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# Seasonal mortality at older ages in England & Wales 1993-2016

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**Abstract**

The UK experiences higher deaths in the winter relative to the other seasons with the seasonal differences in mortality increasing with age. As the population ages it becomes increasingly important to understand seasonal mortality trends and the implications for an ageing population. This paper investigates seasonal mortality in England & Wales for ages 65-94 for all causes of death combined over the period 1993-2016 and by each major cause of death over the period 2001-2015. The reasons for higher deaths in winter are complex but influenza and cold/poor housing are recognised as major contributing factors. Government initiatives aimed at reducing the higher winter death rate are discussed. Females are more affected by seasonal differences in mortality than males experiencing a greater gap between summer and winter mortality rates than males. Mortality improvements differed between the seasons with the winter experiencing greater improvements over the period compared with the summer for both males and females. All the major causes of death, with the exception of neoplasms, continue to exhibit seasonal differences in mortality. Seasonal differences in mortality in England & Wales, therefore, remain important and should be considered when analysing and modelling mortality at older ages.

**Keywords**

**Seasonal mortality; Mortality improvements by season; Excess winter mortality**

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## 1. Introduction

The dramatic improvements in life expectancy experienced in the UK since the start of the 20th century has contributed to an ageing population. The proportion of the population aged over 65 has risen from approximately 5% in 1911 to 18% in 2016 in England & Wales. The oldest old, those aged 85 and over are now the fastest growing section of the population in the UK (Dunnell 2008). Mortality at older ages varies by season contributing to mortality and longevity risk for insurers and pension providers. Seasonal differences in mortality between populations and between sub-populations are a source of demographic basis risk while seasonal mortality trends influence projections of future mortality and are a source of trend risk. Seasonality of mortality increases with age and as the population ages it, therefore, becomes more important to understand seasonal mortality trends and the implications for mortality and longevity risk.

Mortality in the UK is highest during the winter season and improvements in winter mortality have the greatest impact on the annual rate of improvement. Mortality at ages 65 and over in the UK improved slowly over most of the 20th century before starting to improve rapidly from the 1970s onwards particularly for males (Gallop 2006). Improvements continued into the new century and age group 65-80 experienced annual rates of improvement of 2.5%-3.0% for males and 2.0%-3.0% for females in the first decade of the 21st century. These improvements compare with an average annual rate of improvement in the UK of 1.6% and 1.4% for males and females respectively over the previous fifty years (Nash 2016). Improvements are expected to continue into the future and at increasingly higher ages in a pattern referred to as the "ageing of mortality improvements" (Willets et al. 2004) albeit at a slower rate. As these are the ages most affected by seasonal differences in mortality projections of future improvements at these older ages should consider if the impact of seasonality should be allowed for when extrapolating past trends.

Despite mild winters Britain experiences relatively high seasonal variations in mortality compared with other European countries often with much more severe winters (Healy 2003, Liddell et al. 2016). Seasonal mortality increases with age from about age 65 onwards – seasonal variations in mortality at ages under 65 are almost negligible – and is higher for females than males (Wilkinson et al. 2004). The increase in winter deaths is due mainly to a rise in respiratory and circulatory deaths with only a small proportion directly due to cold temperatures (ONS 2016). The reasons for higher deaths in winter are complex but influenza and cold/poor housing are recognised as major factors (Vestergaard et al. 2017, Public Health England 2018, Guertler et al. 2018). Influenza activity increases in the winter and contributes to the higher winter death rate either directly or indirectly by increasing deaths due to causes such as pneumonia and a wide variety of respiratory and circulatory diseases and may occur weeks after the initial infection (Dushoff et al. 2006). Influenza activity varies from year to year with some influenza strains more virulent than others (Hardelid et al. 2012) and the resulting fluctuations in winter mortality rates contribute to the volatility of annual mortality rates. In addition to an increased number of deaths influenza also results in increased hospital admissions and GP visits and places severe strain on the NHS and other social services (Flemming et al 2016, Matias et al. 2016). Government policies, in particular the national flu vaccination programme which offers annual vaccinations to those most at risk of complications from influenza (including those aged 65 and over), aim to reduce the impact of influenza in the population (Public Health England 2017).

Social issues also impact on seasonal variations in mortality with poor quality housing, fuel poverty/lack of heating (cold housing) and deprivation all cited as contributing factors (Clinch et al. 2000, Aylin et. 2001, Healy 2003). The problem of higher winter deaths (and also higher rates of illness and hospitalisation during the winter) at older ages is recognised as a public health concern. According to a report by the Strategic Society Centre (Lloyd 2013) government policies in the UK aimed at reducing these seasonal fluctuations can be categorised as focussing on the cost of heating (e.g. winter fuel payments, cold weather payments, warm homes discount), cold weather responses (e.g. cold weather plan), public health interventions (e.g. seasonal flu vaccination programme, public health outcomes framework), home insulation and general attempts to address the effect of the cold. A study by Iparraguirre (2014) concluded that almost half of the reduction in Excess Winter Deaths in England & Wales between 1999/2000 and 2012 could be attributed to the winter fuel payments.

