Estimating the changing population of the 'oldest old'

Ercilia Dini and Shayla Goldring
Office for National Statistics

The population of England and Wales is becoming older. This poses an increasing demand for detailed data on the size and trends of the population at the oldest ages. Using the recently released Office for National Statistics estimates of the population aged 90 and over in England and Wales, this article shows trends in the population of the oldest old and demographic causes of the rapid increase in centenarians during the twentieth century. It also presents further validation of the ONS estimates of the oldest old with estimates from other data sources.

Introduction

The population of England and Wales is becoming older.[1, 2] The ageing of the population is determined by past changes in fertility and mortality. These changes started to gather pace in the late nineteenth and early twentieth century.[1] At that time, birth and death rates were relatively high, with large numbers of deaths occurring during infancy and childhood. Overall, over the past 150 years, there have been falls in both the death and birth rates. These have resulted in changes in the chances of survival into later life and in the size of generations available to survive. Decreases in mortality during the second half of the twentieth century, combined with fertility below replacement level since 1973[3], have resulted in the increasingly aged population seen today. National population projections indicate that population ageing will continue for the next few decades.[4] This is due to the effect of large numbers of people from the 1960s baby boom who are currently of working age, reaching retirement age, combined with smaller numbers of people replacing them in the working population.

As the older population grows and life expectancy increases, information on the size and characteristics of this population becomes more important for policy makers. Until recently, broad age groups have often been used in estimates when describing the characteristics of the population at older ages, for example 65 years and over, or 75 years and over. This is because historically they represented a small proportion of the population and so estimates by finer age banding would be unreliable. However, the increase in life expectancy over the last century means that reaching extreme ages is no longer rare. Recent articles published in *Population Trends* have used the definition of 85 years and over to detail the demographic and social characteristics of the oldest old. [5,6] As these articles note, setting an age limit to identify the oldest old should reflect the dynamic process of population ageing.

There is an increasing demand for detailed data on the size and trends of the population in the oldest ages; in particular for the age 90 years and over. Estimates of the population aged 90 and over by single year of age and sex are required for calculating age specific mortality rates and for population projections.

This article uses the recently released Office for National Statistics (ONS) experimental estimates of the population aged 90 years and over in England and Wales. It shows trends in the population of the oldest old and the demographic causes of the rapid increase in centenarians during the twentieth century. It also validates the ONS estimates of the oldest old with estimates from other data sources.

Data sources

The census is the most authoritative source of information on the population of England and Wales. It is held every ten years and the last census was in 2001. Between censuses ONS mid-year population estimates (based on the census) become the most reliable data source on population by age and sex. At present mid-year estimates of those aged 90 years and over are grouped to increase reliability, preventing detailed analyses of population trends at very old ages. ONS recently released experimental population estimates of the very elderly in England and Wales for 2002 to 2006, by single year of age and sex for ages 90 to 104, and grouped for 105 and over.[7] These estimates were produced using the Kannisto-Thatcher (KT) method.[8] Previous research comparing KT with other methods have been conducted using data for several countries.[1] Brief summaries of the method used by ONS to produce mid-year population estimates and the experimental estimates are shown in **Boxes 1** and **2**.

This article also uses the ONS actual, historical and projected mortality database/life tables for England and Wales. The mortality database/life tables are updated every two years. The latest update was made in early 2008 to take account of the revised population estimates and the new mortality assumptions used in the latest 2006-based national population projections.

This article presents comparisons of ONS experimental estimates for the population 90 years and over with 2001 Census counts and with data from the ONS-Longitudinal Study (ONS-LS). In addition data on numbers of birthday messages from HM the Queen or the Secretary of State for Work and Pensions to individuals aged 100 years were also used to validate the ONS estimates for 2001 and 2006.

Box one

Summary of the method used to construct ONS mid-year estimates of the population in England and Wales (cohort component method)[9]

- Take the previous mid-year resident population and age-on by one year
- Then estimate the natural population change between 1 July and 30 June by adding births and subtracting deaths that occurred between these dates (one year)
- Allow for international migration by adding inflows and subtracting outflows
- Allow for internal migration by adding inflows and subtracting outflows
- Special estimates are made for: UK armed forces, foreign armed forces and dependants, prisoners and school borders

The method is slightly different in census years. The main difference is that instead of ageing on the population by a year, the census-base population is aged on to account for the period between census day and 30 June.

Box two

Summary of the Kannisto-Thatcher method used to construct ONS experimental estimates of the very elderly

The KT method[8] is a version of the survivor ratio method. These methods provide age-specific estimates of population at older ages using data from death registrations.

For a particular cohort at a particular age, the ratio of the number of survivors to the numbers in the cohort who died in the previous k years is estimated from the experience of the previous m cohorts. This ratio is then applied using the most recently available mortality data. To compensate for the fact that reduced mortality at higher ages may increase the size of this ratio over time, a correction factor is applied. The factor is the same for each year of age and constrains the estimates to sum to the national estimate of the population aged 90 and over.

Since the method requires numbers of survivors in the previous m cohorts, these have to be estimated using current year estimates and previous year's deaths data. The calculations are performed sequentially for single years of age, starting with the oldest, which is taken to be 120. For the method to work it is necessary to first assume that the survivorship to age 121 is zero.

Where the cohort in question is not yet extinct the survivor ratio can be estimated from the experience of the previous cohorts.

A limitation to the method is that the addition of a further year's mortality data results in changes in the single year of age estimates for previous years.

