Northern Ireland Statistics & Research agency

Chapter 2
Seasonality of Mortality in Northern Ireland

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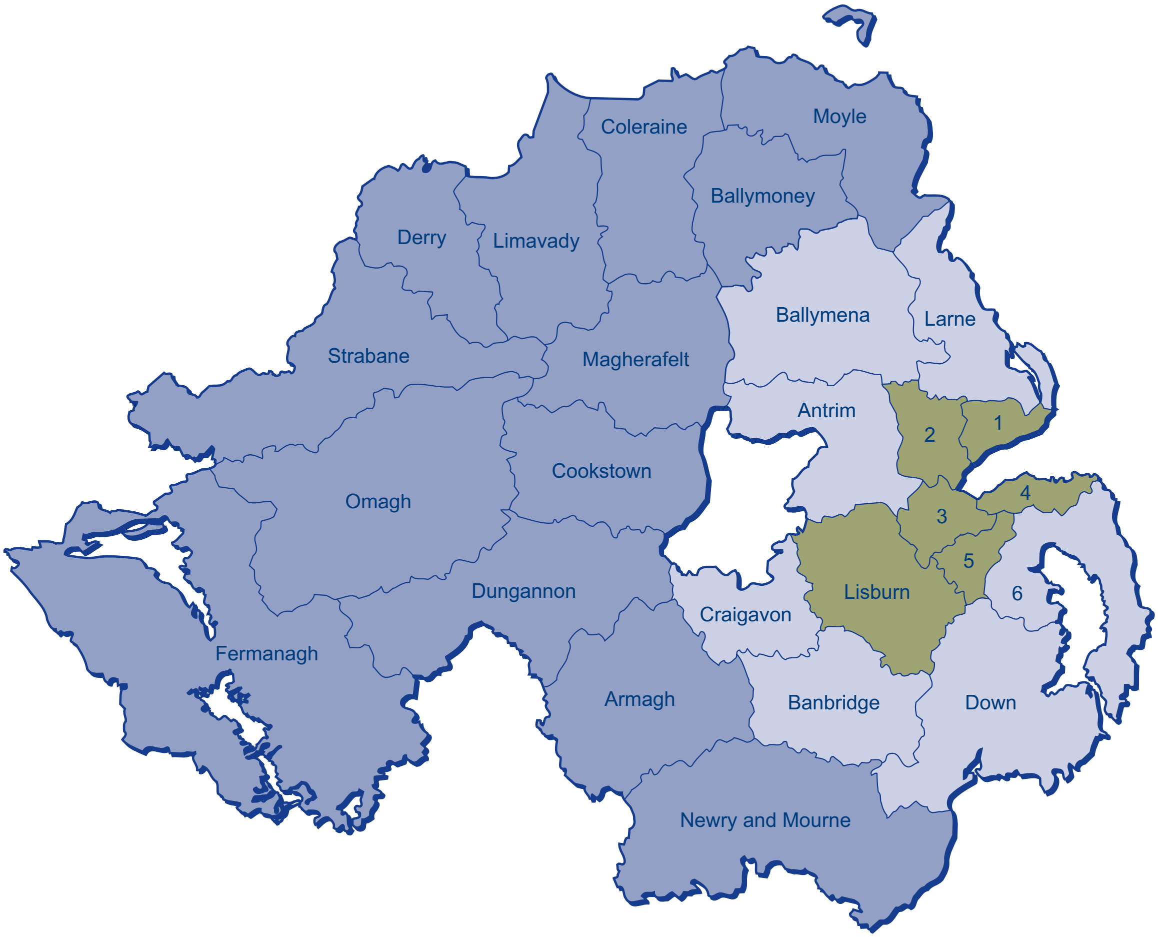
Northern Ireland Regional Areas and Local Government Districts

Belfast Area
East of Northern Ireland
West of Northern Ireland



1. Carrickfergus
2. Newtownabbey
3. Belfast
4. North Down
5. Castlereagh
6. Ards

2.1 Introduction[1]

2.1.1. The number of deaths occurring shows variation over time, with peaks and troughs being recorded within each year. These may be long term trends or apparently random fluctuations, but many are periodic in nature, with the peaks and troughs occurring in a regular cycle. The duration of the cycle may be a day, a week or longer, and it reflects a periodicity in the factors governing death.

2.1.2. The population's exposure to some agent of death may periodically change, for example, the daily and weekly cycles of traffic flow increase and decrease the risk of a road traffic accident. It may also be the case that the vulnerability of the population may vary over time, for example, in agrarian societies with limited access to imported food, food becomes increasingly scarce through the year, leaving the population most debilitated just before harvest.

2.1.3. Comparatively long cycles within a year are often described as 'seasonal'. The fact of seasonal variation in illness and in the number of deaths occurring was known to classical Greek historians and doctors. There is a range of causes for such seasonal variation. Summer epidemics of infectious diseases were common before and during the 19th century, with evidence of summer mortality peaks being found into the early 20th century (Carson et al, 2006). In 1929, 19 per cent of deaths in Northern Ireland were caused by infectious diseases (NISRA, 2010, p50). However even in the 1840s William Farr commented on the excess of deaths in winter over summer (GRO England, 1841, p102-109). From the late 19th Century, summer epidemics were on the wane, and attention turned to excess winter deaths which have a variety of causes including low temperature, high air pollution and winter epidemics of diseases such as influenza.

2.2 Death Registration

2.2.1. Understanding of seasonality and its causes may also be affected by the way data is analysed. As an example mortality statistics are typically presented based on the date on which a death was registered, rather than the date on which it occurred. This is commonly done in order to have access to speedily available, definitive data. This approach does however have limitations. Most deaths are registered within the year of their occurrence, but eight per cent of deaths are delayed in their registration beyond this period (NISRA, 2010, p25). There are a variety of reasons for this, including the closure of offices at holiday periods and the need for post-mortems or further investigations and procedures in the case of sudden or unexpected deaths. Deaths due to certain causes (for example, circulatory diseases and in particular external causes) are more likely than others to be affected by the need for certification by the coroner (see Table 2.1).

Table 2.1: Registered deaths by cause of death and type of death certificate (percentages), 2010

	Cause of Death				
Type of Death Certificate	**Circulatory Disease (I00-I99)**	**Respiratory Disease (J00-J99)**	**External Causes (V01-Y98)**	**All Other Causes**	**Total**
Coroners	*32%*	*12%*	*99%*	*11%*	*22%*
Medical certificate	*68%*	*88%*	*1%*	*89%*	*78%*
Total	*100%*	*100%*	*100%*	*100%*	*100%*
Number	**4,476**	**1,886**	**840**	**7,255**	**14,457**

[1] Detailed data tables to accompany this report are available from the CD attached to this report or from the NISRA website

2.2.2. Holiday-linked delays are most marked at Christmas/New Year, Easter and, in Northern Ireland specifically, the twelfth of July holiday period. The effect on statistics for shorter periods, such as months and seasons, is likely to be proportionately more marked.

