Brief Communication: Rethinking the Impact of the 1918 Influenza Pandemic on Sex Differentials in Mortality

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KEY WORDS mortality; infectious diseases; epidemics; Gibraltar; influenza; tuberculosis

ABSTRACT This study will assess the general impact of the 1918 influenza on overall mortality and its impact on mortality attributable to pulmonary tuberculosis in a small-scale population. Using life table and decomposition methodologies, changes in mortality in Gibraltar used a scheme that identified a pre-epidemic period (1904–1917), the epidemic year (1918), and the post-epidemic period (1919–1927). Overall health in both sexes fell significantly in 1918 with a drop in life expectancy at birth, however, health quickly rebounded in the post-epidemic period. In the case of women, there was a significant increase in life expectancy at birth after the epidemic. The impact of influenza on the magnitude of sex differentials in the life expectancy at birth fell during epidemic year but returned to a level comparable to that of the pre-epidemic period. With respect to respiratory tuberculosis deaths, the immediate impact of influenza was restricted to only a significant increase in the rate among women (aged 15–54). In the post-epidemic period, tuberculosis mortality rates returned to the pre-epidemic state in both sexes. The findings from Gibraltar stand in contrast opposition to results reported for experience in the United States during the 1918 flu. Am J Phys Anthropol 139:584–590, 2009. ©2009 Wiley-Liss, Inc.

The 1918 Influenza Pandemic is infamous for being the most deadly influenza virus, globally killing 20–40 million and infecting approximately 20–50% of the World's population (Reid et al., 2001). The 1918 pandemic was unique in that a mortality rate from influenza was greatest in young people aged 15–45 years (Noymer and Garenne, 2000; Chowell et al., 2008). In Geneva, Switzerland, for example, the influenza morbidity rate exceeded 50%, and mortality was highest in males aged 21–40 years (Chowell et al., 2006). Death from influenza resulted from infection of the lungs, primarily fatal pneumonia, as such the mortality rate from pneumonia was the highest in the 1918 pandemic (Reid et al., 2000). Recent research on regional influenza morbidity and mortality indicate differential rates in rural versus urban settings (McSweeny et al., 2007). The influenza mortality rate was significantly higher in towns and cities than in rural areas in New Zealand, Wales, and England (McSweeny et al., 2007; Chowell et al., 2008). The rurality protection from mortality during the pandemic may have been due to social distancing (lower person-person contact) and remoteness lowering transmission of infection from towns to rural areas (McSweeny et al., 2007). Difference in regional mortality was substantial in some countries such as England and Wales where urban settings had 30–40% higher rate of mortality from influenza (Chowell et al., 2008). However, smaller towns had a significantly higher influenza mortality rates than larger towns and cities had a significantly lower influenza mortality rate than larger towns. Lower mortality rates in large towns and cities may represent better organized community and medical care (McSweeny et al., 2007; Chowell et al., 2008).

Noymer and Garenne (2000) speculate that *Mycobacterium tuberculosis* and influenza interacted in the 1918 United Stated pandemic; specifically that mortality occurred among those infected with TB through a selection effects such that deaths from influenza will reduce the incidence of deaths due to pulmonary tuberculosis in subsequent years. Indeed it was very likely that secondary pneumonia caused by influenza was exacerbated by tuberculosis (Noymer and Garenne, 2000). Chowell et al. (2008) suggest that the trends in tuberculosis regional mortality rates should mirror that of influenza during the 1918 pandemic. Thus, urban areas would have had higher rates of tuberculosis than rural settings (Chowell et al., 2006).

Based on aggregate data drawn from the published literature, Noymer and Garenne (2000) drew a number of conclusions regarding the impact of the 1918 influenza epidemic on mortality in the United States. They posited that

1. The influenza epidemic had a strong and fairly long-lasting effect on differential mortality by sex, diminishing the earlier female advantage
2. The mechanism for this change was a selection effect whereby those with tuberculosis in 1918 were more likely than others to die of influenza
3. This outcome affected males more than females because tuberculosis morbidity was disproportionately male
4. The reduction of the pool of male tuberculosis cases lowered the male tuberculosis death rate in the years following 1918, and finally in the aftermath of the epidemic, and finally,

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5. Male life expectancy moved closer to the longer female life expectancy.

