Australian Government
Centre for Population

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Australian Government Actuary

# LIFE TABLES BY STATE AND TERRITORY

A MICRODATA APPROACH TO RESIDENT SUB-GROUP LIFE TABLES

PREPARED BY THE AUSTRALIAN GOVERNMENT ACTUARY FOR THE CENTRE FOR POPULATION

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*Strong evidence. Deep insights. Collaborative approach.*

Manager
Media and Speeches Unit
The Treasury
Langton Crescent
Parkes ACT 2600
Email: media@treasury.gov.au

## CONTENTS

# 1. Introduction

## 1.1 Background and purpose

The Australian Government Actuary (AGA) prepared this paper for the Centre for Population (the Centre) to inform assumptions about Australia's future mortality. The Centre asked AGA to investigate the mortality experience of sub-groups of the Australian resident population. This paper explores the mortality experience of each state and territory. These state and territory life tables are based on the mortality of male and female Australian residents over the 2015 and 2016 calendar years. The AGA have also prepared separate papers exploring the different mortality experiences of: Australian-born and overseas-born Australian residents; and residents classified by relative socio-economic advantage and disadvantage.

In contrast to the AGA's Australian Life Tables and the life tables produced by the Australian Bureau of Statistics (ABS), this sub-group life table project uses confidential microdata to investigate the mortality experience of the population sub-groups of interest. This microdata is sourced from the ABS DataLab as part of the Multi-Agency Data Integration Project (MADIP). We thank the ABS for access to this confidential unit record data. A disclaimer on the use of this data is provided in section 1.2 .

The lead researchers of this work are Jesse Braid and Limin Wang of the AGA, Treasury, and Guy Thorburn, the Australian Government Actuary. Aaron Bruhn, also of the AGA, provided an additional review.

## 1.2 Disclaimer

Legislative requirements ensure that privacy and secrecy of the data is maintained. For access to MADIP data under Section 16A of the *Australian Bureau of Statistics Act 1975* or enabled by section 15 of the Census and Statistics (Information Release and Access) Determination 2018, source data is de-identified. Data about specific individuals has not been viewed in conducting this analysis. In accordance with the Census and Statistics Act 1905, results have been treated where necessary to ensure that they are not likely to enable identification of a particular person or organisation.

The results of these studies are based, in part, on migration data supplied by the Department of Home Affairs (Home Affairs) to the ABS under the *Australian Border Force Act 2015*, which requires that such data is only used for the purposes of the *Census and Statistics Act 1905* or performance of functions of the ABS as set out in section 6 of the *Australian Bureau of Statistics Act 1975*. Any discussion in this paper of data limitations or weaknesses is in the context of using the data for this specific purpose, and not related to the ability of the data to support Home Affairs' core operational requirements.

# 2. Methodology

## 2.1 Data

In contrast to the traditional approach of calculating mortality rates from grouped data, these sub-group life tables are based on unit record data comprising the entire resident population of interest. This allows us to analyse mortality experience at the level of an individual, which can then be aggregated to form the specific sub-groups of interest, from which the population-level mortality tables can be determined.

We have relied on the MADIP Basic Longitudinal Extract data (BLE 2011-2016). This is formed from the Medical Enrolment Data Base (MEDB), Social Security Related Information (SSRI), Personal Income Tax (PIT) and 2016 Census data. The BLE serves as a base data set that represents the population normally resident in Australia.

In addition to BLE 2011-2016, registries death data and the quarterly Home Affairs net overseas migration data (from Q1 2006 to Q4 2017) were also used.

To determine where a death should be assigned, the data provides a choice between the state or territory of the registration of death or the state or territory of residency. This is only an issue of any significance for deaths of New South Wales (NSW) residents that were registered in the Australian Capital Territory (ACT). This study uses residency data. The alternate approach would have overstated ACT mortality rates.

## 2.2 Crude mortality rates

The calculation of the crude mortality rates requires a measure of both the number of deaths and the population which was at risk of dying over the same period. These need to be calculated for each age and gender.

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 exposed-to-risk only if their death (had they died) would have been included in the relevant death count. Deaths in this paper refer to those who were residents and whose death occurred in Australia during the calendar years 2015 and 2016. The appropriate exposed-to-risk is, therefore, exposure of people who were residents of Australia during the same period.

To determine the exposed-to-risk, we identified all individuals within the BLE 2011-2016 data who had any activity in any particular year in Australia. Combining this extracted BLE data with both the death registration data, and the Home Affairs net overseas migration data, allowed the construction of an Australian resident population suitable for life table purposes.

The exposed-to-risk is calculated directly from the underlying dates (dates of residency, date of birth, and date of death if applicable) pertinent to each individual. This is referred to as the direct or individual exposure method, which is made possible via the available ABS DataLab microdata. The central exposed-to-risk is then calculated by aggregating the individual exposure for all individuals in the sub-group of interest.

The exposed-to-risk on 30 June 2016 differed slightly (<1 per cent) from the official estimated resident population (ERP) produced by the ABS, as at 30 June 2016. There are many legitimate reasons why the 2 data sources may not reconcile exactly. To maintain consistency with the official ERP, we developed a series of adjustment factors to apply to the exposures calculated from the MADIP population. Separate factors were developed for each age-gender-state combination. The 2015 resident population was based on the 2016 resident population, with further adjustments based on the occurrence of deaths as well as traveller data.