2.2.3. In order to understand the nature of information on cause of death, it is necessary to understand the way in which registration information is obtained. In the United Kingdom (UK) recording of death is a statutory obligation and most death certificates are completed by doctors (the rest by coroners) according to a standardised World Health Organisation protocol. The medical certificate records the conditions that lead directly to death, with the one that started the morbid train of events (the underlying cause of death) entered last in Part One. The medical certificate also shows conditions that contributed to, but did not directly cause death. These conditions are then coded according to the current International Classification of Disease (ICD).

2.2.4. Clearly considerable variation in what is recorded can occur dependent on such matters as the detail of the information available to the certifying doctor (dependent in part on the investigations carried out) and the complexity of the medical condition of the deceased.

2.2.5. Changes in coding practice over time have modified the interpretation recorded. For instance, in the early 20th century 'old age' was a bona-fide cause of death and until the 1950s was one of the most commonly certified cause of death for those aged 70 and over. More recently, changes in coding practices have led to the allocation of this category to bronchopneumonia, circulatory disease and, to some extent, cancers. In 2001, the introduction of ICD10 in the UK was associated with a 20 per cent reduction in the number of deaths attributed to pneumonia and a corresponding increase in those attributed to chronic debilitating diseases (O'Reilly et al, 2005). Since 2004, changes to the level of investigation of sudden deaths have produced a discernable reduction in the proportion of deaths attributed to circulatory causes, throughout the United Kingdom (see Morris, 2007 in relation to Northern Ireland).

2.2.6. Furthermore, a judgement is required on how far back the 'conditions resulting in death' may reasonably be considered. Information relating to events prior to involvement of medical professionals will inevitably be less complete and may indeed be altogether unavailable, particularly if it relates to disciplines outside medicine such as environmental science or meteorology. More fundamentally, the model is based on the assumption of a 'train' of events, where one thing leads to another, when in fact it sometimes happens that it is the interaction of several events or circumstances, none in themselves lethal, that leads to death. For example, the combination of an electric shock at a normally sub-lethal level and a mild heart condition can prove fatal, although neither in isolation would have been lethal[2]. In a situation where several sub-critical circumstances combine to produce a critical effect, it may be difficult to assign one of them to be the 'underlying cause of death', whilst regarding the others as 'contributory'. It is the interaction of them all that is fatal.

[2] In this example, it is likely that the electric shock, as an easily identifiable discrete event, would be treated as cause of death, rather than the ongoing heart condition. In the event of interaction between a heart condition and a less easily identified external event such as exposure to cold weather or high levels of air pollution, it is likely that the heart condition would be treated as cause of death.

2.3 Seasonal Factors Affecting Mortality

2.3.1. Even where it is clear that excess seasonal mortality occurs, and that it can be readily monitored by a standard statistic, it is desirable to go beyond the fact, to explore the causes for such mortality. This is perhaps less clear-cut. There are known to be at least three possible major seasonally linked factors affecting mortality which can be readily identified, although the relationship is complicated. As these factors are associated with seasonal change it means they are also associated with each other, and it can be difficult to determine how they interact. In addition to this, there are instances where either extreme of conditions may be harmful, and it is intermediate conditions that are most healthy.

Temperature

2.3.2. Low temperatures, normally associated with winter, can impact on mortality. In addition to the fairly uncommon case of hypothermia, where lethal lowering of body temperature occurs, low temperature can modify blood chemistry and thickness (McKee, 1990), making an individual more vulnerable to circulatory events. Prolonged exposure to the cold may also result in depletion of the ability of the body to cope with potentially dangerous events, including infections. There are a number of policy measures relating to social security benefits and to energy efficiency of housing, intended to improve the ability of the population to cope with cold weather.

2.3.3. The situation is complicated by the fact that hot weather also can increase mortality, as in the heat wave of 2003. This was most notable in the South East of England, where the hottest conditions occurred, and other parts of England were less affected (Johnson et al, 2005). Heat stress can kill directly or by exacerbating circulatory conditions.

2.3.4. The Irish summer is perhaps more noted for cool, wet weather than for heat waves, although hot weather does sometimes occur. Given that intermediate temperatures are healthiest, it is helpful to take account of this by using heating degree-days (see Box 1 for definition) rather than simple temperature to monitor the effect.

Box 1: Definition of heating degree-days

Heating degree-days are a measure of the level of heating required in a given period, computed by the number of degrees the daily temperature falls below the threshold where the need for heating begins (15.5° C), summed over all days in the period. Given the variability of weather over time and place, it is not easy to assemble a single value that can be regarded as typical of the experience of Northern Ireland.

Monthly temperature data is easily available from 1994/95 onwards.

2.3.5. Except in comparatively limited periods of summer, external air temperatures in Northern Ireland are below the optimum for human health. This is a general environmental effect and suitable clothing, housing, heating and lifestyle are required to mitigate it. Any failure to use these means fully, whether by reason of poverty, preference or personal circumstances, results in an individual being exposed to the consequences. The outcome to this exposure is dependent on the vulnerability of the individual concerned, with the elderly and the very young at greater risk.

Influenza

2.3.6. Many epidemic outbreaks of influenza and other respiratory viral infections occur in the winter. The modern lifestyle facilitates the winter spread of such epidemics, with schools, colleges, churches and other organisations operating winter-centred programmes that facilitate contact, and consequent infection, between individuals. In summer on the other hand, all social classes, rather than simply the upper classes as in earlier times, disperse on holidays. There is an interaction with climate. Colder weather encourages, if not forces, people to remain in their homes, increasing the chances of cross-infection within the household, but reducing the likelihood of encountering infection from outside. Such weather may also reduce the resistance of individuals to the infecting agent, thereby increasing the level of illness, and thereby the risk of mortality.

2.3.7. Influenza tends to be unpredictable in its effects. It is an infectious disease that is particularly prone to epidemic spread of both old and new strains of the virus that causes the disease. Epidemics are much more complex in their manifestation and development than simple environmental conditions such as temperature and atmospheric pollution. The outcome when individuals are exposed to the virus (not all develop the illness, others are affected, some suffering a more virulent form of the illness than others) is dependent not just on their general vulnerability, as occurs with temperature, but also on levels of acquired antibodies due to previous exposures. This leaves the very young at particular risk (see high levels of 0-4 year old consultations for flu, CDSC, 2005) due to their limited previous contact with flu[3].

