ARC CENTRE OF EXCELLENCE IN POPULATION AGEING RESEARCH

THE UNIVERSITY OF MELBOURNE

AUSTRALIAN LIFE TABLES: 150 YEARS IN THE MAKING

1. INTRODUCTION

The first to estimate the lifespan of Australians was Morris Birkbeck Pell, Professor of Mathematics at the University of Sydney. In 1867, at a meeting of the Royal Society of New South Wales, he presented the first Australian life table, showing the numbers and probabilities of survival between each age and the following birthday. He also showed that the life expectancy for a newborn in the colony was 45.6 years – 5 years more than in England and 13 more than in Belgium. Since then, life tables have become a valuable tool in demography, economics, insurance, and public health. An example life table is shown on the last page.

To mark 150 years since Pell's publication, the ARC Centre of Excellence in Population Ageing Research (CEPAR) and the Melbourne School of Population and Global Health (Global Burden of Disease Group and Centre for Health Policy) held a symposium in Melbourne on 13 November 2017. This fact sheet summarises key insights from the event, including the trends and drivers of mortality change, inequalities in life expectancy, and the potential for future improvements (names of presenters are shown under each heading).

2. LONG-TERM TRENDS

PETER McDONALD

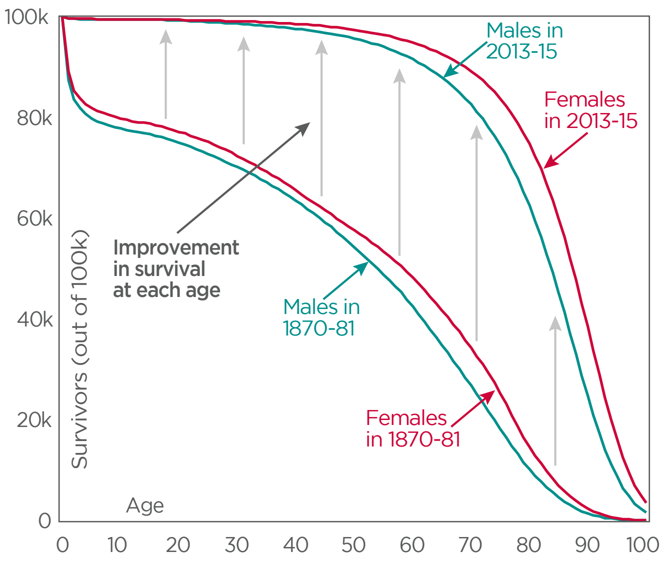
Since the 1870s, Australian life expectancy has soared from 46.5 years for males and 49.6 years for females to 80.4 and 84.6 years, respectively (Figure 1).

But mortality declines have not been uniform. Before 1950, the main contributor was a fall in infant mortality. In the 1960s and 1970s the decline slowed due to the rise of smoking in earlier decades. And recent mortality declines were largely among the over-50s.

Further increases in life expectancy would require mortality improvements among the oldest old. McDonald calculated that death rates at younger ages are now so low that if no woman died before age 75, female life expectancy would rise by just 2.2 years (Figure 2).

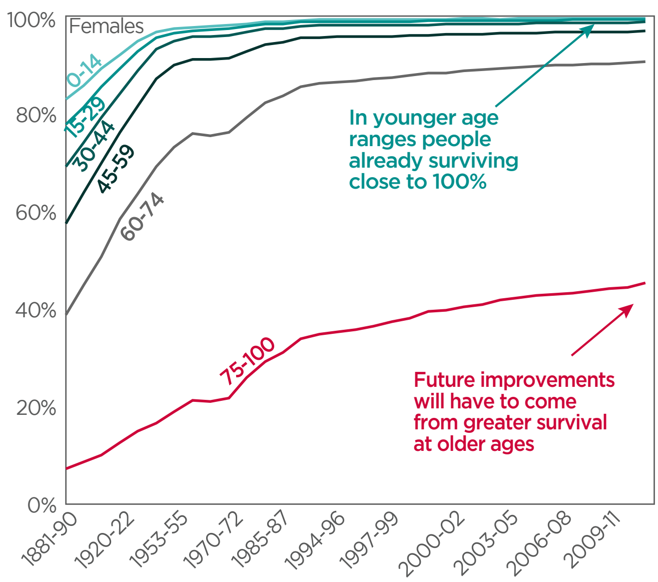
McDonald also pointed to large geographic variation in lifespans (see Section 6). The highest life expectancy in Australia is among women on Sydney's North Shore (87.3 years). The lowest is among men in the Northern Territory outside Darwin (72.5 years). This is related to indigenous mortality (see Section 4).

FIGURE 1. SURVIVORS AT EACH AGE IN AUST.



