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A socially neutral disease? Individual social class, household wealth and mortality from Spanish influenza in two socially contrasting parishes in Kristiania 1918–19

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Abstract

The Spanish influenza pandemic of 1918–19 was one of the most devastating diseases in history, killing perhaps as many as 50–100 million people worldwide. Much of the literature since 1918 has favored the view that mortality from Spanish influenza was class neutral. This view has prevailed, even though several contemporary surveys showed that there indeed were clear differences between the classes in disease incidence and that case fatality rates from influenza and pneumonia also varied according to socioeconomic status. Furthermore, studies of more recent influenza epidemics have also shown that there can be clear class differentials in mortality in this type of illness—is there any reason to believe that Spanish influenza was different? This paper is the first study in which individual- and household-level data which are unique for the period are utilized to test the conservative hypothesis that Spanish influenza was a socially neutral disease with respect to mortality. Through the use of Cox regressions in an analysis of two socially contrasting parishes in the Norwegian capital city of Kristiania, it is shown that apartment size as an indicator of wealth of a household, in addition to social status of place of residence, were the only socioeconomic variables that had an independent and significant effect on mortality after controlling for age, sex and marital status.

Keywords: Spanish influenza mortality 1918–19; Socioeconomic factors; Contextual effects; Norway; Event history analysis; Cox proportional hazards

Introduction

Socioeconomic differences between classes as a factor in the incidence of disease, mortality and survival have been documented for different time periods in all countries for which data exists (Feinstein, 1993; Kunst & Mackenbach, 1994). These kinds of differences have been documented for a number of causes of illness and death, including cardiovascular diseases (Vallin, Meslé, & Valkonen, 2001), several types of cancer (Kravdal, 2003), chronic obstructive pulmonary disease (Prescott & Vestbo, 1999), and mortality associated with excessive alcohol consumption (Mäkelä, Valkonen, & Martelin, 1997). There is also ample evidence that there were distinct differences between the social classes with respect to the main causes of death in historical populations, particularly for tuberculosis and cholera fatalities (e.g. Gjestland & Moen, 1988; Hansen, 1985).

This paper addresses the general question whether a social gradient is also prevalent in mortality from influenza in annual epidemics. In particular, it examines the role of socioeconomic status, both of individuals, households and neighborhoods, in explaining the

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variance in mortality associated with the Spanish influenza pandemic which may have killed 50–100 million worldwide in 1918–19 (Johnson & Mueller, 2002). Indeed, socioeconomic differentials have also been reported for influenza and pneumonia combined, not only in the risk of dying (Kitagawa & Hauser, 1968, 1973; Regidor, Calle, Navarro, & Domínguez, 2003; Singh & Siahpush, 2001), but also in the actual risk of contracting influenza (Dutton, 1988; Glezen, Paredes, & Taber, 1980). Moreover, the socioeconomic differences in mortality from influenza and pneumonia found in these studies, which include the United States in 1950, 1960 and the period 1979–89, and Spain in 1996–97, were among the greatest compared to any other cause of death. However, only a very few studies have been specifically directed towards explaining the social profile of these two causes of death. When examining the data from these relatively recent influenza epidemics, can there be any reason to doubt that the lower socioeconomic classes had a higher mortality from influenza and pneumonia than the higher classes during the pandemic in 1918?

House-to-house surveys conducted in the United States and Norway in 1918–19 showed that there were marked social differences in both the incidence and lethality from Spanish influenza (Britten, 1932; Collins, 1931; Hanssen, 1923; Sydenstricker, 1931; Vaughan, 1921), while a similar study of four cities in England found no clear relationship between incidence and/or case fatality rates and social status (Great Britain Ministry of Health, 1920). Debate has continued in the literature ever since 1918 over whether social status played any role in mortality from the 1918–19 pandemic; most studies contend that it was socially neutral. Proponents of the ‘‘socially neutral’’ view claim that Spanish influenza struck blindly and randomly because the pandemic introduced a new virus that few, if any, had the immunity to fight. They argue that Spanish influenza differed to annual epidemics in which a large part of the population has acquired immunity from exposure to previous epidemics (Brainerd & Siegler, 2003; Crosby, 2003; Rice, 1988; Stevenson, 1921; Tomkins, 1992; van Hartesveldt, 1992; Winter & Robert, 1997). A second argument commonly used to support this view is the fact that in 1918, the largest relative increase in death rates all over the world was among people between the age of 20 and 40 years as opposed to the very young and the elderly as is normally seen during annual influenza epidemics. However, many previous studies did not carry out a careful statistical investigation of the association between mortality and socioeconomic status themselves. They tended instead to rely upon anecdotal evidence from physicians of the time, using this to support the argument that Spanish influenza was a ‘‘classless’’ disease because the odds of survivability seemed to favor the most robust and previously healthy of those aged 20–40 years. The argument was made that even kings and presidents were laid low by influenza. A possible explanation for this view having prevailed in the literature may be that too little distinction has been made between the risk of being *infected* by influenza on the one hand (‘‘everybody gets it’’), and the risk of actually *dying* from influenza or pneumonia. In the first instance, the *risk of contracting the disease* may be only moderately associated with socioeconomic status, while several studies have shown that there was a strong connection between *mortality* from the disease and socioeconomic status. On the other hand, some scholars argue that like tuberculosis and cholera, Spanish influenza claimed higher death rates amongst the destitute and most poorly situated than among the wealthy and privileged (Hersch, 1920, 1932; Johnson, 2001; Mamelund, 2003b; McCracken & Curson, 2003; Sydenstricker, 1931; Zylberman, 2003). Supporters of this view admit that the virus itself may have had certain attack properties that were independent of social class. However, it would appear that there indeed were clear social differences in a person’s chance of *surviving* the disease.

Most of the previous studies on socioeconomic status and mortality from the 1918–19 pandemic have been univariate and descriptive in type. The contributions from them therefore fail to demonstrate the independent effects on Spanish influenza mortality of age, sex, socioeconomic class, crowding, ethnicity, spatial diffusion, climate, and other geographical variables. Recent exceptions to this pattern in the nature of the studies are the cross-sectional studies of the United States (Brainerd & Siegler, 2003) and England and Wales (Johnson, 2001), who, respectively, found no and only weak indications of class differentials in mortality. Studies of Sydney, Australia (McCracken & Curson, 2003), and Norway (Mamelund, 2003b) on the other hand could report a significant social gradient in mortality. However, because the associations in these studies were not estimated using individual-level data, no definitive conclusion could be drawn as to whether or not there were any causal links between these variables.

This paper is the first to apply Cox proportional hazard models combined with ‘‘state of the art’’ data for the period on the level of individuals, households, and parish, to contest the conservative assumption that Spanish influenza was a socially neutral disease with respect to mortality. No earlier study on the subject has ever included data on different levels of aggregation in the same model to search for the causes of variation in Spanish influenza mortality. The paper uses mortality and census data from two intentionally selected socially contrasting parishes in the Norwegian capital of Kristiania (renamed Oslo in 1924), namely Frogner and Grønland-Wexels. The nominal censuses for 1918 and 1919 used here allow a very close follow-up of individuals from the start of the pandemic in the early spring of 1918 through to the end of it in the winter of 1919. Finally, registration of deaths and the carrying out of the censuses were on the whole undisturbed by the First World War, as Norway was a neutral country. Such data are seldom available for the belligerent countries. Existing data from such countries are usually unreliable because of gaps in registration and because it is difficult to separate deaths from the pandemic from direct or indirect deaths caused by the war.

