Australian Government
Centre for Population

Australian Government
Australian Government Actuary

LIFE TABLES BY RELATIVE SOCIO-ECONOMIC ADVANTAGE AND DISADVANTAGE

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.

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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 future mortality. The Centre asked the AGA to investigate the mortality experience of sub-groups of the Australian resident population. This paper explores the mortality experience of Australian residents by relative socio-economic advantage and disadvantage. The AGA have also prepared separate papers that explore the different mortality experiences of residents of different states and territories, and Australian-born and overseas-born Australian residents.

Socio-Economic Indexes for Areas (SEIFA) rank areas in Australia according to relative socio-economic advantage and disadvantage. The indexes are based on information from the 5-yearly Census of Population and Housing. The 4 indexes developed by the Australian Bureau of Statistics (ABS) are Index of Relative Socio-Economic Disadvantage (IRSD), Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD), Index of Economic Resources (IER), and Index of Education and Occupation (IEO).

These 4 indexes capture different aspects of socio-economic status, by area, arranged into deciles. Decile 10 represents the most advantaged and least disadvantaged areas, whereas decile 1 represents the least advantaged and most disadvantaged areas. As shown in Charts 1 and 2, the mortality experience per area (as measured by crude [aggregate] death rate) is relatively similar across each index. We have adopted IRSAD as the index for this paper. The strongest indicator for IRSAD is income.

Chart 1. Male crude death rates by SEIFA indexes, 30 June 2016

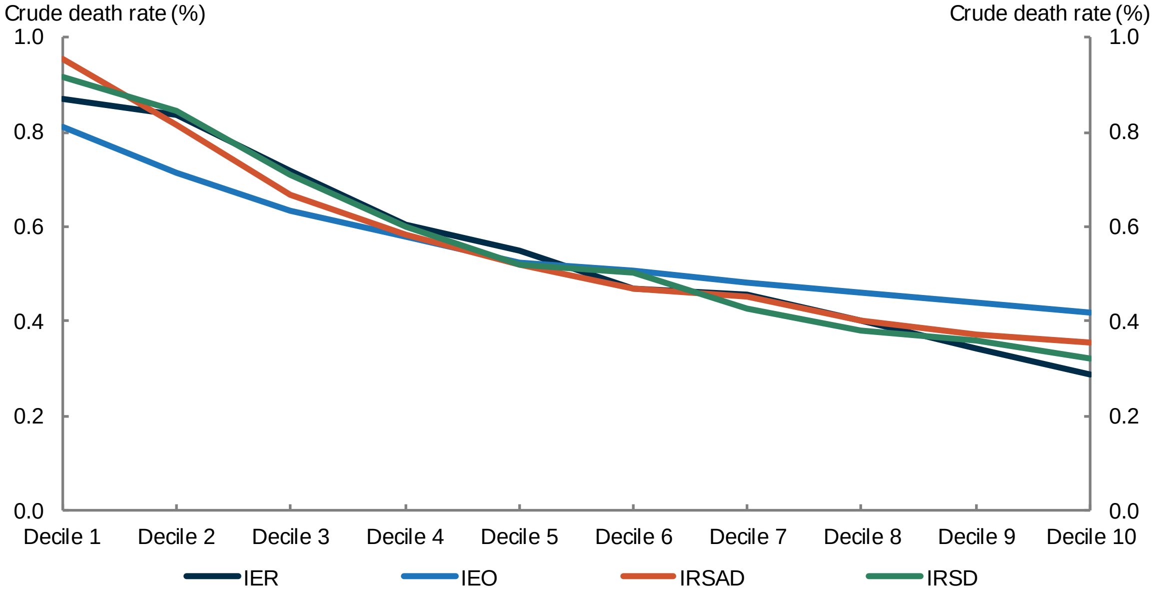
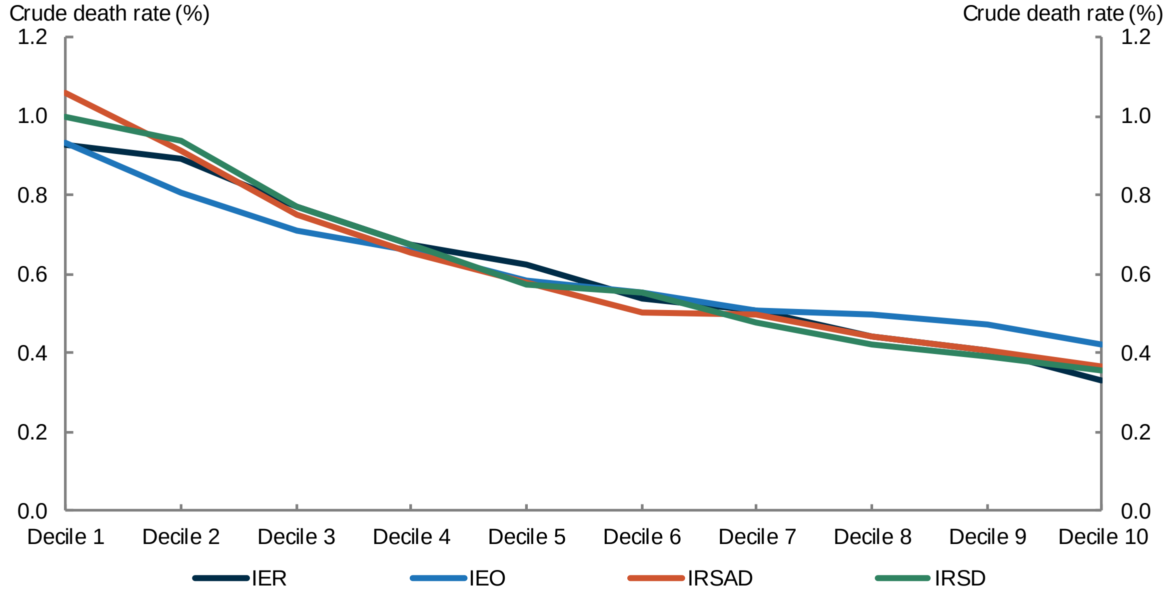


