Measuring a pandemic: Mortality, demography and geography*

NIALL P.A.S. JOHNSON

1918 Influenza. The 1918-19 influenza pandemic is now regarded as one of the three largest mortality events in human history, with only the 6th century Justinian plagues and the Black Death of the 14th century of similar stature. While estimates of total mortality have varied, the latest published tally (Johnson and Mueller 2002) argues that as many as 100 million people died in little over a year, a similar tally to those two earlier much longer-lasting plagues, and well in excess of the 8.5 to 10 million deaths attributed to the First World War; greater also than the mortality of World War Two – and greater even than the combined mortality of both the World Wars. This paper examines the mortality, demography and geography of this pandemic, largely from a quantitative perspective, using the British experience to illustrate the impact of this massive pandemic.

This was an influenza pandemic that struck a world poorly equipped to deal with such a curse. The influenza virus itself was not identified until 1933, attempts to create vaccines were thus doomed to failure as they could not identify the causative agent. Without vaccines all sort of cures were suggested – ranging from bed rest to colloidal mercury – and, of course, there was great debate about the medicinal benefits of alcohol! In many locations attempts at quarantine were attempted. In some instances this meant restricting or closing public entertainments, bars, cinemas, etc. In others it meant attempts to prevent anyone entering the community from outside. But with a disease as pervasive and as easily transmitted as influenza such attempts were doomed to failure (Johnson 2001).

One of the most compelling aspects of the 1918-19 influenza pandemic is how universal that experience was. Across all variations – national, racial, social, economic, climatic, belligerent or neutral and so on – the pandemic was played out in much the same way. The timing, the three waves of mortality (Figure 1), the age distribution of mortality (Figures 2-4), and how that mortality was brought about, frequently with pneumonic complications and what became the infamous 'heliotrope cyanosis' where victims turned a bluish-purple tinge are so consistent as to almost render trivial any variations (Phillips and Killingray 2003; Johnson 2003).

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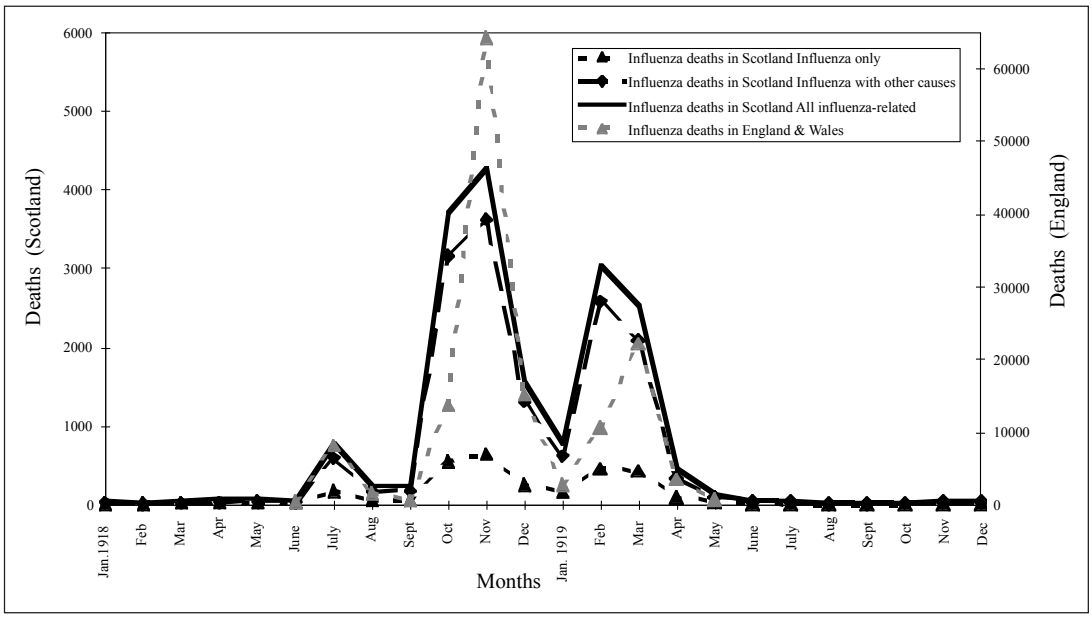
Fig. 1. *Waves of influenza mortality*

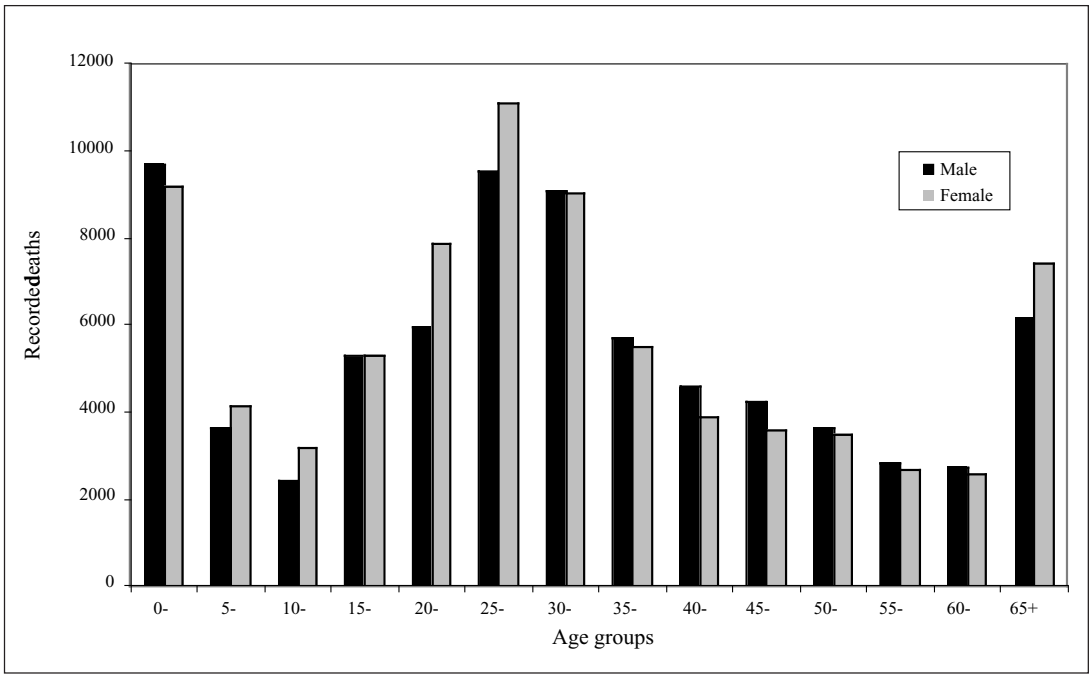


Data sources: Registrar-General (1920), Registrar-General for Scotland (1919).

The pattern of mortality by age (Figures 2-4) is one of the distinguishing features of this pandemic. While the mortality rate was not much changed from 'normal' flu – a 1-3% case fatality rate – who was dying was much changed. Throughout the centuries of recorded influenza outbreaks, it has always claimed the eldest and the youngest portions of the population, the most vulnerable, producing a U-shaped curve of age mortality (Crosby 1989). This was not the case in 1918-19. Young adults bore the brunt of mortality in this pandemic, to such an extent the age mortality curve is more a W than a U (Figure 2). Just why is a very contentious issue, particularly as this pattern is universal whereas the explanations proffered tend to be local.