Trends in the population of the oldest old

The number and proportion of those aged 85 and over in England and Wales has risen rapidly over the last century. At the start of the twentieth century only 48,000 people (0.1 per cent of the total population) in England and Wales were aged 85 and over. A century later, this number had reached 1 million, a twenty-fold increase, resulting in this group representing 2 per cent of the total population. The 2006-based national population projections show that population growth at the oldest ages is likely to continue, with the number aged 85 and over being projected to be just over 2.5 million in 2031 (4 per cent of the projected total population size).[4]

Figure 1 shows how the overall population age structure has changed since 1901. It is possible to see evidence of the final stage of the first

Figure 1 | Proportions of total population by quinary age group and sex, England and Wales, 1901, 1951 and 2001
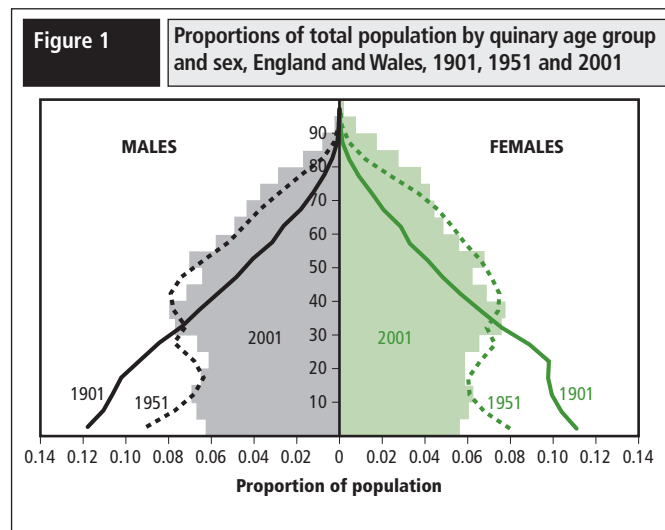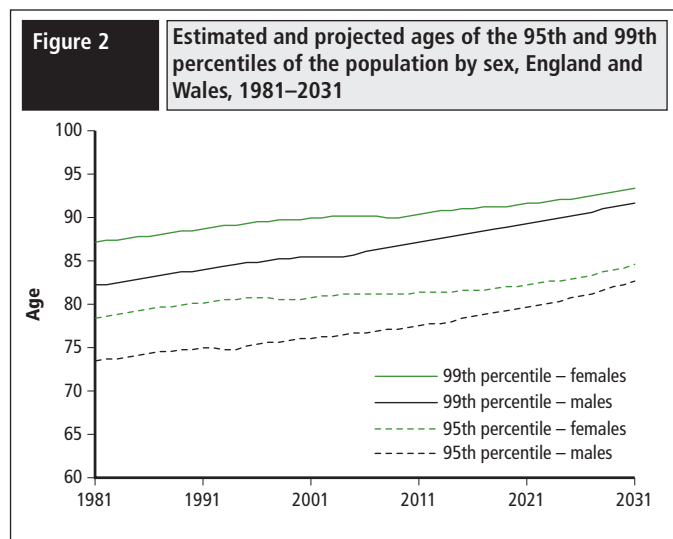
Source: Censuses, Office for National Statistics

demographic transition (that is transition from high to low fertility and high to low mortality) between 1901 and 1951, characterised by the lower proportions of younger people and higher proportions of people aged over 50. In 2001, there is evidence of a further fall in fertility and also increases in the proportion of the population aged 75 and over. The bulge for 2001 around the ages of 35–55 represents the ageing of the post war baby boom generation.

Another way of illustrating how the distribution of the population has changed at the oldest ages is by looking at the uppermost percentiles. **Figure 2** shows the estimated ages above which the oldest 1 and 5 per cent of the population are found. Actual figures are presented for the period between 1981 and 2006 and the projected figures between 2007 and 2031. In 1981, the age above which the oldest 5 per cent of the male population was found was 73; in 2006 the corresponding age was 77, and it is projected that by 2031 the cut-off for the oldest 5 per cent of the male population in England and Wales will have risen to 82 years. For females the corresponding ages separating the oldest 5 per cent of the population from the rest are respectively 78, 81 and 84.

In 2006, 1 per cent of the male population were above the age of 86, but by 2031 1 per cent of the population will be above the age of 92. In 1981, 1 per cent of the female population in England and Wales was above the age of 87. It is projected that by 2031 this percentage of women will be above the age of 93.

The increases in the population at oldest ages are the result of the decline in mortality rates seen during the twentieth century and also the relatively high numbers of births seen between the end of the nineteenth and beginning of the twentieth century.[10] The implied extension of life can be considered an achievement; however, it raises concerns about increases in spending on pensions and health and social care. It also increases the demand for more detailed information on the age structure in the oldest ages.

Inter-censal estimates of the oldest old

As the number and share of the population increases at the oldest ages, reliable estimates by single year of age become more important. **Table 1** presents the recently published ONS estimates of the population aged 90 and over for age groups 90–94, 95–99 and 100 and over, by sex. It also presents the previously unreleased estimates for 2001.

An estimated 373,130 people aged 90 to 99 were resident in England and Wales in 2006. This is a 12 per cent increase from 333,490 in 2001. The number of females at all ages is greater than the number of males because women live longer than men. In 2006 there were about three women aged 90 to 99 for each man aged 90 to 99. However, the gap has narrowed over time reflecting recent relative improvements in male mortality at older ages. Between 2001 and 2006, the number of men aged between 90 and 99 increased by 24 per cent whereas for women the increase was just over 8 per cent.