Chart 2. Female crude death rates by SEIFA indexes, 30 June 2016



Between different deciles, there are significant differences in death counts and therefore the mortality rate, given that the deciles have similar population size. For example, the number of deaths in decile 1 is twice the number of deaths in decile 10. This introduces an additional data challenge, with the underlying mortality experience based on less death data, for higher deciles.

As far as we are aware, this is the first comprehensive analysis of Australian mortality by SEIFA. The use of confidential microdata via the ABS DataLab as part of the Multi-Agency Data Integration Project (MADIP), allows this investigation to be undertaken. 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 Limin Wang (of the AGA) and Guy Thorburn (the Australian Government Actuary), with additional review provided by Aaron Bruhn (also of the AGA).

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

Similar to the prior AGA research papers, the generation of life tables by relative advantage and disadvantage are based on unit record data comprising the entire resident population of interest. This approach is particularly useful to analyse SEIFA mortality experience at a micro level, which can then be aggregated to form the specific sub-groups of interest.

We have used 'Statistical Area Level 1' (SA1) as the relevant specification of area, as differentials in mortality rates between SA1 areas are apparent. If using larger geographical areas than represented by SA1, the SEIFA-specific mortality experience is moderated more than the underlying SA1 data would suggest should be the case.

In terms of data specifying the relevant SEIFA location or residence, the MADIP Basic Longitudinal Extract data (BLE 2011 - 2016) provides most decile information at the SA1 level. However, approximately 3 to 4 per cent of microdata does not have a SEIFA decile indicator at this level. To reduce the quantum of missing SEIFA SA1 information, the file 'madip_sa1_long'[1] was used. The remnant population without an allocated SEIFA decile after the use of both data files was around 1.8 per cent

The death data provides age at death, gender, and state of death registration. The total number of deaths in 2015 and 2016 closely matches ABS published information. As for the residence data above, not all deaths were able to be linked back to usual residence or SEIFA area. With the ABS DataLab providing further death by SEIFA decile information, the missing SEIFA information was reduced to around 3.3 per cent.

However, the missing SEIFA death data was not uniformly distributed across ages. Chart 3 shows that missing death data by SEIFA is much more significant at younger ages. This is most prominently seen for deaths aged 0, for which approximately 77 per cent of deaths do not have SEIFA data.

The sparseness of death data at young ages adds another layer of uncertainty for estimating mortality rates at those ages.

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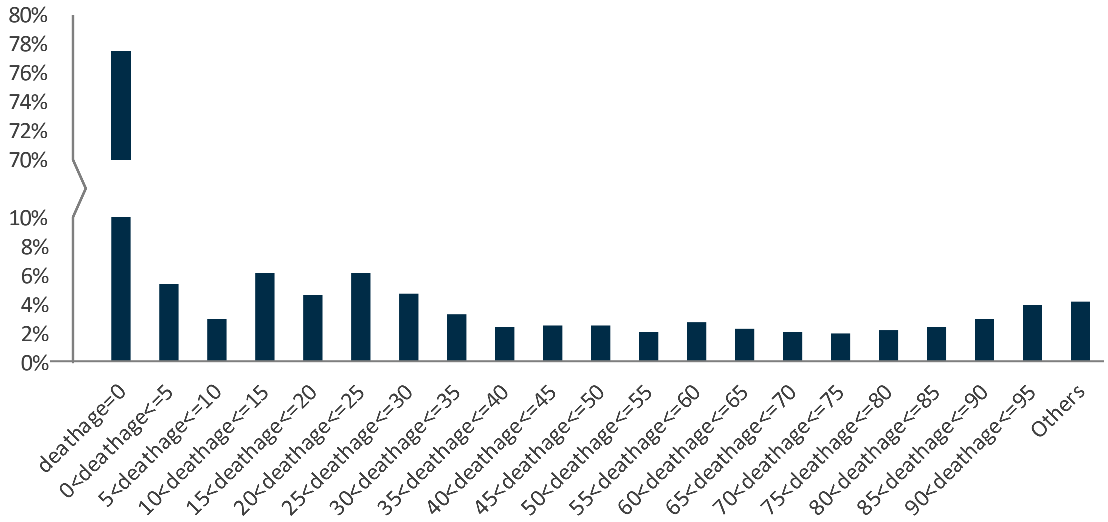
[1] Also termed 'intercensa1 location'.

Chart 3. PERCENTAGE OF MISSING SEIFA IN DEATH DATA



To allocate the 3.3 per cent of deaths without a SEIFA decile to the appropriate SEIFA decile, a probability simulation process was used. This used age at death, gender, and state information, to better target the simulated allocation of a relevant decile to those deaths without prior SEIFA information.