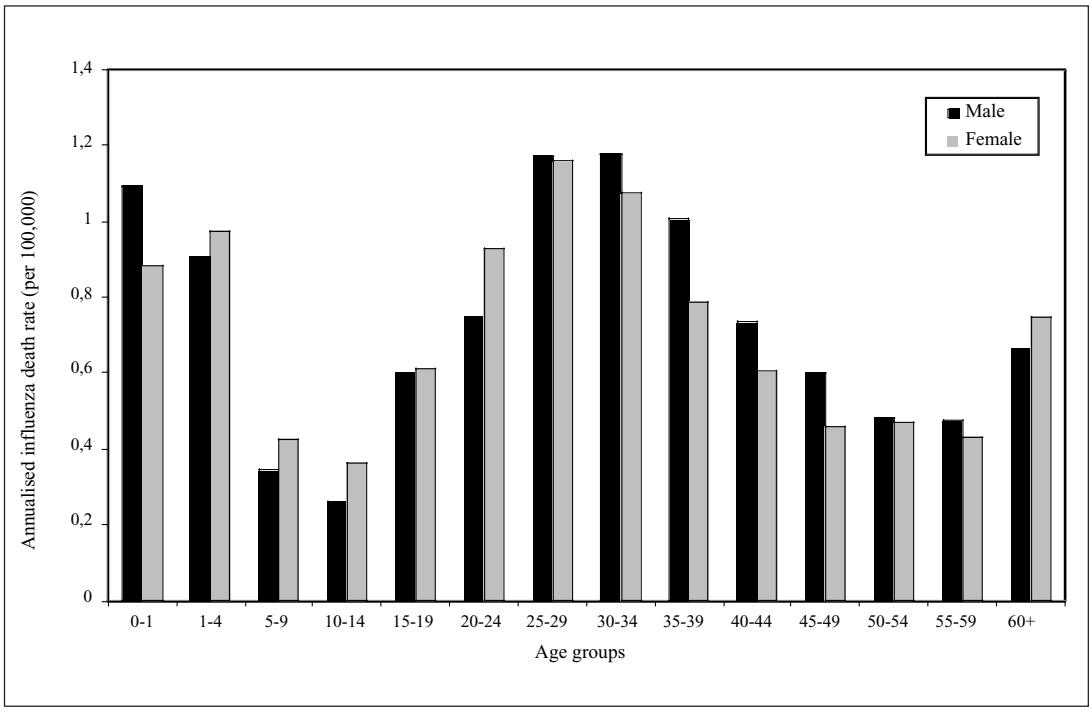
Calculating mortality. Determining the true extent of past pandemics is notoriously difficult, but is doubly so with a disease such as influenza. One of the most difficult areas for those working on past outbreaks of disease is that of data. What data there are tends to be patchy. There are also concerns about how valid, accurate or robust the data are. The limitations can include non-registration, missing records, misdiagnosis, inaccurate non-medical certification and may also vary greatly between locations. Recognising these limitations it is also generally accepted that recorded statistics of influenza morbidity and mortality are likely to be a significant understatement. This section presents an estimation of the mortality caused by the pandemic, firstly in Britain and then globally. For Britain I examine England and Wales and how the Registrar-General estimated mortality there, apply the same methods to Scotland and then refine the British estimate by examining the causes of death used in the 'excess deaths' methods, the role of the pandemic in encephalitis lethargica mortality, and the questions of pregnancy and averted births.

Fig. 2. *Age distribution of influenza mortality in England and Wales, 1918-19*



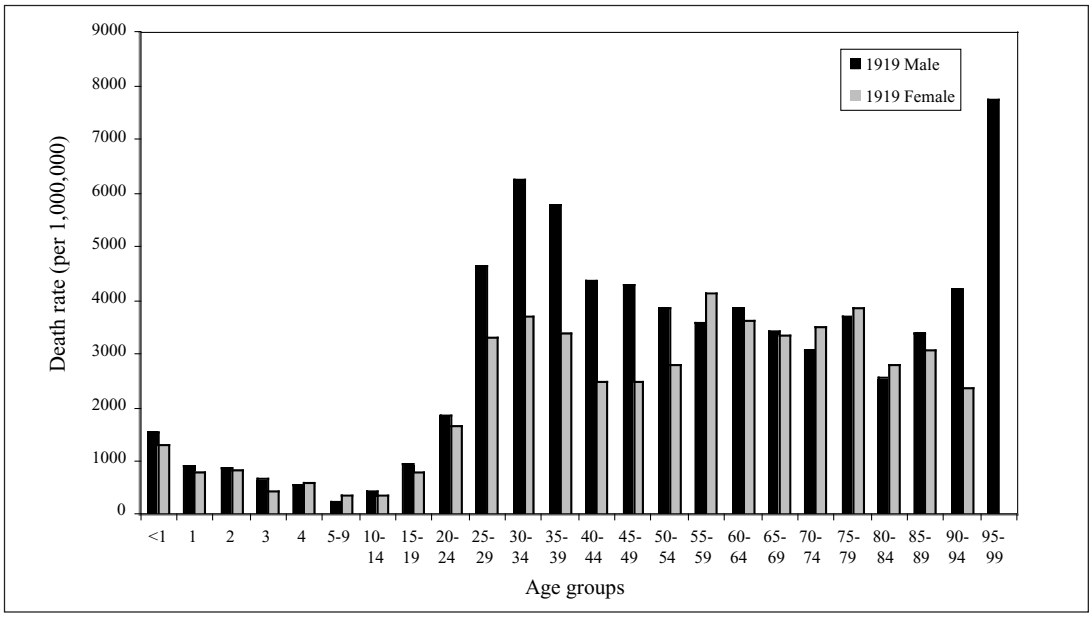
Data source: Registrar-General (1920), *Annual Report of the Registrar-General* 1918 and 1919.

Fig. 3. *Age distribution of influenza mortality in Spain, 1918*



Data source: Echeverri (1998).

Fig. 4. *Age distribution of influenza mortality in Australia, 1919*



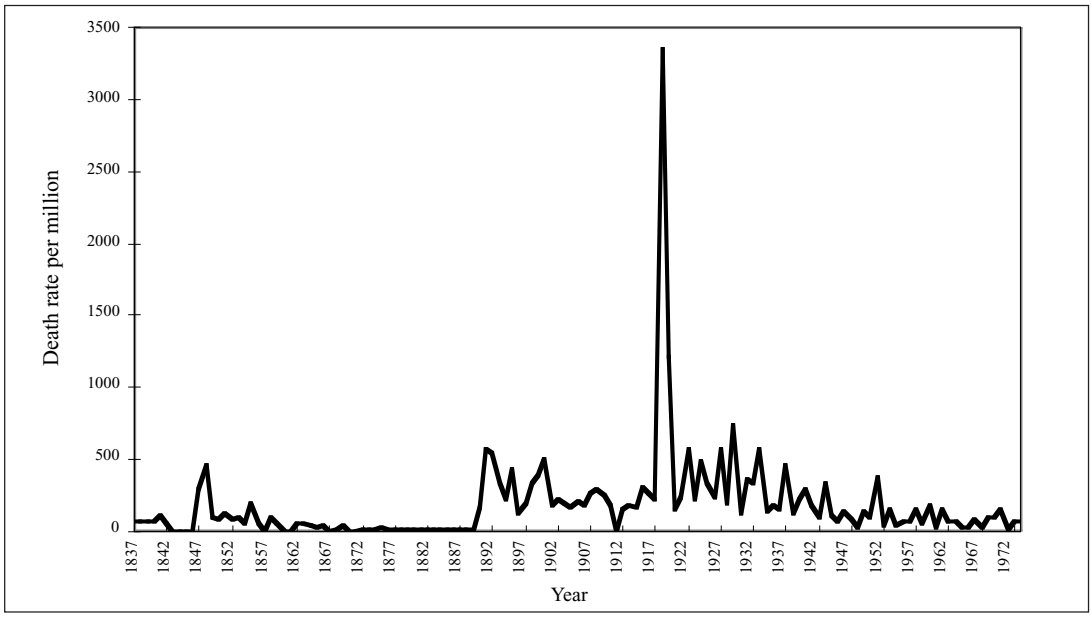
Data source: Australia (1920, 1131).

UK mortality. Britain is long-acquainted with influenza. The Registrar-General (or RG) has been recording influenza mortality since 1837. Currently, between three and four thousand people die each year in Britain as a result of influenza and influenza-related causes. In the winter of 1989-90 an estimated 29,000 Britons died during an influenza epidemic. But never before (or yet again) in the influenza record was there to be such an upturn as in 1918-19 (Figure 5). Apart from the War, 1918 was a relatively healthy year in England and Wales until the final quarter and the 'flu. The influenza pandemic transformed it into the first year since records began in which the number of deaths exceeded the number of births (Registrar-General 1919, xxvii).

The RG recorded that during the forty-six weeks of the pandemic in England and Wales 151,446 people had died, of whom 140,989 were civilians. The annualised civilian death rate is 4.774 per thousand. However, these are the deaths allocated to influenza only (Registrar-General 1920, 3). The basic statistics from the RG's report led the Ministry of Health to conclude «That the mortality in England and Wales, as a whole, attributable directly or indirectly, to influenza, is without any precedent in magnitude; [...] That the toll taken at the young adult ages of life is without any know [sic] West European or North American precedent» (Ministry of Health 1920, 40).