Data

Parishes

There are two reasons for limiting the analysis to the two parishes of Frogner and Grønland-Wexels, which are comparable in size and tally together 41,000 individuals or 16 per cent of a total population in Kristiania of 260,000 on 1 February 1918 (Wexels was merged with Grønland in 1919). First, significant differences in all-cause mortality as well as cause-specific mortality have already been shown to exist between the traditionally poor, high-mortality parishes to the east of the city and the wealthy, low-mortality parishes to the west since the 1880s. Hence, Grønland-Wexels (east) and Frogner (west) both constitute typical examples worthy of study (e.g. Arctander, 1928; Barstad, 1997; Gjestland & Moen, 1988; Rognerud & Stensvold, 1998). The Kristiania of 1918 was a divided city, with large east–west differences with respect to income, education, and employment. The east–west differences could also be seen in the stature and weight of individuals as a proxy of disease and nutritional history, standard of housing, sanitation, hygiene, household crowding, crime, the number of social security recipients, and child welfare cases (e.g. Arctander, 1928; Geirsvold, 1917; Kjeldstadli, 1990; Kristiania Statistiske kontor, 1920; Schiøtz, 1920; Statistisk sentralbyrå, 1955).

The extreme social polarization between the east and the west sides of the city began when the industrial elite moved to their summer homes on the west side of the city and started to live in them year round in the 1860s. This was probably a reaction to increasing inner-city pollution and the desire to live further away from the shabby and overcrowded industrial working class suburbs (Myhre, 1990). In 1918, most of the wealthy bourgeois and middle class in Kristiania therefore lived in the western parishes, while the relatively poor working class constituted the majority in the eastern parishes of the city. However, Grønland-Wexels had a substantial middle-class, and Frogner was actually relatively heterogeneous with a substantial working class population of maid servants, private chauffeurs and porters who lived in the homes of the wealthy (see Table 2). In 1901, the only year for which income data are available by parish relatively close to the study period, the average income per person after deductions for Frogner residents was more than six times that of residents in Grønland (Kristiania Statistiske kontor, 1900, p. 143). The two well-defined and well-known socially contrasting parishes of Frogner and Grønland-Wexels are intentionally selected to ensure that there is sufficient variance in socioeconomic status within the parameters of the study to be able to document socioeconomic differences in Spanish influenza mortality, if these exist, at the level of individuals, households and/or the parish. A second reason for selecting only two parishes for this study is simply because digitization of the census data for the entire city of Kristiania with its 19 parishes would have been too costly and time-consuming.

Study population

The data on the study population for Frogner and Grønland-Wexels are taken from the two nominal censuses of Kristiania made on the night of 31 January to 1 February 1918 and 1919 (Oslo City Archive). The total number of observations is close to 47,000 (Table 1). Only *de jure* residents are considered, but the study population also includes individuals who were permanently resident or working in hostels or institutions. Examples of institutions included in the study are a prison, a Red Cross nursing home, a boarding school for deaf pupils, and some rest homes for the elderly. For details on reliability of census data, completeness of record linkage, and assumptions on exposure time for people who moved frequently, in particular maid servants, see a previous version of this paper (Mamelund, 2004).

Dependent variable

In the analysis, the exposure to mortality risk starts on 1 February 1918. Right censoring is caused by deaths from causes other than those associated with Spanish influenza, when an individual moves out of the parishes in question, and at the cutoff date of 1 February 1919. The nominal data on deaths are from the unpublished report Anmeldte døde i Oslo 1918–1921 (Oslo City Archive). Of the 608 all-cause deaths in Frogner and Grønland-Wexels during the intercensal year of 1918–19, 250 deaths are here linked with the Spanish influenza pandemic, of which 81 and 169 deaths occurred among *de jure* residents in Frogner and Grønland-Wexels, respectively (see distribution of the deaths by independent variables in Table 4). Fatal cases of the disease usually occurred when influenza was followed by bacterial complications such as

Table 1
The study population in the parishes of Frogner and Grønland-Wexels combined from 1 February 1918 to 1 February 1919

Individuals followed			
From	To	Cases	Per cent
02.01.1918	02.01.1919	34,127	72.7
02.01.1918 or intercensal date of birth	Date of death	608	1.3
02.01.1918	Date of moving out of parish	6087	13.0
Date of moving into parish	02.01.1919	5591	11.9
Date of intercensal birth	02.01.1919	559	1.1
Number of observations		46,972	100.0

Source: Oslo City Archive, Censuses of 1918 and 1919 for the parishes of Frogner and Grønland-Wexels, and Anmeldte døde i Oslo 1918–21.

bronchopneumonia and lobar pneumonia, or by viral or combined viral and bacterial pneumonia. Of the 250 deaths, two-thirds were caused by influenza and pneumonia while the rest were deaths caused by other frequently reported complications (stated as secondary cause of death on the death certificates) following influenza (stated as primary cause of death on the death certificates). Examples of such complications included for example emphysema, pleuritis, lung embolus, acute diarrhea, tetanus, nephritis, and cardiac failures (e.g. myocarditis or pericarditis), or other diseases that were symptomatically difficult to distinguish from influenza and/or pneumonia and that might be labeled ''acute catarrhs in the respiratory organs'', acute bronchitis and diphtheria, bronchial asthma, or chronic bronchitis. It should be pointed out that the data used here are not controlled for the fact that some of the 250 deaths considered also would have occurred during a normal epidemic influenza season (see Mamelund, 1998). The information given on the death certificates, including cause and date of death, name, age, sex, and occupation, was very reliable and generally in accordance with similar information given for persons identified in the 1918 census (Mamelund, 2004).

Independent variables

The data for the independent variables included in the analysis are taken from the 1918 and 1919 censuses for Frogner and Grønland-Wexels described above. Descriptive statistics appear in Table 2.

Individual-level variables

Age for each individual is defined as the person's exact age on 1 February 1919. In the analysis, 13 age categories are considered, and have been chosen to reflect the W-shaped age pattern of Spanish influenza death rates observed all over the world (Great Britain Ministry of Health, 1920). The categorical age groups were chosen after a model with a continuous age distribution of death risks was inspected. A relatively large age interval, 5–24 years, was selected as a reference for the age effects in the analysis. This was done for two reasons: first, it was selected because the reference category should not be biased because of too few deaths included, and second, because the mortality for any given 5-year age group within the 5–24 year interval did not differ significantly from one another.

Five marital status groups are included in the analysis to control for the assumed protective and selective effect of marriage on mortality: never married, married, widow/widower, separated, and divorced. Three individual-level, occupation-based social classes are also defined. The *bourgeois* include capitalists, estate owners, shipping, large-scale retail, whole salesmen, chief executives, chief editors, clergy, high-ranking military officers, professors, doctors, dentists, attorneys, architects, leading authors, actors, and artists, pharmacists, Supreme Court judges, engineers, ambassadors, consuls, senior government officials, Members of Parliament, and directors of banking, finance, insurance and so on. Examples of professions considered as belonging to the *middle class* are teachers, nurses, clerical officers, police inspectors and constables, customs officers, office-clerks in the postal services, telegraph messengers, librarians, port authorities, vergers, sorters, poor-relief assistants, the self-employed in small-scale retail, craft, and industry, those with a craft master certificate, and finally, pensioners. The *working class* includes foremen and workers in the cottage industries, industrial factories, quarrying industries, shipbuilding, sawmills and construction work, transportation, cleaning and janitorial services, cashiers and shop assistants, seamen, fishermen, porters, and household staff and servants. Included in this category are also some of the poorest individuals in society, namely private and national social security recipients, a handful of prisoners, certain foster children, the disabled, the mentally ill and the physically

