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The Effect of In Utero Exposure to Asian Flu (1957-58) on Future Earnings¹

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Abstract

The “fetal origin hypothesis” predicts that the exposure to unfavorable environments early in life negatively affects future health and non-health (e.g. income) outcomes. This paper evaluates this theory by examining the effect of in utero exposure to influenza pandemic of 1957-58, the 2nd biggest of the 20th century, on the future earnings of exposed cohort. Using data from National Longitudinal Survey of Youth 1979 (NLSY79), a difference-in-differences model is estimated for four demographic groups: white and non-white males and females. While the effect of this exposure on earnings of white individuals is statistically insignificant, the effect is both (economically and statistically) significant and contradictory for non-whites. Non-white females experienced a \$6100 loss in their yearly wage while the wage of non-white males increased by about \$11900.

Keywords: Fetal origin hypothesis; Earnings, Asian flu, NLSY79.

JEL classification: I12, I19, N32

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I. Introduction

The long run effects of in utero exposure to unfavorable environment have been studied extensively in the literature. The majority of studies have mainly focused on the negative effects of such exposure on the health of an individual later in life in order to evaluate the fetal origin hypothesis (Barker 1990). The hypothesis states that once a fetus is exposed to a negative shock, it changes its normal growth path and through this permanent change, an individual has a higher probability of developing chronic diseases later in life (Barker 1990). Another stream of literature on fetal origin hypothesis focuses on non-health related outcomes. The idea is that a change in the growth path of a fetus may result in lower levels of cognitive and physical development and therefore lower education and income in the future. Studies that belong to this stream of literature are relatively limited comparing to the other one but their outcome of interest is equally important from the policy perspective.

This study adds to this growing literature by examining the effect of in utero exposure to the influenza pandemic of 1957-58 (also known as Asian Flu 1957; hereafter Asian Flu) on earnings of impacted individuals. Asian Flu is the 2nd most severe influenza pandemic of past century (Kilbourne 2006) but (to the best of my knowledge) other than one study³, no previous research on the non-health effects of this pandemic exists. The Asian Flu provides a natural experiment to assess the effect of in utero exposure to hazardous environment on later in life outcomes given the fact that almost 1 in 4 individuals in U.S. were infected by it and the infection spread through the schools and throughout the U.S. within two months (Henderson 2009). Given the severity of this pandemic and the fact that the exposed cohort is more relevant to the current days (comparing to the influenza pandemic of 1918 that is examined extensively in the literature), this study provides a valuable insight for policy makers who are interested in the income effect of such pandemics. Moreover, comparing to

³The exception is Kelly (2011) who studies the effect of in-utero exposure to Asian Flu on test score of British students and reports some negative effects.

other disasters such as earthquakes and famines (that are also examined in the literature), influenza pandemics are much more frequent and affect more people and therefore they are relatively more important and relevant to the duty of health officials.

Using data from National Longitudinal Survey of Youth 1979 (NLSY79), a difference-in-differences (DID) model with year of birth fixed effects is specified to estimate the effect of in utero exposure to Asian Flu on the earnings of affected individuals. Earnings are measured in terms of average Total Net Family Income and average Wage over the course of 20 years (i.e. 1990-2010)⁴. The DID model specifically looks at the change in earnings of individuals who were born in the last 4 months of 1957 (i.e. exposed to Asian Flu) comparing them to those who were born earlier in that year. It also uses the data for individuals who were born in the following years (i.e. 1959-64 who were not exposed to Asian Flu) to control for any cyclical change in the earning of individuals who are born in the last 4 months of any year comparing to those who are born earlier in that year. A simple ordinary least square (OLS) estimation, as it is used in some previous works such as the influential work of Almond (2006), would not distinguish between such cyclical changes in earnings and the adverse effect of the influenza pandemic. Moreover, the use of year of birth fixed effects allows the model to account for any factor that affects the earnings of a specific cohort. The main assumptions of the framework used in this study are as follows: all factors that affect a particular birth-year cohort (other than Asian Flu) has identical impact on all individuals born in that year; all the cyclical changes in earning are similar across different birth-cohorts; and more importantly, individuals who are born in the last 4 months of 1957 (and therefore experienced in utero exposure to Asian Flu) are not affected by another factor. The results show that out of four demographic groups that are considered in this study, Asian Flu only affected Non-white individuals. This pandemic decreased non-white females' wage by about \$6100 which is %26 of their average yearly wage but surprisingly increased non-white males'

⁴Both variables are available in each round of survey. For more information about these variables please see the link provided in the reference section for NLSY79.

wage by about \$11900 (%25 of their yearly average wage).