Figure 3 shows the estimated numbers of male and female centenarians for England and Wales over the period 1911 to 2006. It is estimated just under 9,000 people were aged 100 and over in 2006; a 90-fold increase since 1911, when there were only an estimated 100 centenarians. The increase has not been constant across this period. Between 1911 and 1940, the average annual increase in the number of centenarians was about 2 per cent. The average annual increase was much higher between 1940 and 1980, at about 6.5 per cent. Since 1980 the increase has slowed down slightly to an average of about 5.5 per cent yearly.

Figure 4 shows the ratio of women to men for the population aged 90 and over and 100 and over between 1911 and 2006. Since 1911 female centenarians have always outnumbered male centenarians due to women having on average greater life expectancy. However, the ratio of female to male centenarians has fluctuated over time. At the beginning of the twentieth century, there were about three centenarian women for each centenarian man. The sharp increase in the ratio at the end of the 1950s must be interpreted with caution because of the small numbers of centenarians during the first half of the twentieth century. However, this could reflect the high number of casualties amongst men in colonial wars as well as higher male emigration to Oceania during the 1880s. Subsequent increases in the ratio seen over the last 35 years reflect greater improvements in mortality at older ages amongst women. A sharp increase in the ratio also occurred during the 1990s, which reflects the higher mortality amongst men during the First World War. Since then, the ratio has begun to decrease due to improvements in male mortality, and in 2006 there were seven centenarian women for each centenarian man.

The time series of the ratio of women to men for the population aged 90 and over is much smoother than the equivalent ratio for centenarians, reflecting their larger numbers. The women to men ratio for the population aged 90 and over shows a small but steady increase from two in 1911 to four in early to mid–1990s. The turning point where the ratio has started to decrease due to improvement in male mortality is seen roughly a decade earlier than that seen among centenarians.

| Figure 2 | Estimated and projected ages of the 95th and 99th percentiles of the population by sex, England and Wales, 1981–2031 |

Source: Mid-year estimates and National Population Projections, Office for National Statistics

| Table 1 | Estimated population aged 90 and over by age group and sex, England and Wales, 2001–2006 |

Age/Age group	2001		2002		2003		2004		2005		2006	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
90–94	66,390	207,680	69,660	211,690	72,740	215,260	76,090	218,090	79,220	220,520	80,380	219,420
95–99	10,000	49,420	10,740	51,620	11,510	53,500	12,400	55,160	13,320	57,130	14,400	58,940
90–99	76,390	257,100	80,400	263,310	84,260	268,760	88,490	273,250	92,530	277,650	94,770	278,360
100 and over	720	5,970	770	6,340	800	6,650	880	6,970	990	7,350	1,120	7,850

Source: Office for National Statistics
Notes: Estimates of the very elderly (including centenarians), 2001 estimates have not been published previously. Figures are rounded to the nearest ten people for each age group.
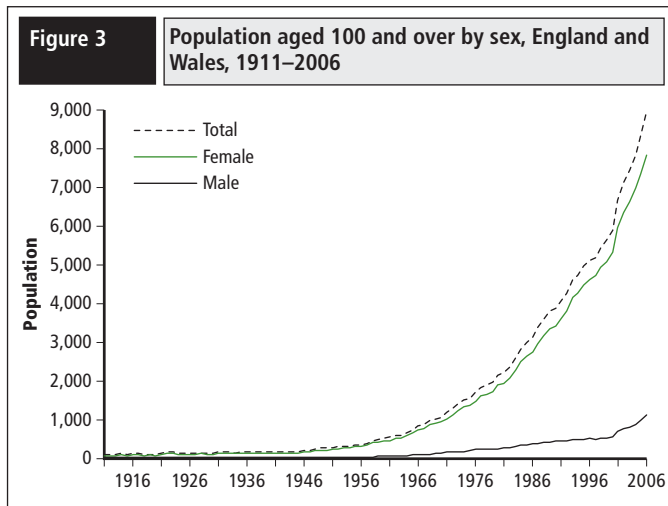
Figure 3 — Population aged 100 and over by sex, England and Wales, 1911–2006

Estimates of the very elderly (including centenarians).
Source: Office for National Statistics
Note: Data prior to 2001 are 1st January; data from 2001 onwards are mid-year
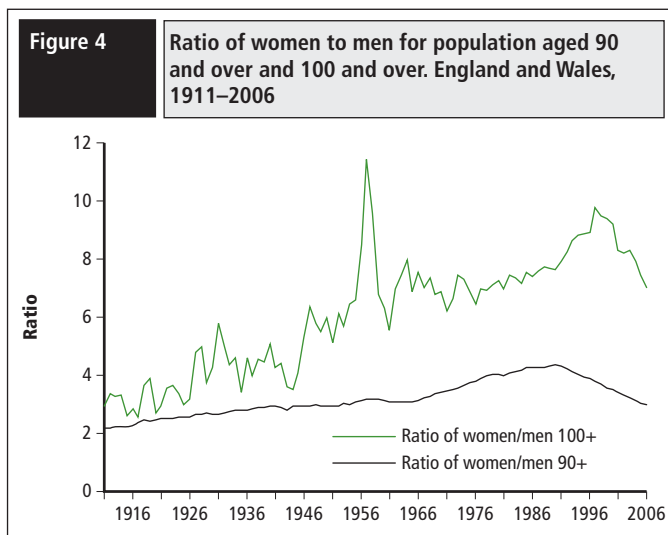
Figure 4 — Ratio of women to men for population aged 90 and over and 100 and over. England and Wales, 1911–2006