2.3.8. Furthermore, actual exposure to the virus, with attendant risk of infection, is very variable. The disease is found to leap considerable distances from one urban centre to another, whilst also diffusing outwards from each centre through its hinterland (Cliff, 1995; Hyman & LaForce, 2003; Handeler, 2003; Roberts et al, 2007). There is no certainty that every location will be reached by the epidemic. Workplaces and schools serve as particular centres of infection (Pellis et al, 2009), thus placing children and younger adults at greater risk of encountering the virus.

2.3.9. The varying interaction of all these factors, combined with the propensity of the virus to mutate to new forms, means that the timing and magnitude of influenza epidemics varies from year to year. The highest levels of influenza consultation in 2001/02 were half of those in the previous year, and a similar pattern occurred in 2004/05, with peaks occurring between November and February (CDSC, 2005). Furthermore, it must be borne in mind that the epidemics do not die away to nothing. A low residual level of influenza consultations continues throughout the year with associated low impact on mortality. This base level of infection, which generally increases in colder weather, is not easily disaggregated from the elevated levels of infection that occur during epidemics. Damage to the immune system caused by the disease may interact with other factors such as cold and atmospheric pollution to give rise to deaths that would not otherwise have occurred. Box 2 contains further details about influenza outbreaks.

Box 2: Influenza outbreaks

Influenza outbreaks do not necessarily result in many deaths directly attributed to this cause. In 2009, 12 deaths were recorded as due to influenza, with 18 deaths attributed to the 2009/10 outbreak of the H1N1 virus (NISRA 2010, p27). The number of GP consultations in that year reached record levels, however the number of influenza deaths may be indirectly linked to the 219 excess winter deaths due to respiratory causes in 2009/10. The disease, as well as having direct effects, increases vulnerability to other diseases and conditions, which can act as proximal cause of death.

This study uses GP consultation rate for influenza and flu-like illness per 100,000 population as a measure of exposure to influenza. It should be borne in mind that willingness to consult a GP is affected by a range of factors such as severity of the illness, the perceived accessibility of the GP, the severity of the weather conditions at the time, and NHS advice on what should be done in the event of illness.

Monthly data is available from 2000-01 onwards.

[3] This vulnerability of the young is a characteristic of infectious diseases observed thoughout history (eg Tuchman, 1978, p196)

2.3.10. Government policy is to reduce levels of influenza infection through programmes of selective immunization, although difficulties are sometimes encountered in ensuring supplies of a vaccine appropriate to recently emerged virus strains.

Atmospheric Pollution

2.3.11. Atmospheric pollution has long been known to be linked with ill health, with its effects having been particularly severe since the Industrial Revolution led to the widespread burning of hydrocarbons, releasing into the air a considerable range of chemicals and particles of varying degrees of toxicity. There is a strong link between climate and the effects of pollution. Chemical transformations proceed more rapidly in the presence of sunlight; wind mixes the air, dispersing the pollution whereas temperature inversions trap still layers of polluted air; and rain washes away pollution, but facilitates the solution of pollutants. The calm, clear, dry and cold conditions of winter anti-cyclones are particularly conducive to the accumulation of atmospheric pollutants (see Box 3 for more details).

2.3.12. Most importantly, however, a substantial proportion of the energy produced by the burning of hydrocarbons is intended for domestic heating. It is generated particularly in the winter period and whenever the weather is cold. Deaths from the Great Smog of 1952 in London were officially estimated at 4,000 but subsequent research suggests that the actual number was three times that. The government of the time was inclined to attribute the additional deaths to influenza and was initially reluctant on economic grounds to address the whole issue (Bell & Davis, 2001, Bell et al, 2004, Kynaston 2010 p257). Despite subsequent government action, smogs do still occur as in 1991 (Anderson et al 1995 and 1996), although the number of deaths are only one hundredth of those occurring during the Great Smog. More recently, the interaction of atmospheric pollution with low temperatures in increasing mortality has been demonstrated (Carder, 2008). Summer anti-cyclones can also trap pollutants (Johnson et al, 2005).

2.3.13. The variable used to measure atmospheric pollution (ie smoke pollution in Belfast) is not a strong indicator of the general Northern Ireland experience. Furthermore, smog, with its attendant ill-effects, is particularly linked to one kind of cold weather arising from anti-cyclonic conditions, which may be subsumed in the wider effects of cold weather which may arise from a range of causes. Current government policy in Northern Ireland is to reduce atmospheric pollution, through a range of measures, for example, introduction of pollution regulations from 1981 onwards and financial assistance in the replacement of coal-fired heating systems.

Box 3: Key information relating to atmospheric pollution

The presence of a range of atmospheric pollutants (smoke, oxides of sulphur, oxides of nitrogen, ozone and other chemicals) is not good for human health. The mortality attendant on the Great Smog of 1952 led to the introduction of Clean Air legislation. The wide range of pollutants and the different circumstances in which they are generated makes it difficult to select a single "typical" pollutant. As with temperature, there is considerable variation in pollution levels over time and space, making it difficult to assemble a single typical value for the whole of Northern Ireland.

This study uses trends in the level of particulates in the centre of Belfast as a broad indicator of pollution. No claim is made that this is a definitive measure, since oxides of sulphur and nitrogen have different characteristics of generation and behaviour.

Monthly data is available from 1992/93 onwards.

2.3.14. All three of these causes; temperature, influenza and atmospheric pollution, can work in two different ways. Firstly, an acute period of very severe conditions, a cold snap such as that in November-December 2010 where temperatures in Northern Ireland reached record lows, a heavy smog or an influenza epidemic, may cause an acute response as individuals or the population as a whole fails to cope with exposure to these factors. Brown et al (2010) demonstrated some evidence for this, but concluded that cold and hot snaps did not fully explain observed mortality.

2.3.15. Alternatively, a prolonged exposure to less severe, but still harmful, conditions (such as the prolonged winters of 1947-48 or 1962-63) may cause a chronic attritional effect on the individual or population concerned, resulting eventually in death or weakening of health that allows other causes of death to become effective. There is no reason to suppose that these two effects are in any way mutually exclusive. A severe or prolonged chronic period followed by a very severe acute episode is likely to prove a particularly lethal combination.

2.4 Excess Winter Deaths in Northern Ireland

2.4.1. Excess winter mortality is a simple method of measuring the seasonal variation associated with mortality (see Box 4 for the definition)[4].

Box 4: Definition of excess winter mortality

Excess winter mortality is defined as the difference between the number of deaths in the four-month "winter" period (December – March) and the average number of deaths in the two four-month periods which precede winter (August – November) and follow winter (April – July).

This is a standard definition which is used across the United Kingdom and by the World Health Organisation.