There have long been problems relating to misdiagnosis and under-reporting of influenza deaths. While influenza has been recorded as a cause of death right from the start of the British records and has not been subject to the changes of definition and recording that have affected the recording of many diseases, it is also recognised that the recorded figures reflect an under-estimation of influenza mortality.

Fig. 5. *Long-term influenza mortality in England and Wales*



Source: Data taken from the *Annual Report of the Registrar-General* for the period 1837-1973.

The English RG's report recognised that there is likely to have been an under-estimation of influenza mortality:

> It is well known that during influenza epidemics the mortality attributed to the disease does not represent the whole of that caused by it. The entries under other headings, especially those of respiratory disease, are always found to increase during an epidemic, and [...] it is still necessary to make allowance for these increases in mortality, allocated to other causes but really attributable to influenza, in endeavouring to measure the loss of life. (Registrar-General 1920, 3)

Consequently, the RG devised three 'excess deaths' methods for estimating the total mortality attributable to the pandemic. (Registrar-General 1920, 3-7). These methods were first applied to the female population, due to the «profound modification of the male civilian population». (Registrar-General 1920, 3)

The first method (specific causes) involved comparing the deaths in the female population for each quarter of the pandemic against deaths in the previous five years (1913-1917). The female population was used as the basis for this as it was deemed to be 'less disrupted' by the war than the male population. Several causes of deaths were examined for 'excess' deaths based on annualised death rates and these deaths then re-allocated as influenza-caused deaths. The causes to be included were pneumonia (all forms), bronchitis, 'organic heart disease' and phthisis (pulmonary tuberculosis).

The second method (other causes) employed was to assess the comparative healthiness of 1918 to the average for the previous five years for all 'other causes' (not influenza and not those diseases listed above) and then to assume that in the

absence of influenza the total mortality would have been in the same ratio as between these causes in 1918 and in the previous five years. Then the 'excess' mortality could be regarded as influenza-related. From this method 1918 is found to have 86.89% of the mortality of the average for the previous five years for those 'other causes' – a relatively healthy year – and from this an 'expected' mortality could be calculated and then removed from the recorded mortality for the pandemic period and the remainder can be claimed to be influenza mortality.

The third estimation method (1918 improvement) was based on the assumption that mortality for the year would have been similar to that found in the first and second quarters of 1918. National mortality for the first quarter was 86.5% of that for the 1913-17 average while in the second quarter of 1918 it was 89.6%. From here it is possible to calculate an expected mortality and compare it with actual mortality. Again the excess can be claimed to be influenza-related.

The original figure of 140,989 deaths gave an annualised civilian death rate due to influenza of 4.774 per thousand. These three 'excess deaths' methods all converged on an adjusted tally of 185,000 civilian deaths, which raises the annualised civilian death rate to 6.264 per thousand.

Scotland. One of the oddities of working with official data in Britain is that the figures for Scotland are recorded separately from those for England and Wales – and this is true for the 1918-19 influenza pandemic. They are not just recorded separately, but published with a much lesser degree of detail. Notwithstanding this, the RG for Scotland stated that the official, registered mortality for the pandemic was 17,575, giving an annual death rate of 4.3 per thousand population (Registrar-General for Scotland 1919) – slightly lower than the recorded rate for England and Wales. Applying the excess methods calculations to the Scottish data produces a range of 27,650 to 33,771 deaths in Scotland – almost double the recorded mortality (Table 1). These new estimates of mortality give annualised death rates of 6.8 to 8.3 per 1,000 (158 to 193 per cent of the original figure). Consequently, the total mortality for the 1918-19 influenza pandemic in Britain would appear to be of the order of 230,000 rather than the recorded 169,021.

Tab. 1. *Estimated pandemic mortality, Scotland*

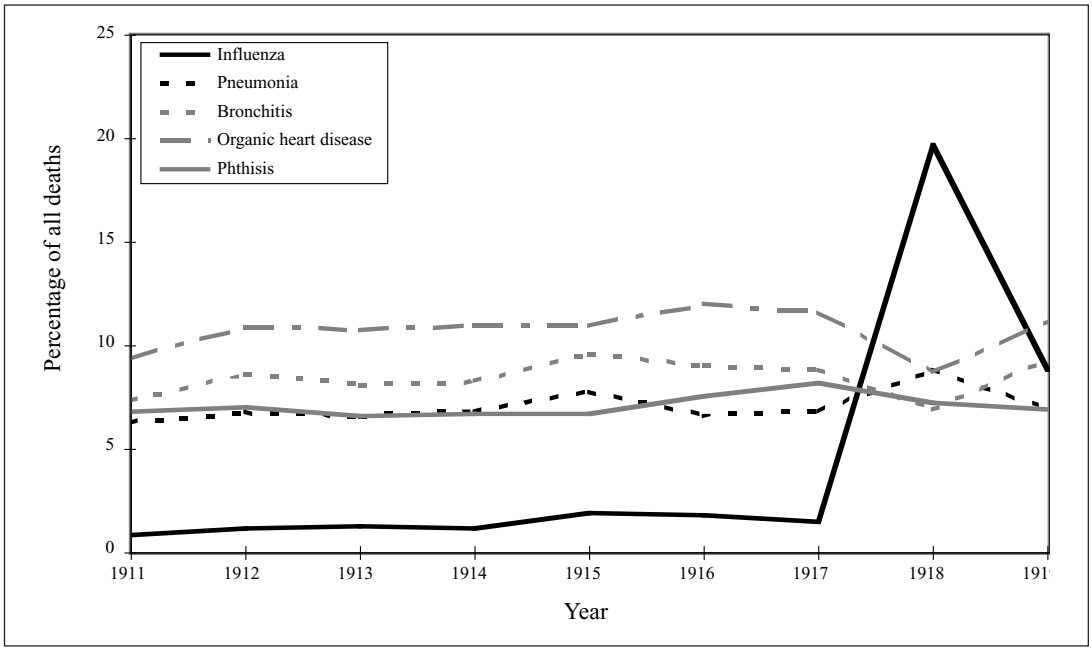
Method	Estimated total pandemic mortality
Specific causes	33,143
'Other' causes	27,650
1918 improvement	33,771

Causes. The RG selected five specific causes to include in their re-calculation of influenza mortality. One way to investigate whether these selections were justified or whether it was necessary to include all of them is by examining the relative importance of each of these causes to total mortality and by examining the age-sex

structure of the mortality caused by these specific causes. The relative importance of each specific cause of death can be demonstrated by calculating the number of deaths from these causes and total deaths for males and females in England and Wales for each year in the period 1911-1919 and determining what proportion of total mortality was caused by the specific causes. Data prior to 1911 is not easily comparable as 1911 saw changes in reporting areas and the disease definitions used.

