Australian Life Tables 2005-07

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DEFINITIONS OF SYMBOLS

Australian Life Tables 2005-07 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 2005-07* (the Tables), which are based on the mortality of Australians over the three year period centred on the 2006 Census of Population and Housing (the Census).

This publication discusses the major features of the 2005-07 Life Tables with particular reference to the previous Australian Life Tables. Mortality improvement factors have been calculated based on the improvements observed over the past 25 and 100 years. The impact of mortality improvement on life expectancies is explored in the context of these two scenarios.

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 seventeenth in the series of official Australian Life Tables. Tables for the years 1881-90, 1891-1900, 1901-10, 1920-22 and 1932-34 were prepared by the Commonwealth Statistician. The first three Tables took into account deaths over a ten year period and each Table 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. The Tables for the years 1946-48 and 1953-55 were prepared by the Commonwealth Actuary. Tables since 1960-62 have been produced quinquennially by the Australian Government Actuary (under the former title of Commonwealth Actuary in the case of the earlier tables).

P. Martin FIAA
Australian Government Actuary

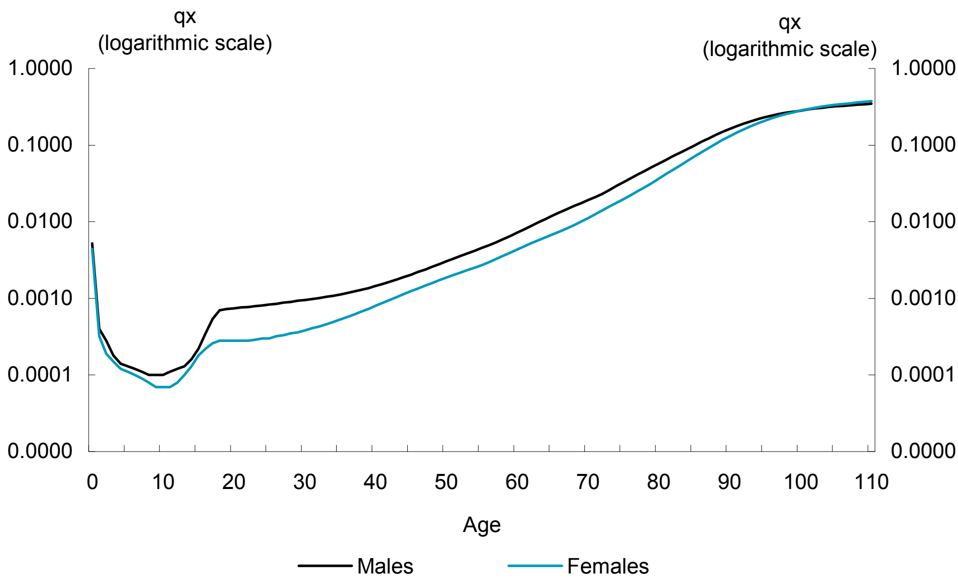
November 2009

1. Mortality of the Australian population

1.1 Results for 2005-07

Figure 1 shows the mortality rates reported in the 2005-07 Life Tables on a logarithmic scale.

Figure 1: Mortality rates 2005-07



The pattern of mortality observed in Figure 1 is typical of Western countries. Mortality rates during the first few years of life are high due to the vulnerability of infants to disease. The rates quickly improve with age as resistance builds. Around age 9 or 10, mortality rates reach a minimum. At this point, the probability of dying within the year is around 1 in 10,000. The steep rise in mortality rates during the teenage years is primarily due to accidental deaths and is more pronounced for males than females.

Mortality rates increase only slowly during the twenties and into the middle thirties. Accidental death rates decline with increasing age but this decline is offset by an increase in rates of death due to disease. The shape of the curves around ages 18 to 21 has not changed much since the 2000-02 Tables, when the previous ‘accident hump’ flattened for the first time in several decades.

It can be argued that the underlying mortality process arising from normal biological ageing can be approximately represented by an exponential function (that is, a plot of mortality rates will appear as a straight line on a logarithmic scale). By fitting such a function between the point of minimum mortality to the point where the observed mortality is roughly exponential (age 47 for males and age 34 for females in the current Tables), it is possible to calculate the ‘excess mortality’ due to abnormal factors over the twenties and thirties. The 2005-07 Tables suggest that the ‘excess mortality’ over these years is of the order of 1,300 deaths per annum for males and 200 deaths per annum for females based on the population profile for the three years covered by the Tables. For males in particular, this is a significant reduction from the comparable figure of 1,800 reported in the 2000-02 Tables

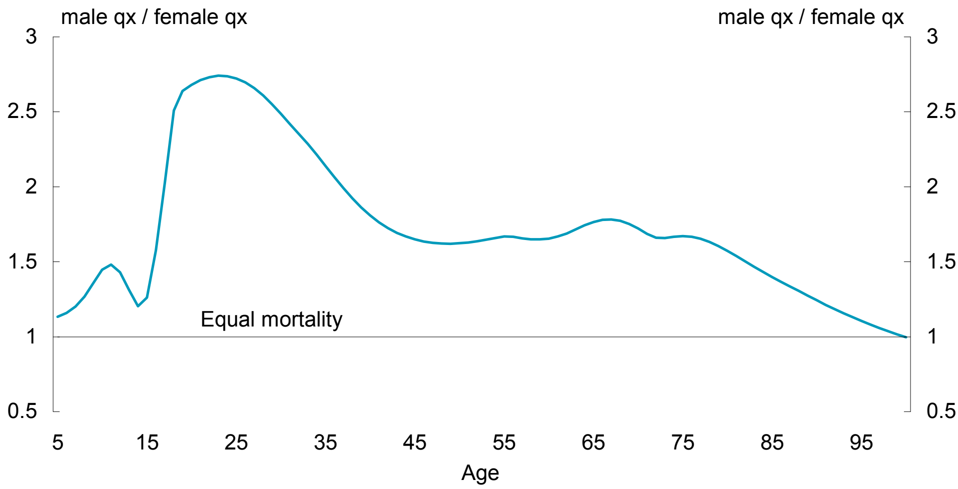
The shapes of the mortality curves for males and females are quite similar, but the absolute rates are significantly different with female mortality being substantially less than male mortality at all but the very oldest ages. This difference is consistent with a number of factors, including:

- 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.

The differential between male and female mortality rates varies with age as shown in Figure 2, with the greatest disparity occurring at age 23 where the death rates for men are about 2.7 times the rates for women.

Figure 2: Ratio of male to female mortality rates 2005-07
Ages 5 to 100



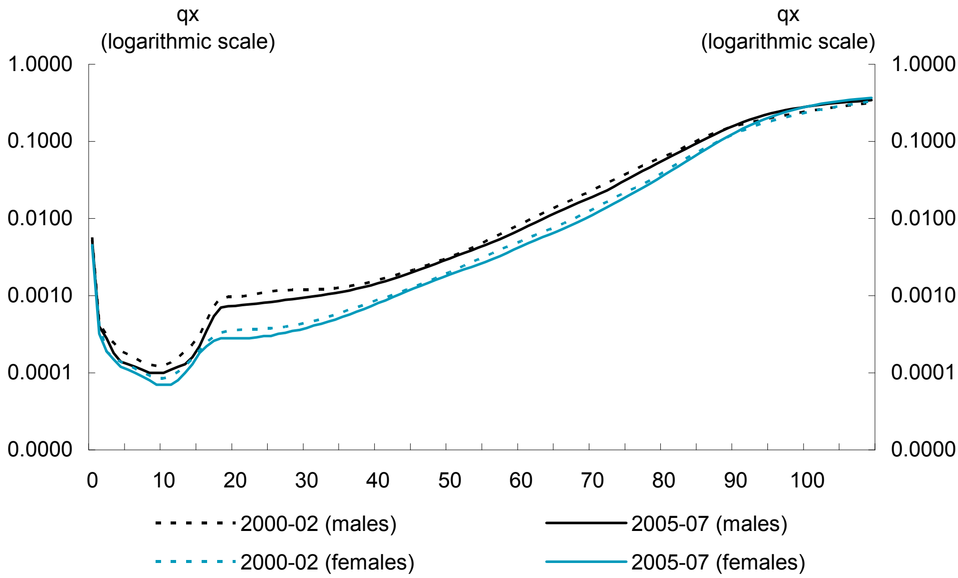
The ratio between the genders reaches a local minimum of close to 1.6 at age 49 and then increases again up until age 67. Above this age, the gap gradually closes and at age 100, the rates for males drop below the female rates. The mortality rates at these very old ages are subject to considerable uncertainty. However, this ‘crossover’ has been a persistent feature in both the raw and graduated mortality rates over the past decade and a half and it seems fair to conclude that the female mortality advantage disappears at these ages.

If the mortality rates reported in these Tables were to persist indefinitely, life expectancy for males would be approximately 79 years for males and 84 years for females. In reality, further reductions in mortality are likely in the future and, as a result, the life expectancy of a child born in 2006 could be anticipated to be somewhat higher than these figures. Just how much higher depends upon future mortality rates and the projection of these rates is a subjective and uncertain task. For the purposes of this report, illustrative mortality improvement factors have been derived from the observed changes in mortality over the past 25 and 100 years respectively. Section 1.4 examines how the allowance for mortality improvement might affect life expectancies.

1.2 Changes since 2000-02

Figure 3 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 are higher than reported in 2000-02. This is partly the result of a technical error in the previous tables which resulted in the exposed populations being over-estimated at these ages with consequently lower mortality rates. However, even after correcting for this error, mortality rates among those aged 94 or more are higher than in 2000-02. It is possible that, with an increasing proportion of the population surviving to these very old ages, the average health status of this group has declined. As with the crossover, this deterioration in mortality at very old ages is a feature which has been noted in overseas literature.

Figure 3: Mortality rates 2000-02 and 2005-07



Infant mortality continued to fall, as it has in every set of published Tables. The decline over the past five years was broadly in line with the experience of the preceding years, with both male and female rates falling by about 1.5 per cent per annum. The rate of improvement over the past decade has been noticeably slower than that observed in the previous 25 years where the rate of improvement consistently averaged around 4.5 per cent per annum.

Mortality in the childhood years has improved, more so for males than for females. However, the number of deaths observed at these ages is very small. Over the age range from 3 to 12, the average number of deaths over the three years is just under

50 for males and fewer than 40 for females. 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. As described in section 2.2, we modified the graduation process for the current Tables to address this issue. The modification reduced the variation in improvement at individual ages, but it is still the age range with the greatest volatility. In these circumstances, 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. Two to 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 later teenage years, the more rapid improvement in male mortality for those in their early twenties means there is no longer a local maximum. The improvement in male rates was greater than for females for all but a couple of ages in this cohort. This is, however, the age group with the greatest disparity between male and female rates and, as illustrated in Figure 2, the gap remains significant.

The level of improvement declines with age over the age range from 25 to 50 for males and 20 to 45 for females before picking up again in middle age. Figure 4 shows the average percentage improvement in mortality rates by gender for three 25-year age bands.