Their paper concluded with an appeal for further inquires requesting accurate and detailed mortality data from other countries (Noymer and Garenne, 2000, p. 59). The present study, although limited in scale, nonetheless presents a novel contribution to the issue by empirically contextualizing the prevailing conditions before, during and after the 1918 influenza epidemic using a multiple-cause mortality data base.

MATERIALS AND METHODS

The research site, Gibraltar, is an unusual location on the global stage: a British Colony, a naval base, a coaling station, a commercial center, a garrison town and a port city. Collectively these attributes created a population that was subjected continuously to a flow of individuals from the Spanish hinterland and more distant locations. As a result, Gibraltar has been open to the importation of deadly pathogens such as yellow fever, cholera and influenza over its history (see e.g., Dansey-Browning, 1918; Sawchuk and Burke, 1998; Sawchuk, 2000).

In terms of its vital records, the available data for this community is excellent in depth and breadth as it not only provides detailed nominative information but as well, draws upon local eco-social factors that may influence the course of a disease. Death registration was well established in Gibraltar as it became compulsory on January 1, 1869. Consequently, Gibraltar's civilian population was legally required to report vital events to ensure their continued presence in the garrison town as their right to residence was on colonial sufferance. Individual data returns relevant here indicate date of death, sex, profession, general cause of death as reported by the informant, occupation of the deceased, primary cause of death, duration of primary cause of death, and the secondary cause of death. A separate death register was kept for the floating or "alien" population. Only those resident in Gibraltar for one year or more were included in the computation of the numerator. With the exception of the number of births, government census returns (1911 and 1921) were used in the estimation of the population at risk. Compulsory birth registration began on January 20, 1887 and for this study, it provides information on the date of birth and sex of the infant that ultimately forms a part of the risk denominator.

For analytical purposes, three periods of study were reconstructed that correspond to a pre-epidemic period (1904–1917), epidemic year (1918) and the immediate post-epidemic period (1919–1927). Changes in health over the study period were assessed using life table methodology. Traditionally, the results from life tables have been used as health indicators of large populations such as nation states, however, recent attention has focused on their utility on smaller scale units such as local communities. Accordingly, the Chiang (1984) approach for estimating statistical properties of the various life table parameters is used here as (1) it produces the most conservative estimates for comparison between local areas, (2) it is easy to calculate (including statistical variance) and (3) sensitivity analysis can be performed on the major assumptions, and (4) it is frequently used by others, such as the WHO, allowing for comparability (Manuel et al., 1998: p. 5). An online template for calculating life expectancy using the Chiang method can be found at http://www.statistics.gov.uk/STATBASE/ssdataset.asp?vlnk=6949&More=Y. To gain a better understanding of the methodological issues associated with the assessment of life expectancy at birth for small populations refer to Toson and Baker (2003).

Because one of the primary objectives of this paper was to assess the impact of the 1918 influenza epidemic on pulmonary tuberculosis (TB) mortality, each cause of death cited in the nominative register under the headings (general, primary, and secondary) was scrutinized for pulmonary tuberculosis in any of the three locations. This follows a similar approach by Dushoff et al. (2005) in their time series analysis of influenza in the United States stating that the construction of a multi-cause data base to be more robust and less sensitive to changes in death coding and nosologic changes. In theory, such an approach should provide a closer approximation of the actual level of respiratory tuberculosis present in the community than values reported in published aggregate reports. Given the low death rates attributable to respiratory tuberculosis, changes in mortality over the study period were assessed using a Poisson-based statistical test (Sawchuk et al., 2003).