This paper analyses seasonal mortality trends (all-cause and by major cause of death) for ages 65 to 94 over the period 1993-2016 for England and Wales for males and females respectively. Trends in mortality improvements are decomposed by season and the implications for future mortality improvements are also considered. The paper is organised as follows: section 2 discusses the seasonal data used for the analysis, section 3 presents seasonal all-cause mortality trends and mortality improvements, section 4 presents seasonal trends by major cause of death and section 5 concludes with a discussion on the implications of seasonality for future mortality at older ages and government strategies for reducing excess winter deaths in England and Wales.

## 2. Data

Annual seasonal death rates were calculated for the period 1993-2016 for ages 65-94 for males and females separately in England & Wales. Data on the number of deaths by age, gender, month and year were obtained from the Office for National Statistics (ONS) and exposure data was obtained from the Human Mortality Database (HMD 2019). Data on the number of deaths by five major causes of death (Circulatory Diseases, Respiratory Diseases, Mental and Behavioural Disorders, Neoplasms and all Other causes of deaths) were also obtained from the ONS for the period 2001-2015 split by single year of age (65-95), gender, month and year. The deaths by each major cause were grouped according to the World Health Organisation (WHO) International Classification of Diseases, Tenth revision (ICD-10).

Deaths, both all-cause and by each major cause of death, were recorded according to the date of occurrence.

Studies of seasonal mortality in the Northern Hemisphere tend to define winter as the period December to the following February or March. To analyse the seasonal mortality and mortality improvement trends for England and Wales the monthly death data for each year was allocated to the four (meteorological) seasons as follows:

| | |
|---|---|
| Spring: | March, April, May |
| Summer: | June, July, August |
| Autumn: | September, October, November |
| Winter: | December, January, February |

The winter season, therefore, spans two calendar years.

The Excess Winter Mortality Index (EWMI) is a simple method widely used to illustrate the relative difference between winter and non-winter deaths in the UK and in other European countries (Healy 2003, ONS 2016). Based on our three month definition of winter the EWMI for the winter spanning year *x* and year *y* ($(EWMI)_{x/y}$) is defined as:

$$Excess\ Winter\ Mortality\ (EWM)_{x/y} = Winter\ Deaths_{x|y} - Average\ Non\ Winter\ Deaths_{x/y}$$

$$Excess\ Winter\ Mortality\ Index\ (EWMI)_{x/y} = \left(\frac{EWM_{x/y}}{Average\ Non\ Winter\ Deaths_{x/y}}\right) * 100$$

The winter and average non winter deaths are calculated as:

$$Winter\ Deaths_{x/y} = \ Deaths\ (Dec)_{year\ x} + Deaths(Jan - Feb)_{year\ y}$$

$$Average\ Non\ Winter\ Deaths_{x/y} =$$

$$\frac{Deaths\ (Aug - Nov)_{year\ x} + Deaths\ (March - June)_{year\ y} + \frac{Deaths\ (July_{year\ x} + July_{year\ y}\ )}{2}}{3}$$

Note that this definition of the EWMI differs from the ONS definition which is based on a four month definition of winter (December to the following March). Figure 1 plots the EWMI for England and Wales for age groups 65-74, 75-84 and 85-94 for males and females respectively for the period 1993/1994 to 2015/2016. The 95% confidence intervals were calculated as EWMI ± 1.96 * EWMI/√EWM. From figure 1 we can see that the higher or excess mortality in winter increases with age though all age groups continue to experience excess winter mortality. The excess winter mortality is generally higher for females than for males over the period.

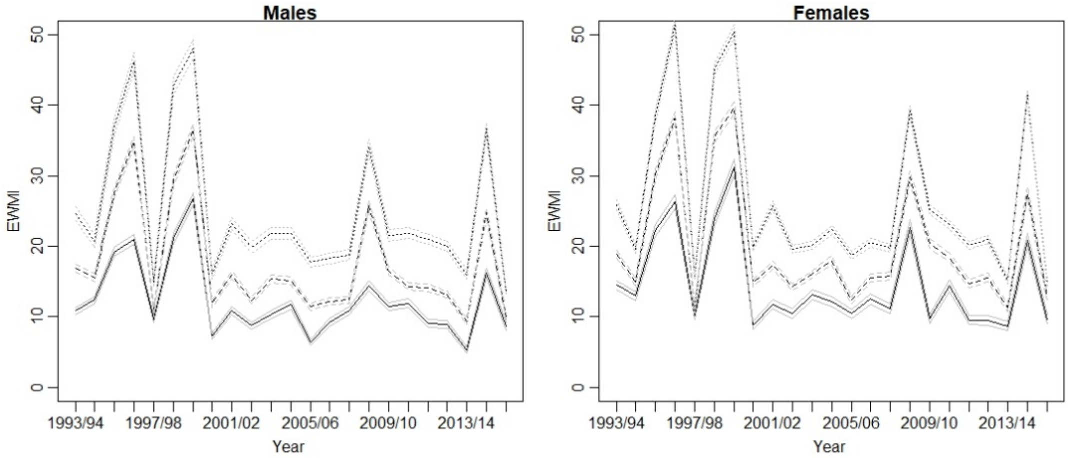



***Figure 1. Excess Winter Mortality Index and corresponding 95% confidence intervals for England and Wales for age groups 65-74 ____, 75-84 _ _ _, 85-94…… for males and females 1993/1994-2015/16.***

