EXAMINING THE LONG TERM MORTALITY EFFECTS OF EARLY HEALTH SHOCKS

by

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Abstract

A growing literature in economics and other disciplines has tied exposure to early health shocks, particularly in utero influenza, to reductions in a variety of socioeconomic and health outcomes over the life course. However, no current evidence exists that examines this health shock on mortality because of lack of available data. This paper uses newly released files from the large, representative National Longitudinal Mortality Study to explore the mortality effects of the 1918 influenza pandemic for those in utero. While the results on socioeconomic outcomes mimic those in the literature, showing reductions in completed schooling and income fifty years following influenza exposure, the findings also suggest no effect on overall mortality or by categories of cause-of-death. These results are counter-intuitive in their contrast with the many reported effects on cardiovascular health as well as the literature linking education with later mortality.

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Introduction

Estimating the existence and magnitude of long term consequences of health insults that occur during early development have been of long standing interest to social science researchers. While there are many earlier precedents for this interest, the so-called “Barker Hypothesis” (Barker 1992) has refocused attention on the potential importance of “fetal programming”—the effects of environmental shocks to health, such as nutritional deprivation *in utero*, that may affect the development of biological systems that have implications in later life. Although there is widespread evidence supporting this hypothesis from animal models, which allow an explicit experimental research design and relatively clear causal inference, there has been limited convincing research in human populations because of the limited ability to harness similar research designs. However, recent research in this area has focused on leveraging plausibly exogenous shocks to early health conditions combined with rich data sources in an attempt to produce causal evidence.

Many researchers, economists in particular, have attempted to exploit variation stemming from relatively short-lived environmental shocks and disasters such as famines, earthquakes, and influenza outbreaks to examine the long term effects on individuals *in utero* during the events, in comparison to individuals *in utero* soon before or soon after the events. Several papers leverage important features of the 1918 flu in order to produce causal estimates. Most importantly, the pandemic struck without warning in October 1918, diffused nationwide in about one month (Sydenstricker 1918), and was over by early 1919, implying that children *in utero* separated by only a few months were exposed to very different conditions. In a series of papers, the effects of the exposure to the flu has been shown to reduce educational attainment, income, and socioeconomic status and increase physical disability, cardiovascular disease, and diabetes and stroke (Almond 2006, Almond and Mazumder 2005, Mazumder et al. 2010).

In contrast to this work, there is very limited evidence of the potential of long term mortality effects of the 1918 flu. The only published research is inconclusive, where the authors use coarse data from 24 countries and find no mortality effects (Cohen et al. 2009). The goal of this paper is to further examine the potential for mortality effects as well as

replicate and extend the results from Almond (2006). Almond (2006) used Decennial Census Data. In contrast, this study uses data from the restricted National Longitudinal Mortality Study (NLMS). Data from the restricted NLMS are matched to date of birth information (to measure flu exposure *in utero*) to mortality data as well as socioeconomic outcomes available in the data that were measured around 1980, when the potentially affected cohorts would be approximately 60 years old.

Background Literature

The effects of early circumstances on life time outcomes have been the subject of a large set of previous work in a variety of disciplines. Much of the research in each of the disciplines is motivated, at least in part, by the so-called “Fetal Origins Hypothesis” or “Barker Hypothesis” (Barker 1992), which focuses on the early sources of later chronic conditions by examining the course of fetal development. There are several major limitations in tests that examine the fetal origins hypothesis in humans. Experimental designs are ethically problematic, so that observational studies are typically used. This limitation then opens up the issue of whether omitted variables might be responsible for the correlations found in many datasets between early health and later outcomes. A second issue with exploring this research question in human populations is the long period of latency between early conditions and later outcomes, maybe 50 or more years in humans, which requires rich data that are often unavailable.

