Exposure to the 1890 Russian Influenza Pandemic and Mortality from the 1918 Spanish Influenza Pandemic

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Abstract

The 1918 Spanish influenza pandemic is known for the unusual increase in deaths among young adults. Research in Ontario has shown that this mortality centers on the age of 28. This paper examines this young adult mortality in regards to possible exposure to the 1890 Spanish influenza pandemic which occurred 28 years previously. Using the newly created Western McMaster Montreal Influenza Pandemic (WMMIP) database of 3,316 death records linked to birth records, the 1901 and 1911 Canadian censuses, marriage records and WWI attestation papers, we explore three hypotheses which may account for this phenomenon: scarring, fetal growth restrictions, and antigenic imprinting. The data lend support for both Fetal Growth Restrictions and Antigenic Imprinting. The WMMIP database allows for an analysis of date of birth which is not possible with the age in whole years as declared on the death records.

Introduction

Age-specific mortality from the 1918 Spanish influenza pandemic has rarely been examined. When this is done in Canada there is a distinct peak at age 28 (Figure 1). While hypotheses have been posited which could explain the young adult mortality, few are able to account for the elevation in number of deaths which occurs at the exact age of 28. This paper explore three main hypotheses which could account for this phenomenon: 1) Scarring, whereby lung tissue is damaged by early-life exposure to influenza which puts an individual at increased risk of death in later life (Preston et al. 1998, Bengtsson and Lindström 2003), 2) Fetal Growth Restrictions, in which resources are redirected to the maternal immune system to the detriment of fetal maturation (Barker 1992, 1995, 2006, McDade et al. 2001), and 3) Antigenic Imprinting (Original Antigenic Sin or Antigenic Seniority), an immunological argument which states that early life exposure to particular strain of influenza conditions the immune system to respond in a similar manner throughout life. This conditioning is stronger the more virulent the first strain encountered (Francis 1953, Kim et al. 2009, Ma et al. 2011, Gagnon et al. 2015). These three hypothesis are

Figure 1 - Deaths from All Causes, Toronto, September to December, 1918.
Source: "Figure 1. Number of deaths by age from all causes in the City of Toronto, September to December, 1918 (September, n=441; October, n=1,885, November n=731, December n=618. Total n=3,675). The vertical line indicates age 28.” From Hallman and Gagnon (2014).
examined to determine whether they could account for the increase in mortality at age 28, using the newly created Western McMaster Montreal Influenza Pandemic Database (WMMIP).

The Western McMaster Montreal Influenza Pandemic Database

Over 23,000 death records of individuals who died in Ontario from September to December, 1918, were obtained from the International Infectious Disease Data Archive at McMaster University. As the WMMIP database was created in order to analyze the unusual young adult mortality in 1918, individuals were limited to those who were five years younger than the peak in deaths at age 28 and five years older than the secondary peak in deaths at age 30. This gave an age range of 23-35 and included those who were born between January 1, 1883, and December 31, 1895. Individuals were included only if they had been born in Ontario, so that we could have access to their birth records. Once the inclusion criteria had been met, 3,316 individuals remained in the database. These death records were linked to birth records, the 1901 and 1911 Canadian censuses, marriage records, and WWI attestation papers to determine exact date of birth, and through that, exact date of death.

Using the reconstructed date of birth, all individuals in the sample who could be linked were assessed according to their age at which they potentially encountered the 1890 influenza pandemic. The date of January 15, 1890 was used as an arbitrary date of exposure, since the 1890 pandemic was only in Ontario for a few months in early 1890.

Results

Using the date of exposure of January 15, 1890, every individual in the sample was assessed for age at exposure. Individuals were divided by age category: those over one year, infants under one year, by the three stages of gestation, and those who had not yet been conceived by the time of the pandemic (Table 1).

<table>
<thead>
<tr>
<th>Age at Exposure</th>
<th>Deaths</th>
<th>Days in Time Period</th>
<th>Expected Deaths</th>
<th>Deaths per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. &gt; 1 year</td>
<td>29-35</td>
<td>1,258 42.5%</td>
<td>2,206 46.4%</td>
<td>1,375.2</td>
</tr>
<tr>
<td>2. 1 to 365 days</td>
<td>28-29</td>
<td>256 8.7%</td>
<td>366 7.71%</td>
<td>228.2</td>
</tr>
<tr>
<td>3. 3rd Trimester</td>
<td>28</td>
<td>82 2.8%</td>
<td>95 2.00%</td>
<td>59.2</td>
</tr>
<tr>
<td>4. 2nd Trimester</td>
<td>28</td>
<td>84 2.8%</td>
<td>94 1.98%</td>
<td>58.6</td>
</tr>
<tr>
<td>5. 1st Trimester</td>
<td>27-28</td>
<td>67 2.3%</td>
<td>94 1.98%</td>
<td>58.6</td>
</tr>
<tr>
<td>6. Not exposed</td>
<td>23-27</td>
<td>1,213 41.0%</td>
<td>1,893 39.87%</td>
<td>1,180.2</td>
</tr>
<tr>
<td>Total</td>
<td>2,960</td>
<td>100.0%</td>
<td>4,748 100.1%</td>
<td>2,960</td>
</tr>
</tbody>
</table>

Table 1 - Age at Potential Exposure to the 1890 Influenza Pandemic.

Note: Age on January 15th, 1890, using the Reconstructed Date of Birth for Individuals born between January 1883 and December 1895, for those who had a reconstructed date at birth.

a. Calculated as the number of deaths multiplied by the proportion of days in the time period.
b. Age at Potential Exposure to Epidemic Influenza
c. Refers to maternal exposure while the decedent was in utero.
The data do not support the scarring hypothesis due to the lack of an increase in deaths among those who were over one year of age at the time of potential exposure. Further, among infants, those who were older than six months of age had lower mortality. If the scarring hypothesis were active, it would be expected to target those over the age of six months, due to the protective effect of breastfeeding for those who had not yet weaned (Wharton 1989, Jackson and Nazar 2006). As those who were in the second and third trimesters had increased mortality, this lends cautious support for the fetal growth restrictions hypothesis. There was little difference between the expected and actual number of deaths for those in the first trimester; however, there was an unusual sex ratio at death, with more female than male deaths. This may be the result of increased male fetal loss in the first trimester. The antigenic imprinting hypothesis has more support from the data. There were fewer deaths among those who were older than one year of age who had likely been exposed to a circulating form of the H1N8 virus in childhood. They would have had greater protection from the H1N1 virus in 1918. There were increased deaths among those under one year and those in utero at the time of potential maternal exposure. These individuals would have been exposed to the purported H3N8 strain at the peak of its virulence. Finally, those who had not yet been conceived by January 15, 1890 had increased mortality, but it was less than for infants and those in utero. These individuals would have also been exposed to the H3N8 virus, but as it decreased in virulence, returning to endemic form.

Conclusions
Our data lend support to the fetal growth restrictions hypothesis and the antigenic imprinting hypothesis as means through which exposure to the 1890 influenza pandemic early in life impacted mortality from the 1918 pandemic in later life. The use of the newly created WMMIP database has allowed for the analysis of exact date of birth, something that was not possible using the age in whole years as declared on the death record.

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