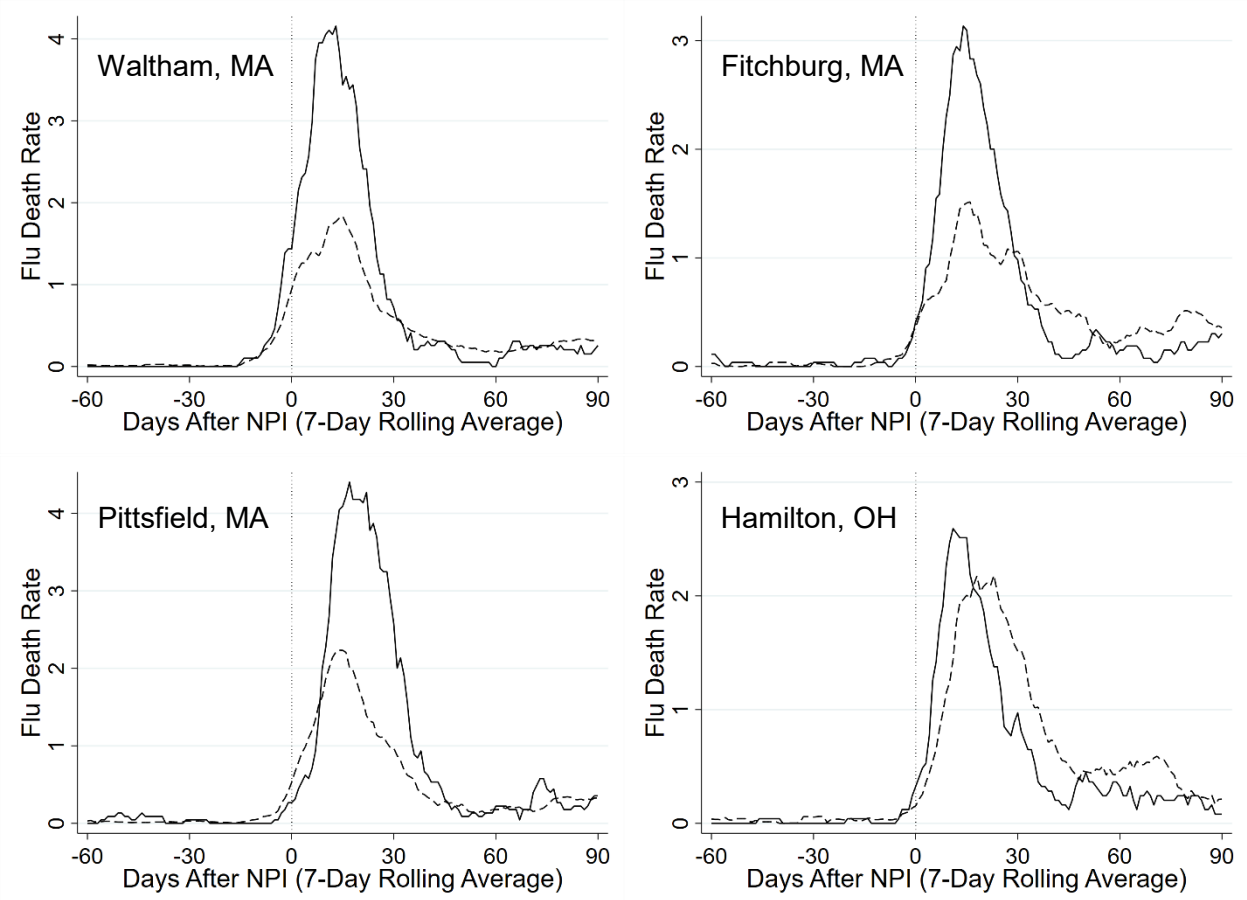
We accessed online newspapers using Genealogy Bank and Chronicling America to identify the first date that NPIs were implemented for all cities in Ohio and Massachusetts that had a population of at least 25,000 in 1910. The four cities that failed to implement any NPIs during the fall of 1918 were Hamilton in Ohio, and Pittsfield, Waltham, and Fitchburg in Massachusetts. We compare death rates between these four "treatment" cities and the other 35 cities in our dataset, using a synthetic control design developed by Abadie, Diamon, and Hainmueller (2010). We construct our synthetic control cities to match the treatment cities on the monthly death rate between January and August of 1918 and the 1910 population. For each treatment city, the available control cities are restricted to those within the same state. Cities that are more similar to the treatment city on these dimensions are weighted more heavily when constructing the synthetic control. P&I mortality data is publicly available at pandemic.familytech.byu.edu.