Table 2
Distribution for the independent variables

Independent variables	Both parishes		Frogner		Grønland-Wexels	
	Count	Per cent	Count	Per cent	Count	Per cent
Individual-level variabels						
Age						
0–1	1314	2.8	486	2.2	828	3.3
2–4	1868	4.0	690	3.2	1178	4.7
5–24	16,679	35.5	7308	33.5	9371	37.3
25–29	5681	12.1	2885	13.2	2796	11.1
30–34	4091	8.7	2113	9.6	1978	7.9
35–39	3207	6.8	1691	7.7	1516	6.0
40–44	3119	6.6	1576	7.2	1543	6.1
45–49	2432	5.2	1213	5.5	1219	4.9
50–54	2192	4.7	1062	4.9	1130	4.5
55–59	1800	3.8	799	3.7	1001	4.0
60–69	2772	5.9	1184	5.4	1587	6.3
70–79	1406	3.0	646	3.0	760	3.0
80+	411	0.9	191	0.9	220	0.9
Sex						
Male	20,977	44.7	7874	36.0	13,103	52.1
Female	25,995	55.3	13,971	64.0	12,024	47.9
Marital status						
Never married	30,221	64.3	14,722	67.4	15,499	61.7
Married	13,495	28.7	5781	26.5	7714	30.7
Widow/widower	2772	5.9	1158	5.3	1614	6.4
Separated	336	0.7	54	0.2	282	1.1
Divorced	148	0.3	130	0.6	18	0.1
Social class						
Bourgeois	8937	19.0	7939	36.4	998	4.0
Middle class	10,595	22.6	6035	27.6	4560	18.1
Working class	25,749	54.8	6966	31.9	18,783	74.8
Occupation not stated	1691	3.6	905	4.1	786	3.1
Household-level variable						
Size of apartment*						
One room	9101	19.4	3328	15.2	5773	23.0
Two rooms	7205	15.3	672	3.1	6533	26.0
Three rooms	10,154	21.6	1529	7.0	8625	34.3
Four rooms	4654	10.0	2204	10.1	2450	9.8
Five rooms	4504	9.6	3334	15.3	1170	4.7
Six rooms	4875	10.4	4558	20.9	317	1.2
Seven rooms	2792	6.0	2663	12.2	129	0.5
Eight rooms+	3687	7.9	3557	16.2	130	0.5
Parish						
Number of observations	46,972	100.0	21,845	100.0	25,127	100.0

All variables are dummy variables which take the value 0 or 1.
*1 room = 1 room, no kitchen; 2 rooms = 1 room and kitchen; 3 rooms = 2 rooms and kitchen, etc.
Source: Oslo City Archive, Censuses of 1918 and 1919 for the parishes of Frogner and Grønland-Wexels.

handicapped. However, this heterogenic group constitutes only a little more than one per cent of the working class.

All individuals are assigned their own scores for social class except for two special cases. Children under 18 years of age who have not yet entered the labor force and who do not have employment (including students and 20–22 year old conscripts with no stated occupation) are assumed to belong to the same occupational social class as the head of the household, typically their father. Secondly, housewives are placed in the same social class as their husbands. A retired person falls in the social class of his or her former employment, if stated.

The three occupation-based social classes are assumed to encompass differentials in income and education which in their turn may have differential effects on health and mortality. Although a relatively large heterogeneity may appear within each class with respect to both income and/or education (e.g. the academic vs. industrialist bourgeois elite), it may be seen that social class as defined here is a reasonably good proxy for these two indices of wealth. The income of an average white-collar clerical officer before the First World War, for example, was double the average income of a factory worker, while a principal officer, here considered part of the bourgeois, earned a salary at least five times that of a factory worker (calculations from Kristiania Statistiske kontor, 1910, pp. 114–15). Although there was some redistribution of income during the First World War, the overall result was greater social differences between the newly rich and old money on the one hand, and the poor on the other hand. The top five per cent and the bottom third had, respectively, 60 and 5 per cent of the total income in 1918–19, while comparable figures in 1909–13 were 35–40 and 10 per cent (calculations from Kristiania Statistiske kontor, 1910–1919).

Household-level variable

One covariate at the household level is defined. This is the size of the apartment in which each household lived in terms of number of rooms. Approximately 95 per cent of all apartments in Kristiania in 1918 were rented (Kjeldstadli, 1990). Apartment size appears to be perfectly correlated with rent: the larger the apartment, the higher the rent (see Tables 3 and 4). Further, it may thus be assumed that size of apartments is a proxy, though an imperfect one, for household income. Although one had to be among the wealthiest to afford the rent of an apartment with six, seven or eight rooms and more (see Tables 3 and 4), the possibility cannot be ruled out that some of the wealthiest persons may have preferred to live in smaller apartments, for example of four or five rooms. Nevertheless, size of apartment is probably a more direct and crisper proxy for income than the occupation-based social classes defined above. Furthermore, the size of each apartment/room in square meters is not known. For example, a sample survey from 1914 of the two- to three-room apartments (one to two rooms including kitchen) indicated that apartments were 23 per cent larger in Frogner than in Grønland (Kristiania Statistiske kontor, 1915). Size of an apartment will therefore not give information on the expected higher rent and income of people residing in Frogner compared to Grønland-Wexels. The same survey found no difference between Frogner and Grønland-Wexels in the proportion of the apartments considered to be unhealthy, namely dark, damp and shabby. This was partly explained by the fact that Frogner had a much higher proportion of apartments located in basements than Grønland-Wexels (8.6 vs. 0.8 per cent).

There are several reasons why income and education (which is assumed to be picked by social class and size of apartments) may be important determinants of mortality. First, as most food in Kristiania had to be bought in stores, nutritional status is dependent on the level of income. Undernourishment does not increase the individual's susceptibility to viral infections such as influenza (Scrimshaw, Taylor, & Gordon, 1959). On the other hand, malnutrition associated with a low intake of nitrogen results in a definite impairment of immune response and a corresponding increase in susceptibility to bacterial diseases (Fox, Hall, & Elveback, 1970). Consequently, whether its victims were undernourished or not played no role as to where the Spanish influenza struck. However, bacterial complications following Spanish influenza, for instance pneumonia, are believed to have taken a greater toll among those who were malnourished. Food expenses increased markedly during the First World War because of increasing shortages and rationing. Some groups, in particular those dependent on public assistance—the disabled, widows, abandoned wives with children, the old and the sick—may have experienced additional problems associated with malnutrition. However, the daily calorie intake of the working class and among low-paid clerical officers in Kristiania appeared not to decline during the years 1914–17, because food that was less expensive, more abundant in supply and equally nutritious replaced the more expensive food stuffs that were in short supply (SSB, 1917, 1918a, 1919, 1920). Nevertheless, after a number of food articles were rationed in the beginning of 1918, the calorie intake for craftsmen hard at work (e.g. carpenters, warehousemen) may have been at subsistence level and possibly only marginal for maintaining body functions and the ability to work. Second, the presumably higher nutritional standard of the more affluent may also have bolstered their immune systems, better enabling them to fight disease, for instance tuberculosis. The risk of a fatal outcome was greater for Spanish influenza patients suffering from active lung tuberculosis or for Spanish influenza patients who had reduced lung capacity after having suffered a non-tubercular lung disease (e.g. chronic bronchitis, bronchial asthma, emphysema, and cystic fibrosis) (Noymer & Garenne, 2000). It was also reported that Spanish influenza activated latent tuberculosis, which in turn may have led to higher mortality. Generally speaking, those with impaired or damaged cardiovascular (e.g. rheumatic heart disease) and/or respiratory systems are the most prone to succumbing to pneumonic complications following influenza. Third, the affluent and the highly educated classes probably had better chances of taking time off from work to convalesce when ill than

Table 3
Influenza and pneumonia mortality (SMR) and indices of deprivation and wealth for 19 parishes in Kristiania 1918–24

