Australian

Life Tables

2010-12

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DEFINITIONS OF SYMBOLS

Australian Life Tables 2010-12 sets out the following functions:

l_x = the number of persons surviving to exact age x out of 100,000 births

d_x = the number of deaths in the year of age x to (x + 1) among the l_x persons who are alive at the beginning of that year

p_x = the probability of a person aged exactly x surviving the year to age (x + 1)

q_x = the probability of a person aged exactly x dying before reaching age (x + 1)

μ_x = the force (or instantaneous rate) of mortality at exact age x

$\mathring{e}_x$ = the complete expectation of life (that is, the average number of years lived after age x) of persons aged exactly x

L_x = the total number of years of life experienced between age x and (x + 1) by l_x persons aged exactly x

T_x = the total number of years of life experienced after age x by l_x persons aged exactly x

NOTE: Figures in the Tables are rounded and hence the usual identities between these functions may not be satisfied exactly.

INTRODUCTION

This publication presents the *Australian Life Tables 2010-12* (the Tables), which are based on the mortality of male and female Australians over the three calendar years centred on the 2011 Census of Population and Housing (the Census).

The report discusses the major features of the 2010-12 Life Tables and reviews developments in mortality, both since the previous Australian Life Tables and over the longer term. A number of measures of longevity are considered and the historic declines in mortality rates are used to estimate mortality improvement factors. The impact of mortality improvement on life expectancies is considered under two improvement scenarios. The lifespan distribution is also considered.

This discussion is followed by the Tables themselves, together with the technical notes on their construction. The appendices include supporting information referred to in the text.

The Tables are also available on the AGA website (www.aga.gov.au/publications) together with past mortality rates and life expectancies and the mortality improvement factors referred to in the body of the report.

This is the eighteenth in the series of official Australian Life Tables. Tables were initially prepared by the Commonwealth Statistician, but since the 1946-48 Tables have been the responsibility of the Australian Government Actuary (or Commonwealth Actuary as the position was formerly designated). The first three Tables, for the years 1881-90, 1891-1900 and 1901-10, took into account deaths over a ten year period and incorporated information from two Censuses. All subsequent Tables have been based on deaths and estimates of population over a period of three years centred on a Census. Since 1960-62, the Censuses, and hence the Tables, have been produced quinquennially.

P. Martin FIAA
Australian Government Actuary

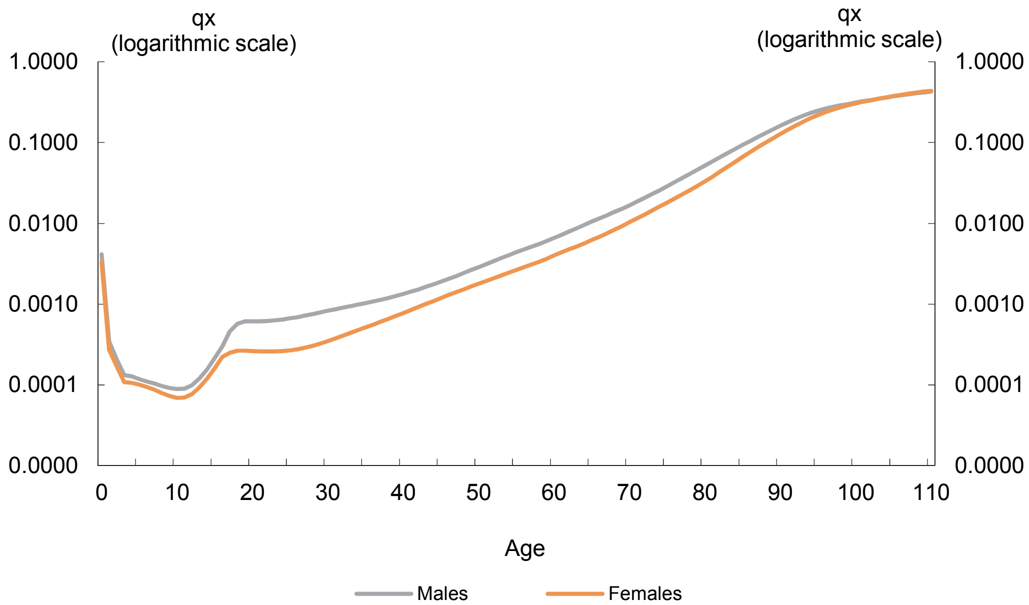
December 2014

1. Mortality of the Australian population

1.1 Results for 2010-12

Figure 1 shows the mortality rates reported in the 2010-12 Life Tables on a logarithmic scale.

Figure 1: Mortality rates 2010-12



The pattern of mortality observed in Figure 1 is typical of developed countries. Mortality rates during the first year of life are relatively high for both males and females, primarily due to congenital abnormalities and perinatal conditions. After the first year of life, an increasing capacity to ward off disease and limited exposure to life threatening situations results in rapidly dropping mortality rates. Around age 10, mortality rates reach a minimum. At this point, the probability of dying within the year is less than 1 in 10,000.

Accidents are the single largest cause of death in childhood. With the developing autonomy of the teenage years, mortality attributable to accidental or self-inflicted causes increases steeply, particularly for males. This growth slows and is briefly, and almost imperceptibly, reversed in the early twenties before rates start to rise again as the falling mortality from accidents is more than offset by increasing rates of death due to disease. The shape of the curves around ages 18 to 21 has not changed much since the 1990-92 Tables, when the previous ‘accident hump’ flattened for the first time in several decades.

The shapes of the mortality curves for males and females are similar, but the absolute rates are different with female mortality being less than male mortality at all but the oldest ages. This difference is consistent with a number of factors, including:

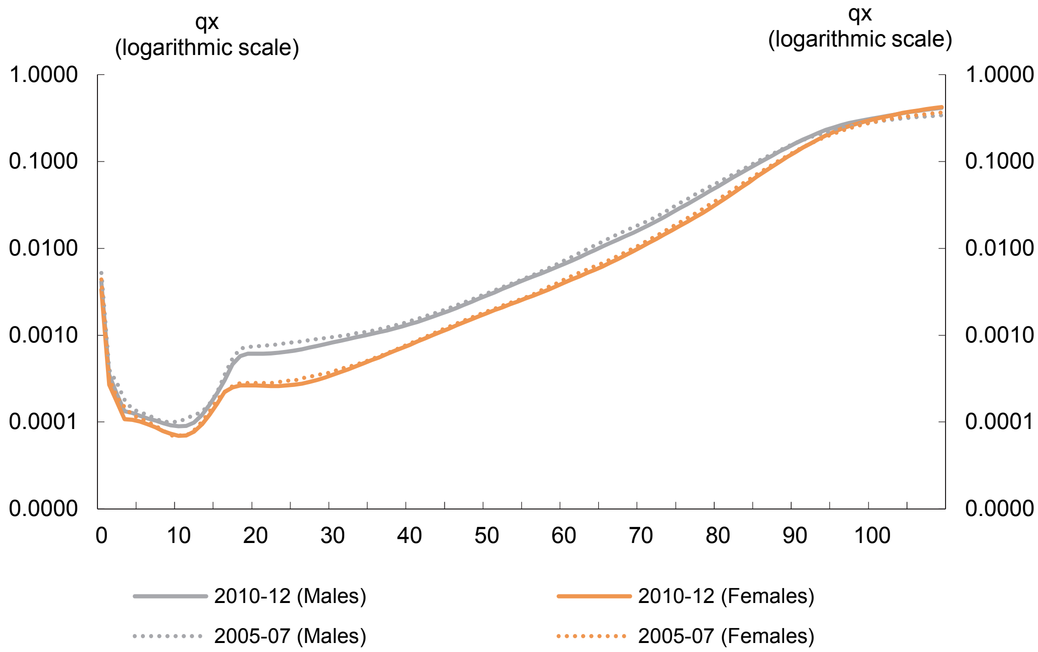
- a greater level of risk-taking behaviour by young males;
- the greater hazards associated with some occupations which have traditionally been dominated by men (such as mining and construction);
- the differences in the incidence of some diseases between men and women; and
- the differences in fatality from diseases which affect both genders.

The first two of these factors relate to behavioural differences, including gender stratification in the labour force, rather than physiological differences between men and women. Physiological differences may, however, in part explain the behavioural divergence. The latter two factors could be expected to be the result of both physiological and lifestyle differences.

1.2 Changes since 2005-07

Figure 2 charts the mortality rates from the current Tables together with those reported five years earlier. It shows that mortality rates have fallen at virtually all ages. The exception is at the very old ages where mortality rates have increased since 2005-07.

Figure 2: Mortality rates 2005-07 and 2010-12



Infant mortality continued to fall, as it has in every set of published Tables. Since the previous Tables, infant mortality has fallen by around 5 per cent per annum.

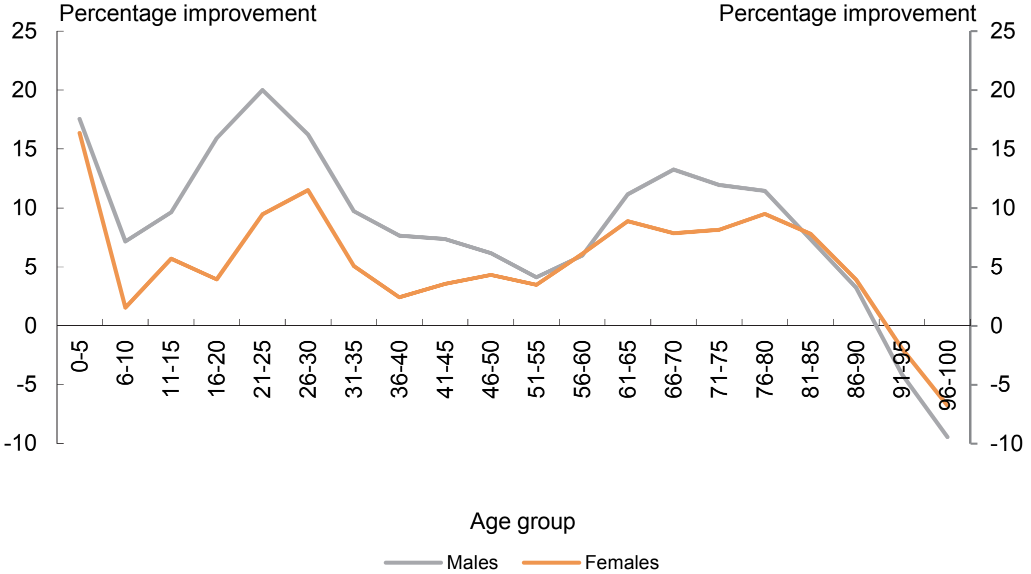
Mortality in the childhood years has also improved, more so for males than for females. However, the number of deaths observed at these ages is very small. This increases the risk that the shape of the smoothed mortality curve will be unduly affected by random variation in the number of deaths reported. We modified the graduation process for the 2005-07 Tables to address this issue and have maintained the approach, which is described in section 2.2, for the current Tables. This is, however, still the age range with the greatest volatility and limited significance should be attached to the changes in mortality at individual ages.

Male mortality has fallen over the teenage and young adult ages, most notably for those in their mid-twenties. Three decades ago, there was a clear peak in male mortality around age twenty, with mortality rates roughly comparable to those applying to males twenty years older. This phenomenon was known as the accident hump. While rates still increase substantially over the teenage years, the more rapid improvement in male mortality for those in their early twenties means there is no longer a distinct peak. This is, however, the age group with the greatest disparity between male and female rates and, as illustrated in Figure 4 overleaf, the gap remains significant.

There was also noticeable improvement in mortality rates over the age range from around the mid-fifties to the early-eighties.

Figure 3 shows the average percentage improvement in mortality rates over the five years following the 2005-07 Tables by gender for five year age bands.

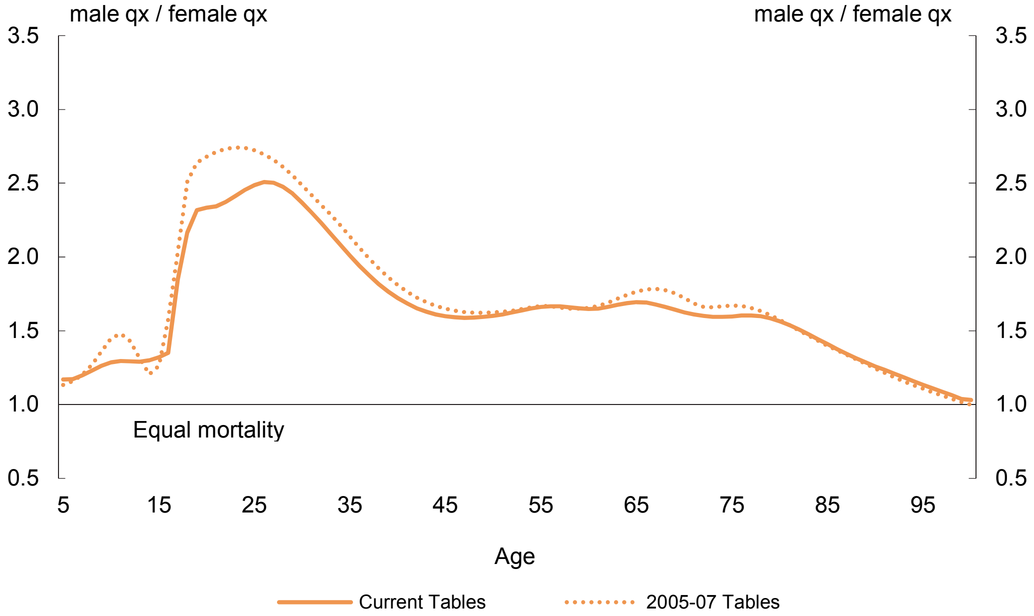
Figure 3: Percentage improvement in mortality since 2005-07 by gender



As noted above, mortality at the oldest ages has deteriorated slightly since 2005-07. For centenarians, part of the explanation is the additional effort which the Australian Bureau of Statistics (ABS) devoted to accurate reporting of age on the Census. This appears to have reduced the incidence of mis-statements and led to a reduction in the population counts at very old ages with a flow-on increase in mortality rates. In addition, our graduation choices were influenced by some analysis using the extinct generations methodology of estimating mortality rates at the oldest ages. However, as Figure 3 shows, the worsening mortality is apparent for those in their nineties, where there is a larger volume of reliable data. This feature has also been observed recently in other developed countries. Since the 1970s, mortality rates have improved noticeably among those aged in their sixties and above. This has led to an increasing proportion of the population surviving to the very old ages which may, in turn, have led to a decline in the average health status of this group. It will be interesting to see whether or not this trend towards higher mortality at the oldest ages persists.

Figure 4 compares the gender differential in mortality rates for the current and previous Tables. It shows that, at most ages, there has been little change, with male and female mortality rates improving in tandem. The main exception is the early adult years where the higher rates of improvement in male mortality have led to a noticeable narrowing of the gap relative to the 2005-07 Tables.

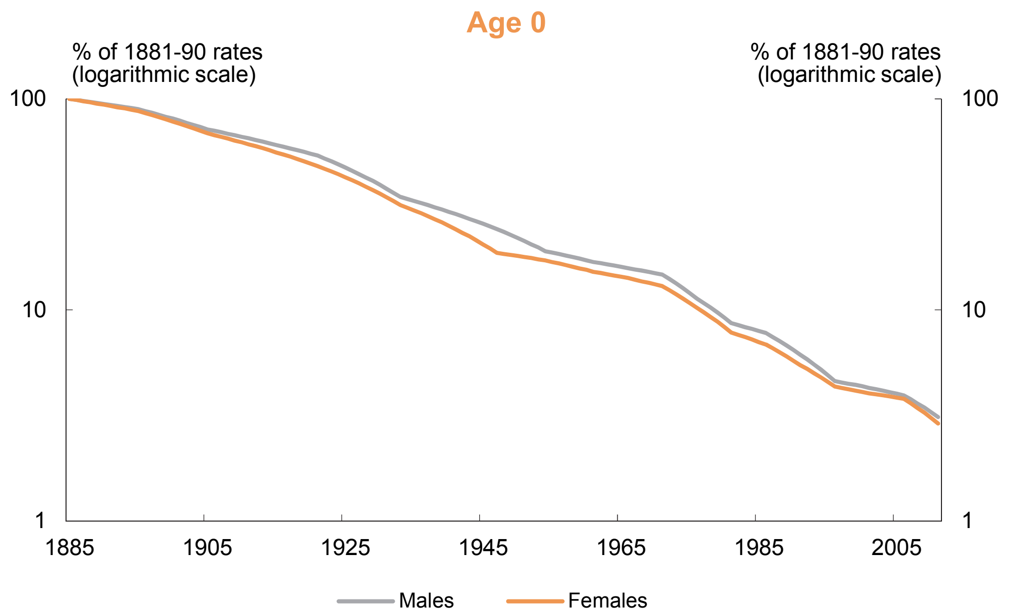
Figure 4: Ratio of male to female mortality rates — Ages 5 to 100, 2005-07 and 2010-12



1.3 Past improvements in mortality

The first official Life Tables for Australia were prepared based on data from the period 1881-90 and there is now a history of 125 years of mortality data. Figure 5 plots the change in mortality rates over time expressed as a percentage of the rates reported in 1881-90. The data for the four ages shown clearly illustrates the diversity of experience for different ages and genders.

