AUSTRALIAN LIFE TABLES 1995-97

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Produced by Australian Government Actuary

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DEFINITIONS OF SYMBOLS

Australian Life Tables 1995-97 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*

$\overset{o}{e}_x$ = the complete expectation of life (i.e., 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 1995-97, which are based on the mortality of Australians over the three year period centred on the 1996 Census.

This publication discusses the major features of the 1995-97 Life Tables, with particular reference to the previous Australian Life Tables. The 1990-92 Life Tables were focussed on changes in mortality rates over the preceding century. In this report, the issue of mortality improvement is examined both in the context of the improvements observed in the past and the implications of different mortality improvement scenarios for future life expectancy. This discussion is followed by the Tables themselves, together with some technical notes on their construction. The appendices include supporting information referred to in the text.

For the first time, the life tables themselves have been included in electronic form with this publication. It is hoped that this will facilitate their use. To allow historical comparison, and to encourage research and discussion, the mortality rates and life expectancies for ages 0 to 100 from all previous Australian Life Tables have also been included in electronic form.

This is the fifteenth 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 are based on 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 (the earlier tables under the former title of Commonwealth Actuary).

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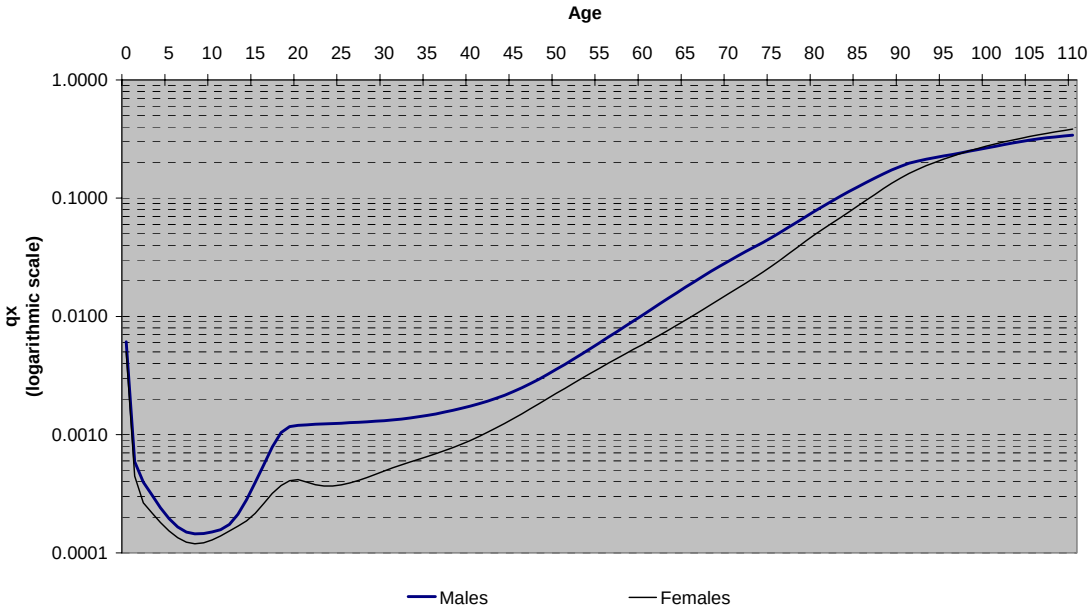
August 1999

1. MORTALITY OF THE AUSTRALIAN POPULATION

1.1 RESULTS FOR 1995-97

Figure 1 shows the mortality rates reported in the 1995-97 Life Tables on a logarithmic scale.

Figure 1: Mortality Rates 1995-97



The pattern of mortality seen 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 as resistance builds, leading to a minimum between ages 8 and 11 for both males and females. At these ages, a human's chance of survival to the end of the year is greater than at any other age. The steep rise in mortality rates during the teenage years is primarily due to accidental deaths associated with leisure activities.

Mortality rates show little change with age between 20 and 29 for males. Over this age range accidental deaths decline, but this is offset by an increase in deaths from disease. For females, deaths from disease do not increase as quickly over these years. As a result, mortality rates decline from ages 20 to 24 with the fall in accidental deaths. This gives the appearance of a "hump" centered at age 20.

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 except the very oldest ages. This difference is the result of a number of factors, including:

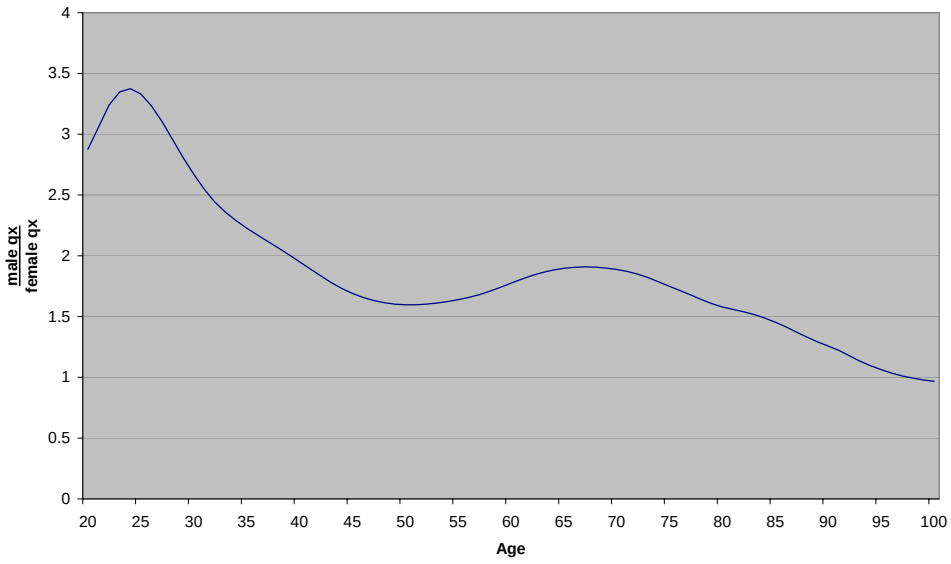
- the greater hazards associated with some occupations which have traditionally been dominated by men (such as mining);

- the differences in the incidence of some diseases between men and women, including the existence of fatal diseases which attack one gender only (such as prostate cancer); and

- the differences in fatality from diseases which affect both genders.

The first of these factors is clearly due to gender stratification in the labour force rather than physiological differences between men and women, although physiological differences may be responsible, in part, for such stratification. The latter two factors, however, might be expected to be the result of both physiological and lifestyle differences.

Figure 2: Ratio of Male to Female Mortality Rates 1995-97 Ages 20 to 100



The differential between male and female mortality rates varies with age as shown in Figure 2, with the greatest deviation occurring around age 25 where the death rates for men are nearly three and a half times the rates for women.

The ratio between the genders reaches a local minimum of close to one and a half at age 50, and then increases to approximately two by age 67. From age 68, the gap gradually closes and just before age 100, the rates for men drop below female rates. This phenomenon has been evident for some time in overseas studies of mortality and in Australian data, and a crossover was incorporated for the first time in the 1990-92 Australian Life Tables. Although the local and international evidence suggests the crossover may be

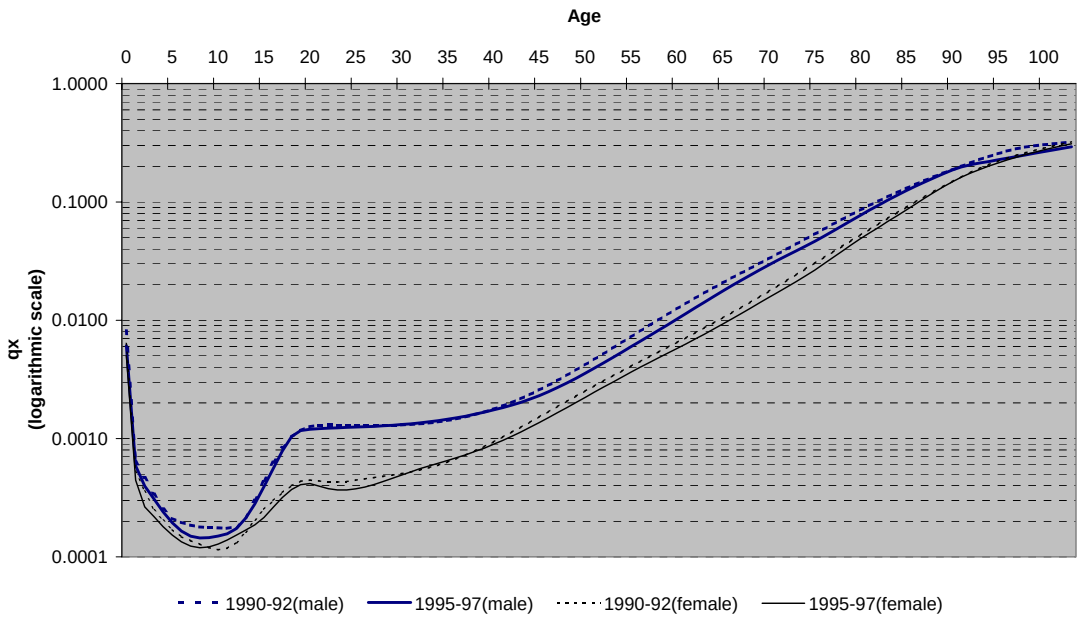
a real phenomenon, the relative paucity of data at these oldest ages means there is considerable uncertainty about the rates near age 100 and, therefore, the exact age at which crossover occurs. The results at these very high ages are, in any case, of largely academic interest as they have minimal impact on the resulting life expectancies.

Assuming the mortality rates reported in these Tables applied indefinitely, life expectancy at birth would be approximately 76 years for males and 81 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 1996 could be anticipated to be somewhat higher than these figures. Just how much higher depends on future mortality rates and the projection of these rates is a subjective and uncertain task. Section 1.4 of this publication examines this issue in more detail.

1.2 CHANGES SINCE 1990-92

Figure 3 provides a comparison between the rates reported in the current Tables and those of five years previously. While it is clear that there have been significant improvements at most ages, the degree of improvement varies over different portions of the curve.

Figure 3: Mortality Rates 1990-92 and 1995-97



Infant mortality fell substantially over the five years to 1995-97, as it had previously between 1985-87 and 1990-92. Rates for males in the first year of life fell by about twenty five percent, from 82 to 61 deaths per ten thousand live births. The male infant mortality rate is now below the female rate of five years ago. Rates for females in the first year of life fell by about twenty percent, from 64 to 51 deaths per ten thousand live births. This continues the steady decline in infant mortality which has been observed since the inception of the Tables.

There have been improvements in mortality over the childhood years, though the changes are not as great as those seen over the period between 1985-87 and 1990-92. Males have generally shown a greater improvement than females, particularly between ages 5 and 11. The drop in male mortality at these ages, coupled with a rise in female rates between ages 10 and 13, have meant that the margin between male and female rates at ages 10 and 11 is almost non-existent. It should be noted that the number of deaths observed at these ages is very small - less than 70 deaths over three years for most of these ages. As a result, limited significance can be attached to the shape of the fitted curve or apparent changes in mortality at these ages.

There has been minimal change in the mortality rates for males between ages 15 and 30. The mortality hump arising from the high accidental death rates in the late teens and early twenties which had been present for a number of decades flattened in 1990-92 and has not returned. The accident 'cliff', as it was coined in the previous Tables, which describes the steep rise in mortality to age 20 followed by almost constant rates, is still very apparent. For females, a significant drop in mortality at the mid-twenties has led to a more pronounced accident hump.

An interesting feature of this section of the curve is a deterioration in mortality for both males and females aged in their mid-thirties. It was noted in the previous Tables that there had been an increase in mortality rates for males and little improvement for females in this age range since 1985-87. A detailed investigation of causes of death would be needed to ascertain the precise causes of this phenomenon.

Over the middle to older years of life, mortality has improved for both males and females. Males generally showed a greater percentage improvement with death rates falling by between ten and twenty percent over the ages from 45 to 80, with the largest improvement between ages 50 and 65. Females experienced an almost constant ten percent improvement over the ages 45 to 80. The greater percentage improvement for men has closed the gap between male and female mortality since 1990-92, most noticeably between the ages of 50 and 65. There has been no improvement in mortality rates since 1990-92 for either gender between ages 86 and 90.