Source: Adapted from McDonald (2017)

FIGURE 2. YEARS LIVED IN AGE RANGE AS % OF MAX



Source: Adapted from McDonald (2017)

3. DRIVERS OF MORTALITY

TIM ADAIR

In the past, declines in mortality were driven by declines in death rates from communicable diseases (Figure 3). From the 1970s, control of non-communicable diseases became more important. For example, lower mortality from ischaemic heart disease accounted for almost half of the improvement in recent decades. In addition, there was a marked decline in transport deaths in the 1970s and 1980s, which coincided with the introduction of compulsory seat-belt laws.

The result has been higher life expectancy in Australia than in most advanced countries. The life expectancy of Australian men generally improved faster than elsewhere (Figure 4), while the life expectancy of Australian women has improved more in line with the average for other high-income countries. Overall, increases in life expectancy in Australia relative to other countries have slowed in recent years.

Relative to Japan, Australian men experience higher mortality from ischaemic heart disease, but have lower mortality from a range of cancers, and from self-harm. Compared to women in the US, Australian women have lower mortality across most types of non-communicable diseases.

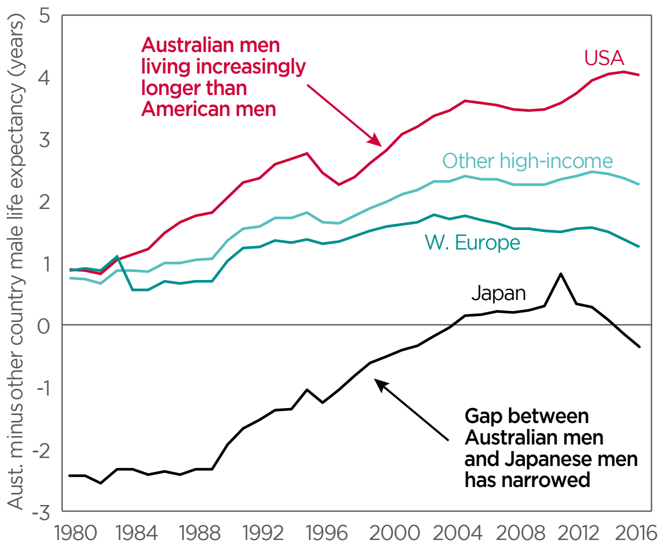
A significant component of the high relative life expectancy in Australia is attributable to cohorts of Australian men born in the 1940s and 1950s. Australian cohorts born since the 1960s, of both sexes, have performed less well on a relative basis.

FIGURE 3. CONTRIBUTION TO LIFE EXPECTANCY GAINS FOR AUSTRALIAN MALES BY CAUSE

		1951-72	1972-93	1993-2015
Communicable	Lower respiratory	0.2	0.4	0.0
	Diarrheal diseases	0.3	0.1	0.0
	Tuberculosis	0.4	-0.1	0.1
	Other Communicable	0.5	0.6	0.2
Non-communicable	Stomach cancer	0.3	0.1	0.1
	Lung cancer	-0.3	0.1	0.4
	Chronic respiratory	-0.3	0.3	0.4
	Other non-communicable	0.6	-0.1	0.4
	Cerebrovascular disease	0.0	1.2	0.6
	Other cancers	-0.2	-0.2	0.7
	Ischaemic heart disease	0.1	3.0	2.4
Injuries	Other injuries	0.2	0.2	0.2
	Transport injuries	0.2	0.8	0.3
	Total	2.0	6.4	5.7

Source: Adapted from GBD (2016)

FIGURE 4. BENCHMARKING AUSTRALIAN LIFE EXP.



Source: Adapted from GBD (2016)

4. INDIGENOUS LIFE EXPECTANCY

TETTEH DUGBAZA & FADWA AL-YAMAN

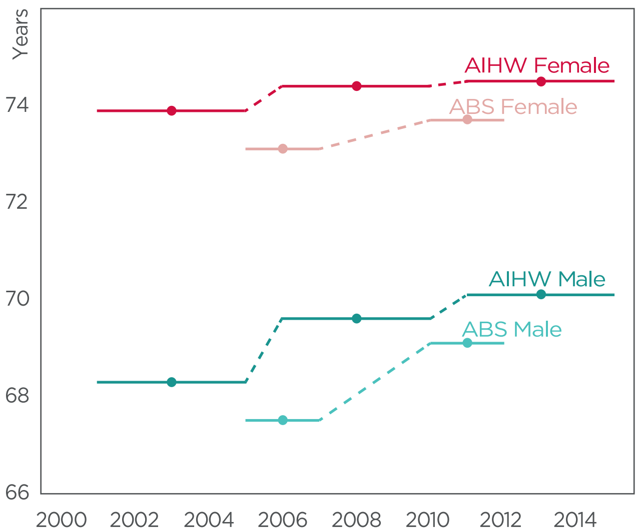
Indigenous life expectancy estimates were first produced about 25 years ago. The late start was in part because indigenous status only began to be recorded on death certificates in the 1980s.

