

## Article

# Mortality in England and Wales: Average life span, 2010

We look at the 3 measures of average life span, life expectancy at birth (mean age at death), median age at death and modal age at death, to better understand mortality at older age. In 2010 the most common age at death was 85 for men and 89 for women; the average life span increased by approximately 10 years for a man and 8 years for a woman.



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# 1. Key points and summary

- The most common age at death in England and Wales in 2010 was 85 for men and 89 for women.
- Over the last 50 years (1960-2010) the average life span has increased by around 10 years for a man and 8 years for a woman.

The population of England and Wales is living longer than ever before. This is due to factors such as large improvements in infant and childhood mortality in the first half of the 20th century and more recently improvements in mortality rates at older ages.

Life span is usually measured by life expectancy at birth, which is highly influenced by deaths at young ages, so recently ONS has been investigating other measures of average life span. For example, the late modal age at death is solely influenced by adult mortality and consequently much more sensitive to improvements in mortality among the older population. Modal age at death has emerged as a particularly useful measure for analysing mortality at older ages and alongside life expectancy at birth and possibly median age at death, can help us to understand the ageing that is characteristic of the population of England and Wales.

## 2. Introduction

Life spans are getting longer, and the ongoing debate around a limit to life expectancy remains <sup>1</sup>. The proportion of older people in the population is increasing in England and Wales and we are seeing year on year increases in the numbers of centenarians<sup>2</sup> and even supercentenarians<sup>3</sup>. An ageing population gives rise to policy concerns around health care, pensions and retirement ages, so it is important to understand changes in the age distribution of death, especially at the oldest ages. Therefore in order to better understand mortality at older ages in England and Wales, ONS has started to analyse different measures of average life span, also referred to as the average age at death.

Life expectancy is the average total life span or the average (mean) number of years a person has before death. ONS regularly reports on life expectancy at birth<sup>4,5</sup>, a measure that is widely used and easily understood and which provides a robust summary of a population's health<sup>6</sup>. Period life expectancy at birth gives the average number of years a person can be expected to live if they were to experience the mortality rates of a particular time and place throughout their lives.

Life expectancy is calculated using a life table. The life table describes the course of mortality throughout the life cycle. It is a method of analysing age-specific death rates and is a standard demographic tool used to measure expectation of life by age. Life tables can also be used to calculate the median age at death and the modal age at death. Average life spans and in particular the measure of modal age at death are key areas of current research<sup>7</sup>.

The average life spans (mean, median and modal ages at death) discussed in this report are calculated from period life tables<sup>8</sup>. That is, the age-specific mortality rates for a particular year are used to produce a life table for that year.

- Life expectancy is the average total life span or the mean age at death.
- The median age at death represents that age at which exactly half the deaths in a given time period were below that age and half the deaths were above that age.
- Modal age at death is the age where death is most likely or most common.

## Notes for introduction

1. Oeppen J and Vaupel J W, (2002) Broken Limits to Life Expectancy.
2. Centenarians are people aged 100 years or more.
3. Supercentenarians are people aged 110 years or more.
4. [National Interim Life Tables](#)
5. [Period and Cohort Life Expectancy Tables](#)
6. Robine J et al, (2006) What can be learnt by studying the adult modal age at death?
7. Other studies include Kannisto V, (2001), Robine J et al, (2006), Ouelette N and Bourbeau R, (2011) and Thatcher R et al, (2010).
8. Period life tables are calculated using age-specific mortality rates for a given period, with no allowance for any actual or projected future changes in mortality.

## 3. Method

The raw data, death registrations and population estimates, have been used in two ways to produce two sets of life tables. The life expectancy at birth and median age at death figures are from life tables calculated from unsmoothed mortality rates for ages 0 to 125. The late modal age at death figures are from life tables calculated from smoothed mortality rates for ages 10 to 125.

The exclusion of data relating to the population aged less than 10 years from the life tables used to calculate modal age at death is because the age at death distribution is bi-modal for a human population. This means that there is a peak of deaths at age 0; more specifically soon after birth, and a second adult or late modal age at death. This is because mortality is high soon after birth, particularly within the first four weeks. Mortality then falls and remains low throughout the teenage and younger adult years, before naturally increasing throughout the rest of adult life. Therefore the analysis of modal age at death in this report focuses on the second or late modal age at death, that is from age 10 to age 125. In this report the late modal age at death is referred to as modal age at death.

The life expectancy at birth and median age at death figures are from life tables calculated from unsmoothed annual data and the late modal age at death figures are from smoothed data. Smoothing removes year on year fluctuations of deaths caused by period effects such as war and flu. If these remained in the data then it would be difficult to identify a single age with the highest number of deaths<sup>1</sup>. Analysis has been carried out on both sets of life tables to ensure the smoothing has not changed expected patterns in the underlying data or in the calculated averages. The [period life expectancy tables](#) published by ONS that are consistent with the figures used in this report are calculated from unsmoothed data.

## Notes for method

1. Ouelette N and Bourbeau R, (2011), Changes in age at death distribution in four low mortality countries: a non parametric approach.

## 4. Trends in average life span

In 2010 life expectancy for a newborn baby boy was 79 years and for a newborn baby girl 83 years. These are the average number of years a baby could expect to live if he or she experienced the mortality rates at each age in 2010 throughout his or her life. An alternative measure of average life span is the age at which half of all deaths occurred before and the other half after (median age at death); in 2010 this was 82 for a man and 85 for a woman, up to three extra years of life than given by life expectancy at birth. The third measure of average life span, the modal age at death, gives a further three or four years of life: 85 and 89 years for a man and woman.