Estimates of the very elderly (including centenarians).
Source: Office for National Statistics
Note: For women/men aged 100 and over: data prior to 2001 are 1st January; data from 2001 onwards are mid-year
For women/men aged 90 and over: data prior to 1980 are 1st January; data from 1980 onwards are mid-year

Changes in survival among the oldest old

The accelerating growth of the oldest population in England and Wales over the twentieth and early twenty first centuries is mainly a result of rapid improvements in mortality at older ages. However it is also attributable to increased births a century before and the sharp decline in mortality at ages from childhood up to age 80.[11] Changes in mortality can be assessed using mortality rates. Survival rates are another particularly effective way of demonstrating improvements in mortality. Survival rates from birth to age 80 and from age 80 to age 100 for different birth cohorts are shown in **Figures 5** and **6**. These demographic components are initially examined in isolation. Their combined effect along with the effect in the number of births a century before, survival beyond 100 and other factors are presented in **Table 2**.
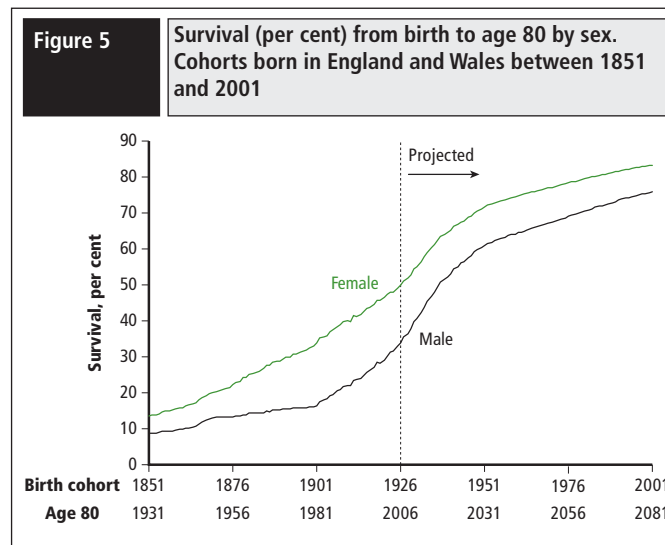
Survival from birth to age 80

Generally, mortality rates have decreased for all ages since the end of the nineteenth century. More recently further decreases have occurred at older ages.[1] This is reflected in the increase in the survival rate from birth to age 80. Figure 5 shows the proportion of males and females who survive or

who are expected to survive from birth to age 80 for cohorts born 1851 to 2001. The estimates are based on actual, estimated historical and projected mortality rates from the 2006-based principal population projections.

Nine per cent of men and about 14 per cent of women born in 1851 survived to their 80th birthday. This proportion increased gradually for those born during the last half of the nineteenth century with the greatest increase in survival seen among females. About 35 per cent of the cohort of women born in 1901 celebrated their 80th birthday in contrast with only 15 per cent of men. The beginning of the twentieth century was the starting point for a steady increase in survival to age 80 for men, but it is also the time at which we see the greatest difference in survival between men and women. A likely explanation for the widening gap between survival of males and females is that many men took up smoking during and after the First World War. [12] About half of the women born during the early 1920s survived to their 80th birthday. The same proportion of survival for men may be seen about 15 years later, by cohorts born during late 1930s.

Based on assumptions for ONS 2006-based national population projections, it is expected that about 75 per cent of men and just over 80 per cent of women born at the end of the twentieth century will survive to their 80th birthday.

Figure 5 — Survival (per cent) from birth to age 80 by sex. Cohorts born in England and Wales between 1851 and 2001
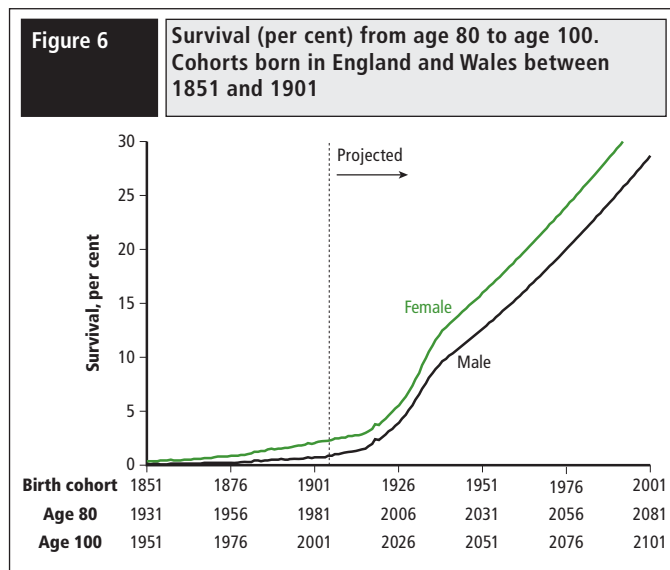
Source: ONS National Population Projections (NPP) actual, historical and projected mortality database/life table – 2006-based principal population projections for England and Wales (available on request)
Note: Pre 1961 mortality rates estimated from English Life Tables and Chester Beattie Tables; 1961–2006 actual mortality rates; post 2006 projected mortality rates

Survival from age 80 to age 100

Mortality rates for the oldest ages started to fall steadily during the second half of the twentieth century. Not only were more people reaching retirement ages but those who did were surviving longer than their predecessors.[1] Figure 6 shows the actual and projected survival from age 80 to age 100 per 100 men and women for cohorts born in England and Wales between 1851 and 2001. For the cohort born in 1851 the likelihood of an 80-year-old reaching their 100th birthday was very small (estimated survival of less than half a per cent). For females born in 1901, this likelihood had increased to just over 2 per cent. The difference in survival from age 80 to 100 between men and women increased during the second half of the twentieth century.