Both the Australian Institute of Health and Welfare (AIHW) and the Australian Bureau of Statistics (ABS) now produce estimates based on direct methods, which use counts of deaths and population by age group. Earlier estimates used incomplete data and were less accurate.

AIHW estimates are based on its Enhanced Mortality Database, which links multiple sources, including hospital, aged care, and state-based registers, to improve identification of indigenous deaths. The AIHW identifies about 10 percent more indigenous deaths than are in registration data.

Both ABS and AIHW estimates show life expectancy increasing for indigenous people – more for males than females (Figure 5). But indigenous life expectancy is growing more slowly than that of the overall population, resulting in a widening gap. It currently stands at about 10 years.

FIGURE 5. INDIGENOUS LIFE EXP. ESTIMATES



Source: ABS (2013), AIHW (2017)

5. MORTALITY IN AGED CARE

JEROMEY TEMPLE & MARIJAN JUKIC

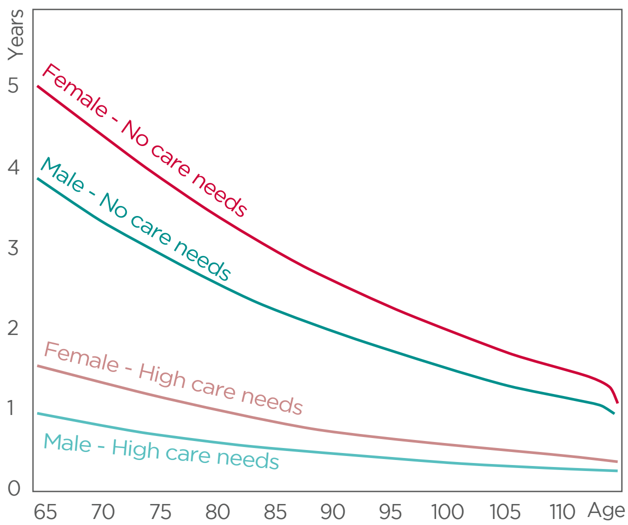
A significant number of Australians interact with the aged care system. In June 2015 about 177,000 people were in residential care, and public funding to the sector was over $9b per year.

Temple and Jukic used administrative data from residential care needs assessments. These record needs relating to activities of daily living (ADL; e.g. domestic activities), behavioural (e.g. cognitive skills) and complex health care (e.g. special feeding), as well as detailed health status information. The dataset lacks geographical and facility information, preventing analysis of mortality across regions or socio-economic groups.

They modelled life expectancy by level of care need and probabilities of transition between different levels of need. Those with higher needs have significantly lower life expectancy, with ADL needs shortening life more than behavioural needs (Figure 6). Different diseases are also incorporated into the modelling, so life expectancy can be estimated based on disease status.

One result is that rising care needs have not been accompanied by rising mortality, which will impact costs. Such insights are relevant for designing aged care services, workforce planning, and budgeting.

FIGURE 6. LIFE EXP. IN AGED CARE BY CARE NEED



Source: Adapted from Temple and Jukic (2017)

6. INEQUALITY IN MORTALITY

PHILIP CLARKE

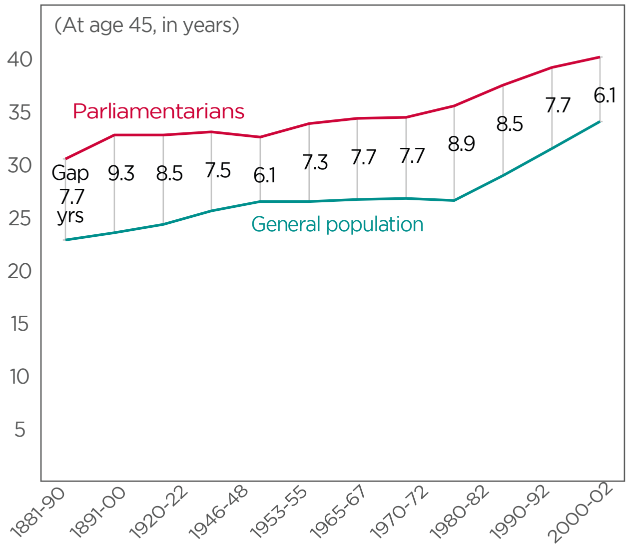
A hindrance in studying inequality of mortality is an absence of data. Clarke presented data on cause-specific mortality from Melbourne Hospital in the 1850s. This type of data is still not available in some Australian states today. Also, few data sources are linked. The linkage of mortality data to the 2011 Census was a step forward – a further step would be to link this to hospital records.

Occasionally there are work-arounds. Clarke presented his work which used mortality of Australian parliamentarians to proxy life expectancy at the top of the income distribution, showing that MPs tend to live 7-9 years longer than average (Figure 7).