As outlined above, a key innovation that has merged the epidemiological focus on specific environmental conditions that may impact fetal development (e.g. famines) with the social science focus on identifying causal effects is the series of studies by Almond and co-authors that have leveraged the 1918 flu pandemic to examine long term effects of this large and specific environmental shock for individuals *in utero*. In particular, Almond (2006) combined birth quarter information from the 1960-1980 US Decennial Census files with socioeconomic and health related measurements during these years, 40-60 years after the exposure to the flu pandemic. For example, figure 1 (taken from Almond 2006) shows visual evidence of a large increase in disability rates at age 60 for individuals in utero in quarters

coinciding with the flu pandemic. The author goes on to produce similar evidence for reductions in years of schooling and income and increases in transfer payment receipt.

Figure 1 (Almond 2006)

Likewise, Almond and Mazumder (2005) use SIPP data to show associations between birth cohort and stroke and diabetes, and Mazumder et al. (2010) have recently used data from the National Health Interview Survey to show associations between birth cohort and cardiovascular disease.

While this large and growing list of conditions and outcomes has been found to be strongly associated with birth cohort, much less research has focused on mortality outcomes. The only published paper in the literature to examine this relationship is Cohen et al. (2009), which uses coarse cohort-level data from 24 developed countries. While the authors find no residual correlations between affected birth cohorts and mortality, analyses using richer individual data are still lacking. No existing evidence has been able to examine links between the 1918 flu exposure and mortality by cause of death and no other research has used the NLMS to answer this type of question.

Data

The NLMS was collected to examine the effects of demographic and socioeconomic characteristics on differentials in mortality. To do this, records from the Current Population Surveys (CPS) from years 1979-1996 are matched to mortality information from death

certificates available for deceased persons through the National Center for Health Statistics (NCHS). Extensive demographic, social, economic, and occupational information is collected in the CPS. The study consists of more than 2.3 million records with over 250,000 identified mortality cases. So, the dataset is cross-sectional with the only “panel” component being mortality outcomes².

This study has two primary sets of dependent variables—mortality outcomes and socioeconomic status outcomes. In order to replicate Almond (2006), this study will examine the relationship between flu exposure *in utero* and several dependent variables, including highest grade completed, employment status, adjusted income, marital status, and home ownership status.

In the mortality analysis, the primary dependent variables in this study include the death indicator variable, which is measured through 2001, and the 3 and 4 digit cause of death variables. These cause of death variables will be collapsed into relevant subgroups (e.g. cardiovascular or accident). Table 1 provides summary statistics for the sample born between 1915-1923. The probability of mortality through 2001 is 35%. Note that the analyses will control for survey year fixed effects in order to hold constant survival until the survey collection. The average years of schooling completed is 11.05 (similar to Almond 2006, which ranges from 10.6 to 11.2 depending on the sample). The high school graduate rate is 57% (Almond is 50-54%), the proportion disabled is 3% (Almond is 6-8%). The proportion “treated” (i.e. born in 1919) is 11% of the sample.

Methods

Following the previous literature on this topic, several sets of regression analysis will be used to examine the effects of exposure to the 1918 flu *in utero* on later outcomes. The key “treatment” variable is whether the individual was *in utero* during the flu pandemic, which,

² While the public use data contains nearly all the necessary information to examine this research question, it does not contain two key elements—month and year of birth and state of residence at birth. Although the public use data contains age, the year the individual was in the CPS has been removed from the public use NLMS data and several CPS data waves have been collapsed into a single file with no identifier for the survey year from the CPS. Thus, the year of birth is unknown in the public file.

while short lived, stretched from October 1918-April 1919 so that individuals born during the final quarter of 1918 and throughout 1919 were potentially exposed. These “treated” individuals will be compared to individuals born in adjacent years. Following much of the current research, the regression will be estimated for cohorts born between 1915-1923 (Mazumder et al. 2010). The main regression specification will be:

$$y_i^t = \beta_0 + \beta_1 I(YOB = 1919) + \beta_2 YOB + \beta_3 YOB^2 + \varepsilon_i$$

where y_i^t denotes an outcome measured at time t for individual i . These outcomes include mortality, years of education, and those listed in the data section. $I(\bullet)$ denotes the indicator function, YOB measures the birth year and β_1 is the coefficient of interest, measuring the departure of outcomes for the 1919 birth cohort from the quadratic cohort trend. The expectation is β_1 will be negative for the socioeconomic status outcomes, which would match the results in Almond (2006), who uses Decennial Census data. And β_1 is hypothesized to be positive in the specifications that examine mortality—suggesting those who were *in utero* during the 1918 flu epidemic (and survived) are more likely to die early. The estimates will be pooled but also separated by gender and race.