Figure 5: Improvements in mortality at selected ages



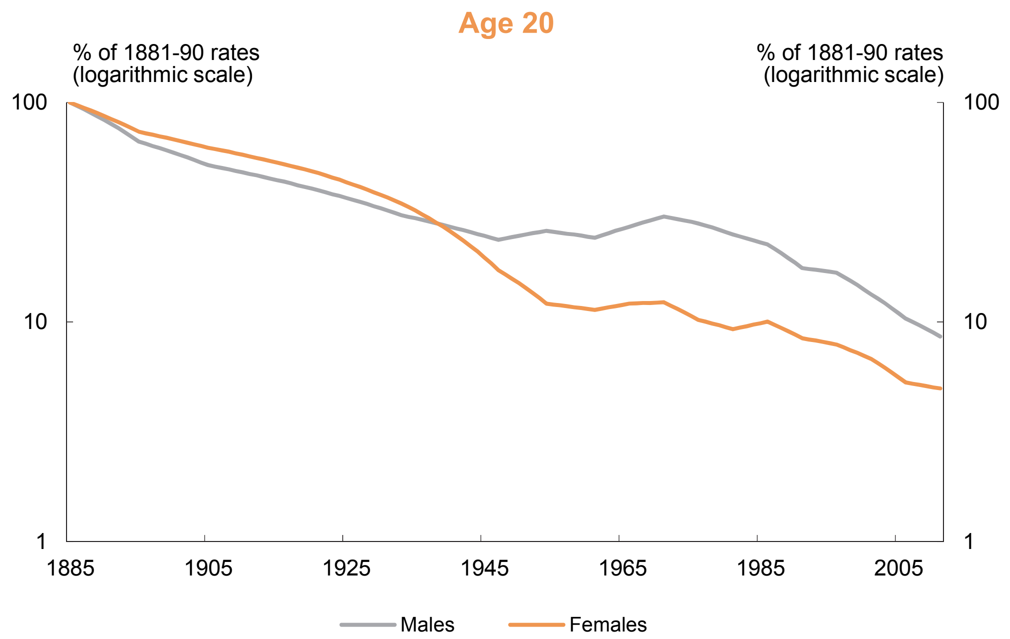
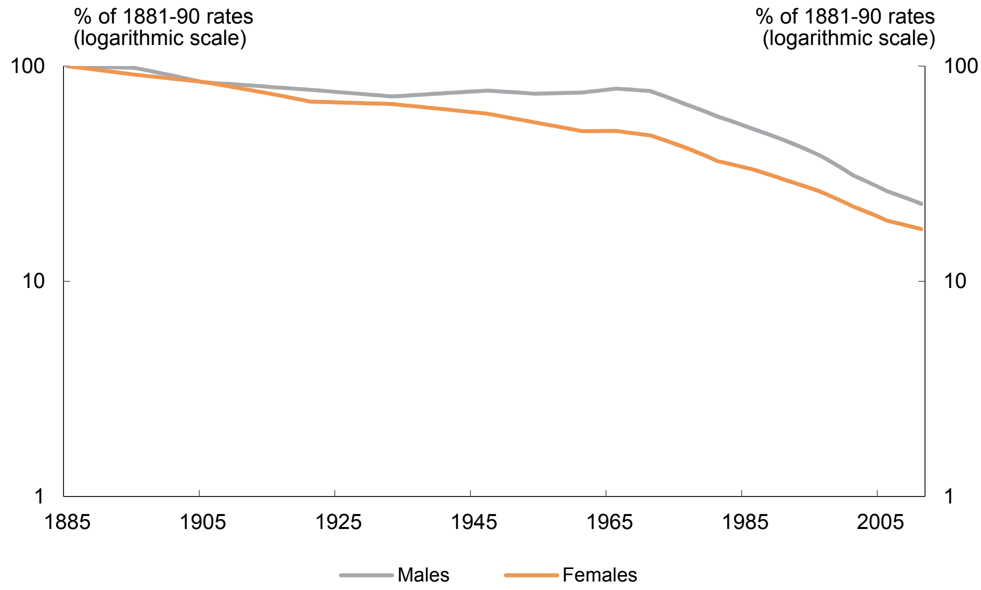
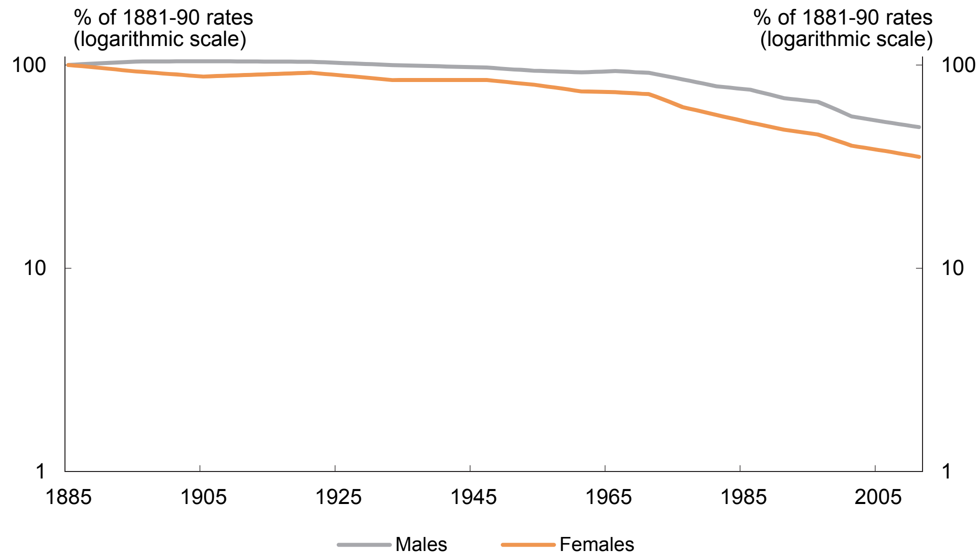


Figure 5: Improvements in mortality at selected ages (continued)

Age 65



Age 85



Infant mortality has shown a sustained and substantial improvement over the entire period, with the improvement for males and females moving closely in parallel. The rates for both males and females are now around 3 per cent of their level in 1881-90 and still do not appear to have reached an underlying minimum rate. While the rate of improvement had slowed somewhat over the decade between the 1995-97 and

2005-07 Tables, the current Tables have shown a return to a similar rate of improvement to that experienced in the 25 years prior to the 1995-97 Tables.

The picture at age 20 is quite different, with male rates initially improving more quickly than female rates but then deteriorating from about 1945 to 1970 before starting to decline again as the accident hump emerged, subsided and then disappeared. For females at this age, the biggest improvements occurred from the 1930s to the 1950s and probably reflected improved maternal mortality experience as medical procedures were reformed and became accessible to more of the population. Mortality rates for 20 year old females are about 5 per cent of the corresponding rates from 125 years ago. For males of the same age, the relativity is around 9 per cent.

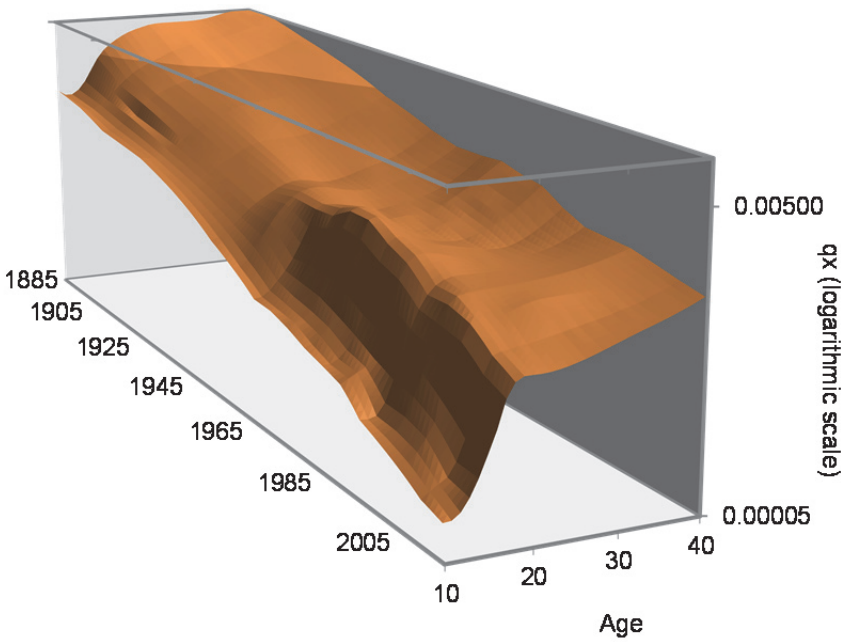
At age 65, the rate of improvement was relatively slow for both males and females until around 1965. This is consistent with the benefits of medical advances up to that time primarily accruing to the young. Since the mid-1960s, however, mortality rates for 65 year olds have more than halved. Male rates for 65 year olds in the 2010-12 Tables are about a quarter of the corresponding rates from the original Tables, while for females the 2010-12 rates are less than 20 per cent of the corresponding rates.

The final chart shows the improvement in rates at age 85. Again, mortality rates at this age showed minimal improvement until the mid-1960s. Since then, there has been a steady improvement in mortality leading to mortality rates for males that are roughly half what they were 125 years ago. For females, the rates are now a third of what they were.

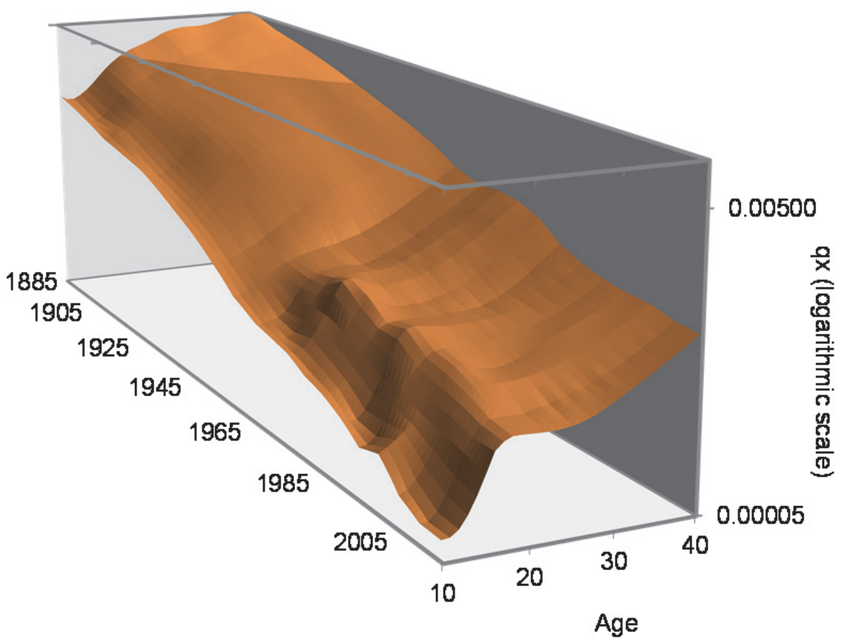
It is also interesting to see how the shape of the mortality curve has changed over time. Figure 6 shows the reported mortality rates for those aged between 10 and 40 as a three dimensional surface, plotted against both age and time. Note that the rates for years in between the Tables have been derived by linear interpolation. The enormous improvements in childhood mortality and the emergence and decline of the accident humps for males and, to a lesser extent, females are clearly visible.

Figure 6: Smoothed mortality rates from 1881-90 to the present — Ages 10 to 40

Males



Females



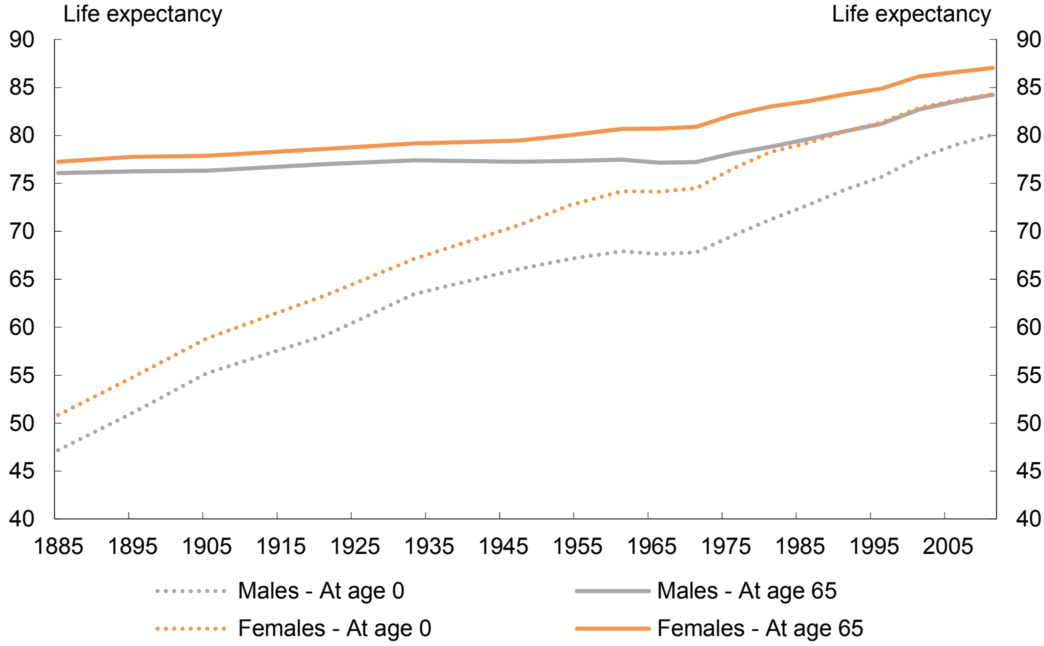
1.4 Longevity

One natural corollary of improving mortality is increasing longevity. Increased longevity has significant implications for both individuals trying to estimate the resources needed for retirement and governments dealing with rising pension and health and aged care obligations.

There are a number of measures of longevity. The most commonly used is life expectancy, which measures the average number of years that would be lived by a representative group of individuals of the same age if they experienced mortality at given rates.

Figure 7 shows how the improvements in mortality described in the previous section have translated into longer life expectancies as reported in the relevant Life Tables (Appendix A sets out the figures on which Figure 7 is based). Note that these reported life expectancies are known as period life expectancies and do not make allowance for any future improvements in mortality which might be experienced over a person's lifetime. In other words, they are based on the assumption that the mortality rates reported in a particular set of Tables would continue unchanged into the future and, as such, represent a summary of mortality at a particular point in time rather than a projection of mortality over future periods. The impact of continuing mortality improvement is discussed in the next section.

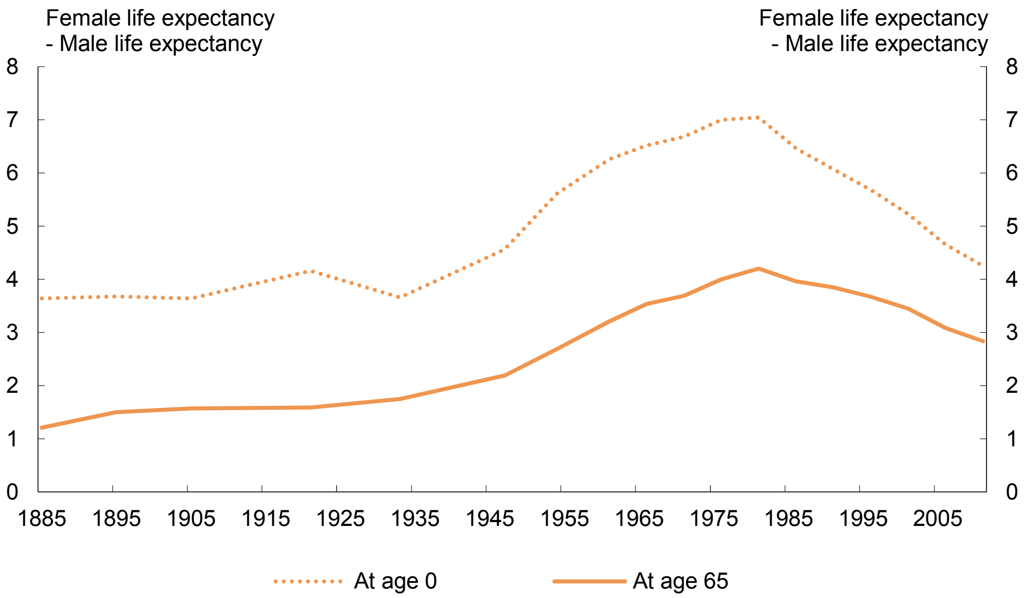
Figure 7: Total life expectancy at selected ages



Period life expectancy at birth has shown dramatic improvement, increasing by over 30 years for both males and females since the inception of the Life Tables. Even at older ages, the substantial improvements in mortality rates for this group over the past forty years have flowed through into significantly increased life expectancies. For example, life expectancy at age 65 has increased by around eight years (more than 70 per cent) for males and ten years (more than 80 per cent) for females.

Figure 8 plots the gap between reported male and female life expectancies at birth and age 65. It shows that over the first third of the twentieth century, male and female life expectancies moved roughly in parallel, with the gap at birth steady at around four years, and the gap at age 65 only around one and a half years. From about 1930, the gap widened for both ages, reaching a maximum in the 1980-82 Tables. Since then, the differential has been declining for both ages. At birth, the gap has declined by almost three years, falling to levels last seen around 70 years ago.