2.2 CRUDE MORTALITY RATES

The calculation of the crude central mortality rates requires a measure of 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, gender, and SEIFA decile.

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 2015 and 2016. The appropriate exposed-to-risk is, therefore, the exposure of people who were residents of Australia during the same period.

With such a large microdata set, there is inevitably some missing information such as gender, date of birth, and so on. Minor mismatches may also exist between the microdata and published ABS summary data. Some adjustments are made to manage consistency between the microdata and official figures.

Two sets of adjustment factors were developed to ensure the exposed-to-risk population from microdata was aligned with both: [1] public ABS information at each SEIFA decile level on Census day; and [2] the estimated resident population at 30 June of each year.

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. This calculated exposed-to-risk was adjusted in line with the adjustment factors described above.

The crude central mortality rates (mx) are then calculated by dividing the number of deaths at a particular age, gender and SEIFA decile by the revised exposed-to-risk for that age, gender and SEIFA decile.

Due to the large proportion of deaths at age 0 with missing SEIFA information, the age 0 experience is aggregated into 2 groups for each gender. One aggregates deciles 1 to 5 together, and the other aggregates deciles 6 to 10 together. For each gender this results in 2 crude mortality rates for age 0, one that applies across deciles 1-5 and one that applies across deciles 6-10.

2.3 CREATION OF SUB-GROUP LIFE TABLES

Having established crude central mortality rates for each age, gender and SEIFA decile, life tables for each sub-group can be derived. The first step was to graduate (smooth) the crude rates up to age 97. A smoothing spline was used.

Due to death data at young ages for some deciles being very limited, an adjustment of death count was required to enable a log scale transformation, prior to a smoothing spline graduation. Where death counts were equal to zero, this involved adjusting those death counts upwards by using death information from neighbouring ages, but retaining the overall number of total deaths.

The smoothed curves show a high degree of distinction across SEIFA deciles in middle and old ages, but the distinction is less at younger ages. That is, several points of crossover of mortality rates between deciles can occur at younger ages. There are various reasons for this to occur, including sparseness of death data at younger ages.

To mitigate unrealistic crossovers and inconsistency across deciles, further minor adjustments were made to assist the smoothing process. These adjustments mainly applied to younger ages, using information from neighbouring ages and/or deciles to shape the fitted curves more appropriately, via linear or polynomial interpolation.

Due to the sparseness of data beyond age 97, mortality rates were extrapolated to older ages using a Makeham curve. This is like 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.

In alignment with various other studies and analysis[2], and even given the sparseness of data, the mortality rates across deciles tend to converge at very old ages. That is, regardless of previous social economic status, mortality rates are similar at older ages. We have taken the average projected mortality rates for older ages across deciles, and blended this with smoothing spline mortality rates, to reach a single mortality rate for centenarian and supercentenarians across all deciles.

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. The mortality improvement factors were sourced from the AGA Australian Life Tables 2015-2017.

Twenty life tables were produced, one for each gender, for each of the 10 SEIFA deciles.

[2] For example, the two other AGA research papers, which although based on the same underlying data as this paper, when considering different groupings of the overall population both showed the similar finding(s) of convergence of mortality rates at older ages. Various theories abound for similar observations, for example see Gavrilov and Gavrilova, 2001, 'The Reliability Theory of Aging and Mortality', Journal of Theoretical Biology 213.

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.

Due to sparseness of data in some deciles and at some ages, and some of the consequent adjustments required as described in this paper, it is possible that differences between the crude and smoothed rates are significant. However, even with the population data disaggregated into 10 deciles for each gender, 84 per cent of the applied 140 statistical tests passed. This compares to 100 per cent of the 28 tests for the birthplace analysis, and 94 per cent of the 112 tests for the state and territory analysis. Given the expected drop off in robustness is a function of the number of categories analysed, in our view 84 per cent demonstrates a relatively high standard of 'fit' across all deciles and genders.

3. Results

The aggregate results for Australia as a whole and by state and territory have been presented in the research paper *Life tables by state and territory*. The aggregate results for Australia and by birthplace have been presented in the research paper *Life tables by birthplace*. In this paper we present the results for each of the 20 life tables, by SEIFA decile and gender.

3.1 Results by deciles

The mortality curves across all deciles are presented in Chart 4 (males) and Chart 5 (females). The mortality curves demonstrate a pattern with what would be expected with lower mortality in higher deciles than lower deciles, for both males and females. The convergence at older ages across all deciles, as previously discussed, is also apparent.

The consequent impact on life expectancies for each SEIFA decile is presented in the next section.