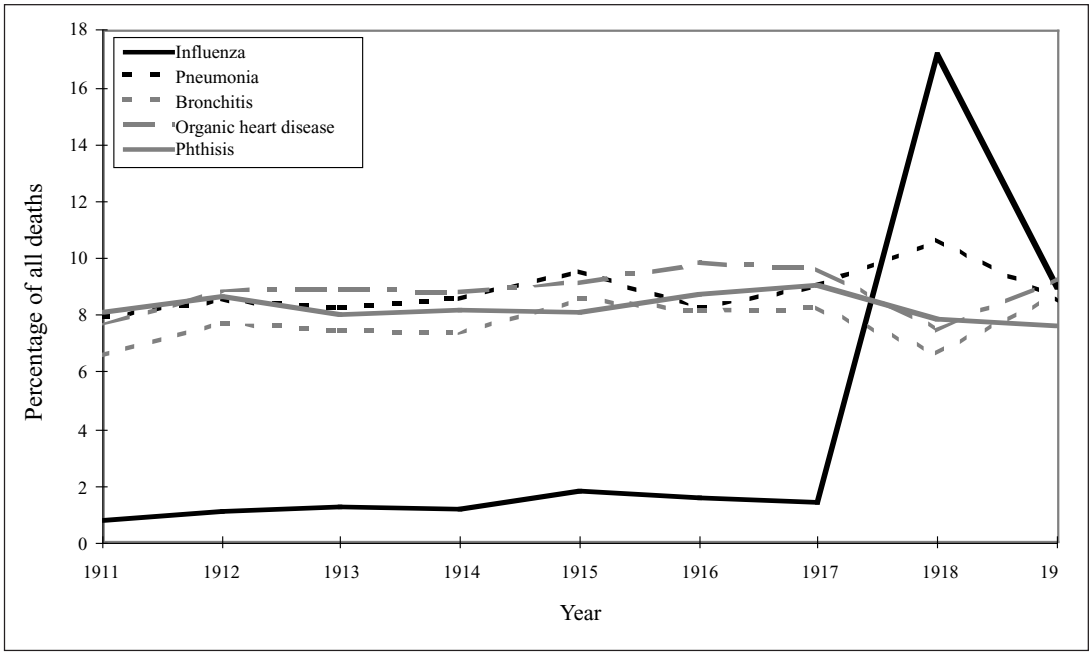
The relative importance of the five specific causes for female mortality in England & Wales is shown in Figure 6. These trends indicate how important each disease was through this period while, to some extent, removing the problem of changing populations and population structure. The female population figures are considered more reliable than those for males which were disrupted by the war. The trends for males (Figure 7) exhibit the same patterns as shown here for females. It is apparent that influenza mortality rose steeply, particularly in young adults. Bronchitis displayed similar patterns of mortality in both periods, as did phthisis with only some increases in female mortality at certain ages, notably young adults. Pneumonia claimed more lives at all age groups among both men and women, whereas organic heart disease actually showed a decrease during the pandemic period. From these two examinations of the causes it seems that deaths attributed to bronchitis and organic heart disease may not have been particularly influenced by the pandemic. A link between phthisis deaths and the influenza seems more problematic, while pneumonia deaths appear to have risen in concert with the pandemic, as expected.

Fig. 6. *Percentage of total mortality by specific causes 1911-19 in England and Wales – Females*



Data source: *Annual Report of the Registrar-General*, 1911-1919.

Fig. 7. *Percentage of total mortality by specific causes 1911-19 in England and Wales – Males*

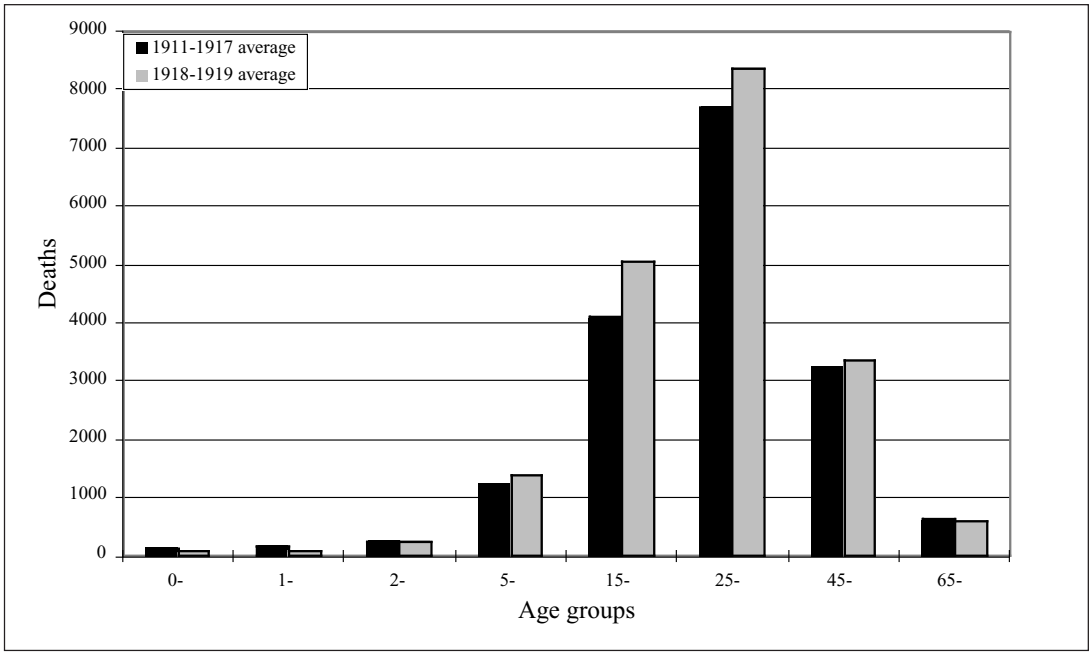


Data source: *Annual Report of the Registrar-General*, 1911-1919.

The next stage is to examine the age-sex structures for each cause to see if there were any changes in the age-sex structure of these causes of death. For all causes of death it was apparent that deaths were up in all age groups. Influenza deaths rose incredibly, especially in the young adult age groups, as we already know. Bronchitis, somewhat surprisingly, displayed similar patterns of mortality in the two periods. This contrasts somewhat with pneumonia, which saw increased mortality in 1918-19 for almost all age groups (and not just young adults). Phthisis displayed increases in female mortality in certain age groups, particularly among young adult women (Figure 8). The cause termed 'organic heart disease' saw deaths from this cause actually dropping during the pandemic period. Where those likely to have died of these cardiac causes being killed by influenza instead? From these two examinations of the causes there may be a case for removing bronchitis and organic heart disease from the further re-calculations and analyses, while pneumonia mortality was undoubtedly affected by the mortality of the pandemic. The case for removing or retaining phthisis is less obvious.

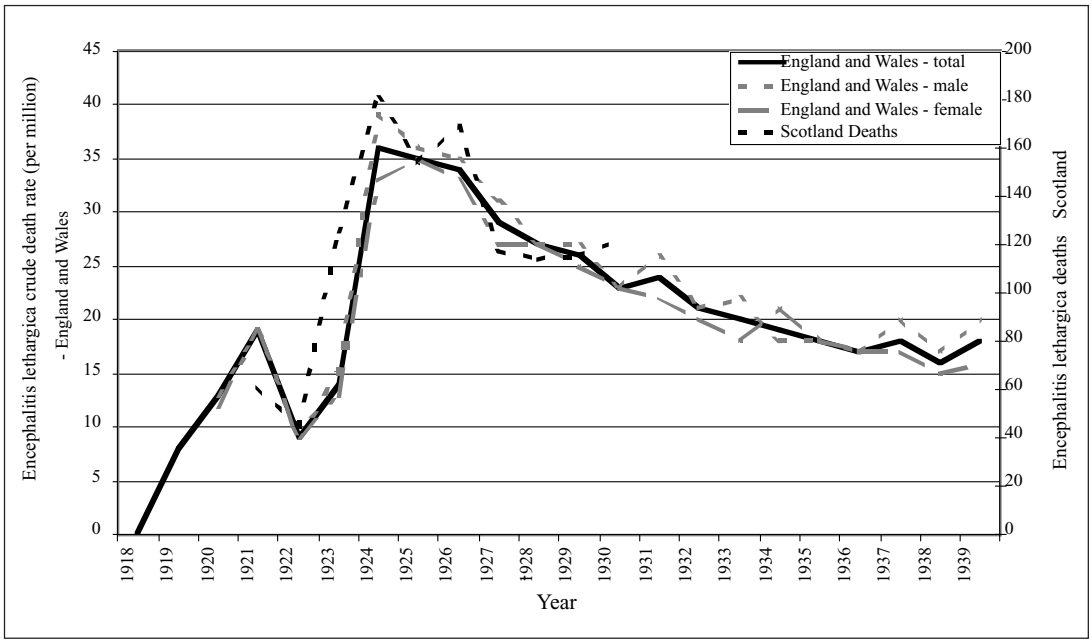
Encephalitis lethargica. There are many conditions that appear to have some connection with influenza, conditions that can be complications of or sequelæ to influenza. For the 1918 pandemic one of the most significant of these was encephalitis lethargica (Ravenholt and Foege 1982). It is interesting to note that in England and Wales encephalitis lethargica only appeared as a separate cause of death in the *Annual Reports of the Registrar-General* for the period 1920-1930. It was only after the influenza pandemic that encephalitis lethargica became apparent in significant numbers, peaking in the mid-1920s (Figure 9).

Fig. 8. *Female phthisis mortality*



Data source: *Annual Report of the Registrar-General*, 1911-1919.