The crude mortality rates ($m_x$) are then calculated by dividing the number of deaths at a particular age and gender by the exposed-to-risk for that age.

## 2.3 Creation of sub-group life tables

Having established crude mortality rates for each age, gender and state or territory, life tables for each sub-group can be derived. The first step was to graduate (smooth) the crude rates up to age 97. Where the data was sufficiently rich to support a direct graduation (New South Wales, Victoria, Queensland, and Western Australia for both males and females, and South Australia for females) smoothing splines were used. Otherwise, crude rates were graduated using a Lidstone transformation with reference to the (smoothed) national mortality rates. This transformation is a technique used to smooth categorical data such as mortality.

Due to the sparseness of data beyond age 97, mortality rates were extrapolated to older ages using a Makeham curve. This is similar to the procedure adopted within the AGA Australian Life Tables 2015-17. It should be noted that, due to the sparsity of data, the exact shape of the extrapolated curve is quite subjective, and the resulting mortality rates are likely to exhibit a high variance at these older ages.

To determine appropriate mortality rates as at 30 June 2016, we added 0.5 years of age and gender-specific historic mortality improvement to the graduated mortality rates. This is because the data on which our analysis was based was from 1 January 2015 to 31 December 2016 – in other words, the experience across the 2 years occurred on average at 31 December 2015, or 6 months short of 30 June 2016. We sourced mortality improvement factors from the AGA Australian Life Tables 2015-2017.

Sixteen life tables were produced, one for each gender across each of the 8 states and territories.

### 2.4 Statistical tests of fit

All tables were subject to a series of statistical tests to assess the quality of the graduation. Similar to the testing conducted for the AGA Australian Life Tables 2015-17, these tests indicated that the deviations between the crude rates and graduated rates were consistent with the hypothesis that the observed deaths represented a random sample from an underlying mortality distribution following the smoothed rates. Applying 7 different tests to each of the 16 life tables meant 112 tests altogether were conducted. Of these, 105 (94 per cent) tests passed. Where some tests failed, it was predominantly due to exceptionally sparse data swaying or biasing some results, such as zero death counts for some younger ages. The test results for males and females are shown in Table 1 and Table 2.

Table 1. Statistical tests (Males)

| Test | NSW | VIC | QLD | SA | WA | TAS | NT | ACT |
|---|---|---|---|---|---|---|---|---|
| Chi-squared | Pass | Pass | Pass | Pass | Pass | Fail | Pass | Fail |
| Standardised deviations | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass |
| Absolute deviations | Pass | Pass | Pass | Pass | Pass | Fail | Pass | Pass |
| Cumulative deviations | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass |
| Sign test | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass |
| Grouping of signs | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass |
| Change of sign test | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass |

Table 2. Statistical tests (Females)

| Test | NSW | VIC | QLD | SA | WA | TAS | NT | ACT |
|---|---|---|---|---|---|---|---|---|
| Chi-squared | Pass | Pass | Pass | Pass | Fail | Pass | Pass | Pass |
| Standardised deviations | Pass | Pass | Pass | Pass | Pass | Fail | Fail | Fail |
| Absolute deviations | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass |
| Cumulative deviations | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass |
| Sign test | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass |
| Grouping of signs | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass |
| Change of sign test | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass |

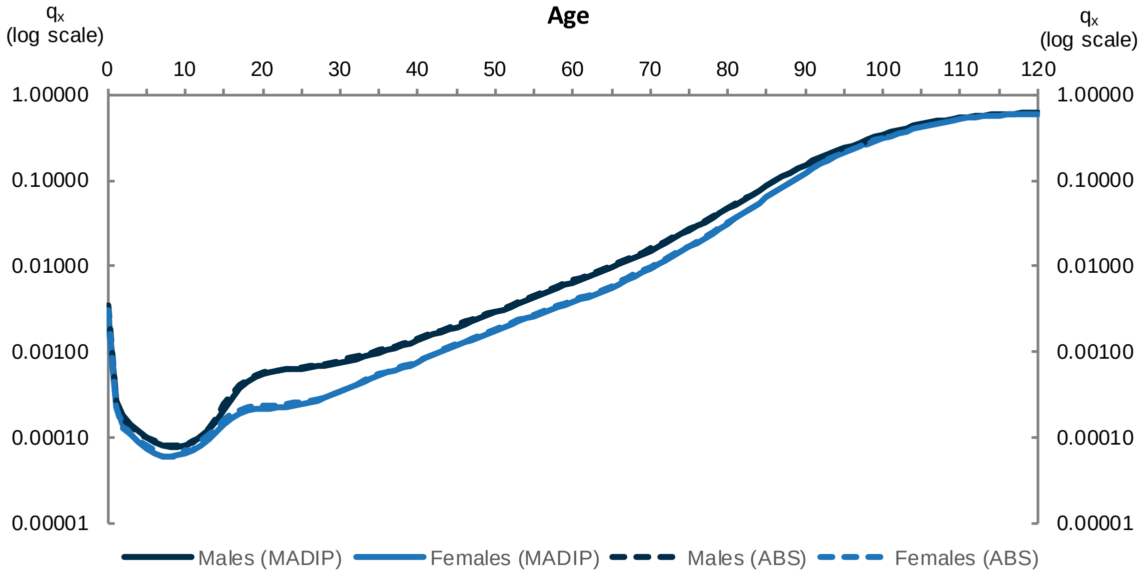
## 3. Results

We present the results for each of the 16 life tables in aggregate for Australia as a whole, then by gender across the 8 states and territories, then within each state and territory.