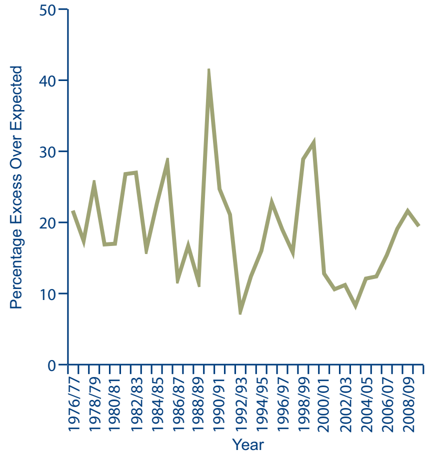
In Northern Ireland the official statistics are most commonly based on analysis of all deaths registered within each calendar year.

In order to highlight variations between causes of death and between different age groups, it is possible to calculate cause-specific and age-specific excess winter mortality, using only data on the relevant causes and age groups.

2.4.2. An analysis was carried out, based on Northern Ireland data using date of death occurrence in the 34 year period 1976/77 to 2009/10. Figure 2.1 shows that overall, excess winter deaths, expressed as a percentage of the expected winter deaths (derived from non-winter deaths), varies from eight per cent to 40 per cent, averaging at 19 per cent.

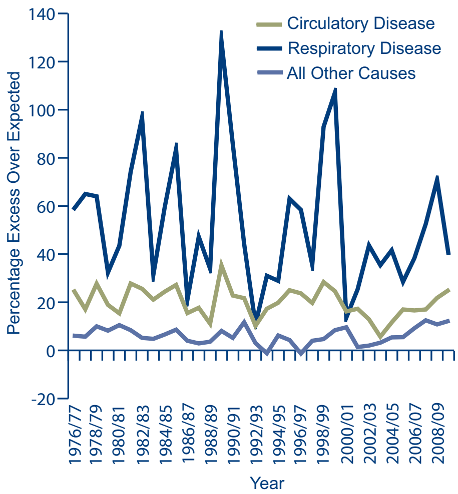
4 A detailed statistical report about Excess Winter Deaths in Northern Ireland, based on registration data, can be found on the NISRA website at the following link: http://www.nisra.gov.uk/demography/default.asp14.htm

Figure 2.1: Overall excess winter mortality in Northern Ireland, 1976/77 to 2009/10



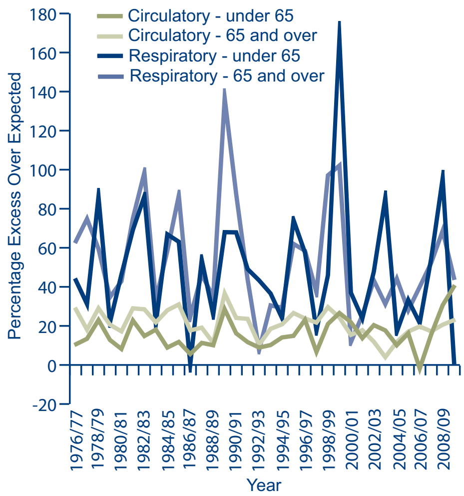
2.4.3. Figure 2.2 shows that respiratory deaths saw the greatest percentage excess, from 11 per cent to 128 per cent (average 53 per cent), compared with six per cent to 35 per cent (average 20 per cent) for circulatory causes and minus one per cent to 12 per cent (average six per cent) for other causes. In 24 of the 34 years, percentage excess winter mortality for respiratory causes exceeds the highest percentage excess for circulatory causes. In absolute terms, respiratory excess winter deaths are greater than circulatory excess winter deaths in nine years of the period, despite the fact that on average, the total number of winter deaths from circulatory causes exceeds those from respiratory causes by a ratio of 2.5:1.

Figure 2.2: Excess winter mortality in Northern Ireland by cause, 1976/77 to 2009/10



2.4.4. Figure 2.3 suggests that in terms of percentage of expected deaths, there is a variation of eight to 53 per cent for older people (65 and over) and three to 50 per cent for younger people (under 65). For both groups, respiratory causes have the highest proportionate excess winter mortality. In 15 years of the 34 year period, it is actually younger people who exhibit proportionately greater excess winter respiratory mortality than older people. In 1989/90, the excess respiratory mortality among older people is 136 per cent of expected deaths, compared with 68 per cent among younger people, whereas in 1999/00, the proportions are 102 per cent and 169 per cent respectively. In absolute terms, the numbers of excess winter respiratory deaths are of course much less among younger people.

Figure 2.3: Excess winter mortality in Northern Ireland by cause and age, 1976/77 to 2009/10



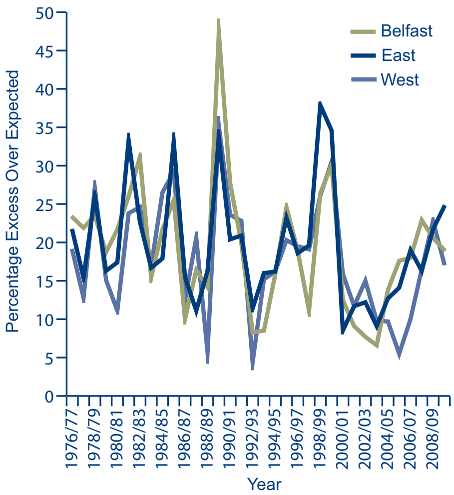
2.4.5. Figure 2.4 shows that considering the percentage of expected deaths, the East varies from nine per cent to 38 per cent (average 20 per cent) compared with seven per cent to 47 per cent (average 19 per cent) in the Belfast Area and four per cent to 35 per cent (average 18 per cent) in the West[5]. This suggests that although there is

5 Belfast Area: Belfast, Carrickfergus, Castlereagh, Lisburn, Newtownabbey and North Down district councils

East: Antrim, Ards, Banbridge, Ballymena, Craigavon, Down and Larne district councils

West: Armagh, Ballymoney, Coleraine, Cookstown, Derry, Dungannon, Fermanagh, Limavady, Newry & Mourne, Magherafelt, Moyle, Omagh, and Strabane district councils relatively little difference in the average experience of the three areas, the Belfast Area experiences a greater range of excess mortality (40 percentage points, compared with about 30 in the rest of Northern Ireland). In 1989/90, the excess is 40 per cent, compared with only 34 to 35 per cent elsewhere in Northern Ireland. For 1999/00, there is no evidence of variation of excess mortality between the parts of Northern Ireland.