Parish	SMR 1918–1919	Adult poor relief recipients 1919–1923 per 1000 adults 1 December 1920	Child welfare cases 1918–1924 per 1000 children 1 December 1920	Number of adults fined 1920–1924 per 1000 adults 1 December 1920	Male adults in custody 1919, 1921, and 1923 per 1000 adult men 1 December 1920	Percentage of pupils aged 7–15 that were underweight[a] March 1920	Average number of persons per room[b] (in 1918)	Average monthly rent (in 1918 NOK) for a flat with kitchen and		Proportion of households 1 February 1918 with		
								One room	Six rooms	Maids	Bathroom	Electricity
City centre												
Vor Frelser	96.6	3.3	49	68.7	42.1	12.2	1.4	17.8	128.1	23.2	21.0	72.5
Johannes	92.8	2.9	74	55.6	44.2	14.8	1.5	17.7	112.3	14.6	12.5	75.9
Trefoldighet	116.0	3.3	41	43.1	36.1	12.2	1.5	18.4	106.2	15.2	9.0	70.9
Jacob	90.1	5.5	65	65.9	38.7	12.2	2.1	18.1	98.5	5.4	1.7	80.1
West												
Frogner	74.9**	0.4	9	7.8	9.6	2.9	1.0	20.0	138.3	48.8	67.2	97.0
Uranienborg	81.2*	1.1	20	16.9	12.6	7.0	1.1	19.9	127.4	39.3	42.0	95.0
Fagerborg	82.2*	1.2	16	15.2	18.3	7.9	1.5	16.3	114.4	26.8	30.9	89.7
Gamle Aker	102.3	2.3	25	23.5	16.4	10.8	1.5	19.2	118.5	16.4	21.2	92.3
Markus	111.1	1.1	16	16.9	13.9	10.9	1.5	21.4	102.9	16.2	22.0	95.8
North-east												
Sagene	108.5	11.5	49	66.1	49.2	13.6	3.1	19.3	56.8	2.3	2.9	78.9
Lilleborg	109.2	9.3	39	52.7	40.3	15.0	2.8	18.1	100.0	3.1	0.7	81.0
Paulus	88.4	6.2	32	54.9	27.7	12.4	2.4	19.5	84.5	2.5	0.1	76.0
Hauges	88.1	4.2	39	52.7	29.7	—	2.0	18.9	99.6	4.6	1.0	76.4
Petrus	132.9***	12.9	58	96.2	54.3	13.6	2.9	17.2	60.0	3.0	0.1	62.0
Mathæus	88.2	6.9	29	50.7	52.2	—	2.3	19.6	85.8	3.2	1.9	71.0
South-east												
Grønland-Wexels	124.4**	8.0	54	105.6	62.6	14.4	2.5	17.7	84.7	3.1	0.9	62.7
Kampen	100.5	8.2	40	94.8	50.5	14.5	2.8	18.0	89.4	2.6	1.7	77.6
Oslo	109.2	4.3	44	53.6	30.7	12.4	1.9	20.9	91.8	7.3	1.5	75.5
Vaalerengen	116.7	5.1	39	86.4	46.0	14.0	2.5	17.6	86.5	3.2	0.8	79.3
Correlations with SMR	1.00	0.51**	0.53**	0.65**	0.72***	0.68**	0.53**	−0.21	−0.59**	−0.53**	−0.52**	−0.62**

$*p<0.10$, $**p<0.05$, $***p<0.01$.

Source: Parish-specific deaths from influenza and pneumonia by age and sex, parish-specific population by age and sex, and standard population by age and sex for the city as a whole. These figures are used to calculate the standardized mortality ratios, and are taken from Kristiania sundhetskommision (1919,1920) and Kristiania Statistiske kontor (1920), respectively. The data on crowding, proportion of households with maids, bathroom and electricity are from Kristiania Statistiske kontor (1920). The data on weight are from Schiøtz, (1920), while the data on crime, poor-relief recipients, and child welfare cases are from Arctander (1928).

[a]The survey was carried out in March 1920, and included 30,000 children in public schools located all over the city as well as private schools which were essentially located in the western parishes of Frogner, Uranienborg and Fagerborg. The figures for underweight youth are corrected for a somewhat different distribution of age and sex across each school (by Schiøtz, (1920)). It should be noted that the schools included in the survey do not recruit pupils exclusively according to the parish borders.

[b]Exclusive kitchen.

Table 4
Results of Cox proportional hazard models for Spanish influenza mortality ($N = 250$ deaths) in the parishes of Frogner and Grønland-Wexels combined in 1918

Independent variables	Deaths	Model 1		Model 2		Model 3	
		e^{coeff}	t-stat	e^{coeff}	t-stat	e^{coeff}	t-stat
Individual-level variables							
Age							
0–1	28	11.58***	9.70	11.55***	9.65	11.43***	9.61
2–4	13	2.95***	3.34	2.95***	3.33	2.93***	3.31
5–24 (ref)	31	1.00	—	1.00	—	1.00	—
25–29	28	2.57***	3.68	2.53***	3.60	2.59***	3.68
30–34	25	3.00***	4.00	2.89***	3.84	2.99***	3.96
35–39	15	2.21**	2.42	2.12**	2.29	2.19**	2.39
40–44	13	1.88*	1.82	1.80*	1.69	1.85*	1.78
45–49	11	2.01**	1.90	1.91*	1.75	1.97*	1.84
50–54	8	1.64	1.20	1.59	1.12	1.64	1.19
55–59	8	1.96**	1.63	1.85*	1.48	1.88*	1.53
60–69	21	3.30***	3.87	3.11***	3.67	3.18***	3.73
70–79	28	9.00***	7.40	8.25***	7.09	8.43***	7.16
80+	16	19.65***	8.58	16.50***	8.02	16.49***	8.03
Sex							
Female (ref)	119	1.00	—			1.00	—
Male	131	1.48***	2.79	1.41***	2.63	1.36**	2.33
Marital status							
Never married (ref)	134	1.00	—	1.00	—	1.00	—
Married	82	1.01	0.07	1.08	0.41	1.04	0.24
Widow/widower	32	0.95	−0.19	0.97	−0.10	0.94	−0.24
Separated	1	0.51	−0.66	0.52	−0.65	0.48	−0.73
Divorced	1	1.48	0.39	1.53	0.42	1.69	0.52
Social class							
Working class (ref)	152	1.00	—	1.00	—	1.00	—
Middle class	43	0.69**	−2.17	0.75	−1.62	0.81	−1.18
Bourgeois	38	0.61***	−2.69	0.64**	−2.06	0.75	−1.26
Occupation not stated	17	1.16	0.56	1.21	0.71	1.28	0.89
Household-level variable							
Size of apartment (average monthly rent in 1918 NOK in parenthesis)							
One room (11.7 NOK) (ref)	73			1.00	—	1.00	—
Two rooms (18.5 NOK)	49			0.70*	−1.87	0.67**	−2.09
Three rooms (30.1 NOK)	53			0.61***	−2.67	0.59***	−2.89
Four rooms (42.4 NOK)	15			0.42***	−3.04	0.44***	−2.85
Five rooms (62.3 NOK)	18			0.55**	−2.19	0.63*	−1.66
Six rooms (80.9 NOK)	11			0.36***	−3.04	0.45**	−2.31
Seven rooms (101.0 NOK)	18			1.00	−0.01	1.22	0.67
Eight rooms+ (8 rooms; 135.5 NOK)	13			0.47**	−2.16	0.58	−1.48
Parish							
Frogner (ref)	81					1.00	—
Grønland-Wexels	169					1.49**	2.05

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

the poor, as they may have had more saved capital to live on. A high proportion of the wealthy probably also had the resources to invest in and benefit from private health insurance. The wealthy would therefore have been able to take to their beds when ill, and would probably have convalesced long enough to avoid pneumonia and other bacterial complications carrying higher fatality risks than influenza. Persons with higher education were probably also more likely to retain and follow up the instructions from municipal health authorities than those of less education.

Parish-level variable

The study only includes a dummy variable (0/1) to control for place of residence. It is assumed that residence in Grønland-Wexels may have a significant and conducive effect on individual mortality relative to those residing in Frogner because of unmeasured characteristics of material deprivation, including dilapidated housing, poor sanitation, and pollution in Grønland-Wexels. This effect may remain even when controlling for individual social class and household-wealth.