Figure 8: Gender differentials in life expectancy at selected ages

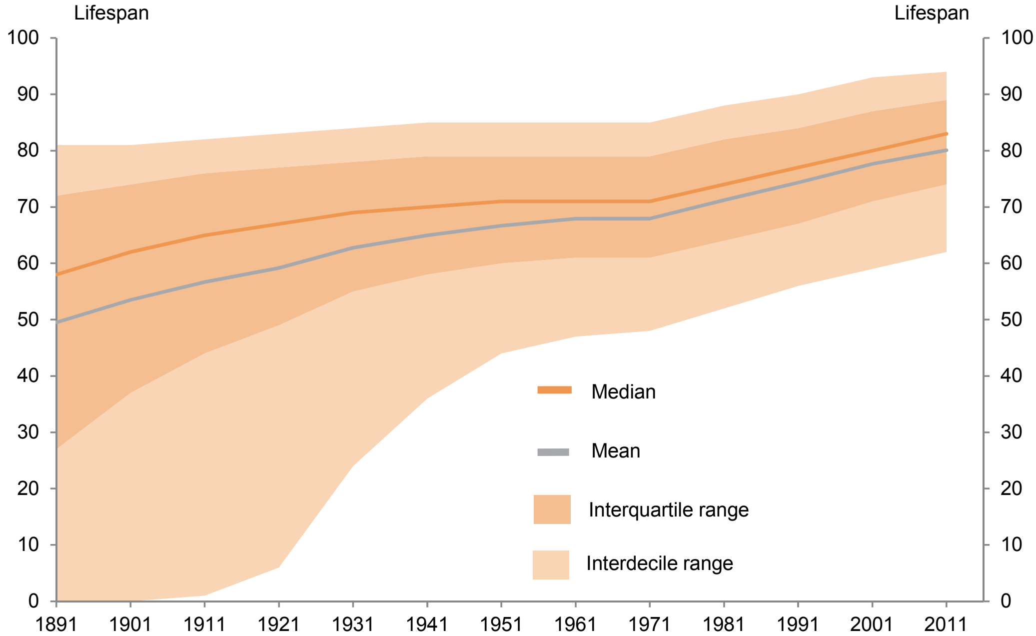


Life expectancy at birth is a commonly used measure to describe population mortality. However, as a single summary statistic, it cannot provide information on the diversity of outcomes. For example, under the mortality rates reported in the current Tables, around 60 per cent of both males and females would be expected to survive beyond the reported life expectancy. This result is separate from the issue of mortality improvements that might occur over an individual's life, which is discussed in the following section.

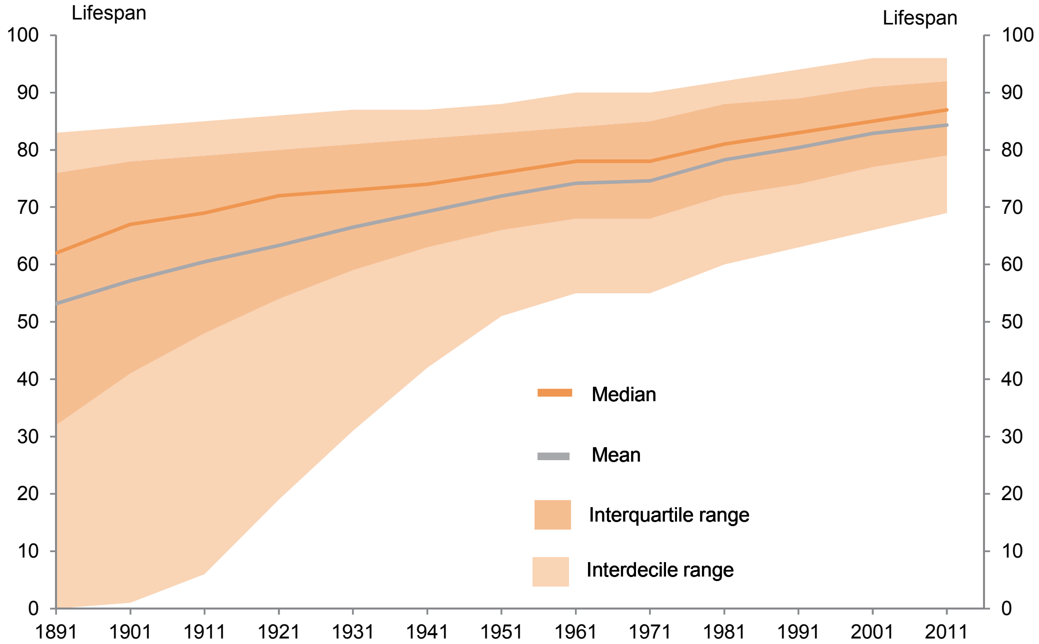
Figure 9 shows how the distribution of lifespan has changed over the past 125 years. The distributions shown here are based on the prevailing mortality rates and do not make allowance for future mortality improvement. The chart shows the period life expectancy, the median of the lifespan distribution and the interquartile and interdecile ranges.

Figure 9: Distribution of lifespan at birth

Males



Females



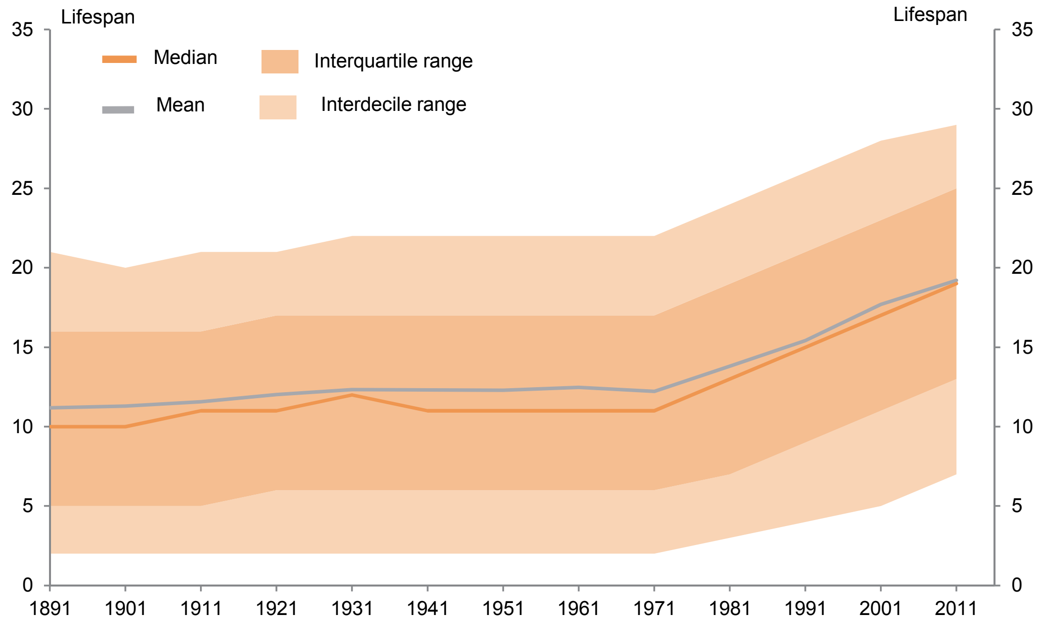
It can be seen that the reported life expectancy and median age of death have moved roughly in parallel. However, over the 125 years, the gap between the two measures has declined by around four years, reflecting the dramatic improvements in infant mortality that have had a greater impact on life expectancy than on median age at death.

While improving mortality at younger ages has tended to concentrate the age of death within a narrower range, outcomes for individuals can still vary widely. The interdecile range, for example, spans a range of over 30 years for males, from 62 to 94 and only slightly less for females, from 69 to 96.

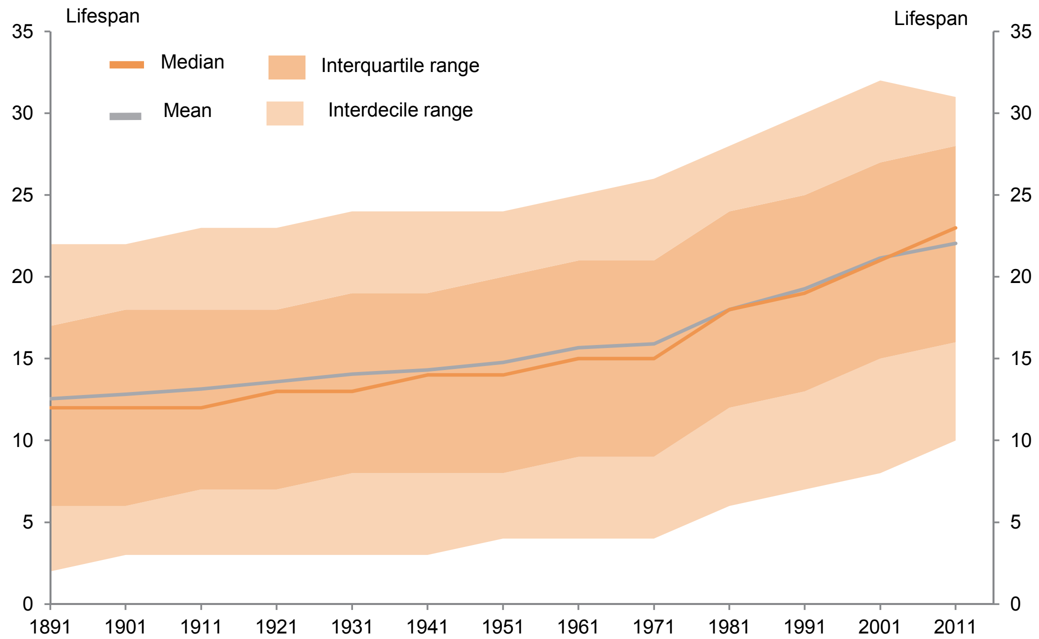
Figure 10 reproduces the distribution of lifespan charts based on the expected outcomes at age 65 rather than birth.

Figure 10: Distribution of lifespan at age 65

Males



Females



A number of differences are apparent. Firstly, the lifespan distribution is relatively symmetrical at this age and as a result the mean and median are more closely aligned.

Secondly, while the interdecile range is significantly less at age 65 than at birth, it has increased slightly over time rather than narrowing. In other words, outcomes at retirement are no more predictable today than they were 100 years ago.

1.5 Allowing for future improvements in mortality

The figures reported in section 1.4 are all based on the cross-sectional mortality rates from a single set of Life Tables. However, section 1.3 highlighted the substantial changes in mortality that could be expected to occur over an individual's life time. By way of illustration, the life expectancy of a boy born in 1886, as reported in the 1881-90 Tables, was 47.2 years, based on the rates in those Tables persisting throughout his life. However, his actual life expectancy would have been some six years higher. This estimate can be obtained by applying the rates reported in subsequent Tables that would be appropriate given his age and the year.

As a result, any realistic measure of longevity needs to consider the possible improvements in mortality that may occur in future. This section focuses on life expectancy in considering the impacts of future mortality improvement. However, the limitations outlined in the previous section of any summary measure such as life expectancy which obscure the diversity of outcomes should be borne in mind.

The issues associated with attempting to estimate more realistic life expectancies by allowing for future mortality improvements were discussed in some detail in the 1995-97 Tables. Those Tables included improvement factors derived from the ratio of the mortality rates in the Tables to those reported in the Tables from 25 and 100 years previously. The current Tables continue the practice of reporting two sets of factors, one based on experience over the last 25 years and the other using the full history of reported mortality. However, the methodology used to determine the factors has been modified slightly. Details on the methodology now being used are provided in Section 2.4.

Figure 11 presents the historical rates of improvement expressed as an annual percentage change in the probability of death at a given age. Note that the lower the value, the higher the improvement in mortality has been. It can be seen that the improvements over the 125 year period have generally been less than the improvements over the past 25 years. The main exception is for the ages around 30 where the rates of improvement over the past 25 years have been less than over the preceding 100 years, particularly for women.

Note that the 25 year improvement factors for the oldest ages have been constrained to be zero. As can be seen from the chart, mortality rates have actually increased since 2005-07 for those at the oldest ages, from age 91 for males and age 92 for females. Over the 25 year period, the fitted mortality improvement factors also showed deteriorating mortality, from age 96 for males and age 98 for females. While there are reasons for assuming that this is a genuine feature related to the improving mortality for those in their seventies and eighties, I have decided to set the factors to zero until more data becomes available.

Figure 11: Historical mortality improvement factors derived from the Australian Life Tables

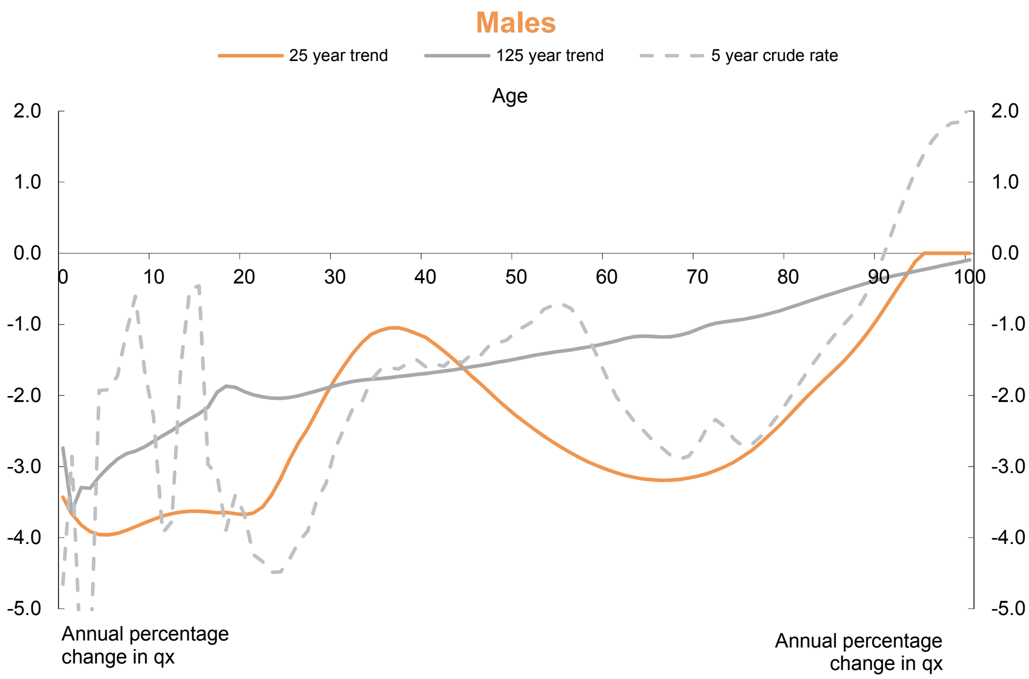
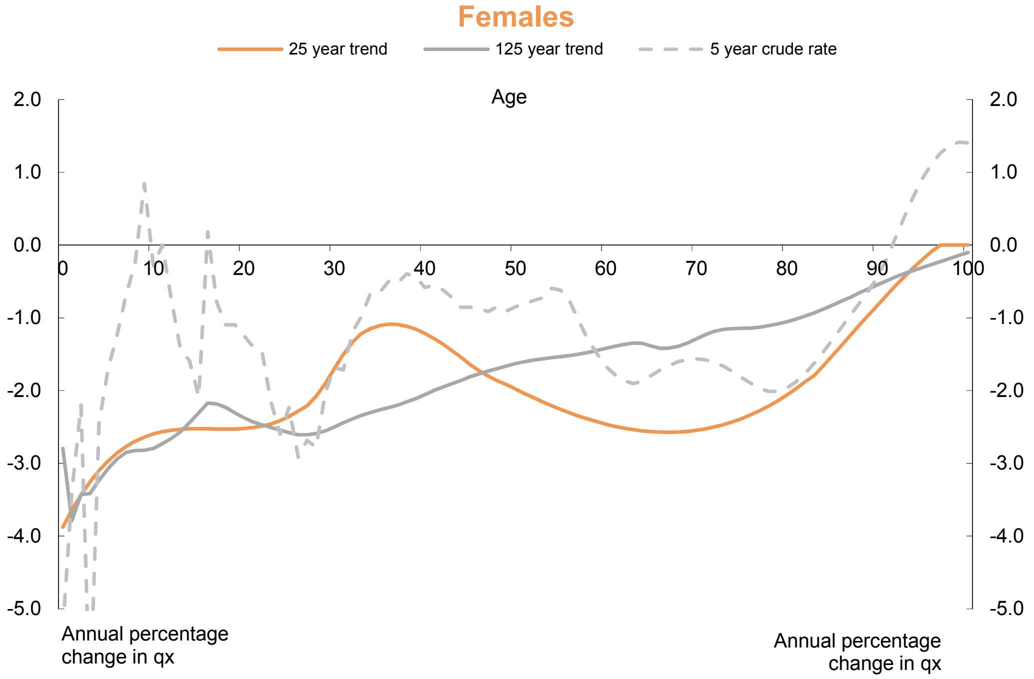


Figure 11: Historical mortality improvement factors derived from the Australian Life Tables (continued)



There are two ways of taking account of mortality improvement in projecting future life expectancies. The first is to apply the same number of years of improvement to the mortality rates at all ages, effectively estimating what future Life Tables might report as life expectancy. This measure, which is known as the period or cross-sectional life expectancy, makes no allowance for improvements over an individual's future lifetime and was discussed in the previous section. So, for example, in calculating a period life expectancy for the year 2020 based on the 2010-12 Tables, nine years of improvement would be allowed for at all ages. The following tables show the projected period life expectancies at ages 0, 30 and 65 using the 25 and 125 year improvement factors.