## 3. All-cause Seasonal Mortality Trends for England and Wales 1993-2016

All-cause mortality trends by season are compared using directly age standardised mortality rates standardised to the 2013 European Standard Population (ESP 2013). The Seasonal Standardised Mortality Rate (SSMR) was calculated as follows:

$$SSMR_{s,x,t} = \sum_x \left( \frac{d_{s,x,t}}{E_{x,t}} * SP_x \right) \Big/ \sum_x SP_x$$

where $d_{s,x,t}$ is the number of deaths at age *x* in season *s* in year *t*, $E_{x,t}$ is the exposed to risk at age *x* in year *t* and $SP_x$ is the 2013 European standard population at age *x*. Note that for the winter season, which spans two consecutive calendar years, the exposed-to-risk was calculated as the weighted average of the exposure for the two consecutive calendar years. Deaths in each season were standardised to 92 days in length. The 2013 European standard population is provided in five year age bands between ages 65 and 94 and for calculation purposes we assumed that the population was split equally across all five ages in each age band. 95% confidence intervals were calculated as:

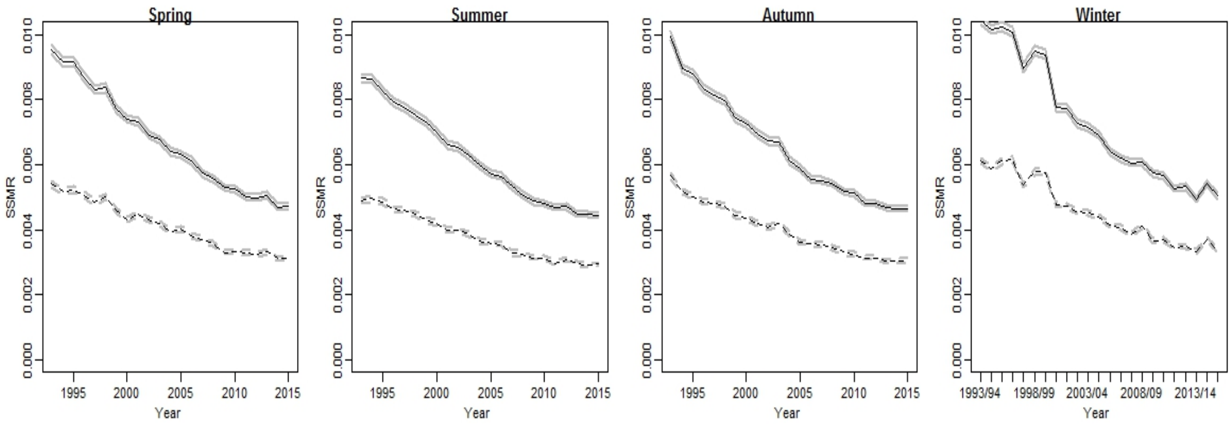
$$SSMR_{s,x,t} \pm 1.96\sqrt{Var(SSMS_{s,x,t})}$$

where:

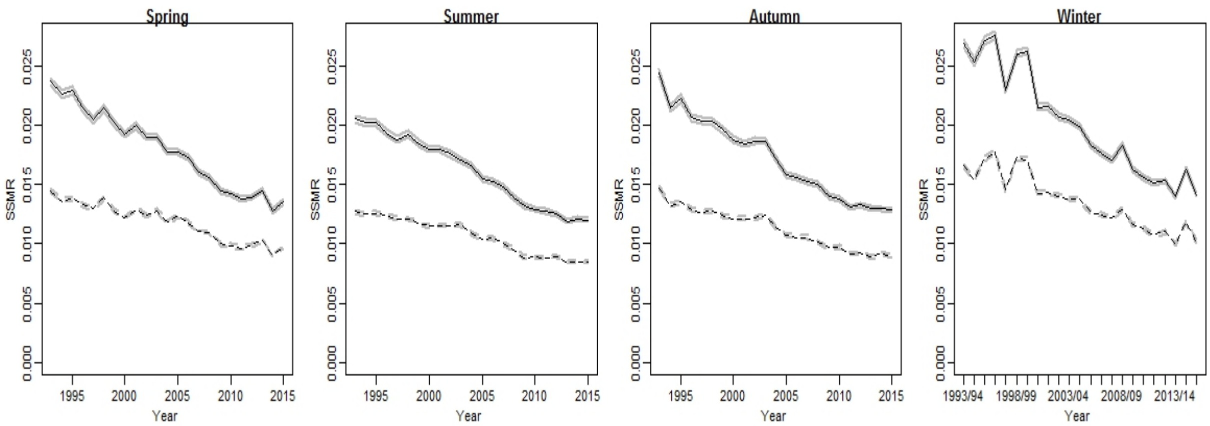
$$Var(SSMR_{s,x,t}) = \sum \left( \frac{\frac{d_{s,x,t}}{E_{x,t}}\left(1 - \frac{d_{s,x,t}}{E_{x,t}}\right)}{E_{x,t}} * \left( \frac{SP_x}{\sum_x SP_x} \right)^2 \right)$$