Fig. 9. *Encephalitis lethargica mortality in Britain 1918-1940*



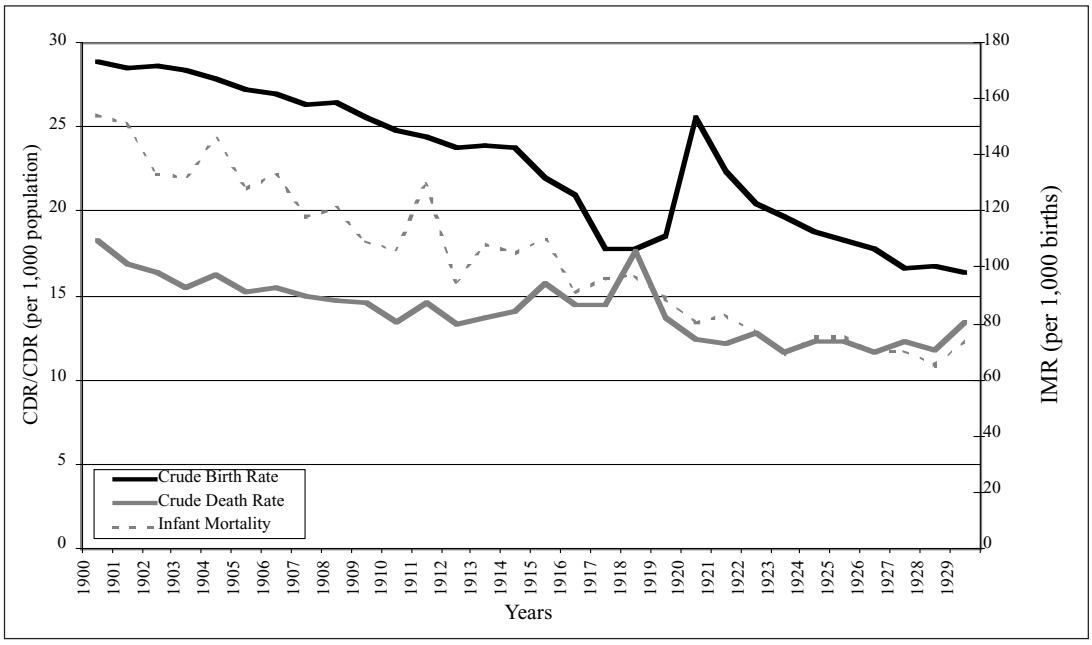
Data source: *Annual Report of the Registrar-General*, 1918-1940.

Total recorded encephalitis lethargica deaths in 1920-1930 in England and Wales were 10,673, with the annual crude death rate ranging from 0 per million (1918) to 36 per million (1924) before steadily falling during the rest of this period.

The Scottish records give another 1,203 deaths for the period with death rates ranging from 1 to 4 per 100,000 population. Thus, if one were to accept that most of these deaths were related to the pandemic they raise the British pandemic mortality to approximately 242,000.

Influenza and pregnancy. We know that influenza mortality levels can be considerably higher among pregnant women, and this is often associated with abortion, miscarriage and/or stillbirth (Kilbourne 1987). This vulnerability was recognised during the pandemic. In South Africa there was also a fall in crude birth rate noted while the crude death rate soared (Phillips 1990, 173-4). However in Britain these vital statistics seem only moderately influenced by the pandemic (Figure 10).

Fig. 10. *Vital statistics, England and Wales 1900-1930*



Data source: *Annual Report of the Registrar-General*, 1900-1930.

It is readily apparent that while the crude death rate (CDR) jumped sharply in 1918, from 14.4 per 1,000 in 1917 to 17.3 per 1,000, before dropping to 13.7 in 1919, the crude birth rate (CBR) and infant mortality rate (IMR) were less affected by the pandemic. The CBR had been in sharp decline throughout the War, stabilised in 1918 before a slight rise in 1919 preceded a marked increase in 1920. Thus the natural increase of population was diminished markedly throughout the war, and the pandemic may have both added to this and ensured it continued for some time after the end of the war. Indeed, as noted earlier, deaths exceeded births during this period and consequently natural increase briefly became natural decrease. It is plausible that the pandemic may have diminished or delayed the later upturn in CBR to an extent. Infant mortality had been trending downwards for

some time and only saw a minor reversal of this trend during 1918. Again, this may be attributable in part to the influenza.

But we have little concrete figures on the impact of pregnancy on influenza morbidity and mortality. Pregnant women contracting influenza were apparently more likely to suffer a fatal outcome if they aborted or went into premature labour. Mortality due to influenza and pneumonia amongst pregnant women who did not abort or enter premature labour was still high. The deaths of more than 2,500 pregnant women were reported in Scotland, England and Wales, and these are only those deaths where the fact of pregnancy was recorded. It is not possible to quantify the deaths of pregnant women who were not recorded as such, particularly those early in their pregnancy. These could well be a significant number, as the RG noted «it seems probable that mention of pregnancy may have been omitted in many cases where the illness [influenza] was not complicated by confinement» (Registrar-General 1920, 36). It has been speculated that influenza had a major impact on the death rate from abortion. The death rate from abortion in 1917 was apparently «one in 6,302 pregnancies» but during the pandemic «the rate works out at one death from influenza-abortion in 624 pregnancies. This rate is about ten times that of the death-rate from abortion in a normal year, and yet refers only to those cases of death from abortion plus influenza, omitting the deaths from abortion uncomplicated by influenza» (Bourne 1922, 437).

Demographic impacts. An event of such a magnitude must have had great demographic consequences. These would extend well beyond the immediate mortality penalty. They could well have included changes or delays in patterns of nuptiality and fertility, the effective loss of life years for a community or nation, and the number of children orphaned. In Britain, however, it is unlikely that it will ever be possible to determine the true extent of many of these demographic impacts. For Britain, and many other nations, it is extremely difficult, if not impossible, to separate out the demographic effects of the pandemic from those of the Great War. This is largely due to the fact that both events focus so heavily on the same segments of the population, the young adults. This population is the most heavily involved in the pandemic mortality, is the most fertile and is also that which suffered the most from the war. Further, the disruption of the population by war rendered the basic population data unreliable and may have disrupted national and local registration processes.

Notwithstanding these difficulties it is still possible to make some observations about the demographic outcomes of the pandemic. Mamelund hopes that work on the Norwegian data may start to reveal the extent of the demographic impact of the pandemic as the Norwegian data is not complicated by the war due to Norway's neutrality and vital registration was long-established there. He suggests that «if Britain is analyzed in a wider European perspective [...] analyzing European countries with sufficiently detailed data, it should be possible, in regression models, to estimate the effect of Spanish Influenza» (Mamelund 2003, 2). But such analysis is beyond the scope of the present work.

Averted births. As already noted, the deaths of more than 2,500 pregnant women from flu were recorded. These were only those deaths where pregnancy was recorded. Obviously then at least 2,500 births were foregone in Britain. It is impossible to quantify the additional deaths of pregnant women not recorded as such, but it is likely that they would not be insignificant. In addition it is likely that with such high levels of morbidity, fewer conceptions would have occurred, although the effect of this may be reversed by the effect of returning troops. But what about those pregnancies that never happened? How many conceptions, pregnancies and births that may have otherwise have been expected to occur did not take place? How many lost or averted births were there due to the deaths of women who may have borne children?

Using the concept of averted births it is possible to suggest the scale of the number of children who were not born due to the deaths of the potential mothers from influenza. Such a calculation is possible given fertility rates and the numbers of female deaths. But which fertility rate? This is difficult to say as late 1918 and early 1919 are clearly a time of transition, a point of inflexion where fertility (and birth rate) reverse the war-time decline and lead to a post-war baby boom. Given this difficulty three rates (Werner 1987, 8) were used and give a range of averted births for England and Wales of 4,357 to 5,497.

This it would appear that something in the vicinity of 5,000 births were averted due to the deaths of the potential mothers. Of course these are based on the premise that there would have been enough males present sufficient to father all these potential children. Given the mortality of the War, and the pandemic, this is not an insignificant consideration. It must be conceded that in relation to the number of live births registered in England and Wales between 1 July 1918 and 30 June 1919, some 623,740, and the RG's estimate of 750,000 pregnancies in the year (Registrar-General 1920, 36) this does not represent a major demographic impact. Indeed, it seems quite plausible these averted births were more than made up for in the surge in the birth rate in the next couple of years.