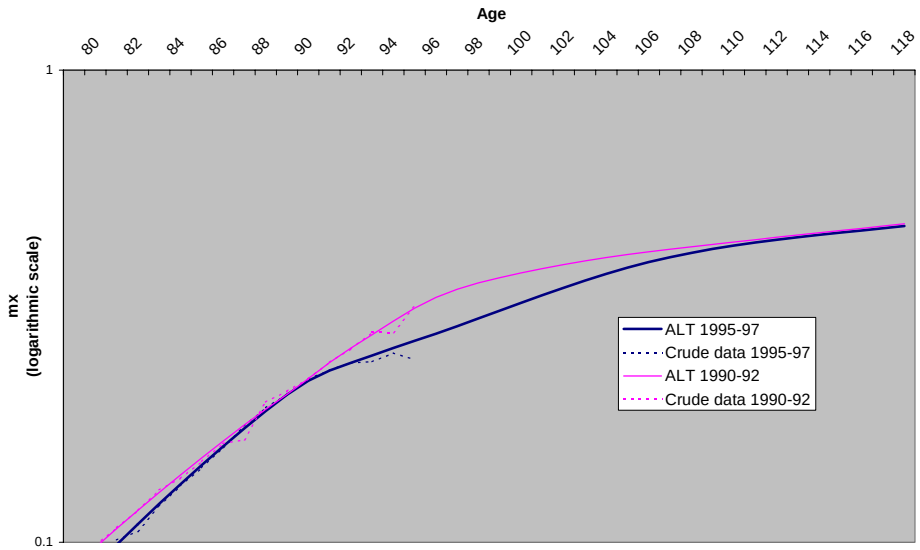
In the 1990-92 Australian Life Tables, a crossover in the male and female rates was included for the first time. This was done in response to a persistent feature in the raw mortality data and having regard to international evidence that male mortality rates fall below female rates at the very oldest ages. In 1990-92, the crossover was assumed to occur at age 103, although the lack of data meant rates at this age were subject to considerable uncertainty. In the current Tables, it appears that male mortality rates are lower than female rates from approximately age 98 onwards. However, there is still uncertainty about the exact age at which crossover occurs.

A feature of Figure 3 is the difference between the Male 1990-92 mortality rates and the current rates for ages 92 and above. During construction of the 1990-92 Life Tables, it was necessary to make various assumptions regarding mortality for the very old due to sparcity of data. As more Australians are living into their nineties, the quantity of data has increased. Between the previous and current Tables, for example, the male population aged 95 or more has increased by 75% from 1,714 to 2,999 and the female population has increased nearly 40% from 7,765 to 10,740. As a result of the larger population, the reliability of the crude rates for the very old has increased, which has allowed us to be more confident in the choice of graduated rates. Over the ages where the population is sufficiently large so as to have confidence in the accuracy of the crude rates, the rates have

dropped since the previous Tables. This has resulted in the need to alter the mortality curve for the very old as shown in Figure 4 below.

The choice of graduated rates is discussed in Section 2.2 of this publication. The change in graduated mortality rates for the very old between 1990-92 and 1995-97 has a negligible effect on life expectancy at birth, and minimal effect on life expectancy for the older ages.

Figure 4: Male Mortality Rates for 1990-92 and 1995-97 Ages 80 to 120



1.3 PAST IMPROVEMENT IN MORTALITY

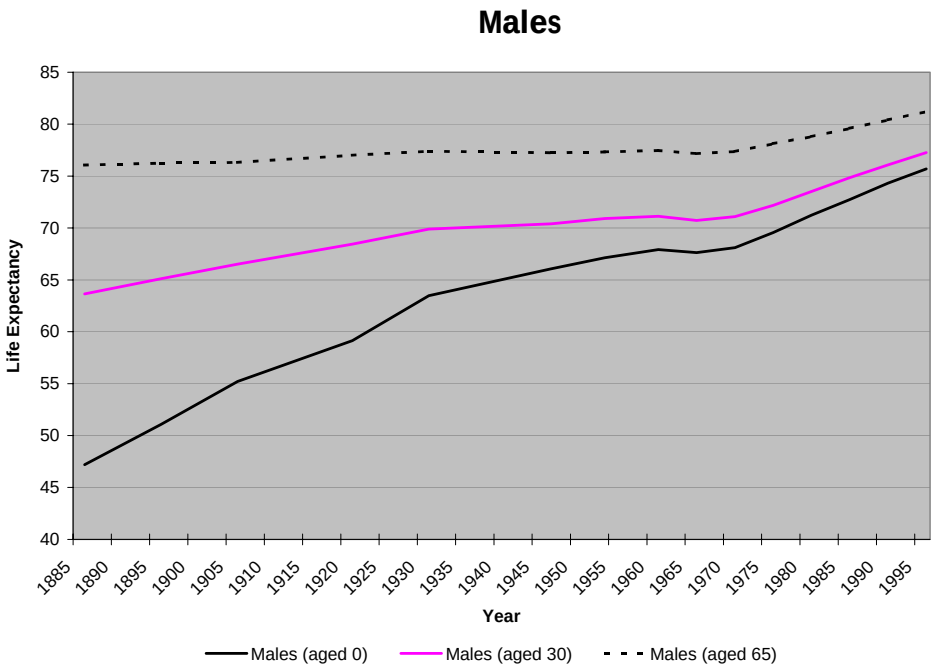
The rate of mortality improvement over the past century has varied with age and gender, but also at different periods. This was reported in some detail in the 1990-92 Australian Life Tables. This section briefly summarises and updates that discussion.

Figure 5 shows the life expectancies at selected ages reported in the Life Tables since 1881-90 (see Table 2 of Appendix A for the figures)[1]. These expectancies do not make allowance for the improvements in mortality experienced over an individual's lifetime. That is, they reflect the cross-sectional rates at a single point in time.

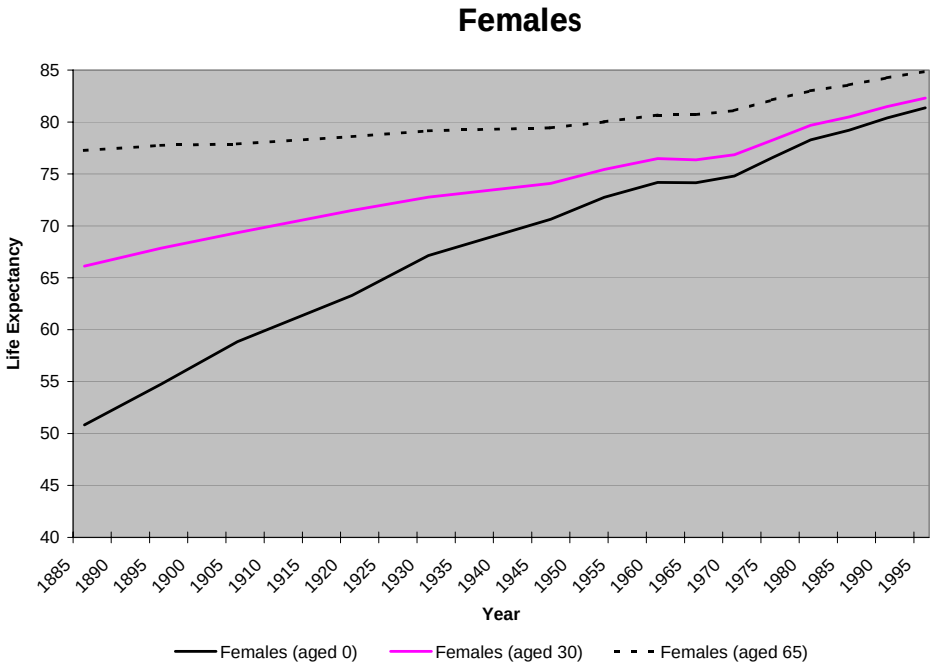
The impact of the substantial improvements in infant and childhood mortality can be clearly seen in the dramatic increase in life expectancies at birth.

An interesting feature of Figure 5 is the rate of increase in life expectancy since 1965-70. Mortality has generally improved more quickly since 1965-70 than in the previous 70 years. This is particularly marked for males aged 65 or more, where life expectancy increased by just over a year to 1965-67 and has since increased by more than four years.

Figure 5: Life Expectancy at Selected Ages[2]

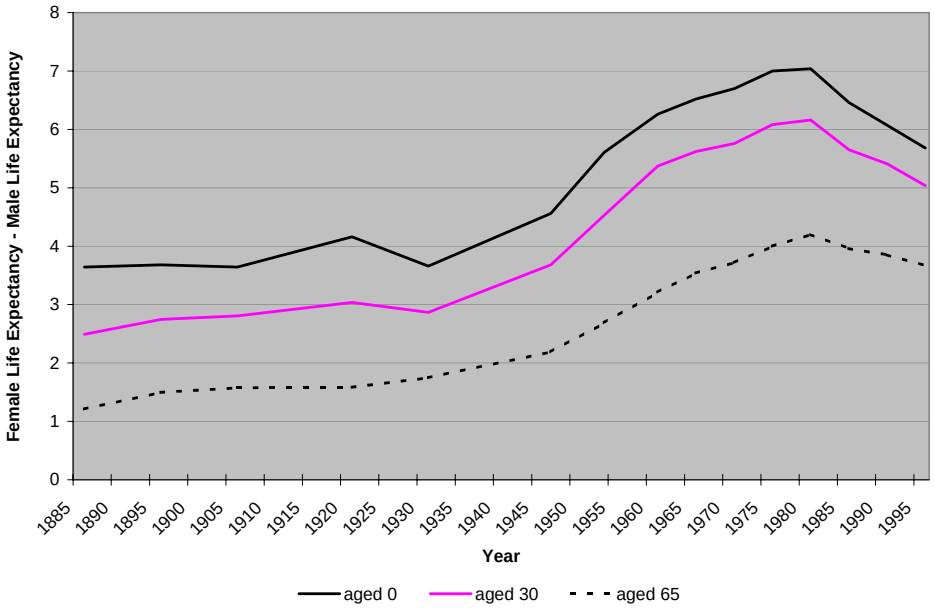


[1] The 1970-72 Life Tables were based on an under-enumerated population. The life expectancy values for 1970-72 in Figure 5 are revised estimates.
[2] Note that the vertical scale for Figure 5 starts at life expectancy of 40.



The divergence of male and female mortality over the last century is illustrated in Figure 6. This chart shows how the gap between male and female life expectancies has generally increased over the century, reaching a peak at 1980. Since then, the gap has narrowed.

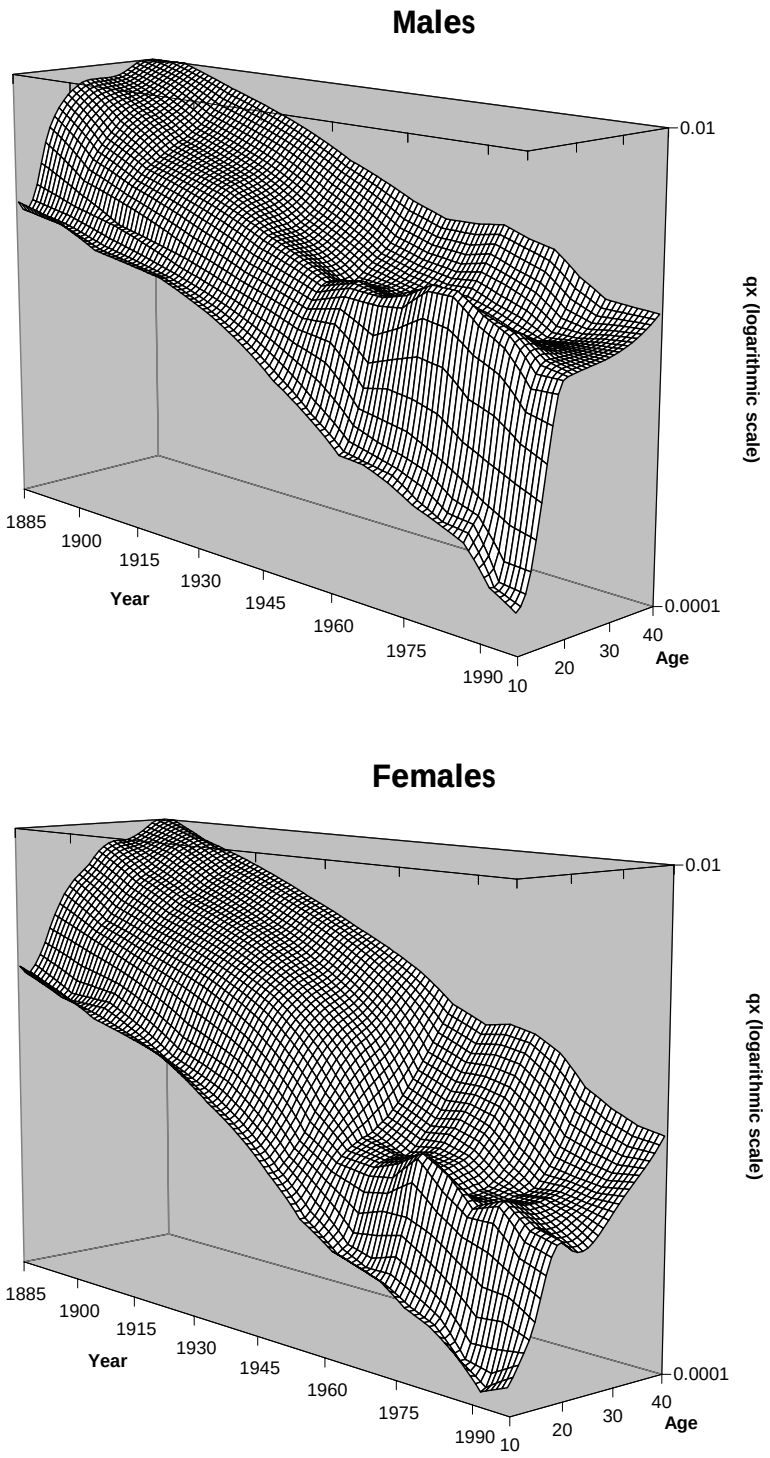
Figure 6: Gender Differentials in Life Expectancy at Selected Ages
(Female minus Male Life Expectancy)



In addition to changes in life expectancy, it is interesting to see how the shape of the mortality curve has changed over the last century. Figure 7 shows how mortality has varied according to the graduated Australian Life Tables since 1881-90. Linear interpolation between years has been used in

order to construct a continuous surface, and as such, the surfaces should only be seen as illustrative.