**Table 1: Average life spans in years, 2010**

	Males	Females
Life expectancy at birth	79	83
Median age at death	82	85
Modal age at death	85	89

Source: Office for National Statistics

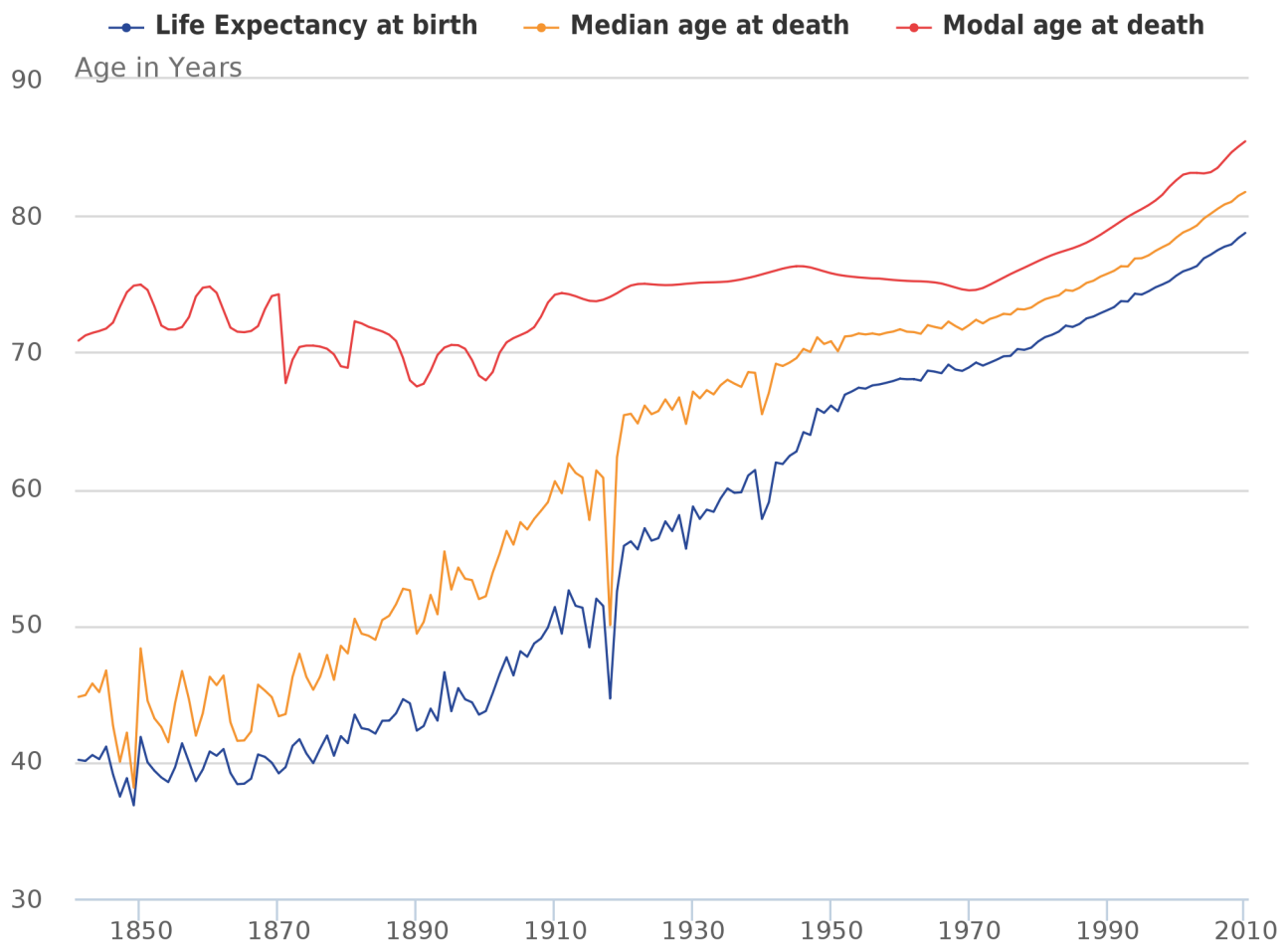
Notes:

1. The figures in this table are calculated from the 2010 life table and are therefore age-standardised. They may differ from the average age at death calculated from deaths registered in England and Wales in 2010.

In Figures 1 and 2 the three measures, life expectancy at birth, median age at death and modal age at death are shown for each year 1841 to 2010.

**Figure 1: Average life spans: Life Expectancy at birth (LE), median age at death and modal age at death, 1841 to 2010, males**