Figure 4: Percentage improvement in mortality since 2000-02

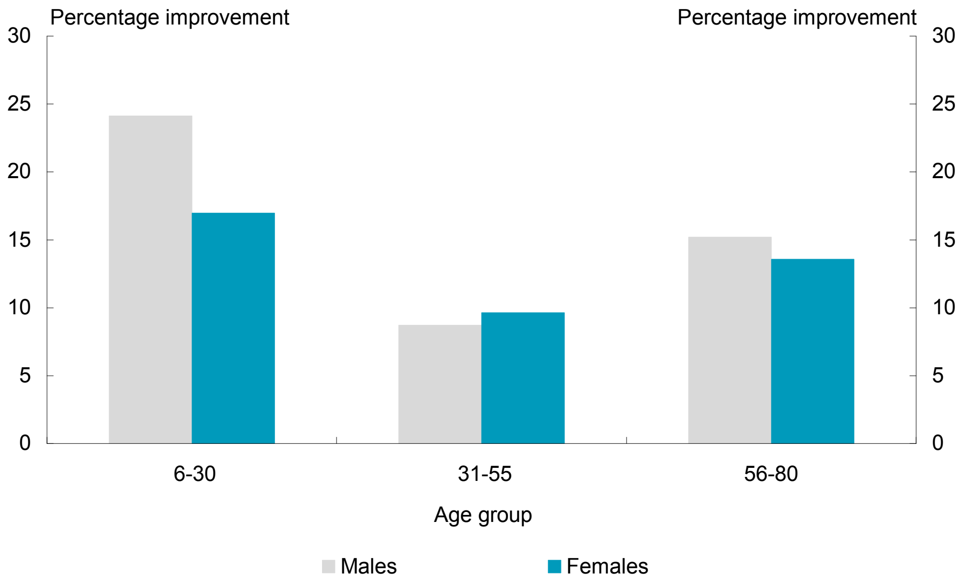
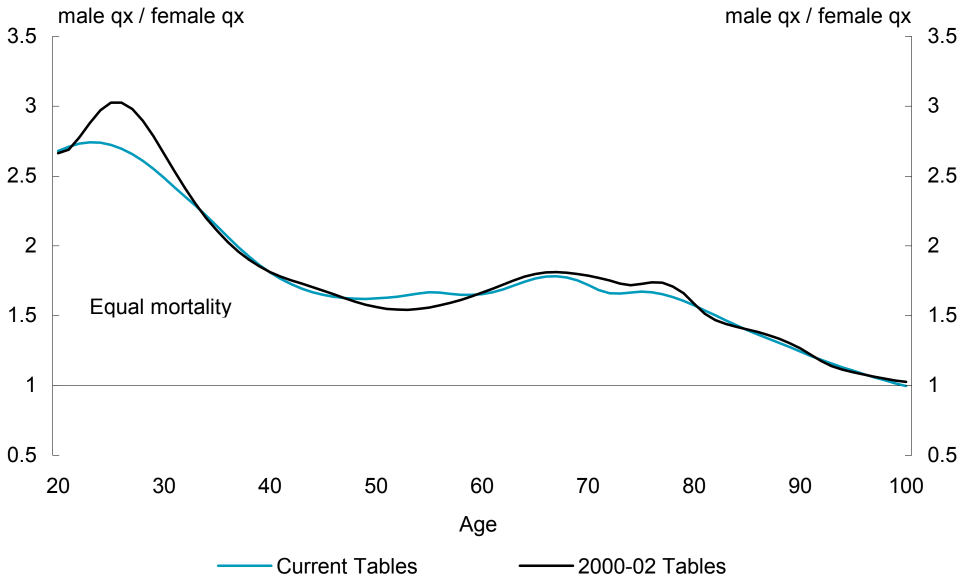


Figure 5 compares the gender differential in mortality rates for the current and previous Tables. It shows that the differences in rates of improvement over the past five years have had a minor impact except over the early adult years where the much higher rates of improvement in male mortality have led to a noticeable narrowing of the gap relative to the 2000-02 Tables. The gap has also continued to narrow for those in their 60s and 70s.

Figure 5: Ratio of male to female mortality rates — Ages 20 to 100 2000-02 and 2005-07

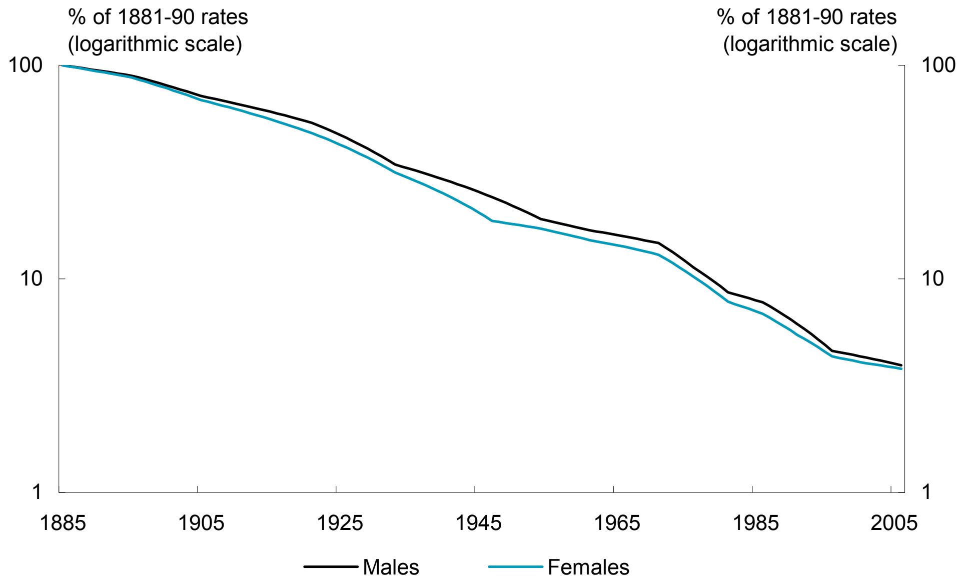


1.3 Past improvements in mortality

The first official Life Tables for Australia were prepared based on data from the period 1881-90 and there is now a history of about 120 years of mortality data. Figure 6 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 6: Improvements in mortality at selected ages

Age 0



Age 20

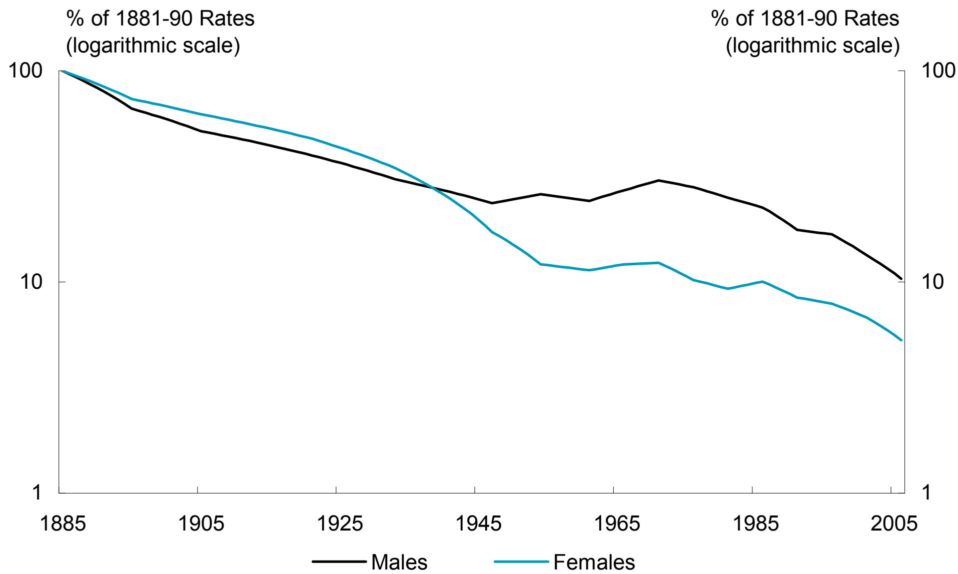
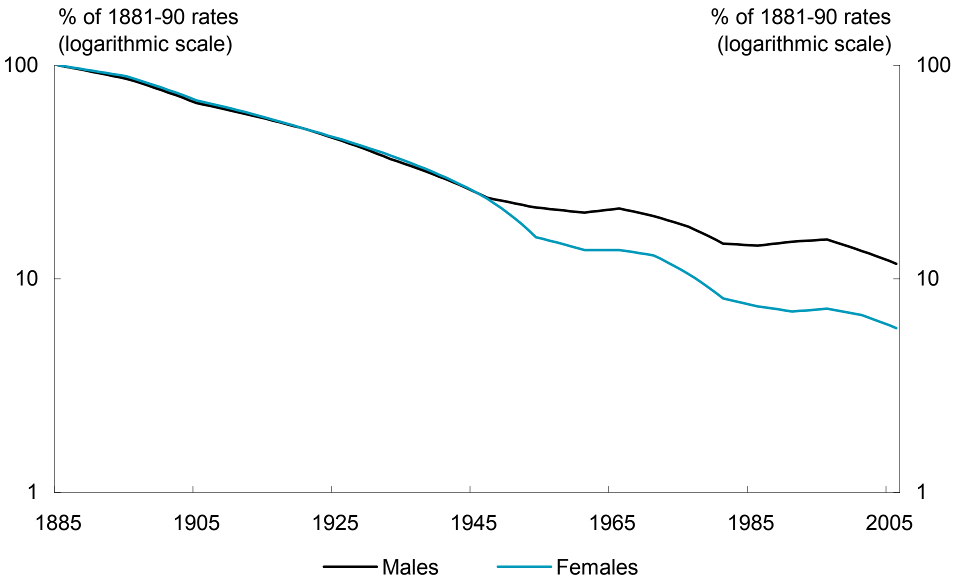
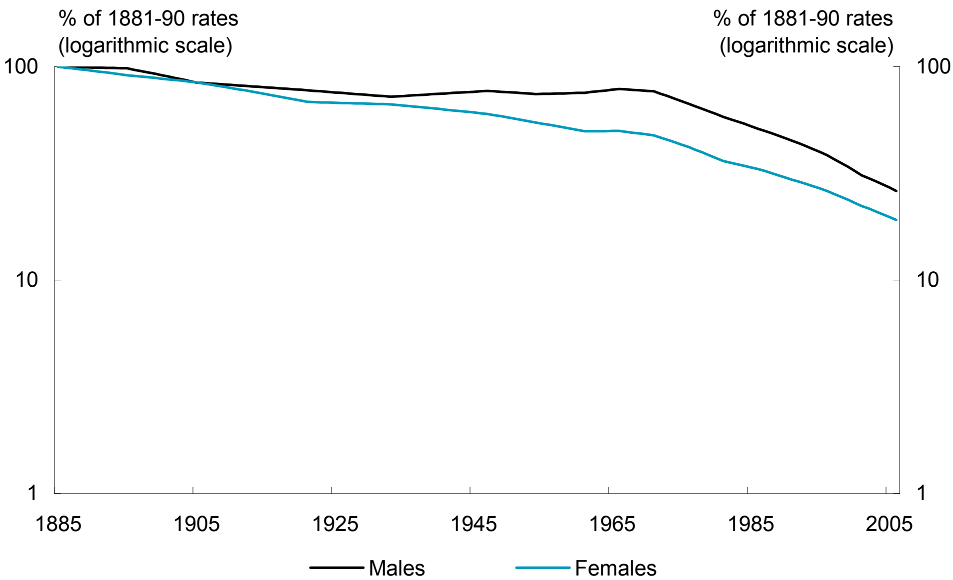


Figure 6: Improvements in mortality at selected ages (continued)

Age 35



Age 65



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 less than 4 per cent of their level in 1881-90 and still do not appear to have reached an underlying minimum rate. The rate of improvement has, however, slowed somewhat over the last decade, particularly relative to the preceding two and a half decades.

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 1920s 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 120 years ago. For males of the same age, the relativity is around 10 per cent.

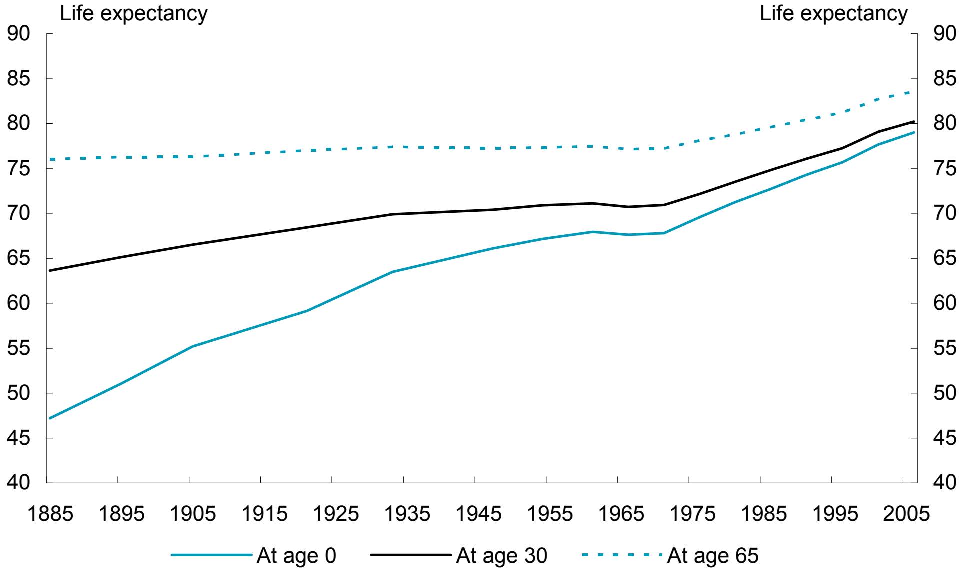
For those in their mid thirties, the improvements for males and females were virtually identical until around 1945. At that point, the rate of improvement for males slowed significantly and in some years reversed, while for females the downward trend continued unabated. Overall, the improvement over the last 120 years is very similar to that for 20 year olds, with male rates being 12 per cent and female rate 6 per cent of the rates reported in 1881-90.

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 2005-07 Tables are about 33 per cent of the corresponding rates in the mid 1960s, while for females the 2005-07 rates are about 38 per cent of the levels of the mid 1960s.