### 3.1 Aggregate results

The aggregate mortality for Australia is shown in Chart 1, for each gender. The gender-specific differences in mortality are, as expected, present in this analysis and closely resemble the differences exhibited in the ABS life tables. Results for each gender also closely align to the respective ABS life table, and we observe a smoother fit for this analysis for females in particular, than is the case for the ABS life table.

**Chart 1. Australian mortality rates, 30 June 2016**




## 3.2 Results by gender, for each state and territory

The mortality for each gender, across each state and territory, is given in Chart 2 and Chart 3.

For both males and females, some differences are apparent between the states and territories. Despite the lower volume of data in the smaller states and territories, relativities between all states and territories are broadly similar to that evident in the ABS state life tables. We discuss that further in the next section.

The Northern Territory (NT) and Tasmania have the highest mortality rates, though NT males at older ages do have good experience relative to other states and territories. This too is a feature of the ABS life tables.

Slight differences also exist in the accident hump for males in their early 20s, which relates to the range of ages of young adults when they experience a period of excess mortality. This excess mortality is generally attributed to the propensity of young adults, particularly males, to engage in riskier behaviours than those outside this age range. Some states retain a feature of level (or slightly decreasing) mortality for the population aged between 20 and 30 (for example the ACT), while others (such as SA) exhibit more consistently increasing mortality throughout this age range.

**Chart 2.** **MALE MORTALITY RATES BY STATE AND TERRITORY, 30 JUNE 2016**

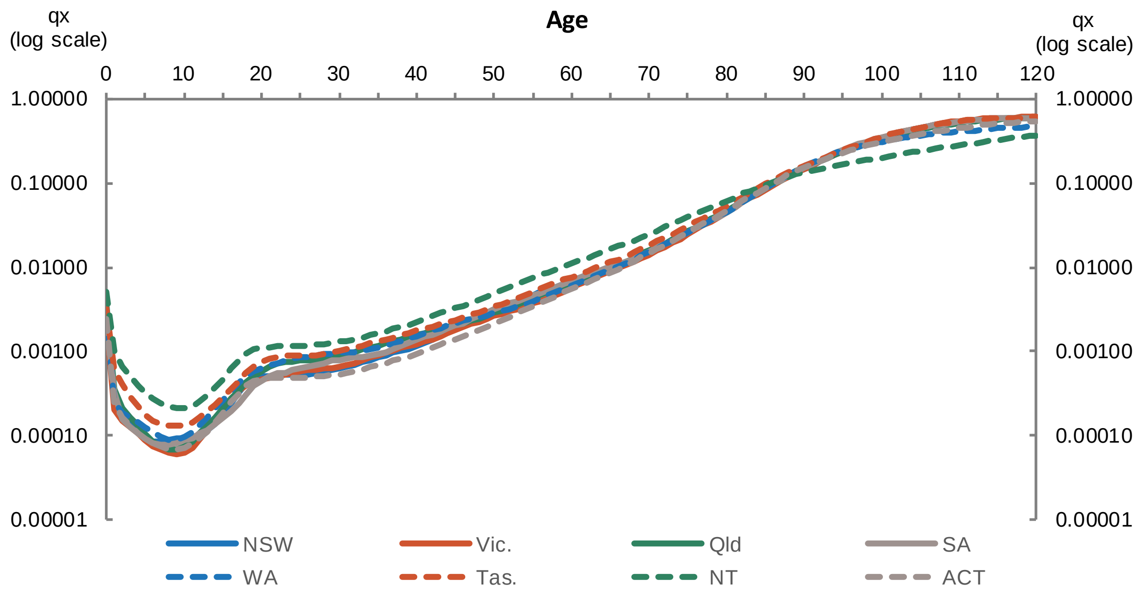
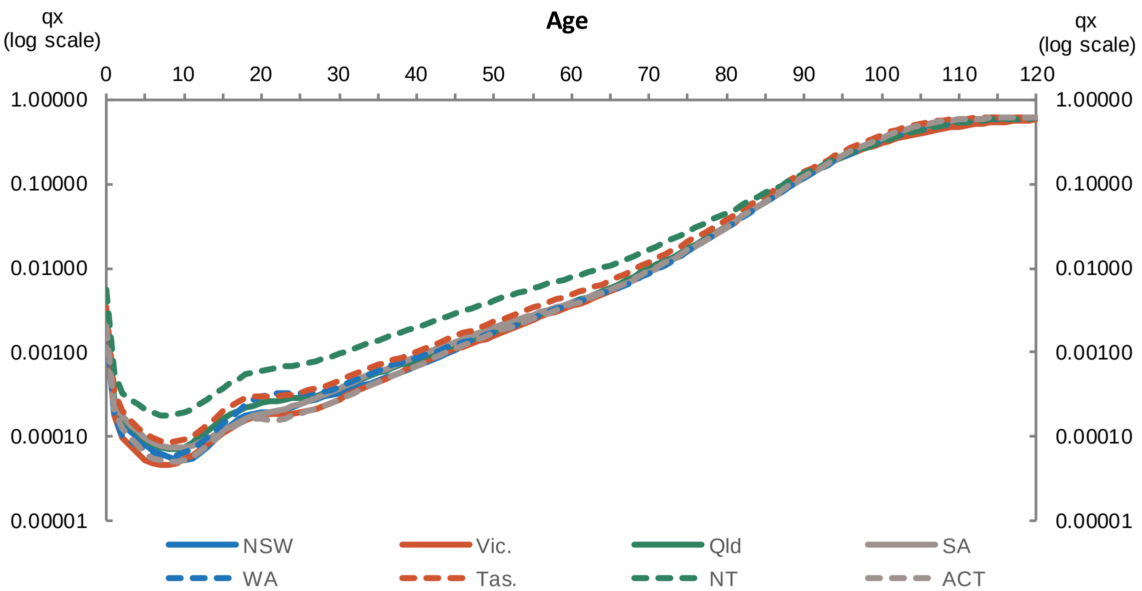