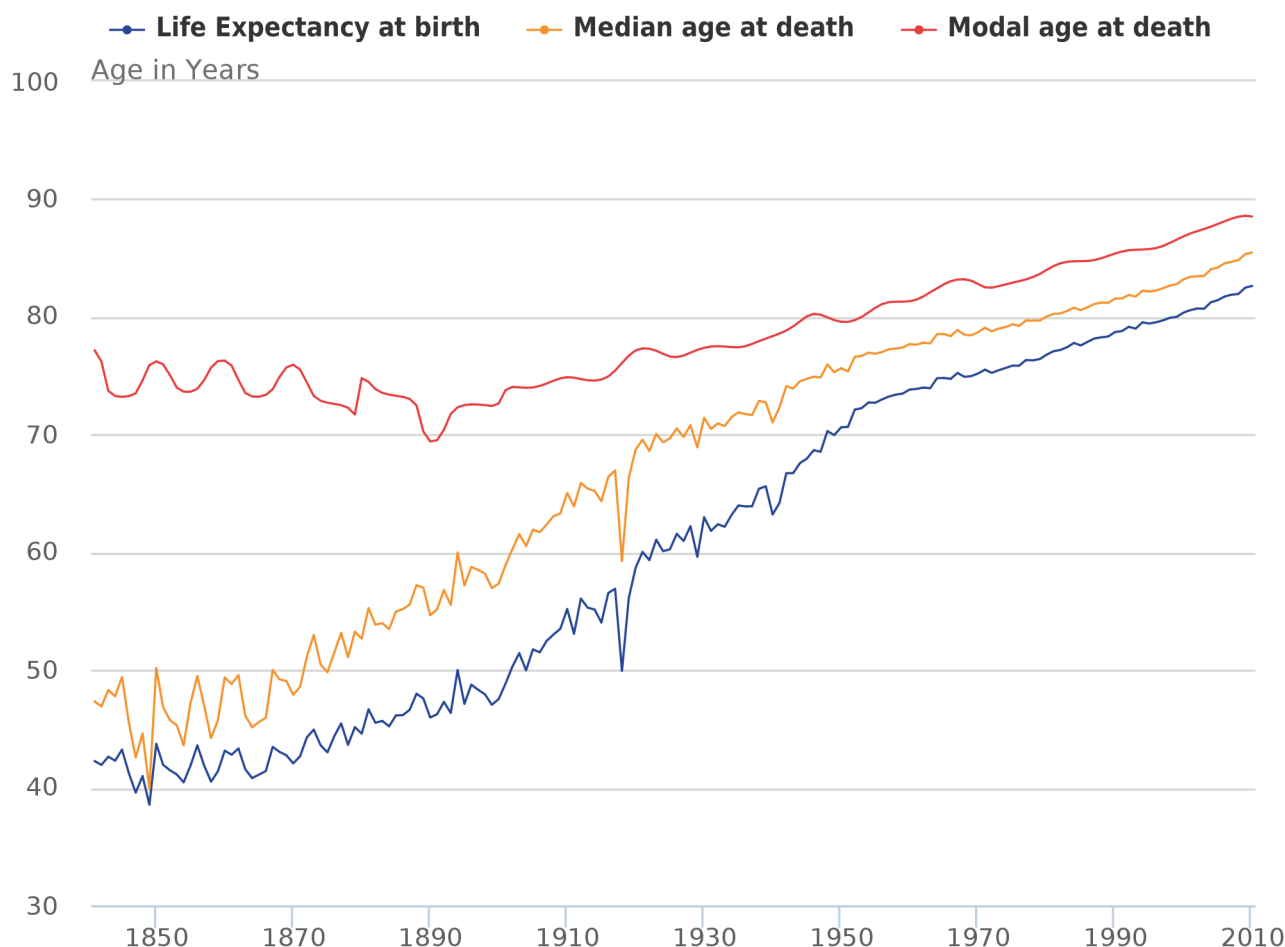
England and Wales



Source: Office for National Statistics

**Figure 2: Average life spans: Life Expectancy at birth (LE), median age at death and modal age at death, 1841 to 2010, females**

England and Wales



Source: Office for National Statistics

Throughout the period, 1841 to 2010, median age at death was higher than life expectancy at birth and modal age at death was the highest. Life expectancy at birth and median age at death had very similar patterns over this time, experiencing substantial increases in the first half of the 20th century. In 1841 life expectancy at birth was 40 years for males and 42 years for females while median age at death was 45 and 47 years respectively. Life expectancy did not increase much in the 19th century and by 1900 was 44 for males and 48 for females. There was more of an increase in median ages at death during this time, which were 52 years and 57 years respectively in 1900. By 1950 these two measures of average life span for both males and females had increased by around 20 years each.

During the 19th century, life expectancy at birth and median age at death were much lower than modal age at death for two reasons. Firstly life expectancy and the median age at death are highly sensitive to changes in mortality among infants and children<sup>1</sup> and during this period deaths at these ages were common. Secondly, deaths to babies and children aged under 10 have been excluded in the calculation of modal age at death. Starting at age 10 avoids the selection of a very young age as the mode<sup>2</sup>, for example in some years during the period 1841 to the early 20th century when infant mortality was very high, it is possible that age 0 would have been selected. Therefore, between 1841 and 1900 the modal age at death was much higher than the other two averages; modal age at death in 1841 was 71 for males and 77 for females and in 1900 it was 68 years and 73 years respectively. Although modal age at death was younger in 1900 than in 1841 this does not indicate a downward trend as the modal age at death was relatively constant during this time and varied year on year between ages 68 to 75 for males and ages 69 to 77 for females. It is likely that the up and down pattern of modal age during this time was mostly because of the relatively low numbers reaching older ages.

During the 20th century, the trends in life expectancy at birth and median age at death have very similar patterns for males and females, although females began the more gradual and relatively smooth year on year increase in average age at death around 1951, some 20 years before males. Modal age at death, however, shows that in the 60 years from around 1910 to 1970 the male and female trends were very different. The female modal age at death, like life expectancy at birth and median age at death, increased throughout this period by around eight years from 75 to 83 years and then continued to 2010, whereas male modal age at death remained relatively constant within the 60 year period, between the ages of 74 and 76.