The determination of the age of origin and destination using the decomposition approach was used to assess changes in life expectancy (Carlson, 2006). Its use here is notable as it is the first time it has been applied for the study of an epidemic. The method is calculated directly from the life table functions: l_x, the number of survivors to age x, based on predetermined radix; L_x, the number of person years lived in a particular age segment; and e_x, the life expectancy of person years to be lived by population at age x. The end result is Andreev's ${}_n\varepsilon_x$ age decomposition value which assigns the differences in life expectancy to the age group where the mortality difference first occurs. This two-dimensional tool has a number of useful features: (1) the method requires only mortality and population data; (2) procedures for calculation are straightforward and it can be carried out using a simple spreadsheet; (3) the method identifies the age segments having the greatest influence, positive or negative, on life expectancy; (4) the method provides a quantitative measure that is easily interpreted; and finally (5) it allows for a detailed description of the mortality patterns and the relative importance of different age intervals on life expectancy (Carlson, 2006).

The great pandemic of 1918: Gibraltar

On June 3, The London Times ran the headline: The Spanish Epidemic—700 Deaths in Ten Days. In fact, the first wave of 'the grippe' had struck Gibraltar, earlier than that reported for Madrid, making its appearance in the latter part of May (Dansey-Browning, 1918). By June the number of cases of influenza rose and subsided by early July, lasting 7–8 weeks in Gibraltar's hot, dry months. The case fatality rate of this first wave of influenza was very low with only eight deaths out of a projected number of cases between 600 and 800 cases and 13 deaths attributed to pneumonia (see Fig. 1).

The second wave began in September, coinciding with the commencement of the rains and falling temperatures. The epidemic reached a peak in October and gradually diminished by November. Unlike the first wave, the second outbreak was much more severe, both in incidence and in the magnitude of the death rate. The number of deaths officially attributed to influenza alone was

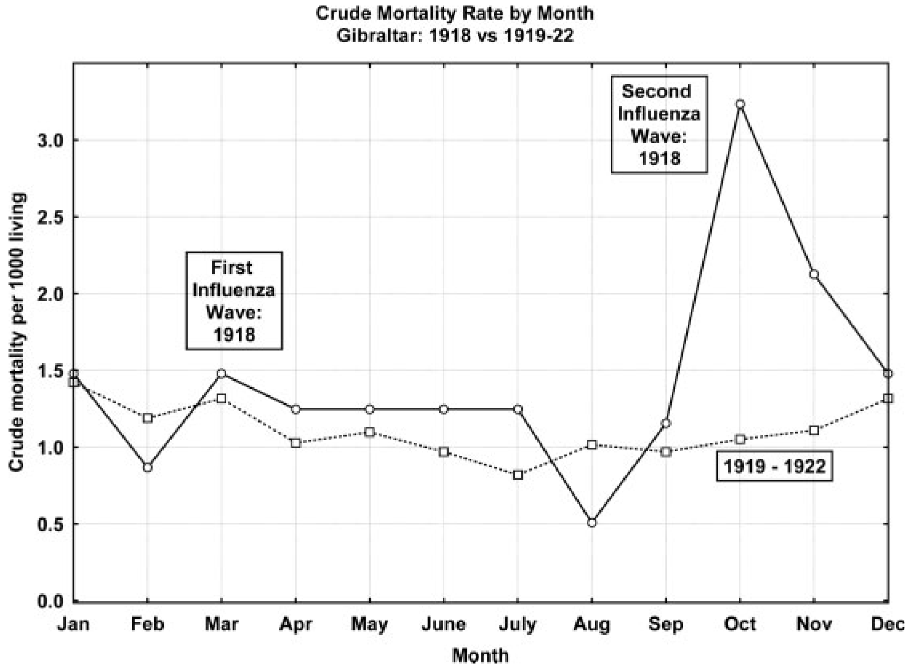

Fig. 1.

Fig. 2. Makeshift camp established to treat influenza patients.

nearly an eight fold increase, with 75 victims and 36 deaths due to pneumonia. During the second wave, estimates of the number of cases ranged anywhere from 3,000 to 6,000 of Gibraltar's civil inhabitants. Figure 2 shows the makeshift camp established to treat influenza patients.