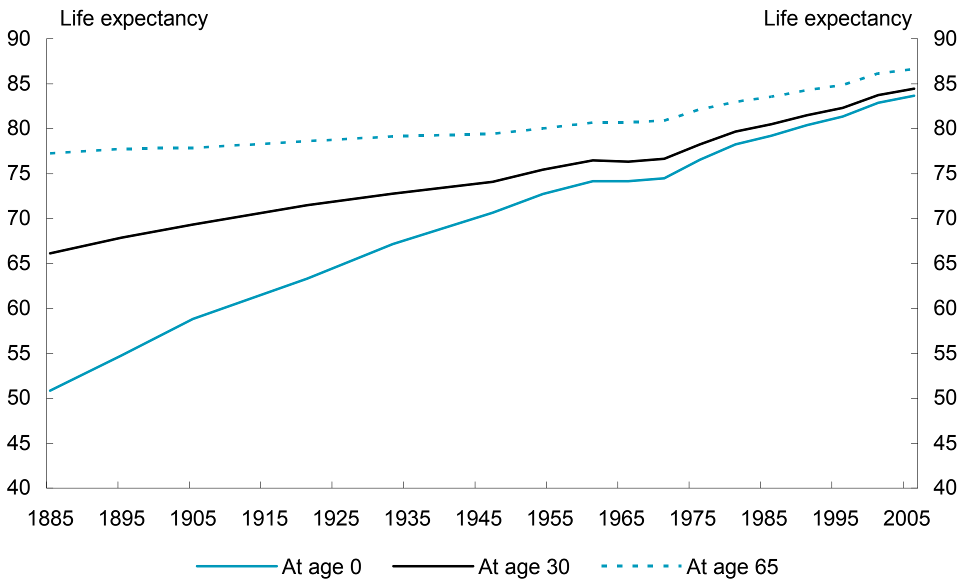
Figure 7 shows how these improvements in mortality have translated into longer life expectancies as reported in the Life Tables since 1881-90 (Appendix A sets out the figures on which Figure 7 is based). Note that these life expectancies do not make allowance for the improvements in mortality which are 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 snapshot of mortality at a particular point in time rather than the mortality that an individual is likely to face over their lifetime.

Figure 7: Total life expectancy at selected ages

Males



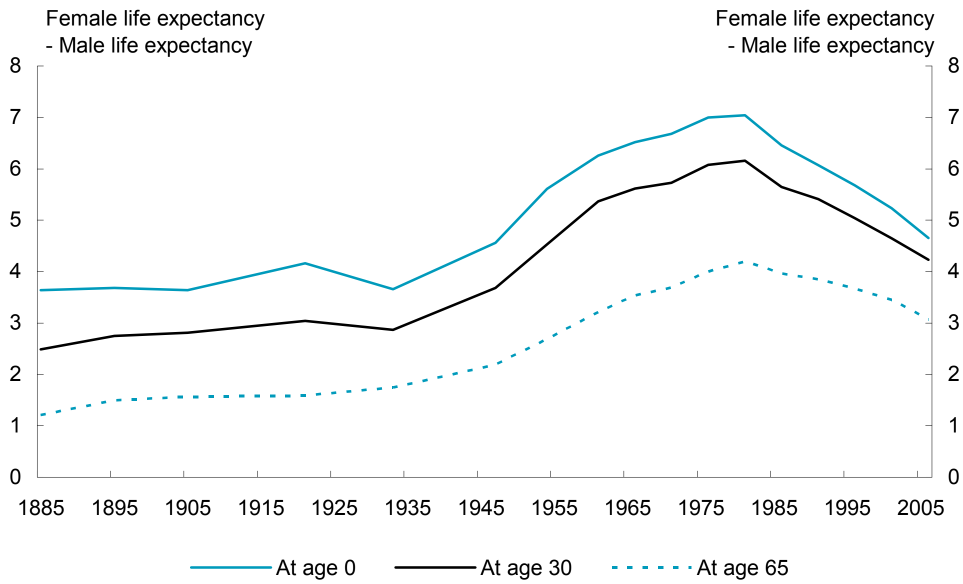
Females



Reported life expectancy at birth has shown dramatic improvement, increasing by over 30 years for both males and females. The narrowing of the gap between life expectancy at birth and age 30 to around nine months for females and fourteen months for males vividly illustrates just how low mortality rates among infants and children now are. At older ages, the substantial improvements in mortality rates for this group over the past thirty years have flowed through into significantly increased life expectancies, with expectation of life at age 65 increasing by around six years for both males and females. This represents an increase of more than 50 per cent for males and 37 per cent for females in the expectation of life at this age.

Figure 8 plots the gap between reported male and female life expectancies at selected ages. It shows that over the first third of the twentieth century, male and female life expectancies moved roughly in parallel, with the size of the gap declining with increasing age. From about 1930, the gap widened at all ages, reaching a maximum in the 1980-82 Tables. Since then, the differential has been declining at all ages. At birth and age 30, the gap has declined by more than a year, falling to levels last seen 50 to 60 years ago.

Figure 8: Gender differentials in life expectancy at selected ages

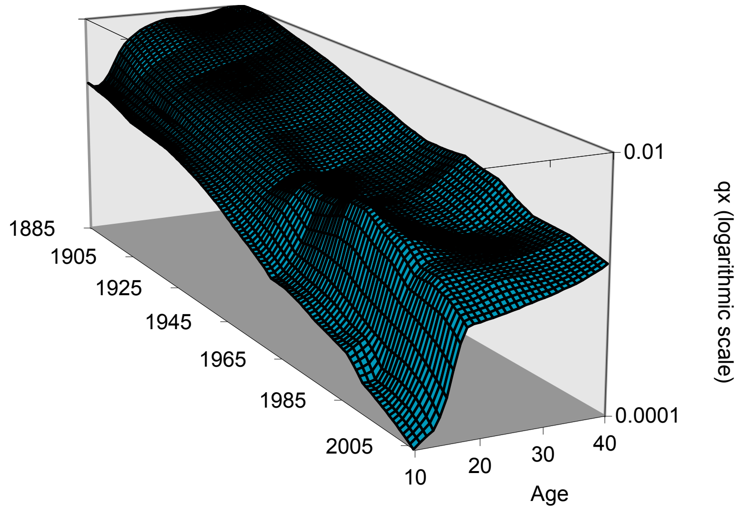


It is also interesting to see how the shape of the mortality curve has changed over time. Figure 9 shows the reported mortality rates as a three dimensional surface, plotted against both age and time. Note that the rates for years in between the Tables have been derived by linear interpolation.

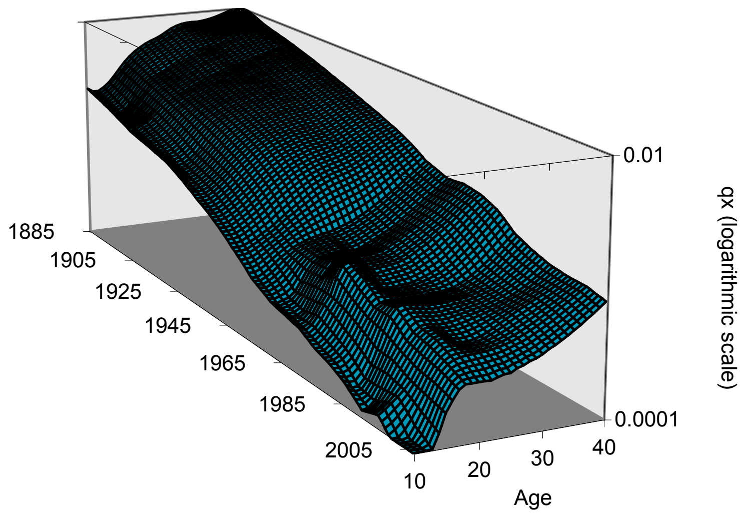
Figure 9 highlights the enormous improvements in childhood mortality and the emergence and decline of the accident humps for males and, to a lesser extent, females.

Figure 9: Smoothed mortality rates from 1881-90 to the present
Ages 10 to 40

Males



Females



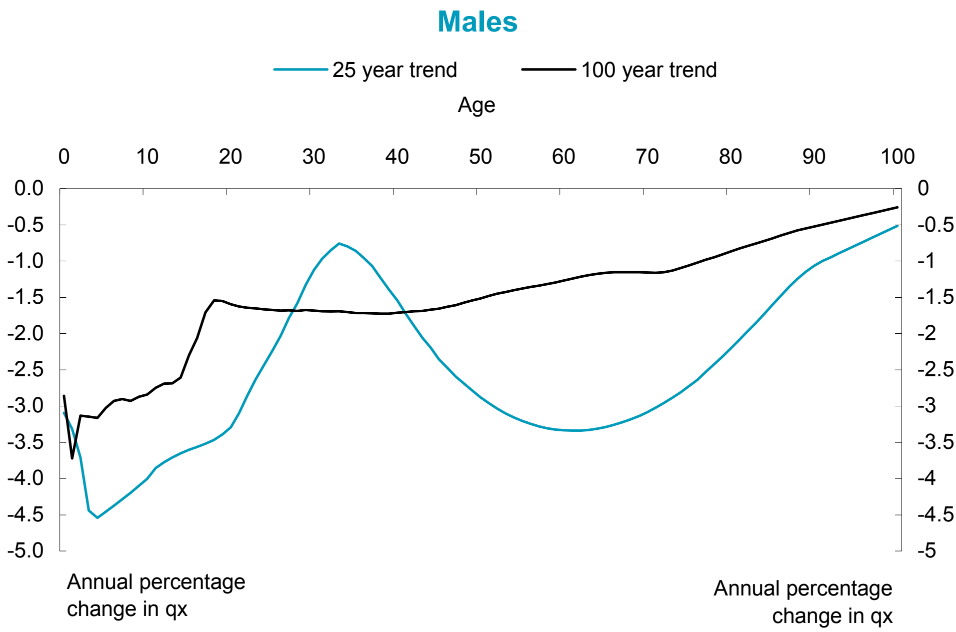
1.4 Allowing for future improvements in mortality

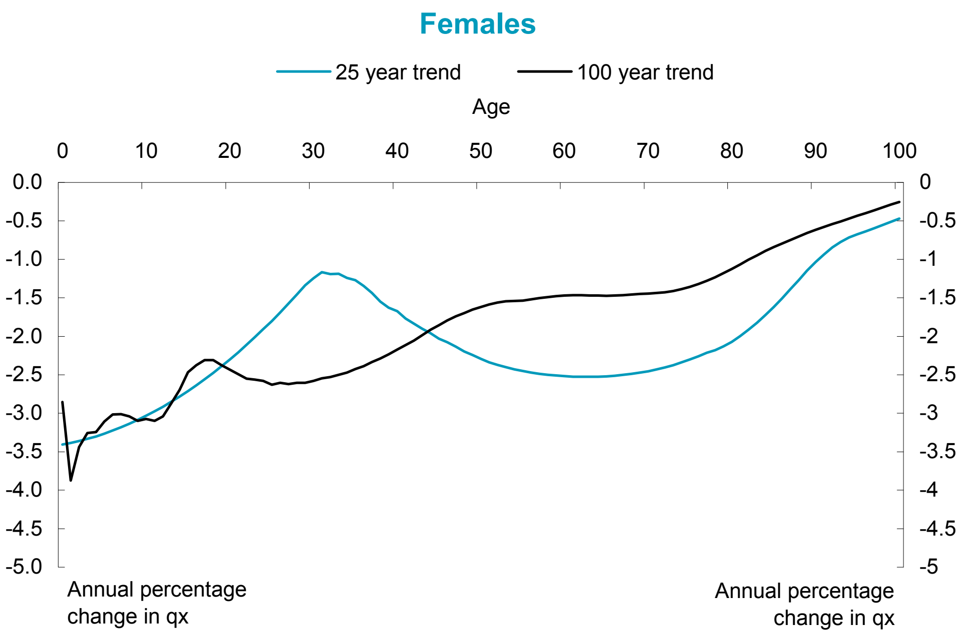
The preceding section underlines the importance of mortality improvement in determining realistic life expectancies. The life expectancy of a boy born in 1886, as reported in the 1881-90 Tables, was 47.2 years, based on the rates in those Tables persisting throughout his life. Applying the rates reported in subsequent tables that would be appropriate given his age and the year, his life expectancy would in practice have been some six years higher. This latter measure of life expectancy is known as cohort life expectancy and requires age and time-specific mortality rates.

The issues associated with attempting to estimate more realistic life expectances by allowing for future mortality improvements were discussed in some detail in the 1995-97 Tables. Those Tables included improvement rates expressed as a yearly percentage change for mortality rates over the preceding 25 and 100 years. The current Tables continue this practice.

Figure 10 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 100 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 a lot less than over the preceding 75 years.

Figure 10: Historical mortality improvement factors derived from the Australian Life Tables





Two measures of life expectancy are presented in this report. The first is the period or cross-sectional life expectancy. Period life expectancies are calculated using the mortality rates from a single year and making no allowance for improvements over an individual's lifetime. So, for example, in calculating a period life expectancy for the year 2020 based on the 2005-07 Tables, 14 years of improvement would be allowed for at all ages. Period life expectancies can be thought of as a summary measure of the mortality rates across the entire Table for a given year and gender.