Global mortality. We have seen how the true level of mortality from the pandemic in Britain was markedly understated. Once again, this is characteristic of the pandemic in most countries. Influenza epidemics have been recognised since 412 B.C. But it is the 1918-19 influenza pandemic that is so noteworthy – an estimated 50 to 100 million died world-wide and half the world's population, some one billion people, were infected (Johnson and Mueller 2002). In many instances the case fatality rates in epidemic and pandemic times are no greater than in normal years, around 1-3%. However in 1918 morbidity was so much greater that even so that the resulting mortality was tremendous. Some countries and some peoples suffered disproportionately. Throughout the Pacific, more than 5% of the population of just about every island died. In Western Samoa 22% of the population died (30% of the adult males, 22% of the adult female population and 10% of children) (Tomkins 1992a). This is the worst (known) case for an entire nation anywhere. However in some isolated cases, e.g. Canadian Inuit, worse fatality rates were recorded with entire communities perishing (Crosby 1989).

In the 1920s, global mortality was estimated to be in the vicinity of 21.5 million. This now seems almost ludicrously low, particularly given that Indian mortality alone has been estimated at 18 million (Mills 1986). A more recent tally claimed it was in the range 24.7-39.3 million, while suggesting «a conservative total of roughly 30 million victims» (Patterson and Pyle 1991, 15). In a recent paper (Johnson and Mueller 2002) an updated account of the total mortality was offered (Table 2).

Tab. 2. *Pandemic mortality (selected locations)*

Location	Published death toll	Published death rate (per 1,000)	Re-calculated death rate
Africa			
Belgian Congo	~300,000	~50	
Cameroon	250,000		445
Egypt	138,600		10.7
Ghana (Gold Coast)	88,500-100,000	~40	43.5
Kenya	150,000	40	57.8
Nigeria	~455,000	30	24.4
Senegal	37,500	30	
South Africa	~300,000	43.97	44.3
North Africa	200,000-248,000	7.5-10	
All sub-Saharan Africa	~2,175,000	~23.1	
Africa	*~2,375,000*	*~18.2*	
Americas			
Brazil	180,000	6.00	6.8
Canada	~50,000	6.25	6.1
Caribbean	~100,000		
Chile	35,000	11.00	
USA	675,000		6.5
Total Latin America	766,000-966,000	8.4-10.6	
Total North America	725,000		
Americas	*~1,540,000*		
Asia			
Ceylon (Sri Lanka)	91,600		17.9
China	4-9.5 million		8.4-20.1
India	18.5 million		6.1
Indonesia	1.5 million		30.4
Japan	388,000	~6.7	7.0
Philippines	93,686	8.00	1.7
Taiwan	25,394		6.9
Southwest Asia	215,000-430,000	5-10	
Asia	*26-36 million*		

Europe			
Austria	20,458	3.00	3.3
Croatia	109,000		
Denmark	12,374	3.50	4.1
Eire	18,367	4.04	4.3
England & Wales	~200,000	~4.9	5.8
Finland	18,000	5.8	5.8
France	240,000	3.9	7.3
Germany	225,330	3.70	3.8
Prussia	236,662	4.5	
Iceland	484	5.4	
Italy	390,000	11.0	10.7
Netherlands	48,042		7.1
Norway	14,676	5.7	5.7
Portugal	59,000	9.7	9.8
Russia/USSR	~450,000	5.00	2.4
Scotland	27,650-33,771	6.8-8.3	5.7-6.9
Spain	257,082	12	12.3
Sweden	34,374	5.41	5.9
Switzerland	23,277	6.00	6.1
Europe	*~250,000*	*~4.8*	
Oceania			
Australia	14,528	2.8	2.7
New Zealand		<20	
Pakeha (non Maori)	6,413	5.8	
Maori	2,160	42.4	
Pacific Islands		>50	
Tonga		42-84	
Western Samoa	8,500	220	236.1
Total Oceania	*~85,000*		
	Global	*>48,798,038*	
	~50-100 million	*~2.5-5*	

Source: Johnson and Mueller (2002, 110-4).

The figures given are by no means a definitive record of the mortality brought about by the pandemic. It must be accepted that much of the mortality may not have been recorded and what figures do exist vary greatly in coverage and reliability. There are many problems with these figures, many reasons why the estimates are shown as quite large ranges. There are a number of data issues one has to keep in mind when trying to make such an enumeration. Ideally we would have figures for entire nations, for the entire pandemic period and for all deaths caused by the pandemic. Unfortunately this is not the case with the vast majority of the data. The figures shown were derived in various ways by many researchers, including re-visiting

official records, re-compiling the recorded numbers, and the calculation of 'excess' deaths. The methods available to individual researchers were often determined by the data available. These variations in method and time and population coverage can give rise to a range of estimates of mortality. These ranges show how uncertain these estimates may be, due to the lack of definitive data on populations, mortality and mortality rates and the variability within the extant data for many locations. The figures given represent the compilation of current knowledge of the pandemic.

Thus global mortality from the influenza pandemic is of the order of 50 million. However, it must be acknowledged that even this vast figure may be substantially lower than the real toll, perhaps as much as 100 percent understated. Consequently, the real pandemic mortality may fall in the range 50 to 100 million. It would seem unlikely that a truly accurate figure can ever be calculated. Notwithstanding this, the scale of mortality undoubtedly makes it one of the largest outbreaks of disease in recorded history, particularly as these deaths occurred in a relatively short time.

Who died? Influenza is widely regarded as among the most egalitarian of diseases. One attempt to examine if this was true for the pandemic was conducted by the RG. The RG's report into the 1918-19 pandemic examined the putative link between influenza mortality and both general health standards (as indicated by the average death rate for 1911-1914), and wealth (indicated by the proportion of indoor domestic servants in 1911) in the London Boroughs. The RG concluded that the «mortality of the late epidemic fell almost alike on the sanitarily just and on the unjust» (Registrar-General 1920, 29).

Another dimension examined by the British public health authorities, and also found to show little association with pandemic mortality, was overcrowding, including measurements of the number of persons per dwelling, persons per room and other aspects of poor housing. Crowding may not have been an issue as the virus was so virulent, so infective that the «necessary exposures and contacts of all persons living under urban conditions are sufficiently numerous to provide opportunities of transfer so effective that any increase above the average is relatively a factor of negligible order» (Ministry of Health 1920, 171). Such findings led Tomkins to contend that «the epidemic was remarkably democratic in its victims» (Tomkins 1992b, 446).

Occupations and mortality. In order to investigate the possible relationship between pandemic mortality and socio-economic status a database linking the demographic structure (male and female populations by age groups), the occupational structure (male and female populations by occupational categories) along with an occupational environment classification developed by the Cambridge Group for the History of Population and Social Structure (Garrett and Reid 1995, 76; Garrett *et al.* 2001) and the infant mortality for 1911 and 1918 to the annualised pandemic influenza mortality rate for 335 administrative areas in England and Wales was constructed. These data came from the Censuses of 1911 and 1921, *Annual Reports of the Registrar-General* and the RG's report (Registrar-General 1920).

Initial investigation of the 1911 and 1921 occupational data and the influenza mortality rates revealed only a small number of potentially important relationships and were the basis for selecting variables for further analysis. For the 1921 data the Cambridge Group had categorised each occupational group into one of four 'environments': agricultural, light, staple or service. All the stronger positive correlations came from either the staple or light categories, with the staple category itself being among the stronger correlations (both for the male and total populations). Furthermore, the strongest negative correlation coefficients were with occupations classified as 'service' by the Cambridge Group. The following variables were selected for further analysis:

- percentage of the working male population in occupations classified as 'staple' in 1921;
- percentage of the working male population in occupations classified as 'service' in 1921;
- percentage of the working male population in occupations classified as 'ships and boats' in 1911;
- proportion of domestic servants per 1,000 households in 1911;
- infant mortality rate (1911);
- population density from the 1921 Census.

These six variables can be said to act as indicators of factors such as social class (occupations and proportion of domestic staff), existing health conditions (IMR), crowding or risk of infection or even place in the national urban hierarchy (density) and proximity to points of entry of the disease (shipping). Placing the six variables in a linear regression analysis to test the contribution or relation to influenza mortality produced a correlation coefficient (r) of 0.5110 and a determination coefficient (r^2) of 0.2612. Thus the hypothesis that existing health standards, proximity to ports, and social class determine influenza mortality was not clearly demonstrated. However, there may be a role for these factors, they may influence the outcome to a degree.