Figure 7: Smoothed mortality rates from 1881-90 to the present Ages 10 to 40



The obvious features of Figure 7 are the general decrease in mortality rates over time, volatility in the late teens and early twenties for both males and females since 1950, and, in particular, the emergence and decline of the male accident hump.

1.4 FUTURE IMPROVEMENT IN MORTALITY

The preceding section highlights the importance of mortality improvement in determining life expectancies. The difficulty in forecasting period life expectancies and, in particular, cohort life expectancies is in predicting the incidence and intensity of any future improvement.

Mortality varies primarily by age, gender and time period. A variety of statistical models have been proposed over the last century that attempt to quantify the effect of these variables on mortality, and in so doing, predict future rates. Curve fitting techniques that model the mortality curve by a variety of mathematical equations are common. Time series approaches that examine the progression of the parameters of such equations over time have been proposed. In addition, multiple regression models can be applied to three-dimensional mortality surfaces such as Figure 7 that capture time along one axis and age along another. A common objection to curve fitting techniques is that forecasts can be very sensitive to the specification of the model and the parameter estimates.

In theory, the most accurate approach to projecting mortality rates would be to consider all the variables that affect mortality and attempt to quantify the effect of anticipated changes. There are many factors that would need to be considered including social trends (eg. exercise, dietary and smoking habits), epidemics, natural disasters or conflicts, changes in the incidence of infectious and chronic diseases, advances in medical technology and the accessibility of healthcare facilities. In addition, it is known that changes in the standard of living and type of occupation impact on mortality. Physiological differences between men and women also play a part, though the extent of the difference varies with age and is difficult to separate from lifestyle factors.

In practice, it is extremely difficult to isolate and quantify the variables that predict mortality as not only will each element be uncertain, but there will be unknown interdependencies between them.

The mortality improvement rates proposed by the Australian Bureau of Statistics were created by projecting trends in causes of death[3]. In the 1997-2051 ABS population projections, short-term rates of mortality change apply to June 2006, and long-term rates apply thereafter. The long-term annual rates of change in age-specific mortality were derived for the five major cause of death groups using average annual rates between six successive periods from 1967-71 to 1992-96. The ABS short-term rates of improvement were derived from the average annual rates of change for the cause of death groups between 1987-91 and 1992-96. The ABS short-term trends have, in general, much higher rates of improvement per annum than the long-term rates, particularly around middle to old age, reflecting the recent trend of marked mortality improvement for the elderly.

[3] The improvement factors are given in Appendix E.

A much simpler approach to projection is to ignore cause of death, and extrapolate aggregate historical trends. That is, assume that the aggregate trends of the past will carry forward into the future.

In the case of simply extrapolating trends, the only judgement required is the appropriate historical period over which to measure improvement. As noted in Section 1.3, rates of improvement have been much greater since the mid-sixties and thus improvement factors based on only this period would be higher than those derived from a more extended period. Future life expectancy has been estimated below based on three sets of mortality rates:

- improvement rates over the last 25 years[4];
- improvement rates over the last 100 years; and
- ABS improvement rates[5].

Figure 8 presents the improvement rates expressed as a yearly percentage change. For example, over the last 25 years, male mortality for new-borns has improved by between 4 % and 4.5 % per annum on average, while for males aged between 25 and 30, annual improvement has been less than 0.5%. The latter result is likely to have been influenced by the emergence of AIDS as a significant cause of death for this group. It is uncertain to what extent this phenomenon could be expected to persist into the future.

Differences between the improvement rates based on the recent past and those derived from a more extended period stand out in Figure 8. In particular, for most ages above 45, both the ABS short-term and 25 year trend improvement rates are greater than the ABS long-term and 100 year trend improvement rates.

Despite the similarities between the ABS short-term and 25 year trend improvement rates for ages 45 and over, there are marked differences for the rest of the age range. These are due to a variety of reasons that include differences in time-span, data and methodology in construction of the rates.

The ABS rates, the 25 year rates, and 100 year trend improvement rates are all plausible, though in reality, medical breakthroughs, natural disasters, pandemics and other events may cause the actual future improvement rates to fall outside the range of the improvement curves in Figure 8.

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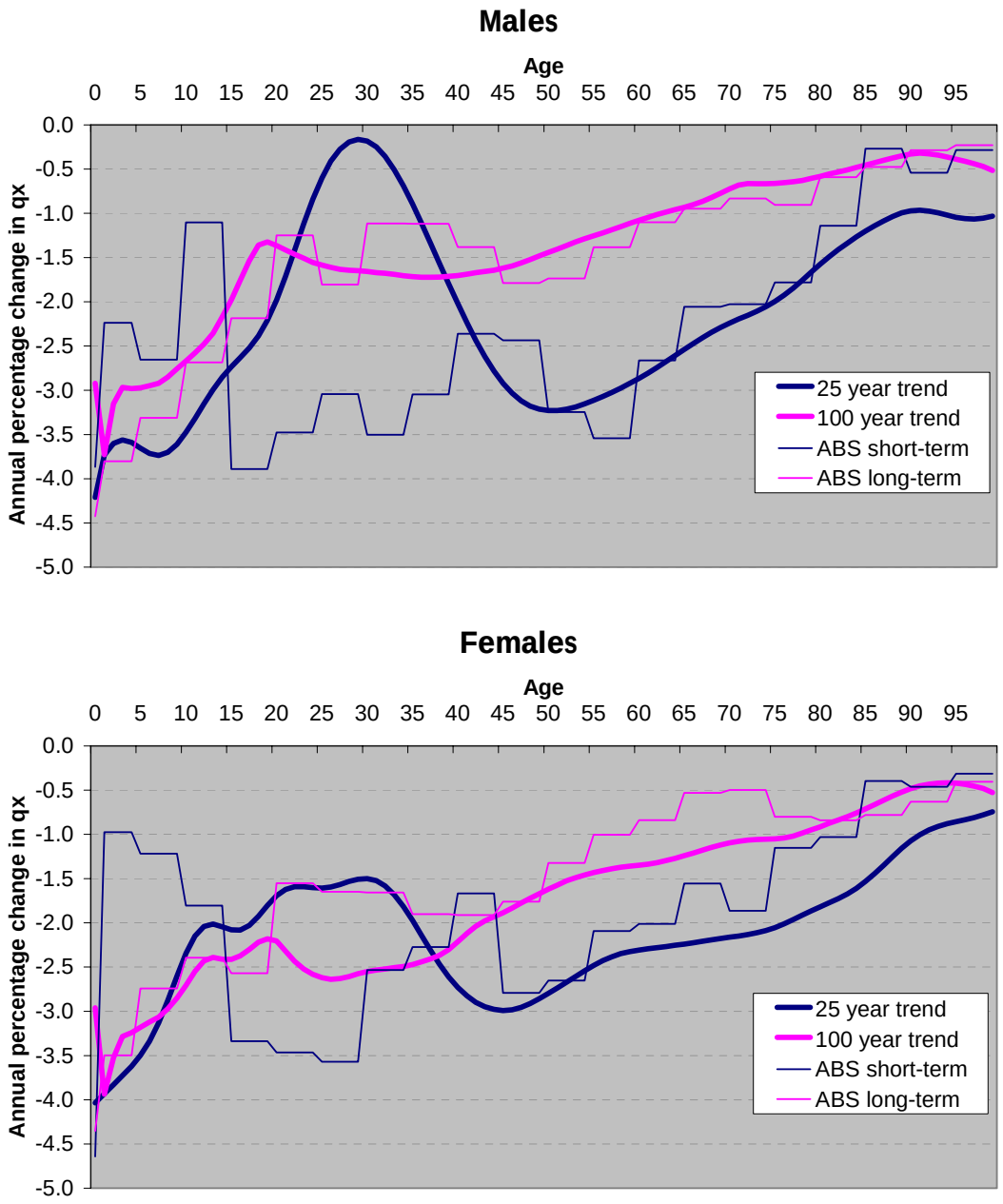
[4] The 25 year improvement rates were calculated by averaging the rates of mortality improvement since 1965-67 and 1975-77. The 1970-72 rates were not used as the published 1970-72 Life Tables were based on an under-enumerated population. The 25 year rates were smoothed in order to remove volatility associated with the relatively short time span over which the rates were calculated.

[5] From page 28 in 'Population Projections, 1997-2051' (ABS Catalogue No. 3222.0). No improvement factors were given for ages 100 and above. For our purposes, for ages 100 and above the improvement factors for ages 95-99 were used in projecting life expectancy.

Figure 8: Future Mortality Improvement Factors - Percentage change in mortality per annum[6]



Mortality rates were projected and future life expectancy was calculated under the 25 year trend, 100 year trend and ABS mortality improvement scenarios. The ABS short-term and long-term rates were combined to produce only one set of projected life expectancy values. The method used to project the rates is described in Section 3.

Two measures of expectation of life are used in this publication: period or cross-sectional; and cohort. Period expectations of life are calculated using

[6] The ABS produces mortality improvement rates by analysing mortality improvement in five-year age bands. As a result the ABS improvement rates have a stepped appearance in Figure 8.

data from one particular year and make no allowance for improvements over an individual's lifetime. In deriving projections of period expectations of life, the same period of improvement is used for at all ages. For example, projected life expectancy in 2010 is calculated assuming 14 years improvement at all ages.

To determine how long an average individual may expect to live, cohort life expectancies are required. Cohort life expectancy takes into account expected future mortality improvement over an individual's lifetime. As an example, period life expectancies for males and females at birth in the 1881-90 Life Tables were 47.2 and 50.8 respectively. The cohort life expectancies for a man and woman born during this period, however, were 53.3 and 58.0 years, representing an increase in life expectancy of 13% and 14% respectively, as a result of mortality improvements over their lifetimes[7].

The table below presents period life expectancies projected using the three improvement scenarios.

Projected period expectation of life at selected ages for three future scenarios

Males

	Age 0			Age 30			Age 65		
	25 yr	100 yr	ABS	25 yr	100 yr	ABS	25 yr	100 yr	ABS
1996	75.7	75.7	75.7	77.3	77.3	77.3	81.2	81.2	81.2
2010	79.0	77.3	78.6	80.2	78.5	79.6	83.2	81.9	82.6
2030	83.0	79.3	80.7	83.8	80.1	81.3	85.9	82.9	83.7
2050	86.4	81.1	82.4	86.4	81.6	82.9	88.5	83.9	84.8

Females

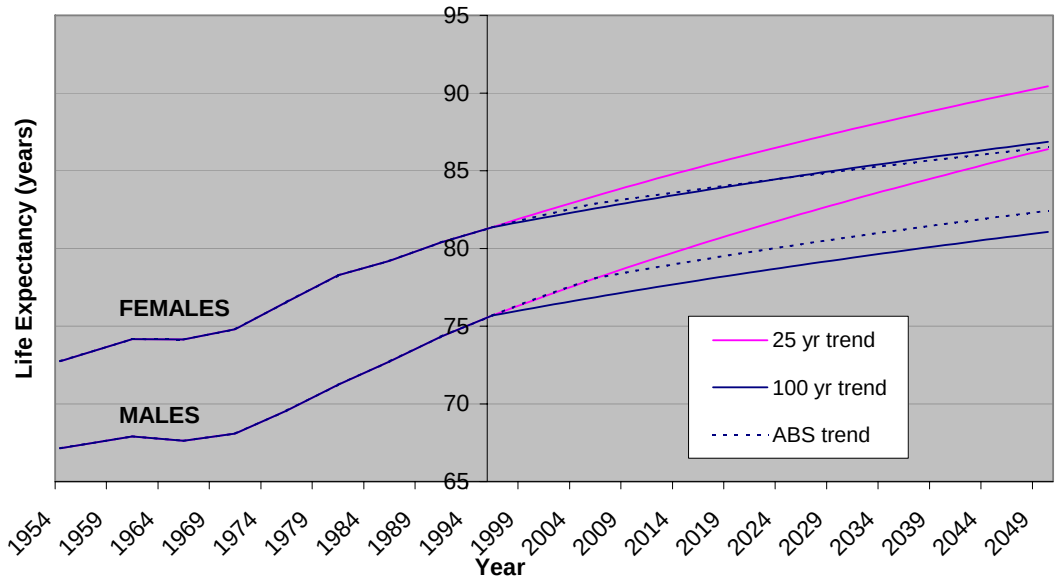
	Age 0			Age 30			Age 65		
	25 yr	100 yr	ABS	25 yr	100 yr	ABS	25 yr	100 yr	ABS
1996	81.4	81.4	81.4	82.3	82.3	82.3	84.9	84.9	84.9
2010	84.1	83.0	83.3	84.8	83.7	83.9	86.7	85.8	85.9
2030	87.5	85.1	85.0	87.9	85.5	85.3	89.2	87.1	87.0
2050	90.4	86.9	86.5	90.4	87.1	86.7	91.5	88.3	88.1

For males and females of all ages, if mortality continues to improve at a rate consistent with the last 25 years, period life expectancy at birth will increase from 75.7 to 86.4 by the year 2050 for males, and from 81.4 to 90.4 for females. On the other hand, if mortality improves at a rate consistent with the last 100 years, or with rates according to ABS projections, increases in period life expectancy will be far more modest. This is illustrated in Figure 9[8].