Mortality has improved over the twentieth century and it is projected that it will continue to improve. Survival from age 80 to age 100 for cohorts born during the twentieth century is projected to increase steadily. Of the cohort born at the beginning of the twenty first century (and who reach their 80th birthday), about 30 per cent are projected to survive from age 80 to age 100. The sex differences in survival at this very old age are smallest for the

Figure 6 — Survival (per cent) from age 80 to age 100. Cohorts born in England and Wales between 1851 and 1901

Birth cohort	1851	1876	1901	1926	1951	1976	2001
Age 80	1931	1956	1981	2006	2031	2056	2081
Age 100	1951	1976	2001	2026	2051	2076	2101

Source: ONS National Population Projections (NPP) actual, historical and projected mortality database/life table – 2006-based principal population projections for England and Wales (available on request)
Note: Pre 1961 mortality rates estimated from English Life Tables and Chester Beattie Tables; 1961–2006 actual mortality rates; post 2006 projected mortality rates
Long-term assumptions for the 2006-based national projections are available from the Government Actuary's Department.[13]

cohorts born between 1920 and 1930. This difference is expected to increase slightly for cohorts born after 1930 and is then expected to remain constant.

Combined effect of demographic components

Estimates of the contribution of each of the demographic components to the rapid increase in centenarians seen between 1951 and 1996 have been published previously.[11] Table 2 presents an update using a similar method. It shows the contribution of the demographic components to the increase in centenarians for the 50 year period 1951 to 2001, and the two 25-year periods 1951–1976 and 1976–2001. It also includes the contribution of the demographic components to the projected increase in centenarians for the period 2001–2051, and the two 25-year periods 2001–2026 and 2026–2051.

Therefore, it allows differences in the drivers of actual and projected centenarian numbers over the period to be seen more clearly. The components analysed are the number of births and the survival of these birth cohorts to age 80, survival from age 80 to age 100, the ratio of survival beyond the age of 100 and 'other reasons'. The method is approximate. For example, it uses as an indicator of the effect of births the ratio of births around the year of those aged 100 (births in 1851, 1876, 1901, 1926 and 1951), whereas clear differences in birth numbers in the previous years also contribute. Care should be taken in the interpretation of the component 'other reasons' as this element is a calculated residual. It will reflect some real reasons not captured by the other components, such as the effects of war deaths, and of migration, but it will also capture the effect of the errors in approximations in the other components. The effect of the demographic components on the increase in centenarians is multiplicative.

There was a 14-fold increase in male centenarians and a 23-fold increase in female centenarians over the last 50 years of the twentieth century. Between 1951 and 2001 the demographic components that most contributed to the increase of both male and female centenarians were improved survival from birth to age 80 and improved survival from age 80 to 100. The relative growth in the number of births between 1851 and 1876 was greater than the relative increase between 1876 and 1901. This contributed to the number of births being a relatively larger component of the increase in centenarians between 1951 and 1976, than for the period 1976 to 2001. Increased survival from birth to age 80 among males and

females born in 1876, compared with those born in 1851, also represents a larger component of the increase in centenarians than corresponding increases in survival seen for the 1901 cohort when compared with the 1876 cohort. This is more apparent for males than females, and is supported by the faster pace of increase in survival from birth to age 80, seen for males born in 1851 as opposed to 1876 (Figure 5).

Improvement in survival at the oldest ages (survival from age 80 to age 100) is greater among men than among women in the period 1976 to 2001. It has to be noted that for both men and women, increases in survival of the oldest old between 1976 and 2001 are the result of accumulated improvements over previous years. The ratio of improvement in survival beyond 100 seems to be constant from 1951 to 2001. While we are not seeing rapid improvements in the survival beyond age 100, continued small improvements may call into question the belief that somewhere above 100 years there is a maximum lifespan which remains fixed. [14]

The projected demographic components of centenarian increase suggest that the contribution of improvements in survival at the oldest ages (survival from age 80 to 100) is set to increase. The greatest increases will be seen amongst men born during the first quarter of the twenty first century. Also expected to show a slight increase are the demographic components 'other reasons', particularly amongst men. However, for the reasons explained previously, care should be taken in its interpretation.

Table 2 — Demographic components contributing to actual and projected increase in male and female centenarians in England and Wales, 1951 to 2051

Demographic component	Period of time (years)			Period of time (years)		
	1951–1976	1976–2001	1951–2001	2001 to 2026	2026–2051	2001–2051
Male						
Number of births	1.4	1.1	1.6	0.8	1.0	0.8
Survival from birth to age 80	1.5	1.2	1.9	2.1	1.8	3.7
Survival age 80 to 100	2.0	2.8	5.6	5.7	3.2	18.2
Ratio of survival beyond 100	1.1	1.1	1.2	1.2	1.3	1.6
Other reasons	1.0	0.7	0.7	1.5	1.1	1.7
Increase in centenarians	**4.8**	**2.8**	**13.5**	**16.6**	**8.4**	**138.7**
Female						
Number of births	1.4	1.1	1.6	0.8	1.0	0.7
Survival from birth to age 80	1.6	1.5	2.5	1.5	1.4	2.1
Survival age 80 to 100	2.4	2.4	5.8	2.7	2.9	7.7
Ratio of survival beyond 100	1.1	1.1	1.2	1.1	1.3	1.5
Other reasons	1.0	0.9	0.9	1.2	1.1	1.3
Increase in centenarians	**6.0**	**3.9**	**23.2**	**4.0**	**6.0**	**23.7**

Source: Office for National Statistics
Note: Period 1951–2001 – actual number of births and mortality rates; period 2001–2051, actual number of births and mortality rates up to 2006; projected from 2007 onwards.