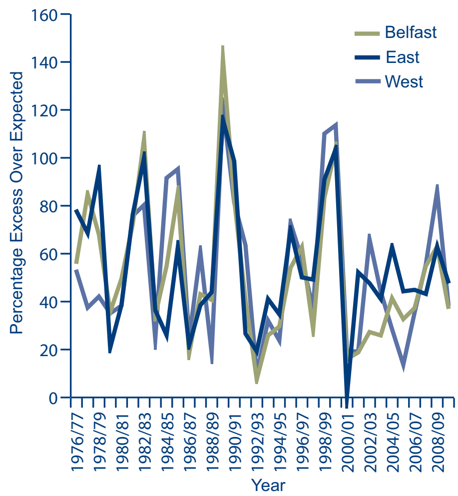
Figure 2.4: Excess winter mortality in Northern Ireland by locality, 1976/77 to 2009/10



2.4.6. Given that respiratory causes show the greatest variation in excess winter mortality, and Belfast is the location with greatest variation overall, it is worth examining the interaction of cause and location. Although numbers are not large, Figure 2.5 shows that excess winter respiratory deaths, as a percentage of expected deaths, have averages ranging from 52 per cent (Belfast) to 55 per cent (East). The range in the East is 115 percentage points and in the West it is 111 percentage points, but in the Belfast Area, it is 133 percentage points.

2.4.7. There are three years out of 34 where the excess was worthy of note[6] in all three of the areas of Northern Ireland (1989/90, 1998/99 and 1999/00). In 1989/90, the excess in the Belfast area was 141 per cent of expected deaths, more than 20 percentage points higher than in the rest of Northern Ireland. It is reasonable to conclude that the peak of excess winter mortality in 1989/90 relates to respiratory causes of death and that there is a particular peak in the Belfast area for that year. In the other two years, the highest peak is in the West, although the difference between areas is less marked, particularly in 1999/00.

Figure 2.5: Excess winter respiratory mortality in Northern Ireland by locality, 1976/77 to 2009/10



2.4.8. Thus from 1976/77 onwards, it is clear that excess winter mortality is most strongly associated with respiratory causes and older people. In some years, the Belfast area is associated with particularly high peaks of excess winter mortality, but this is not a universal pattern. In a significant number of years, the proportionate excess of winter respiratory mortality is greater among younger people (under 65 years) than among older people, although the absolute numbers are less.

2.4.9. This is consistent with the view that influenza epidemics contribute to higher levels of mortality, whether such epidemics occur in winter, as seems to have been the case in

6 Where 'worthy of note' is defined as more than one standard deviation away from the mean

1989/90, 1999/99 and 1999/00, or in autumn, as happened in 2003/04 and 2009/10. They can affect more severely the elderly (1989/90) or the young (1999/00). They can also affect one part of Northern Ireland with particular virulence. The 1989/90 peak of very high excess winter mortality in Belfast is consistent with an epidemic spreading strongly through the city and its immediate hinterland, but failing to reach all the smaller urban centres in other parts of Northern Ireland.

2.5 Seasonality of Mortality in Europe

2.5.1. The pattern of seasonal mortality is by no means simple. Excess winter mortality in Europe, as measured using the standard measure (see Box 4 for definition), is at its highest in areas and countries of southern Europe such as Portugal, Spain and Sicily, and at its lowest in countries of northern Europe such as Finland and Sweden (McKee, 1990; Healy, 2003). This is somewhat counter-intuitive, given that the winters of northern Europe are so much more severe, and it is argued that the people of southern European countries devote their resources to ensuring that houses are comfortable in the heat of summer, rather than warm in winter.

2.5.2. There is possibly more to matters than just this, since locations with relatively warm winters and cool summers are likely to reduce the mortality differential between the two periods. This configuration is a characteristic of maritime climates, and Iceland records no excess winter deaths. Furthermore, if access to housing adequate to the climate were an issue, one might expect the more wealthy to be less vulnerable. The differences in winter mortality between Whitehall civil servants of varying rank do not appear to support this hypothesis (van Rossum, 2001). This is possibly a national rather than a class issue, with the general level of housing available being ill-suited to the climate. The United Kingdom and Republic of Ireland, despite their maritime location, exhibit higher excess winter deaths than may be found in countries such as Norway and Germany, which have a colder winter.

2.6 Excess Winter Death Indicator – a Critique

2.6.1. It will be noted that there are some issues which may be raised with the current definition of excess winter deaths. Firstly, "winter" is defined as the period December to March. This is hardly a universal or rigorous definition of "winter". Apart from the difference in timing of the colder period between northern and southern hemispheres, there are notable climatic differences between various locations. For instance, winter for Arkhangelsk in northern Russia begins in late November when temperatures fall below 0°C and they remain there until late April, whereas winter for Palermo in Sicily starts and finishes somewhat earlier, but it is characterised by the temperature falling below 20°C (not 0°C), a temperature which would be quite warm for summer, never mind winter, in Arkhangelsk! Not only the temperature level but the period of lower temperature varies. Excess winter mortality is simply a measure of periodic variation in deaths. On its own, it provides no assessment of the changes in the impact of low temperature, high air pollution and epidemics, whose effects are quite likely to occur both before and after the winter period.

2.6.2. In the context of the calculation of excess winter mortality, the Easter holiday poses particular problems because it occurs near the division between "winter" and "non-winter". Just as the Christmas-New Year holiday can delay registration of a death into another calendar year, so the Easter holiday can delay registration into another season. This is not, however, a constant effect.

2.6.3. In a quarter of all years, Easter is in "winter" (late March), with a significant risk of a death registration being delayed until the non-winter period. In the other years, Easter falls after the "winter" period and the likelihood that registration will not be until the following winter is very much less. As a consequence, an early Easter tends to reduce the number of deaths registered in winter and to increase the number of deaths registered in non-winter. This has the effect of reducing the computed excess winter mortality.

2.6.4. The calculation of excess winter mortality using the date of death occurrence is perfectly feasible, although it suffers from the practical problem that the death counts are constantly changing as late registrations are recorded. It is a number of years before the counts finally stabilise as individual cases are subject to post-mortem, inquiry and inquest, the last of these being particularly likely to take some time. The advantage, however is that administrative artefacts are reduced and eventually eliminated.

2.6.5. Table 2.2 shows the average winter excess mortality using the two methods for the period 1976/77 to 2009/10, distinguishing between those years with an early Easter and those with a later Easter. The table shows, on average during the period, excess winter mortality is 910 using date of occurrence, compared with 801 using date of registration. The difference in estimates for years with Easter not in winter is 76 (926 compared to 851), much less than the difference of 220 (858 compared to 638) for years with Easter in winter. A winter Easter is associated with seven per cent less excess winter mortality in that period (reflecting differences between the years), using the occurrence method of calculation, but with 25 per cent less excess mortality using the registration method of calculation.