Despite the high number of flu cases, Gibraltar's official newspaper remained relatively mute on the crisis issuing few public notices. This response was in keeping with that found in England where medical professionals in Britain arguably played a "passive role" when faced with a severe public health crisis (Loeb, 2005). Accordingly, there was criticism from the non-official newspapers regarding the lack of precautionary measures taken regarding the reception of the sick from ships arriving from abroad, the disinfection of the clothing of patients brought in from the bay and the manner in which patients were brought into the heart of the town where the Civil Hospital was situated. The lack of sufficient medical staff to cope with the epidemic also created a state of alarm in the mind of the public as by the end of October it was reported by the Medical Officer of Health that there was unprecedented misery and neglect among the poor families infected with influenza. Throughout the epidemic period, knowledge regarding the nature and spread of influenza in Gibraltar was wanting. Ironically, the English seven page official pamphlet, dated October 1918, outlining the current state of knowledge on influenza did not reach Gibraltar until the 28th of November—days after the last case of the flu. In the Annual Colonial Report of 1918, a summary of the outstanding features of the year made no reference to the Influenza epidemic (Gibraltar, 1919).

One of the consequences of the 1918 epidemic was that influenza became a notifiable disease in Gibraltar and accordingly, authorities were able to monitor the prevalence of this disease (see Fig. 3). However, this initiative was short lived as the disease was removed from the list of notifiable infectious diseases after 1939 and information on influenza was only obtained through the courtesy of medical practitioners. Prior to the 1918 pandemic, outbreaks of influenza only received note when the number of cases stimulated anxiety among the population. Such was the case in when a mild epidemic form of influenza struck at the end of 1891 and ended in April of 1892 (MacPherson, 1893). Of the 154 cases reported only one case proved fatal.

The great blot on the sanitary history of Gibraltar

In order to fully grasp the impact of the 1918 influenza on tuberculosis mortality, a brief statement on one of Gibraltar's few endemic diseases is warranted (see e.g., Sawchuk and Herring, 1984; Burke and Sawchuk,

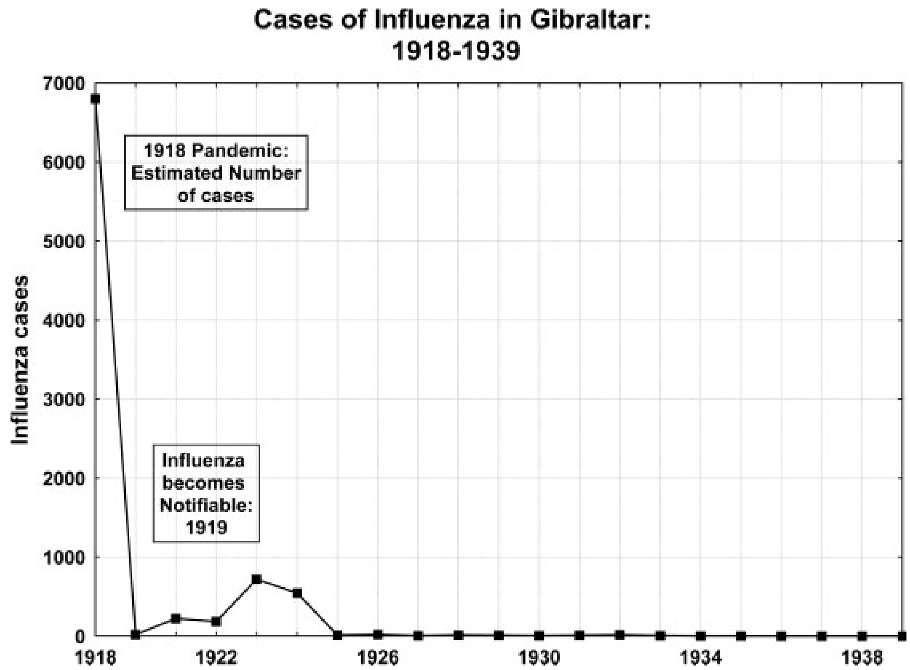

Fig. 3.