Chart 4. Male mortality rates by deciles, 30 June 2016

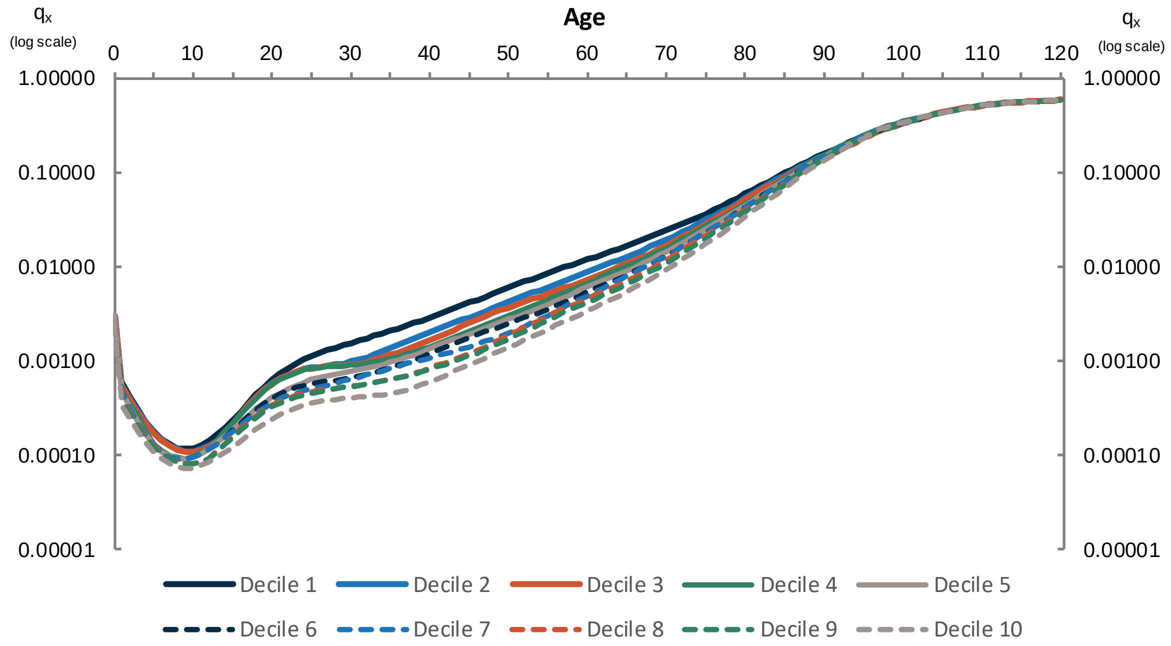
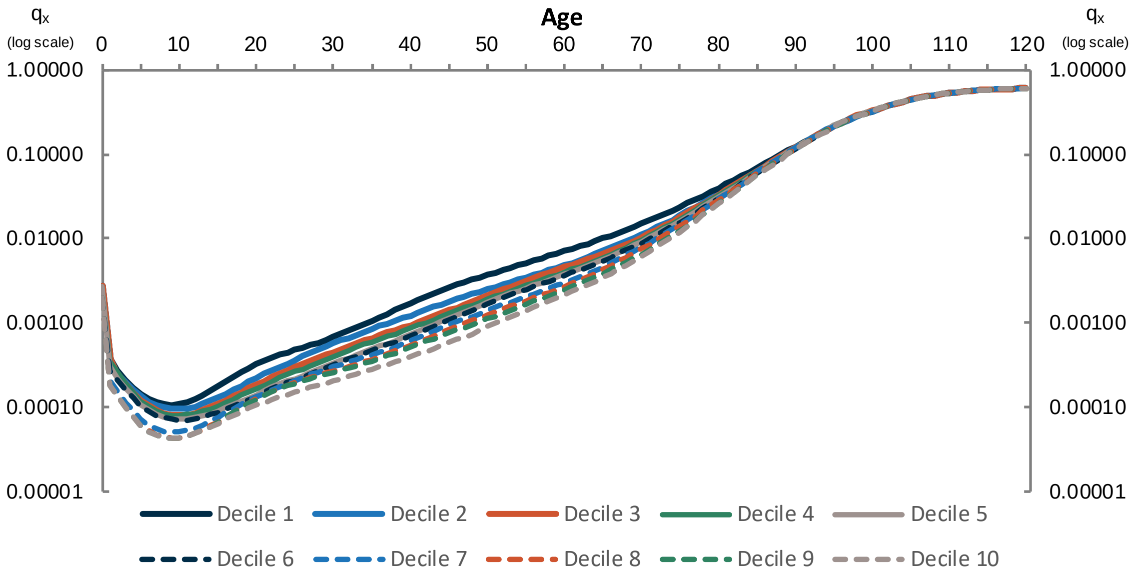


Chart 5. FEMALE MORTALITY RATES BY DECILES, 30 JUNE 2016



For greater clarity of differences between deciles, Chart 6 presents male mortality and Chart 7 presents female mortality for deciles 1, 5 and 10. Decile 5 can be considered as a proxy to Australian aggregate mortality, as a point of comparison[3].

Clear differentials between each decile are more apparent here. The mortality rates of decile 1 are higher than decile 5 at all ages except 0 (which have been merged for deciles 1-5), and very old ages. Similarly, mortality rates in decile 5 are higher than decile 10 at all ages except very old ages.

Interestingly, the accidental death hump is more prominent for males in higher deciles, and difficult to distinguish differences across deciles for females.

[3] This is because it is close to the median decile, which strictly speaking is decile 5.5 (the midpoint of decile 5 and decile 6), which of course is not an actual construct here. However, with the number of deaths weighted more to the lower deciles than higher deciles, decile 5 is a better proxy to the aggregate Australian population experience than decile 6.