[7] Cohort life expectancies for these examples were calculated by interpolating mortality rates for those years not covered by the Australian Life Tables.

[8] The 1970-72 Life Tables were based on an under-enumerated population. The life expectancy values for 1970-72 in Figure 9 are revised estimates. Note the vertical axis starts at life expectancy of 65 years.

Figure 9: Period life expectancy and projected life expectancy at birth 1954 to 2050.



The numbers presented so far give an indication of what future Australian Life Table life expectancies may be, but are not estimates of the future life span (or cohort life expectancy) of an individual. The table below presents cohort life expectancies for selected ages. These life expectancies take account of the improvement in mortality occurring over an individual's life time.

Projected cohort expectation of life at selected ages for three future scenarios

Males

	Age 0			Age 30			Age 65		
	25 yr	100 yr	ABS	25 yr	100 yr	ABS	25 yr	100 yr	ABS
1996	89.2	81.3	82.6	85.3	80.2	81.4	82.8	81.7	82.2
2010	91.9	82.7	84.0	88.0	81.4	83.4	85.0	82.5	83.5
2030	95.4	84.5	85.7	91.5	83.0	84.8	87.9	83.5	84.6
2050	98.6	86.1	87.1	94.8	84.4	86.2	90.9	84.5	85.7

Females

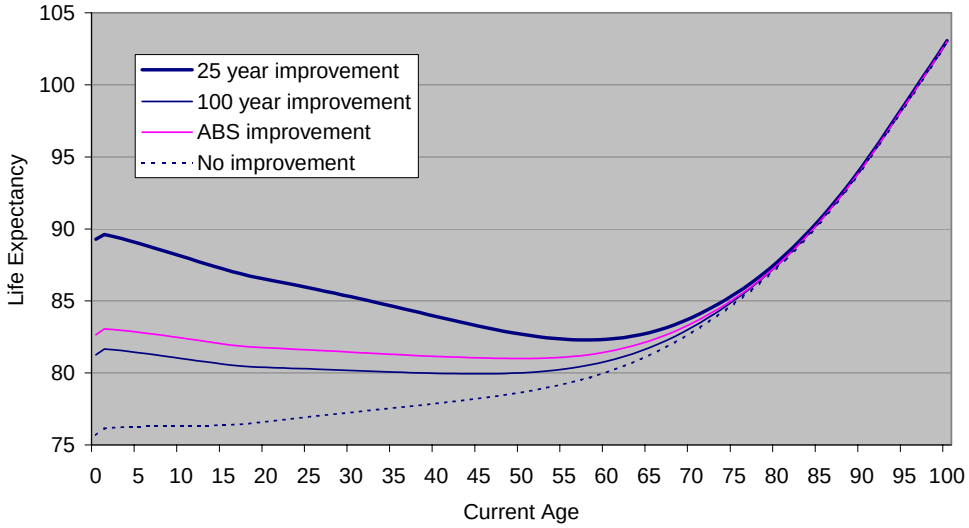
	Age 0			Age 30			Age 65		
	25 yr	100 yr	ABS	25 yr	100 yr	ABS	25 yr	100 yr	ABS
1996	92.9	87.9	87.4	89.5	86.0	85.9	86.7	85.8	85.9
2010	95.0	89.2	88.7	91.7	87.3	87.3	88.7	86.7	86.9
2030	97.5	91.0	90.3	94.4	89.0	88.8	91.2	88.1	88.0
2050	99.8	92.5	91.7	96.8	90.6	90.1	93.6	89.3	89.1

For example, if mortality continues to improve at a rate consistent with the last 25 years, a male born in 1996 may expect to live 89.2 years on average, to the year 2086. Under the same mortality improvement assumption, a male aged 30 in 1996 will, on average, experience fewer years of additional mortality improvement, and accordingly will expect to live only to age 85.3.

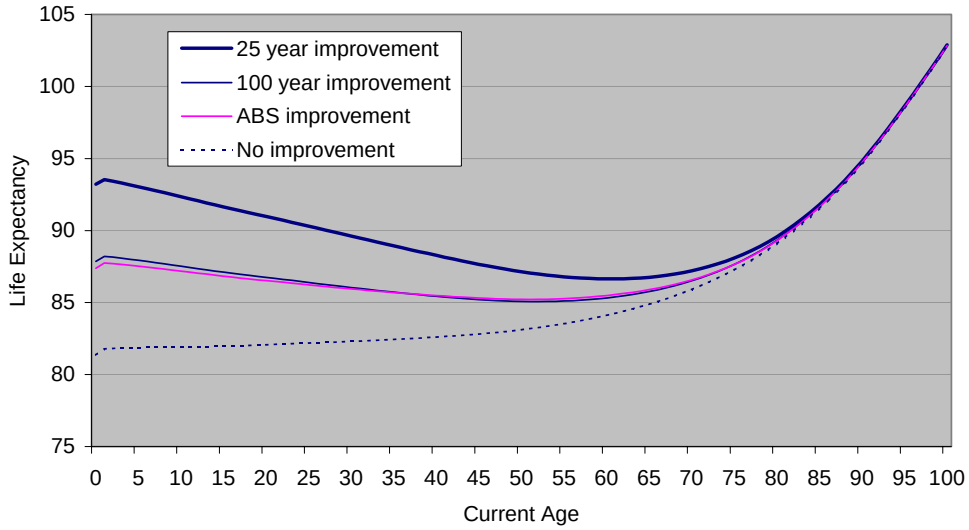
Figure 10 presents cohort life expectancies for those currently alive in the Australian population. It shows that children born today can expect to live considerably longer than the period life expectancies reported in the Life Tables[9]. The additional life expectancy (the gap between the 'no improvement' line and the other lines) reduces with increasing age, reflecting the lesser amount of future time for improvements to emerge for those at older ages. 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 10: Male and Female Life Expectancies by Current Age

Males



Females



[9] The method of presentation of cohort life expectancies used in Figure 10 was taken from a paper by Craig Thorburn titled "Births, Deaths, Passports and Pensions", Australian Actuarial Journal, Forthcoming. Note that the vertical axis of Figure 10 starts at Life Expectancy of 75 years.

The period and cohort projected life expectancy figures included above illustrate a variety of plausible outcomes for future mortality. The range of results highlights the considerable uncertainty associated with such projections and emphasises the need to consider the purposes for which any projections are to be used before the selection of improvement factors.

In particular, the numbers provided here should not be used in any other context without consideration of the appropriateness of the method by which they were derived or without reference to the substantial and unavoidable uncertainty.

AUSTRALIAN LIFE TABLES 1995-97: MALES

Age	l_x	d_x	p_x	q_x	μ_x	$\mathring{e}_x$	L_x	T_x
0	100,000	610	0.99390	0.00610		75.69	99,471	7,568,783
1	99,390	59	0.99941	0.00059	0.00070	75.15	99,359	7,469,312
2	99,331	39	0.99960	0.00040	0.00049	74.20	99,310	7,369,953
3	99,292	31	0.99969	0.00031	0.00034	73.22	99,276	7,270,643
4	99,261	24	0.99976	0.00024	0.00027	72.25	99,249	7,171,367
5	99,237	19	0.99981	0.00019	0.00021	71.26	99,227	7,072,118
6	99,218	16	0.99983	0.00017	0.00018	70.28	99,210	6,972,890
7	99,202	15	0.99985	0.00015	0.00016	69.29	99,194	6,873,681
8	99,187	14	0.99986	0.00014	0.00015	68.30	99,180	6,774,486
9	99,173	14	0.99985	0.00015	0.00014	67.31	99,165	6,675,307
10	99,158	15	0.99985	0.00015	0.00015	66.32	99,151	6,576,141
11	99,143	16	0.99984	0.00016	0.00015	65.33	99,136	6,476,990
12	99,128	17	0.99983	0.00017	0.00016	64.34	99,119	6,377,855
13	99,110	21	0.99979	0.00021	0.00019	63.35	99,100	6,278,736
14	99,089	28	0.99972	0.00028	0.00024	62.36	99,076	6,179,635
15	99,062	39	0.99961	0.00039	0.00033	61.38	99,043	6,080,559
16	99,023	55	0.99944	0.00056	0.00047	60.41	98,997	5,981,516
17	98,967	78	0.99921	0.00079	0.00066	59.44	98,931	5,882,519
18	98,890	103	0.99896	0.00104	0.00092	58.49	98,840	5,783,588
19	98,787	115	0.99883	0.00117	0.00112	57.55	98,729	5,684,749
20	98,671	118	0.99880	0.00120	0.00119	56.61	98,612	5,586,019
21	98,553	119	0.99879	0.00121	0.00121	55.68	98,493	5,487,407
22	98,433	120	0.99878	0.00122	0.00122	54.75	98,373	5,388,914
23	98,313	121	0.99877	0.00123	0.00123	53.81	98,253	5,290,541
24	98,192	122	0.99876	0.00124	0.00124	52.88	98,131	5,192,288
25	98,070	123	0.99875	0.00125	0.00125	51.94	98,009	5,094,157
26	97,947	123	0.99874	0.00126	0.00126	51.01	97,886	4,996,148
27	97,824	124	0.99873	0.00127	0.00127	50.07	97,762	4,898,263
28	97,700	125	0.99872	0.00128	0.00128	49.14	97,637	4,800,501
29	97,574	127	0.99870	0.00130	0.00129	48.20	97,511	4,702,864
30	97,448	128	0.99869	0.00131	0.00131	47.26	97,384	4,605,352
31	97,320	130	0.99867	0.00133	0.00132	46.32	97,255	4,507,968
32	97,190	132	0.99864	0.00136	0.00135	45.38	97,124	4,410,713
33	97,058	134	0.99862	0.00138	0.00137	44.44	96,991	4,313,589
34	96,924	137	0.99858	0.00142	0.00140	43.50	96,856	4,216,597
35	96,787	141	0.99855	0.00145	0.00144	42.57	96,717	4,119,742
36	96,646	145	0.99850	0.00150	0.00148	41.63	96,574	4,023,025
37	96,501	149	0.99845	0.00155	0.00152	40.69	96,427	3,926,451
38	96,352	155	0.99839	0.00161	0.00158	39.75	96,275	3,830,025
39	96,197	161	0.99833	0.00167	0.00164	38.81	96,117	3,733,750
40	96,036	167	0.99826	0.00174	0.00171	37.88	95,953	3,637,633
41	95,869	175	0.99818	0.00182	0.00178	36.94	95,782	3,541,680
42	95,694	183	0.99808	0.00192	0.00187	36.01	95,603	3,445,898
43	95,511	194	0.99797	0.00203	0.00197	35.08	95,415	3,350,294
44	95,317	206	0.99784	0.00216	0.00209	34.15	95,215	3,254,880
45	95,112	220	0.99769	0.00231	0.00223	33.22	95,003	3,159,664
46	94,892	236	0.99751	0.00249	0.00240	32.30	94,775	3,064,661
47	94,656	256	0.99730	0.00270	0.00259	31.38	94,529	2,969,886
48	94,400	278	0.99705	0.00295	0.00282	30.46	94,263	2,875,356
49	94,121	304	0.99677	0.00323	0.00309	29.55	93,972	2,781,094
50	93,817	334	0.99644	0.00356	0.00340	28.64	93,653	2,687,122
51	93,483	368	0.99606	0.00394	0.00375	27.74	93,302	2,593,469
52	93,115	406	0.99564	0.00436	0.00415	26.85	92,915	2,500,167
53	92,709	449	0.99516	0.00484	0.00460	25.97	92,488	2,407,252
54	92,260	496	0.99463	0.00537	0.00511	25.09	92,017	2,314,764