The remainder of this paper is organized as follows. Section II provides a brief introduction to the Asian Flu and related studies regarding the health effects of this pandemic along with a review of the literature on the fetal origin hypothesis with respect to the non-health outcomes. Section III describes the data and introduces the model used for the analysis. Section IV reports the results and section V concludes.

II. Literature Review

The 1957-58 influenza outbreak known as the 1957 Asian Flu is one of the three major influenza pandemics of the 21st century (Kilbourne 2006). The pandemic began in February 1957 in China and arrived in U.S. by June and infected %25 of the population (Henderson 2009). The first sign of a major spread of this virus in U.S. appeared in the September 20th release of Morbidity and Mortality weekly report (MMWR 1957) of Center for Disease Control (CDC). The report covers the week ended on September 14th and confirms 100,000 cases throughout the U.S. (MMWR 1957). During this time (i.e. July 1957) a specific surveillance program in CDC was designed to monitor the cases of influenza (Henderson 2009) so the uncertainty about the beginning of this pandemic is much lower which reduces the measurement error (and the resulted bias toward zero of the parameter estimates) that normally happens due to the ambiguity of beginning date of similar historical pandemics. The pick of this epidemic was in October (Henderson 2009) and related to the beginning of school year (Glass et.al. 2006; Potter et.al. 2012). In terms of geographical pattern, states on the west coast were exposed sooner (by the middle of September) but very soon (by the end of this month) states along the east coast were affected as well (Henderson 2009). The epidemic began to evade by the end of year but made a short and less severe come back in the following year which ended by April 1958 (Henderson 2009). Although a vaccine was developed and provided to the public during this pandemic (Kilbourne 2006) the effectiveness of it did

not exceed %60 of the cases (Henderson 2009). For this study, only the data for last months of 1957 is used due to the fact that the pandemic was the most severe and prevalent in the U.S.

The Asian Flu was a neurotropic type of virus (Torrey 1991) and epidemiological studies have shown that maternal exposure to these type of virus during the development of a fetus can result in reduction of cognitive abilities later in life (Asp et.al 2009). Previous studies have consensus that Influenza virus adversely affect the development of a fetus' brain but they are divided on whether the virus finds its way to the fetus or indirectly affects it through, for example, the inflammatory response of mother's body (Shi et.al. 2005). The damage to the nerve system can results in diseases such as Schizophrenia which has been studied in several countries without any consensus about the adverse effect of Asian Flu (Kunugi et.al. 1995). In fact, Selten et.al (2009) conduct a meta-analysis of the available research on the effect of maternal exposure to Asian Flu and risk of Schizophrenia in children and concluded that none of the available studies has been able to find any relationship. They particularly refuted some of the statistical methodologies that have led to the conclusion that there is relationship between these two variables (Selten et. al. 2009). The implication of these studies for the current paper is that the earnings of affected individuals can reduce due to their lower cognitive ability resulted from in utero exposure to influenza virus but this effect may not be large enough to be detected for Asian Flu since the reduction of cognitive ability in exposed cohort is not clear from previous studies.

The potential health related effects of Asian Flu have been studied from other perspectives. Using clinical data from Baltimore, Hardy et.al. (1961) find that pregnant women in their first trimester are affected the most by the Flu in terms of childbirth complications⁵. There are other studies with a focus on specific cases in U.S. that has shown a higher death rate among pregnant women during this epidemic (For example see: Greenberg et.al. 1958;

⁵They, however, admit that their data is not good enough to statistically make a firm conclusion.

Freeman Barno 1960). Higher death rate among pregnant women can introduce selection bias for the estimated effect of Asian flu on earnings of impacted individuals. Mothers who died during this pandemic are those who had lower genetic endowments and their children would also be among those who would have adversely affected the most had they survived from this pandemic. Those individuals who survived are with higher endowments and therefore higher ability and this results in (absolute value) lower estimates for the effect of Asian Flu on their earnings than what it should have estimated in the absence of selection bias.