In other work, Clarke used data from the Household Income and Labour Dynamics in Australia (HILDA) surveys. This showed a life expectancy gap of around 6 years at age 20 between individuals in the poorest and richest income quintiles (Figure 8). He found that geography had no effect once individual characteristics were accounted for.

Clarke called for more focus on life expectancy inequalities, proposing a 'health poverty index' for Australia, which would measure the share of individuals whose life expectancy (estimated from individual characteristics) is more than five years below average for their age and sex. He noted that better data could identify treatment gaps, and contribute to lowering cardiovascular and cancer mortality across different groups.

FIGURE 7. LIFE EXP. GAP BETWEEN AUSTRALIAN PARLIAMENTARIANS AND GEN. POPULATION



Source: Adapted from Clarke (2017)

FIGURE 8. LIFE EXP. GAP BETWEEN RICH AND POOR AUSTRALIANS, 2001-2007

Source: Adapted from Clarke and Leigh (2011)

7. MORTALITY FORECASTING

VLADIMIR CANUDAS-ROMO

Two key methods that can forecast future life expectancy were presented: the Double Gap Model (a statistical technique) and the Expert Judgement Model.

The Double Gap Model involves (1) fitting a trend to the highest observed female life expectancy in the world to forecast its future evolution; (2) modelling the gap between this highest observed level and that seen in a given country to predict the future female life expectancy in that country; and (3) using the historical gender gap within a country to predict male life expectancy.

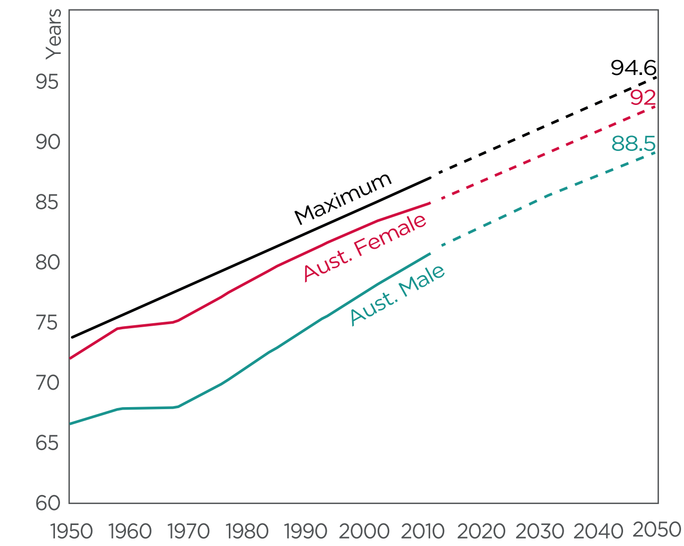
The Double Gap Model provides measures of uncertainty surrounding future forecasts. Estimated using Australian data, it predicts rises in female life expectancy to 92 by 2050, and male to 88.5 (Figure 9). But back-testing with historical data, the model under-predicts life expectancy gains since 1990. Under-predicting increases in life expectancy is not uncommon in Australia (Chomik 2015).

The Expert Judgement Model relies on the predictions of medical experts about future trends in cause-specific mortality. It explicitly tries to account for likely future improvements in medicine and public health. A recent application involved consultations with clinical expert panels, who were given presentations on historical trends in cause-specific mortality, and then asked to predict changes in the top six causes over the period to 2040 at different ages (Figure 10; Canudas-Romo et al. 2016).

Overall, the predicted increase in life expectancy was similar to statistical predictions and those produced by official bodies. Key drivers were lower mortality from cancer and cardiovascular disease, thanks to public health interventions (mainly related to reducing smoking).

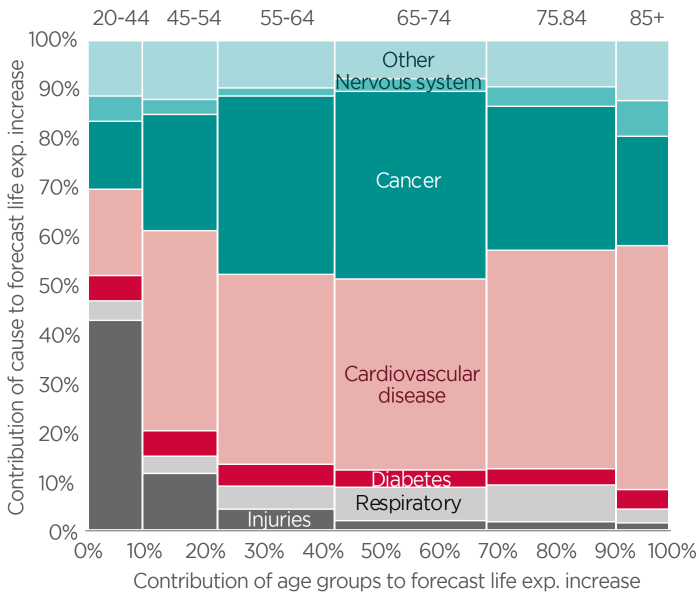
Such insights complement those from other research. For example, using French data, CEPAR researchers found that a cure for cancer would extend life expectancy by 2.2 years for those aged 65 and 3.4 years for newborns (Alai et al. 2015).