AUSTRALIAN LIFE TABLES 1995-97: MALES - *continued*

Age	l_x	d_x	p_x	q_x	μ_x	$\mathring{e}_x$	L_x	T_x
55	91,765	548	0.99403	0.00597	0.00568	24.22	91,495	2,222,747
56	91,217	606	0.99336	0.00664	0.00631	23.36	90,919	2,131,252
57	90,611	670	0.99261	0.00739	0.00702	22.52	90,282	2,040,332
58	89,942	741	0.99177	0.00823	0.00783	21.68	89,578	1,950,050
59	89,201	819	0.99082	0.00918	0.00873	20.86	88,798	1,860,473
60	88,382	905	0.98976	0.01024	0.00974	20.05	87,937	1,771,674
61	87,477	1,000	0.98857	0.01143	0.01088	19.25	86,985	1,683,737
62	86,477	1,103	0.98725	0.01275	0.01214	18.46	85,934	1,596,753
63	85,374	1,214	0.98578	0.01422	0.01355	17.70	84,776	1,510,819
64	84,159	1,333	0.98416	0.01584	0.01512	16.94	83,503	1,426,043
65	82,826	1,460	0.98237	0.01763	0.01685	16.21	82,107	1,342,540
66	81,365	1,594	0.98040	0.01960	0.01876	15.49	80,580	1,260,433
67	79,771	1,735	0.97826	0.02174	0.02086	14.79	78,916	1,179,853
68	78,036	1,879	0.97592	0.02408	0.02314	14.11	77,109	1,100,938
69	76,158	2,026	0.97340	0.02660	0.02563	13.44	75,157	1,023,829
70	74,132	2,172	0.97069	0.02931	0.02832	12.80	73,058	948,672
71	71,960	2,317	0.96780	0.03220	0.03120	12.17	70,813	875,614
72	69,642	2,458	0.96471	0.03529	0.03429	11.56	68,425	804,801
73	67,185	2,593	0.96141	0.03859	0.03759	10.96	65,899	736,376
74	64,592	2,729	0.95775	0.04225	0.04119	10.38	63,239	670,477
75	61,863	2,872	0.95358	0.04642	0.04525	9.82	60,439	607,238
76	58,991	3,023	0.94876	0.05124	0.04995	9.27	57,492	546,799
77	55,968	3,175	0.94327	0.05673	0.05538	8.74	54,393	489,307
78	52,793	3,320	0.93711	0.06289	0.06155	8.24	51,144	434,914
79	49,473	3,449	0.93028	0.06972	0.06849	7.76	47,758	383,769
80	46,023	3,554	0.92278	0.07722	0.07619	7.30	44,254	336,011
81	42,469	3,626	0.91462	0.08538	0.08467	6.87	40,661	291,758
82	38,843	3,659	0.90581	0.09419	0.09395	6.46	37,015	251,097
83	35,185	3,647	0.89636	0.10364	0.10403	6.08	33,358	214,082
84	31,538	3,587	0.88627	0.11373	0.11493	5.73	29,738	180,724
85	27,951	3,478	0.87557	0.12443	0.12666	5.40	26,201	150,986
86	24,473	3,322	0.86426	0.13574	0.13924	5.10	22,797	124,785
87	21,151	3,123	0.85236	0.14764	0.15267	4.82	19,572	101,987
88	18,029	2,886	0.83990	0.16010	0.16697	4.57	16,564	82,416
89	15,142	2,619	0.82702	0.17298	0.18210	4.35	13,809	65,851
90	12,523	2,329	0.81400	0.18600	0.19790	4.16	11,333	52,042
91	10,194	2,014	0.80244	0.19756	0.21332	3.99	9,160	40,709
92	8,180	1,689	0.79354	0.20646	0.22621	3.86	7,309	31,550
93	6,491	1,385	0.78656	0.21344	0.23599	3.73	5,775	24,241
94	5,105	1,124	0.77980	0.22020	0.24440	3.62	4,523	18,466
95	3,981	906	0.77255	0.22745	0.25330	3.50	3,512	13,943
96	3,076	721	0.76547	0.23453	0.26267	3.39	2,701	10,431
97	2,354	569	0.75822	0.24178	0.27194	3.28	2,058	7,730
98	1,785	445	0.75049	0.24951	0.28177	3.18	1,553	5,672
99	1,340	345	0.74230	0.25770	0.29239	3.07	1,160	4,118
100	994	265	0.73378	0.26622	0.30367	2.98	856	2,959
101	730	201	0.72508	0.27492	0.31544	2.88	625	2,103
102	529	150	0.71625	0.28375	0.32754	2.79	450	1,478
103	379	111	0.70748	0.29252	0.33986	2.71	321	1,028
104	268	81	0.69892	0.30108	0.35215	2.64	226	707
105	187	58	0.69071	0.30929	0.36417	2.57	157	481
106	129	41	0.68302	0.31698	0.37570	2.51	108	325
107	88	29	0.67595	0.32405	0.38651	2.45	73	217
108	60	20	0.66964	0.33036	0.39639	2.40	49	144
109	40	13	0.66404	0.33596	0.40523	2.36	33	94

AUSTRALIAN LIFE TABLES 1995-97: FEMALES

Age	l_x	d_x	p_x	q_x	μ_x	$\mathring{e}_x$	L_x	T_x
0	100,000	502	0.99498	0.00502		81.37	99,560	8,136,802
1	99,498	44	0.99955	0.00045	0.00058	80.78	99,474	8,037,242
2	99,454	26	0.99974	0.00026	0.00033	79.81	99,440	7,937,768
3	99,428	22	0.99978	0.00022	0.00023	78.83	99,417	7,838,328
4	99,406	18	0.99982	0.00018	0.00020	77.85	99,397	7,738,911
5	99,388	15	0.99985	0.00015	0.00017	76.87	99,380	7,639,515
6	99,373	13	0.99987	0.00013	0.00014	75.88	99,366	7,540,134
7	99,359	12	0.99988	0.00012	0.00013	74.89	99,353	7,440,768
8	99,347	12	0.99988	0.00012	0.00012	73.90	99,341	7,341,415
9	99,335	12	0.99988	0.00012	0.00012	72.91	99,329	7,242,074
10	99,323	13	0.99987	0.00013	0.00012	71.91	99,317	7,142,744
11	99,311	14	0.99986	0.00014	0.00013	70.92	99,304	7,043,427
12	99,297	15	0.99985	0.00015	0.00015	69.93	99,289	6,944,124
13	99,282	17	0.99983	0.00017	0.00016	68.94	99,273	6,844,834
14	99,265	18	0.99981	0.00019	0.00018	67.96	99,256	6,745,561
15	99,246	21	0.99978	0.00022	0.00020	66.97	99,236	6,646,305
16	99,225	26	0.99974	0.00026	0.00024	65.98	99,212	6,547,069
17	99,199	32	0.99968	0.00032	0.00029	65.00	99,184	6,447,857
18	99,167	37	0.99963	0.00037	0.00035	64.02	99,149	6,348,673
19	99,131	40	0.99959	0.00041	0.00039	63.04	99,111	6,249,524
20	99,090	41	0.99958	0.00042	0.00042	62.07	99,069	6,150,414
21	99,049	39	0.99960	0.00040	0.00041	61.09	99,029	6,051,344
22	99,010	37	0.99962	0.00038	0.00039	60.12	98,991	5,952,315
23	98,972	36	0.99963	0.00037	0.00037	59.14	98,954	5,853,324
24	98,936	36	0.99963	0.00037	0.00037	58.16	98,918	5,754,370
25	98,899	37	0.99962	0.00038	0.00037	57.18	98,881	5,655,453
26	98,862	39	0.99961	0.00039	0.00038	56.21	98,843	5,556,572
27	98,824	40	0.99959	0.00041	0.00040	55.23	98,804	5,457,729
28	98,783	43	0.99957	0.00043	0.00042	54.25	98,762	5,358,925
29	98,740	46	0.99954	0.00046	0.00045	53.27	98,718	5,260,163
30	98,695	49	0.99951	0.00049	0.00048	52.30	98,671	5,161,445
31	98,646	52	0.99948	0.00052	0.00051	51.32	98,621	5,062,774
32	98,595	55	0.99944	0.00056	0.00054	50.35	98,568	4,964,153
33	98,540	58	0.99941	0.00059	0.00057	49.38	98,511	4,865,586
34	98,482	61	0.99938	0.00062	0.00060	48.41	98,452	4,767,075
35	98,421	64	0.99935	0.00065	0.00064	47.44	98,389	4,668,623
36	98,357	68	0.99931	0.00069	0.00067	46.47	98,323	4,570,233
37	98,289	72	0.99927	0.00073	0.00071	45.50	98,253	4,471,910
38	98,217	76	0.99922	0.00078	0.00075	44.53	98,179	4,373,657
39	98,141	82	0.99917	0.00083	0.00080	43.56	98,100	4,275,477
40	98,059	88	0.99911	0.00089	0.00086	42.60	98,016	4,177,377
41	97,972	94	0.99904	0.00096	0.00093	41.64	97,925	4,079,361
42	97,877	102	0.99895	0.00105	0.00100	40.68	97,827	3,981,436
43	97,775	111	0.99886	0.00114	0.00109	39.72	97,720	3,883,609
44	97,664	122	0.99876	0.00124	0.00119	38.76	97,604	3,785,889
45	97,542	133	0.99863	0.00137	0.00130	37.81	97,477	3,688,285
46	97,409	146	0.99850	0.00150	0.00143	36.86	97,337	3,590,808
47	97,263	161	0.99834	0.00166	0.00158	35.92	97,183	3,493,471
48	97,102	177	0.99817	0.00183	0.00174	34.98	97,014	3,396,288
49	96,924	196	0.99798	0.00202	0.00192	34.04	96,828	3,299,274
50	96,728	216	0.99777	0.00223	0.00212	33.11	96,622	3,202,446
51	96,513	238	0.99754	0.00246	0.00235	32.18	96,396	3,105,824
52	96,275	262	0.99728	0.00272	0.00259	31.26	96,146	3,009,428
53	96,013	288	0.99700	0.00300	0.00286	30.34	95,871	2,913,282
54	95,725	317	0.99669	0.00331	0.00316	29.43	95,569	2,817,411

AUSTRALIAN LIFE TABLES 1995-97: FEMALES - *continued*

Age	l_x	d_x	p_x	q_x	μ_x	$\mathring{e}_x$	L_x	T_x
55	95,408	348	0.99636	0.00364	0.00348	28.53	95,237	2,721,842
56	95,060	381	0.99599	0.00401	0.00383	27.63	94,873	2,626,606
57	94,679	416	0.99560	0.00440	0.00420	26.74	94,474	2,531,733
58	94,263	454	0.99518	0.00482	0.00461	25.86	94,039	2,437,259
59	93,809	495	0.99473	0.00527	0.00505	24.98	93,565	2,343,219
60	93,314	539	0.99423	0.00577	0.00553	24.11	93,049	2,249,654
61	92,776	587	0.99368	0.00632	0.00606	23.25	92,486	2,156,605
62	92,189	640	0.99306	0.00694	0.00664	22.39	91,874	2,064,119
63	91,549	699	0.99236	0.00764	0.00730	21.54	91,205	1,972,245
64	90,850	765	0.99158	0.00842	0.00804	20.70	90,473	1,881,041
65	90,085	837	0.99071	0.00929	0.00888	19.88	89,673	1,790,567
66	89,248	918	0.98972	0.01028	0.00982	19.06	88,797	1,700,894
67	88,331	1,006	0.98861	0.01139	0.01087	18.25	87,836	1,612,098
68	87,325	1,102	0.98738	0.01262	0.01205	17.46	86,782	1,524,262
69	86,223	1,207	0.98600	0.01400	0.01338	16.67	85,628	1,437,480
70	85,015	1,320	0.98447	0.01553	0.01485	15.90	84,365	1,351,852
71	83,695	1,441	0.98278	0.01722	0.01648	15.14	82,985	1,267,487
72	82,254	1,570	0.98091	0.01909	0.01829	14.40	81,480	1,184,502
73	80,684	1,712	0.97878	0.02122	0.02031	13.67	79,840	1,103,021
74	78,972	1,870	0.97633	0.02367	0.02264	12.96	78,051	1,023,181
75	77,102	2,046	0.97346	0.02654	0.02535	12.26	76,095	945,130
76	75,056	2,244	0.97010	0.02990	0.02854	11.58	73,951	869,036
77	72,812	2,462	0.96618	0.03382	0.03227	10.92	71,600	795,084
78	70,349	2,697	0.96166	0.03834	0.03665	10.28	69,021	723,485
79	67,652	2,936	0.95659	0.04341	0.04165	9.67	66,203	654,464
80	64,716	3,165	0.95110	0.04890	0.04718	9.09	63,151	588,261
81	61,551	3,372	0.94521	0.05479	0.05316	8.53	59,881	525,109
82	58,179	3,561	0.93880	0.06120	0.05963	8.00	56,413	465,228
83	54,618	3,733	0.93165	0.06835	0.06682	7.48	52,765	408,815
84	50,885	3,888	0.92360	0.07640	0.07494	7.00	48,953	356,049
85	46,997	4,020	0.91447	0.08553	0.08422	6.53	44,998	307,096
86	42,978	4,122	0.90409	0.09591	0.09486	6.10	40,924	262,099
87	38,856	4,181	0.89240	0.10760	0.10708	5.69	36,768	221,175
88	34,675	4,174	0.87963	0.12037	0.12083	5.32	32,584	184,407
89	30,501	4,083	0.86612	0.13388	0.13582	4.98	28,448	151,823
90	26,418	3,906	0.85214	0.14786	0.15176	4.67	24,446	123,375
91	22,512	3,643	0.83815	0.16185	0.16826	4.39	20,665	98,929
92	18,868	3,309	0.82463	0.17537	0.18475	4.15	17,184	78,264
93	15,559	2,930	0.81168	0.18832	0.20080	3.93	14,062	61,081
94	12,629	2,538	0.79901	0.20099	0.21652	3.72	11,328	47,019
95	10,091	2,156	0.78629	0.21371	0.23237	3.54	8,982	35,691
96	7,934	1,796	0.77361	0.22639	0.24854	3.37	7,007	26,710
97	6,138	1,466	0.76110	0.23890	0.26485	3.21	5,379	19,702
98	4,672	1,174	0.74876	0.25124	0.28118	3.07	4,062	14,323
99	3,498	921	0.73660	0.26340	0.29754	2.93	3,018	10,261
100	2,577	710	0.72462	0.27538	0.31393	2.81	2,206	7,243
101	1,867	536	0.71284	0.28716	0.33032	2.70	1,586	5,037
102	1,331	398	0.70124	0.29876	0.34672	2.59	1,122	3,451
103	933	289	0.68985	0.31015	0.36310	2.50	781	2,329
104	644	207	0.67866	0.32134	0.37945	2.41	534	1,549
105	437	145	0.66769	0.33231	0.39575	2.32	360	1,014
106	292	100	0.65693	0.34307	0.41200	2.24	239	654
107	192	68	0.64639	0.35361	0.42817	2.17	156	416
108	124	45	0.63608	0.36392	0.44425	2.10	100	260
109	79	29	0.62599	0.37401	0.46023	2.03	63	160

2. CONSTRUCTION OF THE AUSTRALIAN LIFE TABLES 1995-97

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 1996. These estimates are based on the 1996 Census of Population and Housing adjusted for under-enumeration and the lapse of time between 30 June and 6 August 1996 (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 1995 to December 1997, classified by sex and age last birthday at the time of death. This covered all registrations of deaths up to and including June 1998, which is estimated to include over 99.95% of all deaths occurring over the three year period. Unadjusted deaths data has been used in the construction of the Life Tables since inclusion of the small number of deaths registered after June 1998 would have a negligible impact on the crude and graduated rates.