The following tables show the projected period life expectancies at ages 0, 30 and 65 using the 25 and 100 year improvement factors.

Projected period life expectancies at selected ages under two improvement scenarios

Males

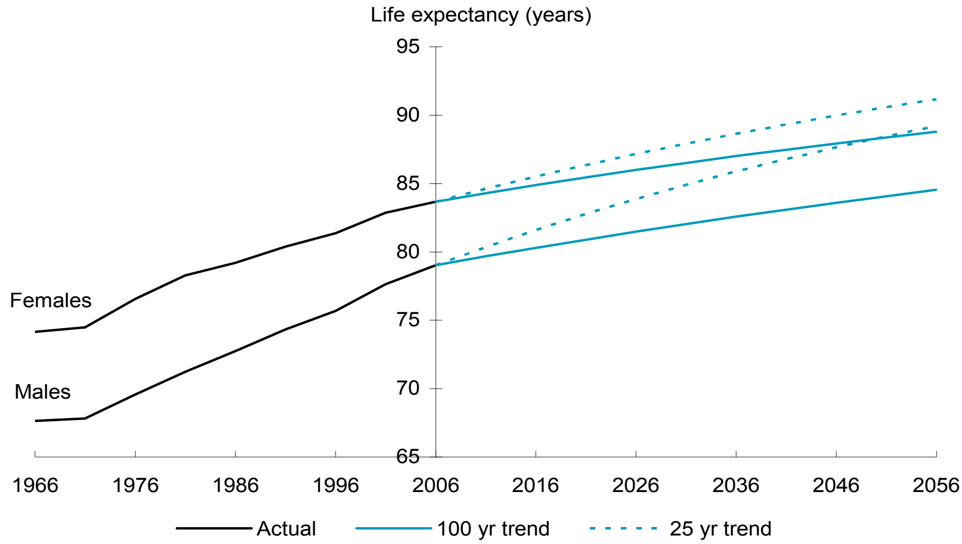
	Age 0		Age 30		Age 65	
	25 year	100 year	25 year	100 year	25 year	100 year
2006	79.0	79.0	80.2	80.2	83.5	83.5
2010	80.1	79.5	81.2	80.6	84.2	83.8
2020	82.5	80.8	83.4	81.7	85.9	84.5
2030	84.7	81.9	85.3	82.6	87.4	85.2
2040	86.6	83.0	87.1	83.6	88.8	85.8
2050	88.3	84.0	88.7	84.5	90.0	86.5

Females

	Age 0		Age 30		Age 65	
	25 year	100 year	25 year	100 year	25 year	100 year
2006	83.7	83.7	84.4	84.4	86.6	86.6
2010	84.4	84.2	85.1	84.9	87.1	86.9
2020	86.2	85.3	86.7	85.9	88.4	87.7
2030	87.8	86.4	88.2	86.8	89.6	88.4
2040	89.2	87.4	89.5	87.7	90.7	89.0
2050	90.5	88.3	90.7	88.5	91.7	89.7

Figure 11 shows how the period life expectancy at birth would change over time under these two improvement scenarios.

Figure 11: Actual and projected period life expectancy at birth — 1966 to 2056



The period life expectancies at birth reported in the current Tables are very close to those projected for 2006 in the 2000-02 Tables under the 25 year improvement scenario. At the age 30 and 65, the 2005-07 life expectancies fall between the life expectancies projected under each of the two mortality improvement scenarios. This suggests that mortality improvement over the last five years has been broadly in line with the historical experience. It should not, however, be taken as an indicator of their expected performance over a longer time frame, where enormous uncertainty remains.

The second measure of life expectancy is the cohort life expectancy. This measure takes into account the improvements that could be experienced over the lifetime of the individual. So, for example, in calculating the cohort life expectancy of a child born in 2015 based on the 2005-07 tables, nine years of mortality improvement will be applied to the mortality rate at age 0, ten years at age one and so on. Cohort life expectancies can be thought of as being a more realistic representation of the unfolding mortality experience of the Australian population.

The following tables show the cohort life expectancies at ages 0, 30 and 65 using the 25 and 100 year improvement factors.

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

Males

	Age 0		Age 30		Age 65	
	25 year	100 year	25 year	105 year	25 year	105 year
2006	91.8	85.6	88.6	83.9	85.6	84.4
2010	92.4	86.0	89.2	84.3	86.3	84.7
2020	93.7	87.0	90.8	85.3	87.9	85.3
2030	94.8	88.0	92.2	86.2	89.4	86.0
2040	95.8	88.8	93.4	87.0	90.8	86.7
2050	96.7	89.6	94.4	87.8	92.0	87.3

Females

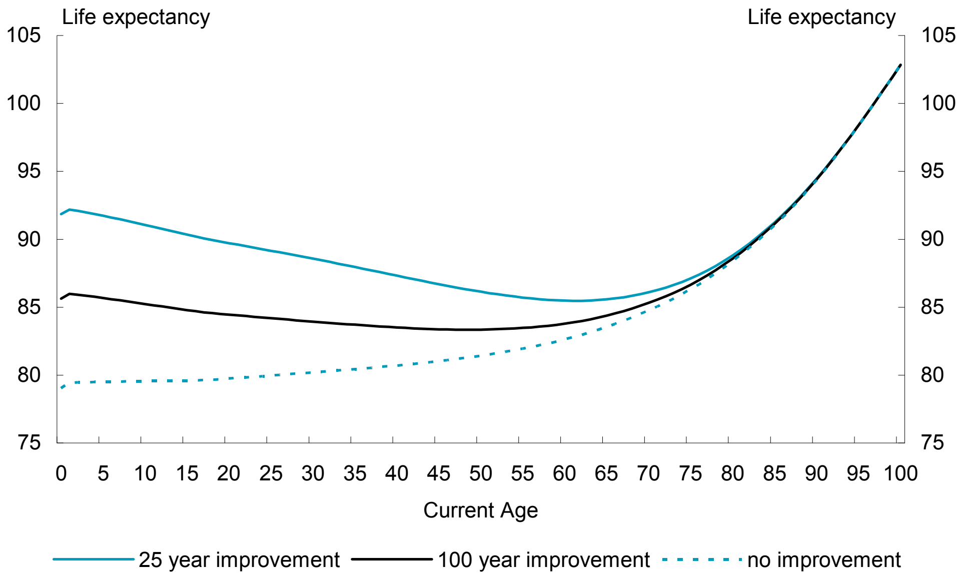
	Age 0		Age 30		Age 65	
	25 year	100 year	25 year	100 year	25 year	100 year
2006	93.5	90.2	90.9	88.4	88.5	87.7
2010	93.9	90.5	91.4	88.7	89.0	88.0
2020	94.9	91.4	92.6	89.6	90.2	88.7
2030	95.8	92.1	93.6	90.4	91.4	89.4
2040	96.6	92.8	94.6	91.1	92.4	90.0
2050	97.3	93.4	95.4	91.8	93.3	90.7

A comparison with the cohort life expectancies reported in the 2000-02 Tables highlights the sensitivity of these results to the mortality improvement assumptions. The cohort life expectancies at birth derived using 25 year mortality improvement factors from the current Tables are about three to four years less than those reported in the 2000-02 Tables. Life expectancies at older ages are also lower but the margin is somewhat less. On the other hand, the results obtained using the 100 year mortality improvement factors show an increase in cohort life expectancies for males relative to the 2000-02 Tables, generally of about one year, and a fall of about one year for females.

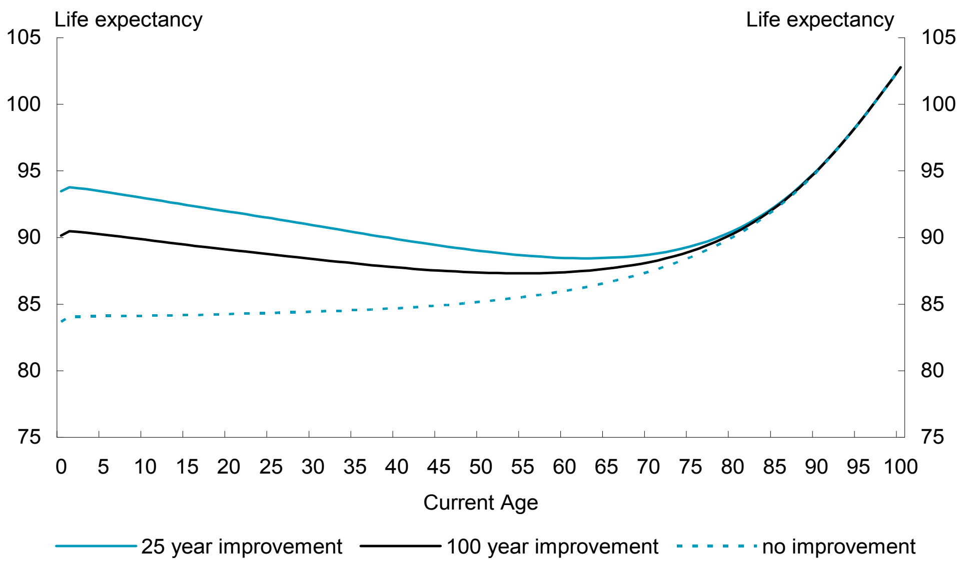
Figure 12 shows the cohort life expectancies for those currently alive in the Australian population. It highlights the considerable gap between the period life expectancies reported in these Tables and the outcomes that would arise if the rates of mortality improvement observed in the past are maintained 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 achieved an advanced age.

Figure 12: 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 as the earliest period is removed from the calculation and the experience from the most recent five years incorporated. For example, for males aged 25, mortality actually increased between the 1975-77 Tables and the 1980-82 Tables. By contrast, over the past five years, mortality fell by almost 30 per cent. As a result, the 25 year mortality improvement factor at this age has more than doubled from 0.8 per cent per annum to 1.8 per cent per annum between the 2000-02 Tables and the current Tables.

Furthermore, the effects of these movements are magnified because the projections assume that mortality improvement will be constant for a particular age. In considering cohort life expectancy at birth, the projected mortality rate to be used at age 25 will include 25 years of mortality improvement; at 0.8 per cent per annum this amounts to an improvement of 18 per cent improvement but at 1.8 per cent the improvement over 25 years is 36 per cent.