FIGURE 9. LIFE EXP: DOUBLE GAP FORECAST



Source: Adapted from Pascariu, Canudas-Romo and Vaupel (2017)

FIGURE 10. CONTRIBUTIONS TO US LIFE EXP. INCREASE 2009-2040: EXPERT JUDGEMENT



Source: Adapted from Canudas-Romo et al. (2016)

8. INSURANCE APPLICATIONS

MICHAEL SHERRIS

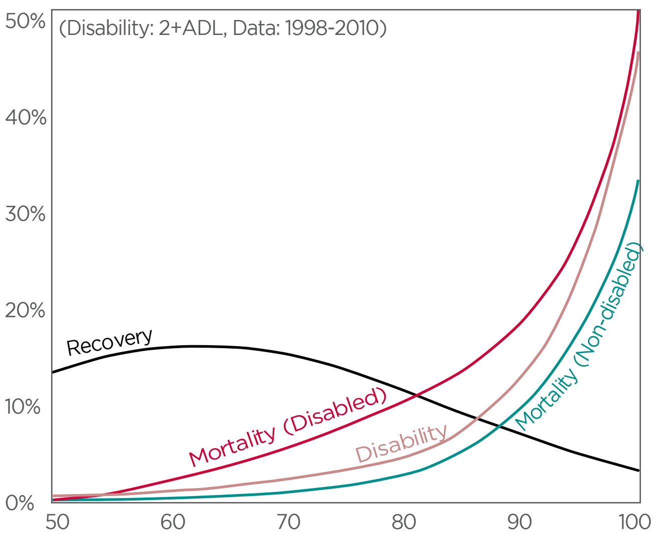
Life tables were first used by the Romans in the third century for tax purposes. In the 17th century, the Netherlands government used them to value publicly issued annuities. And James Dodson, a British mathematician and actuary, used the City of London's Bills of Mortality to calculate long-term insurance premiums in the 18th century.

M.B. Pell, whose life tables this Symposium commemorates, was himself involved in insurance. He was a consultant and a director of a life insurance association, and published multiple articles in the London-based *Journal of the Institute of Actuaries*.

Today, the most common application of life tables is pricing insurance products, with estimates by risk factor (e.g. smoking, occupation, location, and marital status). Statistical techniques account for these differences in risk, while also capturing the uncertainty in life expectancy that cannot be attributed to individual factors.

Modern techniques also enable actuaries to study mortality in both healthy and disabled states and capture the probability of transitions between these states (Figure 11). This is important for pricing long-term care insurance. Some companies are now able to offer life expectancy estimates based on very limited data. Some have used machine learning algorithms to estimate a person's physiological age based on only a selfie.

FIGURE 11. US FEMALE TRANSITION RATES BY AGE



Source: Adapted from Fong, Shao and Sherris (2015)

9. HEALTH EXPENDITURE

HELEN JORDAN

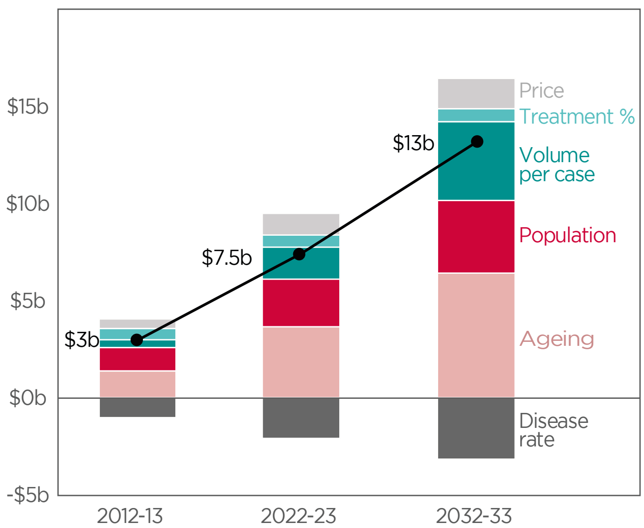
Healthcare is costly: total public and private healthcare expenditure in Australia makes up around 10% of GDP. And these costs are predicted to rise: the Australian Government projects that its healthcare spending will rise from 4.2% of GDP in 2015 to 5.7% in 2055 (Commonwealth Treasury 2015).

Such projections are driven by demographic factors, such as ageing and population growth; and non-demographic factors, such as the demand for healthcare, prices, technological changes, and efficiency gains.