2003). Until the beginning of the study period, there was little done to combat the disease. In fact, Medical Officers of Health spoke of the high incidence of pulmonary tuberculosis as the great blot on the sanitary history of Gibraltar. The high incidence of tuberculosis in Gibraltar was not surprising, given the fact that the vast majority of the population lived in highly overcrowded and unsanitary conditions and they belonged to the poor working classes. Medical authorities invariably identified the source of the problem as the communal patio life style, where accommodation in a multi-family dwelling unit, back to back dwelling units, crowding and poor ventilation in one-room apartments was commonplace. Industrial hygiene was poor with long working hours, and exposure to contaminants and dust (for example, coal heavers and tobacco workers). Local customs further aggravated the situation, such as: (1) visiting the sick in their rooms, (2) spitting in living spaces and in the streets, (3) dry sweeping of rooms of the sick, (4) feeding children from spoons and plates used by sick relations, (5) greeting of relatives, friends and neighbors by kissing, (7) the poor selling off the bedding and clothing of deceased TB patients and finally, (6) a general ignorance of the public regarding the nature and spread of the disease (Horrock, 1904). Aid to the tuberculosis patient and their families was limited to 'public relief' and through the charity of family, friends, and neighbors. The isolation of the sick in government run institutions (e.g., sanitarorium) was delayed until the opening of the King George V Hospital in 1939.

While Figure 4 provides insight in the trend of pulmonary TB since compulsory notification in 1906, the problem of under reporting is readily apparent. The magnitude of concealment can be seen in the number of cases reported during the government enquiry of 1911 and then followed a resumption of the normal state of affairs of notifying cases when absolutely necessary. In Gibraltar, it was common practice that it was only when an affected individual could no longer earn a sufficient wage that notification was made to the authorities so that relief from the government could be accessed.

As late as 1947 an independent Home Office report on the status of pulmonary tuberculosis in Gibraltar noted that the disease still carried a considerable social stigma that in fact played a role in the accuracy of notification and certification as a cause of death (Young, 1947). One further indication of the stigma associated with tuberculosis was that the Spanish-born Gibraltarians would not entertain a marriage to an individual where a member of the family had a history of tuberculosis.

RESULTS: CONSEQUENCES OF THE 1918 EPIDEMIC

Life table estimates over the study period, shown in Table 1, shows the prevailing state of mortality where the life expectancy at birth for males and females was 45.66 and 54.54 respectively, yielding a difference of 6.88 years between the sexes. For 1918, the life expectancy differential between the sexes increased to 8.77 years, as the life expectancy at birth for males and females fell to 39.60 and 48.41, respectively. In the post-epidemic period, life expectancy values in both sexes rose with only female population showing a significant rise (Z test = 2.86, P = 0.01). As a result of this trend, the difference between the sexes returned to pre-epidemic level and stood at 8.32 years.

Using the pre-epidemic values as the starting point for the age at origin decomposition analysis, Table 2 shows the impact and aftermath on Gibraltar's mortality profile with respect to the influenza epidemic. Among males, the decline during 1918 in life expectancy at birth was years. As Table 2 shows the decline was not was not shared equally by all ages where elevated mortality levels peaked in the age interval 25–34, accounted for