Projected period life expectancies at selected ages under two improvement scenarios

Males

	Age 0		Age 30		Age 65	
	25 year	125 year	25 year	125 year	25 year	125 year
2011	80.1	80.1	81.0	81.0	84.2	84.2
2020	82.2	81.1	82.9	81.9	85.6	84.7
2030	84.3	82.1	84.8	82.8	87.1	85.3
2040	86.0	83.1	86.4	83.6	88.3	85.8
2050	87.6	83.9	87.9	84.4	89.4	86.3
2060	88.9	84.8	89.1	85.1	90.4	86.8

Females

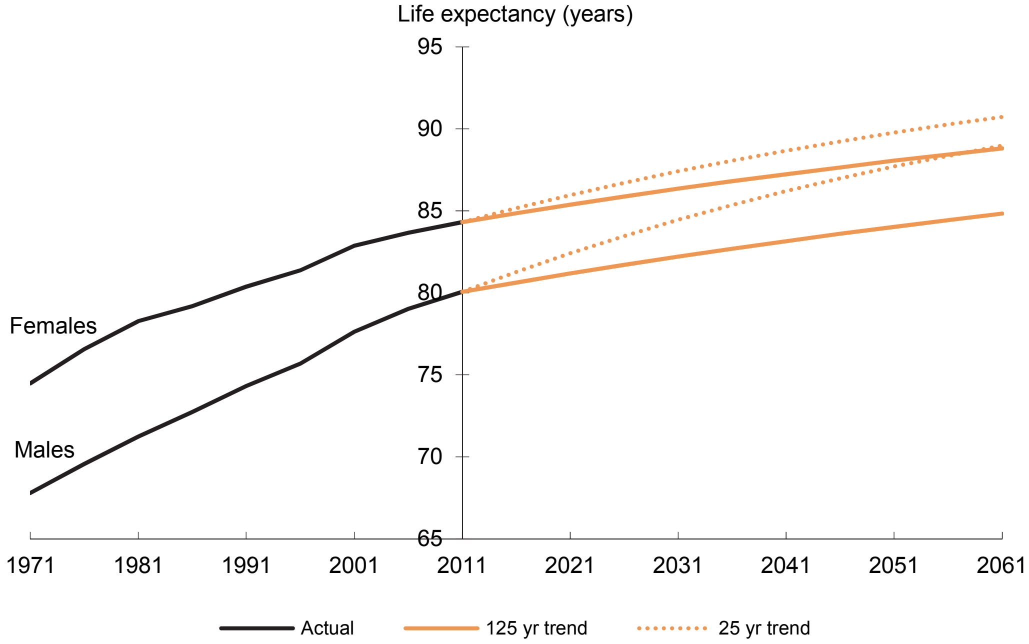
	Age 0		Age 30		Age 65	
	25 year	125 year	25 year	125 year	25 year	125 year
2011	84.3	84.3	85.0	85.0	87.0	87.0
2020	85.8	85.3	86.3	85.8	88.1	87.6
2030	87.3	86.3	87.6	86.7	89.2	88.3
2040	88.6	87.2	88.8	87.5	90.1	88.8
2050	89.7	88.0	89.9	88.2	91.0	89.4
2060	90.6	88.7	90.8	88.9	91.7	90.0

The 2005-07 Tables projected a period life expectancy at birth for a boy born in 2011 of 80.3 years under the 25 year improvement scenario and 79.7 years under the 100 year improvement scenario. The current Tables estimate a life expectancy roughly midway between these two figures. For a girl born in 2011, the equivalent figures from the 2005-07 Tables were 84.6 and 84.3 years. The current estimate is thus consistent with the 100 year improvement factors reported in 2005-07.

For the future years, the projected period life expectancies are a little lower than those projected in the previous Tables, most notably under the 25 year improvement scenario. This reflects that the rate of improvement in mortality over the five years to 2011 was, on average, slightly lower than over the five years to 1986.

Figure 12 shows how the period life expectancy at birth would change over time under these two improvement scenarios.

Figure 12: Actual and projected period life expectancy at birth — 1971 to 2061



The second measure of life expectancy is what is termed cohort life expectancy. This measure takes into account the improvements that could be experienced over the future lifetime of the individual. So, for example, in calculating the cohort life expectancy of a child born in 2020 based on the 2010-12 tables, nine years of mortality improvement will be applied to the mortality rate at age 0, ten years at age one and so on. In the example provided at the beginning of this section, the life expectancy for a child born in 1886 calculated using the mortality rates as they changed over his lifetime is a cohort life expectancy. Cohort life expectancies can be thought of as being a more realistic representation of the unfolding mortality experience of the Australian population, though the uncertainties around future rates of mortality improvement need to be kept in mind.

The following tables show the cohort life expectancies at ages 0, 30 and 65 using the 25 and 125 year improvement factors.

Projected cohort expectation of life at selected ages under two improvement scenarios

Males

	Age 0		Age 30		Age 65	
	25 year	125 year	25 year	125 year	25 year	125 year
2011	90.5	85.6	88.1	84.2	86.0	84.9
2020	91.4	86.4	89.2	84.9	87.4	85.4
2030	92.2	87.2	90.3	85.7	88.7	85.9
2040	92.9	87.9	91.2	86.4	89.8	86.5
2050	93.5	88.5	92.0	87.1	90.7	87.0
2060	93.9	89.1	92.7	87.7	91.6	87.5

Females

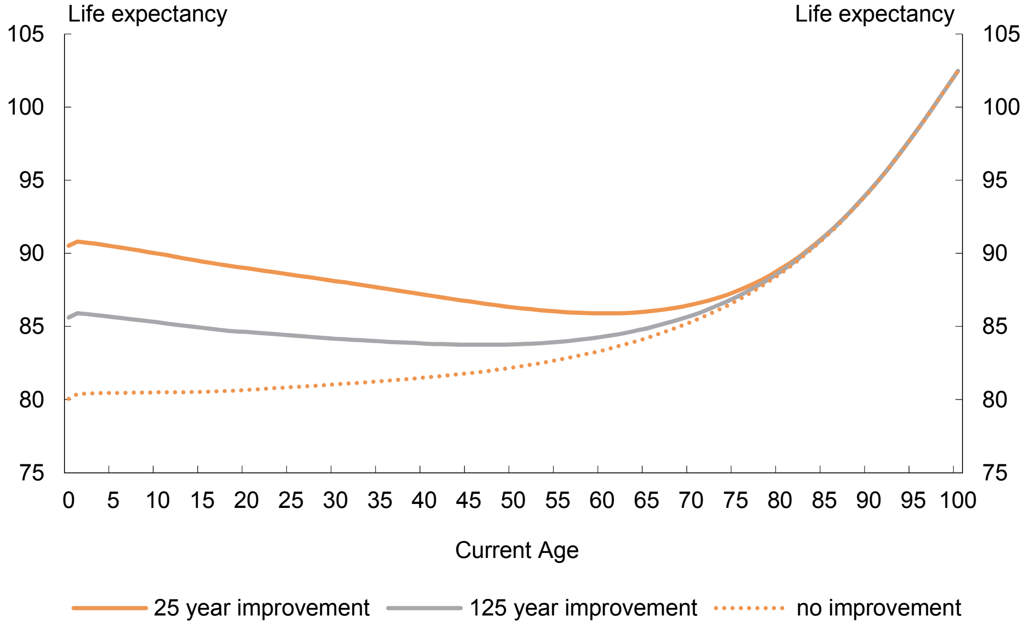
	Age 0		Age 30		Age 65	
	25 year	125 year	25 year	125 year	25 year	125 year
2011	92.2	90.0	90.3	88.4	88.6	87.9
2020	92.9	90.6	91.1	89.1	89.5	88.5
2030	93.5	91.3	92.0	89.8	90.5	89.1
2040	94.1	91.9	92.7	90.5	91.4	89.7
2050	94.5	92.5	93.3	91.1	92.1	90.3
2060	95.0	93.0	93.8	91.6	92.7	90.8

A comparison with the cohort life expectancies reported in the 2005-07 Tables shows that the reduced mortality improvement factors have led to a decline in life expectancies under almost every scenario, with the greatest differences of two to three years reported under the 25 year improvement factors for life expectancy at birth. This is the result of the small changes in the mortality improvement factors being magnified when mortality is being projected many years into the future. The one exception is for males aged 65 under the 125 year improvement scenario. The improvement factors themselves are marginally less than those reported in 2005-07. This is in part due to a change in the period from 100 years (used in the 2005-07 Tables) to 125 years used here. Despite this, since the rate of improvement in male mortality over the five years to 2010-12 was faster than the 125 year average, there has been a very small increase in the cohort life expectancy in the short term. Further into the future, the effect of the lower improvement factors more than offsets the lighter initial mortality rates.

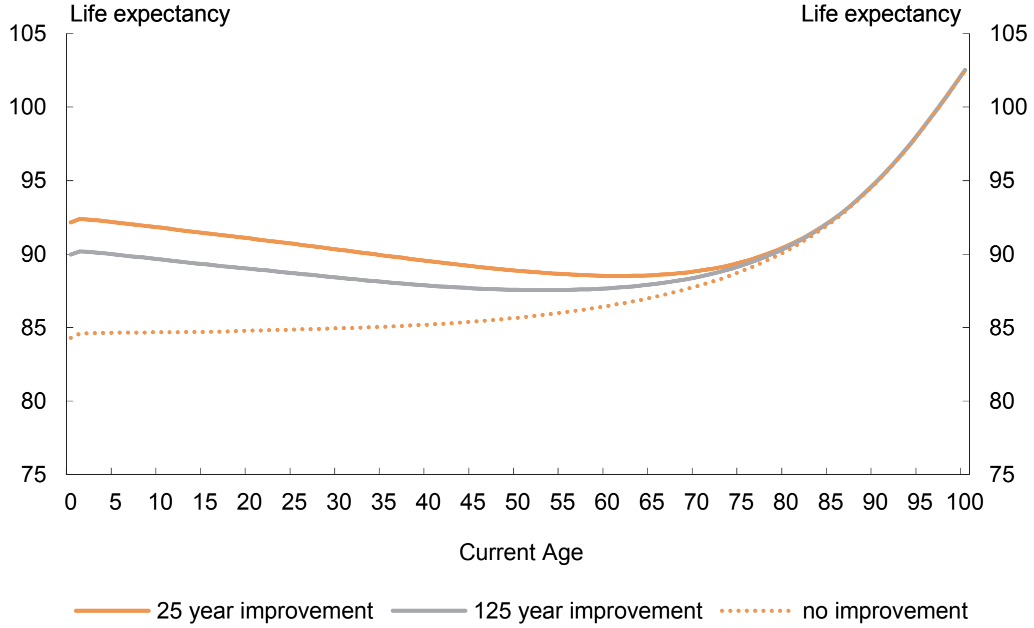
Figure 13 shows the cohort life expectancies for those currently alive in the Australian population. It highlights the considerable gap between the period life expectancies reported in these Tables and the outcomes that would arise if the rates of mortality improvement observed in the past are maintained in the future. The additional life expectancy (the gap between the 'no improvement' curve and the other two curves) reduces with increasing age, reflecting the shorter period for improvements to have an impact. At very old ages, the gap has disappeared but the curve rises, reflecting the fact that these people have already reached an advanced age.

Figure 13: Cohort life expectancies by current age

Males



Females

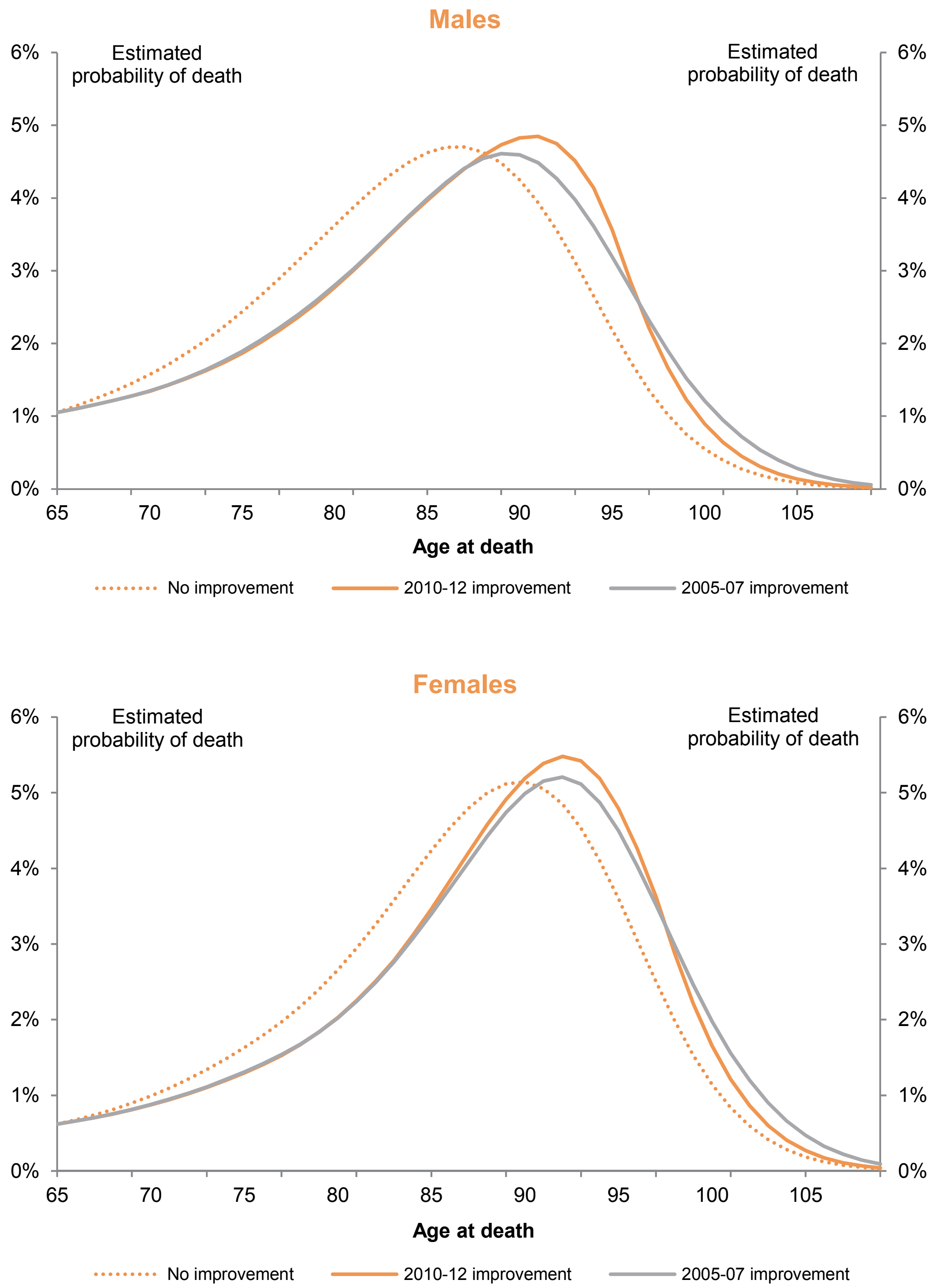


The period and cohort life expectancies set out above illustrate what would occur if mortality continued to improve at the rates observed in the past. Measured mortality improvement can change appreciably between successive Tables, particularly for the factors derived from the most recent 25 years of experience where the earliest period is removed from the calculation and the experience from the most recent five years incorporated. So, for example, at age 45 the 25 year improvement factor has reduced from 2.35 per cent per annum to 1.72 per cent per annum, reflecting the fact that mortality at this age dropped by almost a quarter between the 1980-82 and the 1985-87 Tables but by only around 5 per cent between 2005-07 and 2010-12 Tables.

Furthermore, the effects of these movements are magnified because the projections assume that mortality improvement will be constant for a particular age. This is not a major issue in the short term. One year into the future, for example, the difference in mortality rates at age 45 under the two assumptions is less than 1 per cent. However, in considering cohort life expectancy at birth, the projected mortality rate to be used at age 45 will include 45 years of mortality improvement and the mortality rate under the 2010-12 assumption is a third higher than it would have been under the 2005-07 assumption.

The sensitivity to changes in mortality improvement is also evident in the projected distribution of deaths, as illustrated in Figure 14. The two improvement scenarios presented are both based on 25 year improvement factors.

Figure 14: Distribution of deaths at age 65 allowing for cohort mortality improvement



This chart also suggests that the range of lifespans under credible mortality improvement scenarios is at least as wide as the range where no allowance for mortality improvement was made. In other words, making an allowance for future improvements in mortality does not decrease the challenges individuals face in dealing with longevity risk in retirement.

History demonstrates that mortality improvement is not constant at a particular age and, indeed, can vary within a quite considerable range. The choice of the period over which mortality is measured will also affect the estimates of mortality improvement. Thus, the estimates of cohort mortality included here must be accepted as projections of outcomes under assumptions which have a certain historical basis. They should be regarded as indicative rather than firm forecasts of life expectancy.