Method of analysis

The analysis consists of two parts. The first part is descriptive, and examines the correlation between mortality from Spanish influenza and indices of deprivation and wealth in the city of Kristiania as a whole, with special focus on the contrast between Grønland-Wexels and Frogner. In the second part of the analysis, the effects of the covariates described above upon those surviving Spanish influenza are estimated using Cox proportional hazards models. The hazard rate for the individual i with n covariates, $X = (X_1, X_2, \ldots, X_n)$, is modeled as

$$h_i(t) = h_0(t)\,e^{\{\beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n\}},$$

where t is time elapsed from 1 February 1918 ($t = 0$) to death from Spanish influenza and where the baseline hazard $h_0(t)$ is a hazard function for an individual who scores zero on all n covariates. Kaplan–Meier estimators were calculated for all covariates included in the models. No serious deviations from the proportionality assumption were found over the time period studied.

Results

Descriptive analysis of the whole capital city of Kristiania

The first cases of influenza associated with Spanish influenza in Norway were reported in the first week of April 1918. However, the first scattered cases of influenza in Kristiania, which later proved to be the smoldering of a pandemic *wave*, occurred on 15 June 1918 (Mamelund, 1998). It was not until the first half of July that the reported disease incidences of influenza began to skyrocket, taking the dimensions of a pandemic wave. Fig. 1 clearly shows a second outbreak of Spanish influenza in 1918, whereby peaks in the crude death rate and the influenza death rate occurred both in mid-July and at the end of October. Furthermore, when comparing the weekly crude death rates in 1918 with the average monthly crude death rates of the non-pandemic years of 1915–17 (which may be considered a norm for mortality levels), it may be seen that the excess in all-cause mortality is explained by an increase in influenza mortality. Note also that the peak in mortality during the summer wave and the fall wave occurred 1–2 weeks after the respective peaks in disease incidence. Unfortunately, weekly disease and mortality figures for 1919 are not available.

Table 3 shows that there were clear east–west differences in Spanish influenza mortality in Kristiania. In Grønland-Wexels and Petrus, mortality was significantly higher than the average for the whole city, while the mortality in Uranienborg, Fagerborg, and in particular Frogner, was significantly lower than the average for the whole city. Mortality in Grønland-Wexels was 50 per cent higher than in Frogner. The east–west differences may also be seen for several indices of deprivation and wealth (Table 3). As for mortality, Frogner is ranked last on all indices for deprivation, but first on all measures for wealth, while the opposite is generally true for Grønland-Wexels. The differences in the indicators between the two parishes are all statistically significant at a very low level. The bivariate correlations between the SMRs and the socioeconomic characteristics for the 19 parishes are moderately strong, but follow the expected directions. All are significant at the 0.05 level, except for monthly average rent for a flat with one room and kitchen. It should be remembered that the associations between the SMRs and the indices of deprivation measured in the years immediately following 1918 must be considered with caution because the deprivation may be a consequence of the influenza pandemic and not the other way around. However, the regional differences in these indices of poverty are considered to be relatively stable, and are probably also good proxies for several years prior to 1918 (Arctander, 1928).

Of particular interest is the finding that the negative correlation between the SMRs and average rent of apartments increases with size (results only shown for apartments of, respectively, one and six rooms, see Table 3). This indicates that mortality differences between those who only could afford to rent small apartments in the two parishes are smaller than for those who could afford to rent large apartments. Furthermore, it is also an intriguing finding that the difference in the average rent of an apartment of the same size between Frogner and Grønland-Wexels increases in a linear fashion with size (not shown); it was found that apartments with one room including kitchen or six rooms including kitchen were, respectively, 1.1 and 1.7 times more expensive in Frogner than in Grønland-Wexels. This result may

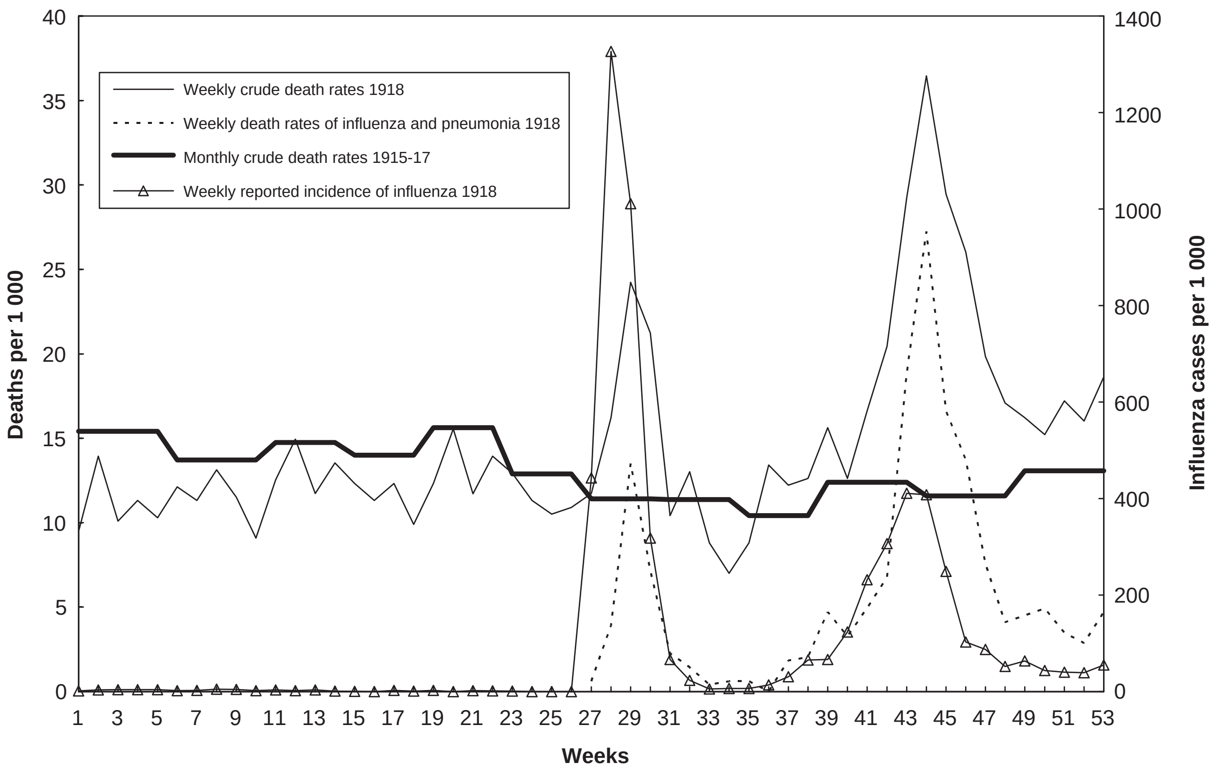

Fig. 1. Weekly crude death rates, incidence rates and death rates from influenza in 1918, and monthly average crude death rates for the years 1915–17 in Kristiania. *Sources*: Kristiania Sundhetskommision, 1919; Mamelund, 2003a.

indicate that people were willing to pay more for apartments, especially the larger ones located in a highly privileged parish with a good reputation (e.g. less crime) than for accommodation located in a socially deprived area with a bad reputation. However, the differences in the rent between the two parishes may be explained in part by the fact that apartments, at least those with two to three rooms, were larger in Frogner than in Grønland (Kristiania Statistiske kontor, 1915).

Multivariate analysis of Grønland-Wexels and Frogner combined

According to model 1, the mortality from Spanish influenza was, respectively, 39 and 31 per cent lower among individuals belonging to the bourgeois and the middle class than among individuals in the working class, net of the effect of age, sex, and marital status (Table 4). The effect is highly significant in statistical terms and seems to contest the commonly held assumption that mortality from Spanish influenza was class neutral. The mortality among the bourgeois was 11.6 per cent lower than among the middle class, but the difference was far from being statistically significant at the 0.10 level.

The mortality premium of individuals belonging to the two upper classes relative to the lowest class remains statistically significant only for the bourgeois when apartment size, a proxy for household income, is included in the analysis in model 2. Anyway, as might be expected, the mortality in the two upper classes was still much lower than in the working class, respectively, by 25 per cent in the middle class and 36 per cent in the bourgeois (Table 4). Mortality was gradually falling for individuals living in apartments with up to six rooms compared to those residing in one-room apartments. The nearly perfect linear decline is broken only by those residing in five-room apartments. The drop in mortality from one apartment size category to the next for apartments with two to six rooms in model 2 is not statistically significant at the 0.10 level, but seems nevertheless to coincide with theory. However, those who lived in six-room apartments had significantly lower mortality than those living in apartments with up to two rooms. Of all apartment size categories, only those residing in apartments with seven rooms did not demonstrate significantly different mortality from those living in one-room apartments.

