Observations on Mortality during the 1918 Influenza Pandemic

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The original purpose of our study was to examine the unusual W-shaped mortality curve associated with the 1918 influenza pandemic and possibly explain the peak in mortality among individuals aged 20–40 years. We plotted age-specific excess mortality instead of total mortality for the 1918 pandemic using a 5-year baseline. For comparison, we also graphed excess mortality curves for the 1957 and 1968 pandemics using 5-year baselines. The 1957 and 1968 curves exhibited the usual U-shaped curve, with high excess mortality among infants and the elderly population relative to young adults. The 1918 curve, however, presented unexpected results. A peak in excess mortality among infants and young adults was seen, but the expected W shape did not result. We instead found negative excess mortality among elderly individuals, suggesting that this group was exposed, at an earlier date, to an influenza strain similar to the so-called Spanish influenza (H1N1) strain.

During the 20th century, the world experienced 3 major influenza virus pandemics. The most recent pandemic occurred in 1968 and was caused by the Hong Kong influenza A (H3N2) strain. It is estimated to have caused 98,100 excess deaths over the 4-year period 1968–1971 [1]. In 1957, the Asian influenza A (H2N2) strain caused ~115,700 excess deaths [1]. The overall impact in mortality of the Asian influenza pandemic was only one-tenth [1] of that observed for the most severe pandemic of the 20th century—the 1918 so-called Spanish influenza A (H1N1) pandemic.

It is estimated that the influenza virus that caused the 1918 pandemic killed 20 million people [2, 3] worldwide from the fall of 1918 through the spring of 1920 [1]. One of the unique features of the pandemic was the high mortality rate seen among healthy young adults aged 20–40 years [1]. The typical age-specific curve for an epidemic is U-shaped. The U shape refers to the observed peaks in mortality that occur for infants and for elderly individuals, the 2 ends of the age spectrum. When the total mortality rates for the 1918 pandemic are plotted against age, a W-shaped curve is seen instead, with a disproportionate increase in the mortality rate for individuals aged 20–40 years. The W shape describes the finding of peaks in mortality among infants, young adults, and elderly individuals. Therefore, one of the distinguishing features of the 1918 pandemic was the peak in mortality among young adults. No sufficient explanation has been presented elsewhere for the observed mortality pattern [1]. Although we are unable to explain the peak in mortality among young adults, we did find that elderly individuals experienced negative excess mortality, which probably can be attributed to exposure to same strain several years before the 1918 pandemic occurred. The far right upswing of the W shape disappeared when excess mortality was plotted instead of total mortality.

METHODS

We reviewed the medical literature via a MEDLINE search, using the terms "pandemic influenza" and "mortality." General requirements for relevancy included English-language text and mention of mortality or a particular pandemic (the 1918, 1957, or 1968 pandemic) as a keyword.

For an accurate gauge of influenza-related mortality, we chose annual excess age-specific mortality due to pneumonia and influenza (P&I). We were not able to examine age-specific mortality by week or month, because those data generally were not available. Only annual age-specific mortality data were available. Data were obtained from the National Center for Health Statistics of the Centers

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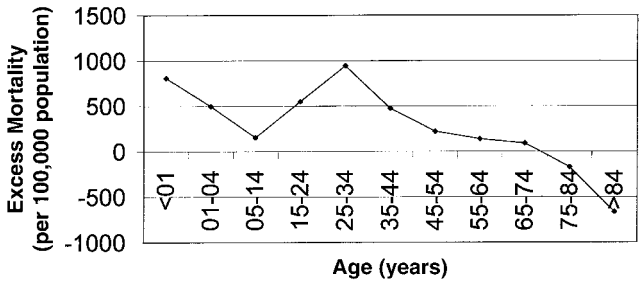

Figure 1. Age group–specific annual excess mortality due to pneumonia and influenza during the influenza pandemic in 1918. The average annual excess mortality for the period of 1913–1917 was used as the baseline.

for Disease Control and Prevention [4, 5] (J. Maurer, unpublished data). The definition of P&I mortality was the same for the 3 pandemics and for the 5-year period preceding each pandemic.