Life expectancy at age 80

There is evidence that increases in the population of centenarians over the twentieth century were largely a result of increases in survival between age 80 and 100 and birth to age 80 as well as increases in the size of the birth cohorts available to survive. The increases in survival from birth to age 80, combined with the increases in survival from age 80 to 100 seen over the second half of the twentieth century, are expected to continue. This suggests that considerable extension to length of life has been and will continue to be achieved at very old ages.

Table 3 presents the life expectancy at age 80 for cohorts born between 1901 and 1961 and the estimated and projected population aged 80 between 1981 and 2041. Life expectancy at age 80 for the cohort of females born in England and Wales at the beginning of the twentieth century was about eight years. The estimated mid-year population of females aged 80 years in

1981 was 152 thousand.[15] The cohort of females born in England and Wales in 1961 is expected to live, on average, for a further 13 years after their 80th birthday in 2041. The population of females aged 80 in 2041 is projected to be twice the size of that of the same age in 1901.

Remaining life expectancy at age 80 for cohorts of men born during the twentieth century has increased and is expected to increase at a greater pace than that for women. Life expectancy at age 80 for the cohort of men born in 1901 was six years but will be 12 years for the cohort born in 1961. The population of men aged 80 in 1901 was 74 thousand, that is, half that of women of the same age. The population of men aged 80 years projected to be alive in 2041 is 3.5 times larger than that in 1901. The older population is growing and is projected to continue to grow. In addition, expectation of life at older ages is expected to continue to increase.

Table 3	Life expectancy at age 80 and estimated and projected population aged 80 by sex, England and Wales				
Birth cohort	Year aged 80	Life expectancy at age 80 (years)		Population aged 80 (in thousands)	
		Male	Female	Male	Female
1901	1981	6	8	74	152
1911	1991	7	8	96	172
1921	2001	8	9	127	202
1931	2011	9	11	136	180
1941	2021	11	12	157	187
1951	2031	12	13	207	244
1961	2041	12	13	252	295

Source: Office for National Statistics
Note: Population aged 80 from 1981 to 2001 are mid-year estimates and are available from the NS- website.[15]
Population aged 80 from 2011 to 2041 are ONS National Population Projections 2006-based projections available from GAD website.[16]

Comparisons of ONS estimates of the oldest old with other data sources

In September 2007 ONS released experimental estimates of the 'very elderly' (including centenarians) for England and Wales for mid-year 2002 to mid-year 2006.[7] The estimates were produced using the Kannisto-Thatcher (KT) method.[8] The KT method has previously been used to provide estimates of the population at older ages for national population projections and in the calculation of age specific mortality rates for national life tables.

The series of estimates up to and including 2001 were not released because of concerns over the differences between the Census counts of the population aged 90 and over and the corresponding estimates. The greatest difference was found for male centenarians.

Results from further validation conducted to understand the differences between the 2001 Census counts and ONS estimates are presented in **Table 4** below. Comparable sources of population data are scarce, particularly for older ages. However, comparisons have been made between the ONS 2001 estimates of population aged 90 and over in England and Wales with corresponding estimates from the ONS -LS. Data on correspondence from HM the Queen or the Secretary of State for Work and Pensions to individuals aged 100 years (**Box 4**) were also used to validate the estimates for 2001 and 2006.

2001 Census and ONS estimates

The differences between the estimates are relatively small for ages 90 and over (Table 4).

This is expected because the estimates are constrained to mid-year estimates of the population aged 90 and over, which are based upon the Census counts aged forward and adjusted using the cohort component method. The small difference can be partly explained because the Census reference date is 29 April 2001, whereas the ONS mid year estimates are for 30 June 2001 and also because of subsequent adjustments made to population estimates.[17,18]

Table 4	2001 Census and ONS estimates of population by age group and sex, England and Wales, 2001				
Age group	ONS estimates		2001 Census		Relative difference ONS estimates and Census	
	Male number	Female number	Male number	Female number	Male per cent	Female per cent
90 and over	77,110	263,070	75,669	260,058	2	1
90–94	66,390	207,680	62,275	202,905	7	2
95–99	10,000	49,420	11,656	50,331	−14	−2
100 and over	720	5,970	1,738	6,822	−59	−12

Source: Office for National Statistics
Note: Negative relative differences: ONS estimates are smaller than Census counts

The Census count of male centenarians (1,738) was 2.4 times greater than the ONS estimate (720). It is recognised that for any census age distributions at advanced ages, those aged 85 and over can suffer from serious reporting problems, with age exaggeration in older ages generally considered to be common. Most reporting problems have been found among reported ages of 95 and over.[19] Previous publications have shown that the numbers of centenarians recorded in England and Wales were overestimated in the 1971, 1981 and 1991 Censuses.[20,21,22] It seems likely the same has occurred with the 2001 Census at the oldest ages.

2001 Census, ONS-LS and ONS estimates

Data from the ONS-LS were used for comparisons with the 2001 Census and ONS estimates of population aged 90 and over. Age groups 90 to 94 and 95 and over were used for these comparisons.

The ONS-LS links Census and vital events data for a one per cent sample of the England and Wales population from 1971 onwards.[23] The longitudinal nature of this dataset makes it possible to check birthdates given by members across censuses and any vital event registrations. This is useful because analysis of the ONS-LS shows that often birthdates and corresponding ages given for members are inconsistent across censuses and also vital registrations.