Disease-level expenditure forecasts by the Australian Institute of Health and Welfare capture these factors for each disease group (Goss 2008). For example, expenditure related to cardiovascular disease was projected to more than double between 2003 and 2033 to about $22b (Figure 12). A substantial increase in spending is projected to come from population ageing, accounting for one quarter of the increase in total health and aged-care expenditure over the projection period.

But a number of other factors could influence future healthcare expenditure that are not normally incorporated into cost projections. These include environmental changes, migration due to conflict and natural disasters, socio-economic conditions, new diseases, and antibiotic resistance.

FIGURE 12. PROJECTED CHANGE IN EXPENDITURE ON CARDIOVASCULAR DISEASE FROM 2003



Source: Adapted from Goss (2008)

10. HOW TO EXTEND LIVES

ALAN LOPEZ

When thinking about how to extend life expectancies, it helps to understand the past. The mortality transition in Australia took place in phases as shown in Figure 13 and also described in Section 3.

Evidence links mortality developments in the 1960s and 1970s to tobacco. Smoking prevalence rose in Australia in the first half of the 20th century, peaking in the 1950s for men and 1960s for women. The consequences were felt decades later when these cohorts entered middle and late ages. Smokers in Australia can expect to live around 10 years less than non-smokers (Figure 14).

Since the 1980s there have been large falls in mortality from major vascular diseases, due to changes in key risks (lower smoking) and better medical management. The male-female life expectancy gap almost halved over this period, as men benefitted more from reductions in smoking, better road safety, and improved medical management. The death rate from motor vehicle accidents has fallen by 80 per cent, and HIV/AIDS mortality has remained comparatively low.

So what does the future hold? Lopez proposed looking at tobacco usage, obesity, drug and alcohol usage, healthcare access and compliance, and the possibility of cures for major diseases such as cancer.

Tobacco usage has declined in Australia alongside public health interventions. Continued attention could lower usage further (e.g. to 5% rate among GPs; Figure 15).

But obesity prevalence has risen since the 1980s, particularly among women, driven by changes in diet and lifestyle (Figure 16). The historic focus on lowering fat intake to the neglect of carbohydrates and total calorific intake didn't help. Obesity does appear to increase mortality risk, but the aggregate impact is uncertain. For example, we don't know if the risk increase from obesity rises with the exposure period (as with smoking).

Australia has moderate rates of alcohol-related mortality, and per capita alcohol consumption has fallen. At the same time, there is evidence that the alcohol consumption of high-risk drinkers may have recently risen. The effect of this polarisation on life expectancy is also unclear.

Future falls in cancer mortality are likely to come from both behavioural change (lower smoking and better diets) and from better medicine (such as vaccines and immunotherapy). Hormone therapies have significantly lowered breast cancer mortality over the past 25 years. There is also increasing evidence that simple preventative medicines, such as statins, can significantly lower vascular disease mortality.

Recent increases in life expectancy have been accompanied by an expansion of morbidity: more years of life lived with disabilities. The biggest causes are depression, musculoskeletal conditions, neurological disorders and diabetes. Lopez suggested that adding "life to years" ought to become a new goal for public policy.

Lopez concluded that the large increases in life expectancy in Australia of the past 40 years are unlikely to be repeated. Gains will be made mainly from more tobacco control and better medicine. But without large changes to the health system, or other bold public policy initiatives, these gains will probably be at half the rate seen over past decades.

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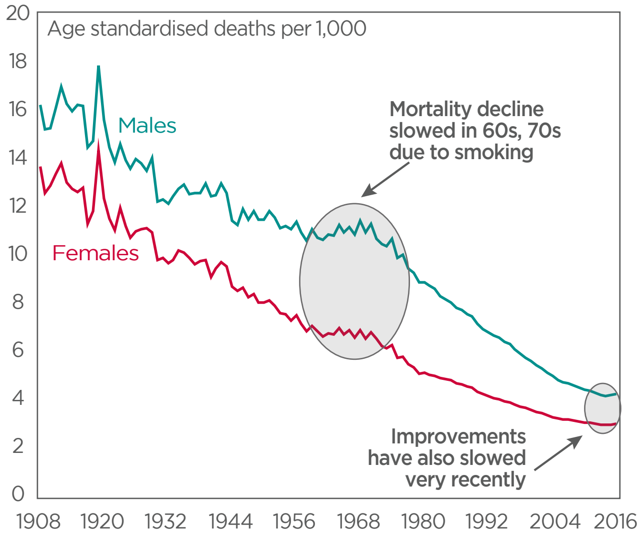
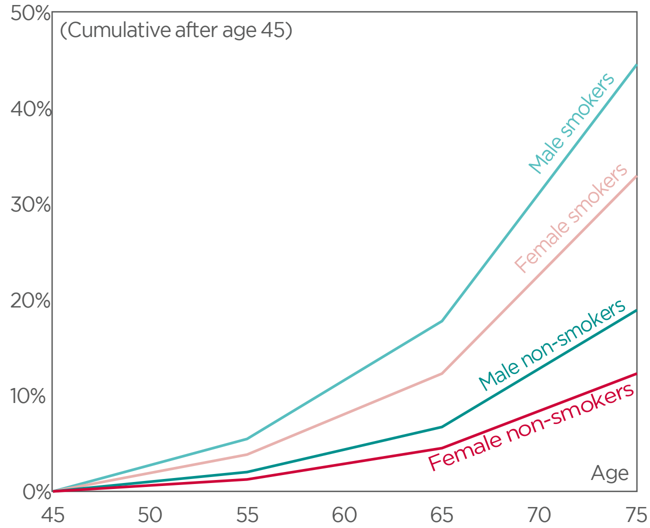
* Material not otherwise referenced is based on work of the presenters
** Presented at 'Mortality in Australia: Marking the 150th anniversary of the first Australian life table' in Melbourne