Figure 2 presents the seasonal standardised mortality rates (SSMRs) for males and females for age groups 65-74, 75-84 and 85-94 over the period 1993-2015 for the spring, summer and autumn seasons and 1993/1994-2015/2016 for the winter season. As expected mortality has declined for both males and females across all age groups and in each season over the period. Mortality is highest in the winter followed, in descending order, by mortality in the spring, autumn and summer. Mortality, at older ages, therefore tends to be higher in the first half of the year relative to the mortality in the second half of the year and the assumption of uniform distribution of deaths (UDD) does not hold at older ages. For both males and females the difference or gap between summer and winter mortality increases with increasing age. For example, the ratio of the winter (2015/16) to summer (2015) SSMRs increased between age groups 65-74 and 85-94 from approximately 1.1 to 1.2 for males and from approximately 1.1 to 1.3 for females.

## Age Group 65-74




## Age Group 76-84




## Age Group 85-94

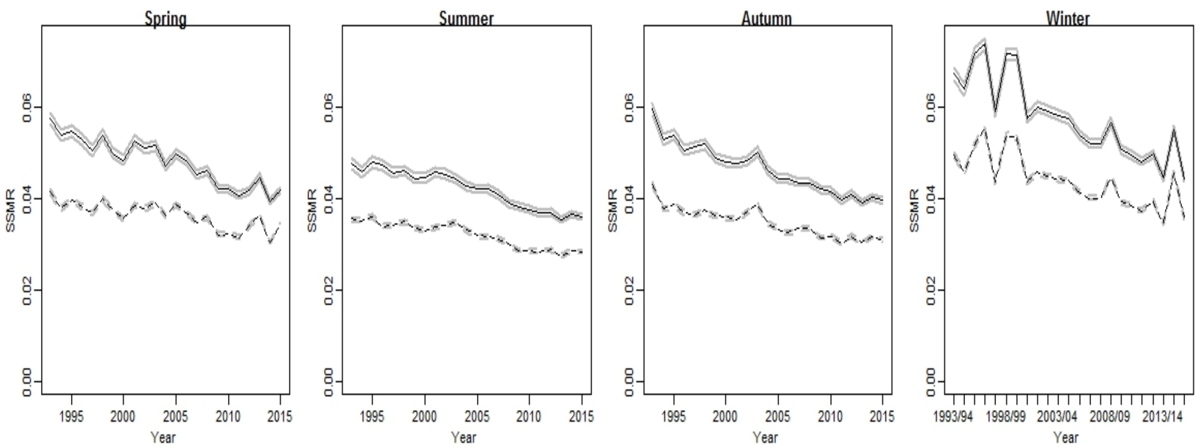



***Figure 2. Seasonal standardised mortality rates (SSMR) and 95% confidence intervals for England & Wales for males for age groups 65-74, 75-84 and 85-94 for males _____ and females _ _ _. Spring, Summer and Autumn: 1993 to 2015 and Winter: 1993/94 to 2015/16.***

Figures 3 and 4 present the corresponding five year average annual improvements in the standardised summer and winter mortality rates for males and females for age groups 65-74, 75-84 and 85-94. Mortality improvements fluctuate from year to year and hence were averaged over five years to provide a smoother estimate of the seasonal rates of improvement. The five year average annual seasonal improvement in year t for season *s* and age group *x* was calculated as:

$$SMI_{s,x,t} = 1 - \left(\frac{SSMR_{s,x,t}}{SSMR_{s,x,t-5}}\right)^{1/5}$$

The range of the annualised improvements was more volatile in the winter ranging from approximately -2.0% to 6.0% for males and -3.0% to 5.0% for females for the age groups shown. The corresponding range of annualised summer improvements was approximately 0.0% to 4% for both males and females. The pattern of mortality improvements changed over the period with winter improvements dominating in the earlier period 2000-2006 and summer improvements dominating in the period 2006-2012 for both males and females. The gap between the summer and winter improvements in the latter period (2006-2012) was smaller than in the previous period (2000-2005). Summer rates of improvements declined in the period 2012-2016 for both males and female while winter rates of improvement showed increased volatility over the same period 2012-2016.