Excess mortality, in this case, is the difference between the mortality rate observed in a pandemic year and the expected or baseline rate in a normal, nonpandemic year. Several alternative methods have been used to determine baselines for estimating excess deaths. We used a simple excess death model to estimate influenza-attributable deaths during the 1918 pandemic and the 2 other pandemics that occurred in the 20th century, those in 1957 and 1968.

We estimated excess mortality rates for all 3 pandemics. The average of the mortality rates for the 5 years before the pandemic year was used as the baseline for each pandemic. This average was then subtracted from the mortality rate of the pandemic year to generate the excess mortality rate for that pandemic. This general method was applied to all 3 pandemics.

RESULTS

We plotted age-specific excess mortality due to P&I for the 1918 pandemic, using the 5-year average mortality rate for 1913–1917 (figure 1). The actual numbers used to generate figures 1–3 are shown in table 1. The peak in mortality among young adults was notable, but the typical W-shaped curve seen when total mortality is plotted against age was not evident. The far right line of the W is not upright but actually points down. Excess mortality dropped after it peaked among young adults and continued to decrease to such a degree that it was negative in the elderly population. Negative excess mortality among the elderly was also apparent in the curves for 1919 and 1920 (data not shown).

An example of the calculations for figure 1 follows: During the 1918 pandemic, the mortality rate per 100,000 population for infants aged <1 year was 2273.3. For the preceding 5-year period of 1913–1917, the average mortality per 100,000 population for the same age group was 1464.0. Therefore, the excess mortality was +809.3 per 100,000 population. For people aged >84 years, the mortality during 1918 was 2230.6 per 100,000 population. For the preceding 5 years, the average mortality was 2895.4. Therefore, the excess mortality was a negative number, −664.8.

For comparison, we used the same method to examine the shape of the curves for the 1957 and 1968 pandemics. Excess mortality curves for 1968 revealed the usual U-shaped curve (figure 2). The P&I excess mortality rates were highest among the very young and the elderly populations and lower among young adults. The curve for 1957 (figure 3) was slightly different, because excess mortality among very young individuals, although still positive, was not as extreme as that in 1968. Nevertheless, in 1957 and 1968, excess mortality did not fall below 0 in the older age groups, as was observed for the 1918 period.

DISCUSSION

Two interesting observations were apparent from examination of the 1918 age-specific excess P&I mortality data. First, the height of the excess P&I mortality peak among young adults in 1918 declined in 1919 and 1920 but remained relatively higher than the excess P&I mortality among very young individuals. The decline in the peak of the excess rates suggests that most of the susceptible young adults were infected in 1918, during the first wave of the pandemic. The susceptible population, however, was probably not completely exhausted, because excess mortality among young adults still occurred in 1919 and 1920, although to a lesser extent.

Second and more interesting is the finding of negative excess mortality

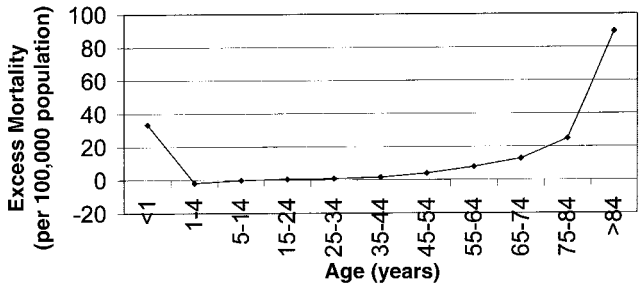

Figure 2. Age group–specific annual excess mortality due to pneumonia and influenza during the influenza pandemic in 1968. The average annual excess mortality for the period of 1963–1967 was used as the baseline.