FIGURE 13. AUSTRALIAN DEATH RATES



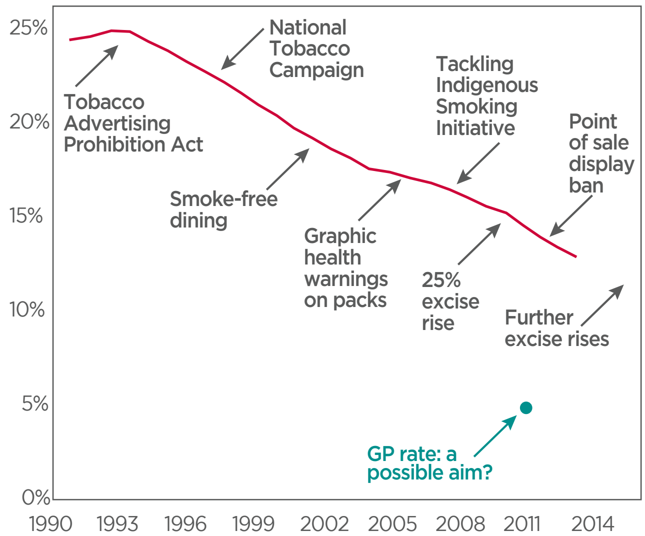
Source: Adapted from Lopez (2017)

FIGURE 14. RISK OF DEATH BY SMOKING STATUS



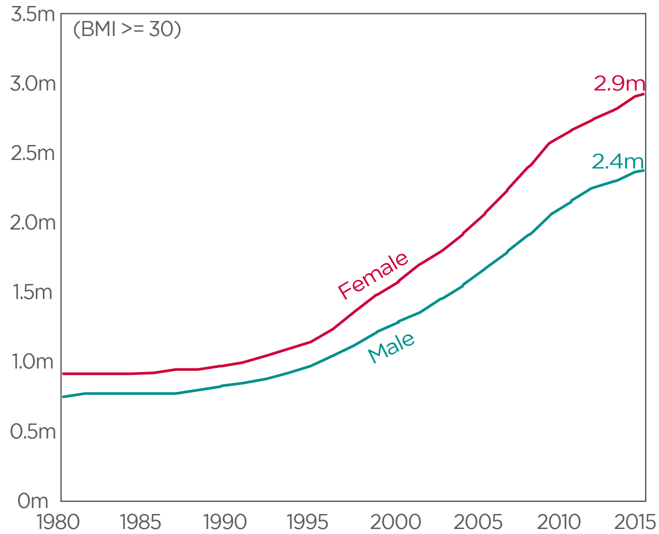
Source: Adapted from Banks et al (2015)

FIGURE 15. SMOKING PREVALENCE IN AUS.



Source: Adapted from Lopez (2017)

FIGURE 16. NUMBER OF OBESE AUSTRALIANS



Source: Adapted from Lopez (2017)

AUSTRALIAN LIFE TABLE, 2014-16

For each exact age x...

...the life table shows the risk of dying before turning one year older...