Results

Table 2 presents results in the spirit of Almond 2006. Controlling for survey year and state of birth fixed effects, the results suggest a 0.068 reduction in years of schooling for the pooled sample. Almond finds a 0.11 reduction for males and a 0.071 reduction for females using the 1980 Census waves. My smaller estimate is consistent with the trend in Almond that the coefficient is reduced in each subsequent Census data wave (from 1960-1980). Column 2 shows a 1.5 percentage point reduction in high school graduation (Almond finds 1.4 and 1.5 for men and women, respectively, in 1980). Column 3 finds no effect for the likelihood of college graduation.

Columns 4-6 examine labor market outcomes. Column 4 finds no effects on whether an individual is currently employed (and the standard errors can rule out even small effects). However, Column 5 shows a 2% reduction in current income and Column 6 shows that

individuals born in 1919 are in occupations with lower status (as measured by average education).

Table 2b extend the analysis to marital, disability, and housing outcomes. Columns 1 and 2 show that individuals born in 1919 do not differ in the likelihood of being married at the time of the survey but are less likely to be never married. Column 3 shows no association between exposure to in utero influenza and current reported disability status, unlike Almond (2006) who finds moderate effects (0.5% off a base of 25%). Column 4 finds no relationship with whether the individual is living in a rural (vs. urban) area at the time of the survey. Column 5 finds small but statistically significant reductions in the likelihood of owning a home.

Since I am able to replicate many of the qualitative findings of Almond (2006) that individuals born in 1919 have worse education and labor market outcomes 20-60 years later, I next examine whether these impacts affect later mortality. In general, the results in Table 3 suggest no effects of in utero influenza exposure on increased mortality risk, conditional on survey year. The precision of the estimates can also rule out relatively large (2 pp) effects. Separating the sample by gender and race shows that the results are robust. Figure 1 presents a non-parametric figure of death rates by birth cohort and again shows no evidence of changes for the 1919 birth cohort, but instead shows a smooth downward trend.

Because the earlier results have suggested that exposure to influenza in utero also reduces years of schooling by approximately 0.07 years and some of the literature on compulsory schooling laws suggest these laws affect years of schooling by a similar magnitude, these results also indirectly question some of the evidence linking education with mortality more generally. Most famously, Lleras-Muney (2005) used compulsory schooling laws as instruments for education to show that an increase of one year of schooling reduced mortality by approximately 8 percentage points. However, the results in this paper are more consistent with evidence from Clark and Royer (in press) that found no mortality effect from educational increases.

To further example the plausibility of lasting mortality effects from the 1918 flu pandemic for those in utero, Table 4 explores whether specific causes of mortality appear to be affected using the 3-digit cause of death codes aggregated into 17 groups. 2 categories are not

listed because they involve infant death. Again, the estimates suggest limited evidence of lasting mortality effects. The only category with a statistically significant estimate is for mental disorders, but the sign is in the unexpected direction (suggesting reduced mortality from influenza exposure). Otherwise, all coefficients are quite small and not statistically significant.

Conclusions

This paper has presented the first evidence in the literature of whether there is a link between long term mortality and exposure in utero to the 1918 influenza epidemic. A host of papers have shown important effects on adult human capital and health outcomes, but no data in the US has been available to examine mortality outcomes. I use a restricted version of the Current Population Survey linked with the National Death Index (i.e. the National Mortality Longitudinal Study) that includes birth date and state of birth information. Although I replicate previous findings of lower human capital attainment and worse labor market outcomes for those exposed, I find no evidence of mortality effects of in utero influenza exposure. These results question the mechanism linking in utero exposure to adult outcomes already in the literature and also question purported links between human capital and later mortality outcomes. Making sense of these findings will require additional research.