Since 1970 male modal age at death has been increasing, and over the last 40 years all three measures have followed similar trends. The difference between the highest and lowest of the three measures was just 6 years in 2010 and this difference has remained relatively constant, as in 1970 it was 6 years for males and 8 years for females.

## Notes for Trends in average life span

1. Kannisto V, (2001), Mode and dispersion of the length of life.
2. Robine J et al, (2006) What can be learnt by studying the adult modal age at death?

## 5. Surviving to old age

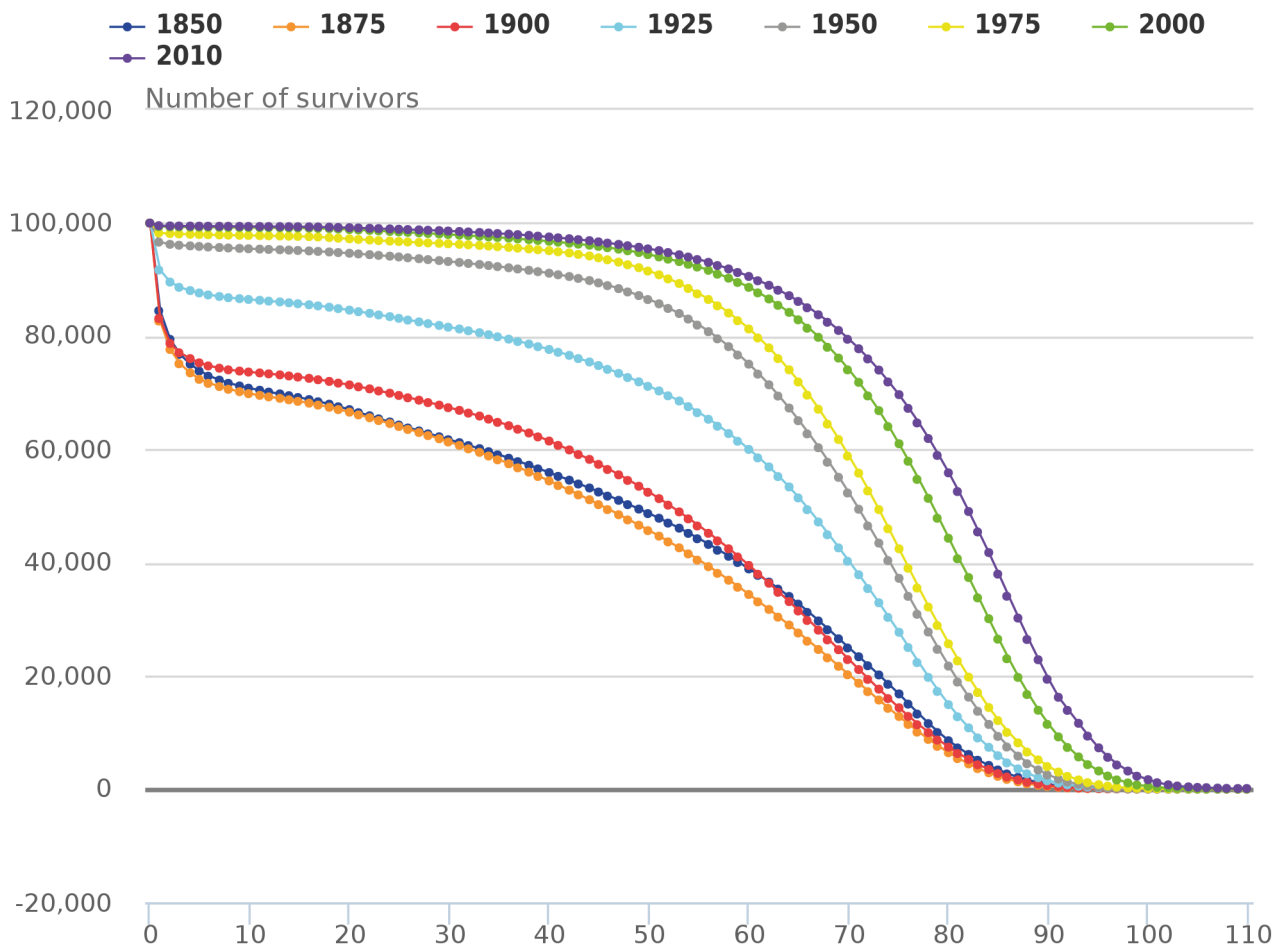
The substantial decline of overall mortality over the last century has made it possible for larger proportions of people to survive to older ages, concentrating deaths into a relatively narrow range of old age. This has made the survival curve (Figures 3 and 4) more rectangular and the age distribution of deaths (Figures 5 and 6) more compressed<sup>1</sup>.

Figures 3 and 4 show the survival curves for the male and female populations in England and Wales for selected years since 1841. The survival curve (the life table  $l_x$  function<sup>2</sup>) begins at age 0 with 100,000 babies and then records the number of survivors at each age as the population moves through the life table and experiences the age-specific death rates for that year. Since everybody ultimately dies, the survival curve falls to zero at whatever age represents the maximum life-span.

The curves in Figures 3 and 4 have become more rectangular in shape over time as the distribution of deaths slides to the right and the slope of the curve appears to be flattening vertically as if it was meeting an invisible wall<sup>1</sup>, illustrated by the grey vertical line<sup>3</sup> on each of the charts. This change in shape reflects the reduction of deaths at young ages and the survival to older ages.