AUSTRALIAN LIFE TABLES 2010-12: MALES

Age	l_x	d_x	p_x	q_x	μ_x	$\mathring{e}_x$	L_x	T_x
0	100,000	412	0.995879	0.004121	0.000000	80.06	99,632	8,006,148
1	99,588	34	0.999654	0.000346	0.000437	79.39	99,569	7,906,516
2	99,553	21	0.999793	0.000207	0.000266	78.42	99,542	7,806,947
3	99,533	13	0.999867	0.000133	0.000159	77.44	99,526	7,707,404
4	99,520	13	0.999873	0.000127	0.000125	76.45	99,513	7,607,878
5	99,507	12	0.999882	0.000118	0.000123	75.46	99,501	7,508,365
6	99,495	11	0.999890	0.000110	0.000114	74.46	99,490	7,408,864
7	99,484	10	0.999896	0.000104	0.000107	73.47	99,479	7,309,374
8	99,474	10	0.999903	0.000097	0.000100	72.48	99,469	7,209,895
9	99,464	9	0.999908	0.000092	0.000094	71.49	99,460	7,110,426
10	99,455	9	0.999911	0.000089	0.000090	70.49	99,451	7,010,967
11	99,446	9	0.999910	0.000090	0.000089	69.50	99,442	6,911,516
12	99,437	10	0.999901	0.000099	0.000093	68.51	99,433	6,812,074
13	99,427	12	0.999880	0.000120	0.000107	67.51	99,422	6,712,642
14	99,416	16	0.999844	0.000156	0.000135	66.52	99,408	6,613,220
15	99,400	21	0.999785	0.000215	0.000181	65.53	99,390	6,513,812
16	99,379	30	0.999699	0.000301	0.000250	64.55	99,365	6,414,422
17	99,349	46	0.999539	0.000461	0.000379	63.56	99,327	6,315,057
18	99,303	57	0.999426	0.000574	0.000528	62.59	99,275	6,215,730
19	99,246	61	0.999386	0.000614	0.000604	61.63	99,216	6,116,455
20	99,185	61	0.999386	0.000614	0.000618	60.67	99,155	6,017,239
21	99,124	61	0.999388	0.000612	0.000613	59.70	99,094	5,918,085
22	99,063	61	0.999383	0.000617	0.000614	58.74	99,033	5,818,991
23	99,002	62	0.999372	0.000628	0.000622	57.78	98,971	5,719,958
24	98,940	64	0.999356	0.000644	0.000635	56.81	98,908	5,620,987
25	98,876	66	0.999334	0.000666	0.000654	55.85	98,844	5,522,078
26	98,811	68	0.999309	0.000691	0.000678	54.89	98,777	5,423,235
27	98,742	71	0.999279	0.000721	0.000706	53.92	98,707	5,324,458
28	98,671	74	0.999246	0.000754	0.000737	52.96	98,634	5,225,751
29	98,597	78	0.999211	0.000789	0.000771	52.00	98,558	5,127,117
30	98,519	81	0.999174	0.000826	0.000807	51.04	98,479	5,028,559
31	98,438	85	0.999135	0.000865	0.000846	50.08	98,395	4,930,080
32	98,352	89	0.999095	0.000905	0.000885	49.13	98,308	4,831,685
33	98,263	93	0.999055	0.000945	0.000925	48.17	98,217	4,733,376
34	98,171	97	0.999013	0.000987	0.000966	47.22	98,122	4,635,159
35	98,074	101	0.998969	0.001031	0.001009	46.26	98,023	4,537,037
36	97,973	106	0.998921	0.001079	0.001055	45.31	97,920	4,439,013
37	97,867	111	0.998867	0.001133	0.001106	44.36	97,812	4,341,093
38	97,756	117	0.998807	0.001193	0.001163	43.41	97,698	4,243,281
39	97,639	123	0.998739	0.001261	0.001226	42.46	97,578	4,145,583
40	97,516	130	0.998662	0.001338	0.001299	41.51	97,452	4,048,005
41	97,386	139	0.998576	0.001424	0.001380	40.57	97,317	3,950,553
42	97,247	148	0.998477	0.001523	0.001473	39.62	97,174	3,853,236
43	97,099	159	0.998366	0.001634	0.001578	38.68	97,021	3,756,062
44	96,940	170	0.998242	0.001758	0.001695	37.75	96,856	3,659,042
45	96,770	184	0.998102	0.001898	0.001827	36.81	96,679	3,562,186
46	96,586	198	0.997945	0.002055	0.001976	35.88	96,488	3,465,507
47	96,388	215	0.997771	0.002229	0.002141	34.95	96,282	3,369,018
48	96,173	233	0.997579	0.002421	0.002324	34.03	96,058	3,272,737
49	95,940	253	0.997366	0.002634	0.002527	33.11	95,815	3,176,679
50	95,687	274	0.997132	0.002868	0.002751	32.20	95,552	3,080,863
51	95,413	298	0.996875	0.003125	0.002997	31.29	95,266	2,985,311
52	95,115	324	0.996595	0.003405	0.003266	30.38	94,955	2,890,046
53	94,791	352	0.996290	0.003710	0.003560	29.49	94,617	2,795,091
54	94,439	381	0.995961	0.004039	0.003879	28.59	94,251	2,700,473

AUSTRALIAN LIFE TABLES 2010-12: MALES (CONTINUED)

Age	l_x	d_x	p_x	q_x	μ_x	$\mathring{e}_x$	L_x	T_x
55	94,058	412	0.995619	0.004381	0.004216	27.71	93,854	2,606,222
56	93,646	444	0.995258	0.004742	0.004568	26.83	93,426	2,512,368
57	93,202	478	0.994866	0.005134	0.004944	25.95	92,965	2,418,941
58	92,723	516	0.994432	0.005568	0.005358	25.09	92,468	2,325,976
59	92,207	558	0.993947	0.006053	0.005818	24.22	91,931	2,233,508
60	91,649	605	0.993400	0.006600	0.006335	23.37	91,350	2,141,576
61	91,044	657	0.992780	0.007220	0.006921	22.52	90,720	2,050,226
62	90,386	716	0.992079	0.007921	0.007586	21.68	90,034	1,959,506
63	89,671	780	0.991296	0.008704	0.008334	20.85	89,286	1,869,473
64	88,890	850	0.990434	0.009566	0.009164	20.03	88,471	1,780,187
65	88,040	925	0.989495	0.010505	0.010073	19.22	87,584	1,691,716
66	87,115	1,003	0.988481	0.011519	0.011060	18.41	86,620	1,604,132
67	86,111	1,086	0.987386	0.012614	0.012124	17.62	85,575	1,517,512
68	85,025	1,175	0.986178	0.013822	0.013283	16.84	84,445	1,431,937
69	83,850	1,273	0.984814	0.015186	0.014581	16.07	83,222	1,347,492
70	82,577	1,383	0.983255	0.016745	0.016058	15.31	81,895	1,264,270
71	81,194	1,505	0.981460	0.018540	0.017757	14.56	80,452	1,182,375
72	79,689	1,643	0.979388	0.020612	0.019720	13.83	78,879	1,101,923
73	78,046	1,795	0.977002	0.022998	0.021989	13.11	77,162	1,023,044
74	76,251	1,963	0.974262	0.025738	0.024606	12.40	75,284	945,882
75	74,289	2,145	0.971130	0.028870	0.027613	11.72	73,232	870,597
76	72,144	2,340	0.967570	0.032430	0.031053	11.05	70,991	797,366
77	69,804	2,545	0.963545	0.036455	0.034966	10.41	68,549	726,375
78	67,259	2,757	0.959013	0.040987	0.039396	9.78	65,899	657,826
79	64,503	2,974	0.953896	0.046104	0.044413	9.18	63,034	591,927
80	61,529	3,193	0.948113	0.051887	0.050112	8.60	59,951	528,893
81	58,336	3,408	0.941583	0.058417	0.056592	8.04	56,650	468,942
82	54,929	3,612	0.934233	0.065767	0.063950	7.51	53,139	412,292
83	51,316	3,798	0.925991	0.074009	0.072282	7.00	49,431	359,153
84	47,518	3,954	0.916793	0.083207	0.081687	6.52	45,553	309,722
85	43,564	4,070	0.906581	0.093419	0.092262	6.06	41,537	264,169
86	39,495	4,135	0.895302	0.104698	0.104105	5.64	37,430	222,632
87	35,360	4,140	0.882914	0.117086	0.117314	5.24	33,287	185,202
88	31,219	4,078	0.869381	0.130619	0.131986	4.87	29,172	151,914
89	27,142	3,944	0.854677	0.145323	0.148220	4.52	25,155	122,742
90	23,197	3,740	0.838789	0.161211	0.166120	4.21	21,308	97,587
91	19,458	3,467	0.821802	0.178198	0.185759	3.92	17,699	76,279
92	15,990	3,131	0.804170	0.195830	0.206919	3.66	14,394	58,581
93	12,859	2,747	0.786395	0.213605	0.229043	3.44	11,452	44,186
94	10,112	2,337	0.768942	0.231058	0.251550	3.24	8,909	32,734
95	7,776	1,927	0.752235	0.247765	0.273869	3.06	6,779	23,825
96	5,849	1,540	0.736659	0.263341	0.295430	2.91	5,048	17,046
97	4,309	1,195	0.722567	0.277433	0.315661	2.78	3,684	11,997
98	3,113	902	0.710284	0.289716	0.333996	2.67	2,640	8,313
99	2,211	663	0.700115	0.299885	0.349585	2.57	1,863	5,673
100	1,548	484	0.687451	0.312549	0.365037	2.46	1,293	3,810
101	1,064	345	0.675387	0.324613	0.383721	2.36	882	2,517
102	719	242	0.663749	0.336251	0.401177	2.27	591	1,635
103	477	166	0.652146	0.347854	0.418497	2.19	389	1,045
104	311	112	0.639579	0.360421	0.436809	2.11	251	656
105	199	74	0.627525	0.372475	0.456416	2.03	159	405
106	125	48	0.615877	0.384123	0.475190	1.96	99	245
107	77	30	0.604637	0.395363	0.493673	1.90	61	146
108	47	19	0.593800	0.406200	0.511805	1.84	36	86
109	28	12	0.583359	0.416641	0.529572	1.79	21	49

Australian Life Tables 2010-12: Females

Age	l_x	d_x	p_x	q_x	μ_x	$\mathring{e}_x$	L_x	T_x
0	100,000	335	0.996648	0.003352	0.000000	84.31	99,709	8,431,213
1	99,665	27	0.999731	0.000269	0.000331	83.60	99,650	8,331,504
2	99,638	17	0.999830	0.000170	0.000213	82.62	99,629	8,231,853
3	99,621	11	0.999892	0.000108	0.000131	81.63	99,615	8,132,224
4	99,610	11	0.999894	0.000106	0.000102	80.64	99,605	8,032,609
5	99,600	10	0.999899	0.000101	0.000104	79.65	99,595	7,933,004
6	99,590	9	0.999906	0.000094	0.000098	78.66	99,585	7,833,409
7	99,580	9	0.999913	0.000087	0.000091	77.66	99,576	7,733,824
8	99,572	8	0.999921	0.000079	0.000083	76.67	99,568	7,634,248
9	99,564	7	0.999927	0.000073	0.000076	75.68	99,560	7,534,681
10	99,557	7	0.999931	0.000069	0.000070	74.68	99,553	7,435,121
11	99,550	7	0.999930	0.000070	0.000069	73.69	99,546	7,335,567
12	99,543	8	0.999923	0.000077	0.000072	72.69	99,539	7,236,021
13	99,535	9	0.999907	0.000093	0.000083	71.70	99,531	7,136,482
14	99,526	12	0.999880	0.000120	0.000104	70.70	99,520	7,036,952
15	99,514	16	0.999838	0.000162	0.000138	69.71	99,506	6,937,432
16	99,498	22	0.999778	0.000222	0.000193	68.72	99,487	6,837,926
17	99,476	25	0.999750	0.000250	0.000240	67.74	99,463	6,738,438
18	99,451	26	0.999735	0.000265	0.000260	66.76	99,438	6,638,975
19	99,424	26	0.999735	0.000265	0.000266	65.77	99,411	6,539,538
20	99,398	26	0.999737	0.000263	0.000264	64.79	99,385	6,440,126
21	99,372	26	0.999739	0.000261	0.000262	63.81	99,359	6,340,741
22	99,346	26	0.999740	0.000260	0.000260	62.82	99,333	6,241,382
23	99,320	26	0.999740	0.000260	0.000260	61.84	99,307	6,142,049
24	99,294	26	0.999737	0.000263	0.000261	60.86	99,281	6,042,742
25	99,268	27	0.999732	0.000268	0.000265	59.87	99,255	5,943,461
26	99,242	27	0.999724	0.000276	0.000271	58.89	99,228	5,844,206
27	99,214	29	0.999712	0.000288	0.000281	57.90	99,200	5,744,978
28	99,186	30	0.999696	0.000304	0.000295	56.92	99,171	5,645,778
29	99,155	32	0.999675	0.000325	0.000314	55.94	99,140	5,546,607
30	99,123	35	0.999651	0.000349	0.000337	54.96	99,106	5,447,468
31	99,089	37	0.999624	0.000376	0.000362	53.98	99,070	5,348,362
32	99,051	40	0.999595	0.000405	0.000390	53.00	99,032	5,249,291
33	99,011	43	0.999562	0.000438	0.000421	52.02	98,990	5,150,260
34	98,968	47	0.999526	0.000474	0.000456	51.04	98,945	5,051,270
35	98,921	51	0.999487	0.000513	0.000493	50.06	98,896	4,952,325
36	98,870	55	0.999444	0.000556	0.000534	49.09	98,843	4,853,429
37	98,815	60	0.999396	0.000604	0.000579	48.12	98,786	4,754,586
38	98,756	65	0.999343	0.000657	0.000630	47.14	98,724	4,655,800
39	98,691	70	0.999286	0.000714	0.000685	46.18	98,656	4,557,077
40	98,620	77	0.999223	0.000777	0.000745	45.21	98,582	4,458,421
41	98,544	83	0.999154	0.000846	0.000811	44.24	98,503	4,359,838
42	98,460	91	0.999079	0.000921	0.000883	43.28	98,416	4,261,336
43	98,370	99	0.998997	0.001003	0.000961	42.32	98,321	4,162,920
44	98,271	107	0.998908	0.001092	0.001047	41.36	98,218	4,064,599
45	98,164	117	0.998812	0.001188	0.001139	40.41	98,106	3,966,381
46	98,047	127	0.998708	0.001292	0.001239	39.45	97,985	3,868,275
47	97,920	137	0.998596	0.001404	0.001348	38.50	97,852	3,770,291
48	97,783	149	0.998476	0.001524	0.001464	37.56	97,709	3,672,438
49	97,634	161	0.998347	0.001653	0.001588	36.61	97,554	3,574,729
50	97,472	175	0.998208	0.001792	0.001722	35.67	97,386	3,477,175
51	97,298	189	0.998060	0.001940	0.001866	34.74	97,205	3,379,788
52	97,109	204	0.997902	0.002098	0.002019	33.80	97,008	3,282,584
53	96,905	220	0.997734	0.002266	0.002183	32.87	96,797	3,185,576
54	96,686	236	0.997554	0.002446	0.002357	31.95	96,569	3,088,779

AUSTRALIAN LIFE TABLES 2010-12: FEMALES (CONTINUED)

Age	l_x	d_x	p_x	q_x	μ_x	$\mathring{e}_x$	L_x	T_x
55	96,449	254	0.997363	0.002637	0.002542	31.02	96,324	2,992,210
56	96,195	274	0.997153	0.002847	0.002742	30.10	96,060	2,895,886
57	95,921	296	0.996916	0.003084	0.002965	29.19	95,775	2,799,827
58	95,625	321	0.996646	0.003354	0.003218	28.28	95,467	2,704,052
59	95,304	349	0.996336	0.003664	0.003509	27.37	95,132	2,608,585
60	94,955	381	0.995992	0.004008	0.003838	26.47	94,768	2,513,452
61	94,575	414	0.995622	0.004378	0.004198	25.57	94,370	2,418,685
62	94,161	449	0.995229	0.004771	0.004580	24.68	93,939	2,324,314
63	93,711	487	0.994804	0.005196	0.004989	23.80	93,471	2,230,375
64	93,224	528	0.994332	0.005668	0.005438	22.92	92,964	2,136,904
65	92,696	575	0.993797	0.006203	0.005942	22.05	92,413	2,043,940
66	92,121	628	0.993186	0.006814	0.006516	21.18	91,812	1,951,528
67	91,493	688	0.992485	0.007515	0.007174	20.33	91,155	1,859,716
68	90,806	756	0.991679	0.008321	0.007931	19.48	90,434	1,768,561
69	90,050	833	0.990754	0.009246	0.008801	18.64	89,641	1,678,127
70	89,218	919	0.989695	0.010305	0.009800	17.80	88,766	1,588,486
71	88,298	1,016	0.988490	0.011510	0.010941	16.98	87,799	1,499,721
72	87,282	1,124	0.987123	0.012877	0.012240	16.18	86,729	1,411,922
73	86,158	1,242	0.985582	0.014418	0.013711	15.38	85,547	1,325,193
74	84,916	1,371	0.983852	0.016148	0.015368	14.60	84,241	1,239,646
75	83,544	1,510	0.981920	0.018080	0.017226	13.83	82,801	1,155,404
76	82,034	1,661	0.979758	0.020242	0.019300	13.08	81,217	1,072,603
77	80,373	1,827	0.977274	0.022726	0.021655	12.33	79,475	991,386
78	78,547	2,014	0.974362	0.025638	0.024398	11.61	77,557	911,912
79	76,533	2,226	0.970918	0.029082	0.027642	10.90	75,439	834,355
80	74,307	2,464	0.966840	0.033160	0.031498	10.21	73,096	758,916
81	71,843	2,728	0.962030	0.037970	0.036078	9.55	70,502	685,820
82	69,115	3,014	0.956392	0.043608	0.041492	8.90	67,633	615,317
83	66,101	3,316	0.949834	0.050166	0.047853	8.29	64,469	547,684
84	62,785	3,624	0.942272	0.057728	0.055271	7.70	60,999	483,215
85	59,161	3,927	0.933625	0.066375	0.063859	7.14	57,222	422,216
86	55,234	4,208	0.923821	0.076179	0.073727	6.61	53,152	364,994
87	51,026	4,450	0.912796	0.087204	0.084989	6.11	48,820	311,842
88	46,577	4,635	0.900496	0.099504	0.097755	5.65	44,272	263,022
89	41,942	4,745	0.886875	0.113125	0.112139	5.22	39,575	218,750
90	37,197	4,765	0.871902	0.128098	0.128253	4.82	34,813	179,175
91	32,433	4,685	0.855556	0.144444	0.146213	4.45	30,079	144,362
92	27,748	4,498	0.837909	0.162091	0.166113	4.12	25,479	114,283
93	23,250	4,200	0.819351	0.180649	0.187798	3.82	21,121	88,804
94	19,050	3,804	0.800324	0.199676	0.210825	3.55	17,112	67,683
95	15,246	3,335	0.781234	0.218766	0.234730	3.32	13,537	50,572
96	11,911	2,829	0.762454	0.237546	0.259059	3.11	10,453	37,034
97	9,081	2,322	0.744323	0.255677	0.283355	2.93	7,879	26,581
98	6,760	1,844	0.727147	0.272853	0.307160	2.77	5,800	18,702
99	4,915	1,419	0.711202	0.288798	0.330014	2.62	4,173	12,902
100	3,496	1,060	0.696737	0.303263	0.351300	2.50	2,939	8,730
101	2,436	776	0.681203	0.318797	0.372350	2.38	2,026	5,791
102	1,659	554	0.666181	0.333819	0.395134	2.27	1,366	3,764
103	1,105	385	0.651594	0.348406	0.417314	2.17	901	2,398
104	720	261	0.637453	0.362547	0.439321	2.08	581	1,498
105	459	173	0.623764	0.376236	0.461093	2.00	367	917
106	286	112	0.610529	0.389471	0.482593	1.92	226	550
107	175	70	0.597752	0.402248	0.503787	1.85	137	324
108	105	43	0.585433	0.414567	0.524639	1.79	81	187
109	61	26	0.573574	0.426426	0.545113	1.73	47	106

2. Construction of the Australian Life Tables 2010-12

There are three main elements in the process of constructing the Australian Life Tables. The first is the derivation of the exposed-to-risk and crude mortality rates from the information provided by the Australian Bureau of Statistics (ABS). The second is the graduation of the crude rates and associated statistical testing of the quality of the graduation. The final task is the calculation of the Life Table functions. This chapter concludes with a discussion of the methodology used to estimate the mortality improvement factors.

