

**NEW EVIDENCE ON THE IMPACTS OF EARLY EXPOSURE TO THE 1918
INFLUENZA PANDEMIC ON OLD-AGE MORTALITY**

by

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Abstract

This paper provides new evidence of the impacts of early life exposure to the 1918 pandemic with old-age mortality by analyzing data from the National Longitudinal Mortality Study (n ~ 220,000). The specifications used year and quarter of birth indicators to assess the effects of timing of pandemic exposure and used Cox proportional hazard models for all-cause mortality outcomes. The findings suggest evidence of excess all-cause mortality for cohorts born during 1918 and mixed evidence for cohorts born in 1917 and 1919. Therefore, contrary to some existing research, the results suggest no consistent evidence of the importance of specific windows of exposure by gestation period.

Introduction

A growing literature has attempted to link early life conditions and old age health and mortality(1, 2). A particular focus has been on the 1918 influenza pandemic due to its immense impacts on mortality and that it was largely unanticipated and short-lived. These features allow precision in measuring the timing of exposure and also the creation of comparison groups born only months before and after the pandemic.

While investigations of the impacts of early life exposure to the 1918 influenza pandemic have shown important effects on adult educational attainment, disability, and disease, there has been limited research using data from the United States that have tied this exposure with old age mortality(3-6). A key explanation for the limited mortality investigations is the lack of data—the exposed cohorts are not included in many survey datasets that have a mortality follow up. An exception is Myrskylä et al. (2012)(7) (henceforth MMC), who used National Health Interview Survey (NHIS) survey data collected between 1989-2006 that was linked with the National Death Index to measure mortality. The authors found a suggestion of excess mortality for some of the exposed birth cohorts and attempted to link these patterns to the timing of exposure (i.e. trimester in utero or early life). However, the pattern of results was not entirely consistent and may have been shaped by at least two interrelated factors—selective mortality, since the exposed cohorts had to survive to be between 70-88 years old to be included in the analysis, and the lack of statistical power to detect differences in effects across cohorts. The current study reduces these issues by using data collected between 1973-2010 with a sample that is nearly two and a half times as large as the NHIS sample. The results suggest a consistent and statistically significant elevated mortality for those born in

1918 but inconsistent results for 1917 and 1919. Thus, contrary to MMC, there is limited evidence of clear differences by exposure window (trimester or early life).

Method

The paper used data from the National Longitudinal Mortality Study, which was collected to examine the effects of demographic and socioeconomic characteristics on differentials in mortality and described elsewhere(8). Briefly, records from the Current Population Surveys (CPS) from years 1973-2010 are matched to mortality information from death certificates available for deceased persons through the National Center for Health Statistics (NCHS) with follow up through 2011. Extensive demographic, social, economic, and occupational information is collected in the CPS. Following MMC, this study limits the birth cohorts in the analysis to 1913-1924 and respondents who report being born in the United States. Following MMC this study considers early life exposures from three waves of the 1918 pandemic (1st Wave: March-July 1918, 2nd Wave: September 1918-December 1918, 3rd Wave: January 1919-March 1919) by examining old age mortality by birth year and quarter of birth. The sample size is approximately 220,000¹, approximately 73% of whom die by 2011.

Statistical Analysis

The paper analyzed mortality by birth cohort. Individuals were considered at-risk at the date of the interview and exited the risk set at either their date of death or at the end of 2011 if they survived through the entire observation period. Dates were measured in quarter-years and Cox proportional hazard regression models were estimated. Non-exposed cohorts (born in

¹ Census requires sample sizes to be rounded to preserve anonymity of the respondents.

1920-1924) and those born earlier than the third quarter of 1917 were combined into a single reference category. Among the exposed cohorts, we used birth quarter and birth year indicators to capture the exposure timing linked to whether exposure occurred postnatally and/or in utero. The analysis also controlled for age and age-squared at baseline survey to adjust for selective mortality (year-of-survey fixed effects were controlled in unreported analysis and produced similar results). A continuous birth year control was included to capture a cohort trend in mortality; sex was also controlled. All analyses were conducted using Stata/SE version 14.

Results and Discussion

Table 1 presents selected summary statistics to compare with MMC and also presents their estimates (from Table 2 Column 1). The average age at baseline for the NLMS data was 65.7 with an average follow up of 16.6 years (compared with 74.5 and 9, respectively in MMC). The key results in MMC (reported in the current Table 1, Column 1) were that two of the three cohorts that were exposed late in gestation and at birth (1918 q2, 1919 q1, but not 1918 q4) experienced excess old-age mortality. A broader look at the collection of results shows a potentially surprising lack of statistically significant effects of exposure (only 2 in 10 coefficients). In contrast, the current results that use a larger dataset that is less sensitive to selective mortality show a much more consistent pattern by quarter of birth. Interestingly, the confidence interval for the new results for the 1919 q1 cohort do not contain the MMC estimate. Altogether, the similarity in the coefficients in the present analysis do not suggest large differences based on exposure timing, contrary to this emphasis in MMC. Rather the imprecision in the MMC estimates across cohorts suggest caution in interpreting differences in

effects as statistically meaningful. Future work might attempt to pool these datasets as well as additional datasets to attempt to examine the potential for impacts on cause of death and by gender and geographic area.

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Table 1

All-Cause Mortality Hazard Ratios by Birth Cohort and Timing of Exposure to 1918 Influenza Pandemic: National Health Interview Survey and National Longitudinal Mortality Study 1913–1924 Cohorts

Dataset	NHIS	NLMS
N	81571	~220,000
Deaths	43808	~160000
Age at Baseline	74.5	65.7
Years of mortality follow up	9	16.6
Birth Cohort, exposure timing	HR (95% CI)	HR (95% CI)
1917q3, 1st year of life	0.99 (0.92, 1.07)	1.02 (0.98, 1.05)
1917q4, 1st year of life	1.06 (0.99, 1.15)	0.98 (0.94, 1.01)
1918q1, 1st year of life	1.03 (0.96, 1.11)	1.07*** (1.03, 1.10)
1918q2, at birth and 3rd trimester	1.08** (1.00,1.16)	1.08*** (1.05, 1.12)
1918q3, 1st and 2nd trimester	0.97 (0.90, 1.05)	1.07*** (1.03, 1.10)
1918q4, at birth and 3rd trimester	1.02 (0.95, 1.10)	1.05** (1.01,1.08)
1919q1, at birth and 3rd trimester	1.09** (1.01, 1.17)	1.00 (0.97, 1.04)
1919q2, 1st and 2nd trimester	1.05 (0.97, 1.13)	1.04* (1.00, 1.08)
1919q3, 1st and 2nd trimester	0.97 (0.90, 1.04)	1.02 (0.99, 1.06)
1919q4, 1st and 2nd trimester	1.00 (0.93, 1.07)	1.03 (1.00, 1.06)

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Note. CI = confidence interval; HR = hazard ratio. We estimated results for all-cause mortality with the Cox proportional hazards model. All models controlled for age and age squared at baseline, gender, and linear trend in birth year.

Number of observations are rounded for confidentiality in the NLMS data.

First column of results reproduced from Table 2, Column 1 in MMC