The analysis was then re-run progressively removing the least significant variable at each stage. These suggest that the IMR and proportion of domestic servants are contributing little or are simply complementing other variables (perhaps the service and staple occupational variables) (Table 3).

Tab. 3. *Regression analysis results*

Variable removed (number of variables used)		r	r^2	Reduction in r^2
None	(6)	0.5110	0.2612	
Proportion domestic servants	(5)	0.5046	0.2546	0.0066
IMR	(4)	0.5029	0.2529	0.0017
Density	(3)	0.4620	0.2135	0.0394
Service	(2)	0.4582	0.2100	0.0035
Staple	(1)	0.3784	0.1387	0.0713

One of the few variables to exhibit a stronger association with the annualised influenza mortality rate was the proportion of the 1911 male workforce in 'Ships and boats'. It was also noted that Hebburn and Jarrow had emerged as residuals from the analysis of other variables and these two locations had the highest proportion of the male workforce in this sector. Further, in Australia it had been reported that one of the highest death rates was among those males employed in occupations classified 'Seas, Rivers, Harbours' (McCracken and Curson 2003, 124).

To investigate this further in the data from England and Wales the areas were separated into two groups, those with no male workers in the sector and those with. While in the group of areas where there were no males employed in this sector the mean and median influenza mortality are slightly lower and the maximum and first quartile also lower than in the other group (areas with male employment in this sector) the minimum, third quartile and standard deviation are all higher (Table 4).

Tab. 4. *Comparison of influenza mortality between groups*

Influenza mortality values	Male workforce in 'Ships and boats'	No male workers in 'Ships and boats'
N	277	56
Minimum	1.880	2.093
Maximum	11.943	7.548
Mean	4.892	4.675
Standard deviation	1.217	1.339
1st quartile	4.061	3.707
Median	4.726	4.679
3rd quartile	5.530	5.584

The Mann-Whitney *U*-test was then used to determine whether these two groups differed significantly or if they essentially came from the same population. The results (Table 5) indicated that at a 95% confidence level the two groups can be regarded as similar and that the presence or absence of shipping as a source of male employment did not materially influence the outcome of the influenza pandemic at the local level.

Tab. 5. *Mann-Whitney U-test results*

Description	Value
N	333
U statistic	7169.5
Expectation	7776
Normalised statistic used for test	-0.892589
Critical value (0.05 level)	-1.9600
Corresponding p-value	0.3721

So is there a socio-economic dimension to influenza mortality? While influenza mortality in the pandemic was spread across the entire community it does appear that there may be an element of class differential in this mortality, but this is not a particularly strong association. As the RG's decennial supplement claimed influenza varies «definitely, though not greatly, with social class» (Registrar-General 1921 Part II. *Occupational Mortality, Fertility, and Infant Mortality*, xvii).

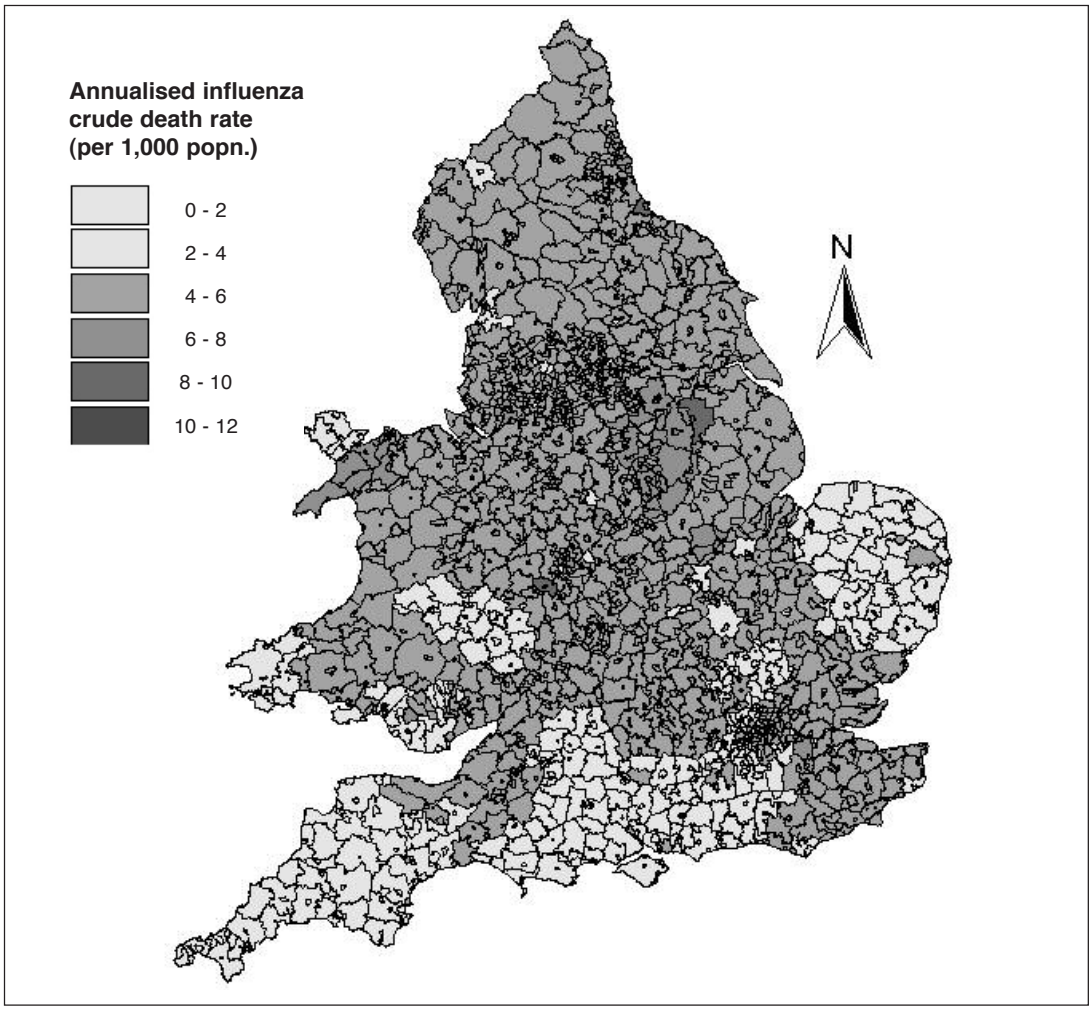
Where? Disease outbreaks are not immediate and ubiquitous; epidemic disease has to reach a population and then develop and spread. In the case of influenza, a disease of short incubation, short duration and high infectivity, however, this can happen quite rapidly. To map the patterns of such an outbreak one would ideally use morbidity data, but here we are restricted to the recorded influenza mortality. It seems reasonable to regard this as an indicator of influenza activity Fortunately, this mortality data is available at weekly intervals and for the local administrative areas for the entire pandemic period, which allowed detailed mapping of the disease in England and Wales (Johnson 2001, 318-50, Appendices B and C).

It has been claimed that the first and third waves hit hardest on the north and in larger urban areas, except London, whereas the second wave was more concentrated in the south, and that overall mortality was fairly similar in all parts of the country. However, it appears that actually the North suffered worse initially and London and the north-east coast seaports were among the earliest centres to report influenza deaths. The first wave struck the North and the Midlands more so than the South. This is also the case for the third wave. The second wave, the most severe one, struck the entire nation with its full force.

There are apparently two stages in the diffusion of pandemic or epidemic influenza. After the introduction of the disease, hierarchical diffusion acts at the national scale while contagious diffusion describes the local pattern. The transport networks are frequently implicated in the spread of infectious disease. The RG's report supports this hierarchical hypothesis by noting that «It is not that the towns suffered excessively [...] but the towns suffered first, and during the first wave of the epidemic they suffered considerably more than the rural towns» (Registrar-General 1920, 12).