2.1 Calculation of exposed-to-risk and crude mortality rates

The calculation of mortality rates requires a measure of both the number of deaths and the population which was at risk of dying — the exposed-to-risk — over the same period. The raw data used for these calculations was provided by the ABS and comprised the following:

(a) Estimates of the numbers of males and females resident in Australia at each age last birthday up to 115 years and over, as at 30 June 2011. These estimates are based on the 2011 Census of Population and Housing adjusted for under-enumeration and the lapse of time between 30 June and 9 August 2011 (the night on which the Census was taken). They differ from the published official estimates of Australian resident population which contain further adjustments to exclude overseas visitors temporarily in Australia and include Australian residents who are temporarily absent.

(b) The numbers of deaths occurring inside Australia for each month from January 2010 to December 2012, classified by sex and age last birthday at the time of death. This data covers all registrations of deaths to the end of 2013 and is considered to be effectively a complete record of all deaths occurring over the three year period.

(c) The number of registered births classified by sex in each month from January 2006 to December 2012.

(d) The number of deaths of those aged 3 years or less in each month from January 2006 to December 2012, classified by sex and age last birthday, with deaths of those aged less than one year classified by detailed duration.

(e) The numbers of persons moving into and out of Australia in each month from January 2010 to December 2012 for those aged 4 or more, and from January 2006 to December 2012 for those aged less than 4, grouped by age last birthday and sex.

Appendix B includes some selected summary information on the population, number of deaths and population movements, while Appendix C provides the detailed estimates of the population at each age last birthday at 30 June 2011, and the number of deaths at each age occurring over the three years 2010 to 2012.

The ABS conducts a five-yearly Census of Population and Housing. Adjusted population estimates based on a particular Census will usually differ from those produced by updating the results of the previous Census for population change (that is, for births, deaths and migration) during the following five years. The difference between an estimate based on the results of a particular Census and that produced by updating results from the previous Census is called intercensal discrepancy. It is caused by unattributable errors in either or both of the start and finish population estimates, together with any errors in the estimates of births, deaths or migration in the intervening period.

The Australian Life Tables are based on the most recent Census population estimates. This is consistent with the view of the ABS that the best available estimate of the population at 30 June of the Census year is the one based on that year's Census, not the one carried forward from the previous period. Intercensal discrepancy can, however, affect the comparability of reported mortality rates, and consequently life expectancies and improvement factors.

The crude mortality rates are calculated by dividing the number of deaths at a particular age by the exposed-to-risk for that age. It is essential, then, that the measure of the exposed-to-risk and the number of deaths should refer to the same population. Effectively, this means that a person in the population should be included in the denominator (that is, counted in the exposed-to-risk) only if their death would have been included in the numerator had they died.

The deaths used in deriving these Tables are those which occurred in Australia during 2010-12, regardless of usual place of residence. The appropriate exposed-to-risk is, therefore, exposure of people actually present in Australia at any time during the three year period. The official population estimates published by the ABS (Australian Demographic Statistics, ABS Catalogue No 3101.0) are intended to measure the population usually resident in Australia and accordingly include adjustments to remove the effect of short-term movements, which are not appropriate for these Tables. Adjustment does, however, need to be made to the exposed-to-risk to take account of those persons who, as a result of death or international movement, are not present in Australia for the full three year period.

The base estimate of the exposed-to-risk at age x, which assumes that all those present on Census night contribute a full three years to the exposed-to-risk, was taken to be:

$$\frac{1}{8}P_{x-2} + \frac{7}{8}P_{x-1} + P_x + \frac{7}{8}P_{x+1} + \frac{1}{8}P_{x+2}$$

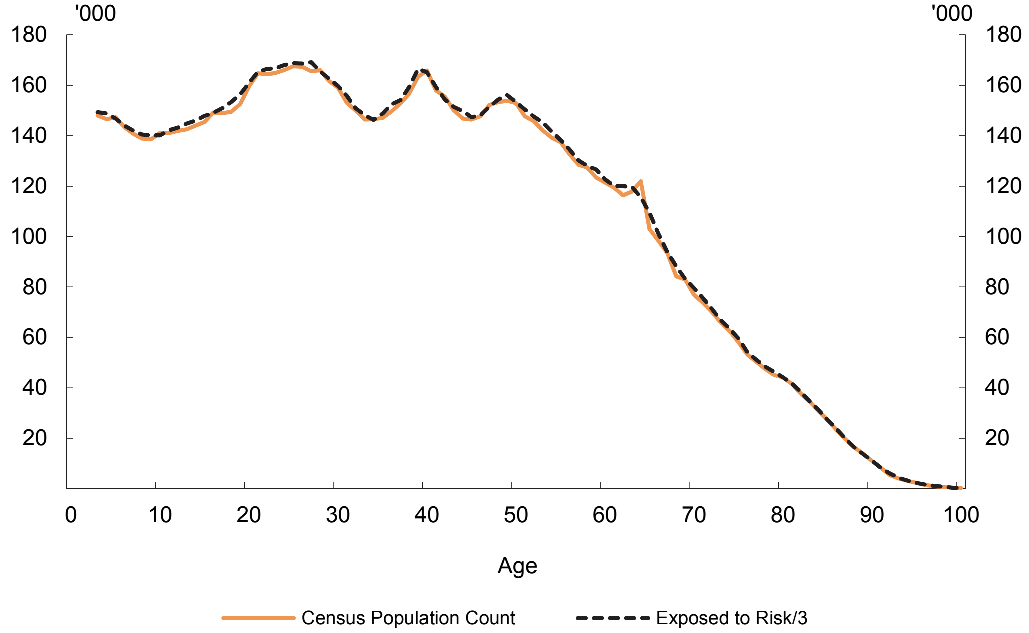
where P_x is the population inside Australia aged x last birthday as measured in the 2011 Census adjusted only for under-enumeration and the lapse of time from 30 June to Census night.

This estimate was then modified to reduce exposure for those who arrived in Australia between January 2010 and June 2011, or who died or left Australia between July 2011 and December 2012. Similarly, exposure was increased to take account of those who arrived between July 2011 and December 2012 or who died or left Australia between January 2010 and June 2011.

Figure 15 compares the Census population count with the exposed-to-risk after all adjustments have been made. It can be seen that the exposed-to-risk formula smooths to some extent the fluctuations from age to age apparent in the unadjusted population count. The peak resulting from the high birth rates in 1971 remains clearly visible, as does the baby boomer cohort who were in their 50s and early 60s at the time of the Census. The impact of net inward migration over recent years can be seen in the fact that the exposed-to-risk sits above the Census population count for most of the prime working ages from 20 to 40, particularly for females.

Figure 15: Comparison of census population count and exposed-to-risk

Males



Females

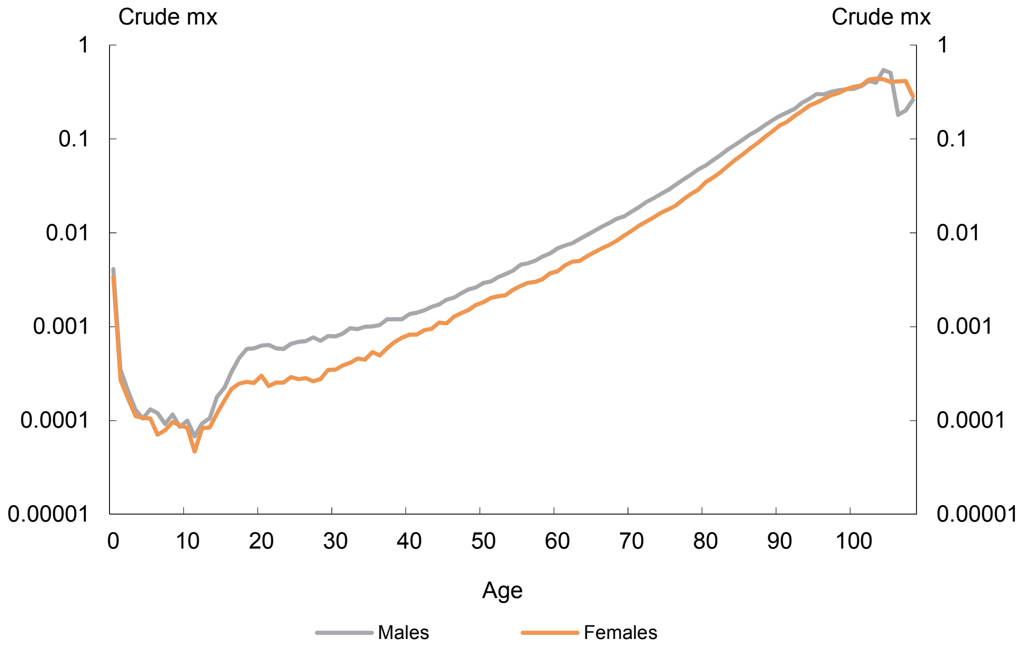
For ages 2 and above, the crude central rate of mortality at age x, m_x, was in most cases calculated by dividing the deaths at age x during 2010, 2011 and 2012 by the relevant exposed-to-risk. An exception was made for ages 4 to 16 inclusive. The very small number of deaths now seen at these ages has increased the potential for random fluctuations to result in dramatically different smoothed mortality rates from one set of Tables to the next. In order to avoid giving undue weight to random variation, we have combined the experience from 2005-07 and 2010-12 over these ages. The deaths data from 2005-07 has been adjusted to take account of the average level of mortality improvement over these ages before combining with the 2010-12 experience.

The exposed-to-risk for ages 0 and 1 was derived more directly by keeping a count of those at each age for each month of the three year period using monthly birth, death and movement records from 2006 to 2012. Because of the rapid fall in the force of mortality, μ_x, over the first few weeks of life, q_x, rather than m_x, was calculated for age zero. The formulae used are available on request.

2.2 Graduation of the crude mortality rates

Figure 16 shows the crude mortality rates. The crude central rates of mortality, even when calculated over three years of experience, exhibit considerable fluctuation from one age to the next, particularly among the very young and very old where the number of deaths is typically low. From a first principles perspective, however, there is no reason to suppose that these fluctuations are anything other than a reflection of the random nature of the underlying mortality process. Hence, when constructing a life table to represent the mortality experience of a population, it is customary to graduate the crude rates to obtain a curve that progresses smoothly with age.

Figure 16: Crude central mortality rates



As with previous Life Tables, a combination of manual graduation and fitted cubic splines was used. Cubic splines were fitted over all but the two youngest ages and the very top of the age distribution. At the oldest ages, there is little exposure and few deaths and a different approach is required. This is discussed below.

The method of cubic splines involves fitting a series of cubic polynomials to the crude rates of mortality. These polynomials are constrained to be not only continuous at the 'knots' where they join, but also to have equal first and second derivatives at those points. This constraint, of itself, is insufficient to ensure that the fitted curve is smooth in the sense of having a low rate of change of curvature. A large number of knots or closely spaced knots would allow the curve to follow the random fluctuations in the crude rates. At the same time, large intervals between the knots can reduce the fitted curve's fidelity to the observed results. The choice of the number and location of knots, therefore, involves a balance between achieving a smooth curve and deriving fitted rates that are reasonably consistent with the observed mortality rates.

For any given choice of knots, the criterion used to arrive at the cubic spline was that the following weighted sum of squares (an approximate χ^2 variable) should be minimised:

$$\sum_{x=x_1}^{x_2} \frac{(A_x - E_x m_x)^2}{E_x m'_x (1 - m'_x)}$$

where:

A_x	is the number of observed deaths aged x in the three years 2010, 2011 and 2012;
E_x	is the central exposed-to-risk at age x;
m_x	is the graduated value of the central mortality rate at age x, produced by the cubic spline;
m'_x	is a preliminary value of m_x obtained by minimising a sum of squares similar to that above, but with A_x as the denominator;
x_1	is the lowest age of the range to which the cubic spline is to be fitted; and
x_2	is the highest age of the range to which the cubic spline is to be fitted.

As in the 2005-07 Life Tables, the knots were initially selected based on observation of the crude data. A computer program was then used to modify the location of the knots to improve the fidelity of the graduated rates to the data, and a series of statistical tests were performed on the rates to assess the adequacy of the fit. A process of trial-and-error was followed whereby a variety of initial knots was input into the program to produce alternative sets of graduated rates. The knots used in the graduation adopted are shown below.

Males:	7	12	16	18	20	32	53	54	61	66	77	90	95
Females:	7	9	14	17	19	27	31	54	58	61	75	91	101

The cubic splines were fitted from ages 2 to 105. In general, a larger number of knots is required at and near the ages where mortality undergoes a marked transition. For males, knots at ages 16, 18 and 20 enabled the construction of a graduated curve that captured the behaviour of mortality rates at the edge of the accident ‘cliff’. Similarly, for females, knots were needed at ages 14, 17 and 19 to capture the sharp increase and subsequent flattening in mortality rates over this age range.

The 2006 Census was the first to record individual ages for those aged 100 or more. It also asked for date of birth which allowed the internal consistency of the records to be checked. As result, both the quality and volume of data at very old ages improved and this process has continued with the 2011 Census where a high priority was placed on data integrity for centenarians. Nonetheless, the data remains scanty and an alternative approach is required for graduation at the very oldest ages.

The rates for these ages were constructed by extrapolating the trend of the crude rates from ages where there were sufficient deaths to make the crude rates meaningful. The trend result was determined by fitting a Makeham curve of the form:

$$q_x = 1 - exp[-A - B \times C^x(C-1)]$$

where *A*, *B* and *C* are constants.

For males, the function was fitted to the crude rates from age 88 to age 104, while for females the data covered ages from 90 to 106. It should be noted that the results are quite sensitive to the age range chosen and there is necessarily a degree of judgement involved. For the current Tables, data on death registrations over the past 25 years was used to estimate mortality rates based on the extinct generations methodology and this influenced the selection of the age ranges used for fitting. The fitted Makeham curve was then used to extrapolate the graduated rates from age 99 for males and 100 for females.

As has been the case for the last six Tables, the raw mortality rates for males and females cross at a very old age. The 1990-92 Tables maintained the apparent crossover as a genuine feature, resulting in male mortality rates falling below the female rates from age 103. Since that time, the crossover in both the raw and graduated rates has varied within a fairly narrow range. The following table summarises the experience.

Life Tables	Crossover in crude rates	Crossover in graduated rates
1990-92	100	103
1995-97	96	98
2000-02	96	103
2005-07	99	100
2010-12	100[1]	103

[1] The male crude rates cross below female rates for the first time at age 100, but female rates are lower at ages 104 and 105. Male rates are lower at all subsequent ages.

A negligible percentage of death registrations in 2010-12 did not include the age at death (less than 0.001 per cent for all ages), and consequently no adjustments were considered necessary to the graduated rates.

A number of tests were applied to the graduated rates to assess the suitability of the graduation. These tests indicated that the deviations between the crude rates and graduated rates were consistent with the hypothesis that the observed deaths represented a random sample from an underlying mortality distribution following the smoothed rates. Appendix D provides a comparison between the actual and expected number of deaths at each age.