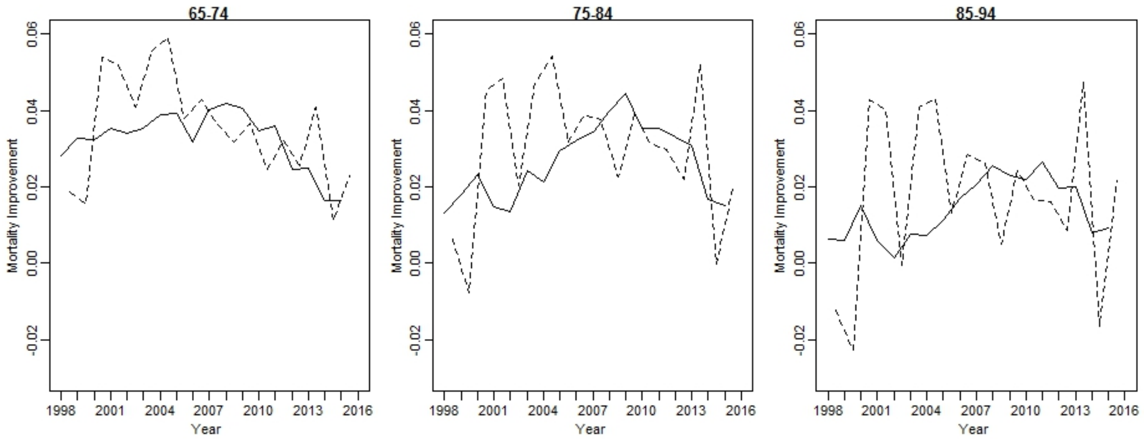



***Figure 3. 5 year average annual mortality improvements for males in England & Wales for summer (1998-2015) _____ and winter (1998/99 – 2015/16)_ _ _ _.***

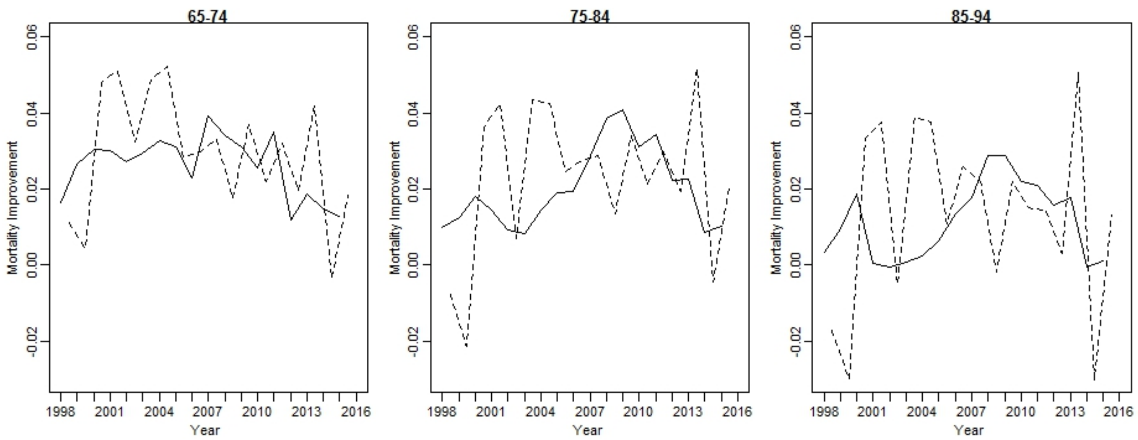



***Figure 4. 5 year average annual mortality improvements for females in England & Wales for summer (1998-2015) _____ and winter (1998/99 – 2015/16)_ _ _ _.***

From figures 3 and 4 it can be seen that the greatest improvements in mortality over the period were experienced in the winter between approximately 2000 and 2005. Age group 65-74 typically experienced 5 year average annualised improvements in excess of 4% per annum while age groups

75-84 and 85-94 had rates of improvements typically in excess of 3% per annum over the period for both males and females. While correlation does not imply causation this period coincided with the introduction of Winter Fuel Payments by the UK government and extensions to the seasonal influenza vaccination programme. The Winter Fuel Payment is an annual payment to those aged 60 and over to help with winter heating costs for the elderly and was introduced in 1997. In 1998 the flu vaccine was made available free of charge to all aged 75 and over - prior to 1998 the flu vaccine had been offered based on clinical risk only. In 2000 the vaccination programme was further extended and was now offered free of charge to all aged 65 and over. National uptake targets were set and GPs were incentivised to offer the vaccine (Joseph et al. 2005). Uptake of the winter flu vaccine in the UK rose from approximately 65% of the population aged 65 and over in 2000 to 75% in 2005. Coverage has remained relatively stable at approximately 72-74% up to 2014 (QualityWatch 2017). The greatest improvements in summer mortality occurred later between 2006 and 2010 and were less significant than the peak of winter improvements.