Table 2.2: Excess winter mortality by method of computation and season of Easter, 1976/77 to 2009/10

	Average Excess Winter Mortality (EWM)	
Occurrence of Easter	**By Date of Registration**	**By Date of Death**
Early Easter (in winter)	851	926
Late Easter (not in winter)	638	858
All Years	801	910
Ratio of average EWM Winter and Non-Winter Easter	0.75	0.93

2.6.6. This Easter effect notably affects the usefulness of excess winter mortality (registration-based) as an indicator. Not only does any difference between two years reflect differences in the impact of seasonal variables of interest, but it also reflects the timing of Easter[7].

2.6.7. It should be noted that the excess winter mortality methodology is not particularly well suited for the analysis of acute effects, since it applies a binary model, pooling information on four winter months and eight other months into two seasons, and then presents the results as a single annual number, the difference between the two seasons. Influenza epidemics do not often last as long as four months, whilst smogs and cold snaps never do. As a consequence, acute episodes tend to be averaged away.

2.6.8. It is possible, nonetheless, to collapse the available monthly data on pollution, influenza and degree-days in a way analogous to the excess winter mortality methodology. On the basis that the monthly level of air pollution, influenza consultations and degree-days is a measure of the risk to which the population was exposed in that month, these values can be summed over the two time periods, averaged and the difference taken as a measure of the relative risk of the two seasons. Conversely, the monthly respiratory deaths may be compared directly with the corresponding risks by cause, rather than being combined into a single annual measure.

2.6.9. Table 2.3 shows the correlations between smoke pollution, influenza consultations, degree-days and respiratory deaths in the period 2000/01 to 2009/10, using monthly data. This period is rather shorter than is ideal, but it is the longest period for which data on all four variables are available. The monthly section shows that the link between smoke pollution and influenza consultations is low, but the links of pollution with temperature and deaths are considerably higher. Influenza consultations are also linked more strongly to temperature and respiratory deaths. The strongest correlation is between temperature and respiratory deaths.

[7] This method was devised by a Renaissance astronomer to implement a 4th century ecclesiastical decision. It is unlikely that it has much relevance to mortality although there may be some impact - an early holiday may perhaps encourage people to undertake outdoor activities in cold wet weather.

Table 2.3: Correlation co-efficients of monthly variables 2000/01 to 2009/10

	Smoke Pollution	Influenza Consultation	Degree-Days	Respiratory Deaths
Smoke Pollution	1			
Influenza Consultations	0.014	1		
Degree-Days	0.408**	0.441**	1	
Respiratory Deaths	0.321**	0.480**	0.751**	1

Source: NISRA data on deaths by date of occurrence, VESMA data on degree-days, CDSCNI data on GP consultations for influenza and influenza-like conditions, Northern Ireland Air Quality database data on smoke pollution in Belfast

** Significant at P< 0.01 level

2.6.10. Detailed statistical analysis of monthly respiratory deaths from 2000/01 to 2009/10 shows that degree-days, influenza consultations and smoke pollution are all statistically significant variables in explaining monthly respiratory deaths. Temperature (degree-days) is shown to be the stronger explanatory variable of the three.

2.6.11. As noted above, the excess winter mortality methodology applies a binary seasonality (“winter” against “non-winter”), and yet conventionally there are four seasons. The seasons of spring and autumn are cooler than summer, and though they may be similar to each other in temperature, the circumstances are rather different. A cold spell in autumn follows a summer period where, on the whole, there has been a time for recuperation and rebuilding of individuals’ health. A similar cold spell in spring is effectively a continuation of the winter which has already depleted the ability of individuals to resist adverse circumstances. The consequences of a given temperature for personal health might be expected to be different in the two seasons.

2.6.12. When two-monthly time-periods are included as explanatory variables in the statistical model of monthly respiratory data, the analysis becomes more robust. Degree-days and influenza consultations are still found to be statistically significant. However the period December/January (early winter) experiences more respiratory deaths than can be explained by the level of temperature and influenza consultations occurring in the period, whilst the period October/November (autumn) experiences fewer deaths.

2.6.13. Whatever the precise explanation may be, this particular aspect of seasonality has an effect on the excess winter mortality computation. Given that the average excess winter mortality is 350 for respiratory deaths (53 per cent of expected mortality), average actual winter deaths are 1,010 and average actual non-winter deaths are 1,320. The detected boost to early winter deaths amounts to 3.8 per cent of all winter respiratory deaths, while the reduction to autumn deaths amounts to 2.5 per cent of all non-winter respiratory deaths. The impact on excess winter respiratory deaths of this factor is thus an increase of six per cent over what might be expected from the impact of temperature and influenza alone.

2.6.14. A more detailed analysis based on data on individuals derived from the Northern Ireland Longitudinal Study (see Box 5 for details of this study) can be undertaken. In the period 2001-08, using information on daily temperature and pollution, together with weekly influenza levels, shows that temperature remains statistically linked to respiratory disease cause of death and is also linked to circulatory causes of death (more strongly so for respiratory deaths). Atmospheric pollution impacts significantly on likelihood of circulatory death and influenza on the likelihood of respiratory death.

Box 5: Northern Ireland Longitudinal Study

The Northern Ireland Longitudinal Study (NILS) is a large-scale data linkage study created by linking individual level administrative and statistical data, such as Census, vital events (births, deaths and marriages) and health registration datasets.

Variables from other sources can also be appended, allowing exploration of cultural, demographic, economic, health, housing and social issues on mortality.

2.6.15. This analysis shows that the excess winter mortality statistic detects many aspects of influenza epidemics, but this does not amount to an ability to disentangle fully the complex relationship between pollution, temperature, influenza and deaths. This task is made more difficult by the fact that there is clear evidence of long term decline in death rates, on which seasonal fluctuations are superimposed.

2.7 Seasonal Variability

2.7.1. In light of the above, it may be helpful to consider alternative seasonal measures. Figures 2.6 to 2.8 show that while daily deaths averaged between 35 and 45 in the months of the period 2001-08, for individual years, the variation could be as great as 37 to 58 in 1999 (Figure 2.7) and as little as 37 to 44 in 2002 (Figure 2.8).