Chart 6. **COMPARISON OF MALE MORTALITY RATES AMONG DECILE 1, 5 AND 10, 30 JUNE 2016**

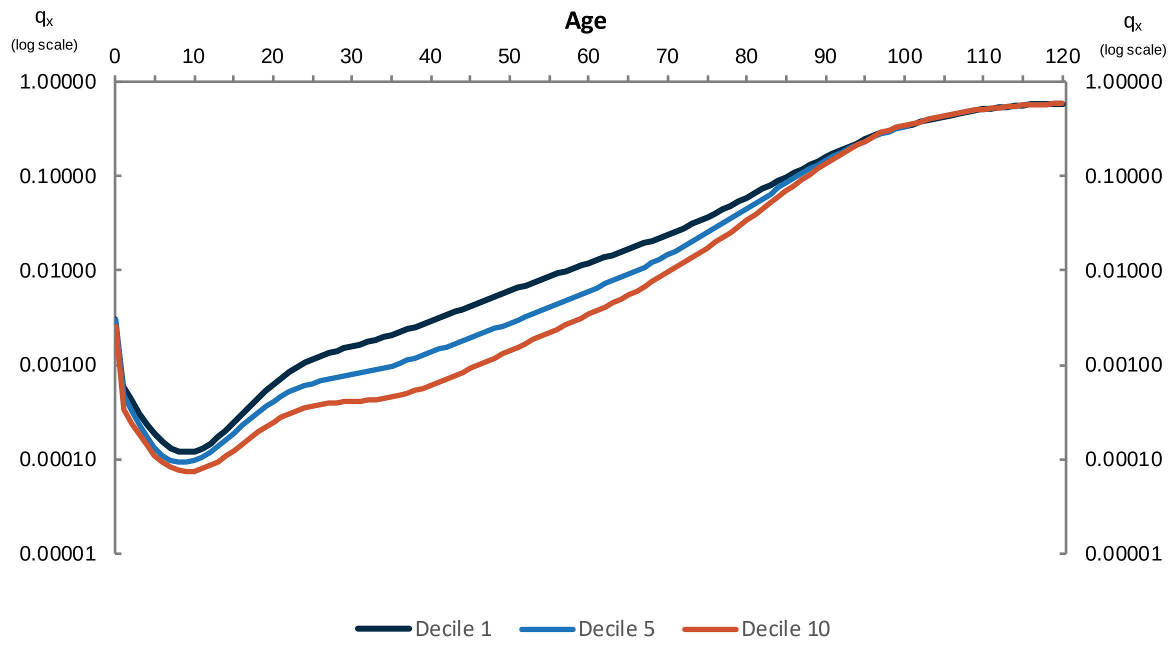
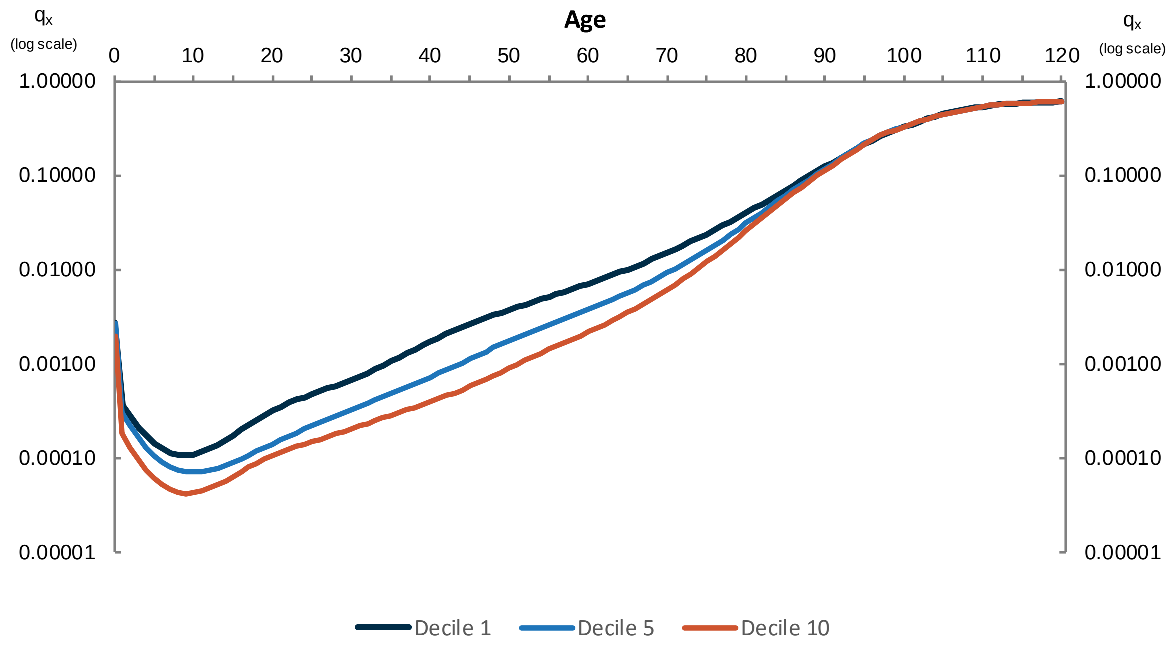


Chart 7. **COMPARISON OF FEMALE MORTALITY RATES AMONG DECILE 1, 5 AND 10, 30 JUNE 2016**



Charts 8, 9 and 10 compare mortality curves between males and females in 3 different deciles: 1, 5 and 10. As expected, these figures show that females exhibit lower mortality than males across all 3 deciles.

The relative gap between males and females in decile 1 is slightly larger than in higher deciles (5 or 10). The relatively high mortality for males in decile 1 is evidenced further, via examination of life expectancy (discussed in the next section).