Table 1 summarises the annualised summer and winter improvements over the period for each age band for males and females. The annualised improvements for the winter and summer seasons for age group *x* were calculated as:

$$Summer\colon\ SMI_{summer,x,1993-2015} = 1 - \left(\frac{SSMR_{summer,x,2015}}{SSMR_{summer,x,1993}}\right)^{1/22}$$

$$Winter\colon\ SMI_{winter,x,1993/94-2015/16} = 1 - \left(\frac{SSMR_{winter,x,2015/16}}{SSMR_{winter,x,1993/94}}\right)^{1/22}$$

Mortality rates are highest in the winter and improvements in winter mortality will therefore have a greater impact than summer mortality improvements on the overall annual improvement rates. From table 1 we can see that overall improvements were greater for males relative to females in both the summer and winter seasons with the greatest differences between male and female improvement rates generally observed in winter. As a result of the higher rates of improvement for males the gap between male and female mortality declined in both seasons with the greatest convergence occurring in the winter. Overall improvements for the period 1993-2016 were higher in the winter relative to the summer for both males and females.

| | **Summer (1993-2015)** | | | **Winter (1993/94 – 2015/16)** | |
|---|---|---|---|---|---|
| **Age Group** | **Males** | **Females** | | **Males** | **Females** |
| **65-74** | 3.0% | 2.3% | | 3.3% | 2.7% |
| **74-84** | 2.4% | 1.8% | | 2.9% | 2.2% |
| **85-94** | 1.3% | 1.0% | | 1.9% | 1.5% |

***Table 1. Annualised summer and winter mortality improvements for males and females in England & Wales by age group.***

## 4. Seasonal Mortality Trends by Major Cause of Death for England & Wales 2001-2015

Seasonal differences in mortality vary by cause of death and changes in the underlying causes of death over time impacts on seasonal all-cause mortality trends. In 2001 the UK moved from classifying deaths according to International Classification of Diseases revision 9 (ICD-9) to revision 10 (ICD-10). ICD-10 represents a significant change from ICD-9 - mortality statistics are not directly comparable across versions 9 and 10 (Rooney at al. 2002) and accordingly we have analysed seasonality by major cause of death from 2001 only.

Figure 5 presents the proportion of deaths for age groups 65-74, 75-84 and 85-94 for the five main causes of death, Circulatory Diseases (I00-I99), Respiratory Diseases (J00-J99), Mental and Behavioural Disorders (including Alzheimer's and dementia) (F00-F99), Neoplasms (C00-D48) and all Other causes (A00-B99, D50-E90, G00-H95, K00-R99, U00-Y89), in 2001 and 2015 for males and females respectively. From figure 5 we can see that in 2001 the main cause of death at older ages was circulatory diseases except for females ages 65-74 where neoplasms were the main cause of death. By 2015, however, neoplasms were the main cause of death for age groups 65-74 and 75-84 and circulatory diseases were the main cause of death for age group 85-94 for both males and females. The proportion of deaths attributed to mental and behavioural disorders (including Alzheimer's and dementia) increased substantially over the period particularly for age group 85-94 (increasing from 3.4% to 12.3% for males and from 5.5% to 17.9% for females for age group 85-94). This increase is due, in part, to changes in the recording of the underlying cause of death by the ONS since 2001. In 2011 and 2014 the ONS updated the ICD-10 coding framework which resulted in an increased number of deaths being coded as a due to mental and behavioural disorders (primarily dementia). The majority of these deaths would previously have been classified as due to either circulatory or respiratory diseases (ONS 2011, ONS 2014). Nevertheless, even allowing for these coding changes mortality due to Alzheimer's and dementia is estimated to have increased by around 5% per annum between 2007 and 2014 (Campbell 2017).