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 2005-07: MALES

Age	l_x	d_x	p_x	q_x	μ_x	$\mathring{e}_x$	L_x	T_x
0	100,000	523	0.99477	0.00523	0.00000	79.02	99,533	7,902,121
1	99,477	40	0.99960	0.00040	0.00047	78.44	99,456	7,802,588
2	99,437	28	0.99972	0.00028	0.00034	77.47	99,422	7,703,132
3	99,409	18	0.99982	0.00018	0.00022	76.49	99,400	7,603,710
4	99,391	14	0.99986	0.00014	0.00015	75.50	99,384	7,504,310
5	99,378	13	0.99987	0.00013	0.00013	74.51	99,371	7,404,926
6	99,365	12	0.99988	0.00012	0.00013	73.52	99,359	7,305,555
7	99,353	11	0.99989	0.00011	0.00012	72.53	99,347	7,206,196
8	99,342	10	0.99990	0.00010	0.00010	71.54	99,337	7,106,849
9	99,332	10	0.99990	0.00010	0.00010	70.55	99,327	7,007,512
10	99,322	10	0.99990	0.00010	0.00010	69.55	99,317	6,908,185
11	99,312	11	0.99989	0.00011	0.00010	68.56	99,307	6,808,868
12	99,301	12	0.99988	0.00012	0.00012	67.57	99,295	6,709,562
13	99,289	13	0.99987	0.00013	0.00012	66.58	99,283	6,610,267
14	99,276	16	0.99984	0.00016	0.00014	65.58	99,269	6,510,984
15	99,260	22	0.99978	0.00022	0.00018	64.59	99,250	6,411,715
16	99,239	35	0.99965	0.00035	0.00027	63.61	99,223	6,312,465
17	99,204	54	0.99946	0.00054	0.00044	62.63	99,179	6,213,242
18	99,150	69	0.99930	0.00070	0.00063	61.66	99,116	6,114,064
19	99,081	72	0.99927	0.00073	0.00073	60.71	99,045	6,014,948
20	99,008	73	0.99926	0.00074	0.00074	59.75	98,972	5,915,903
21	98,935	75	0.99924	0.00076	0.00075	58.80	98,898	5,816,931
22	98,860	76	0.99923	0.00077	0.00077	57.84	98,822	5,718,033
23	98,784	78	0.99921	0.00079	0.00078	56.88	98,745	5,619,211
24	98,706	80	0.99919	0.00081	0.00080	55.93	98,666	5,520,466
25	98,626	82	0.99917	0.00083	0.00082	54.97	98,585	5,421,800
26	98,544	84	0.99915	0.00085	0.00084	54.02	98,502	5,323,215
27	98,460	87	0.99912	0.00088	0.00087	53.06	98,417	5,224,713
28	98,374	89	0.99910	0.00090	0.00089	52.11	98,330	5,126,295
29	98,285	91	0.99907	0.00093	0.00092	51.16	98,240	5,027,966
30	98,194	93	0.99905	0.00095	0.00094	50.20	98,147	4,929,726
31	98,100	96	0.99902	0.00098	0.00096	49.25	98,053	4,831,579
32	98,004	99	0.99899	0.00101	0.00099	48.30	97,955	4,733,526
33	97,905	103	0.99895	0.00105	0.00103	47.35	97,854	4,635,571
34	97,802	106	0.99892	0.00108	0.00107	46.40	97,750	4,537,717
35	97,697	109	0.99888	0.00112	0.00110	45.45	97,643	4,439,967
36	97,587	114	0.99883	0.00117	0.00114	44.50	97,531	4,342,325
37	97,473	120	0.99877	0.00123	0.00120	43.55	97,414	4,244,794
38	97,353	126	0.99871	0.00129	0.00126	42.60	97,291	4,147,380
39	97,228	132	0.99864	0.00136	0.00132	41.66	97,162	4,050,089
40	97,096	141	0.99855	0.00145	0.00140	40.71	97,026	3,952,927
41	96,955	149	0.99846	0.00154	0.00149	39.77	96,881	3,855,901
42	96,805	160	0.99835	0.00165	0.00159	38.83	96,726	3,759,020
43	96,646	170	0.99824	0.00176	0.00170	37.89	96,562	3,662,293
44	96,476	183	0.99810	0.00190	0.00183	36.96	96,385	3,565,732
45	96,292	196	0.99796	0.00204	0.00197	36.03	96,195	3,469,347
46	96,096	212	0.99779	0.00221	0.00212	35.10	95,991	3,373,151
47	95,884	228	0.99762	0.00238	0.00230	34.18	95,771	3,277,160
48	95,655	247	0.99742	0.00258	0.00248	33.26	95,534	3,181,389
49	95,409	267	0.99720	0.00280	0.00269	32.34	95,277	3,085,856
50	95,141	288	0.99697	0.00303	0.00292	31.43	94,999	2,990,579
51	94,853	312	0.99671	0.00329	0.00316	30.53	94,699	2,895,580
52	94,541	338	0.99643	0.00357	0.00343	29.63	94,374	2,800,881
53	94,204	364	0.99614	0.00386	0.00372	28.73	94,024	2,706,507
54	93,840	393	0.99581	0.00419	0.00403	27.84	93,646	2,612,482

Australian Life Tables 2005-07: Males (continued)

Age	l_x	d_x	p_x	q_x	μ_x	$\mathring{e}_x$	L_x	T_x
55	93,447	424	0.99546	0.00454	0.00437	26.95	93,237	2,518,837
56	93,022	459	0.99507	0.00493	0.00474	26.08	92,796	2,425,599
57	92,564	498	0.99462	0.00538	0.00516	25.20	92,318	2,332,803
58	92,066	544	0.99409	0.00591	0.00565	24.34	91,798	2,240,485
59	91,522	597	0.99348	0.00652	0.00622	23.48	91,228	2,148,687
60	90,925	656	0.99279	0.00721	0.00687	22.63	90,602	2,057,459
61	90,269	721	0.99201	0.00799	0.00761	21.79	89,915	1,966,856
62	89,548	793	0.99115	0.00885	0.00844	20.96	89,158	1,876,942
63	88,756	871	0.99019	0.00981	0.00936	20.14	88,327	1,787,784
64	87,885	954	0.98915	0.01085	0.01037	19.34	87,415	1,699,456
65	86,931	1,043	0.98800	0.01200	0.01147	18.54	86,418	1,612,041
66	85,888	1,136	0.98677	0.01323	0.01268	17.76	85,328	1,525,623
67	84,752	1,235	0.98543	0.01457	0.01398	16.99	84,143	1,440,295
68	83,517	1,337	0.98399	0.01601	0.01539	16.24	82,857	1,356,152
69	82,180	1,442	0.98245	0.01755	0.01690	15.49	81,468	1,273,295
70	80,738	1,550	0.98080	0.01920	0.01852	14.76	79,972	1,191,827
71	79,188	1,663	0.97900	0.02100	0.02026	14.04	78,366	1,111,856
72	77,525	1,799	0.97680	0.02320	0.02226	13.33	76,638	1,033,489
73	75,726	1,970	0.97398	0.02602	0.02482	12.64	74,756	956,851
74	73,756	2,167	0.97062	0.02938	0.02801	11.96	72,689	882,095
75	71,589	2,371	0.96688	0.03312	0.03169	11.31	70,420	809,406
76	69,218	2,572	0.96284	0.03716	0.03572	10.68	67,948	738,985
77	66,646	2,768	0.95847	0.04153	0.04007	10.07	65,278	671,037
78	63,878	2,960	0.95366	0.04634	0.04485	9.48	62,414	605,759
79	60,918	3,148	0.94833	0.05167	0.05015	8.92	59,359	543,346
80	57,770	3,328	0.94240	0.05760	0.05607	8.38	56,121	483,986
81	54,443	3,496	0.93578	0.06422	0.06271	7.86	52,708	427,865
82	50,946	3,648	0.92840	0.07160	0.07018	7.36	49,134	375,158
83	47,298	3,776	0.92017	0.07983	0.07857	6.89	45,420	326,023
84	43,523	3,872	0.91104	0.08896	0.08800	6.45	41,593	280,603
85	39,651	3,928	0.90093	0.09907	0.09854	6.03	37,690	239,010
86	35,723	3,937	0.88980	0.11020	0.11032	5.64	33,753	201,321
87	31,786	3,889	0.87764	0.12236	0.12342	5.27	29,835	167,568
88	27,897	3,776	0.86466	0.13534	0.13779	4.94	25,997	137,733
89	24,121	3,592	0.85108	0.14892	0.15319	4.63	22,307	111,736
90	20,529	3,343	0.83714	0.16286	0.16940	4.36	18,834	89,429
91	17,186	3,041	0.82304	0.17696	0.18619	4.11	15,638	70,595
92	14,144	2,702	0.80898	0.19102	0.20334	3.89	12,764	54,957
93	11,443	2,344	0.79516	0.20484	0.22062	3.69	10,241	42,193
94	9,099	1,986	0.78176	0.21824	0.23778	3.51	8,076	31,952
95	7,113	1,644	0.76894	0.23106	0.25459	3.36	6,264	23,876
96	5,469	1,330	0.75685	0.24315	0.27083	3.22	4,780	17,612
97	4,140	1,053	0.74563	0.25437	0.28626	3.10	3,592	12,832
98	3,087	817	0.73542	0.26458	0.30066	2.99	2,660	9,241
99	2,270	621	0.72634	0.27366	0.31377	2.90	1,945	6,580
100	1,649	465	0.71795	0.28205	0.32558	2.81	1,405	4,636
101	1,184	345	0.70825	0.29175	0.33790	2.73	1,002	3,231
102	838	252	0.69980	0.30020	0.35124	2.66	706	2,228
103	587	181	0.69232	0.30768	0.36252	2.60	491	1,523
104	406	128	0.68557	0.31443	0.37270	2.54	339	1,031
105	278	89	0.67931	0.32069	0.38213	2.49	231	693
106	189	62	0.67390	0.32610	0.39075	2.44	156	462
107	127	42	0.66890	0.33110	0.39828	2.40	105	305
108	85	29	0.66343	0.33657	0.40589	2.35	70	200
109	57	19	0.65808	0.34192	0.41417	2.30	46	130

AUSTRALIAN LIFE TABLES 2005-07: FEMALES

Age	l_x	d_x	p_x	q_x	μ_x	$\mathring{e}_x$	L_x	T_x
0	100,000	440	0.99560	0.00440	0.00000	83.67	99,616	8,367,345
1	99,560	32	0.99968	0.00032	0.00042	83.04	99,543	8,267,729
2	99,528	19	0.99981	0.00019	0.00024	82.07	99,518	8,168,186
3	99,509	15	0.99985	0.00015	0.00016	81.08	99,502	8,068,668
4	99,494	12	0.99988	0.00012	0.00013	80.10	99,488	7,969,166
5	99,482	11	0.99989	0.00011	0.00011	79.11	99,477	7,869,678
6	99,471	10	0.99990	0.00010	0.00011	78.11	99,466	7,770,201
7	99,461	9	0.99991	0.00009	0.00010	77.12	99,457	7,670,735
8	99,453	8	0.99992	0.00008	0.00009	76.13	99,448	7,571,278
9	99,445	7	0.99993	0.00007	0.00007	75.14	99,441	7,471,830
10	99,438	7	0.99993	0.00007	0.00007	74.14	99,434	7,372,389
11	99,431	7	0.99993	0.00007	0.00007	73.15	99,427	7,272,954
12	99,424	8	0.99992	0.00008	0.00007	72.15	99,420	7,173,527
13	99,416	10	0.99990	0.00010	0.00009	71.16	99,411	7,074,107
14	99,406	13	0.99987	0.00013	0.00011	70.16	99,400	6,974,696
15	99,393	18	0.99982	0.00018	0.00015	69.17	99,384	6,875,297
16	99,375	22	0.99978	0.00022	0.00020	68.19	99,364	6,775,913
17	99,353	26	0.99974	0.00026	0.00024	67.20	99,340	6,676,548
18	99,327	28	0.99972	0.00028	0.00027	66.22	99,313	6,577,208
19	99,299	28	0.99972	0.00028	0.00028	65.24	99,286	6,477,894
20	99,272	28	0.99972	0.00028	0.00028	64.25	99,258	6,378,609
21	99,244	28	0.99972	0.00028	0.00028	63.27	99,230	6,279,351
22	99,216	28	0.99972	0.00028	0.00028	62.29	99,202	6,180,121
23	99,188	29	0.99971	0.00029	0.00028	61.31	99,174	6,080,919
24	99,160	30	0.99970	0.00030	0.00030	60.32	99,145	5,981,745
25	99,130	30	0.99970	0.00030	0.00030	59.34	99,115	5,882,600
26	99,100	32	0.99968	0.00032	0.00031	58.36	99,084	5,783,485
27	99,068	33	0.99967	0.00033	0.00033	57.38	99,052	5,684,401
28	99,036	35	0.99965	0.00035	0.00034	56.40	99,018	5,585,349
29	99,001	36	0.99964	0.00036	0.00036	55.42	98,983	5,486,330
30	98,965	38	0.99962	0.00038	0.00037	54.44	98,947	5,387,347
31	98,928	41	0.99959	0.00041	0.00040	53.46	98,908	5,288,400
32	98,887	43	0.99957	0.00043	0.00042	52.48	98,866	5,189,492
33	98,845	45	0.99954	0.00046	0.00044	51.50	98,822	5,090,626
34	98,799	48	0.99951	0.00049	0.00047	50.52	98,775	4,991,804
35	98,751	52	0.99947	0.00053	0.00051	49.55	98,725	4,893,029
36	98,698	56	0.99943	0.00057	0.00055	48.58	98,671	4,794,304
37	98,642	61	0.99938	0.00062	0.00059	47.60	98,612	4,695,633
38	98,581	66	0.99933	0.00067	0.00064	46.63	98,548	4,597,021
39	98,515	72	0.99927	0.00073	0.00070	45.66	98,480	4,498,473
40	98,443	79	0.99920	0.00080	0.00076	44.70	98,404	4,399,993
41	98,364	86	0.99913	0.00087	0.00083	43.73	98,322	4,301,589
42	98,279	93	0.99905	0.00095	0.00091	42.77	98,233	4,203,267
43	98,185	102	0.99896	0.00104	0.00099	41.81	98,135	4,105,034
44	98,083	112	0.99886	0.00114	0.00109	40.85	98,028	4,006,899
45	97,971	121	0.99876	0.00124	0.00119	39.90	97,912	3,908,871
46	97,850	132	0.99865	0.00135	0.00129	38.95	97,785	3,810,959
47	97,718	144	0.99853	0.00147	0.00141	38.00	97,647	3,713,175
48	97,574	155	0.99841	0.00159	0.00153	37.05	97,498	3,615,528
49	97,419	169	0.99827	0.00173	0.00166	36.11	97,336	3,518,030
50	97,251	182	0.99813	0.00187	0.00180	35.17	97,161	3,420,694
51	97,069	196	0.99798	0.00202	0.00195	34.24	96,972	3,323,533
52	96,873	211	0.99782	0.00218	0.00210	33.31	96,768	3,226,561
53	96,661	227	0.99765	0.00235	0.00227	32.38	96,549	3,129,793
54	96,434	243	0.99748	0.00252	0.00244	31.45	96,314	3,033,244