(c) The number of births classified by gender in each month from January 1991 to December 1997.

(d) The number of deaths of those aged 3 years or less in each month from January 1991 to December 1997, 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 1995 to December 1997 for those aged 4 or more, and from January 1991 to December 1997 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 1996, and the number of deaths at each age occurring over the three years 1995 to 1997.

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 1995-97, 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:

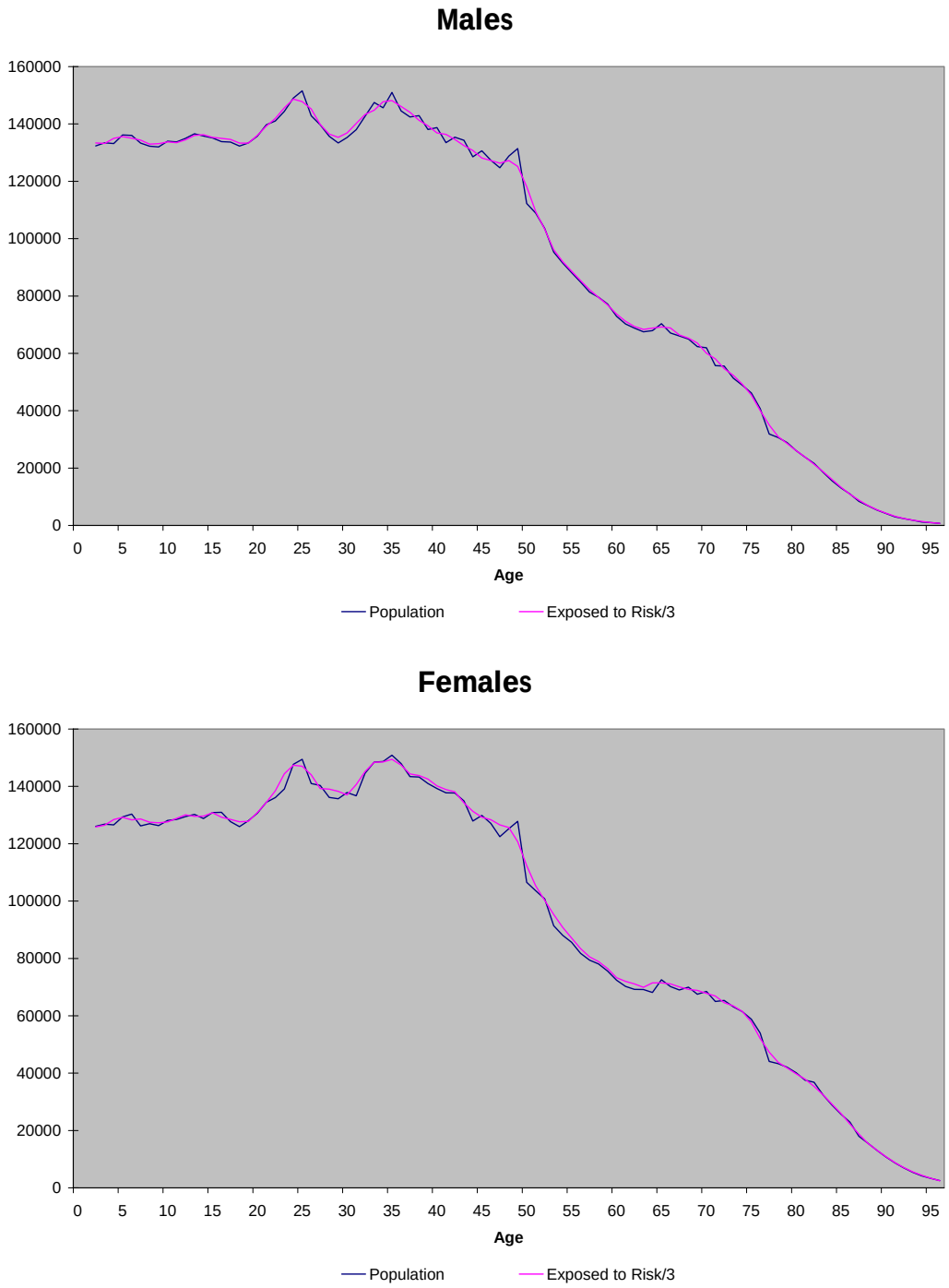
$$\frac{1}{8}P_{x-2} + \frac{7}{8}P_{x-1} + P_x + \frac{7}{8}P_{x+1} + \frac{1}{8}P_{x+2}$$

where P_x is the population inside Australia aged *x* last birthday as measured in the 1996 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 1995 and June 1996, or who died or left Australia between July 1996 and December 1997. Similarly, exposure was increased to take account of those who arrived between July 1996 and December 1997 or who died or left Australia between January 1995 and June 1996.

Figure 11 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. Peaks resulting from the high birth rates in 1961 and 1971-72 remain clearly visible, as does the population 'cliff' relating to the dramatic increase in births following the end of World War II.

Figure 11: Comparison of Census Population Count and Exposed-to-Risk



For ages 2 and above, the crude central rate of mortality at age x, m_x, was calculated by dividing the deaths at age x during 1995, 1996 and 1997 by the relevant exposed-to-risk.

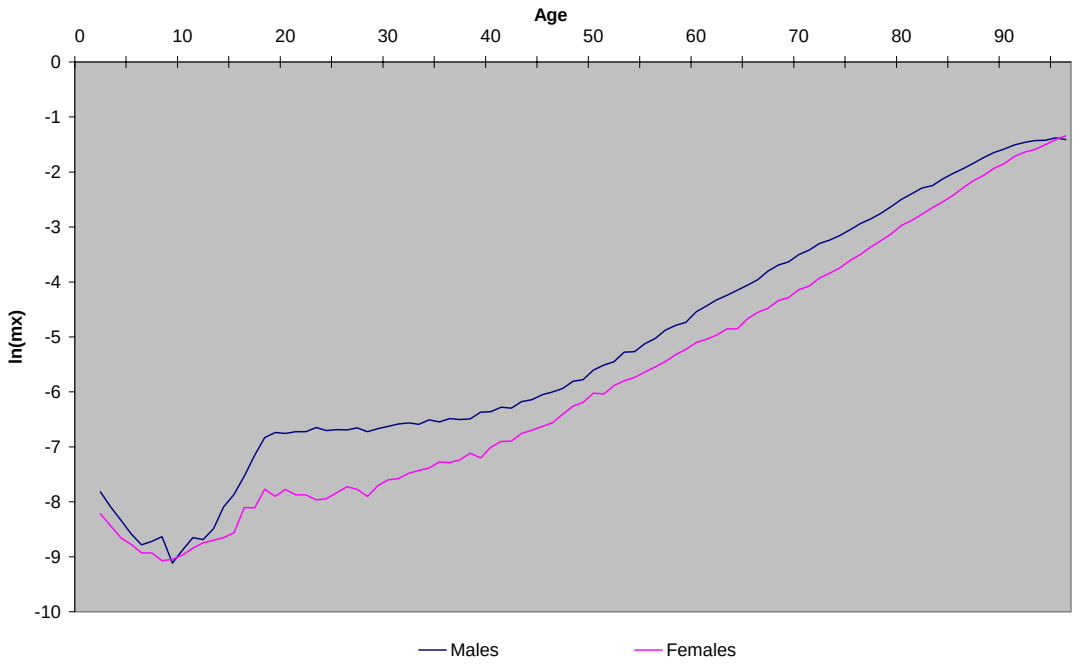
The exposed-to-risk for ages 0 and 1 was derived more directly by keeping a count of those at each age for each month of the three year period using monthly birth, death and movement records from 1991 to 1997. Because of the rapid fall in the force of mortality, μ_x, over the first few weeks of life, 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

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 or very old ages where the number of deaths is typically low. 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. As with the four previous Life Tables, a combination of manual graduation and fitted cubic splines was used. In contrast to previous Tables, cubic splines were fitted to the younger ages as well as the main range of ages, with manual graduation being confined to the very oldest ages.

The absence of population data by single year of age above age 98 meant that special techniques were used for the very oldest ages, as described below.

Figure 12: Crude Central Mortality Rates



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:

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

where:

A_x is the number of observed deaths aged *x* in the three years 1995, 1996 and 1997;

E_x is the 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^1 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.

In contrast to previous Life Tables, a computer program was developed to assist in optimising the location of the knots. The program in itself, however, was not sufficient to produce the final graduated rates, as it concentrated on fidelity to data at the expense of smoothness. Initial knots were selected based on observation of the crude data. The computer program modified 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:	2	3	10	17	18	20	40	54	66	72	75	88
Females:	2	3	13	15	20	21	32	58	71	77	80	86

The cubic splines were fitted from ages 2 to 96. 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 17, 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, two knots were located at ages 20 and 21 to capture the local maximum in mortality rates. Due to the larger age range, and the numerous mortality transitions over this age range, more knots were needed than in previous Australian Life Tables.

As had been the case in 1980-82, 1985-87 and 1990-92, the raw mortality rates for males and females cross at a very old age. The 1990-92 Australian Life Tables maintained the apparent crossover as a genuine feature, placing it between ages 102 and 103. The current set of crude mortality rates points to a shift in the age at which crossover occurs, placing it in the upper 90's. Confidence intervals constructed around the crude rates suggest that the crossover occurs somewhere between age 94 and 99. The very small number of lives at the upper ages and the associated volatility in crude rates from year to year mean that the exact age at which crossover occurs is uncertain. The final graduated tables place the crossover around age 98.

Graduated rates for the very old ages were constructed by extrapolating the trend of the crude rates for those aged in their 90's, and by considering the crude and graduated rates selected for the 1990-92 Australian Life Tables. Initially, a Makeham curve was fit to the crude rates for ages 90 to 96 and projected to age 120. Because of the high uncertainty associated with the older ages, graduated rates over age 100 from the 1990-92 Australian Life Tables were used as a basis for the projections. For males, the projected curve was modified by blending the extrapolated rates with the graduated rates from ALT 1990-92 for ages 100 and over. For females, the projected Makeham rates were consistent with the graduated rates from ALT 1990-92, and no blending was required.

As in 1990-92, a negligible percentage of death registrations in 1995-97 did not include the age at death (less than 0.008 of a percent 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 observed deaths representing a random sample from an underlying mortality 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:

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

$$d_x = l_x q_x$$

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

$$p_x = 1 - q_x$$

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

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

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

$$T_x = l_x \overset{o}{e}_x$$

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, 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, 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 1995-97 Tables can be used to estimate probabilities of persons living or dying at some time in the future, on the assumption that mortality rates remain unchanged at the 1995-97 level.

The continuing improvement in mortality exhibited in these Tables suggests that this assumption will tend to underestimate survival probabilities.

As mentioned in Section 1.4, the Australian Bureau of Statistics publication 'Population Projections 1997 to 2051' (Catalogue No. 3222.0) includes an analysis of recent trends in mortality and suggests a series of future improvement factors. These factors, which are reproduced in Appendix E, can be applied to the mortality rates included in the current Life Tables to estimate future mortality and life expectancy. Appendix E also contains a series of future improvement factors that were derived by extrapolating the historical trends in Australian mortality improvement over the last 25 years and 100 years.

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

$$q_x(t) = q_x \times \prod_{r=1997}^{t} \left(1 + \frac{I_x(r)}{100}\right)$$

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

$I_x(r)$ is the rate of improvement at age *x* from year (*r*-1) to year *r* 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 50 year old female whose mortality in 1996 is given in the current Life Tables. ie. $q_x(t) = q_{50}(1996) = 0.00223$
>
> The table below sets out $q_x(t)$ for t=1996, 1997 and 2050 using the three different improvement scenarios.