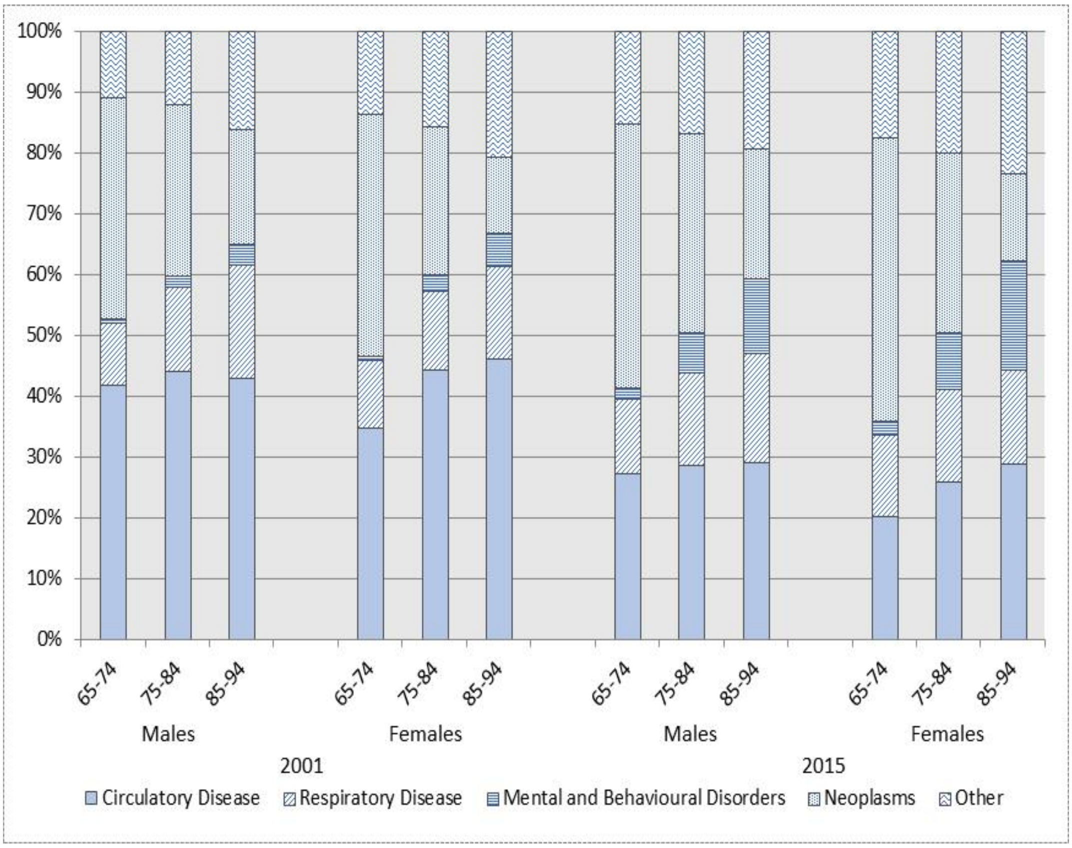



***Figure 5. Proportion of deaths in England & Wales ages 65-94 by major cause of death in 2001 and 2015 for males and females.***

Figure 6 presents the Excess Winter Mortality Index (EWMI) for males and females for age group 65-94 for each of the major causes of deaths over the period 2001 to 2015. The EWMI was highest and most volatile for respiratory diseases followed by mental and behavioural disorders. Respiratory diseases show a clear gap in the EWMI for males and females indicating that females experience much higher excess winter mortality for respiratory diseases compared with males. Females also tend to show slightly higher excess winter mortality compared to males for circulatory diseases and "other" diseases though the gap is much less significant than in the case of respiratory diseases. In comparison neoplasms show little or no seasonal differences in mortality for either males or females. The EWMI, while volatile, appears reasonably level over the period for each of the major causes of death shown with no significant increase or decrease noticeable over the period.

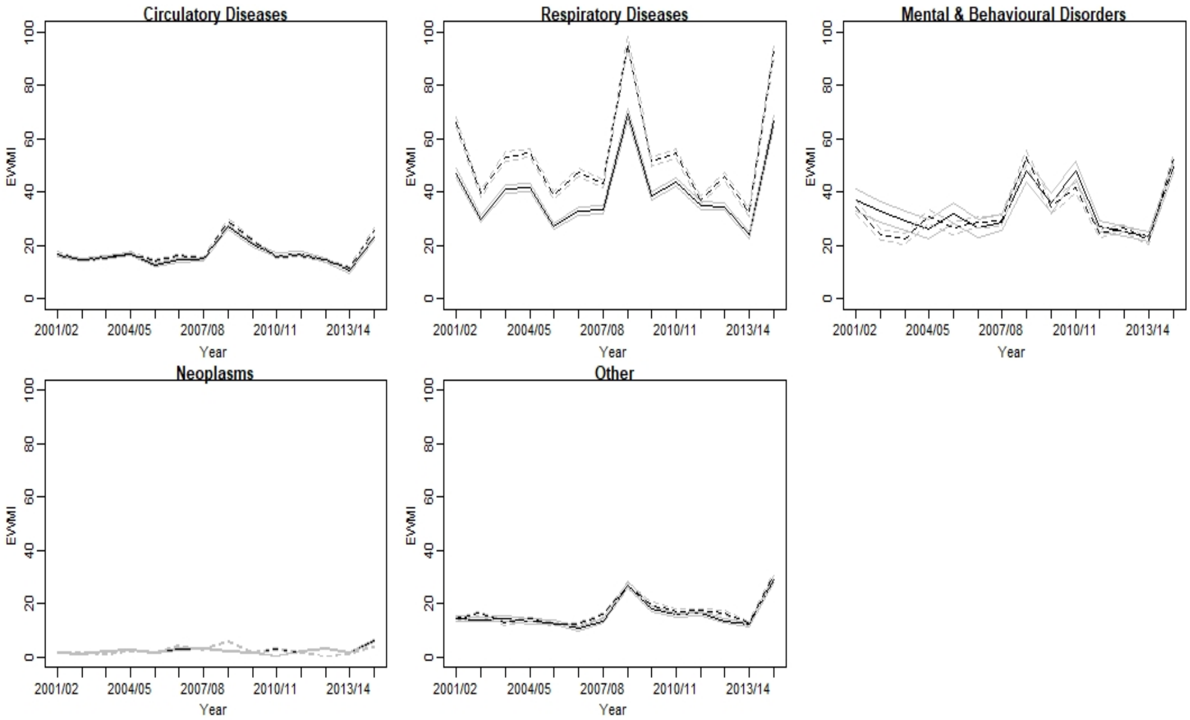



***Figure 6. Excess Winter Mortality Index (EWMI) and 95% confidence intervals by major cause of deaths for age group 65-94 in England and Wales for males _____ and females _ _ _ _.***