AUSTRALIAN LIFE TABLES 2005-07: FEMALES (CONTINUED)

Age	l_x	d_x	p_x	q_x	μ_x	$\mathring{e}_x$	L_x	T_x
55	96,191	262	0.99728	0.00272	0.00262	30.53	96,062	2,936,930
56	95,930	284	0.99704	0.00296	0.00284	29.61	95,790	2,840,868
57	95,646	311	0.99675	0.00325	0.00310	28.70	95,493	2,745,078
58	95,335	341	0.99642	0.00358	0.00341	27.79	95,167	2,649,585
59	94,993	375	0.99605	0.00395	0.00377	26.89	94,809	2,554,419
60	94,618	413	0.99564	0.00436	0.00416	26.00	94,415	2,459,610
61	94,206	451	0.99521	0.00479	0.00458	25.11	93,983	2,365,195
62	93,754	491	0.99476	0.00524	0.00502	24.23	93,512	2,271,211
63	93,263	533	0.99428	0.00572	0.00549	23.35	93,000	2,177,699
64	92,730	578	0.99377	0.00623	0.00599	22.48	92,445	2,084,699
65	92,152	626	0.99321	0.00679	0.00652	21.62	91,843	1,992,254
66	91,526	680	0.99257	0.00743	0.00712	20.76	91,191	1,900,411
67	90,846	742	0.99183	0.00817	0.00781	19.92	90,481	1,809,220
68	90,104	813	0.99098	0.00902	0.00861	19.08	89,704	1,718,739
69	89,291	894	0.98999	0.01001	0.00954	18.24	88,852	1,629,035
70	88,398	986	0.98885	0.01115	0.01061	17.42	87,913	1,540,183
71	87,412	1,089	0.98754	0.01246	0.01184	16.61	86,877	1,452,270
72	86,323	1,206	0.98603	0.01397	0.01327	15.82	85,730	1,365,394
73	85,117	1,335	0.98432	0.01568	0.01490	15.03	84,461	1,279,664
74	83,782	1,477	0.98237	0.01763	0.01675	14.27	83,056	1,195,203
75	82,305	1,631	0.98018	0.01982	0.01886	13.51	81,503	1,112,147
76	80,674	1,797	0.97772	0.02228	0.02122	12.78	79,790	1,030,644
77	78,876	1,981	0.97489	0.02511	0.02391	12.05	77,902	950,855
78	76,896	2,182	0.97162	0.02838	0.02703	11.35	75,822	872,952
79	74,714	2,405	0.96781	0.03219	0.03065	10.67	73,530	797,130
80	72,308	2,647	0.96339	0.03661	0.03489	10.01	71,006	723,600
81	69,661	2,908	0.95825	0.04175	0.03984	9.37	68,229	652,594
82	66,753	3,182	0.95233	0.04767	0.04560	8.75	65,185	584,364
83	63,571	3,461	0.94555	0.05445	0.05225	8.17	61,863	519,179
84	60,109	3,736	0.93784	0.06216	0.05990	7.61	58,264	457,316
85	56,373	3,996	0.92912	0.07088	0.06865	7.08	54,396	399,052
86	52,377	4,224	0.91935	0.08065	0.07859	6.58	50,283	344,657
87	48,153	4,408	0.90846	0.09154	0.08981	6.11	45,962	294,374
88	43,745	4,531	0.89642	0.10358	0.10243	5.68	41,487	248,412
89	39,214	4,579	0.88322	0.11678	0.11652	5.28	36,925	206,925
90	34,635	4,535	0.86906	0.13094	0.13205	4.91	32,359	170,001
91	30,100	4,390	0.85415	0.14585	0.14881	4.57	27,888	137,641
92	25,710	4,147	0.83870	0.16130	0.16662	4.27	23,612	109,753
93	21,563	3,819	0.82290	0.17710	0.18529	3.99	19,623	86,141
94	17,744	3,425	0.80696	0.19304	0.20462	3.75	15,996	66,518
95	14,319	2,992	0.79105	0.20895	0.22440	3.53	12,786	50,522
96	11,327	2,545	0.77533	0.22467	0.24443	3.33	10,017	37,736
97	8,782	2,108	0.75995	0.24005	0.26453	3.16	7,693	27,719
98	6,674	1,701	0.74505	0.25495	0.28449	3.00	5,791	20,027
99	4,972	1,339	0.73075	0.26925	0.30412	2.86	4,275	14,236
100	3,634	1,028	0.71719	0.28281	0.32322	2.74	3,096	9,961
101	2,606	770	0.70445	0.29555	0.34158	2.63	2,202	6,865
102	1,836	564	0.69265	0.30735	0.35901	2.54	1,538	4,663
103	1,272	405	0.68184	0.31816	0.37532	2.46	1,058	3,125
104	867	284	0.67200	0.32800	0.39043	2.38	716	2,067
105	583	196	0.66309	0.33691	0.40433	2.32	478	1,351
106	386	133	0.65507	0.34493	0.41703	2.26	315	873
107	253	89	0.64790	0.35210	0.42847	2.20	205	557
108	164	59	0.63983	0.36017	0.43976	2.15	132	352
109	105	39	0.63200	0.36800	0.45247	2.09	84	220

2. Construction of the Australian Life Tables 2005-07

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.

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 99 years and over, as at 30 June 2006. These estimates are based on the 2006 Census of Population and Housing adjusted for under-enumeration and the lapse of time between 30 June and 8 August 2006 (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 2005 to December 2007, classified by sex and age last birthday at the time of death. This covered all registrations of deaths to the end of 2008 and is considered to be effectively a complete record of all deaths occurring over the three year period.

(c) The number of births classified by gender in each month from January 2001 to December 2007.

(d) The number of deaths of those aged 3 years or less in each month from January 2001 to December 2007, classified by gender 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 2005 to December 2007 for those aged 4 or more, and from January 2001 to December 2007 for those aged less than 4, grouped by age last birthday and gender.

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 2006, and the number of deaths at each age occurring over the three years 2005 to 2007.

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 2005-07, 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 (Estimated Resident Population, ABS Catalogue No 3201.0) 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:

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

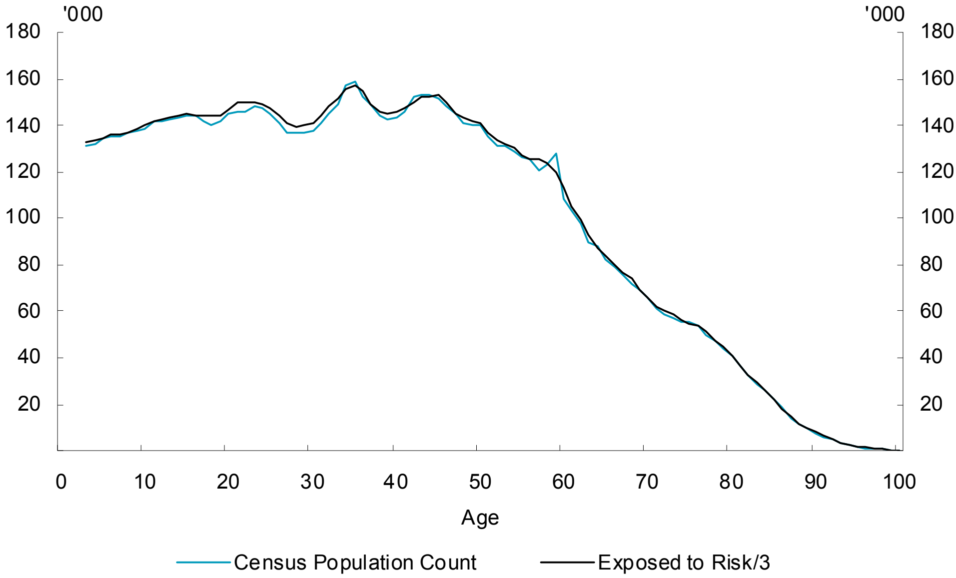
where P_x is the population inside Australia aged x last birthday as measured in the 2006 Census adjusted only for under-enumeration and the lapse of time from 30 June to Census night.

This estimate was then modified to reduce exposure for those who arrived in Australia between January 2005 and June 2006, or who died or left Australia between July 2006 and December 2007. Similarly, exposure was increased to take account of those who arrived between July 2006 and December 2007 or who died or left Australia between January 2005 and June 2006.

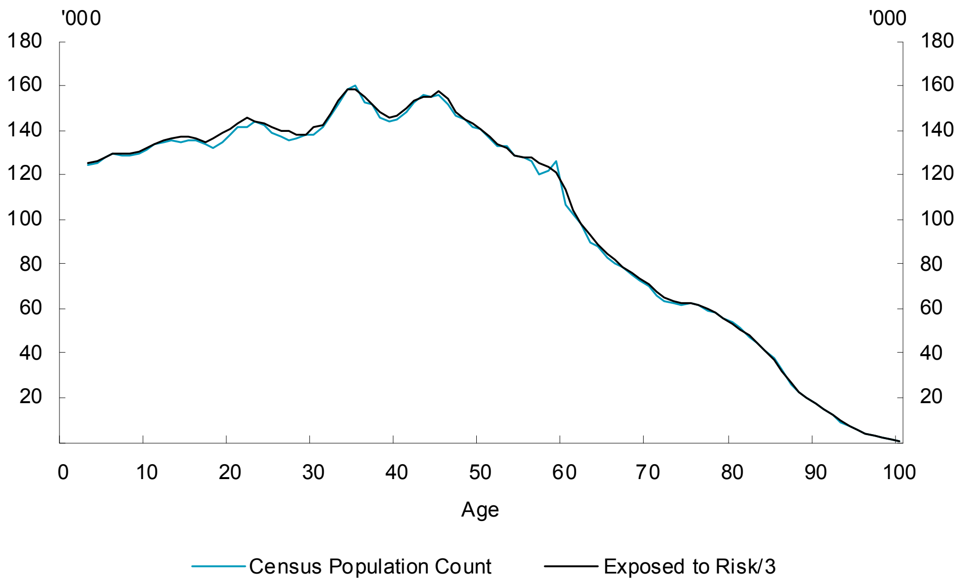
Figure 13 compares the Census population count with the exposed-to-risk after all adjustments have been made. It can be seen that the exposed-to-risk formula smoothes to some extent the fluctuations from age to age apparent in the unadjusted population count. The peak resulting from the high birth rates in 1971 remains clearly visible, as does the baby boomer cohort who were in their late 40s and 50s at the time of the Census. The impact of significant 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.

Figure 13: Comparison of census population count and exposed-to-risk

Males



Females



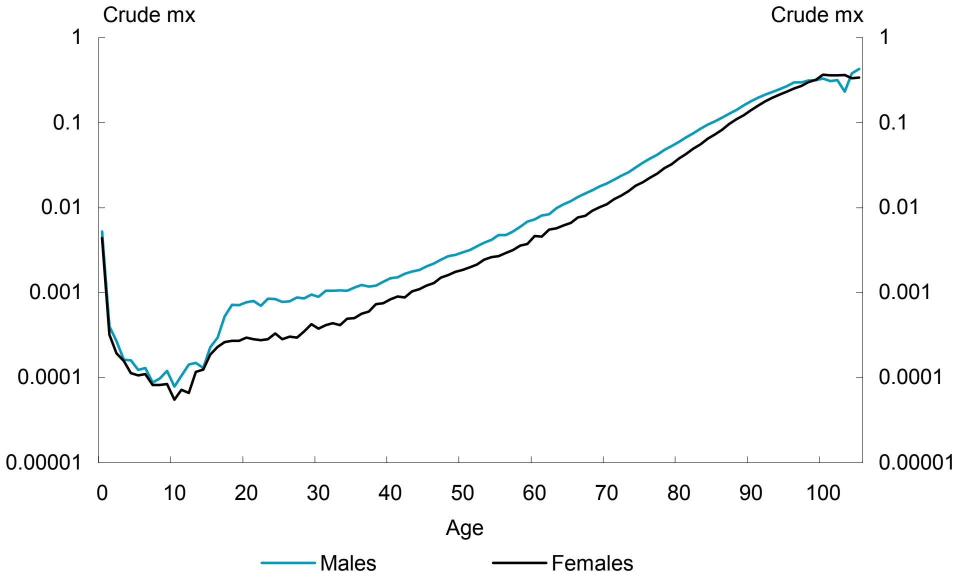
For ages 2 and above, the crude central rate of mortality at age x, m_x, was in most cases calculated by dividing the deaths at age x during 2005, 2006 and 2007 by the relevant exposed-to-risk. An exception was made for ages 4 to 16 inclusive. Deaths over the these ages have fallen to less than half the number observed two decades ago, despite the growth in the populations at risk. This 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 2000-02 and 2005-07 over these ages. The deaths data from 2000-02 has been adjusted to take account of the average level of mortality improvement over these ages before combining with the 2005-07 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 2001 to 2007. 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 14 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 distribution. 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 14: Crude central mortality rates



As with the six 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:

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

where:

A_x	is the number of observed deaths aged x in the three years 2005, 2006 and 2007;
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 2000-02 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:	4	16	19	21	22	32	57	60	73	75	78	89	94
Females:	4	11	17	20	22	35	36	57	58	65	78	91	105

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, 19, 21 and 22 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 17, 20 and 22 to capture the sharp increase and subsequent flattening in mortality rates over this age range. A further group of knots was required around age 75 to achieve the transition to the old age rates for males, while for females a pair of knots at ages 57 and 58 was needed to adequately fit the data.