ONS-LS data have been selected for members enumerated in the 1991 and 2001 Censuses. The selection method was carried out to ensure a robust estimate of the subgroup of LS members aged 90 and over in 2001. Only LS members with a consistent age reported across previous censuses and vital event registrations were selected. **Box 3** gives details of the ONS–LS and the selection rules.

The results indicate that there was some mis-reporting of age at the oldest ages, as the ONS-LS estimates are consistently lower than the respective Census counts (**Figure 7**). It is also possible that multiple enumeration has occurred at these very old ages in the Census. ONS-LS data correct for multiple enumeration and LS members are not imputed.

The results show that ONS estimates for males and females aged 90 to 94 are slightly higher than both Census counts and ONS-LS members enumerated using the selection method described in Box 3. While small differences are likely because of the different reference dates (Census and ONS-LS 29 April 2001, ONS estimates 30 June 2001), there does seem to be some evidence that KT method may be over-estimating slightly the population aged in their early 90s. Proportionally the overestimation is small, as the ONS experimental estimates are 3 per cent larger than the Census and 11 per cent larger than the ONS LS estimate.

Box three

ONS Longitudinal Study and selection method used to obtain robust estimates of LS members aged 90 and over enumerated in the 1991 and 2001 Censuses

The ONS Longitudinal Study (LS) contains linked census and vital event data for one per cent of the population of England and Wales. Information from the 1971, 1981, 1991 and 2001 Censuses is linked with life events information (i.e. members' birth, death and cancer registration). Sample selection is based on birth dates, using four dates (day and month) to create a sample which is representative of the population of England and Wales.

The selection method used in the present study to estimate LS members aged 90 and over enumerated in the 2001 Census selects LS members enumerated at the 1991 Census and those entering/re-entering the study between the 1991 and 2001 Census Days. Age is calculated as age on Census day in 1991. All dates of birth stated at any vital event or census enumeration were examined. Where dates of birth differed the following rules were used to decide the most likely age at Census Day in 1991.

1. Where dates of birth differed but calculated ages (in years) did not, no change was made.

2. Where two different calculated ages were generated but one was more frequent (for example, three censuses gave corresponding ages but a death registration presented a different age), the age occurring most frequently was selected.

3. Where two different calculated ages were generated but both occurred the same number of times and the difference between ages was three years or lower, the minimum age was selected.

4. Where three different calculated ages were generated but one was more frequent than the combined frequencies of the other two (for example, the same age was given at three censuses but a death and cancer registration gave different ages) the age occurring most frequently was selected.

5. Where three different calculated ages were generated but one occurred the same number of times as the other two combined (e.g. same age at two census but differed at death and cancer registration) and the maximum difference between all ages was three years or less the minimum age was selected.

6. Where more than three ages were generated or in the case of rules 3 and 5 above the age difference was greater than three years the records for that LS member were excluded from the analysis.

Also included in the selection were LS members who had not been accounted for in the 1991 Census and those who had entered the LS sample in 2001 but had no previous LS history. These included both LS members traced and untraced (with no record) in the National Health Service Central Register (NHSCR) computer system. The selection method described above was applied for the selection of these LS members.

The ONS-LS estimates shown in Figure 7 have been calculated by multiplying the sample figures by the sampling fraction (100/1.09). These estimates represent the population aged 90 and over as in the 2001 Census after adjusting for mis-reported age. They are subject to sampling error. The ONS-LS estimates refer to 29 April 2001 (Census Day).

Figure 7	ONS experimental, 2001 Census and ONS-LS estimated population, ages 90–94 and 95 and over for males and females in England and Wales
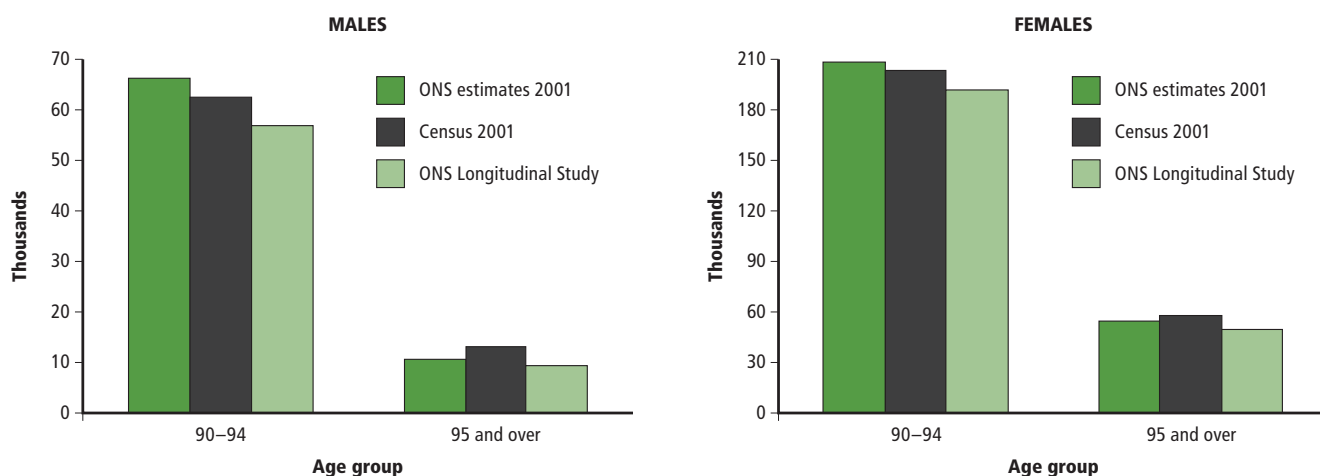
The grouped ONS estimate for males aged 95 and over is in reasonable agreement with the ONS-LS estimate. The census count of males aged 95 and over is higher than both ONS and ONS-LS estimates. For this age group, the relative difference between ONS and ONS-LS estimates is smaller than the relative difference between ONS estimates and the census count.