When a control for residence in either Frogner or Grønland-Wexels is included in model 3 while individual-level and household-level variables are simultaneously accounted for, it is found that the negative effect on mortality of belonging to the bourgeoisie is no longer statistically significant (Table 4). Nevertheless, the mortality in the two most advantageous classes is still, respectively, 19 (middle class) and 25 per cent (bourgeois) lower compared to the working class. This finding thus remains inconsistent with the conservative and dominant class neutrality hypothesis. However, the gradually dropping mortality by apartment size remains statistically significant, the exceptions being the two largest apartment size categories.

In model 3, it was estimated that Spanish influenza mortality was 49 per cent higher in the deprived parish of Grønland-Wexels than in the privileged parish of Frogner, all other factors being the same. (Note that the difference in mortality between the parishes in the multivariate analysis is comparable to that found in the descriptive analysis.) This would suggest that there are unobserved and unaccounted factors at the parish level that affected Spanish influenza mortality above and beyond the characteristics of individuals and households. Alternatively, the parish of residence picks up individual- or household-level variations due to omitted or poorly specified variables already included in the models.

Surprisingly, there are no significant effects of marital status on mortality. However, when estimating model 3 in Table 4 for all-cause mortality (608 deaths) rather than for Spanish influenza mortality (250 deaths), it appeared that married persons had 20 per cent lower mortality than the reference group of never married (significant at 0.10 level). The W-shaped effects of age and sex on mortality are shown as expected in all models net of the effect of other variables. There was a higher risk of mortality for infants, young adults and the elderly, and the risk of mortality was higher for males than females. Only infants and individuals 70 years and older had significantly and substantially higher mortality than individuals 30–34 years of age. There was a continuous decline in mortality from one 5 year age group to the next for ages 30–34 to 50–54, but the mortality risk of the 50–54 year age group was not statistically different from those in the high-risk age group of 30–34 years. Although half of the genetic material of the Spanish influenza virus has been discovered in the last couple of years, it is still not understood why the death rate in young adults from Spanish influenza was relatively large compared to a normal epidemic influenza season (Oxford et al., 2005).

In model 3, it was found that the mortality among men from Spanish influenza was 35 per cent higher than the mortality among women when all other factors were the same. There are usually little or no discernable male–female influenza mortality differences during a normal epidemic influenza season, but in 1918–19, the influenza mortality for males in the age group 20–40 increased far more than for females in many countries, as was observed for example in the United States, Norway, and New Zealand (Crosby, 2003; Mamelund, 1998; Rice, 1988). Noymer and Garenne (2000) have convincingly argued that the differences between the sexes in mortality rates from Spanish influenza might be due to the higher disease incidence of tuberculosis in men than in women. In this paper, interactions of age and sex are not included in the models because such interactions are not thought to affect—or add to the understanding—of the variables of focus in this study, namely social class and wealth. Moreover, the models with only main effects presented here may already be at the limit of being methodologically sound because of the low number of events (deaths) available, and a further separation of the independent variables would probably have made the estimated coefficients unreliable and difficult to interpret.

Discussion

Effects of individual social class and household wealth on mortality

One of the main findings in this analysis is that mortality from Spanish influenza was 19–25 per cent lower among the two upper classes compared to the working class when all other factors were the same (model 3). This relationship between mortality and social class was not statistically significant, but nevertheless in accordance with the hypothesis. Furthermore, when using apartment size as a proxy for household income, it was found that size of apartment had a negative effect on mortality. This relationship is statistically significant and partly linear, all other factors being the same. For example, it was estimated that those living in apartments with two, three and four rooms had, respectively, 34, 41 and 56 per cent lower mortality than those residing in a one-room apartment.

It is not surprising that the largest relative effects on mortality of any of the covariates included in the models are found for infants, young adults and persons older than age 70. However, it is interesting to note that the relative mortality risk for persons 30–34 years of age (experienced a three times greater risk of mortality than the reference category), a population group that normally has little to fear from influenza, was much greater than the largest relative mortality risk for any apartment size category (households residing in apartments with four and six rooms experienced 0.55–0.56 times lower risks than the reference category). Nevertheless, the results of this paper seem to contest the commonly held view that the Spanish influenza pandemic was a socially neutral disease with respect to mortality. It also challenges the premise that the social mortality profile from Spanish influenza was any different than that of a number of other causes of death, including mortality in more recent influenza epidemics (Kitagawa & Hauser, 1968, 1973; Regidor et al., 2003; Singh & Siahpush, 2001). More specifically, the socioeconomic differences in mortality reported in this paper are consistent with several other modern and historical studies of general as well as cause-specific mortality in Kristiania by class, wealth and parish (e.g. Barstad, 1997; Geirsvold, 1917; Gjestland & Moen, 1988; Hansen, 1985; Rognerud & Stensvold, 1998). The findings are also consistent with the cross-sectional and multivariate studies of Spanish influenza by McCracken and Curson (2003), Mamelund (2003b) and Johnson (2001) for, respectively, the city of Sydney, Australia, for Norway, and for England and Wales; however, they do not concur with the findings of a similar study by Brainerd and Siegler (2003) for the United States. Likewise, the results also concur with the contemporary house-to-house influenza surveys conducted for cities in the United States and Bergen, Norway, in 1918 (Britten, 1932; Collins, 1931; Hanssen, 1923; Sydenstricker, 1931; Vaughan, 1921), although not with a study of certain English cities (Great Britain Ministry of Health, 1920).

How large are the class and wealth differentials in Spanish influenza mortality found in this paper compared to other studies? Unfortunately, there are no other studies of Spanish influenza which have used individual-level data and multivariate models to estimate the effects of class or social factors on mortality. However, there are a couple of studies of more recent influenza *epidemics* who have used comparable data and methods. The socioeconomic indices (direct measures of education and income) used in these studies are not directly comparable to the ones used here (social class as proxy for individual-level income and education, and size of apartment as proxy for income levels of households), but a comparison of the size of the effects of these measures on mortality is nevertheless worth doing. For example, Kitagawa and Hauser (1968) in their study of mortality from combined influenza and pneumonia in the United States in 1960 have found that male and female (white) mortality amongst those with less than 8 years of schooling was, respectively, 1.6 and 1.7 times that of those with one or more years at college. Another study by the same authors documents that the mortality of men from low-income families in Chicago in 1950 was twice that of men from high-income families (Kitagawa & Hauser, 1973). Singh and Siahpush (2001) have found similar negative effects of education and income on mortality for the United States in the period between 1979 and 1989, but these effects were only statistically significant for men; the combined influenza and pneumonia mortality of those with 8 or fewer years of schooling was 1.4 times that of those with 16 or more years of education, while the mortality of low-income families was 2.7 times that of high-income families. In a study of Madrid, Spain, in the time period 1996–97, Regidor et al. (2003) demonstrated that a reduction in education of one year caused a 3.7 per cent increase in mortality among men and 3.4 per cent among women. The average Spanish influenza mortality of those living in four- to six-room apartments in Kristiania in 1918–19 was 50 per cent lower than that of those living in one-room apartments, i.e. a relative effect not very different from that for education in the United States 1960 and 1979–89, but much lower than the relative income effect on mortality in Chicago 1950 and the United States 1979–89. When it is assumed that mortality risks in model 3 in the present paper are a linear function of size of apartments, a reduction of size of an apartment with one room caused an increase in mortality by 7 per cent, i.e. an effect twice as large as that found for education in the Madrid study.