While most of the studies are focused on the direct health effects of Asian Flu, the effects of this pandemic on other dimensions of offspring's life, such as education attainment or income, are also of great interest. The idea of long term health effects of in utero exposure to a dangerous environment is explained theoretically first by Barker (1990) through what is known as the "fetal origin hypothesis". He connected the unfavorable intrauterine environment to the development of organs in fetus and therefore a permanent effect on health which may not appear until years later (Barker 1990). Almond and Currie (2011) recently reviewed the economic literature on fetal origin hypothesis and showed that in utero adverse shocks affect "educational attainment, employment, income, marital status, welfare dependency, and neighborhood characteristics (p. 161)" negatively. While several studies have examined the fetal origin hypothesis on non-health outcomes resulted from the 1918 Spanish Flu, to my knowledge, only Kelly (2011) has focused on these types of outcomes for 1957 Asian Flu. Using British data, she shows that Asian Flu affected the test scores of children who were in-uterus during the pandemic (Kelly 2011) which is similar to the results of studies on 1918 influenza pandemic. One major finding of Kelly's research is that the birth weight is not a good proxy to assess the impact of Asian Flu (Kelly 2011). This is in line with the theory of damage to the brain cells which would be hard to measure through weight. To my knowledge, the non-health effects of Asian Flu has not been studied for the United States and specifically, the income effect of this pandemic has not been examined before and this

paper, therefore, also fills this gap.

III. Data and Methodology

In order to examine the effect of Asian Flu on individuals in United States who were exposed to it while in uterus, this study utilizes the National Longitudinal Survey of Youth 1979 (NLSY79). This survey follows a representative sample of young individuals who were born between 1957 and 1964. The first round of this survey was conducted in 1979 and included 12,686 respondents with half of them being male and about %60 white. The retention rate of this survey is relatively high and about %75 by 2010. Moreover, the attrition cannot be considered affected by the exposure to Asian Flu and therefore, there is no concern regarding the selection bias using this survey.

NLSY79 has two advantages over census data that is used in the previous studies. First, it provides the information regarding the exact date of birth for individuals which helps to precisely identify those who were exposed to Asian Flu while in utero. The data available through Census doesn't provide this opportunity in the years after 1980 and even in the years before that, the quarter of birth is the closest that one could get to the actual date of birth. Second, given the main variable of interest in this study, i.e. earnings, the data should come from the working years of individuals who were exposed to the Asian Flu as well as those who were not. NLSY79 provides data for 20 years of this period for individuals who were born between 1957 and 1964. These individuals were too young in 1980 (last round of census with the quarter of birth variable) to be compared regarding their income. Therefore unlike previous studies, it is impossible to use census data for the purpose of this paper.

Figure 1 and equation 1 display the DID framework that is used in this paper. Usual DID models look at the change in an outcome variable for the treatment group before and after they receive the treatment and compare it to the similar change in the control group

(who only receives a placebo). Therefore, the outcome variables observed in both periods are for the same individuals. However, this is not an option for the particular question that this study tries to answer. The design here uses the idea of treatment-year and treatment-months to reformulate the DID setting (see figure 1). Individuals who were born in 1957 are those who belong to the treatment-year and those who were born in 1959-64 belong to the control-years group⁶. Moreover, those who are born in the last 4 months of each year belong to the treatment-months group. One can imagine that those who were born in the last 4 month of the 1957 received the actual treatment (Asian Flu) and those who were born in the last 4 months of other years received the placebo. Therefore, the DID model here assesses how much the income of individuals on average changes when they are born in the last 4 months of the year 1957 (and therefore exposed to Asian Flu) and compares it to the change in income for cohorts who were born in the other years. Therefore, this model can separate any cyclical change in the income of those who were born in the later months of 1957 which is not due to the negative effect of Asian Flu.

This deviation from standard DID models may seems to imply some strong and unacceptable assumptions which are needed to be addressed carefully. A usual DID model follows the same individuals before and after receiving the treatment/placebo but here, the outcome variable is not observed for the same individuals before and after the treatment. However, this does not require a strong assumption that individuals born before and after September 1957 are the same. The required assumption is that any discontinuity other than Asian Flu that happens to those who were born in the last 4 months of 1957 also happens to those who were born in the same months of the following years. The inclusion of year of birth fixed effect variables also allows for a cohort born in a particular year to deviate from other years but the deviation is assumed to be the same for all of the months in that year.

⁶Individuals born in 1958 all experienced in utero exposure to Asian Flu so they are all removed from the sample. Moreover, those who were born outside U.S. are also not included. The variable for year and month of birth used in this study is the revised one (i.e. 1980 round of survey instead of 1979).