Chart 8. MALE AND FEMALE MORTALITY RATES IN DECILE 1, 30 JUNE 2016

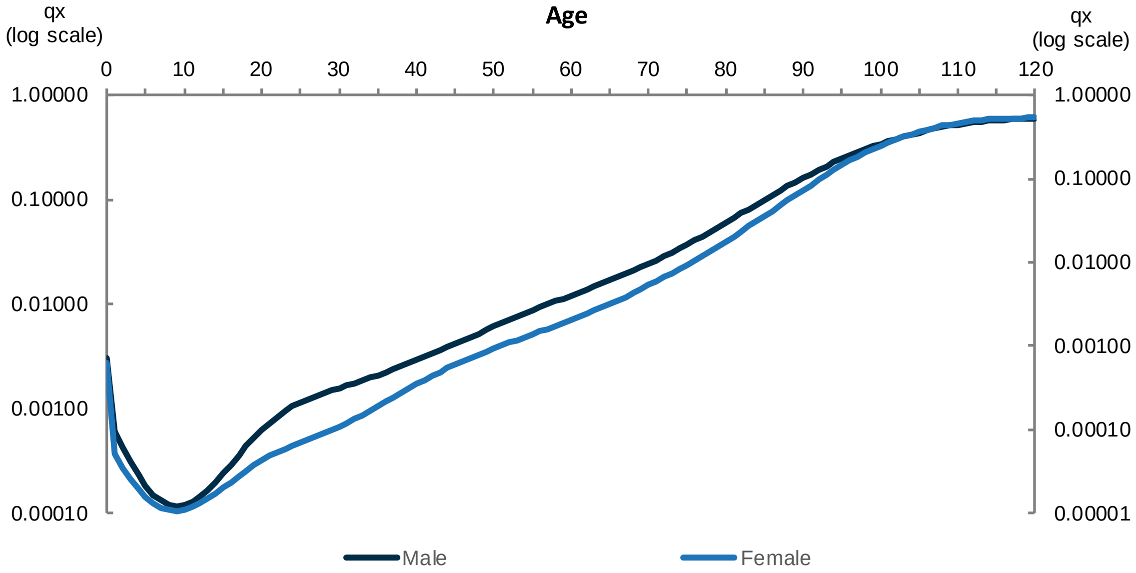


Chart 9. MALE AND FEMALE MORTALITY RATES IN DECILE 5, 30 JUNE 2016

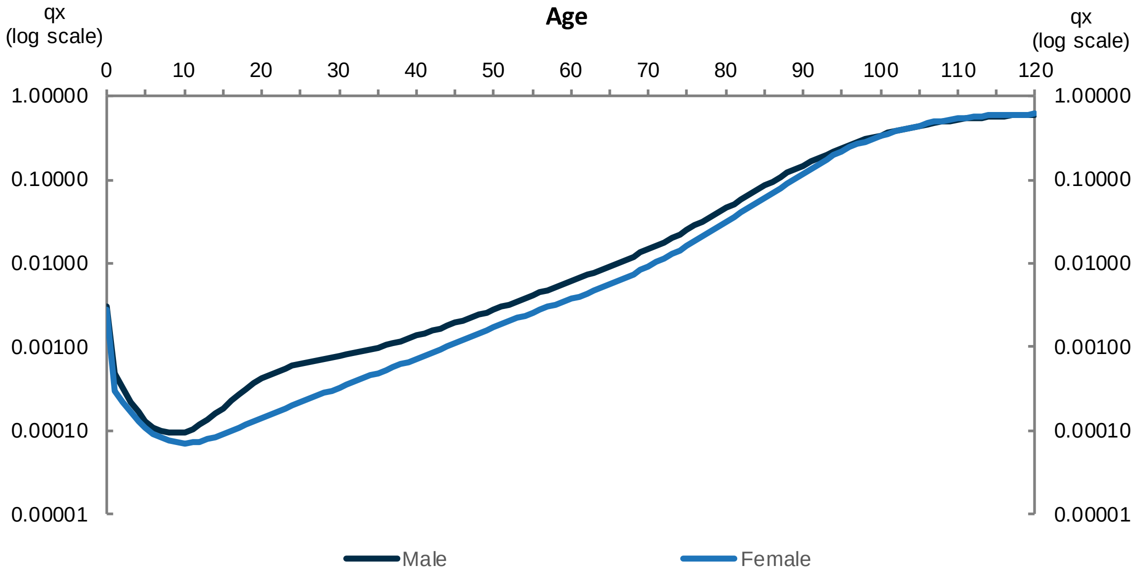
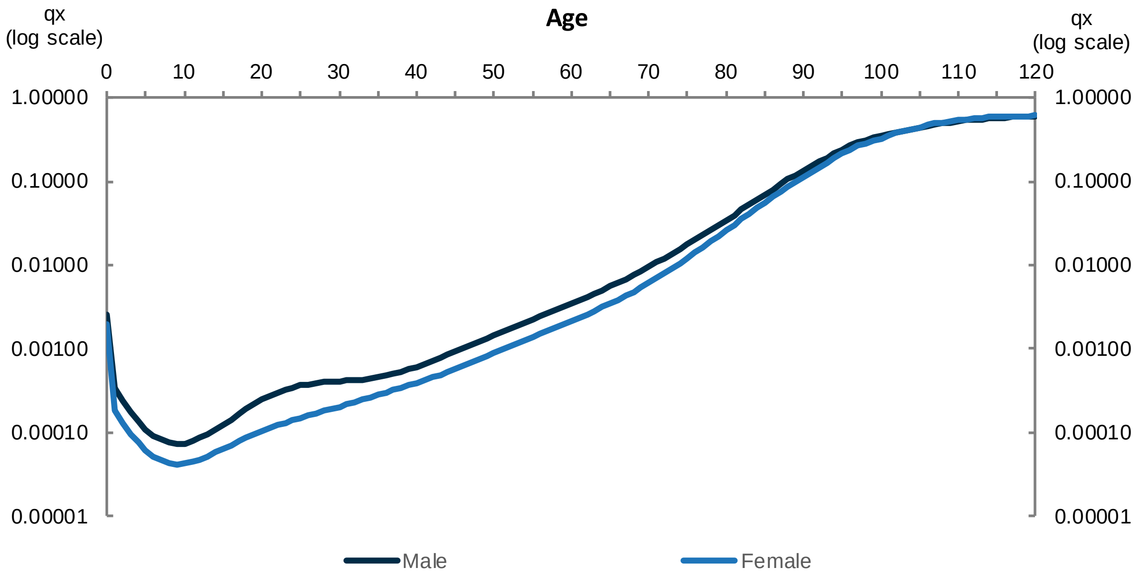