Scenario	$q_{50}(1996)$	$q_{50}(1997)$	$q_{50}(2050)$
25 year trend	0.00223	$q_{50}(1996)\times\left(1-\frac{2.7974}{100}\right)$ $= 0.002168$	$q_{50}(1996)\times\left(1-\frac{2.7974}{100}\right)^{54}$ $= q_{50}(1996)\times 0.216075 = 0.00048$
100 year trend	0.00223	$q_{50}(1996)\times\left(1-\frac{1.6199}{100}\right)$ $= 0.002194$	$q_{50}(1996)\times\left(1-\frac{1.6199}{100}\right)^{54}$ $= q_{50}(1996)\times 0.413992 = 0.00092$
ABS trend	0.00223	$q_{50}(1996)\times\left(1-\frac{2.6508}{100}\right)$ $= 0.002171$	$q_{50}(1996)\times\left(1-\frac{2.6508}{100}\right)^{10}\times\left(1-\frac{1.3241}{100}\right)^{44}$ $= q_{50}(1996)\times 0.76441\times 0.55627 = 0.00095$

Under the ABS improvement scenario, short-term rates are used from the present to June 2006 and long-term rates of improvement are used thereafter.

Any of the three sets of improvement factors given in Appendix E can be used to construct future mortality rates. The three sets give different projected rates which highlights the uncertainty associated in predicting future mortality (see Section 1.4 for discussion of the various improvement scenarios).

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. Similarly, the higher improvement factors applying at youngest ages mean that the projected rates will diverge from the current rates more quickly.

Clearly, there is considerable uncertainty associated with projecting mortality rates. As such, rates and life expectancy estimates projected using the ABS, the 25 year trend or 100 year trend improvement factors, or indeed any other assumptions, including the assumption of no mortality improvement, should be suitably qualified.

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 years 1970-72 have been preferred to the published Tables, the latter having been based on an under-enumerated population.

TABLE 1(a): 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

TABLE 1(b): 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

TABLE 2(a): 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

TABLE 2(b): 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

APPENDIX B

POPULATION

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

Year	*Males*	*Females*	*Total*
1947	3,797,370	3,781,988	7,579,358
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

Figures shown for Censuses before 1966 exclude Aborigines. Figures shown for 1971, 1976, 1981, 1986, 1991 and 1996 have been adjusted by the Statistician to allow for under-enumeration at the Censuses. Figures for 1991 and 1996 are given at 30 June 1991 and 1996 and have been adjusted for the length of time between 30 June and Census.

DEATHS

Year	*Males*	*Females*	*Total*
1995	66,185	58,974	125,159
1996	67,970	60,265	128,235
1997	67,283	61,321	128,604
Total	201,438	180,560	381,998

These numbers do not include deaths of Australian residents overseas, but do include deaths of overseas residents in Australia.

MOVEMENTS OF THE POPULATION

Year	*Males*		*Females*		*Total*	
	Arrivals	*Departures*	*Arrivals*	*Departures*	*Arrivals*	*Departures*
1995	3,281,768	3,211,018	3,168,833	3,133,794	6,450,601	6,344,812
1996	3,669,974	3,605,528	3,451,714	3,395,517	7,121,688	7,001,045
1997	3,957,176	3,912,028	3,518,105	3,478,470	7,475,281	7,390,498
Total	10,908,918	10,728,574	10,138,652	10,007,781	21,047,570	20,736,355

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 1996 AND DEATHS IN THE THREE YEARS 1995-97, AUSTRALIA: MALES

Age last birthday	*Population*	*Deaths*	*Age last birthday*	*Population*	*Deaths*
0	129,613	2,364	52	103,550	1,330
1	133,515	230	53	95,341	1,474
2	132,376	161	54	91,516	1,422
3	133,410	122	55	88,140	1,579
4	133,161	97	56	84,860	1,673
5	136,161	76	57	81,388	1,876
6	136,036	62	58	79,550	1,980
7	133,313	66	59	77,156	2,025
8	132,237	71	60	72,905	2,354
9	131,968	44	61	70,249	2,521
10	134,037	56	62	68,795	2,755
11	133,721	70	63	67,516	2,945
12	134,940	68	64	67,917	3,259
13	136,557	84	65	70,366	3,573
14	135,766	125	66	67,099	3,942
15	135,103	156	67	66,113	4,448
16	133,872	217	68	64,963	4,869
17	133,658	316	69	62,382	5,038
18	132,323	432	70	61,964	5,425
19	133,328	473	71	55,738	5,689
20	135,738	475	72	55,554	6,043
21	139,720	502	73	51,340	6,149
22	141,026	513	74	48,923	6,311
23	144,370	568	75	46,209	6,463
24	149,047	548	76	40,732	6,377
25	151,525	553	77	31,926	6,049
26	142,803	540	78	30,613	5,918
27	139,706	541	79	28,896	6,194
28	135,699	493	80	26,088	6,446
29	133,370	515	81	23,831	6,539
30	135,298	544	82	21,677	6,475
31	137,990	581	83	18,564	5,953
32	142,737	606	84	15,576	5,720
33	147,495	596	85	12,993	5,249
34	145,628	661	86	10,953	4,686
35	150,969	638	87	8,419	4,184
36	144,534	669	88	6,862	3,687
37	142,424	650	89	5,366	3,178
38	142,904	643	90	4,183	2,634
39	138,043	716	91	3,012	2,143
40	138,744	710	92	2,380	1,693
41	133,471	766	93	1,820	1,331
42	135,376	745	94	1,219	994
43	134,284	826	95	985	759
44	128,539	844	96	737	526
45	130,659	904	97	369	385
46	127,388	944	98	311	217
47	124,696	997	99	218	139
48	128,792	1,149	100	139	105
49	131,432	1,164	101 and over	240	170
50	112,256	1,307	Not stated		22
51	108,936	1,324	*Total*	9,048,337	201,438

POPULATION AT 30 JUNE 1996 AND DEATHS IN THE THREE YEARS 1995-97, AUSTRALIA: FEMALES

Age last birthday	*Population*	*Deaths*	*Age last birthday*	*Population*	*Deaths*
0	123,511	1,840	52	100,775	836
1	125,821	164	53	91,418	868
2	126,063	102	54	88,102	878
3	126,801	82	55	85,626	929
4	126,571	67	56	81,757	973
5	129,367	60	57	79,380	1,037
6	130,382	51	58	78,062	1,154
7	126,201	51	59	75,603	1,229
8	126,973	44	60	72,386	1,336
9	126,292	45	61	70,263	1,392
10	128,124	49	62	69,200	1,487
11	128,453	56	63	69,161	1,637
12	129,494	62	64	68,126	1,678
13	130,268	65	65	72,584	2,005
14	128,786	68	66	70,201	2,251
15	130,832	75	67	69,048	2,377
16	130,972	117	68	69,965	2,711
17	127,677	116	69	67,548	2,848
18	125,978	162	70	68,460	3,237
19	128,046	142	71	64,979	3,402
20	130,656	165	72	65,390	3,811
21	134,472	154	73	63,180	4,073
22	136,096	158	74	61,495	4,374
23	139,089	151	75	58,861	4,696
24	147,722	157	76	53,952	4,725
25	149,438	175	77	44,088	4,921
26	140,984	191	78	43,351	5,108
27	140,343	176	79	42,132	5,519
28	136,162	154	80	40,088	6,111
29	135,693	187	81	37,541	6,367
30	137,839	206	82	36,840	6,691
31	136,704	216	83	32,403	6,875
32	144,603	246	84	28,872	6,886
33	148,455	265	85	25,673	6,866
34	148,627	277	86	22,957	6,791
35	150,841	310	87	17,994	6,512
36	147,927	303	88	15,594	5,947
37	143,409	312	89	13,057	5,691
38	143,273	351	90	10,802	5,133
39	141,009	319	91	8,720	4,746
40	139,231	380	92	6,973	4,122
41	137,735	419	93	5,411	3,437
42	137,657	419	94	4,192	2,917
43	134,888	469	95	3,335	2,463
44	127,904	487	96	2,526	1,967
45	129,881	513	97	1,511	1,465
46	127,102	543	98	1,185	1,047
47	122,410	628	99	833	712
48	125,279	721	100	507	523
49	127,814	742	101 and over	843	1,008
50	106,519	817	Not stated		8
51	103,615	754	*Total*	9,172,939	180,560

Population numbers for 99, 100 and 101 and over have been estimated by the Australian Government Actuary based on individual age death data and a population figure for ages 99 and over provided by the ABS of 2,183 for females and 597 for males.

APPENDIX D

COMPARISON OF ACTUAL AND EXPECTED DEATHS IN THE THREE YEARS 1995-97, AUSTRALIA: MALES

	Actual	*Expected*	*Deviation*		*Accumulation*	
Age	*deaths*	*deaths*	+	-	+	-
2	161	158	3		3	
3	122	123		1	2	
4	97	97		0	2	
5	76	79		3		1
6	62	67		5		6
7	66	60	6		0	
8	71	58	13		13	
9	44	58		14		1
10	56	60		4		5
11	70	63	7		2	
12	68	70		2	0	
13	84	86		2		2
14	125	115	10		8	
15	156	160		4	4	
16	217	226		9		5
17	316	317		1		6
18	432	417	15		9	
19	473	468	5		14	
20	475	490		15		1
21	502	506		4		5
22	513	521		8		13
23	568	539	29		16	
24	548	554		6	10	
25	553	555		2	8	
26	540	549		9		1
27	541	533	8		7	
28	493	525		32		25
29	515	527		12		37
30	544	540	4			33
31	581	561	20			13
32	606	584	22		9	
33	596	602		6	3	
34	661	629	32		35	
35	638	647		9	26	
36	669	657	12		38	
37	650	670		20	18	
38	643	681		38		20
39	716	699	17			3
40	710	716		6		9
41	766	747	19		10	
42	745	775		30		20
43	826	806	20		0	
44	844	847		3		3
45	904	889	15		12	
46	944	952		8	4	
47	997	1,025		28		24
48	1,149	1,127	22			2
49	1,164	1,217		53		55

Age	Actual deaths	Expected deaths	Deviation +	Deviation -	Accumulation +	Accumulation -
50	1,307	1,265	42			13
51	1,324	1,295	29		16	
52	1,330	1,355		25		9
53	1,474	1,398	76		67	
54	1,422	1,486		64	3	
55	1,579	1,593		14		11
56	1,673	1,706		33		44
57	1,876	1,830	46		2	
58	1,980	1,972	8		10	
59	2,025	2,127		102		92
60	2,354	2,277	77			15
61	2,521	2,454	67		52	
62	2,755	2,670	85		137	
63	2,945	2,937	8		145	
64	3,259	3,297		38	107	
65	3,573	3,693		120		13
66	3,942	4,088		146		159
67	4,448	4,379	69			90
68	4,869	4,774	95		5	
69	5,038	5,144		106		101
70	5,425	5,356	69			32
71	5,689	5,704		15		47
72	6,043	5,893	150		103	
73	6,149	6,178		29	74	
74	6,311	6,386		75		1
75	6,463	6,484		21		22
76	6,377	6,320	57		35	
77	6,049	6,135		86		51
78	5,918	6,027		109		160
79	6,194	6,192	2			158
80	6,446	6,285	161		3	
81	6,539	6,387	152		155	
82	6,475	6,328	147		302	
83	5,953	6,166		213	89	
84	5,720	5,787		67	22	
85	5,249	5,291		42		20
86	4,686	4,747		61		81
87	4,184	4,206		22		103
88	3,687	3,645	42			61
89	3,178	3,125	53			8
90	2,634	2,636		2		10
91	2,143	2,125	18		8	
92	1,693	1,690	3		11	
93	1,331	1,332		1	10	
94	994	1,025		31		21
95	759	778		19		40
96	526	577		51		91
97	385	374	11			80
98	217	261		44		124
99	139	195		56		180
100	105	129		24		204
101 and over	170	214		44		248
Total	198,822	199,070				

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.