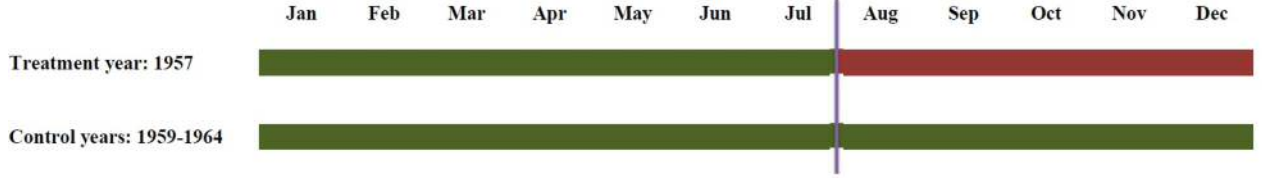


Figure 1: DID design of this study

The model used in this study is introduced in equation 1:

$$(EQ.1) \quad Y_{i,b} = \alpha + \beta_1 Y57 + \beta_2 Last4Month + \beta_3 Treatment + Year_b + \epsilon_{i,b}$$

$Y_{i,b}$ measures the outcome variable for individual i who was born in year b . The outcome variables used in this study are (average) total net family income and (average) wage. The average value of these variables is calculated using all available data for survey years between 1990 and 2010⁷ for each individual⁸. The decision to use average (also known as permanent) income variables instead of a particular year is to reduce the measurement error as it has been done in previous studies (see Currie and Thomas (1995) for example who also use NLSY79 data). The existence of a random error in measurement of a dependent variable (i.e. income/ wage), as it is assumed here, would increase the standard error of the parameter estimates but it does not introduce any bias. $Y57$ is a dummy variable that captures if a person was born in year 1957 and $Last4Month$ determines whether an individual was born in any of the last 4 months of years 1957-1964⁹. Therefore, the interaction of these two dummy variables is the variable of interest which is called $Treatment$ in the model. Finally, $Year_b$ represents the year of birth fixed effects and ϵ is the white noise.

⁷All dollar values are first converted to 2013 dollar using CPI factor.

⁸Not all of the individuals have data for all survey years between 1990 and 2010 so the average values are constructed for each respondent based on the available data. Respondent with no available data are removed from sample

⁹See footnote 4.

Tables 1a and 1b present some summary statistics for two outcome variables used in this study. The data is divided into 16 groups, depending on an individual's race and gender and when he was born. It is clear from both tables that earnings (both the average income and wage) of individuals who were born in the last 4 months of the year is relatively lower than those who were born in the first 8 months. This suggests that a simple comparison of average earnings for people who were born before and after August 1957 will be misleading in determining the effect of Asian Flue on earnings. The other important statistic to mention is that white individuals' total net family income is almost two times of the non-whites and this is mainly because of the fact that white males receive almost two times in wage comparing to any other group¹⁰.

¹⁰If one looks at the earnings of different races and genders in each year separately, a relatively similar "earning gap" also exists in each round of survey

Table 1a. Average Total Net Family Income according to the birth cohort and race-gender

Race & Gender	Birth Cohorts				Total
	Jan-Aug	Sep-Dec	Jan-Aug	Sep-Dec	
	(1957)	(1957)	(1959-64)	(1959-64)	
White Male (n=2,429)	114286 (11541)	110915 (11377)	92208 (2511)	96222 (4064)	96317 (2226)
White Female (n=2,517)	98813 (6469)	94128 (8634)	93777 (2928)	96438 (4310)	95030 (2203)
Non-white Male (n=1,798)	60893 (5677)	71663 (8875)	57817 (2124)	56449 (2719)	58385 (1596)
Non-white Female (n=1,823)	59109 (4557)	43630 (5831)	55039 (1852)	49161 (2012)	53208 (1319)

Note: Standard errors in parentheses

Table 1b. Average Wage according to the birth cohort and race-gender

Race & Gender	Birth Cohorts				Total
	Jan-Aug	Sep-Dec	Jan-Aug	Sep-Dec	
	(1957)	(1957)	(1959-64)	(1959-64)	
White Male (n=2,433)	67921 (3932)	68623 (6365)	60118 (1378)	58397 (1818)	60790 (1063)
White Female (n=2,422)	33328 (1911)	32081 (3937)	33454 (926)	33128 (1156)	33287 (678)
Non-white Male (n=1,800)	37313 (2967)	48131 (5946)	37327 (1080)	36654 (1438)	37657 (845)
Non-white Female (n=1,825)	30659 (2174)	23120 (2425)	26869 (656)	25463 (933)	26631 (517)

Note: Standard errors in parentheses

IV. Results and Discussion

Results of the DID model are shown in tables 2a and 2b. Parameter estimates are statistically not different from zero for white individuals which indicates that the effect of Asian Flu on their earnings (in terms of total net family income or wage) is ignorable. The result for non-white demographic group is somewhat contradictory. Parameter estimates for total net family income are not statistically significant but they have completely opposite signs for male versus female population. This variable, however, combines all sources of income, including benefits received from government, and it can be the case that those “social security” payments make up and even exceed the loss in earned income of individuals who were affected by Asian flu. This is not the case here given that table 2b shows similar contradictory results for wages (which is a good measure of earned income) of individuals. In fact, the parameter estimates for total net family income seems to be highly close to those estimated only use the wage component indicating that earned income derives the results in both tables and there is no over compensation effect.