...and the expected remaining years of life (if rates in 2014-16 applied in future)

	Male		Female			Male		Female			Male		Female			Male		Female			Male		Female	
x	qx	ex	qx	ex	x	qx	ex	qx	ex	x	qx	ex	qx	ex	x	qx	ex	qx	ex	x	qx	ex	qx	ex
0	0.36%	80.4	0.33%	84.6	20	0.06%	61.0	0.02%	65.0	40	0.14%	41.8	0.08%	45.4	60	0.68%	23.8	0.40%	26.7	80	4.79%	8.9	3.19%	10.4
1	0.03%	79.7	0.02%	83.8	21	0.06%	60.0	0.02%	64.0	41	0.15%	40.9	0.09%	44.5	61	0.73%	22.9	0.43%	25.8	81	5.41%	8.3	3.64%	9.7
2	0.02%	78.8	0.01%	82.9	22	0.06%	59.0	0.02%	63.0	42	0.17%	39.9	0.09%	43.5	62	0.79%	22.1	0.46%	24.9	82	6.11%	7.7	4.19%	9.1
3	0.01%	77.8	0.01%	81.9	23	0.06%	58.1	0.03%	62.1	43	0.18%	39.0	0.10%	42.6	63	0.86%	21.3	0.50%	24.1	83	6.90%	7.2	4.81%	8.4
4	0.01%	76.8	0.01%	80.9	24	0.06%	57.1	0.03%	61.1	44	0.19%	38.1	0.11%	41.6	64	0.93%	20.4	0.55%	23.2	84	7.79%	6.7	5.54%	7.8
5	0.01%	75.8	0.01%	79.9	25	0.07%	56.2	0.03%	60.1	45	0.20%	37.1	0.12%	40.6	65	1.01%	19.6	0.60%	22.3	85	8.80%	6.2	6.36%	7.3
6	0.01%	74.8	0.01%	78.9	26	0.07%	55.2	0.03%	59.1	46	0.22%	36.2	0.13%	39.7	66	1.10%	18.8	0.66%	21.4	86	9.93%	5.8	7.28%	6.7
7	0.01%	73.8	0.01%	77.9	27	0.07%	54.2	0.03%	58.1	47	0.23%	35.3	0.14%	38.7	67	1.20%	18.0	0.73%	20.6	87	11.16%	5.4	8.32%	6.2
8	0.01%	72.8	0.01%	76.9	28	0.07%	53.3	0.03%	57.1	48	0.25%	34.4	0.15%	37.8	68	1.33%	17.2	0.81%	19.7	88	12.49%	5.0	9.51%	5.7
9	0.01%	71.8	0.01%	75.9	29	0.07%	52.3	0.03%	56.2	49	0.28%	33.5	0.17%	36.9	69	1.46%	16.5	0.90%	18.9	89	13.92%	4.6	10.85%	5.3
10	0.01%	70.8	0.01%	74.9	30	0.08%	51.3	0.04%	55.2	50	0.30%	32.5	0.18%	35.9	70	1.61%	15.7	0.99%	18.0	90	15.46%	4.3	12.36%	4.9
11	0.01%	69.8	0.01%	73.9	31	0.08%	50.4	0.04%	54.2	51	0.32%	31.6	0.20%	35.0	71	1.78%	14.9	1.11%	17.2	91	17.09%	4.0	14.00%	4.5
12	0.01%	68.8	0.01%	72.9	32	0.09%	49.4	0.04%	53.2	52	0.35%	30.7	0.21%	34.0	72	1.98%	14.2	1.23%	16.4	92	18.81%	3.7	15.76%	4.1
13	0.01%	67.8	0.01%	71.9	33	0.09%	48.5	0.05%	52.2	53	0.38%	29.8	0.23%	33.1	73	2.19%	13.5	1.38%	15.6	93	20.57%	3.5	17.62%	3.8
14	0.02%	66.9	0.01%	70.9	34	0.10%	47.5	0.05%	51.3	54	0.41%	29.0	0.25%	32.2	74	2.44%	12.8	1.55%	14.8	94	22.33%	3.2	19.60%	3.5
15	0.02%	65.9	0.02%	70.0	35	0.11%	46.6	0.05%	50.3	55	0.45%	28.1	0.27%	31.3	75	2.72%	12.1	1.74%	14.0	95	23.89%	3.0	21.63%	3.3
16	0.03%	64.9	0.02%	69.0	36	0.11%	45.6	0.06%	49.3	56	0.49%	27.2	0.29%	30.4	76	3.03%	11.4	1.96%	13.3	96	25.53%	2.8	23.74%	3.0
17	0.04%	63.9	0.02%	68.0	37	0.12%	44.7	0.06%	48.3	57	0.53%	26.3	0.32%	29.4	77	3.38%	10.7	2.20%	12.5	97	27.43%	2.6	25.86%	2.8
18	0.05%	62.9	0.02%	67.0	38	0.12%	43.7	0.07%	47.4	58	0.57%	25.5	0.34%	28.5	78	3.78%	10.1	2.48%	11.8	98	29.58%	2.5	27.95%	2.6
19	0.05%	61.9	0.02%	66.0	39	0.13%	42.8	0.07%	46.4	59	0.62%	24.6	0.37%	27.6	79	4.25%	9.5	2.80%	11.1	99	32.00%	2.3	29.93%	2.5

Source: ABS (2017). Note: Period measures of life expectancy don't take account of future mortality improvements so may under-estimate years of expected life.