COMPARISON OF ACTUAL AND EXPECTED DEATHS IN THE THREE YEARS 1995-97, AUSTRALIA: FEMALES

Age	Actual deaths	Expected deaths	Deviation +	Deviation -	Accumulation +	Accumulation -
2	102	100	2		2	
3	82	83		1	1	
4	67	70		3		2
5	60	59	1			1
6	51	52		1		2
7	51	48	3		1	
8	44	46		2		1
9	45	46		1		2
10	49	49		0		2
11	56	54	2		0	
12	62	60	2		2	
13	65	65		0	2	
14	68	72		4		2
15	75	85		10		12
16	117	102	15		3	
17	116	123		7		4
18	162	142	20		16	
19	142	157		15	1	
20	165	164	1		2	
21	154	160		6		4
22	158	157	1			3
23	151	159		8		11
24	157	163		6		17
25	175	166	9			8
26	191	168	23		15	
27	176	171	5		20	
28	154	181		27		7
29	187	192		5		12
30	206	202	4			8
31	216	221		5		13
32	246	242	4			9
33	265	261	4			5
34	277	276	1			4
35	310	293	17		13	
36	303	305		2	11	
37	312	317		5	6	
38	351	336	15		21	
39	319	355		36		15
40	380	376	4			11
41	419	402	17		6	
42	419	433		14		8
43	469	459	10		2	
44	487	491		4		2
45	513	530		17		19
46	543	579		36		55
47	628	630		2		57
48	721	689	32			25
49	742	732	10			15

Age	Actual deaths	Expected deaths	Deviation +	Deviation -	Accumulation +	Accumulation -
50	817	753	64		49	
51	754	780		26	23	
52	836	820	16		39	
53	868	860	8		47	
54	878	904		26	21	
55	929	954		25		4
56	973	1,005		32		36
57	1,037	1,065		28		64
58	1,154	1,143	11			53
59	1,229	1,213	16			37
60	1,336	1,273	63		26	
61	1,392	1,370	22		48	
62	1,487	1,486	1		49	
63	1,637	1,608	29		78	
64	1,678	1,812		134		56
65	2,005	2,001	4			52
66	2,251	2,206	45			7
67	2,377	2,407		30		37
68	2,711	2,637	74		37	
69	2,848	2,913		65		28
70	3,237	3,183	54		26	
71	3,402	3,487		85		59
72	3,811	3,734	77		18	
73	4,073	4,080		7	11	
74	4,374	4,422		48		37
75	4,696	4,665	31			6
76	4,725	4,742		17		23
77	4,921	4,883	38		15	
78	5,108	5,134		26		11
79	5,519	5,567		48		59
80	6,111	5,981	130		71	
81	6,367	6,399		32	39	
82	6,691	6,706		15	24	
83	6,875	6,892		17	7	
84	6,886	6,946		60		53
85	6,866	6,944		78		131
86	6,791	6,723	68			63
87	6,512	6,409	103		40	
88	5,947	5,968		21	19	
89	5,691	5,657	34		53	
90	5,133	5,207		74		21
91	4,746	4,657	89		68	
92	4,122	4,084	38		106	
93	3,437	3,505		68	38	
94	2,917	2,941		24	14	
95	2,463	2,431	32		46	
96	1,967	1,930	37		83	
97	1,465	1,375	90		173	
98	1,047	1,007	40		213	
99	712	763		51	162	
100	523	490	33		195	
101 and over	1,008	857	151		346	
Total	178,548	178,202				

APPENDIX E

FUTURE PERCENTAGE MORTALITY IMPROVEMENT FACTORS - MALES

Age	*25 year*	*100 year trend*	*Age*	*25 year*	*100 year*
0	-4.2126	-2.9218	51	-3.2289	-1.4030
1	-3.7325	-3.7305	52	-3.2142	-1.3624
2	-3.6000	-3.1540	53	-3.1882	-1.3227
3	-3.5600	-2.9684	54	-3.1536	-1.2849
4	-3.5889	-2.9800	55	-3.1134	-1.2532
5	-3.6533	-2.9746	56	-3.0701	-1.2206
6	-3.7136	-2.9481	57	-3.0242	-1.1865
7	-3.7356	-2.9213	58	-2.9746	-1.1508
8	-3.7011	-2.8501	59	-2.9212	-1.1133
9	-3.6102	-2.7586	60	-2.8646	-1.0775
10	-3.4767	-2.6696	61	-2.8050	-1.0436
11	-3.3187	-2.5786	62	-2.7418	-1.0123
12	-3.1530	-2.4786	63	-2.6752	-0.9840
13	-2.9939	-2.3565	64	-2.6067	-0.9568
14	-2.8534	-2.1722	65	-2.5383	-0.9316
15	-2.7357	-1.9784	66	-2.4710	-0.9021
16	-2.6317	-1.7590	67	-2.4057	-0.8647
17	-2.5220	-1.5373	68	-2.3444	-0.8220
18	-2.3856	-1.3578	69	-2.2893	-0.7744
19	-2.2071	-1.3237	70	-2.2403	-0.7229
20	-1.9808	-1.3631	71	-2.1953	-0.6797
21	-1.7126	-1.4134	72	-2.1520	-0.6629
22	-1.4184	-1.4617	73	-2.1075	-0.6651
23	-1.1203	-1.5078	74	-2.0572	-0.6650
24	-0.8412	-1.5550	75	-1.9969	-0.6610
25	-0.6006	-1.5835	76	-1.9257	-0.6534
26	-0.4104	-1.6090	77	-1.8450	-0.6431
27	-0.2751	-1.6327	78	-1.7572	-0.6266
28	-0.1938	-1.6427	79	-1.6658	-0.6056
29	-0.1638	-1.6464	80	-1.5755	-0.5817
30	-0.1827	-1.6566	81	-1.4897	-0.5557
31	-0.2483	-1.6696	82	-1.4093	-0.5317
32	-0.3578	-1.6768	83	-1.3348	-0.5064
33	-0.5067	-1.6910	84	-1.2659	-0.4805
34	-0.6881	-1.7049	85	-1.2012	-0.4548
35	-0.8932	-1.7156	86	-1.1399	-0.4269
36	-1.1128	-1.7218	87	-1.0837	-0.3998
37	-1.3394	-1.7225	88	-1.0346	-0.3735
38	-1.5679	-1.7200	89	-0.9957	-0.3486
39	-1.7955	-1.7132	90	-0.9716	-0.3282
40	-2.0191	-1.7014	91	-0.9647	-0.3192
41	-2.2346	-1.6865	92	-0.9736	-0.3254
42	-2.4366	-1.6702	93	-0.9944	-0.3425
43	-2.6200	-1.6583	94	-1.0204	-0.3637
44	-2.7815	-1.6419	95	-1.0437	-0.3860
45	-2.9195	-1.6203	96	-1.0594	-0.4122
46	-3.0326	-1.5949	97	-1.0637	-0.4407
47	-3.1196	-1.5602	98	-1.0543	-0.4691
48	-3.1800	-1.5207	99	-1.0314	-0.5148
49	-3.2156	-1.4810	100 and over	-1.0314	-0.5901
50	-3.2304	-1.4418			

FUTURE PERCENTAGE MORTALITY IMPROVEMENT FACTORS - FEMALES

Age	*25 year*	*100 year trend*	*Age*	*25 year*	*100 year*
0	-4.0365	-2.9615	51	-2.7357	-1.5722
1	-3.9322	-3.9373	52	-2.6721	-1.5249
2	-3.8297	-3.5247	53	-2.6065	-1.4884
3	-3.7279	-3.2837	54	-2.5413	-1.4584
4	-3.6225	-3.2412	55	-2.4803	-1.4325
5	-3.4987	-3.1823	56	-2.4267	-1.4094
6	-3.3378	-3.1222	57	-2.3827	-1.3876
7	-3.1282	-3.0670	58	-2.3493	-1.3709
8	-2.8745	-2.9714	59	-2.3255	-1.3586
9	-2.6007	-2.8501	60	-2.3079	-1.3491
10	-2.3457	-2.7082	61	-2.2928	-1.3350
11	-2.1503	-2.5487	62	-2.2791	-1.3175
12	-2.0405	-2.4310	63	-2.2665	-1.2963
13	-2.0149	-2.3903	64	-2.2538	-1.2706
14	-2.0434	-2.4119	65	-2.2396	-1.2408
15	-2.0794	-2.4136	66	-2.2243	-1.2100
16	-2.0811	-2.3740	67	-2.2085	-1.1771
17	-2.0284	-2.2994	68	-2.1924	-1.1467
18	-1.9273	-2.2163	69	-2.1765	-1.1195
19	-1.8042	-2.1806	70	-2.1622	-1.0954
20	-1.6939	-2.2061	71	-2.1485	-1.0769
21	-1.6215	-2.3200	72	-2.1328	-1.0650
22	-1.5919	-2.4338	73	-2.1129	-1.0584
23	-1.5924	-2.5212	74	-2.0871	-1.0548
24	-1.6029	-2.5816	75	-2.0532	-1.0504
25	-1.6061	-2.6183	76	-2.0118	-1.0409
26	-1.5936	-2.6388	77	-1.9649	-1.0200
27	-1.5664	-2.6293	78	-1.9148	-0.9855
28	-1.5329	-2.6056	79	-1.8652	-0.9487
29	-1.5058	-2.5750	80	-1.8186	-0.9129
30	-1.4983	-2.5512	81	-1.7732	-0.8749
31	-1.5217	-2.5343	82	-1.7263	-0.8367
32	-1.5827	-2.5213	83	-1.6733	-0.7994
33	-1.6822	-2.5062	84	-1.6092	-0.7577
34	-1.8152	-2.4930	85	-1.5328	-0.7112
35	-1.9724	-2.4722	86	-1.4446	-0.6629
36	-2.1418	-2.4405	87	-1.3483	-0.6131
37	-2.3110	-2.4088	88	-1.2504	-0.5651
38	-2.4696	-2.3668	89	-1.1564	-0.5214
39	-2.6106	-2.3018	90	-1.0731	-0.4832
40	-2.7300	-2.2135	91	-1.0038	-0.4521
41	-2.8259	-2.1198	92	-0.9501	-0.4309
42	-2.8984	-2.0402	93	-0.9100	-0.4192
43	-2.9488	-1.9776	94	-0.8801	-0.4157
44	-2.9794	-1.9322	95	-0.8559	-0.4204
45	-2.9912	-1.8861	96	-0.8333	-0.4332
46	-2.9839	-1.8335	97	-0.8087	-0.4538
47	-2.9569	-1.7762	98	-0.7794	-0.4808
48	-2.9127	-1.7237	99	-0.7443	-0.5266
49	-2.8575	-1.6703	100 and over	-0.7443	-0.5985
50	-2.7974	-1.6199			

ABS FUTURE PERCENTAGE MORTALITY IMPROVEMENT FACTORS

	Short-term Rates		*Long-term Rates*	
Age	*Males*	*Females*	*Males*	*Females*
0	-3.8667	-4.6420	-4.4246	-4.3533
1-4	-2.2375	-0.9735	-3.8010	-3.4991
5-9	-2.6553	-1.2185	-3.3124	-2.7426
10-14	-1.1031	-1.8067	-2.6844	-2.3942
15-19	-3.8908	-3.3381	-2.1840	-2.5684
20-24	-3.4783	-3.4663	-1.2487	-1.5527
25-29	-3.0435	-3.5713	-1.8051	-1.6465
30-34	-3.5039	-2.5345	-1.1153	-1.6581
35-39	-3.0455	-2.2739	-1.1169	-1.9000
40-44	-2.3598	-1.6669	-1.3803	-1.9111
45-49	-2.4357	-2.7914	-1.7871	-1.7607
50-54	-3.2469	-2.6508	-1.7351	-1.3241
55-59	-3.5435	-2.0909	-1.3839	-1.0044
60-64	-2.6626	-2.0114	-1.1008	-0.8398
65-69	-2.0578	-1.5548	-0.9467	-0.5294
70-74	-2.0265	-1.8639	-0.8306	-0.4961
75-79	-1.7804	-1.1535	-0.9029	-0.8020
80-84	-1.1390	-1.0289	-0.5900	-0.8401
85-89	-0.2676	-0.3977	-0.4745	-0.7804
90-94	-0.5389	-0.4620	-0.2852	-0.6293
95-99	-0.2850	-0.3143	-0.2289	-0.4042

Reproduced from 'Population Projections, 1997-2051' (ABS Catalogue No. 3222.0). The ABS regularly produces mortality improvement factors. Although the factors given above were the latest at the time of publication of this paper, new factors will be produced by the ABS in the future.

Future mortality improvement factors were not published for ages 100 and above. The calculations using ABS improvement factors in this publication have assumed that improvement for ages 100 and above is the same as improvement for ages 95-99.

The short-term rates should be applied for years to June 2006 and the long-term rates from July 2006 to 2051. See Section 3 for an example of how to apply the improvement rates. Note that over time, discontinuities in the mortality rates at the boundaries of the age groups will become increasingly severe and further adjustment may be needed if a smooth progression of rates is required.

CONTENTS OF DISKETTE

There are seven files on the disk provided in both Excel and text formats. In addition, a 'readme' file lists the data files and some information regarding the previously published Life Tables.

females_95-97.xls
males_95-97.xls

These files contain the 1995-97 Life Tables. l_x, d_x, L_x, and T_x are shown as integers. p_x, q_x and μ_x are given to 6 decimal places.

$\overset{\circ}{e}_x$ is given to two decimal places. The definitions and formulae adopted for calculating the functions are described in Section 2.3.

females_alltables_lifeexpectancies.xls
males_alltables_lifeexpectancies.xls

These files contain the life expectancy values as published in all fifteen official Australian Life Tables from 1881-1890 to 1995-97. Life expectancy is given for ages 0 to 100 for all Tables with the exception of 1946-48, 1953-55, and 1960-62 where life expectancy is given for ages 0 to 99.

females_alltables_qx.xls
males_alltables_qx.xls

These files contain the initial mortality rates (the probability of a person aged exactly x dying before reaching age (x+1)) for ages 0 to 100 as published in all fifteen official Australian Life Tables from 1881-1890 to 1995-97.

Improvement factors.xls

This file contains the improvement factors discussed in Section 1.4 of the text and presented in Appendix E. Future mortality rates can be generated using these improvement factors by following the methods outlined in Section 3 of this publication.