How important, in epidemiological terms, are the socioeconomic differences in the combined influenza and pneumonia mortality demonstrated in the present and previous studies? In other words, how large are the socioeconomic differences in influenza and pneumonia mortality compared to corresponding differences for other causes of death? Kitagawa and Hauser (1973) showed that influenza and pneumonia were the two causes of death that showed the greatest socioeconomic differences in Chicago in 1950, surpassed only by tuberculosis, while Singh and Siahpush (2001) found that only mortality from stomach cancer and homicides displayed larger socioeconomic differences than influenza and pneumonia combined. Estimations of socioeconomic mortality differences for other causes of death in 1918, in particular tuberculosis, would probably be distorted because many individuals who died in that year would normally have died from other causes than Spanish influenza (see Noymer & Garenne, 2000).

There are a number of interesting interactions that were not modeled in the present paper due to the rather limited number of events (deaths) available. Among them is the interaction between age and sex. In the models that were estimated, it was indirectly assumed that households that resided in apartments of equal size were equally wealthy across the two parishes studied, and that the different classes were similarly homogeneous. However, in the descriptive analysis it was for example found that for apartments of equal size, households in Frogner paid more in monthly rent than those in Grønland, and that this difference increased with the size of the apartment. A control for such differences would have been made if interactions between parish and apartment size had been included in the models; nevertheless the even more important questions would have remained unanswered, namely what is the household income and the percentage of income spent on rent?

Explaining the contextual effects on mortality

Another important finding of the analysis is that the population residing in one of the most deprived parishes in the Norwegian capital in 1918, Grønland-Wexels, experienced a 49 per cent higher mortality from Spanish influenza than the population living in the chiefly wealthiest parish of Frogner, even after controlling for individual occupation-based social class and apartment size. How may this contextual effect be explained?

The contextual effect may be of two types. The first is *group means* for individual-level variables, e.g., average income, wealth or the level of education of the individuals residing in an area. The second type is commonly referred to as being *global,* for example geographical characteristics confined to an area. Global effects include such factors as climate, pollution, reputation of an area, quality of housing, the location of a hospital or medical resources, in general, aspects that cannot be summed up from individual-level characteristics. In this paper, contextual effects are picked up in a rather simple way through the use of a dummy variable. Simply substituting the dummy variable with one of the deprivation or wealth indices seen in Table 3 would of course not give sufficient variation to explain why location of residence should have an independent effect on individual mortality. Ideally, some global or group mean variable at a level lower than the parish, e.g., a locally based definition of neighborhoods, or administrative units like census tracts, wards, blocks or streets, should therefore have been included in the analysis. In principle, it would have been possible to sum up occupation-based social class or other social factors for a given unit from the individual-level data used in the analysis, but this approach was not pursued due to the limited number of events (deaths) available. Instead, the analysis relies on official statistics on socioeconomic characteristics and the local history and sociology of the two parishes in question. Other studies not related to Spanish influenza that have analyzed a few well-defined and intentionally selected socially contrasting neighborhoods have also been extremely useful in assessing the role of individual and contextual effects on individual mortality.

Effects of group means?

Concentrated poverty in Grønland-Wexels. There are several multilevel studies which have found no or only weak effects of area of residence on mortality when controlling for individual-level socioeconomic indices, while other studies have demonstrated a strong effect on mortality of living in socially deprived areas (Pickett & Pearl, 2001). A classic example of the latter is a study of a federally designated "poverty area" in the city of Oakland, California (Haan, Kaplam, & Camacho, 1987), while a more recent example is a study of Renfrew/Paisley, the most deprived area in Scotland (Davey Smith, Hart, Watt, Hole, & Hawthorne, 1998). The Haan et al. (1987) study is particularly interesting because the authors found no significant effect of individual socioeconomic indices on mortality while the poverty area dummy variable was highly significant. The suggested explanation was that the residents in the poverty area were exposed to higher crime rates, poorer housing, lack of transportation, and higher levels of environmental contaminants. The results of the Haan et al. (1987) study, including analyses of specific causes of death, have also been replicated for several other metropolitan poverty areas in the United States (Waitzman & Smith, 1998).

The extreme social polarization between Grønland-Wexels and Frogner had prevailed for more than half a century by 1918. Thus, there seems to be good reasons to believe that the dummy variable for parish picks up some of these well-known but unaccounted and strongly significant differences in wealth and poverty (see Table 3). Moreover, not only official deprivation statistics, but also qualitative research shows that Grønland-Wexels could have been defined a "poverty area" as in Haan et al. (1987), with certain apartment blocks ("gråbeinsgårder") and streets demonstrating concentrated poverty (Kjeldstadli, 1990, p. 71). In a quantitative and qualitative study of the spatial differences in poverty and mortality in Kristiania, Arctander (1928, p. 143) concluded that living in these pockets of extreme poverty for a long period of time had an independent and deteriorating effect on physical and mental health above and beyond the individual's own social status. Arctander (1928) also made a statistical comparison of the deprivation status of different streets within each parish and combined it with statements from various local child welfare clerks and poor-relief assistants. A deprivation score was calculated combining the disease incidence of tuberculosis, proportion of adult poor-relief recipients, child welfare cases, and crime rates, but unfortunately, these scores were not published by identifiable street names. Arctander (1928) found that the most disadvantageous streets created a suburban belt, including a large part of Grønland-Wexels, which embedded the city center. This pre-industrial area was originally built outside the city, but as the city sprawled, it was left as a belt with slums encircling the city center (Kjeldstadli, 1990, p. 62). No disadvantageous streets were found in Frogner. Unfortunately, Arctander (1928) did not classify the streets according to indices of wealth.

Concentrated affluence: is there a health culture in Frogner? Lagasse, Humblet, Lenaerts, Godin, and Moens (1990) have disputed the finding that an area may impose low mortality on its resident individuals net of the effect of individual socioeconomic factors, arguing that this may be more the result of a "health culture" among wealthy and highly educated people residing in this area. Several studies have documented that social differences exist in the ability to make self-diagnosis and the ability to understand and to retain general knowledge about health care, and that such differences may result in class differences in disease incidence and mortality (Feinstein, 1993; Townsend & Davidson, 1982). Furthermore, while becoming aware of health information is important, there may also be differences between the socioeconomic classes in their awareness of the importance of also following through on the instructions issued by health authorities or physicians.

The health authorities in Kristiania basically limited their activities to surveillance of cleanliness and sanitation in the city throughout the Spanish influenza pandemic, and to give precautionary health advice (Kristiania Sundhetskommision, 1919). In mid-October 1918, the health authorities issued an advisory urging people not to voluntarily expose themselves to infection, especially those who were not infected during the relatively mild summer wave and had thereby not gained relative immunity. In addition, people were urged to wash their hands and to refrain from the bad habit of spitting, to cover their mouth when coughing or sneezing, to go to bed as early as possible after the onset of influenza symptoms, and to remain in bed until they were free of fever. This information was printed in the newspapers and on posters in public places, but probably fewer of the less well educated and thus more of the bourgeois and the middle class than working class became aware of the importance of the messages. It may therefore be possible that individuals living in Frogner had relatively low mortality because they lived in an area where a majority of the *neighbors* belonged to the industrialist or cultural elite who are assumed to be highly conscious of health matters. People living in Frogner would therefore run a relatively low risk of being infected by colleagues at work, neighbors or family members because they would have taken to their beds early after the onset of influenza symptoms, and because they stayed in bed until free of symptoms (unfortunately, morbidity data to test this hypothesis is not available).

Global effects?

Location of working class employment. It has previously been reported that Spanish influenza in Norway first started in congested industrial areas, spreading most rapidly within the working class population (Mamelund, 1998). Several of the factories that offered employment to the working class in Kristiania were located along the Aker River in the eastern parishes of the city. Because a large part of the working class in Grønland-Wexels probably both lived and worked in the same community, and worked at factories and industries where they encountered numerous workers from neighboring parishes, the influenza may have spread faster here than among the elite who lived in Frogner. These people worked either downtown where most of the offices of private firms where located, or in public offices which were scattered all over the city. Furthermore, most everyday interactions, for instance grocery shopping, or a visit to some city office, took place within the parish of residence, or at least, respectively, within the eastern or western side of the city (Kjeldstadli, 1990).