2.3 Calculation of life table functions

As noted above, the function graduated over all but the very youngest ages was the central rate of mortality, m_x. The formulae adopted for calculating the functions included in the Life Tables were as follows:

$$q_x = \frac{m_x\left[1 - \frac{1}{12}\frac{q_{x-1}}{p_{x-1}}\right]}{1 + \frac{5}{12}m_x}$$

$$d_x = l_x q_x$$

$$l_{x+1} = l_x - d_x$$

$$p_x = 1 - q_x$$

$$\mu_x = \frac{1}{12l_x}[7(d_{x-1} + d_x) - (d_{x-2} + d_{x+1})]$$

$$\mathring{e}_x = \frac{1}{l_x}\sum_{i=1}^{120} l_{x+t} + \frac{1}{2} - \frac{1}{12}\mu_x$$

$$L_x = T_x - T_{x+1}$$

$$T_x = l_x \mathring{e}_x$$

l_0, the radix of the Life Table, was chosen to be 100,000.

All of the Life Table entries can be calculated from q_x using the formulae above with the exception of L_0, $\mathring{e}_0$, μ_1 and μ_2. These figures cannot be calculated using the standard formulae because of the rapid decline in mortality over the first year of life. Details of the calculations of L_0, $\mathring{e}_0$, μ_1 and μ_2 can be provided on request.

2.4 Estimation of mortality improvement factors

As noted in Section 1.5, a slightly different methodology has been adopted for estimating mortality improvement factors for the current publication. In previous Tables, the improvement factor at any given age has been calculated using the following formula:

$$I_x = \left[\left(\frac{q_x(t)}{q_x(t-n)}\right)^{\frac{1}{n}} - 1\right] \times 100$$

where

I_x is the rate of improvement at age x;

$q_x(t)$ is the mortality rate at age x in the current Tables; and

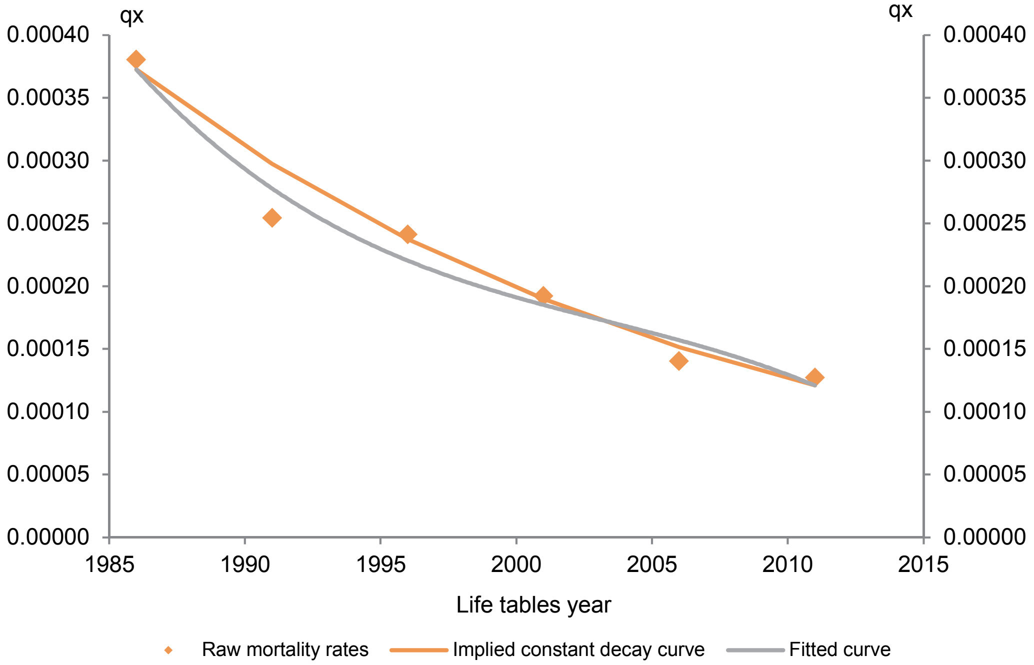
$q_x(t-n)$ is the mortality rate reported for age x in the Tables n years previously.

This measure depends only upon the mortality rates at the beginning and end of the period and gives no weight to the experience over the intervening period. As a result, this methodology can yield results that do not reflect the general pattern of mortality improvement over the period.

The alternative methodology which has been adopted for these Tables is to fit a polynomial to the mortality rates over the period of interest (either 25 years or the full history of the Life Tables) and use the fitted values for estimating the mortality improvement. The results produced on this basis are not dissimilar to those generated by the previous approach of calculating the annual percentage change between the mortality rate at the start and end of the period, but it ensures that factors reflect the experience over the whole period, not just the end points.

Figure 17 illustrates this process for a male aged 4 looking at improvement over the last 25 years. In this case, a cubic polynomial has been fitted to the six data points and the values for from the fitted function used to estimate the constant annual improvement that would give rise to the same results.

Figure 17: Estimating mortality improvement for a male aged 4



3. USE OF LIFE TABLES FOR PROBABILITY CALCULATIONS

As well as being the most recent actuarially determined record of mortality rates, the 2010-12 Tables can be used to project the probabilities of persons living or dying at some time in the future. This does, however, require an assumption on what will happen to mortality rates over the intervening period.

The simplest assumption is that mortality rates remain unchanged at the 2010-12 level. However, the continuing improvement in mortality exhibited in these Tables suggests that this assumption will tend to underestimate survival probabilities.

A range of assumptions can be made about future mortality improvements. Appendix E contains the two series of improvement factors derived from the historical trends in Australian mortality improvement over the last 25 years and 125 years. These factors can be applied to the mortality rates included in the current Life Tables to obtain projections of future mortality and life expectancy scenarios.

The process for incorporating future improvements can be expressed in the following mathematical form:

$$q_x(t) = q_x \times \left(1 + \frac{I_x}{100}\right)^{(t-2011)}$$

where

$q_x(t)$	is the mortality rate at age x in year *t*;
q_x	is the mortality rate reported for age x in the current Tables; and
I_x	is the rate of improvement at age x as shown in Appendix E.

Other mortality functions can then be calculated using the formulae given in section 2.3.

An example of how to apply this formula is given below:

Consider a 35 year old female. Her mortality in 2011 is given in the current Life Tables as 0.000513. That is, $q_{35}(2011)$= 0.000513

The table below sets out the calculation of the projected mortality rate for a 35 year old female in future years —$q_{35}(t)$for t =2012, 2015 and 2050 — using the two improvement scenarios.

	25 year improvement factors	125 year improvement factors
$q_{35}(2011)$	0.000513	0.000513
$q_{35}(2012)$	$q_{35}(2011) \times \left(1 + \frac{-1.1057}{100}\right)^{1} = 0.000507$	$q_{35}(2011) \times \left(1 + \frac{-2.2666}{100}\right)^{1} = 0.000501$
$q_{35}(2015)$	$q_{35}(2011) \times \left(1 + \frac{-1.1057}{100}\right)^{4} = 0.000491$	$q_{35}(2011) \times \left(1 + \frac{-2.2666}{100}\right)^{4} = 0.000468$
$q_{35}(2050)$	$q_{35}(2011) \times \left(1 + \frac{-1.1057}{100}\right)^{39} = 0.000333$	$q_{35}(2011) \times \left(1 + \frac{-2.2666}{100}\right)^{39} = 0.000210$

The two sets of improvement factors given in Appendix E should be treated as illustrative rather than forecasts. What the future will bring cannot be known. Using a particular set of factors allows the impact of a given scenario on mortality rates and associated life table functions to be quantified. It cannot say anything about what mortality rates will actually be. The differences in the projected rates under the two scenarios presented here highlight the uncertainty associated with modelling future mortality.

The importance of allowing for future improvements in mortality rates depends on the purpose of the calculations being carried out, the ages involved and the time span that is being considered. Clearly, the longer the time span being considered, the more significant will be the effect of mortality improvements. At the same time, the longer the time span being considered, the greater will be the uncertainty surrounding the projected rates. Similarly, the higher the improvement factors the more quickly the projected rates will diverge from the current rates.

Appendices

Appendix A

The comparisons made in this Appendix are based on the published Australian Life Tables for the relevant years except that revised estimates for the 1970-72 Tables have been preferred to the published Tables, the latter having been based on an under-enumerated population.

Historical summary of mortality rates — males

	Age					
Life Tables	0	15	30	45	65	85
1881-90	0.13248	0.00372	0.00867	0.01424	0.04582	0.18895
1891-00	0.11840	0.00290	0.00698	0.01183	0.04496	0.19629
1901-10	0.09510	0.00255	0.00519	0.01083	0.03859	0.19701
1920-22	0.07132	0.00184	0.00390	0.00844	0.03552	0.19580
1932-34	0.04543	0.00149	0.00271	0.00659	0.03311	0.18864
1946-48	0.03199	0.00115	0.00186	0.00554	0.03525	0.18332
1953-55	0.02521	0.00109	0.00170	0.00478	0.03412	0.17692
1960-62	0.02239	0.00075	0.00157	0.00485	0.03454	0.17363
1965-67	0.02093	0.00079	0.00150	0.00500	0.03603	0.17617
1970-72	0.01949	0.00080	0.00142	0.00479	0.03471	0.16778
1975-77	0.01501	0.00070	0.00128	0.00453	0.03067	0.16043
1980-82	0.01147	0.00057	0.00126	0.00370	0.02671	0.14848
1985-87	0.01030	0.00050	0.00129	0.00291	0.02351	0.14276
1990-92	0.00814	0.00044	0.00131	0.00256	0.02061	0.12975
1995-97	0.00610	0.00039	0.00131	0.00231	0.01763	0.12443
2000-02	0.00567	0.00030	0.00119	0.00218	0.01420	0.10556
2005-07	0.00523	0.00022	0.00095	0.00204	0.01200	0.09907
2010-12	0.004121	0.000215	0.000826	0.001898	0.010505	0.093419

Historical summary of mortality rates — females

	Age					
Life Tables	0	15	30	45	65	85
1881-90	0.11572	0.00299	0.00828	0.01167	0.03550	0.18779
1891-00	0.10139	0.00248	0.00652	0.00917	0.03239	0.17463
1901-10	0.07953	0.00219	0.00519	0.00807	0.02998	0.16459
1920-22	0.05568	0.00144	0.00387	0.00606	0.02426	0.17200
1932-34	0.03642	0.00113	0.00279	0.00523	0.02365	0.15837
1946-48	0.02519	0.00061	0.00165	0.00411	0.02133	0.15818
1953-55	0.01989	0.00048	0.00096	0.00341	0.01943	0.15018
1960-62	0.01757	0.00038	0.00082	0.00300	0.01769	0.13927
1965-67	0.01639	0.00041	0.00085	0.00313	0.01774	0.13782
1970-72	0.01501	0.00042	0.00077	0.00299	0.01684	0.12986
1975-77	0.01184	0.00037	0.00062	0.00264	0.01493	0.11644
1980-82	0.00905	0.00031	0.00052	0.00207	0.01283	0.10656
1985-87	0.00794	0.00026	0.00053	0.00180	0.01179	0.09781
1990-92	0.00634	0.00025	0.00051	0.00152	0.01049	0.09021
1995-97	0.00502	0.00022	0.00049	0.00137	0.00929	0.08553
2000-02	0.00466	0.00020	0.00045	0.00130	0.00789	0.07528
2005-07	0.00440	0.00018	0.00038	0.00124	0.00679	0.07088
2010-12	0.003352	0.000162	0.000349	0.001188	0.006203	0.066375

Complete expectation of life at selected ages — males

	Age			
Life Tables	0	30	65	85
1881-90	47.20	33.64	11.06	3.86
1891-00	51.08	35.11	11.25	3.79
1901-10	55.20	36.52	11.31	3.65
1920-22	59.15	38.44	12.01	3.62
1932-34	63.48	39.90	12.40	3.90
1946-48	66.07	40.40	12.25	3.84
1953-55	67.14	40.90	12.33	4.01
1960-62	67.92	41.12	12.47	4.08
1965-67	67.63	40.72	12.16	4.07
1970-72	67.81	40.94	12.21	4.13
1975-77	69.56	42.18	13.13	4.45
1980-82	71.23	43.51	13.80	4.67
1985-87	72.74	44.84	14.60	4.89
1990-92	74.32	46.07	15.41	5.23
1995-97	75.69	47.26	16.21	5.40
2000-02	77.64	49.07	17.70	6.11
2005-07	79.02	50.20	18.54	6.03
2010-12	80.06	51.04	19.22	6.06

Complete expectation of life at selected ages — females

	Age			
Life Tables	0	30	65	85
1881-90	50.84	36.13	12.27	3.90
1891-00	54.76	37.86	12.75	4.12
1901-10	58.84	39.33	12.88	4.19
1920-22	63.31	41.48	13.60	4.06
1932-34	67.14	42.77	14.15	4.30
1946-48	70.63	44.08	14.44	4.32
1953-55	72.75	45.43	15.02	4.52
1960-62	74.18	46.49	15.68	4.79
1965-67	74.15	46.34	15.70	4.85
1970-72	74.80	46.86	16.09	5.03
1975-77	76.56	48.26	17.13	5.49
1980-82	78.27	49.67	18.00	5.74
1985-87	79.20	50.49	18.56	6.09
1990-92	80.39	51.48	19.26	6.40
1995-97	81.37	52.30	19.88	6.53
2000-02	82.87	53.72	21.15	7.28
2005-07	83.67	54.44	21.62	7.08
2010-12	84.31	54.96	22.05	7.14

Appendix B

Population

The Australian population as shown by the last twelve Censuses was:

Year	Males	Females	Total
1954	4,546,118	4,440,412	8,986,530
1961	5,312,252	5,195,934	10,508,186
1966	5,841,588	5,757,910	11,599,498
1971	6,506,224	6,431,023	12,937,247
1976	6,979,380	6,936,129	13,915,509
1981	7,416,090	7,440,684	14,856,774
1986	7,940,110	7,959,691	15,899,801
1991	8,518,397	8,584,208	17,102,605
1996	9,048,337	9,172,939	18,221,276
2001	9,533,996	9,670,962	19,204,958
2006	10,123,089	10,247,880	20,370,969
2011	10,972,862	11,085,920	22,058,782

Figures shown for Censuses before 1966 exclude Aborigines. Figures shown for Censuses from 1971 onwards have been adjusted by the Statistician to allow for under-enumeration. Since 1991, the Census has been held in August. Figures for these years are given at 30 June of the relevant year and have been adjusted for the length of time between 30 June and Census night.

Deaths

Year	Males	Females	Total
2010	73,019	69,721	142,740
2011	75,324	71,388	146,712
2012	75,545	73,279	148,824
Total	**223,888**	**214,388**	**438,276**

These numbers do not include deaths of Australian residents overseas, but do include deaths of overseas residents who are in Australia at the time of their death.

Movements of the population

Year	Males		Females		Total	
	Arrivals	Departures	Arrivals	Departures	Arrivals	Departures
2010	7,009,440	7,021,128	6,494,003	6,437,629	13,503,443	13,458,757
2011	7,401,102	7,376,657	6,820,686	6,747,096	14,221,788	14,123,753
2012	7,742,837	7,690,737	7,214,926	7,102,845	14,957,763	14,793,582
Total	**22,153,379**	**22,088,522**	**20,529,615**	**20,287,570**	**42,682,994**	**42,376,092**

These numbers are not evenly distributed by age and whether arrivals exceed departures or vice-versa may vary from age to age.