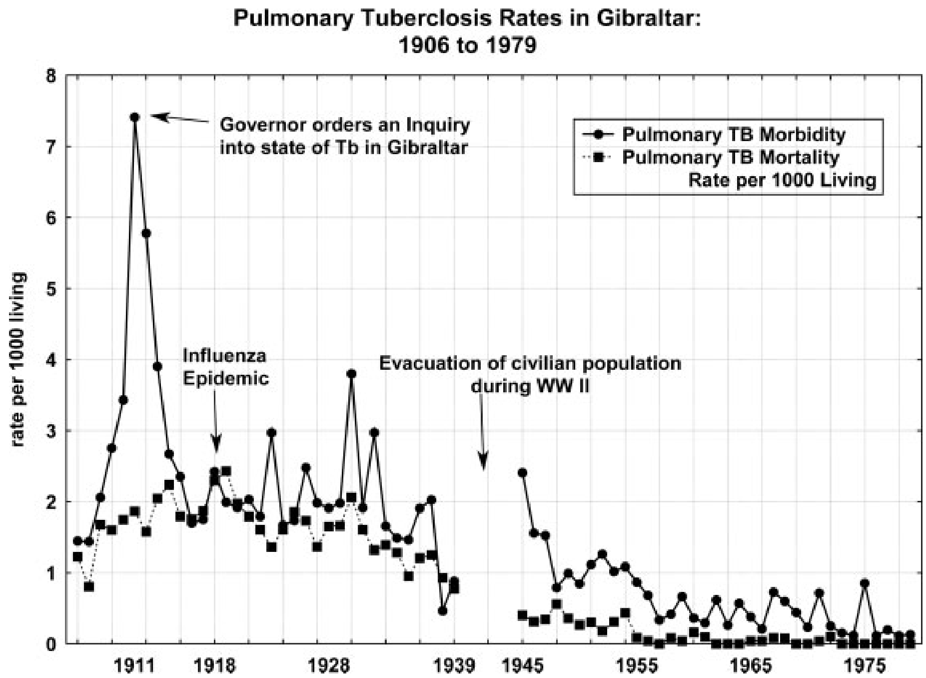

Fig. 4.

TABLE 1. Life expectancy at birth by sex for Gibraltar, 1904–1927

Period	Male, mean and SE	Female, mean and SE	Sex difference	*Z* value
P_1: 1904–1917	45.66 ± 0.52	52.54 ± 0.56	6.88	8.98, *P* = 0.001
P_2: 1918	39.60 ± 1.78	48.41 ± 2.02	8.77	3.26, *P* = 0.01
P_3: 1919–1927	46.86 ± 0.67	55.19 ± 0.74	8.32	8.32, *P* = 0.001

Statistical tests over time: *Z* test as computed by Chiang (1984:164–165). Males: P_1 vs P_2, $Z = 3.25$, $P = 0.01$; P_2 vs P_3, $Z = 3.80$, $P = 0.1$; $Z = 1.41$, ns; females: P_1 vs P_2, $Z = 1.94$ ns, ns; P_2 vs P_3, $Z= 3.16$, $P = 0.01$; $Z = 2.86$, $P = 0.05$.

TABLE 2. Decomposition of age of origin for changes in life expectancy, Andreev's $_n\varepsilon_x$, in Gibraltar during the pre- and post-epidemic periods relative to the influenza epidemic year of 1918

	Males				Females			
	P_1 vs P_2		P_2 vs P_3		P_1 vs P_2		P_2 vs P_3	
Age	Andreev's $_n\varepsilon_x$	Percent of change	Andreev's $_n\varepsilon_x$	Percent of change	Andreev's $_n\varepsilon_x$	Percent of change	Andreev's $_n\varepsilon_x$	Percent of change
Under 1	0.4821	−8.00	−0.5771	−7.98	0.9163	−22.15	−1.0731	−15.81
1–4	−0.1627	2.70	1.0838	14.99	0.1980	−4.79	0.6529	9.62
5–9	−0.3148	5.22	0.3503	4.84	−0.6515	15.75	0.7617	11.22
10–14	0.1397	−2.32	−0.2288	−3.16	0.2604	−6.29	−0.3198	−4.71
15–19	−0.4223	7.01	0.5658	7.83	−1.1087	26.80	0.9535	14.05
20–24	−1.1284	18.72	1.0929	15.12	−0.3511	8.49	0.4221	6.22
25–35	−2.4672	40.93	2.4892	34.43	−3.2548	78.67	3.6145	53.26
35–45	−1.4109	23.40	1.6620	22.99	−0.8940	21.61	1.1944	17.60
45–55	−0.5713	9.48	0.4473	6.19	0.5000	−12.09	0.0286	0.42
55–65	−0.2557	4.24	0.3442	4.76	0.3903	−9.43	−0.1836	−2.71
65–75	0.0403	−0.67	0.0321	0.44	−0.1385	3.35	0.6268	9.24
75–85	0.0396	−0.66	−0.0324	−0.45	0.0001	0.00	0.0820	1.21
85 plus	0.0030	−0.05	0.0006	0.01	−0.0040	0.10	0.0260	0.38
Total change	−6.0286		7.2300		−4.138		6.7859	

40.9% of the decline. Eighty-one percent of the decline in life expectancy at birth during the epidemic year occurred during the ages 20–44. During the post-epidemic period, the increase in life expectancy at birth of 7.23 years occurred largely in the reproductive ages (that is, 20–44) where an increase of 72.4% of the increase was noted. Changes in the Andreev's $_n\varepsilon_x$ values before and after the epidemic revealed a mirror-like pattern where the rise and fall of values reflected of the state of mortality before and after the pandemic. The