Graduated rates for the uppermost ages were constructed by extrapolating the trend of the crude rates from age 95 to an age where there were sufficient deaths to make the crude rates meaningful; age 104 for males and 111 for females. The trend result was determined by fitting a Makeham curve to the crude rates over this age range. The Makeham curve was then used to extrapolate the graduated rates from age 105 for males and 107 for females. The Makeham curve for males was very much flatter than that fitted for females and we decided to increase the male rates half way to the female rates for ages above 99.

As has been the case for the last five 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, placing it between ages 102 and 103. The 1995-97 set of crude mortality rates suggested a reduction in the age at which crossover occurs, placing it in the upper 90s and the crossover was placed at age 98. The crude rates for the 2000-02 Tables crossed at age 96 but after graduation, the crossover was placed at age 103.

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 these very old ages have improved. For the current Tables, the crude rates crossed at 99 and graduation increased this by only one year to 100. Thus, while the placement of the crossover is necessarily uncertain due to the relatively small volume of data and associated volatility in crude rates from one Table to the next, over the last four tables it has fallen within a five year age band, with the current Tables placing it at the midpoint of this range.

A negligible percentage of death registrations in 2005-07 did not include the age at death (less than 0.03 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 representing 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:

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

$$d_x = l_x q_x$$

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

$$p_x = 1 - q_x$$

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

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

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

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

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.

3. USE OF LIFE TABLES FOR PROBABILITY CALCULATIONS

As well as being the most recent actuarially determined record of mortality rates, the 2005-07 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 2005-07 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 100 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:

$$q_x(t) = q_x \times \left(1 + \frac{I_x}{100}\right)^{(t-2006)}$$

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 63 year old female. Her mortality in 2006 is given in the current Life Tables as 0.00572. That is, $q_{63}(2006)$ = 0.00572

The table below sets out the calculation of the projected mortality rate for a 63 year old female in future years — $q_{63}(t)$ for t =2007, 2010 and 2050 — using the two improvement scenarios.

	25 year improvement factors	100 year improvement factors
$q_{63}(2006)$	0.00572	0.00572
$q_{63}(2007)$	$q_{63}(2006)\times\left(1-\frac{2.5268}{100}\right)$ = 0.005575	$q_{63}(2006)\times\left(1-\frac{1.4688}{100}\right)$ = 0.005636
$q_{63}(2010)$	$q_{63}(2006)\times\left(1-\frac{2.5268}{100}\right)^{4}$ = 0.005163	$q_{63}(2006)\times\left(1-\frac{1.4688}{100}\right)^{4}$ = 0.005391
$q_{63}(2050)$	$q_{63}(2006)\times\left(1-\frac{2.5268}{100}\right)^{44}$ = 0.001855	$q_{63}(2006)\times\left(1-\frac{1.4688}{100}\right)^{44}$ = 0.002983

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

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

Complete expectation of life at selected ages — males

	Age		
Life Tables	0	30	65
1881-90	47.20	33.64	11.06
1891-00	51.08	35.11	11.25
1901-10	55.20	36.52	11.31
1920-22	59.15	38.44	12.01
1932-34	63.48	39.90	12.40
1946-48	66.07	40.40	12.25
1953-55	67.14	40.90	12.33
1960-62	67.92	41.12	12.47
1965-67	67.63	40.72	12.16
1970-72	68.10	41.10	12.37
1975-77	69.56	42.18	13.13
1980-82	71.23	43.51	13.80
1985-87	72.74	44.84	14.60
1990-92	74.32	46.07	15.41
1995-97	75.69	47.26	16.21
2000-02	77.64	49.07	17.70
2005-07	79.02	50.20	18.54

Complete expectation of life at selected ages — females

	Age		
Life Tables	0	30	65
1881-90	50.84	36.13	12.27
1891-00	54.76	37.86	12.75
1901-10	58.84	39.33	12.88
1920-22	63.31	41.48	13.60
1932-34	67.14	42.77	14.15
1946-48	70.63	44.08	14.44
1953-55	72.75	45.43	15.02
1960-62	74.18	46.49	15.68
1965-67	74.15	46.34	15.70
1970-72	74.80	46.86	16.09
1975-77	76.56	48.26	17.13
1980-82	78.27	49.67	18.00
1985-87	79.20	50.49	18.56
1990-92	80.39	51.48	19.26
1995-97	81.37	52.30	19.88
2000-02	82.87	53.72	21.15
2005-07	83.67	54.44	21.62

APPENDIX B

Population

The Australian population as shown by the last eleven 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

Figures shown for Censuses before 1966 exclude Aborigines. Figures shown for 1971, 1976, 1981, 1986, 1991, 1996, 2001 and 2006 have been adjusted by the Statistician to allow for under-enumeration at the Censuses. Since 1991, the Census has been held in August. Figures for 1991, 1996, 2001 and 2006 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
2005	67,523	63,916	131,349
2006	68,839	65,510	134,349
2007	71,447	68,107	139,554
Total	**207,809**	**197,533**	**405,342**

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
2005	5,557,715	5,517,689	5,108,317	5,022,120	10,666,032	10,539,809
2006	5,743,249	5,664,547	5,167,206	5,079,642	10,910,455	10,744,189
2007	6,090,035	6,034,148	5,493,563	5,421,965	11,583,958	11,456,113
Total	**17,390,999**	**17,216,384**	**15,769,086**	**15,523,727**	**33,160,085**	**32,740,111**

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 2006 and deaths in the three years 2005-07, Australia — males

Age	Population	Deaths	Age	Population	Deaths
0	137,142	2,107	52	131,617	1,412
1	133,215	157	53	131,552	1,531
2	131,863	107	54	128,806	1,642
3	131,550	65	55	126,318	1,810
4	132,079	64	56	125,839	1,795
5	134,757	50	57	120,511	1,970
6	135,688	53	58	122,914	2,221
7	135,644	36	59	128,140	2,468
8	136,510	40	60	108,036	2,487
9	137,324	50	61	103,539	2,540
10	138,726	33	62	97,683	2,500
11	141,998	45	63	89,588	2,752
12	141,896	61	64	88,021	2,872
13	142,339	64	65	82,127	3,027
14	143,270	56	66	79,287	3,216
15	144,257	99	67	75,814	3,382
16	144,591	128	68	71,875	3,567
17	141,421	228	69	69,111	3,729
18	139,874	313	70	66,313	3,825
19	141,924	310	71	61,145	3,991
20	145,217	342	72	58,941	4,257
21	145,795	359	73	57,185	4,559
22	145,722	315	74	55,513	5,048
23	148,494	382	75	55,271	5,554
24	147,772	378	76	53,469	6,059
25	145,090	346	77	49,760	6,430
26	140,700	345	78	47,596	6,805
27	136,920	374	79	44,296	7,046
28	136,577	359	80	40,960	7,255
29	136,913	400	81	36,590	7,345
30	138,033	378	82	32,686	7,335
31	140,798	457	83	28,931	7,426
32	144,884	468	84	25,918	7,339
33	149,262	486	85	22,212	6,930
34	156,961	495	86	18,884	6,295
35	158,929	543	87	13,723	5,643
36	152,278	572	88	11,052	4,925
37	149,190	532	89	9,453	4,548
38	144,668	530	90	7,658	4,168
39	142,998	585	91	6,058	3,676
40	143,664	646	92	4,628	3,103
41	145,606	674	93	3,379	2,440
42	152,324	754	94	2,352	1,898
43	153,253	810	95	1,667	1,452
44	153,474	852	96	1,165	1,086
45	151,534	940	97	684	728
46	148,662	997	98	475	490
47	145,121	1,064	99	331	326
48	141,342	1,160	100 and over	464	521
49	140,060	1,194			
50	139,951	1,263	Not stated		20
51	135,295	1,299	Total	10,123,089	207,809

Population at 30 June 2006 and deaths in the three years 2005-07, Australia — females

Age	Population	Deaths	Age	Population	Deaths
0	130,510	1,667	52	132,851	869
1	125,413	117	53	132,926	965
2	124,538	73	54	128,996	1,011
3	124,761	59	55	128,064	1,034
4	125,691	43	56	126,182	1,130
5	127,887	41	57	120,428	1,199
6	129,309	43	58	122,128	1,335
7	128,760	32	59	126,479	1,367
8	128,600	32	60	106,259	1,587
9	130,009	33	61	102,125	1,430
10	130,985	22	62	98,361	1,634
11	134,268	29	63	89,555	1,592
12	134,837	27	64	87,581	1,647
13	135,354	48	65	82,839	1,689
14	135,055	51	66	80,433	1,890
15	135,432	77	67	78,941	1,895
16	135,537	94	68	74,811	2,089
17	133,676	106	69	73,074	2,251
18	132,252	111	70	69,944	2,332
19	134,690	113	71	66,218	2,553
20	138,317	125	72	63,666	2,704
21	141,713	121	73	62,892	2,956
22	141,470	120	74	61,449	3,401
23	144,190	122	75	62,549	3,711
24	142,113	142	76	61,965	4,145
25	139,326	120	77	59,520	4,534
26	137,402	127	78	58,196	5,089
27	136,037	124	79	55,629	5,444
28	136,554	144	80	53,834	6,019
29	137,954	176	81	51,571	6,551
30	138,300	160	82	47,593	7,109
31	141,827	178	83	44,291	7,401
32	146,492	194	84	41,305	7,973
33	151,549	191	85	37,638	8,128
34	158,659	234	86	32,957	7,971
35	160,395	238	87	25,681	7,834
36	152,353	265	88	22,456	7,602
37	151,315	275	89	20,088	7,339
38	145,683	326	90	17,495	7,373
39	144,099	329	91	15,240	7,100
40	145,076	369	92	12,245	6,624
41	147,990	408	93	9,330	5,705
42	152,849	407	94	7,279	4,752
43	156,110	482	95	5,390	3,924
44	155,162	515	96	3,946	3,118
45	155,746	575	97	2,691	2,369
46	151,727	602	98	1,868	1,792
47	146,697	670	99	1,209	1,268
48	144,902	701	100 and over	1,995	2,466
49	141,505	756			
50	140,443	788	Not stated		12
51	136,196	818	Total	10,247,879	197,533

APPENDIX D

Comparison of actual and expected deaths in the three years 2005-2007, Australia — males

Age	Actual Deaths	Expected Deaths	Deviation +	Deviation -	Accumulation +	Accumulation -
2	107	110		3		3
3	65	72		7		10
4	64	56	8			2
5	50	51		1		3
6	53	47	6		3	
7	36	44		8		5
8	40	42		2		7
9	50	41	9		2	
10	33	42		9		7
11	45	45		0		7
12	61	50	11		4	
13	64	58	6		10	
14	56	70		14		4
15	99	97	2			2
16	128	151		23		25
17	228	233		5		30
18	313	302	11			19
19	310	317		7		26
20	342	327	15			11
21	359	340	19		8	
22	315	347		32		24
23	382	354	28		4	
24	378	362	16		20	
25	346	367		21		1
26	345	370		25		26
27	374	371	3			23
28	359	378		19		42
29	400	390	10			32
30	378	404		26		58
31	457	425	32			26
32	468	449	19			7
33	486	476	10		3	
34	495	506		11		8
35	543	532	11		3	
36	572	545	27		30	
37	532	551		19	11	
38	530	566		36		25
39	585	594		9		34
40	646	634	12			22
41	674	682		8		30
42	754	741	13			17
43	810	807	3			14
44	852	868		16		30
45	940	942		2		32
46	997	993	4			28
47	1064	1042	22			6
48	1,160	1,109	51		45	
49	1,194	1,195		1	44	
50	1,263	1,283		20	24	
51	1,299	1,350		51		27

Comparison of actual and expected deaths in the three years 2005-2007, Australia — males (continued)