**Figure 3: Number of Survivors by Age, from the Period Life Tables, England and Wales, Males**

Selected Years

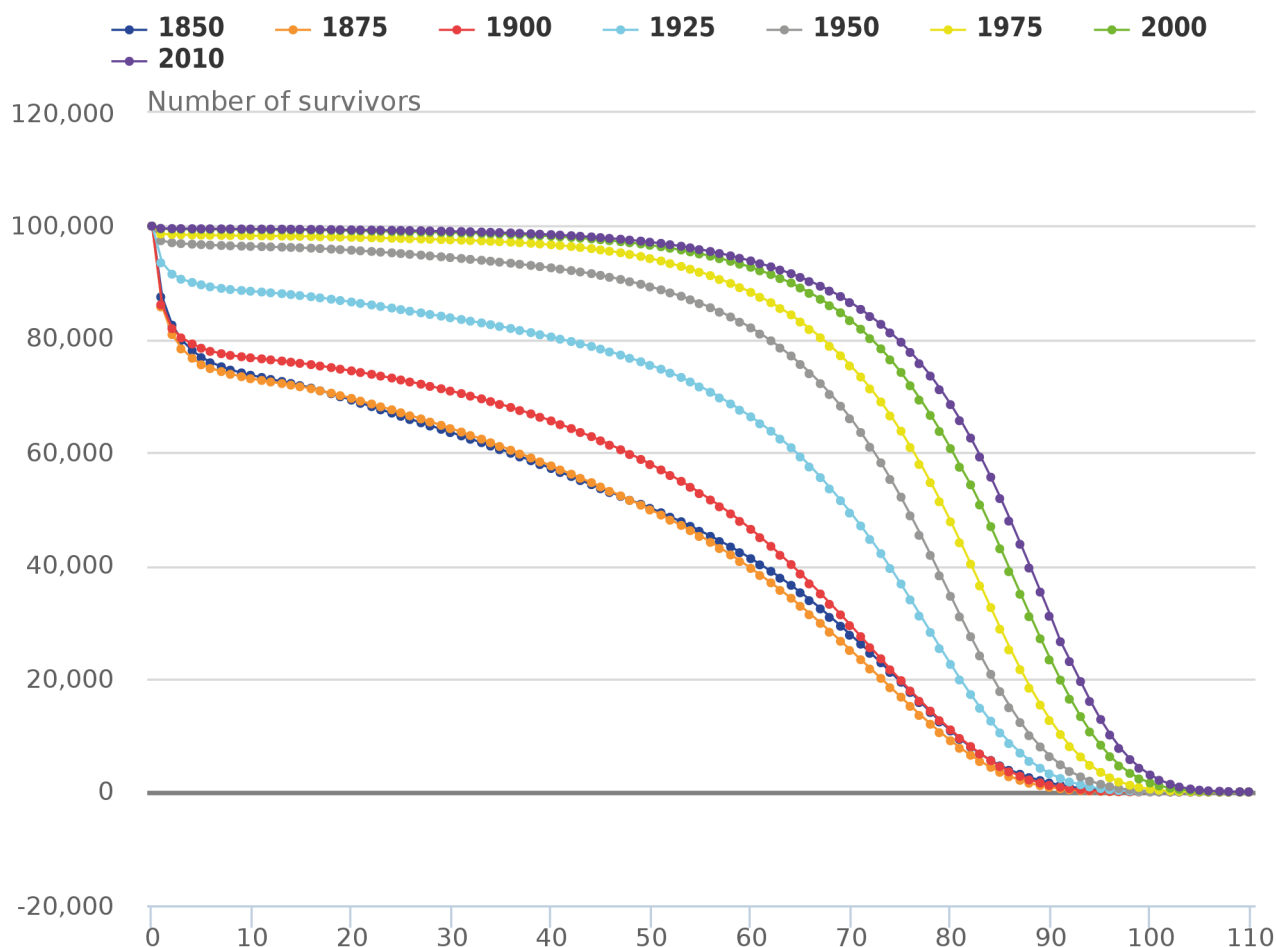


Source: Office for National Statistics



**Figure 4: Number of Survivors by Age, from the Period Life Tables, England and Wales, Females**

Selected Years



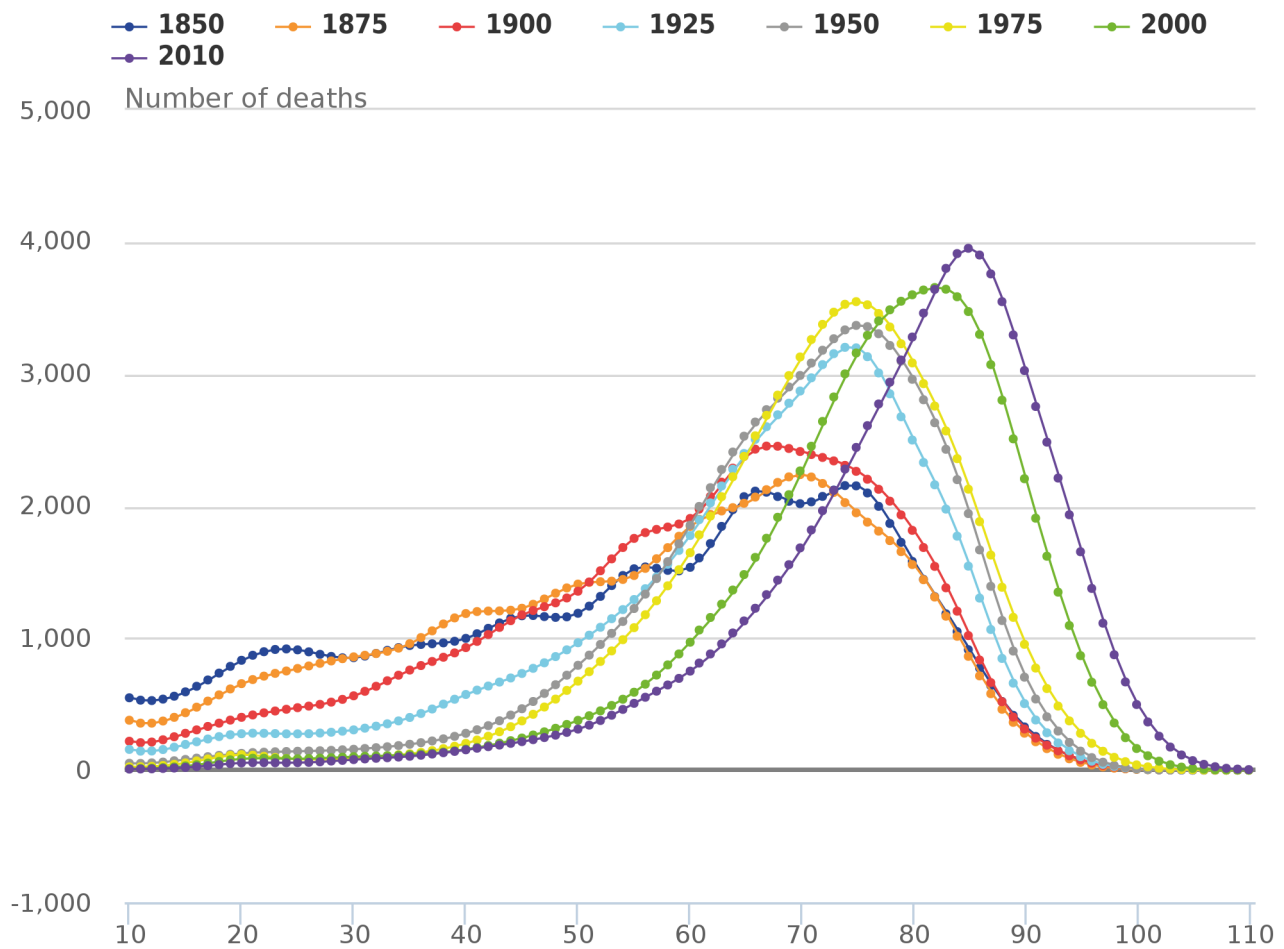
Source: Office for National Statistics

In the years from 1850 to 1925 there is a slope between ages 0 and 5 which is almost non-existent in the years from 1950, showing the decline in the numbers of infant deaths. The improvement in survival to older ages is shown by the increasing age over time at the point where the slope begins its rapid decline. For example, the age at which the number of survivors falls below 90,000 is increasing. In the years 1850, 1875 and 1900, this was before age one for both males and females, in 1925 it was age 2 for males and 5 for females and by 1950 it had reached age 44 for males and 49 for females. This increase has continued and by 2010 it had reached 61 years for males and 67 years for females.

Figures 5 and 6 show the distribution of deaths by age from the life tables (the life table  $d_x$  function<sup>4</sup>). They exclude deaths occurring at ages below 10 years so we can better see the distributions over time at the oldest ages. The charts show the compression of deaths at older ages into a narrower range of ages i.e. the curve becomes narrower. This is particularly noticeable in the 2010 curve in the chart for males. In both Figures 5 and 6 the peak in the number of deaths is both moving to the right, that is increasing in age, and moving upward, meaning more deaths are occurring at the peak or modal age at death. For example, in the life table for 1925 modal age at death for men was 75 years and for women 77 years and three per cent of deaths from the population of 100,000 occurred at these ages. By 2010 modal age at death was 85 and 89 for men and women respectively and the proportion of deaths was four per cent.