Table 2 presents the overall annualised improvements for the period 2001 to 2014 in the Seasonal Standardised Mortality Rates (SSMRs) for winter and summer for each of the major causes of death for age group 65-94 for males and females. SSMRs were calculated using the method described in section 3. Mental and behavioural disorders show negative rates of improvement but, as discussed earlier, this is primarily due to changes in the recording of the underlying cause of death by the ONS resulting in a higher number of deaths being classed as due to mental and behavioural disorders since 2011. Ignoring mental and behavioural disorders, males show higher rates of improvement in each cause of death in both the summer and winter relative to females. Circulatory diseases show the highest rates of improvement over the period in both the summer and winter for males and females. Neoplasms and circulatory diseases show relatively similar levels of improvement in the summer and winter seasons while deaths due to respiratory diseases and "other" show larger differences between the summer and winter rates of improvement.

| | Summer (2001-2014) | | | Winter (2001/02 – 2014/15) | |
|---|---|---|---|---|---|
| | **Males** | **Females** | | **Males** | **Females** |
| **Circulatory Diseases** | 5.2% | 5.1% | | 4.8% | 4.5% |
| **Respiratory Diseases** | 2.4% | 1.3% | | 0.9% | 0.0% |
| **Mental & Behavioural Disorders** | -7.2% | -6.6% | | -8.8% | -8.8% |
| **Neoplasms** | 1.3% | 0.6% | | 1.0% | 0.4% |
| **Other** | 1.0% | 0.8% | | -0.3% | -0.6% |

***Table 2. Annualised summer and winter mortality improvement rates for age group 65-94 for males and females in England & Wales by major cause of death.***

## *5.* Conclusions

In the UK mortality at older ages varies by season and mortality models should consider if seasonal differences in mortality should be allowed for when modelling and projecting mortality rates at these ages. The effect of seasonal changes in mortality is not uniform but varies by factors such as gender, region, socio-economic status and health status (Rozar 2012, Healy 2003) thereby increasing the risks associated with mortality and longevity modelling. Mortality is highest in the winter months with the gap between winter and summer mortality rates increasing with increasing age. Over the period 1993-2016 the gap between summer and winter all-cause mortality rates in England & Wales declined at all ages. However relative differences by season between males and females and by major cause of death varied over the same period. Insurers and pension schemes should understand the impact of seasonality on past mortality trends (all-cause and by cause of death) and the implications for future trends when setting mortality assumptions for pension and annuity type products.

Improvement rates in England & Wales differ by season and are more volatile in the winter season compared with the summer season. At older ages analysis of past mortality trends should consider the difference or gap in seasonal improvement rates and how this gap changes over time. Actuarial methods for projecting future mortality tend to be based on past mortality data either directly by extrapolating past trends or by basing assumptions of future rates of improvement on an analysis of past rates via the “targeting” method (Booth et al. 2008, Whelan S 2008, Wong-Fupuy et al. 2004). Significant differences and changing spreads between winter and summer improvement rates increase the uncertainty associated with such projections. Differences in seasonal mortality trends are a source of trend risk for future mortality projections and this is a particular risk for mortality projections by cause of death where there are significant seasonal differences for certain causes of death. Furthermore the winter experienced greater convergence of male and female mortality rates over the period compared with the summer and changing seasonal trends could impact on future mortality differentials between males and females at older ages.

The problem of excess winter mortality and morbidity is widely recognised in the UK and strategies have been implemented at the local, regional and national level in recent years to address the problem. England introduced the first Cold Weather Plan in 2011 which aims to “prevent the major avoidable effects on health during periods of cold weather in England by alerting people to the negative effects of cold weather and enabling them to prepare and respond accordingly”. The Cold Weather plan is published annually and is supported by multiple national agencies (Public Health England (PHE), NHS England, the Local Government Association, the Met Office and the Department of Health and Social Care). In 2013/2014 the National Institute for Health and Care Excellence (NICE) in the UK issued guidance on excess winter deaths and illness and the health risks associated with cold homes with the aim of improving the health and wellbeing of people vulnerable to the cold (www.nice.org.uk/guidance/ng6). The guidance included recommendations on identifying people at risk of cold homes, identifying strategies for people living in cold homes, training practitioners to help people with cold homes, raising awareness of how to keep warm at home and ensuring buildings meet required standards. In March 2016 NICE issued a quality standard (QS117) on preventing excess winter deaths and illness associated with cold homes (www.nice.org.uk/guidance/qs117). Excess winter mortality is also an indicator included in the Public Health Outcomes Framework, first published in 2012, which sets out desired outcomes for public health and how they will be measured through the use of indicators (www.gov.uk/government/publications/public-health-outcomes-framework-2016-to-2019). As the population continues to age it is important to understand the various strategies being implemented for tackling higher winter mortality rates and the implications for future mortality trends.

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