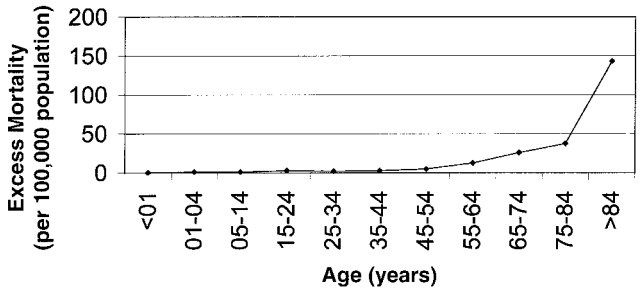

Figure 3. Age group–specific annual excess mortality due to pneumonia and influenza during the influenza pandemic in 1957. The average annual excess mortality for the period of 1952–1956 was used as the baseline.

among elderly individuals. This was unexpected. This finding has been inferred previously [6, 7]. Collins [6] showed no excess mortality in his 1945 article on age-specific excess P&I mortality for 1918–1919 (see his figure 8). Taubenberger [7] plotted the excess mortality against age for the 1918 pandemic. His excess P&I mortality curve shows that the elderly population had a lower mortality rate in 1918 than that observed for the baseline period of 1911–1917. From these 2 curves, negative excess mortality among the elderly population for the 1918 pandemic can be inferred. A likely explanation for this negative excess mortality is that elderly adults had been previously exposed to an influenza virus similar to the 1918 strain and, as a result, were immune to the pandemic virus in 1918.

Schoenbaum [8], in reviewing the 1918 pandemic, notes that "persons age 20–40 accounted for the bulk of the excess deaths" and goes on to say that "compared to this bulge among younger people, the elderly were relatively spared." He explains this mortality pattern with a hypothesis similar to our own, stating, "There may have been some population factors associated with this unusual pattern of morbidity and mortality, the most likely being that the elderly may have been relatively protected by prior exposure to a strain with a similar surface antigen." Our data provide evidence to support this hypothesis.

One possible limitation in these analyses may be the use of yearly data instead of weekly data. Because the 1918 pandemic started in the middle of the year and lasted into 1919, our use of 1917 as the baseline may not have been as accurate as the use of the true baseline of the winter of 1917–1918. Another limitation resulting from the use of yearly data may be the late reporting of deaths. Glezen [1] has questioned the validity of the use of the prepandemic year as a baseline, because the baseline period may not have been free of influenza activity.

Our reexamination of the mortality data from influenza pandemics in the 20th century pries open the black box of the 1918 pandemic a little further [3, 8–12]. A complete picture of the contents of the black box—and an explanation for the unique pattern of age-specific mortality—is still lacking. A seroepidemiologic study of serum specimens collected before the 20th century might shed light on the issue of prior immunity and provide a better understanding of the lack of excess mortality among elderly individuals in the 1918–1920 period [13].

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Table 1. Derivation of data from the 1918, 1957, and 1968 influenza pandemics that were used to chart excess mortality for figures 1–3.

Time period	Age group, years										
	<1	1–4	5–14	15–24	25–34	35–44	45–54	55–64	65–74	75–84	>84
1918	2273	718	176	581	993	555	348	382	646	1179	2231
1913–1917[a]	1464	221	23	31	47	80	127	245	558	1353	2895
Excess	809	497	153	550	946	475	221	137	89	(174)	(665)
1957	240	18	4	6	6	10	21	44	107	299	980
1952–1956[a]	240	17	3	3	4	8	16	32	81	261	837
Excess	0	1	1	3	2	3	5	12	26	37	143
1968	235	10	2	3	4	9	20	42	106	331	1168
1963–1967[a]	202	12	2	2	4	8	16	34	93	306	1078
Excess	33	(2)	0	1	1	2	4	8	13	25	89

NOTE. Data are no. of deaths per 100,000 population. Fractions have been rounded up, resulting in slight discrepancies in some excess mortality totals.

[a] Average annual mortality for the 5-year time period before the pandemic.

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