Chart 10. Male and female mortality rates in decile 10, 30 June 2016



4. Life expectancies

The relativities in mortality between each SEIFA decile and across the genders can be seen further by examining the inferred life expectancies, for various ages, for both the sub-groups and the aggregate Australian population.

The top 3 rows of Table 1 represent life expectancies for the aggregate Australian population at ages 0, 25, 65, and 85, for each of 3 life tables:

- Australian Life Tables 2015-17, produced by the AGA
- Life Tables, States, Territories and Australia 2015-2017, prepared by the ABS
- MADIP Microdata 2016, as described in the AGA research paper *Life tables by state and territory*.

Table 1. National and SEIFA decile life expectancies, 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
ABS life tables 2015-2017	80.5	56.2	19.7	6.3	84.6	60.1	22.3	7.3
MADIP microdata 2016	80.9	56.5	19.9	6.3	84.9	60.3	22.5	7.3
SEIFA decile 1	75.9	51.6	17.7	6.0	81.2	56.8	20.8	7.2
SEIFA decile 2	78.4	54.2	18.7	6.1	83.5	59.1	22.0	7.3
SEIFA decile 3	79.6	55.4	19.3	6.3	84.1	59.6	22.1	7.3
SEIFA decile 4	80.3	56.0	19.6	6.2	84.6	60.1	22.4	7.3
SEIFA decile 5	81.1	56.8	20.1	6.4	85.1	60.5	22.6	7.4
SEIFA decile 6	81.8	57.4	20.4	6.4	85.4	60.8	22.8	7.5
SEIFA decile 7	82.2	57.8	20.5	6.4	85.9	61.2	23.0	7.4
SEIFA decile 8	83.0	58.6	21.0	6.7	86.3	61.6	23.2	7.5
SEIFA decile 9	83.4	58.9	21.2	6.7	86.8	62.1	23.6	7.6
SEIFA decile 10	84.6	60.1	21.9	6.8	87.2	62.5	23.7	7.6

The life expectancy for the aggregate Australian population is, as suggested in footnote 3 (pg. 10), closer to the decile 5 experience than the decile 6 experience. This holds across all 4 age points of reference.

The life expectancy in decile 10 (the most advantaged and least disadvantaged area) is 8.5 years and 5.8 years higher than decile 1 (the least advantaged and most disadvantaged area) for males and females, respectively.

Chart 11 compares the relative change in life expectancy between adjacent decile groups. As expected, the change in life expectancy when going from a lower to a higher SEIFA decile is always positive.

The largest gap in life expectancies between neighbouring decile groups occurs between deciles 1 and 2, for both males and females. The gap in life expectancy of 2.4 and 2.3 years for males and females respectively, is more than twice as large as any other gaps between deciles. This highlights the significant poorer experience of those in decile 1 relative to all others in higher deciles.

In general, changes in life expectancy between adjacent decile groups are larger for males than females, with 7 of the 9 adjacent comparisons showing a higher change for males. This reflects the higher overall difference in life expectancy for males across all deciles (8.5 years) and indicates that male mortality experience is more strongly differentiated across deciles than females.

