Age distribution of cases and deaths during the 1889 influenza pandemic

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\textbf{ABSTRACT}

Using historical data taken from archival records from five European countries and the United States, we evaluate the age distributions of influenza cases and deaths during the 1889 influenza pandemic. We found that the clinical attack rate in 1889 was relatively high and constant between the ages of 1 and 60 years, but was lower outside of the extremes of this age range. By contrast, age-specific influenza-related mortality rates were J-shaped and increased with age beyond 20 years. We conclude that the age-specific attack rates of the 1889 pandemic were most similar to those of the 1918 pandemic and that influenza-related mortality rates did not follow a W-shaped curve as was observed during the 1918 pandemic. Adding 1889 to the short catalogue of influenza pandemics previously studied makes the 1918 pandemic even more exceptional in terms of mortality burden and age distribution of deaths.

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1. Introduction

Although the existence of influenza pandemics has been acknowledged since the 16th century [1,2], little is known about the quantitative dynamics and epidemiology of historical pandemics predating the 20th century. It is particularly important to document the epidemiology of past pandemics to guide preparedness plans for future ones. For instance, a shift in the age distribution of cases and of deaths can be considered as a signature feature of influenza pandemics [3], and this information has been useful to define priority groups for vaccination in the context of the 2009 pandemic.

There is limited information about the epidemiology of the 1889 “Russian flu” pandemic. Of all articles referenced in PubMed under the keywords “influenza pandemic” as of December 2010, more than 500 discuss the 1918 pandemic, close to 200 articles discuss the 1957 and 1968 pandemics, more than 3000 articles refer to the 2009 pandemic, while only 17 articles provide information about the 1889 pandemic.

In a previous paper, we analyzed historical datasets describing the first wave of the 1889 pandemic in 14 European countries and the United States [4]. We showed that the disease spread quickly from Saint Petersburg, Russia to Europe with a mean speed of 394 km/week and that the American continent was hit only 70 days after Saint Petersburg. The first wave of this pandemic was characterized by a median clinical attack rate of 60% across 408 administrative units studied, a case fatality ratio ranging from 0.1% to 0.28%, and a median basic reproduction number ($R_0$) of 2.1 (inter-quartile range = 1.9–2.4). However, no information on the age patterns of cases and deaths was available in this study [4].

In this paper, we analyze available historical data to describe the age distribution of clinical infections associated with the 1889 pandemic and quantify variations in influenza-related mortality with age.

2. Materials and methods

We identified relevant documents by studying the bibliography of Patterson’s reference book [5] and systematically searching on-line resources, including web search engines (Google\textsuperscript{TM}, Google Scholar\textsuperscript{TM}, Yahoo\textsuperscript{TM}), online bibliographical databases (PubMed, Web of Science\textsuperscript{®}) and catalogues of public libraries [6–13]. The queries used the following English keywords: “epidemic”, “grippe”, “influenza”, “mortality”, “pandemic”, “1889”, “1890”, and individual country names. We also translated these keywords in French, German, Italian, and Spanish.

All documents retrieved were manually analyzed and additional searches were conducted based on the bibliographical references of retrieved documents. Documents with redundant information or impertinent information were excluded, such as clinical case...
descriptions. Seventy percent of the documents were downloaded from the internet.

We eventually selected 99 documents for this analysis, which provided data on mortality rates, clinical attack rates, or case fatality ratios for the 1889 pandemic (see Appendix A, Table 1 for further detail). Among these 99 documents, seven provided data on the age distribution of influenza cases and/or deaths during years 1889–1890. The seven articles contained datasets compiled from surveys conducted specifically during the pandemic as well as vital statistics. There was no electronic version of four of the five key publications (Friedrich [14], Schmid [15], Parsons [2,16]), which were only available through libraries or booksellers.

2.1. Surveys

We identified six physician surveys conducted on the occasion of the pandemic by public health authorities in France [17], Germany [14], Sweden [18], Switzerland [15], United Kingdom (England and Wales) [2,16], and the United States (Massachusetts) [19]. These surveys were performed in different settings and used non-standardized questionnaires. No clinical definition of an influenza case was used. In Germany and Switzerland, for example, questionnaires were addressed to general practitioners in contact with patients in their every day practice. The Swiss questionnaire sent in February 1890 included questions regarding the number of clinical influenza cases by age and week from December 1889 to January 1890, the number of influenza-specific and influenza-related deaths by age, the spatial and temporal spread and clinical manifestations of the disease. In England, questionnaires were sent to Medical Officers of Health, who were not necessarily in direct contact with patients. The national sanitary services were successful in their initiative. For example, 65% of the English sanitary districts, 40% of the Swiss physicians, and 21% of the German sent reports [20].

Age-related data were extracted from the German, Swedish, and Swiss surveys [14,15,21] From the German survey, we retrieved the age distribution of influenza cases in Mönchen per week from December 1889 to February 1890 [14]. We compiled age-specific estimates of clinical attack rates for a Swedish population of 25,026 from Linoth [18] and Skog [21].

A survey of general practitioners in Switzerland [15] yielded critical data, including cumulative age-specific attack rates in the town of Ermatingen in winter 1889–1890, age-specific national mortality rates from influenza and related pathologies, and age-specific mortality for the 15 largest cities of Switzerland from January 1889 to February 1891. We aggregated the attack rates in six age classes in order to compare with Bertillon’s report providing data for French and other European cities [22]. For the Swiss analysis, we used the post-pandemic winter 1890–1891 as a reference for a non-pandemic year, as the second wave of the pandemic began in March 1890 in Switzerland [15].