Figure 2.6: Average daily deaths per month, 2001 to 2008 – non-zero y-axis

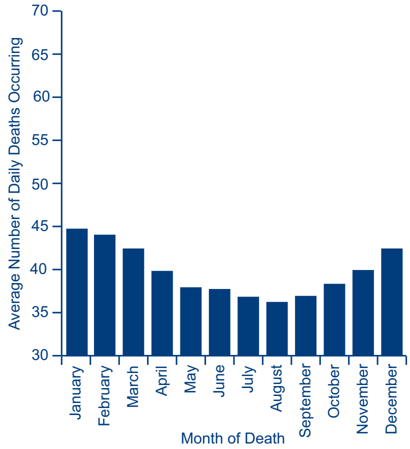


Figure 2.7: Average daily deaths by month of occurrence, 1999 – non-zero y-axis

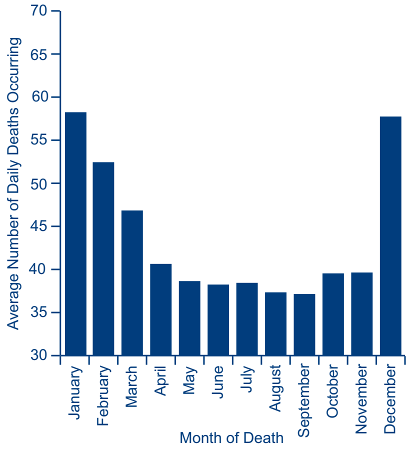
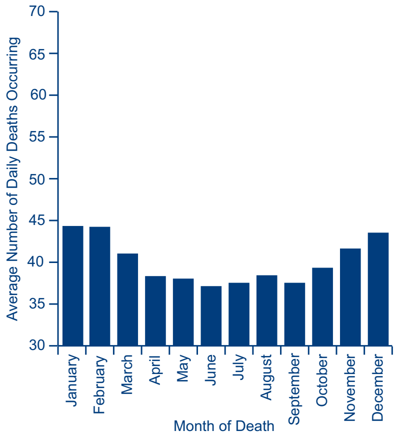
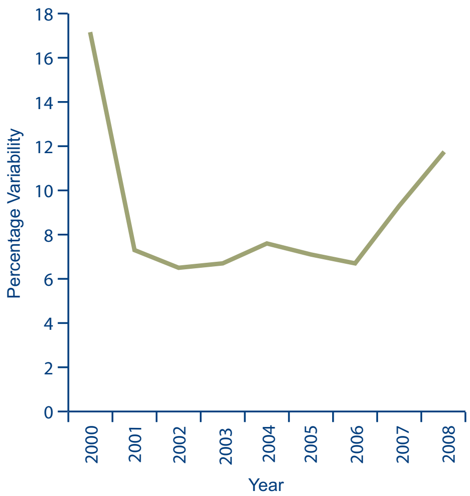


Figure 2.8: Average daily deaths by month of occurrence, 2002 – non-zero y-axis



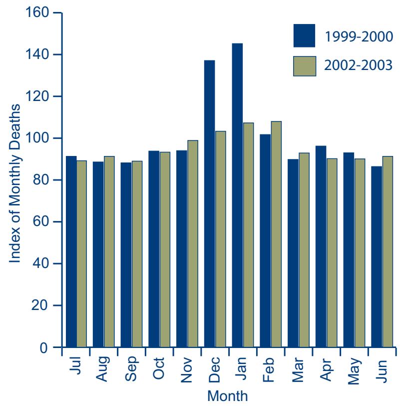
2.7.2. Monthly total deaths, respiratory deaths, circulatory deaths and other deaths in the period 2000-2008, can be analysed by month of occurrence and indexed to mean monthly deaths for the period 1976-2010[8] (see Figure 2.9). The mean and the standard deviation for each year are calculated from the monthly values, and the latter expressed as a percentage of the former[9]. Figure 2.9 shows the annual level of variability in the period 2000-2008, with peaks in 2000 and 2008, when influenza outbreaks occurred.

Figure 2.9: Annual Variation in monthly deaths, 2000 to 2008



2.7.3. Figure 2.10 compares the indexed total monthly deaths for 1999-2000, when there was a severe influenza outbreak and 2002-03, when there was not[10]. The monthly pattern is very similar in both years, for most of the year, with higher levels of death in the generally colder months, but superimposed on this is a significant peak in December and January for 1999-2000. As noted, there was a very severe influenza outbreak in that period, although unfortunately, figures on the level of influenza consultations are not available.

Figure 2.10: Index of monthly variation of deaths in 1999-00 and 2002-03



Note: 100 = Average monthly number of deaths, 1976 to 2010

2.7.4. Looking more closely at cause of death, over the entire 35 year comparison period (1976 to 2010), the annual variability in monthly deaths is 4.2 per cent for deaths other than respiratory and circulatory, rising to 10.6 per cent for circulatory and 23.5 per cent for respiratory deaths, giving an overall variability of 9.6 per cent for all deaths.

2.7.5. Within the nine years 2000-2008, the variability measure lay within the range 4.8 to 7.9 per cent for deaths other than respiratory and circulatory, rising to 7.2 to 12.6 per cent for circulatory and 14.3 to 53.3 per cent for respiratory deaths. This demonstrates the immense variability of levels of respiratory death

8 Deaths are analysed by month of occurrence. To allow for any effects due to delays in death registration, results for 2009 and 2010 are not shown in these tables.

9 This measure subsumes some variability due to the differences in month length, including the effects of Leap Years.

10 July-June years are used here to avoid separating the winter months of December and January into different periods.

compared with other causes. The analysis also shows the impact of declining numbers of circulatory deaths, with only one month (of 108) in 2000-2008 exceeding the monthly average for 1976-2010.

2.7.6. In order to take account of the desire for speedy assessments of trends, Table 2.4 examines monthly death registrations in the period 2006-2011, indexed to average monthly death registrations in the period. This shows a range in the monthly means for a five year period from 88.8 (August) to 128.1 (January). There was unusually cold weather in November and December 2010, and the level of deaths registered was 105.9 (cf average 98.1) in November 2010 and 105.8 (cf average 100.5) in December 2010. By January 2011, after the thaw set in, the level was 126.5, below the recent average for that month. There is, therefore, evidence to suggest that the cold weather was associated with a higher than usual level of deaths. Monthly data which are speedy and not complex to compute are thus more sensitive and informative.

Table 2.4: Index of monthly death registrations, 2006/11

Month of	Registration Year						Five Year
Registration	2006	2007	2008	2009	2010	2011[P]	Average
January		127.6	129.9	137.9	118.8	126.5	128.1
February		109.6	103.0	102.6	102.1	96.7	102.8
March		107.2	108.1	103.0	117.4	107.3	108.6
April		104.4	108.4	95.4	95.8	90.1	98.8
May		99.8	91.7	88.4	83.2	100.6	92.7
June		92.8	95.9	99.3	95.6	95.7	95.9
July	94.4	93.1	98.3	91.4	86.9		92.8
August	94.2	94.1	84.0	80.2	91.4		88.8
September	93.3	80.3	98.9	94.4	91.4		91.7
October	101.2	105.0	98.4	95.0	94.6		98.8
November	97.6	99.1	92.8	95.2	105.9		98.1
December	86.1	91.6	116.7	102.5	105.8		100.5

[P] Provisional data

2.8 Conclusion

2.8.1. In conclusion, therefore, the excess winter mortality statistic in isolation should be treated with some caution. It has considerable advantages, in that it has an evident simplicity of concept and produces an easily comprehended number. Furthermore, it can be applied to a single year, in a way that is not possible for more sophisticated analytical techniques, and the result for that single year can highlight a specific issue meriting further investigation. On the other hand a great deal of underlying information is pooled in order to generate the statistic. If this underlying data can be matched to correspondingly detailed data on explanatory variables, a much more robust analysis is possible.