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Tables

Table 1
Descriptive Statistics
National Longitudinal Mortality Study
Birth Cohorts 1915-1923

Variable	N	Mean	SD
Mortality	147942	0.35	0.48
Education	147942	11.05	3.29
HS Grad	147942	0.57	0.49
College Grad	147942	0.10	0.31
Log (Income)	147942	9.57	0.94
Married	147942	0.71	0.45
Never Married	147942	0.05	0.21
Widowed	147942	0.16	0.37
Divorced	147942	0.05	0.22
Separated	147942	0.02	0.13
Retired	147942	0.57	0.50
Disabled	147942	0.03	0.17
Employed	147942	0.36	0.48
Rural	147942	0.31	0.46
Own Home	147942	0.82	0.39
Year of Birth = 1919	147942	0.11	0.31
First Trimester	147942	0.11	0.31
Second Trimester	147942	0.08	0.27
Third Trimester	147942	0.08	0.27
Month of Birth	147942	6.49	3.44
Female	147942	0.54	0.50
Black	147942	0.08	0.27
Hispanic	147942	0.03	0.18
Asian	147942	0.01	0.11
Other Race	147942	0.00	0.06

Notes: Census Bureau does not allow reporting of minimum and maximum values

Table 2
Adult Outcomes Associated with a 1919 Birth Year
Education and Labor Market Outcomes

Outcome	Education	HS Grad	College Grad	Current Employed	Log (Income)	Occupational Education
Fixed Effects?	Survey Wave, POB	Survey Wave, POB	Survey Wave, POB	Survey Wave, POB	Survey Wave, POB	Survey Wave, POB
Year of Birth = 1919	-0.068* (0.04)	-0.015*** (0.00)	-0.001 (0.00)	-0.003 (0.01)	-0.024*** (0.01)	-0.036*** (0.01)
Year of Birth	0.224*** (0.08)	0.045*** (0.02)	-0.003 (0.01)	0.077** (0.03)	0.116*** (0.03)	0.131** (0.06)
Year of Birth - Squared	-0.003* (0.00)	-0.001** (0.00)	0 (0.00)	-0.001 (0.00)	-0.002*** (0.00)	-0.002 (0.00)
Female	-0.095*** (0.03)	0.018*** (0.01)	-0.053*** (0.00)	-0.197*** (0.02)	-0.264*** (0.00)	-0.429*** (0.03)
Black	-2.286*** (0.17)	-0.295*** (0.02)	-0.062*** (0.00)	-0.030*** (0.01)	-0.542*** (0.01)	-0.431*** (0.02)
Hispanic	-3.665*** (0.11)	-0.350*** (0.01)	-0.072*** (0.01)	-0.044*** (0.01)	-0.363*** (0.01)	-0.356*** (0.03)
Asian	-1.855*** (0.21)	-0.185*** (0.03)	-0.025 (0.02)	-0.003 (0.01)	-0.150** (0.07)	-0.239*** (0.03)
Other Race	-1.339*** (0.01)	-0.112*** (0.00)	0.010*** (0.00)	0.030*** (0.00)	0.264*** (0.00)	-0.019*** (0.00)
Constant	8.318*** (0.76)	0.038 (0.15)	0.137*** (0.04)	-0.283 (0.34)	8.531*** (0.33)	10.213*** (0.57)
Observations	147942	147942	147942	147942	147942	147942
R-squared	0.11	0.105	0.019	0.208	0.103	0.122

Notes: Robust standard errors in parentheses, clustered at the state of birth level. *** p<0.01, ** p<0.05, * p<0.1. POB: Place (state) of birth. Occupational education is the average educational level of individuals in the chosen occupation (within sample).