**Figure 5: Number of Deaths by Age from the Period Life Tables for England and Wales, Males**

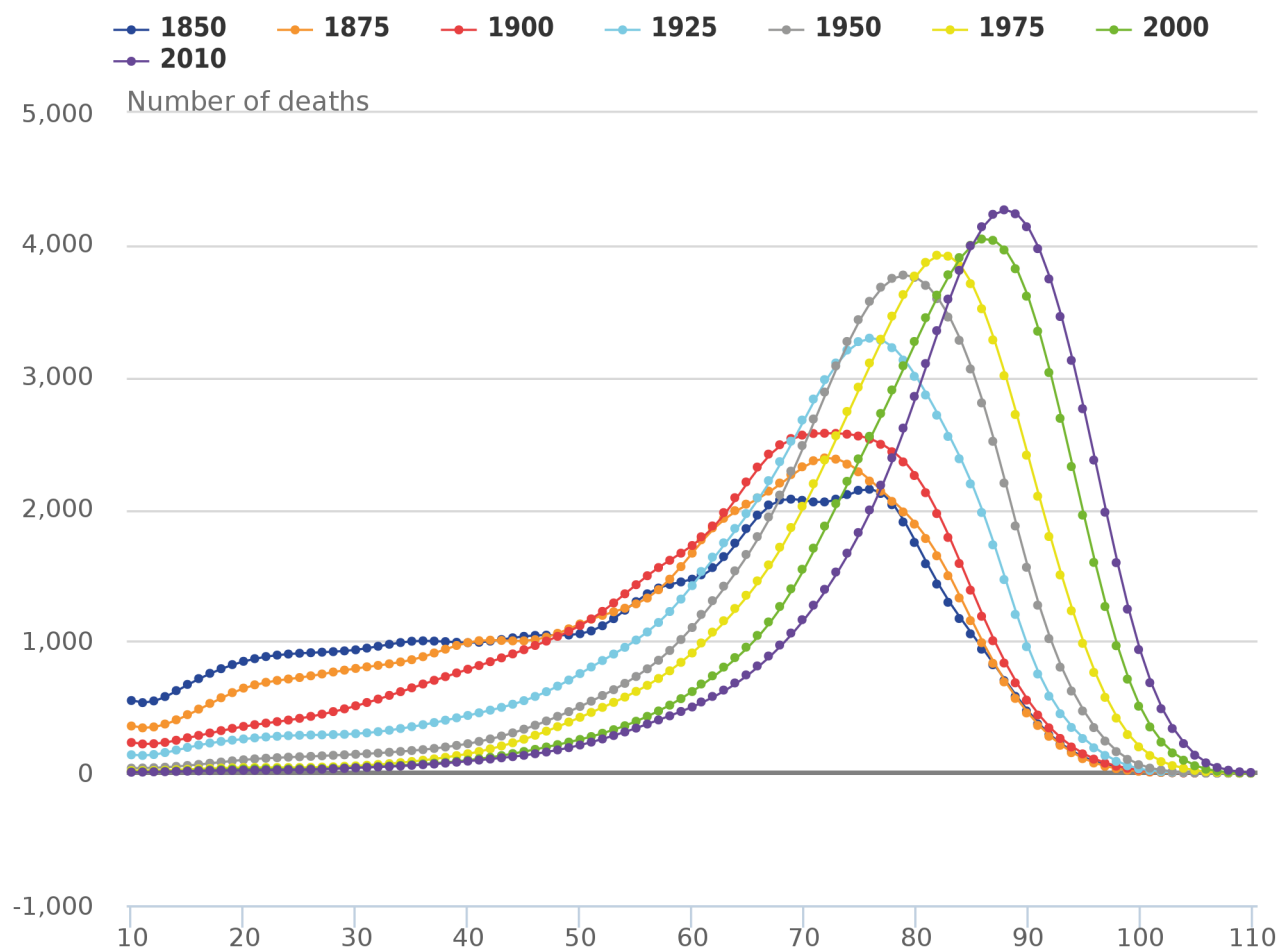
Selected Years



Source: Office for National Statistics

**Figure 6: Number of Deaths by Age from the Period Life Tables, England and Wales, Females**

Selected Years

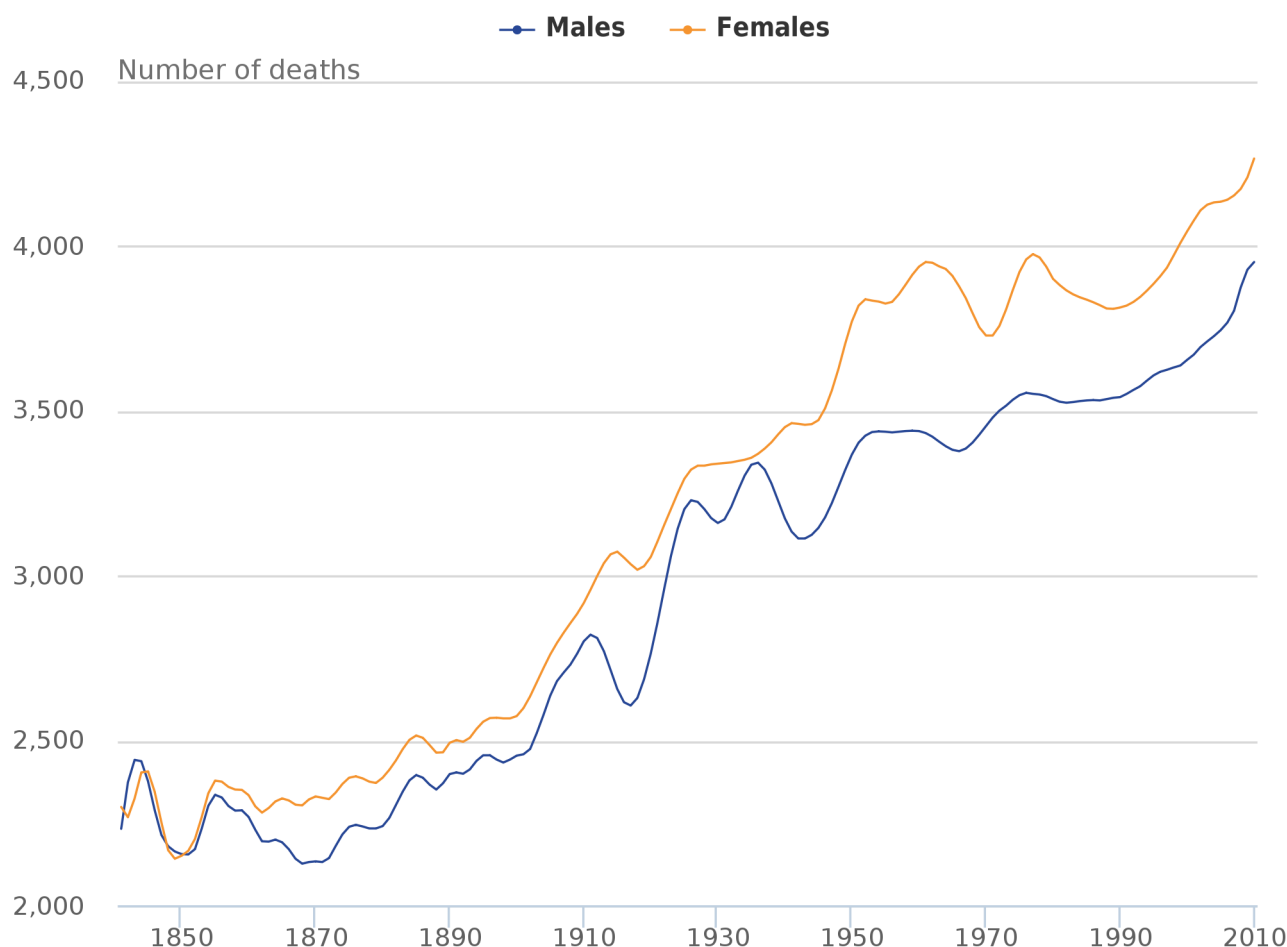


Source: Office for National Statistics

In 1980 James Fries, professor of medicine at Stanford University School of Medicine, proposed that there would be a compression of mortality in populations that were experiencing low mortality at young ages, such as in England and Wales. He noted that life expectancy at birth was increasing faster than life expectancy at older ages suggesting the existence of an upper boundary to the adult life span<sup>1</sup>. Fries' life span theory proposed that in the future (around 2045) populations would reach a modal age at death of 85 with a standard deviation of four years (81 to 89 years), resulting in around 10 per cent of all deaths occurring at the modal age<sup>6</sup>. How close are we in England and Wales to this theory? Figure 7 shows the number of deaths occurring at the modal age for each year from 1841 to 2010. In England and Wales modal age at death in 2010 has reached 85 years for males and 89 years for females (in 1980 it was 77 and 84 respectively) and only around four per cent of all deaths occurred at modal age. So we have surpassed Fries' theoretical 85 years and have a wider age distribution of deaths.

**Figure 7: Number of Deaths at Modal Age at Death from the Period Life Tables, 1841 to 2010**

England and Wales



Source: Office for National Statistics

Fries also predicted that the proportion of very old persons would not increase as we reach an upper limit to the life span. In England and Wales, as in most other countries where mortality is concentrated at older ages, larger percentages of people are surviving to older ages than ever before. In 1980 the percentage of the population aged 85 and over was just over one per cent and by 2010 this had doubled. In addition the estimated number of [centenarians](#) in England and Wales has risen five-fold from 2,280 in 1980 to 11,610 in 2010. The existence of an upper limit to life expectancy is much debated, as we have seen continued increases in life expectancy at birth over the last 50 years of around two and half months per year for males and slightly less for females. The information presented in this report suggests that in England and Wales an upper limit to life span has not yet been reached and that we will almost certainly see further increases in each of the three average ages at death.