Figure 1. The effect of failure to implement a non-pharmaceutical intervention (NPI) on monthly deaths per 1,000 people.



Notes: The figure shows the number of deaths per 1,000 people in each month of 1918 for the four cities in our sample that failed to implement a non-pharmaceutical intervention (NPI) during the fall of 1918. In each panel, the solid line represents the death rate for the indicated city, while the dashed line represents the death rate for its synthetic control city. Note that the scale of the vertical axis changes to reflect the severity of the pandemic in each city. Data are from digitized individual death records for Ohio and Massachusetts, aggregated to the monthly level.

Figure 2. The effect of failure to implement a non-pharmaceutical intervention (NPI) on the seven-day rolling average of pneumonia and influenza (P&I) deaths per 10,000 people.



Notes: The figure shows the number of daily P&I deaths (7-day rolling average) per 10,000 people, for the four cities in our sample that failed to implement an NPI during the fall of 1918. In the synthetic control cities, deaths per day are represented by a dashed line, and are shown relative to the date that the first NPI was implemented (indexed by 0). For the treatment cities, death rates are represented by a solid line, and the value of 0 corresponds to the median intervention date for the synthetic control cities. Note that the scale of the vertical axis changes to reflect the severity of the pandemic in each city. Data are from digitized individual death records for Ohio and Massachusetts.

References

1. S. Correia, S. Luck, E. Verner, Pandemics Depress the Economy, Public Health Interventions Do Not: Evidence from the 1918 Flu. *SSRN*. DOI: 10.2139/ssrn.3561560 (2020).

2. K. Clay, J. Lewis, E. Severnini, Pollution, Infectious Disease, and Mortality: Evidence from the 1918 Spanish Influenza Pandemic. *J Econ Hist* 78, 1179–1209 (2018).

3. K. Clay, J. Lewis, E. Severnini, What Explains Cross-City Variation in Mortality During the 1918 Influenza Pandemic? Evidence from 438 U.S. Cities. *SSRN*. DOI: 10.2139/ssrn.3335921 (2019).

4. H. Markel, *et al.*, Nonpharmaceutical Interventions Implemented by US Cities During the 1918-1919 Influenza Pandemic. *JAMA* 298, 644–654 (2007).

5. R. Hatchett, C. Mecher, M. Lipsitch, Public health interventions and epidemic intensity during the 1918 influenza pandemic. *Proc Natl Acad Sci U S A* 104, 7582–7587 (2007).

6. J. Price, M. Clement, S. Fujimoto, J. Merrell, S. Rawlings, A. Bay. Automated Cause-of-Death Tagging from 1918 Ohio Death Records. Working Paper, Brigham Young University. https://ssrn.com/abstract=3781891 (2021).

7. B. Beach, K. Clay, M. Saavedra, The 1918 Influenza Pandemic and its Lessons for COVID-19. *Natl Bur Econ Res*. DOI: 10.3386/w27673 (2020).

8. A. Abadie, A. Diamond, J. Hainmueller, Synthetic Control Methods for Comparative Case Studies: Estimating the Effect of California's Tobacco Control Program. *J Am Stat Assoc* 105, 490, 493-505 (2010).