2.8.2. Although the statistic is mostly calculated using data based on the date of death registration, in the interests of using speedily available and stable data, this approach is likely to underestimate the excess in years where Easter occurs in March. It is possible, however, to produce annual measures based on monthly data which are speedy and not complex to compute. These are more sensitive and informative.

2.8.3. As noted, government has a range of policies intended to address the impact of factors having a seasonal effect on mortality. These may directly address the issues, for example, through improvement of house heating and insulation, implementation of effective smoke-free zones or introduction of immunisation programmes, or they may be indirect, for example, winter fuel payments. Despite the name of the benefit, few households operate hypothecated accounting systems that would ensure that the money received is spent solely (or indeed at all) on fuel costs, and the impact of the benefit is likely to be an overall easing of the household's financial circumstances. This is likely to be the outcome with financial assistance that is not linked to work explicitly intended to effect housing improvements. It is also necessary to validate the policies through evaluating their effects on mortality.

2.8.4. It is difficult to interpret any seasonality in mortality that may be identified, in the absence of data on seasonal factors which may be driving mortality. In earlier years, the Registrar General's report included meteorological information, recognizing that the weather had an impact on health. It would be helpful if more information on seasonal mortality could be published by the Registrar General.

References

Anderson HR, Limb ES, Bland JM, Ponce de Leon A, Strachan DP, & Bower JS 'Health effects of an air pollution episode in London, December 1991.' *Thorax 1995; 50: 1188-1193*

Anderson HR, Ponce de Leon A, Bland JM, Bower JS, & Strachan JP 'Air pollution and daily mortality in London: 1987-92' *BMJ 312 March 1996: 665*

Bell ML & Davis DL 'Reassessment of the Lethal London Fog of 1952: Novel Indicators of Acute and Chronic Consequences of Acute Exposure to Air Pollution' *Environmental Health Perspectives Volume 109, Supplement 3 June 2001* 389-394

Bell ML, Davis DL, & Fletcher, T 'A Retrospective Assessment of Mortality from the London Smog Episode of 1952: The Role of Influenza and Pollution' *Environmental Health Perspectives Vol 112, No 1 January 2004* 6-8

Brown G, Fearns V & Wells C 'Exploratory analysis of seasonal mortality in England and Wales, 1998 to 2007' *Health Statistics Quarterly 48 Winter 2010* 58-79

Carder M, McNamee R, Beverland I, Elton R, Van Tongeren M, Cohen GR, Boyd J, MacNee W, & Agius RM 'Interacting effects of particulate pollution and cold temperature on cardiorespiratory mortality in Scotland' *Occup Environ Med 2008;65*:197-204

Carson C, Hajat S, Armstrong B & Wilkinson P 'Declining Vulnerability to Temperature-related Mortality over the 20th Century' *Am J Epidemiology 164 (1) Jul 2006* p77-84

Cliff A 'Incorporating Spatial Components into Models of Epidemic Spread' p119-149 in *Epidemic Models: their Structure and Relation to Data* ed Mollison D Publications of the Newton Institute, Cambridge University Press, Cambridge 1995

CDSC (NI) *Enhanced Surveillance of Influenza in Northern Ireland: Summary Season 2004-05* Communicable Disease Surveillance Centre (Northern Ireland) Belfast 2005

General Register Office, Third Annual Report of Births, Deaths and Marriages in England. London: HMSO, 1841, pp. 102-09

Hadeler KP 'The Role of Migration and Contact Distribution in Epidemic Spread' p199-210 in *Bio-terrorism: Mathematical Modeling Applications in Homeland Security* ed Banks HT & Castillo-Chavez C, Society for Industrial and Applied Mathematics, Philadelphia, 2003

Healy JD 'Excess winter mortality in Europe: a cross country analysis identifying key risk factors' *Epidemiol Community Health* 2003;57:784-789

Hyman TM & Laforce, T 'Modelling the spread of Influenza among cities' p211-236 in *Bio-terrorism: Mathematical Modeling Applications in Homeland Security* ed Banks HT & Castillo-Chavez C, Society for Industrial and Applied Mathematics, Philadelphia, 2003

Johnson H, Kovats RS, McGregor G, Stedman J, Gibbs M, Walton H, Cook L, & Black E, 'The impact of the 2003 heat wave on mortality and hospital admissions in England' *Health Statistics Quarterly* 25 Spring 2005 6-11

Kynaston D *Family Britain* 1951-57 Bloomsbury London 2010

NISRA *Eighty-eighth Annual Report of the Registrar General 2009* Northern Ireland Statistics and Research Agency Belfast 2010

McKee CM, 'Deaths in winter in Northern Ireland: the role of low temperature' *The Ulster Medical Journal, Volume 59, No. 1, April 1990* p17-22

Morris C, '*Fuel Poverty, Climate and Mortality in Northern Ireland*' Occasional Paper 25 NISRA Belfast 2007

O'Reilly D, Rosato M & Connolly S 'Trends in mortality in Northern Ireland' in *Eighty-Third Annual Report of the Registrar General 2004* Northern Ireland Statistics and Research Agency Belfast 2005 p 23-51

Pellis L, Ferguson NM & Fraser C 'Threshold Parameters for a model of epidemic spread among households and workplaces' *J Roy Society 24, 6 (40) Nov 2009* p979-987

Roberts MG, Baker M, Jennings LC, Sertsiou G & Wilson N 'A model for the spread and control of pandemic influenza in an isolated geographical region' *J Roy Society 22, 4 (13) Apr 2007* p325-330

Tuchman B *A Distant Mirror: The Calamitous Fourteenth Century Penguin*, London 1978

van Rossum CTM, Shipley MJ, Hemingway H, Grobbee DE, Mackenbach JP, & Marmot MG 'Seasonal variation in cause-specific mortality: Are there high-risk groups? 25-year follow-up of civil servants from the first Whitehall study' Int. *J. Epidemiol 2001* 30 (5): 1109-1116

Web link

Northern Ireland Air Quality Data and Statistics Database

http://www.airqualityni.co.uk/data.php (accessed 21/06/11)