**Chart 3.** **FEMALE MORTALITY RATES BY STATE AND TERRITORY, 30 JUNE 2016**




The mortality for each state and territory, split by gender, is shown in Charts 4 to 11. Consistent across all states and territories, as expected, is that females experience lower mortality than males. The crossover of relative mortality at very old ages is also apparent for all states and territories, other than NSW and Victoria. This feature is most apparent in the NT, where it begins to emerge at the age of 90.

Again, a range of differences between states and territories are evident. This includes the relative gaps between males and females around the age of the traditional accident hump.

To a degree some differences are related to the extent which smoothing of crude mortality rates is applied at ages with very sparse data – particularly the experience for the very young in all but the largest states. Relative experience may also change with the period of investigation, for example, the addition of a third year. Nevertheless, a relatively consistent methodology across all jurisdictions shows subtle differences that are based on the experience itself.

**Chart 4.** NEW SOUTH WALES MORTALITY RATES, 30 JUNE 2016

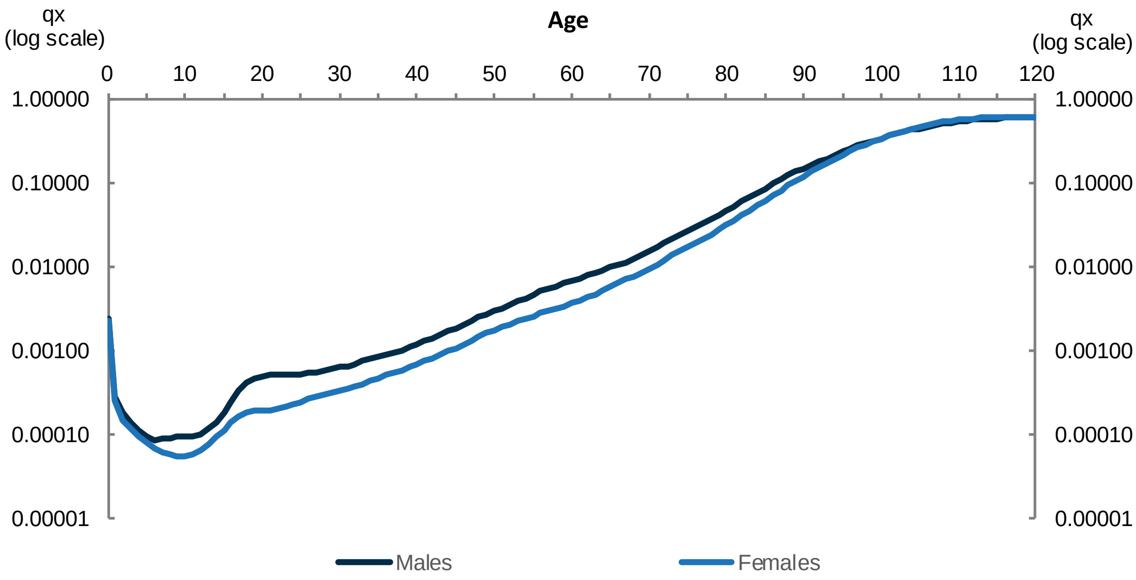



**Chart 5.** VICTORIA MORTALITY RATES, 30 JUNE 2016

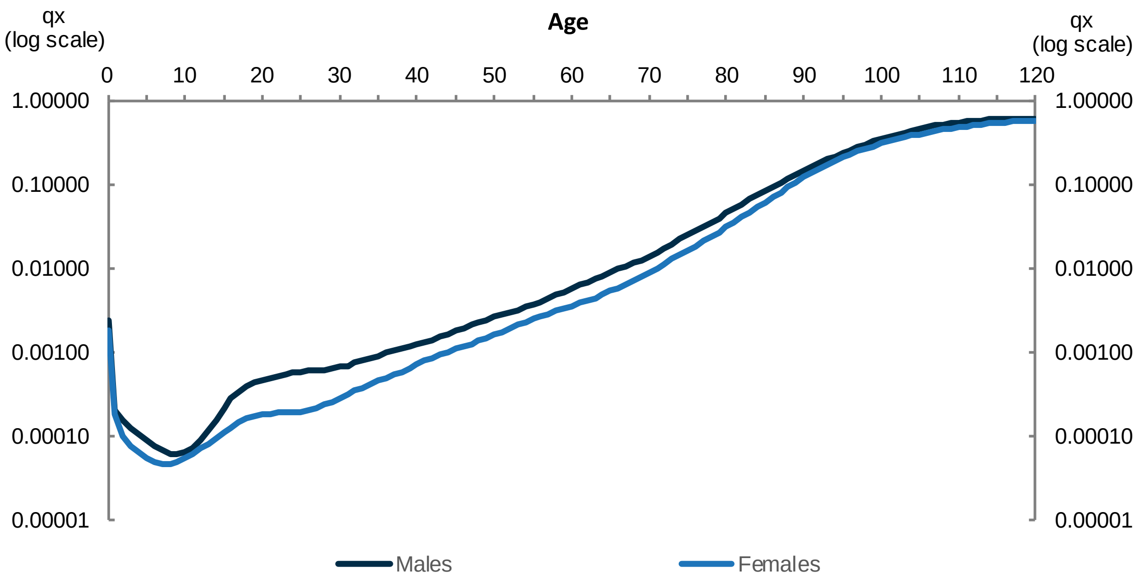


**Chart 6.** **Queensland mortality rates, 30 June 2016**

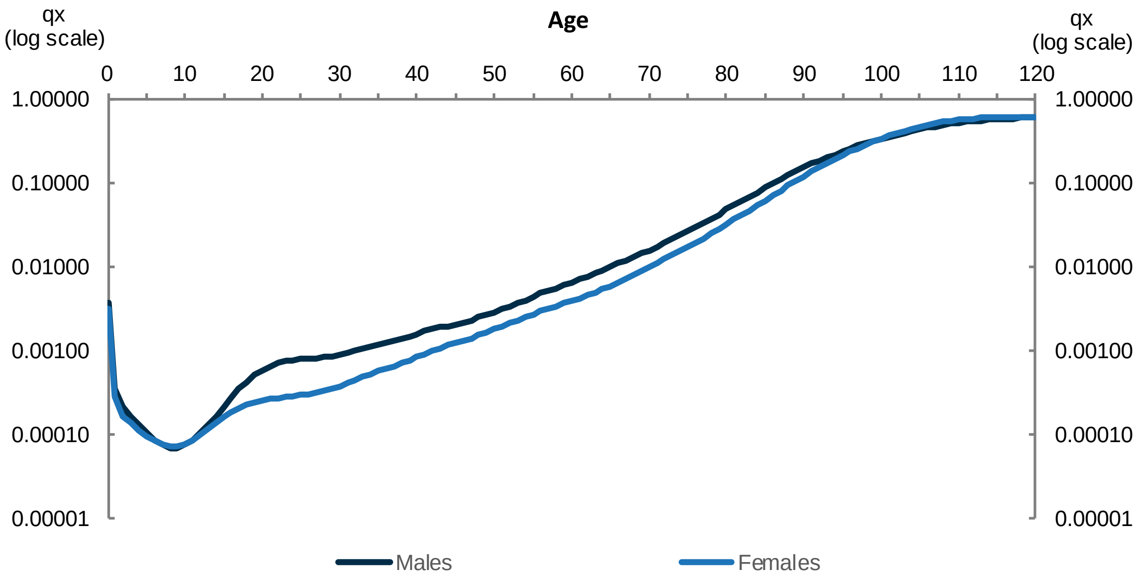



**Chart 7.** **South Australia mortality rates, 30 June 2016**

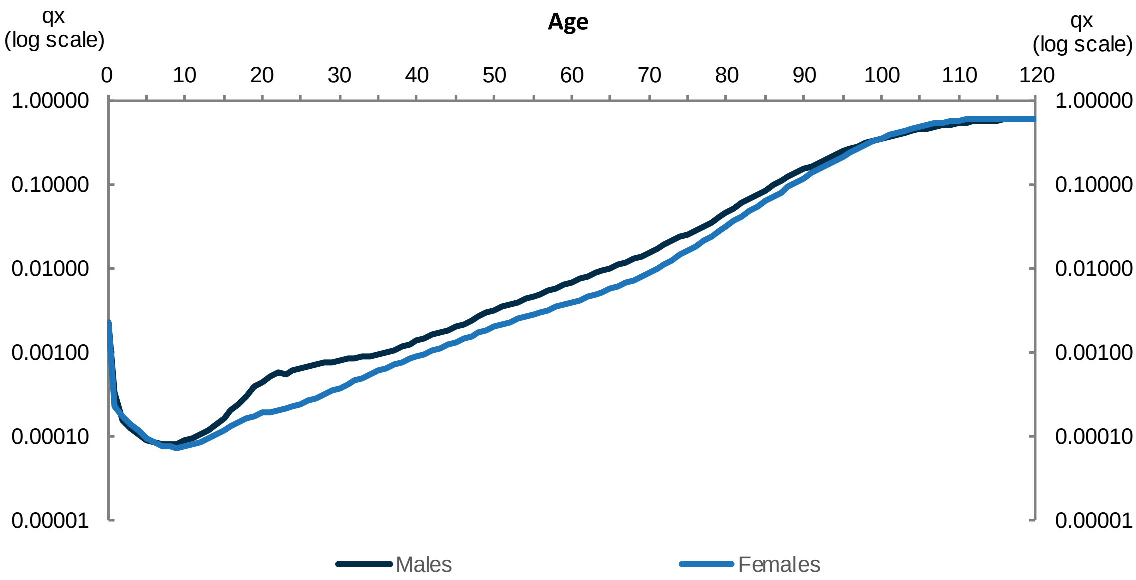


**Chart 8.** **WESTERN AUSTRALIA MORTALITY RATES, 30 JUNE 2016**

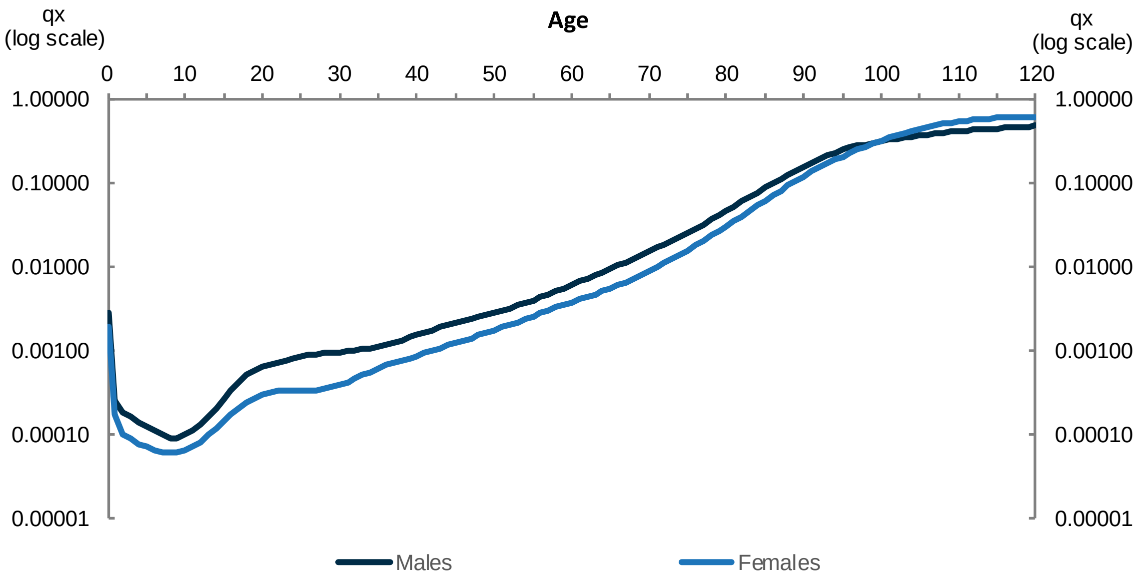



**Chart 9.** **TASMANIA MORTALITY RATES, 30 JUNE 2016**

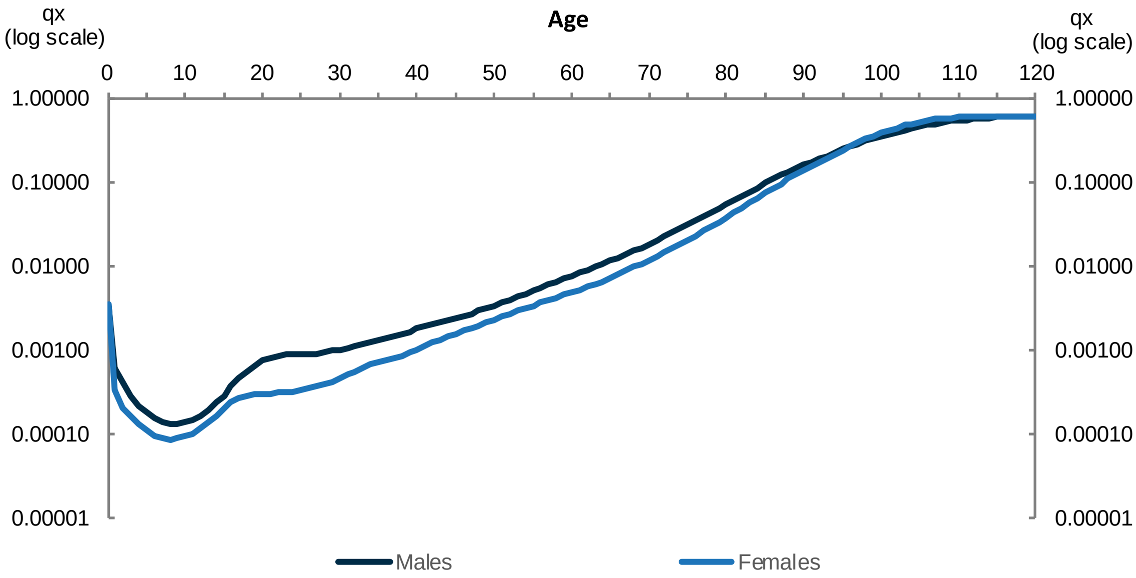


**Chart 10. Northern Territory mortality rates, 30 June 2016**

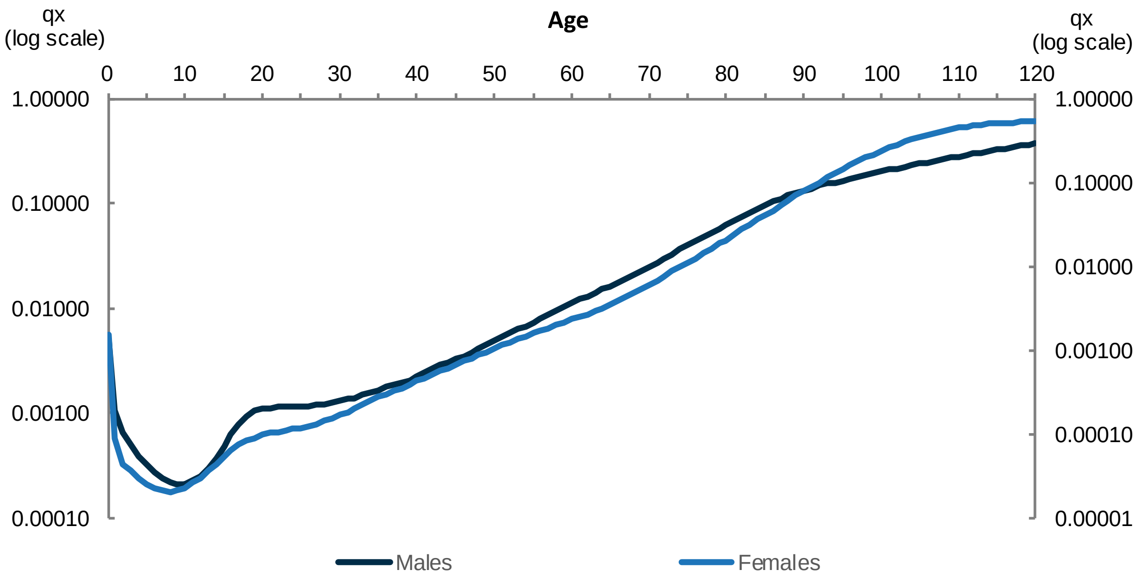