2.2. Vital statistics

Vital statistics provided complementary information on the age distribution of influenza-related deaths during the 1889 pandemic. We compiled weekly all-cause deaths for six age groups in Berlin, Paris, and Vienna from December 1889 to the first week of February 1890 from Bertillon’s report [22].

From an English report containing information about the 1889 and 1918 pandemics [23], we compiled age-specific all-cause mortality and all-age mortality from influenza, pneumonia, and bronchitis in England and Wales and in the city of London. The data contained in this report [23] were summarized in a well-cited study conducted by Parsons, which was published soon after the 1889 pandemic [2,16].

2.3. Estimates of clinical attack rates and mortality rates

To calculate attack rates and mortality rates, we used age-specific population estimates for each geographical location. In some cases, the population data were available in the same reports as the morbidity or mortality data. When population data were not available from pandemic reports, we used additional data from census registrars [24,25]. For German and Austrian cities (Berlin and Vienna), we used the distribution given by Friedrich [14] for the city of München.

3. Results

3.1. Age distribution of attack rates

The age-specific morbidity data from Ermatingen, Switzerland and Sweden presented the same pattern of low attack rates in infants under one year (18–35%), high attack rates between 1 year and 60 years of age (60–70%), and lower attack rates in older age groups (~50%, Fig. 1A and B).

3.2. Age distribution of mortality

Data from München [26] indicate that there was a one-week interval between peaks in incidence and mortality (see Appendix A, Fig. 1). The curve of all-cause mortality by age was J-shaped in England and Wales, with high rates among children under 5 years, low rates between the ages of 5 and 20 years, and increasing rates beyond 20 years (Fig. 2). Similar age patterns were observed in mortality due to influenza, pneumonia, and bronchitis in England and Wales, Switzerland, and the city of London. Interestingly, despite variation in absolute mortality rates across these locations, the relative age patterns of deaths were consistent, with highest burden experienced by senior populations.

![Fig. 1.](image) Age-specific clinical attack rate in Switzerland and Sweden. The CAR per class group (A) in Ermatingen, Switzerland (1,330 inhabitants) [15] and (B) in Sweden [21] for a population of 27,008 (bars represent the CI) present the same pattern with lower attack rates before 1 year and after 60 years old.
A comparison of weekly mortality rates for the 15 largest cities of Switzerland during the pandemic winter of 1889–1890 and the post-pandemic winter of 1890–1891 (Fig. 3) reflects an excess mortality in age groups over 20 years of age and no excess mortality in younger groups. Similarly, the temporal examination of age-specific all-cause mortality during the 1889–1890 winter in Berlin, Vienna, and Paris suggests that all age groups over 20 years experienced excess mortality (Fig. 4).

4. Discussion

In this analysis, we compiled information from multiple sources on the age distribution of cases and deaths during the 1889 influenza pandemic. We show that attack rates were high (~60%) in individuals aged 1–60 years and lower in infants and seniors. By contrast, influenza-related mortality was J-shaped, with highest rates in infants and people over 20 years of age.

The age-specific attack rates associated with the 1889 pandemic differ from the 1918 patterns [27–29], with high rates among children and young adults, decreasing after the age of 30 years. In contrast to the 1889 pandemic, the 1957 pandemic was characterized by highest rates among school-aged children [27,28,30,31] and the 1968 pandemic by rather constant attack rates [27,28,32]. The J-shaped age distribution of influenza-related mortality in 1889 was typical of that observed in pandemic and interpandemic periods [33–35], with the notable exception of the 1918 pandemic, which was “W” shaped [34–36].

Despite the high clinical attack rate of the 1889 pandemic (median: 60%), the total mortality burden of this pandemic remained low. This is likely explained by a low case fatality ratio, estimated to range between 0.1% and 0.28% [4]. It is therefore possible that excess mortality may have existed in age groups other than the very young and older adults; however, it may not have been detected due to limitations of the available data.

The German, Swedish, and Swiss surveys conducted among general practitioners were a major source of information on clinical attack rates and mortality [14,15,21]. Still, several limitations are worth noting. In particular, there was no standard definition for clinical influenza, survey procedures were heterogeneous, questionnaires were not standardized, and classifications of diseases differed. As a consequence, it was difficult to compare mortality and morbidity data between countries.

Over the two years of this research, we noticed an increase in the number of documents made available on the internet. For example, all issues of the Lancet (1823 to present) can now be downloaded online, while this was not the case when our search began. Nevertheless, a number of important sources are still only available through libraries or booksellers. Therefore, the search for historical epidemiological documents cannot rely solely on the internet. A wealth of historical data remains unexploited and warrants analysis using modern tools of quantitative epidemiology. In this paper, we analyzed age-specific clinical attack rates and mortality associated with the 1889 influenza pandemic, but there are

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Fig. 2. Mortality rate per age in 1890 in England and Wales and Switzerland. The “J” shape of (A) the all-cause mortality rate in England and Wales [23] is the same as the one for (B) the mortality rate per influenza, pneumonia and bronchitis in England and Wales [23], (C) in Switzerland [15] and (D) in London [23].
other pandemics for which similar data are available, including the 1847–1848 influenza pandemic [2] and the 1892 cholera pandemic [37]. In conclusion, by examining age-specific data from the 1889–1890 influenza pandemic, we observed that the clinical attack rates were high (60%) between the ages of one and 60 years and lower in infants and seniors. We also found that low or no excess mortality was observed among young adults in 1889–1890, compared with the elderly, and that influenza death rates increased monotonously with age after 20. This pattern is very different from the “W” shaped mortality curve associated with the 1918 pandemic. Our study of the 1889–1890 influenza pandemic further emphasizes the unique characteristics of the 1918 influenza pandemic in terms of severity and age distribution of cases, both of which remain unexplained.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.vaccine.2011.02.050.

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