Chart 11. LIFE EXPECTANCY GAP AT BIRTH BETWEEN ADJACENT SEIFA DECILE GROUPS, 30 JUNE 2016

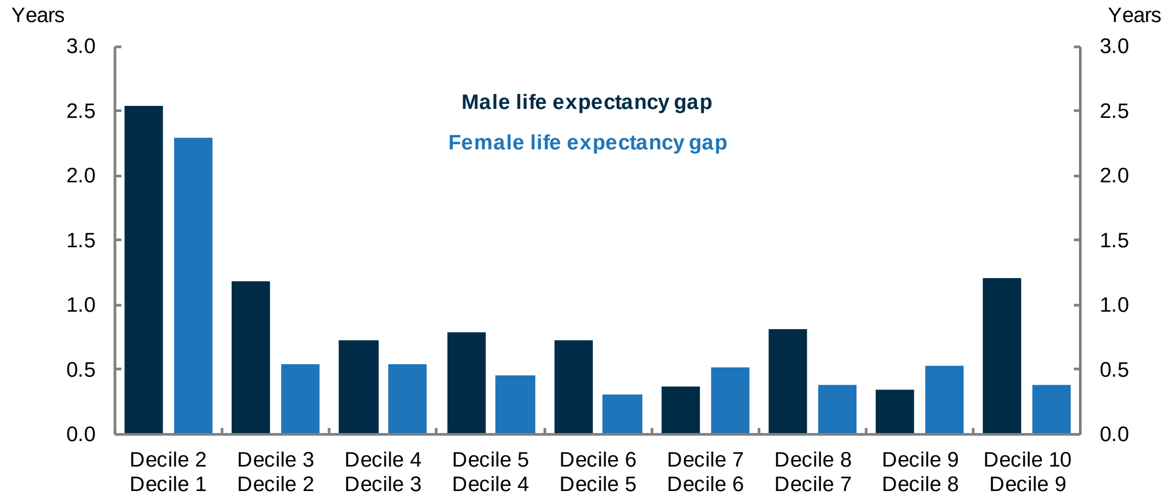
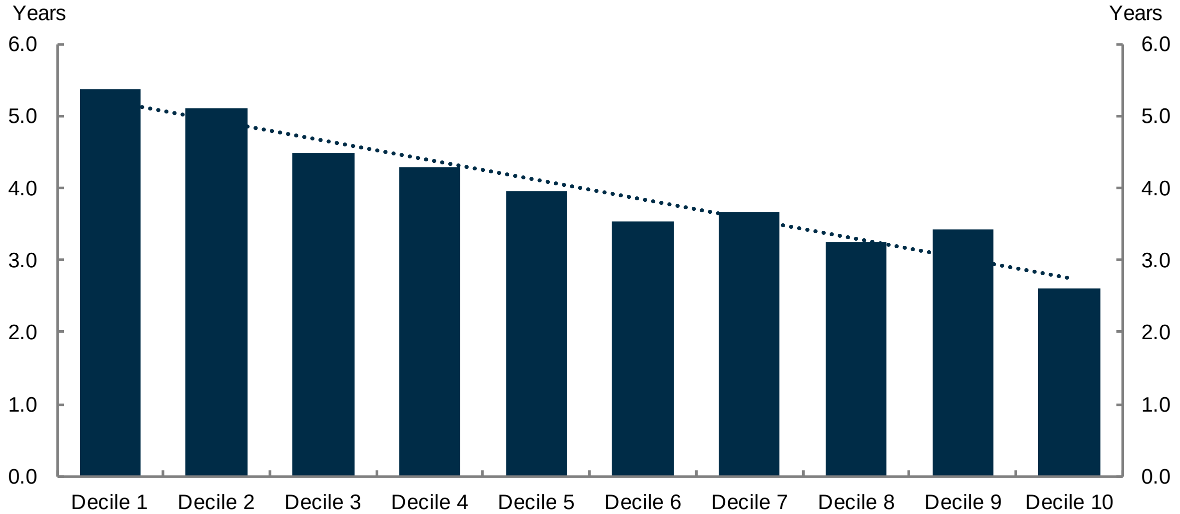


Chart 12 indicates another interesting feature of the experience. Differences in life expectancy between males and females decrease in size, as the SEIFA decile increases. For example, in decile 1 the life expectancy for females was 5.4 years higher than for males, but for decile 10 this difference has reduced to 2.7 years. Furthermore, the drop-off in difference when moving from decile 1 to 10 is approximately linear.

Chart 12. LIFE EXPECTANCY GAP AT BIRTH BETWEEN GENDERS, 30 JUNE 2016



5. DISCUSSION

Mortality modelling using microdata is a point of difference of this study, compared to the approaches the AGA uses to develop the Australian Life Tables and the ABS uses to develop its state and territories 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 areas.

The Australian Institute of Health and Welfare (AIHW) have produced occasional analyses into mortality differences between various sub-groups of the Australian population, including socio-economic status (SES).

We understand that the most recent analysis by SEIFA was included in the publication *Australia's health 2020*[4]. Their years of investigation, source and type of data, and measure of mortality, are all points of difference with our study.

We understand that this is the first analysis in Australia of mortality by SEIFA deciles, to produce graduated life tables. The use of SEIFA deciles gives insights on the impact of relative advantage and disadvantage on mortality, which could complement alternative analyses, such as mortality by remote/metropolitan areas, and/or First Nations Australians or non-indigenous populations.

The graduated mortality rates pass a high proportion of standard statistical tests that indicate the results of the overall graduation of the underlying crude mortality rates are sound and fit for purpose (adoption in Treasury population projections).

All research has limitations, and in this study the mortality investigation is based on aggregating individuals under a SEIFA code, rather than personal economic and social circumstances. Nevertheless, the microdata provides useful information, enabling an investigation that proxies a mix of income, wealth, occupation, education, and other socio-economic characteristics.

Furthermore, with many local governments encouraging a mix of public and private housing near each other, it is possible that differences in mortality between individuals of differing socio-economic circumstances, could be understated when analysing by SEIFA decile. Conversely, individuals with similar socio-economic status but living in different SEIFA deciles, could have quite different mortality experience. For example, those in metropolitan versus remote areas. Nevertheless, the results of this study show these are significant, and support intuitive differences in mortality across SEIFA areas.

[4] Australian Institute of Health and Welfare 2020. Australia’s health 2020 data insights. Australia’s health series no. 17. Cat. no. AUS 231. Canberra: AIHW.