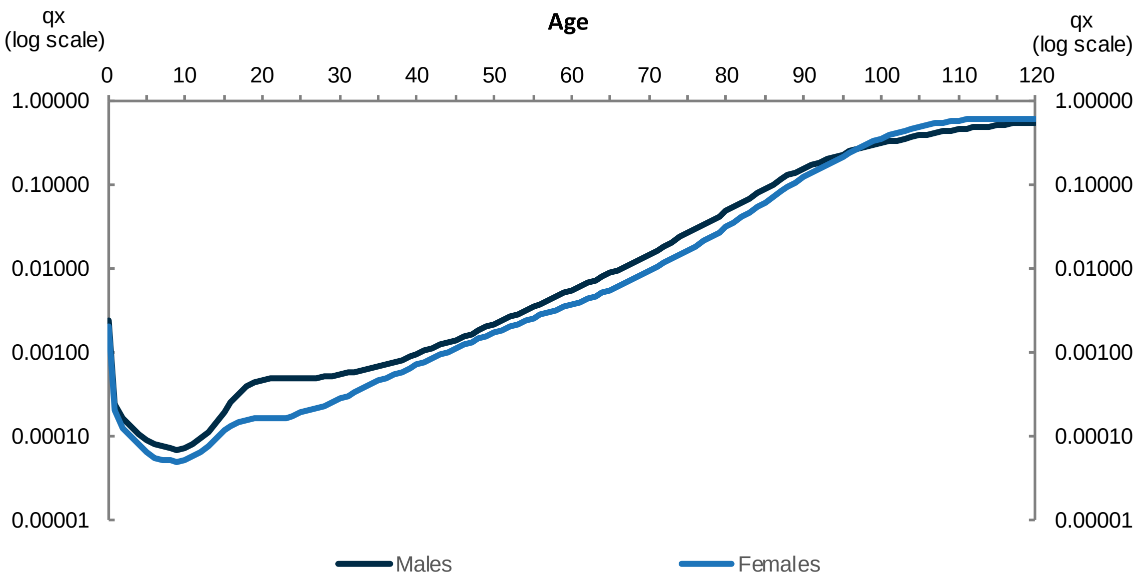



**Chart 11. Australian Capital Territory mortality rates, 30 June 2016**




# 4. Discussion

Differences between states and territories closely resemble those apparent in the ABS state life tables. This is despite the use of:

- 2 years of data in this study, compared to 3 years used for the ABS tables
- different data sources, and
- different approaches.

Relativities between states and territories also hold across the genders. This can be seen by examining the inferred life expectancies, for various ages, for both the sub-group and the aggregate Australian populations. Firstly, in terms of aggregate Australian experience, we compare the life expectancies at ages 0, 25, 65 and 85 between the approach in this paper, and those arising from the AGA's Australian Life Tables 2015-17 and from the ABS life tables.

**Table 3. DIFFERENCES IN NATIONAL LIFE EXPECTANCIES AT SELECTED AGES, 30 JUNE 2016**

| | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| Age | 0 | 25 | 65 | 85 | 0 | 25 | 65 | 85 |
| Australian Life Tables 2015-17 | 80.8 | 56.5 | 19.9 | 6.4 | 84.9 | 60.4 | 22.5 | 7.4 |
| MADIP microdata 2016 | 80.9 | 56.5 | 19.9 | 6.3 | 84.9 | 60.3 | 22.5 | 7.3 |
| ABS life tables 2015-17 | 80.5 | 56.2 | 19.7 | 6.3 | 84.6 | 60.1 | 22.3 | 7.3 |

Given the differences, there is remarkably close alignment of life expectancies at all selected ages. The biggest difference is 0.4 years, between this study and the ABS life tables, for males at birth (equating to a 0.5 per cent difference).

We now compare the specific state and territory life expectancies at the same ages as Table 3, across the 2 mortality studies in question. As would be expected when splitting aggregate data into smaller sub-groups, some differences across different methodologies increase, for some sub-groups.