TABLE 3. Pulmonary tuberculosis mortality from 15 to 54 in Gibraltar from 1904 to 1927

	Males			Females		
Period	Deaths	Population at risk	Rate	Deaths	Population at risk	Rate
P_1: 1904–1917	169	70,395	2.40	134	83,213	1.61
P_2: 1918	16	5,103	3.13	17	5,956	2.85
P_3: 1919–27	135	45,927	2.94	80	53,604	1.49

Rate: deaths due to pulmonary TB per 1,000 living aged 15–54. Poisson based tests by sex: P_1, male vs female $Z = 3.47$, $P = 0.01$; P_2, male vs female $Z = 1.27$, ns; P_3, male vs female $Z = 4.89$, $P = 0.001$. Poisson based tests over time for each sex: males P_1 vs P_2, $Z = 1.02$, ns; P_2 vs P_3, $Z = 0.244$, ns; P_1 vs P_3, $Z = 1.75$, ns; females P_1 vs P_2, $Z = 2.25$, $P = 0.05$, P_2 vs P_3, $Z = 2.47$, $P = 0.01$, P_1 vs P_3, $Z = 0.53$, ns.

pattern suggests that the impact of the epidemic had little immediate consequence on the pattern of mortality among males in the years following 1918 pandemic.

Compared to men, women during the year 1918 showed a smaller decline in life expectancy at birth (4.13 years) relative to their prevailing mortality pattern in the pre-epidemic period (see Table 2). The distribution of Andreev's ${}_n\varepsilon_x$ age values for females showed a slightly different pattern where the maximum decline of mortality was concentrated in a single age interval, 25–34, with almost 80% of the decline solely in that one age bracket. In aftermath of the epidemic, life expectancy for females rose significantly to 55.19 ± 0.74, to a level above that seen in the pre-epidemic period (see Table 1). Looking at the mortality pattern across all ages showed that the impact of the influenza epidemic on the overall mortality profile of the community was minimal where the correlation between pre- and post-epidemic mortality pattern was again virtually a mirror copy of the fall and rise of age of origin decomposition Andreev's ${}_n\varepsilon_x$ values.

Turning to the impact of the epidemic on pulmonary TB, the results shown in Table 3 show that while respiratory tuberculosis rates among males did increase, from 2.40 to 3.13 per 1,000 among men between the ages 15 and 54 during the epidemic period, the rise was not statistically significant (Z test = 1.02, ns). After the epidemic, there was in fact a slight rise in pulmonary TB, but again the change, an increase, was not significant (Z test = 0.244, ns). Overall, the rates of pulmonary TB remained stable over the study period albeit with the temporary minor changes in 1918. Among females, the impact of influenza on pulmonary TB mortality was markedly different as respiratory tuberculosis mortality increased significantly during the epidemic period from 1.61 to 2.85 per 1,000 women aged 15–54 (Z test = 2.25, $P = 0.05$). As a result, the difference in pulmonary TB mortality rates between the sexes diminished and became temporarily non-significant (Z test = 1.269, ns). Following the epidemic, pulmonary TB rates fell to 1.49 per 1,000 among women 15–54, the decline was statistically significant (Z test = −2.247, $P = 0.05$). However, from the vantage point of the pre- versus post-epidemic periods, the rate change from 1.61 to 1.49 was not significant (Z test = −0.538, ns). These results suggest that the impact of influenza on pulmonary TB among women was at best temporary.

CONCLUSION

Clearly, the Gibraltar case-study yields results in contrast to those found in the American study. One answer to this disparity is that we are simply seeing inter-population variation inherent in a system responding to an epidemic. Another possibility may lie in differences in methodology and/or the quality of registration. In either case, assessing the consequences of an epidemic across time and space will remain highly problematic as the impact will vary according to the local ecology, the biocultural properties of the community, local conditions that play a role in the speed and dispersal of the pathogen, and the state of immunity of the host population.

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