Birthday messages from HM the Queen and Secretary of State for Work and Pensions

ONS estimates of people aged 100 years in 2001 and 2006 were compared with the number of birthday messages from HM the Queen or the Secretary of State for Work and Pensions to residents in England and Wales. Box 4 gives details of the data source.

Table 5	ONS estimates of the population aged 100 and the number of birthday messages from HM the Queen or the Secretary of State for Work and Pensions to residents aged 100, males and females, England and Wales, 2001 and 2006.

Year	ONS estimates		Birthday messages*	
	Male	Female	Male	Female
2001	347	2,524	476 (392)	3,119 (2,584)
2006	527	3,219	630 (521)	3,710 (3,115)

*in brackets: number of birthday messages adjusted for subsequent deaths by applying half the probability of dying between exact age 100 and exact age 101
Sources: ONS estimates, birthday messages from HM the Queen or the Secretary of State for Work and Pensions, Department for Work and Pensions.
Note: Birthday messages issued to residents in Great Britain. An adjustment was made to estimate the numbers in England and Wales only. For details of the method see Box 4.

Box four

Birthday messages from HM the Queen and the Secretary of State for Work and Pensions

Data on the number of congratulatory messages sent by HM the Queen or the Secretary of State for Work and Pensions to mark a 100th birthday during 2001 and 2006, were used to compare with the ONS estimates for age 100.

Residents in Great Britain are entitled to receive a congratulatory 100th birthday card from HM the Queen or the Secretary of State (for non-British nationals), if they accept a visit from the Pensions Service to confirm their birthday. However, if they don't wish to receive a card or are not on the Pension Service list and do not request a card themselves, they will not be counted in the dataset.

The data used for the comparison referred to birthday messages sent to residents in England, Wales and Scotland. An adjustment was made to estimate the population receiving a birthday message in England and Wales only. For 2006 the estimated population aged 100 in Scotland was subtracted from the birthday messages sent to individuals aged 100 in Great Britain. For 2001, the adjustment was based on the proportion of individuals aged 100 out of the population aged 90 and over seen in Scotland in 2006.[24]

The numbers of birthday messages refer to those who have survived to exact age 100 in a calendar year. The ONS experimental estimates relate to the population aged between 100 and 101, that is 100.5, resident in England and Wales at mid-year (30 June). Given the high mortality rate at this age we can assume that some of those receiving birthday messages will not be alive at the mid-year point and therefore, will not be included in the estimate of the population. An adjustment was made to the number of messages issued by applying half the cohort mortality rate to the numbers of messages issued in each calendar year (adjusted estimates shown in brackets in **Table 5)** to make them more comparable with the ONS experimental estimates. The comparison in Table 5 shows that ONS estimates are in good agreement with the numbers of birthday messages issued.

Key findings

- The fastest increase in numbers of centenarians was seen between 1940 and 1980.
- Increases in survival between age 80 and 100 have contributed most to the increase in centenarians seen between 1951 and 2001.
- The large cohorts born in the second half of the nineteenth century contributed to the fast increase in centenarians seen between 1951 and 2001.
- Survival rates between age 80 and 100 are projected to increase; the greatest increases are projected for men born during the first quarter of the twenty first century.
- The ONS–Longitudinal Study provides evidence that supports the ONS estimates of population aged 95 and over.
- The number of congratulatory messages sent by HM the Queen or the Secretary of State for Work and Pensions to mark a 100th birthday during 2001 and 2006 support the ONS estimates of population age 100 years in those years.

Conclusions

This article has reported on the increasing number of the oldest old in England and Wales seen during the twentieth century, and has highlighted that this trend is set to continue over the next few decades. It has explained the main components driving this change and also provided an indication of their relative contribution to population change at the oldest ages.

The analysis has shown that the rapid increase seen in the population of centenarians during the second half of the twentieth century was driven by the increase in births in the second half of the nineteenth century, the decrease in mortality in infancy and childhood which began at the end of the nineteenth century, and the substantial increases in survival from age 80 to 100 experienced by these cohorts. The decomposition of the demographic components showed that the decline in mortality beyond age 80 contributed most to the increase in the population of centenarians.

The analysis presented in this article shows that the cohorts born in 1951 and 1961 are expected to live about 12 years after their 80th birthday. By 2031 the population aged 80 and over in England and Wales is estimated to be 4.8 million; and the population aged 85 and over is estimated to be just over 2.5 million.[4] This is due to increasing survival at the oldest ages which is projected to continue during the twenty first century. In addition, the numbers of people aged 85 and over are projected to rise further between 2031 and 2035, and between 2041 and 2057 because of the increased numbers of births 85 years previously.

Robust estimates of the population at very old ages and information on their health and social characteristics are of increasing importance. They will provide the base for planning of health care and social services. The growing importance of estimates and information for this increasingly diverse age group has been addressed earlier in a cross-government strategy report.[25] This has been emphasised by non-governmental organisations such as Age Concern in their recent report. [26]

ONS has recently released experimental estimates of population aged 90 and over by sex in England and Wales for years 2002 to 2006. This article includes the previously unpublished estimates of population aged 90 and over by sex for 2001. It also presents further, more recent validation of these estimates with estimates from other data sources.

Acknowledgements

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