**Table 4. MADIP MICRODATA LIFE EXPECTANCIES AT SELECTED AGES ACROSS STATES AND TERRITORIES, 30 JUNE 2016**

| | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| Age | 0 | 25 | 65 | 85 | 0 | 25 | 65 | 85 |
| New South Wales | 81.0 | 56.6 | 19.9 | 6.4 | 85.0 | 60.4 | 22.5 | 7.3 |
| Victoria | 81.5 | 57.1 | 20.2 | 6.4 | 85.3 | 60.6 | 22.6 | 7.3 |
| Queensland | 80.5 | 56.2 | 19.7 | 6.3 | 84.7 | 60.2 | 22.4 | 7.4 |
| South Australia | 80.8 | 56.3 | 19.8 | 6.3 | 84.8 | 60.2 | 22.5 | 7.3 |
| Western Australia | 80.7 | 56.4 | 19.9 | 6.2 | 85.1 | 60.5 | 22.7 | 7.4 |
| Tasmania | 79.0 | 54.9 | 18.8 | 6.0 | 82.9 | 58.5 | 21.2 | 6.7 |
| Northern Territory | 76.3 | 52.7 | 17.9 | 6.9 | 79.5 | 55.5 | 20.0 | 6.8 |
| Australian Capital Territory | 81.6 | 57.2 | 19.9 | 6.2 | 85.1 | 60.5 | 22.5 | 7.3 |

**Table 5. ABS 2015-17 LIFE EXPECTANCIES AT SELECTED AGES ACROSS STATES AND TERRITORIES, 30 JUNE 2016**

| | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| Age | 0 | 25 | 65 | 85 | 0 | 25 | 65 | 85 |
| New South Wales | 80.3 | 55.9 | 19.4 | 6.1 | 84.6 | 60.1 | 22.3 | 7.3 |
| Victoria | 81.3 | 56.9 | 20.0 | 6.3 | 85.0 | 60.4 | 22.4 | 7.2 |
| Queensland | 80.0 | 55.8 | 19.5 | 6.0 | 84.4 | 60.0 | 22.3 | 7.4 |
| South Australia | 80.3 | 55.9 | 19.6 | 6.2 | 84.5 | 60.0 | 22.4 | 7.3 |
| Western Australia | 80.3 | 56.1 | 19.7 | 6.2 | 84.9 | 60.3 | 22.7 | 7.4 |
| Tasmania | 78.7 | 54.6 | 18.5 | 5.9 | 82.9 | 58.5 | 21.1 | 6.6 |
| Northern Territory | 75.9 | 52.4 | 17.8 | 6.5 | 79.4 | 55.4 | 19.5 | 6.9 |
| Australian Capital Territory | 81.1 | 56.8 | 19.7 | 6.6 | 85.2 | 60.6 | 22.5 | 7.3 |

The largest absolute difference between this analysis and ABS life tables is 0.7 years for NSW males aged 0 and 25, which equates to a 1.3 per cent difference in the latter case. Although some differences are inevitable, the overall summary is that relatively close alignment is observed for both genders, across all states and territories.

Differences do exist between state and territories. The NT and Tasmania experience the lowest life expectancies at most ages for both males and females. The ACT and Victoria experience the highest. For males, life expectancies at age 0 range from 76.3 years in the NT to 81.6 years in the ACT. For females, life expectancies range from 79.5 years in the NT to 85.3 years in Victoria. The broad relativities by state and territory are similar across both this analysis and ABS life tables.

Of some note is that this study shows NT males have the highest life expectancy of those aged 85, and with the previously mentioned feature of the gender crossover of mortality at older ages, male life expectancy at age 85 even exceeds that of females in this territory.

## 5. Conclusion

Mortality modelling using microdata is a point of difference of this study, compared to the approaches the AGA uses to develop the Australian Life Table and the ABS uses to develop its life tables. The use of microdata allows a more detailed estimation of exposed-to-risk, which in turn opens the path for mortality investigations across new, previously unexplored sub-groups.

Although there are 3 key differences to the establishment of other life tables – in terms of data source, the data period being 2 years rather than 3 years, and the approach used – there is very close alignment in aggregate results across the life tables. This alignment generally also holds when results are broken down into state and territory sub-groups, with some minor differences both expected, and apparent.

The approach used passes a series of statistical tests that indicate the results of the overall graduation of the underlying crude mortality rates are sound and fit for purpose (adoption into Treasury population projections).

This study demonstrates the proof of concept for examining Australian sub-group mortality in this way. It suggests that sub-groups can be formed based on other variables of interest, with some confidence that appropriate mortality experience can be established, subject to the statistical checking and testing as described in this paper.

The results of this study show that some differences in mortality experience do exist across the states and territories. Victoria and the ACT generally have the lowest mortality for males and females, with Tasmania and the NT the highest. However, at older ages NT males in particular have better mortality than much of the rest of the country, with male mortality being better than female mortality from age 90 onwards.

At the oldest ages, male mortality appears lighter than female mortality in most states and territories. This is a feature of the AGA's Australian Life Tables 2015-17 and has been evident in all Australian Life Tables since 1990-92. While this pattern has been persistent for many years, it should always be remembered that the results at the oldest ages are subject to a higher level of uncertainty due to the smaller cohort of Australians reaching these ages.

Mortality at younger ages also differs between states and territories. The difference between male and female mortality through the years of the traditional accident hump is also differentiated across gender as well as states and territories. Some of these differences can be attributed to the consequence of very sparse data at young ages, which when smoothed using the graduation approaches adopted, can lead to differences being apparent. However, the mortality tables are simply reflecting differences in the data and underlying experience itself.