## Notes for surviving to old age

1. Thatcher R et al, (2010), The compression of deaths above the mode, Demographic Research, Vol 22, pp 505-538
2.  $l_x$  - the number of survivors to exact age  $x$  of 100,000 live births of the same sex who are assumed to be subject throughout their lives to the mortality rates experienced in the year to which the life table relates.
3. The position of the vertical line is arbitrary and is only used for an illustrative purpose.
4.  $d_x$  - the number dying between exact age  $x$  and  $(x+1)$  described similarly to  $l_x$ , that is  $d_x = l_x - l_{x+1}$
5. Fries J, (1980) Aging, natural death and the compression of morbidity, New England Journal of Medicine, pp 131
6. Robine J et al, (2006) What can be learnt by studying the adult modal age at death?

## 6. Background notes

1. Life tables are produced by ONS on a regular basis and the raw data, numbers of deaths and population, required to produce life tables are available by request from [info@ons.gov.uk](mailto:info@ons.gov.uk) and the [Human Mortality Database](#) for England and Wales back as far as 1841. ONS have produced historic life tables for England and Wales for each year 1841 to 2010 and tables of life expectancy figures are available on the ONS website, but historically only from 1981. Life tables for years before 1981 are available by request to [lifetables@ons.gsi.gov.uk](mailto:lifetables@ons.gsi.gov.uk).
2. The [life table](#) is a purely hypothetical calculation. The basic assumption is that the given number of births, an arbitrary number called the radix (ONS uses 100,000), are subject as survivors pass through each year of age, to the mortality rates prevailing for each age. [Period life tables](#) are calculated using age-specific mortality rates for a given period, with no allowance for any actual or projected future changes in mortality. This means that period life expectancy at birth for a given time period and area is an estimate of the average number of years a newborn baby would survive if he/she experienced the particular area's age-specific mortality rates for that time period throughout his/her life. Life expectancy is the average number of years a person has before death. This is conventionally calculated from birth, but can also be calculated from any specified age. This gives the remaining further number of years a person on average can expect to live given the age they have attained.
3. Details of the policy governing the release of new data are available by visiting [www.statisticsauthority.gov.uk/assessment/code-of-practice/index.html](http://www.statisticsauthority.gov.uk/assessment/code-of-practice/index.html) or from the Media Relations Office email: [media.relations@ons.gsi.gov.uk](mailto:media.relations@ons.gsi.gov.uk)