The parameter estimates for wage is statistically significant for both non-white male and females at %90 significance level. Exposure to Asian Flu deteriorated yearly wage of non-white females by about \$6100 which is about %26 of their actual average wage. However, non-white male’s wage improved as a result of this exposure by about \$11900 which is also about %25 of their average yearly wage. The selection bias can theoretically explain the contradictory results of male versus female individuals if the Asian Flu caused higher death rate in male fetuses. However, this is not an effect reported in any of the previous studies related to Asian Flu.

Table 2a. The effect of Asian Flu on Average Total Net Family Income

	White Male	White Female	Non-White Male	Non-White Female
Asian Flu	-6759 (16935.90)	-6911 (12065.98)	11969 (11060.33)	-9521 (7918.33)
Sample size	2429	2517	1798	1823
F(all covariates)	1.60	1.43	0.69	1.60
R2	0.01	0.00	0.00	0.01

Significance level: * 0.1, ** 0.05, *** 0.01

Note1: Robust standard errors in parentheses

Note2: All regressions include controls for year fixed effects and a dummy to determine whether a person was born in the last 5 months of the year.

Table 2b. The effect of Asian Flu on Average wage

	White Male	White Female	Non-White Male	Non-White Female
Asian Flu	2616 (7844.48)	-1179 (4642.11)	11874* (6900.48)	-6114* (3460.00)
Sample size	2433	2422	1800	1825
F(all covariates)	1.31	0.87	0.85	1.50
R2	0.01	0.00	0.01	0.01

Significance level: * 0.1, ** 0.05, *** 0.01

Note1: Robust standard errors in parentheses

Note2: All regressions include controls for year fixed effects and a dummy to determine whether a person was born in the last 5 months of the year.

There are different reasons that can explain why a lot of parameter estimates are statistically insignificant in this study. First, the issue of sampling weights and survey design has not been handled perfectly. Receiving access to the confidential data (that is necessary for this purpose) requires undertaking a particular procedure which was hard to accomplish given the time constraints of this study. This can be easily resolved in the future and not having an appropriate survey design is not at all an important driver of the above outcomes.

More importantly, the sample size of NLSY79 may never be big enough to identify small changes in earnings and this requires the use of other samples. However, even a bigger sample may not detect the effect of Asian Flu due to the sample selection. It should be noted that diseases such as Influenza results in higher mortality rate and therefore a positive selection bias when studying the long run effects of these disease (Almond Currie 2011; Almond et.al. 2012). In other words, those who survive are stronger individuals with higher endowments that can compensate for the negative effects of the disease that they have been exposed to it. In such case, a better design that can take the selection bias into account is necessary to reveal the true effect of Asian Flu on the future earnings of individuals.

V. Conclusion

Using data from NLSY79, this paper evaluates the fetal origin hypothesis by looking at the in utero exposure to influenza pandemic of 1957-58 and its effect on future earnings. The two variables of interest in this study are average total net family income and average wage for years between 1990 and 2010. Moreover, a DID model with year of birth fixed effects is specified and estimated using the data for individuals who were born in 1957 (the treatment group) and 1959-64 (the control group).

The results are statistically insignificant for models that estimate the effect of Asian Flu on average total net family income of all demographic groups. But, the parameter estimates for the effect of this pandemic on average wage non-white individuals is economically and statistically significant. The results are, however, contradictory for minority male versus female group. In utero exposure to Asian Flu reduces the yearly average wage of non-white female population by about \$6100 (or %26) but increases the wage of non-white individuals by about \$11900 (or %25). In the available research on mortality rate of Asian Flu, there is no particular sign of gender specific selection bias that can explain this contradictory result.

The future extension of this paper will include data for individuals' place of birth to use the variation in the severity of Asian Flu between states to better identify the effect of this pandemic on the earning of affected cohort. Moreover, previous studies on the influenza pandemic of 1918 has also looked at other outcomes such as education (e.g. test score, high school graduation or years of schooling) and disability which this study will also include them in the future. It is worth noting that NLSY79 collects extensive data about its respondents that provides an excellent opportunity to evaluate the effect of Asian Flu on other variables that is usually not possible using other surveys.

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