Age	Actual Deaths	Expected Deaths	Deviation +	Deviation -	Accumulation +	Accumulation -
52	1,412	1,429		17		44
53	1,531	1,536		5		49
54	1,642	1,646		4		53
55	1,810	1,731	79		26	
56	1,795	1,858		63		37
57	1,970	2,029		59		96
58	2,221	2,198	23			73
59	2,468	2,348	120		47	
60	2,487	2,460	27		74	
61	2,540	2,526	14		88	
62	2,500	2,652		152		64
63	2,752	2,741	11			53
64	2,872	2,862	10			43
65	3,027	3,045		18		61
66	3,216	3,189	27			34
67	3,382	3,372	10			24
68	3,567	3,572		5		29
69	3,729	3,695	34		5	
70	3,825	3,841		16		11
71	3,991	3,953	38		27	
72	4,257	4,232	25		52	
73	4,559	4,622		63		11
74	5,048	5,060		12		23
75	5,554	5,548	6			17
76	6,059	6,075		16		33
77	6,430	6,502		72		105
78	6,805	6,767	38			67
79	7,046	7,071		25		92
80	7,255	7,276		21		113
81	7,345	7,267	78			35
82	7,335	7,265	70		35	
83	7,426	7,291	135		170	
84	7,339	7,237	102		272	
85	6,930	6,990		60	212	
86	6,295	6,386		91	121	
87	5,643	5,779		136		15
88	4,925	5,081		156		171
89	4,548	4,588		40		211
90	4,168	4,142	26			185
91	3,676	3,645	31			154
92	3,103	3,068	35			119
93	2,440	2,428	12			107
94	1,898	1,889	9			98
95	1,452	1,419	33			65
96	1,086	1,017	69		4	
97	728	719	9		13	
98	490	482	8		21	
99	326	329		3	18	
100	224	226		2	16	
Total	205,228	205,212				

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 2005-2007, Australia — females

Age	Actual Deaths	Expected Deaths	Deviation +	Deviation -	Accumulation +	Accumulation -
2	73	71	2		2	
3	59	57	2		4	
4	43	47		4		0
5	41	43		2		2
6	43	39	4		2	
7	32	35		3		1
8	32	31	1			0
9	33	29	4		4	
10	22	28		6		2
11	29	29		0		2
12	27	34		7		9
13	48	42	6			3
14	51	55		4		7
15	77	73	4			3
16	94	90	4		1	
17	106	107		1		0
18	111	114		3		3
19	113	116		3		6
20	125	117	8		2	
21	121	120	1		3	
22	120	123		3		0
23	122	124		2		2
24	142	127	15		13	
25	120	130		10	3	
26	127	133		6		3
27	124	139		15		18
28	144	143	1			17
29	176	151	25		8	
30	160	163		3	5	
31	178	174	4		9	
32	194	191	3		12	
33	191	210		19		7
34	234	232	2			5
35	238	250		12		17
36	265	265		0		17
37	275	281		6		23
38	326	298	28		5	
39	329	321	8		13	
40	369	352	17		30	
41	408	394	14		44	
42	407	440		33	11	
43	482	484		2	9	
44	515	530		15		6
45	575	585		10		16
46	602	625		23		39
47	670	654	16			23
48	701	694	7			16
49	756	740	16			0
50	788	791		3		3
51	818	834		16		19

Comparison of actual and expected deaths in the three years 2005-2007, Australia — females (continued)

Age	Actual Deaths	Expected Deaths	Deviation +	Deviation -	Accumulation +	Accumulation -
52	869	878		9		28
53	965	929	36		8	
54	1,011	977	34		42	
55	1,034	1,045		11	31	
56	1,130	1,136		6	25	
57	1,199	1,226		27		2
58	1,335	1,333	2			0
59	1,367	1,440		73		73
60	1,587	1,491	96		23	
61	1,430	1,501		71		48
62	1,634	1,547	87		39	
63	1,592	1,599		7	32	
64	1,647	1,662		15	17	
65	1,689	1,729		40		23
66	1,890	1,830	60		37	
67	1,895	1,944		49		12
68	2,089	2,063	26		14	
69	2,251	2,225	26		40	
70	2,332	2,385		53		13
71	2,553	2,543	10			3
72	2,704	2,740		36		39
73	2,956	2,997		41		80
74	3,401	3,330	71			9
75	3,711	3,728		17		26
76	4,145	4,141	4			22
77	4,534	4,580		46		68
78	5,089	5,008	81		13	
79	5,444	5,480		36		23
80	6,019	5,956	63		40	
81	6,551	6,511	40		80	
82	7,109	7,006	103		183	
83	7,401	7,464		63	120	
84	7,973	7,914	59		179	
85	8,128	8,224		96	83	
86	7,971	8,142		171		88
87	7,834	7,818	16			72
88	7,602	7,538	64			8
89	7,339	7,464		125		133
90	7,373	7,398		25		158
91	7,100	7,088	12			146
92	6,624	6,510	114			32
93	5,705	5,673	32			0
94	4,752	4,766		14		14
95	3,924	3,960		36		50
96	3,118	3,143		25		75
97	2,369	2,394		25		100
98	1,792	1,764	28			72
99	1,268	1,252	16			56
100	947	860	87		31	
Total	194,218	194,187				

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	100 Year	Age	25 Year	100 Year
0	-3.0925	-2.8589	56	-3.2468	-1.3575
1	-3.3186	-3.7244	57	-3.2805	-1.3389
2	-3.7074	-3.1324	58	-3.3066	-1.3187
3	-4.4384	-3.1437	59	-3.3254	-1.2947
4	-4.5426	-3.1649	60	-3.3369	-1.2683
5	-4.4602	-3.0267	61	-3.3412	-1.2419
6	-4.3750	-2.9309	62	-3.3386	-1.2173
7	-4.2870	-2.9015	63	-3.3291	-1.1928
8	-4.1962	-2.9317	64	-3.3130	-1.1747
9	-4.1026	-2.8704	65	-3.2902	-1.1613
10	-4.0061	-2.8436	66	-3.2609	-1.1556
11	-3.8565	-2.7509	67	-3.2253	-1.1525
12	-3.7751	-2.6931	68	-3.1835	-1.1531
13	-3.7075	-2.6866	69	-3.1357	-1.1555
14	-3.6519	-2.6089	70	-3.0819	-1.1593
15	-3.6051	-2.2982	71	-3.0223	-1.1623
16	-3.5626	-2.0615	72	-2.9571	-1.1552
17	-3.5183	-1.7100	73	-2.8863	-1.1318
18	-3.4650	-1.5416	74	-2.8101	-1.0980
19	-3.3939	-1.5524	75	-2.7286	-1.0596
20	-3.2948	-1.5966	76	-2.6375	-1.0209
21	-3.1000	-1.6246	77	-2.5299	-0.9835
22	-2.8587	-1.6439	78	-2.4239	-0.9460
23	-2.6347	-1.6522	79	-2.3172	-0.9083
24	-2.4346	-1.6646	80	-2.2066	-0.8696
25	-2.2337	-1.6718	81	-2.0925	-0.8297
26	-2.0318	-1.6829	82	-1.9749	-0.7931
27	-1.7836	-1.6780	83	-1.8536	-0.7583
28	-1.5795	-1.6883	84	-1.7301	-0.7223
29	-1.3308	-1.6738	85	-1.6055	-0.6851
30	-1.1233	-1.6837	86	-1.4809	-0.6471
31	-0.9687	-1.6921	87	-1.3584	-0.6105
32	-0.8491	-1.6947	88	-1.2465	-0.5787
33	-0.7580	-1.6928	89	-1.1489	-0.5522
34	-0.7995	-1.7067	90	-1.0671	-0.5256
35	-0.8602	-1.7171	91	-0.9997	-0.4990
36	-0.9624	-1.7196	92	-0.9457	-0.4725
37	-1.0711	-1.7211	93	-0.8917	-0.4459
38	-1.2350	-1.7263	94	-0.8377	-0.4193
39	-1.3904	-1.7290	95	-0.7837	-0.3928
40	-1.5449	-1.7128	96	-0.7297	-0.3662
41	-1.7262	-1.7053	97	-0.6757	-0.3397
42	-1.8921	-1.6930	98	-0.6217	-0.3131
43	-2.0580	-1.6872	99	-0.5677	-0.2865
44	-2.1959	-1.6703	100	-0.5137	-0.2600
45	-2.3534	-1.6555	101	-0.4597	-0.2334
46	-2.4701	-1.6290	102	-0.4057	-0.2068
47	-2.5929	-1.6081	103	-0.3517	-0.1803
48	-2.6911	-1.5742	104	-0.2977	-0.1537
49	-2.7896	-1.5438	105	-0.2437	-0.1271
50	-2.8796	-1.5153	106	-0.1898	-0.1006
51	-2.9611	-1.4811	107	-0.1358	-0.0740
52	-3.0344	-1.4499	108	-0.0818	-0.0475
53	-3.0994	-1.4253	109	-0.0278	-0.0209
54	-3.1564	-1.3988	110	0.0000	0.0000
55	-3.2055	-1.3767	111	0.0000	0.0000

Future percentage mortality improvement factors — females

Age	25 Year	100 Year	Age	25 Year	100 Year
0	-3.4069	-2.8530	56	-2.4696	-1.5205
1	-3.3854	-3.8748	57	-2.4860	-1.5019
2	-3.3604	-3.4392	58	-2.4995	-1.4898
3	-3.3318	-3.2563	59	-2.5102	-1.4791
4	-3.2996	-3.2421	60	-2.5183	-1.4715
5	-3.2639	-3.1058	61	-2.5237	-1.4676
6	-3.2246	-3.0169	62	-2.5265	-1.4670
7	-3.1817	-3.0089	63	-2.5268	-1.4688
8	-3.1353	-3.0382	64	-2.5244	-1.4720
9	-3.0853	-3.0988	65	-2.5195	-1.4741
10	-3.0317	-3.0747	66	-2.5118	-1.4715
11	-2.9746	-3.0988	67	-2.5014	-1.4658
12	-2.9139	-3.0382	68	-2.4881	-1.4575
13	-2.8497	-2.8704	69	-2.4718	-1.4502
14	-2.7819	-2.6963	70	-2.4524	-1.4444
15	-2.7105	-2.4677	71	-2.4297	-1.4381
16	-2.6356	-2.3774	72	-2.4035	-1.4281
17	-2.5571	-2.3095	73	-2.3736	-1.4122
18	-2.4750	-2.3106	74	-2.3398	-1.3883
19	-2.3894	-2.3757	75	-2.3018	-1.3580
20	-2.3002	-2.4337	76	-2.2593	-1.3220
21	-2.2074	-2.4913	77	-2.2120	-1.2794
22	-2.1111	-2.5483	78	-2.1808	-1.2317
23	-2.0112	-2.5604	79	-2.1320	-1.1793
24	-1.9077	-2.5787	80	-2.0719	-1.1236
25	-1.8007	-2.6275	81	-1.9981	-1.0654
26	-1.6901	-2.6045	82	-1.9150	-1.0058
27	-1.5759	-2.6192	83	-1.8240	-0.9463
28	-1.4582	-2.6025	84	-1.7247	-0.8900
29	-1.3369	-2.6026	85	-1.6177	-0.8389
30	-1.2468	-2.5804	86	-1.5057	-0.7924
31	-1.1682	-2.5451	87	-1.3887	-0.7473
32	-1.1898	-2.5306	88	-1.2687	-0.7013
33	-1.1869	-2.5009	89	-1.1480	-0.6553
34	-1.2437	-2.4724	90	-1.0346	-0.6132
35	-1.2725	-2.4247	91	-0.9324	-0.5771
36	-1.3468	-2.3864	92	-0.8450	-0.5410
37	-1.4356	-2.3359	93	-0.7725	-0.5049
38	-1.5496	-2.2864	94	-0.7159	-0.4688
39	-1.6267	-2.2325	95	-0.6747	-0.4327
40	-1.6738	-2.1705	96	-0.6335	-0.3966
41	-1.7711	-2.1127	97	-0.5923	-0.3605
42	-1.8365	-2.0541	98	-0.5511	-0.3244
43	-1.9000	-1.9859	99	-0.5099	-0.2883
44	-1.9602	-1.9135	100	-0.4687	-0.2522
45	-2.0289	-1.8556	101	-0.4275	-0.2162
46	-2.0745	-1.7938	102	-0.3863	-0.1801
47	-2.1329	-1.7407	103	-0.3451	-0.1440
48	-2.1960	-1.6965	104	-0.3039	-0.1079
49	-2.2426	-1.6518	105	-0.2627	-0.0718
50	-2.2934	-1.6184	106	-0.2215	-0.0357
51	-2.3399	-1.5858	107	-0.1803	0.0000
52	-2.3728	-1.5635	108	-0.1391	0.0000
53	-2.4020	-1.5467	109	-0.0979	0.0000
54	-2.4278	-1.5419	110	-0.0567	0.0000
55	-2.4503	-1.5346	111	0.0000	0.0000