Table 2b
Adult Outcomes Associated with a 1919 Birth Year
Other Outcomes

Outcome Fixed Effects?	Current Married Survey Wave, POB	Never Married Survey Wave, POB	Disabled Survey Wave, POB	Rural Survey Wave, POB	Own Home Survey Wave, POB
Year of Birth = 1919	0.002 (0.00)	-0.004*** (0.00)	0.002 (0.00)	0.001 (0.00)	-0.009*** (0.00)
Year of Birth	0.031*** (0.01)	0.002 (0.00)	-0.006** (0.00)	-0.003 (0.01)	0.030*** (0.01)
Year of Birth - Squared	-0.001* 0.00	0 0.00	0.000* 0.00	0 0.00	-0.001*** 0.00
Female	-0.213*** (0.02)	-0.003** (0.00)	-0.020*** (0.00)	-0.024*** (0.00)	-0.040*** (0.01)
Black	-0.214*** (0.01)	0.019*** (0.01)	0.043*** (0.00)	-0.173*** (0.03)	-0.193*** (0.01)
Hispanic	-0.085*** (0.00)	0.015*** (0.00)	0.023*** (0.00)	-0.202*** (0.01)	-0.192*** (0.01)
Asian	-0.058*** (0.02)	0.019*** (0.01)	0.020** (0.01)	0.022 (0.05)	-0.108*** (0.01)
Other Race	-0.019*** 0.00	0.010*** (0.00)	-0.009*** 0.00	-0.234*** (0.00)	-0.133*** (0.00)
Constant	0.534*** (0.09)	0.033 (0.03)	0.093*** (0.03)	0.352*** (0.08)	0.549*** (0.07)
Observations	147942	147942	147942	147942	147942
R-squared	0.106	0.003	0.011	0.035	0.034

Notes: Robust standard errors in parentheses, clustered at the state of birth level. *** p<0.01, ** p<0.05, * p<0.1. POB: Place (state) of birth. Occupational education is the average educational level of individuals in the chosen occupation (within sample).

Table 3
Effects of 1919 Birth Year on Later Mortality

Outcome Sample	Mortality Full Survey, POB	Mortality Full Survey, POB	Mortality Male Survey, POB	Mortality Male Survey, POB	Mortality Female Survey, POB	Mortality Female Survey, POB	Mortality Black Survey, POB	Mortality Black Survey, POB	Mortality White Survey, POB	Mortality White Survey, POB
Fixed Effects										
Year of Birth = 1919	0.004 (0.006)	0.003 (0.006)	0.001 (0.011)	0.001 (0.010)	0.006 (0.004)	0.005 (0.004)	-0.006 (0.013)	-0.007 (0.013)	0.004 (0.006)	0.003 (0.006)
Year of Birth	-0.062*** (0.01)	-0.059*** (0.01)	-0.066*** (0.02)	-0.062*** (0.02)	-0.061*** (0.01)	-0.058*** (0.01)	-0.003 (0.04)	0.001 (0.04)	-0.067*** (0.01)	-0.064*** (0.01)
Year of Birth - Sq	0.001*** 0.000	0.001*** 0.000	0.001** 0.000	0.001** 0.000	0.001*** 0.000	0.001*** 0.000	0 (0.001)	0 (0.001)	0.001*** 0.000	0.001*** 0.000
Female	-0.151*** (0.00)	-0.153*** (0.00)					-0.168*** (0.01)	-0.163*** (0.01)	-0.152*** (0.00)	-0.154*** (0.00)
Black	0.080*** (0.01)	0.050*** (0.01)	0.086*** (0.01)	0.045*** (0.01)	0.076*** (0.01)	0.054*** (0.01)				
Hispanic	-0.054*** (0.01)	-0.102*** (0.01)	-0.066*** (0.02)	-0.119*** (0.02)	-0.044*** (0.01)	-0.086*** (0.01)				
Asian	-0.009 (0.02)	-0.034 (0.02)	-0.024 (0.02)	-0.049*** (0.02)	0.006 (0.03)	-0.016 (0.03)				
Other Race	-0.205*** (0.00)	-0.222*** (0.00)	-0.264*** (0.00)	-0.270*** (0.00)	-0.162*** (0.00)	-0.184*** (0.00)				
Education		-0.013*** (0.00)		-0.015*** (0.00)		-0.011*** (0.00)		-0.007*** (0.00)		-0.015*** (0.00)
Constant	1.258*** (0.097)	1.370*** (0.094)	1.331*** (0.168)	1.448*** (0.157)	1.058*** (0.085)	1.156*** (0.084)	0.722** (0.335)	0.727** (0.341)	1.317*** (0.114)	1.450*** (0.114)
Observations	147942	147942	67737	67737	80205	80205	11637	11637	128695	128695
R-squared	0.054	0.062	0.036	0.046	0.027	0.033	0.054	0.056	0.052	0.061