Appendix C

Population at 30 June 2011 and deaths in the three years 2010-12, Australia — males

Age	Population	Deaths	Age	Population	Deaths
0	146,853	1,906	52	145,771	1,495
1	148,944	152	53	141,976	1,591
2	148,563	92	54	139,231	1,686
3	148,038	58	55	137,425	1,907
4	146,570	47	56	132,782	1,905
5	147,285	58	57	128,442	1,982
6	143,377	52	58	127,381	2,148
7	140,767	39	59	123,382	2,290
8	138,817	49	60	121,479	2,515
9	138,535	36	61	119,482	2,647
10	141,047	42	62	116,425	2,806
11	141,132	29	63	117,830	3,100
12	141,933	40	64	121,936	3,294
13	142,614	46	65	102,981	3,461
14	144,029	78	66	98,256	3,532
15	145,529	99	67	93,521	3,589
16	149,246	148	68	84,158	3,736
17	148,936	210	69	82,941	3,742
18	149,512	267	70	76,870	4,025
19	152,573	276	71	73,880	4,258
20	159,395	304	72	70,068	4,560
21	164,764	318	73	65,836	4,679
22	164,325	294	74	62,534	4,977
23	164,860	289	75	58,053	5,166
24	166,055	332	76	53,165	5,331
25	167,580	348	77	50,262	5,699
26	167,267	356	78	47,518	6,012
27	165,510	392	79	45,083	6,604
28	165,950	351	80	44,225	6,970
29	161,761	389	81	41,532	7,454
30	159,079	379	82	37,757	7,784
31	153,114	396	83	34,506	8,047
32	149,954	438	84	30,783	8,161
33	146,452	417	85	27,301	8,047
34	146,599	440	86	23,339	7,910
35	147,084	450	87	19,641	7,410
36	149,598	475	88	16,340	6,895
37	152,794	558	89	13,830	6,475
38	156,643	574	90	10,864	5,804
39	163,467	600	91	8,260	4,762
40	165,792	673	92	5,398	3,815
41	157,920	674	93	4,071	3,142
42	155,512	695	94	3,090	2,564
43	150,127	740	95	2,254	2,106
44	146,841	777	96	1,528	1,486
45	146,421	859	97	1,007	1,097
46	147,725	908	98	668	747
47	152,144	1,034	99	397	481
48	153,302	1,160	100 and over	554	697
49	153,835	1,227			
50	152,965	1,346	Not stated		6
51	147,710	1,374	Total	10,972,862	223,888

Population at 30 June 2011 and deaths in the three years 2010-12, Australia — females

Age	Population	Deaths	Age	Population	Deaths
0	139,392	1,439	52	148,677	944
1	140,907	114	53	145,401	959
2	140,987	73	54	141,607	1,064
3	140,624	47	55	139,408	1,140
4	138,632	45	56	135,866	1,202
5	139,405	44	57	131,691	1,210
6	135,031	29	58	129,816	1,259
7	133,098	32	59	124,990	1,409
8	132,183	39	60	123,372	1,457
9	132,069	36	61	121,053	1,631
10	133,783	34	62	117,259	1,786
11	134,631	19	63	117,772	1,812
12	135,145	34	64	121,668	1,985
13	134,877	35	65	103,212	2,035
14	136,932	49	66	99,830	2,082
15	137,773	69	67	95,276	2,148
16	141,476	93	68	86,544	2,200
17	141,150	106	69	84,415	2,366
18	140,932	112	70	79,015	2,560
19	145,855	113	71	76,119	2,760
20	153,569	140	72	72,898	2,920
21	156,879	112	73	69,229	3,066
22	156,328	123	74	66,603	3,367
23	157,191	122	75	65,017	3,518
24	157,939	142	76	61,547	3,670
25	159,569	136	77	58,395	4,091
26	161,692	139	78	56,872	4,436
27	161,121	128	79	54,894	4,869
28	161,563	133	80	55,508	5,708
29	158,005	166	81	53,392	6,166
30	156,902	164	82	50,454	6,833
31	152,073	177	83	48,133	7,492
32	149,482	189	84	44,642	8,011
33	147,533	204	85	41,706	8,559
34	147,359	198	86	38,386	9,014
35	148,055	241	87	34,154	9,353
36	150,954	225	88	30,186	9,499
37	154,893	276	89	26,561	9,584
38	159,789	328	90	22,463	9,256
39	167,151	378	91	17,690	8,125
40	170,354	410	92	12,711	7,262
41	160,590	406	93	10,419	6,329
42	159,217	438	94	8,449	5,788
43	152,665	443	95	6,444	4,973
44	149,513	506	96	5,092	4,142
45	149,389	498	97	3,443	3,323
46	151,143	582	98	2,376	2,417
47	154,909	648	99	1,576	1,772
48	156,872	708	100 and over	2,507	3,324
49	156,334	805			
50	156,178	857	Not stated		6
51	151,088	922	Total	11,085,920	214,388

Appendix D

Comparison of actual and expected deaths in the three years 2010-2012, Australia — males

Age	Actual Deaths	Expected Deaths	Deviation		Accumulation	
			+	-	+	-
2	92	93		1		1
3	58	59		1		2
4	47	57		10		12
5	58	52	6			6
6	52	48	4			2
7	39	44		5		7
8	49	41	8		1	
9	36	39		3		2
10	42	37	5		3	
11	29	39		10		7
12	40	43		3		10
13	46	52		6		16
14	78	69	9			7
15	99	95	4			3
16	148	134	14		11	
17	210	209	1		12	
18	267	264	3		15	
19	276	288		12	3	
20	304	296	8		11	
21	318	304	14		25	
22	294	308		14	11	
23	289	314		25		14
24	332	325	7			7
25	348	337	11		4	
26	356	350	6		10	
27	392	366	26		36	
28	351	374		23	13	
29	389	385	4		17	
30	379	396		17		0
31	396	405		9		9
32	438	409	29		20	
33	417	420		3	17	
34	440	433	7		24	
35	450	461		11	13	
36	475	494		19		6
37	558	524	34		28	
38	574	571	3		31	
39	600	630		30	1	
40	673	663	10		11	
41	674	681		7	4	
42	695	705		10		6
43	740	743		3		9
44	777	791		14		23
45	859	840	19			4
46	908	914		6		10
47	1034	1014	20		10	
48	1,160	1,123	37		47	
49	1,227	1,235		8	39	
50	1,346	1,321	25		64	
51	1,374	1,412		38	26	

Comparison of actual and expected deaths in the three years 2010-12, Australia — males (continued)

Age	Actual Deaths	Expected Deaths	Deviation		Accumulation	
			+	-	+	-
52	1,495	1,510		15	11	
53	1,591	1,619		28		17
54	1,686	1,720		34		51
55	1,907	1,821	86		35	
56	1,905	1,920		15	20	
57	1,982	2,011		29		9
58	2,148	2,144	4			5
59	2,290	2,305		15		20
60	2,515	2,439	76		56	
61	2,647	2,610	37		93	
62	2,806	2,861		55	38	
63	3,100	3,142		42		4
64	3,294	3,331		37		41
65	3,461	3,465		4		45
66	3,532	3,510	22			23
67	3,589	3,577	12			11
68	3,736	3,681	55		44	
69	3,742	3,822		80		36
70	4,025	4,026		1		37
71	4,258	4,250	8			29
72	4,560	4,456	104		75	
73	4,679	4,657	22		97	
74	4,977	4,957	20		117	
75	5,166	5,227		61	56	
76	5,331	5,351		20	36	
77	5,699	5,692	7		43	
78	6,012	6,069		57		14
79	6,604	6,549	55		41	
80	6,970	7,048		78		37
81	7,454	7,515		61		98
82	7,784	7,850		66		164
83	8,047	7,984	63			101
84	8,161	8,121	40			61
85	8,047	8,004	43			18
86	7,910	7,835	75		57	
87	7,410	7,420		10	47	
88	6,895	6,882	13		60	
89	6,475	6,421	54		114	
90	5,804	5,800	4		118	
91	4,762	4,858		96	22	
92	3,815	3,936		121		99
93	3,142	3,112	30			69
94	2,564	2,506	58			11
95	2,106	1,986	120		109	
96	1,486	1,515		29	80	
97	1,097	1,114		17	63	
98	747	772		25	38	
99	481	504		23	15	
100	292	319		27		12
Total	221,419	221,431				

The expected deaths are the number of deaths under the assumption that the graduated rates are correct. Deviation refers to the difference between the actual and expected number of deaths. Accumulation at age x is the sum of the deviations from age 2 to age x. Note that this table only covers the ages for which we can calculate an exposed to risk from the Census data.

Comparison of actual and expected deaths in the three years 2010-12, Australia — females

Age	Actual Deaths	Expected Deaths	Deviation +	Deviation -	Accumulation +	Accumulation -
2	73	72	1		1	
3	47	46	1		2	
4	45	45		0	2	
5	44	42	2		4	
6	29	39		10		6
7	32	35		3		9
8	39	32	7			2
9	36	29	7		5	
10	34	28	6		11	
11	19	28		9	2	
12	34	31	3		5	
13	35	39		4	1	
14	49	50		1		0
15	69	69		0		0
16	93	95		2		2
17	106	107		1		3
18	112	115		3		6
19	113	119		6		12
20	140	123	17		5	
21	112	126		14		9
22	123	126		3		12
23	122	125		3		15
24	142	128	14			1
25	136	132	4		3	
26	139	136	3		6	
27	128	141		13		7
28	133	147		14		21
29	166	156	10			11
30	164	164		0		11
31	177	173	4			7
32	189	185	4			3
33	204	196	8		5	
34	198	210		12		7
35	241	230	11		4	
36	225	254		29		25
37	276	280		4		29
38	328	315	13			16
39	378	353	25		9	
40	410	388	22		31	
41	406	417		11	20	
42	438	439		1	19	
43	443	467		24		5
44	506	499	7		2	
45	498	544		46		44
46	582	592		10		54
47	648	651		3		57
48	708	714		6		63
49	805	779	26			37
50	857	836	21			16
51	922	885	37		21	

Comparison of actual and expected deaths in the three years 2010-12, Australia — females (continued)

Age	Actual Deaths	Expected Deaths	Deviation +	Deviation -	Accumulation +	Accumulation -
52	944	937	7		28	
53	959	1,002		43		15
54	1,064	1,055	9			6
55	1,140	1,108	32		26	
56	1,202	1,167	35		61	
57	1,210	1,244		34	27	
58	1,259	1,311		52		25
59	1,409	1,398	11			14
60	1,457	1,497		40		54
61	1,631	1,589	42			12
62	1,786	1,732	54		42	
63	1,812	1,878		66		24
64	1,985	1,989		4		28
65	2,035	2,034	1			27
66	2,082	2,072	10			17
67	2,148	2,172		24		41
68	2,200	2,236		36		77
69	2,366	2,352	14			63
70	2,560	2,518	42			21
71	2,760	2,682	78		57	
72	2,920	2,872	48		105	
73	3,066	3,058	8		113	
74	3,367	3,325	42		155	
75	3,518	3,586		68	87	
76	3,670	3,826		156		69
77	4,091	4,107		16		85
78	4,436	4,464		28		113
79	4,869	4,989		120		233
80	5,708	5,522	186			47
81	6,166	6,160	6			41
82	6,833	6,871		38		79
83	7,492	7,462	30			49
84	8,011	7,963	48			1
85	8,559	8,522	37		36	
86	9,014	9,008	6		42	
87	9,353	9,399		46		4
88	9,499	9,544		45		49
89	9,584	9,488	96		47	
90	9,256	9,126	130		177	
91	8,125	8,285		160	17	
92	7,262	7,261	1		18	
93	6,329	6,356		27		9
94	5,788	5,666	122		113	
95	4,973	5,013		40	73	
96	4,142	4,176		34	39	
97	3,323	3,324		1	38	
98	2,417	2,487		70		32
99	1,772	1,784		12		44
100	1,246	1,247		1		45
Total	210,751	210,796				

The expected deaths are the number of deaths under the assumption that the graduated rates are correct. Deviation refers to the difference between the actual and expected number of deaths. Accumulation at age x is the sum of the deviations from age 2 to age x. Note that this table only covers the ages for which we can calculate an exposed to risk from the Census data.

Appendix E

Future percentage mortality improvement factors — males

Age	25 Year	125 Year	Age	25 Year	125 Year
0	-3.4288	-2.7381	56	-2.8061	-1.3581
1	-3.6655	-3.6244	57	-2.8743	-1.3382
2	-3.8228	-3.2972	58	-2.9365	-1.3156
3	-3.9158	-3.3042	59	-2.9925	-1.2911
4	-3.9580	-3.1433	60	-3.0421	-1.2624
5	-3.9618	-3.0081	61	-3.0851	-1.2317
6	-3.9381	-2.8937	62	-3.1212	-1.2008
7	-3.8966	-2.8211	63	-3.1502	-1.1761
8	-3.8455	-2.7798	64	-3.1719	-1.1646
9	-3.7917	-2.7228	65	-3.1860	-1.1714
10	-3.7407	-2.6423	66	-3.1924	-1.1799
11	-3.6968	-2.5661	67	-3.1908	-1.1753
12	-3.6629	-2.4918	68	-3.1809	-1.1543
13	-3.6403	-2.4093	69	-3.1625	-1.1186
14	-3.6294	-2.3296	70	-3.1355	-1.0689
15	-3.6288	-2.2549	71	-3.0996	-1.0192
16	-3.6361	-2.1645	72	-3.0545	-0.9845
17	-3.6473	-1.9551	73	-3.0000	-0.9634
18	-3.6465	-1.8704	74	-2.9359	-0.9478
19	-3.6634	-1.8855	75	-2.8587	-0.9291
20	-3.6780	-1.9436	76	-2.7673	-0.9060
21	-3.6540	-1.9921	77	-2.6629	-0.8793
22	-3.5687	-2.0201	78	-2.5482	-0.8479
23	-3.4008	-2.0355	79	-2.4248	-0.8109
24	-3.1730	-2.0411	80	-2.2927	-0.7706
25	-2.9059	-2.0276	81	-2.1569	-0.7284
26	-2.6603	-2.0033	82	-2.0237	-0.6856
27	-2.4675	-1.9699	83	-1.8961	-0.6438
28	-2.2302	-1.9348	84	-1.7777	-0.6024
29	-1.9860	-1.8992	85	-1.6586	-0.5619
30	-1.7702	-1.8632	86	-1.5324	-0.5221
31	-1.5823	-1.8306	87	-1.3948	-0.4831
32	-1.3996	-1.8032	88	-1.2428	-0.4451
33	-1.2550	-1.7834	89	-1.0757	-0.4080
34	-1.1425	-1.7708	90	-0.8925	-0.3721
35	-1.0873	-1.7617	91	-0.6988	-0.3377
36	-1.0500	-1.7504	92	-0.5046	-0.3066
37	-1.0488	-1.7349	93	-0.3103	-0.2801
38	-1.0803	-1.7204	94	-0.1161	-0.2535
39	-1.1315	-1.7056	95	0.0000	-0.2270
40	-1.1836	-1.6917	96	0.0000	-0.2004
41	-1.2735	-1.6755	97	0.0000	-0.1739
42	-1.3768	-1.6579	98	0.0000	-0.1473
43	-1.4796	-1.6394	99	0.0000	-0.1208
44	-1.5964	-1.6211	100	0.0000	-0.0943
45	-1.7166	-1.5993	101	0.0000	-0.0677
46	-1.8316	-1.5761	102	0.0000	-0.0412
47	-1.9501	-1.5560	103	0.0000	-0.0146
48	-2.0672	-1.5336	104	0.0000	0.0000
49	-2.1814	-1.5098	105	0.0000	0.0000
50	-2.2849	-1.4849	106	0.0000	0.0000
51	-2.3840	-1.4601	107	0.0000	0.0000
52	-2.4785	-1.4366	108	0.0000	0.0000
53	-2.5682	-1.4139	109	0.0000	0.0000
54	-2.6528	-1.3932	110	0.0000	0.0000
55	-2.7322	-1.3754	111	0.0000	0.0000

Future percentage mortality improvement factors — females

Age	25 Year	125 Year	Age	25 Year	125 Year
0	-3.8751	-2.7935	56	-2.3056	-1.5182
1	-3.6399	-3.7868	57	-2.3497	-1.4989
2	-3.4335	-3.4259	58	-2.3903	-1.4779
3	-3.2541	-3.4139	59	-2.4273	-1.4498
4	-3.0996	-3.2333	60	-2.4605	-1.4200
5	-2.9684	-3.0703	61	-2.4897	-1.3923
6	-2.8586	-2.9384	62	-2.5147	-1.3674
7	-2.7682	-2.8477	63	-2.5355	-1.3468
8	-2.6954	-2.8223	64	-2.5517	-1.3491
9	-2.6384	-2.8178	65	-2.5633	-1.3859
10	-2.5953	-2.7961	66	-2.5700	-1.4181
11	-2.5643	-2.7310	67	-2.5717	-1.4163
12	-2.5434	-2.6568	68	-2.5683	-1.3889
13	-2.5310	-2.5637	69	-2.5594	-1.3458
14	-2.5250	-2.4425	70	-2.5451	-1.2894
15	-2.5236	-2.3054	71	-2.5250	-1.2309
16	-2.5250	-2.1709	72	-2.4991	-1.1852
17	-2.5273	-2.1838	73	-2.4671	-1.1580
18	-2.5286	-2.2279	74	-2.4288	-1.1484
19	-2.5272	-2.3052	75	-2.3842	-1.1460
20	-2.5211	-2.3711	76	-2.3330	-1.1404
21	-2.5085	-2.4299	77	-2.2750	-1.1273
22	-2.4875	-2.4693	78	-2.2101	-1.1078
23	-2.4563	-2.5079	79	-2.1382	-1.0832
24	-2.4130	-2.5404	80	-2.0589	-1.0526
25	-2.3558	-2.5786	81	-1.9722	-1.0167
26	-2.2828	-2.6051	82	-1.8779	-0.9764
27	-2.2079	-2.6066	83	-1.7947	-0.9313
28	-2.0778	-2.5890	84	-1.6626	-0.8819
29	-1.8990	-2.5522	85	-1.5241	-0.8286
30	-1.6979	-2.5014	86	-1.3825	-0.7727
31	-1.5005	-2.4404	87	-1.2404	-0.7154
32	-1.3325	-2.3871	88	-1.1005	-0.6576
33	-1.2144	-2.3409	89	-0.9645	-0.6006
34	-1.1487	-2.3019	90	-0.8299	-0.5448
35	-1.1057	-2.2666	91	-0.6948	-0.4905
36	-1.0875	-2.2326	92	-0.5589	-0.4383
37	-1.0918	-2.1982	93	-0.4281	-0.3903
38	-1.1160	-2.1554	94	-0.3064	-0.3491
39	-1.1577	-2.1095	95	-0.1964	-0.3079
40	-1.2145	-2.0539	96	-0.0865	-0.2668
41	-1.2839	-1.9977	97	0.0000	-0.2256
42	-1.3635	-1.9495	98	0.0000	-0.1844
43	-1.4508	-1.9034	99	0.0000	-0.1432
44	-1.5435	-1.8576	100	0.0000	-0.1021
45	-1.6396	-1.8112	101	0.0000	-0.0609
46	-1.7261	-1.7685	102	0.0000	-0.0197
47	-1.8008	-1.7320	103	0.0000	0.0000
48	-1.8632	-1.6985	104	0.0000	0.0000
49	-1.9150	-1.6631	105	0.0000	0.0000
50	-1.9784	-1.6306	106	0.0000	0.0000
51	-2.0396	-1.6033	107	0.0000	0.0000
52	-2.0983	-1.5810	108	0.0000	0.0000
53	-2.1545	-1.5623	109	0.0000	0.0000
54	-2.2078	-1.5455	110	0.0000	0.0000
55	-2.2583	-1.5327	111	0.0000	0.0000