The RG for England and Wales determined that, based on elevated influenza mortality, the pandemic had tormented and killed for 46 weeks in both countries, from the week ending 29 June 1918 through to 10 May 1919. Figure 11 illustrates the RG's conclusion that the «more populous centres suffered very slightly more [...] but the incidence upon town and country was very nearly equal. The northern parts of the country [...] suffered decidedly more, on the whole, than the southern» (Registrar-General 1920, 24). This figure also shows that the Midlands suffered as much as the North, and of the south if was the south west and East Anglia that escaped the worst of the pandemic. This pattern generally supports recent work that suggests that urban areas, coastal areas and areas well-served by mass communication and transport links suffered higher mortality than rural, inland and isolated areas (Mamelund 1998).

Fig. 11. *Pandemic influenza mortality in England and Wales*



Conclusion. The British authorities had reported mortality from the 1918-19 influenza in England, Wales and Scotland as being 169,021. Re-calculations of that mortality have lifted that estimate to more than 240,000. This new estimate includes the 'excess' deaths that have been re-attributed to the pandemic from a number of other causes, including encephalitis lethargica. The pandemic's impact was by no means limited to simply those extremely high levels of morbidity and rapid surges in mortality seen in the three waves of influenza in 1918 and 1919, there were also extensive and potentially long-term demographic impacts. However, with World War I also having its impact, particularly as both had their greatest impact on the same young adult population, it may be difficult to have quantify these impacts. While British mortality was greatly understated the same is true globally. For decades a figure of 20-odd million has been much repeated but is a gross understatement of a global toll of 50 to 100 million influenza victims. Whether or not there is a socio-economic dimension to influenza mortality remains unclear. However, what appears clear is that there are both hierarchical and contagious elements to the spread of influenza.

References

Australia 1920, *Official Yearbook of the Commonwealth of Australia*, Melbourne.

A.W. Bourne 1922, *Influenza: Pregnancy, Labour, the Puerperium and Diseases of Women*, in F. G. Crookshank (ed.), *Influenza: Essays by Several Authors*, William Heinemann (Medical Books) Ltd., London.

A.W. Crosby 1989, *America's forgotten pandemic: The influenza of 1918*, Cambridge University Press, Cambridge.

B. Echeverri 1998, *Spanish Influenza seen from Spain.* paper presented at *The Spanish'Flu 1918-1998: Reflections on the Influenza Pandemic of 1918 after 80 Years* conference, Cape Town, 12-15 September.

E. Garrett, A. Reid 1995, *Thinking of England and taking care: family building strategies and infant mortality in England and Wales 1891-1911*, «International Journal of Population Geography», 1, 69-102.

E. Garrett, A. Reid, K. Schurer, S. Szreter 2001, *Changing family size in England and Wales: place, class, and demography, 1891-1911*, Cambridge University Press, Cambridge.

K.F. Kiple (ed.) 1993, *The Cambridge World History of Human Disease*, Cambridge University Press, Cambridge.

N.P.A.S. Johnson 2003, *The overshadowed killer: influenza in Britain in 1918-19,* in H. Phillips, D. Killingray (eds.), *The Spanish Flu Pandemic of 1918-19: New Perspectives*, Routledge, London, 132-55.

N.P.A.S. Johnson 2001, *Aspects of the historical geography of the 1918-19 influenza pandemic in Britain*, unpublished PhD dissertation, University of Cambridge.

N.P.A.S. Johnson, J. Mueller 2002, *Updating the accounts: Global mortality of the 1918-1920 'Spanish' influenza pandemic,* «Bulletin of the History of Medicine», 76, 105-15.

E.D. Kilbourne 1987, *Influenza*, Plenum Medical Books, New York.

H. Phillips 1990, *'Black October': the Impact of the Spanish Influenza Epidemic of 1918 on South Africa*, Archives Year Book for South African History, Government Printer, Pretoria.

H. Phillips, D. Killingray (eds.) 2003, *The Spanish Flu Pandemic of 1918-19: New Perspectives*, Routledge, London.

K. McCracken, P. Curson 2003, *Flu downunder: a demographic and geographic analysis of the 1918 pandemic in Sydney, Australia*, in H. Phillips, D. Killingray (eds.), *The Spanish Flu Pandemic of 1918-19: New Perspectives*, Routledge, London, 110-31.

S.-E. Mamelund 2003, *Can the Spanish Influenza pandemic of 1918 explain the baby-boom of 1920 in neutral Norway?*, Memorandum 01/2003, Department of Economics, University of Oslo.

S.-E. Mamelund 1998, *Spanskeskyen i Norge 1918-1920: Diffusjon og demografiske konsekvenser*, unpublished Masters dissertation, University of Oslo.

I.D. Mills 1986, *The 1918-1919 Influenza Pandemic – The Indian Experience*, «Indian Economic and Social History Review», 23, 1-40.

Ministry of Health 1920, *Report on the pandemic of influenza 1918-1919*, Ministry of Health/HMSO, London.

K.D. Patterson, G.F. Pyle 1991, *The Geography and Mortality of the 1918 Influenza Pandemic*, «Bulletin of the History of Medicine», 65, 4-21.

R.T. Ravenholt, W.H. Foege 1982, *1918 Influenza, Encephalitis Lethargica, Parkinsonism*, «The Lancet», October 16, 860-64.

Registrar-General 1919, *Annual Report of the Registrar-General 1918*, Registrar-General/HMSO, London.

Registrar-General 1920, *Supplement to the Eighty-First Annual Report of the Registrar-General, Report on the mortality from influenza in England and Wales during the epidemic of 1918-19*, Registrar-General/HMSO, London.

Registrar-General 1921, *Decennial Supplement England and Wales 1921. Part II. Occupational Mortality, Fertility, and Infant Mortality*, Registrar-General/HMSO, London.

Registrar-General for Scotland 1919, *Report on the Mortality from Influenza in Scotland during the Epidemic of 1918-19: A Supplement to the Annual Reports of the Registrar-General for Scotland*, Registrar-General for Scotland/HMSO, Edinburgh.

S.M. Tomkins 1992a, *The Influenza Epidemic of 1918-19 in Western Samoa,* «Journal of Pacific History», 27, 181-97.

S.M. Tomkins 1992b, *The failure of expertise: Public health policy in Britain during the 1918-19 influenza epidemic*, «Social History of Medicine», 5, 435-54.

B. Werner 1987, *Fertility statistics from birth registrations in England and Wales, 1837-1987*, «Population Trends», 48, 4-10.

Summary

Measuring a pandemic: Mortality, demography and geography

Influenza in 1918-19 was truly pandemic, extending into all parts of the world. Not only did it have a global extent, it exhibited marked universality – universality in reach and universality in impact. Included in these universal characteristics were high levels of morbidity, elevated levels of mortality and a mortality that had its greatest impact on young adults. This paper examines some of the quantitative aspects of the mortality, demography and geography of the pandemic, particularly in the United Kingdom. It includes an estimation of the mortality caused by the pandemic, firstly in Britain and then globally. For Britain I examine the mortality in England and Wales and how the Registrar-General estimated mortality there, apply the same methods to Scotland and then refine the British estimate by examining the causes of death used in the 'excess deaths' methods, the role of the pandemic in encephalitis lethargica mortality, and the questions of pregnancy and averted births. The mortality in England and Wales is then examined in terms of socio-economic variations before a discussion of the basic geography of the mortality in Britain.

Riassunto

Misurare una pandemia: mortalità, demografia e geografia

L'influenza del 1918-19 risultò in una grave pandemia e coinvolse tutto il mondo, esibendo una chiara universalità sia nella diffusione che nell'impatto. Essa fu caratterizzata da elevati livelli di morbidità e di mortalità che, in quest'ultimo caso, colpì duramente i giovani adulti. Questo lavoro prende in esame alcuni degli aspetti quantitativi della mortalità, della demografia e della geografia della pandemia soprattutto nel Regno Unito, includendo un tentativo di stima delle morti dovute all'influenza prima in Gran Bretagna e poi globalmente. Per l'Inghilterra e il Galles si sono utilizzati i Registrar-General e si è poi esteso lo stesso metodo di stima della mortalità alla Scozia. Per la Gran Bretagna le stime sono sate raffinate esaminando le cause di decesso e utilizzando i metodi di 'excess deaths'; si sono valutati il ruolo della pandemia nella mortalità per encefalite letargica e la questione delle gravidanze e delle nascite evitate. Dopo una sintetica discussione sulla geografia della mortalità, si è passati all'esame delle sue variazioni conseguenti a modificazioni socio-economiche in Inghilterra e Galles.