Location of hospitals and medical resources. There were no effective vaccines or antiviral drugs in 1918 to combat Spanish influenza. Doctors and nurses were therefore more or less helpless, and patients who were hospitalized and who received care from professional health practitioners did not appear to have any lower mortality than those who were nursed by their families at home. Indeed, on the contrary, quiet nursing at home may have been the key to survival. Hospitalization may in fact have worsened the condition of a patient due to transmission and spreading of bacteria such as pneumococcus within the wards (Oxford, Sefton, Jackson, Johnson, & Daniels, 1999). The argument that the affluent could afford better (private) health care and medicine than the poor may thus not be the most relevant for explaining the differences in Spanish influenza mortality.

Location of dilapidated housing. The *quality* of housing may have played a role in the risk of developing and dying from influenza. This study did not include indicators of the socio-environmental risk factors associated with dilapidated housing. Reference has already been made of a survey from 1914 showing that there was no difference between Frogner and Grønland-Wexels in the proportion of the two- to three-room apartments considered to be unhealthy (Kristiania Statistiske kontor, 1915). Little is known about the relative conditions of apartments with three or more rooms. However, because of increasing shortage of housing during the 1914–18 war (only 0.1 per cent of the apartments were on average vacant), an increasing number of families, probably more in Grønland-Wexels than in Frogner, were forced to live in cold and damp basements, draughty attic stories, garden pavilions and hen houses, in conditions not normally permitted for human habitation by the city government (SSB, 1955). Low-income groups probably also lacked sufficient heating, despite their access to discount stamps on coal (SSB, 1918b). In addition to poor ventilation, hygiene and sanitation, all of the conditions mentioned above may be associated with respiratory symptoms, reduced lung function, and lower socioeconomic status (Prescott & Vestbo, 1999). Some of the effect of parish on individual mortality may therefore be explained by the fact that the dummy variable picks up unaccounted spatial differences in the quality of housing.

Unspecified confounders?

In the analysis it was found that individual occupation-based social class had a weak and non-significant effect on mortality net of the effect of a seemingly strong effect of place of residence. A reason for this may also be that the dummy variable for parish picks up unobserved and unaccounted variation at the individual level. This is because occupational social class may not have been modeled with enough theoretical crispness with respect to education and income. The dummy variable for parish may also pick up unobserved and unaccounted variations at the household level. The reason that households residing in apartments of seven or more rooms did not display significantly lower mortality than households residing in one-room apartments may be that size of apartment is only a proxy for household income. In other words, if direct information on income and education had been available and included in the models, instead of proxies for these two indices of wealth, the seemingly positive effect of residency in Grønland-Wexels on mortality may have disappeared.

Omitted confounders?

A further reason that place of residence seems to play an important role in explaining the variation in mortality may be that it picks up individual-level variation due to omitted confounders. Anthropometric measures as proxies of nutritional history and information on pre-existing diseases which are associated with a higher susceptibility to influenza are examples of omitted individual-level variables that probably could have added further insight into the variation of mortality (although some of these aspects may be accounted for by occupation-based social class or size of apartment). Unfortunately, such information is not available in the current database. The relatively high bivariate correlation found between the percentage of the pupils that were underweight in the different parishes in Kristiania in 1920 and mortality from Spanish influenza in 1918–19 (see Table 3), lends support to the hypothesis that poor nutrition leads to higher mortality. Furthermore, Echeverri (2003) and Mamelund (2003b) have found significant negative associations between the average height of conscripts and influenza death rates in, respectively, Spain and Norway in 1918–19 using cross-sectional data. Geirsvold (1917) reported that mortality from tuberculosis was three times higher in Grønland (2.9 deaths per 1000) than in Frogner (0.8 deaths per 1000) during the First World War. Arctander (1928) also reported similar differences between the same parishes. Actual work experience—including work load, type of work (manual/non manual), working conditions, whether a worker does shifts, works overtime, and how many hours are worked per day—is a final example of omitted and unaccounted information not included in this study (although some of these aspects may be accounted for by occupation-based social class). It may be reasonable to believe that many years of heavy manual and physical labor, at least 10 h a day possibly combined with poor and overcrowded working conditions, might have damaged or impaired the general health of the working class relative to that of the bourgeois and the middle class.

Conclusion

Debate has continued in the literature ever since 1918 over whether there were socioeconomic differences in mortality from the 1918–19 pandemic, with massive support for the view that it was socially neutral. Cox proportional hazard models and unique data at the level of individuals and households combined with a control for place of residence are used for the very first time in this paper to ascertain whether there were differences in mortality from Spanish influenza with respect to individual occupation-based social class and household wealth in two socially contrasting parishes in the Norwegian capital of Kristiania (renamed Oslo in 1924) in 1918.

The analysis showed that mortality for the two upper classes was 19–25 per cent lower compared to the working class (not significant) and that the mortality of those living in apartments with four to six rooms were on average 50 per cent lower than those residing in one-room apartments (significant). The analysis also showed that when individual social class and household-level wealth is accounted for, simply living in a ‘‘poverty area’’ has a significant effect in explaining the variance in Spanish influenza mortality. Those living in one of the most impoverished parishes in the city, Grønland-Wexels, had 49 per cent higher mortality than those residing in the Norwegian capital’s most privileged parish of Frogner. The finding may have two explanations: first, the parish of residence may pick up income, wealth and educational differences imperfectly captured by social class and size of apartments, or alternatively, parish may pick up other omitted and unaccounted social and/or epidemiological risk factors. Second, the effect of parish may also be explained by unmeasured characteristics of material deprivation, including dilapidated housing, poor sanitation and pollution in the ‘‘impoverished area’’. Furthermore, because the wealthy understood the importance of remaining in bed until free of symptoms, and indeed, were also in the economic position to do so, they had a greater chance of avoiding pneumonia which often followed severe cases of influenza.

The findings in this paper challenge the conservative view that Spanish influenza was an ''egalitarian'' or classless disease whose victims were struck randomly in terms of mortality from the disease. In addition to the four most peculiar and well-documented features of the Spanish influenza, its high death toll, with 50–100 million deaths worldwide, the relatively high overall lethality, its proclivity to affect males, and the fact that the highest relative increase in the death rates was experienced by those between the age of 20 and 40, another prominent, but perhaps *non-peculiar* feature of the disease in Kristiania, and possibly also in other locations, was the significantly lower mortality of the wealthy residing in large apartments, and the higher mortality in the impoverished parish of Grønland-Wexels compared to the wealthy parish of Frogner.

The findings in this study are important for two reasons. First, the socioeconomic differences in mortality from Spanish influenza in Kristiania are comparable to later studies in which it was found that mortality from influenza and pneumonia in annual epidemics demonstrates some of the largest socioeconomic differences of all causes of death. Second, the results from the present study are of international relevance because unique individual and household-level data have been used to make the analysis. This type of data is difficult to obtain for other countries; furthermore, because Norway was neutral and as a whole not affected by the war, it was therefore possible to estimate an effect of the Spanish influenza on mortality net of the effect of the war. However, in future studies it would be desirable to have an even larger sample to work with to ensure not only large variation in the independent variables, but also more variation in the dependent variable, namely the number of deaths.

The World Health Organization and leading experts on influenza agree that another influenza pandemic is inevitable and possibly imminent. A new pandemic may arise if avian influenza not only develops ability to jump directly from birds to humans, as has been reported to have occurred in Southeast Asia several times since 1997, but also goes trough a genetic transformation such that the virus that causes the disease can easily jump from human to human. The worst case scenario is a pandemic like Spanish influenza. Because relatively large social differences in mortality from Spanish influenza as well as later influenza epidemics have been documented, it is tempting to predict significant socioeconomic differences in mortality risks when the next influenza pandemic comes.

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