Notes: Robust standard errors in parentheses, clustered at the state of birth level. *** p<0.01, ** p<0.05, * p<0.1. POB: Place (state) of birth.

Table 4
Effects of a 1919 Birth Year on Later Mortality by Cause of Death

Cause of Death	Infectious	Neoplasm	Endocrine	Blood	Mental	Nervous	Circulatory	Respiratory	Digestive	Congenital	Injury
Year of Birth = 1919	0.001 0.000	0.005 (0.005)	-0.001 (0.002)	0 0.000	-0.001*** 0.000	0 (0.001)	-0.001 0.000	0 (0.002)	0.001 (0.001)	0 0.00	0.001 0.00
Year of Birth	-0.004*** (0.001)	-0.012*** (0.005)	-0.002 (0.001)	0.001 0.000	0 (0.001)	0.001 (0.001)	-0.018*** (0.006)	-0.005 (0.003)	-0.003** (0.001)	0 0.00	-0.005** 0.00
Year of Birth - Squared	0.000*** 0.000	0 0.000	0 0.000	-0.000* 0.000	0 0.000	-0.000* 0.000	0 0.000	0 0.000	0 0.000	0 0.00	0.000** 0.00
Female	-0.001*** 0.000	-0.043*** (0.002)	-0.001* (0.001)	-0.000* 0.000	-0.001*** 0.000	-0.002*** 0.000	-0.077*** (0.003)	-0.016*** (0.001)	-0.003*** 0.000	0 0.00	-0.008*** 0.00
Black	0.005*** (0.001)	0.029*** (0.004)	0.007*** (0.001)	0 0.000	-0.001** 0.000	-0.002*** (0.001)	0.041*** (0.006)	-0.003 (0.003)	0.003*** (0.001)	0 0.00	0.002* 0.00
Hispanic	0 0.000	-0.035*** (0.006)	0.014*** (0.002)	-0.001*** 0.000	-0.001*** 0.000	0 (0.001)	-0.035*** (0.005)	-0.010*** (0.002)	0.002 (0.002)	0 0.00	-0.002** 0.00
Asian	0.003*** (0.001)	-0.018*** (0.006)	0.009*** (0.003)	0 0.000	0.004** (0.002)	-0.004*** (0.001)	-0.007 (0.013)	-0.005 (0.004)	0.002 (0.004)	-0.000*** 0.00	0.002 0.00
Other Race	0.003*** 0.000	-0.082*** (0.006)	-0.008*** (0.001)	0.000** 0.000	0 0.000	-0.003*** 0.000	-0.106*** (0.008)	-0.026*** (0.001)	-0.010*** (0.001)	-0.000*** 0.00	0 0.00
Observations	147942	147942	147942	147942	147942	147942	147942	147942	147942	147942	147942

Notes: Robust standard errors in parentheses, clustered at the state of birth level, MFX shown. *** p<0.01, ** p<0.05, * p<0.1.

POB: Place (state) of birth. Causes not shown: "Ill defined", Skin, Musculoskeletal, and Genitourinar

Figures

Figure 1
Mortality Rate by Birth Cohort from 1915-1923