Improving Measurement of Inequalities in Working Age Mortality and Life Expectancy using an Individual-Level Socio-Economic Index: Insights from Australia

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Extended Abstract

Background

Large and widening inequalities in mortality rates and life expectancy have been found across several high-income countries in recent years. In Australia, research has shown premature death rates in the most disadvantaged quintile to have not improved during the early 2010s and to be more than double that of the most advantaged quintile, when measured using the Index of Relative Advantage and Disadvantage (IRSAD) at the SA2 level (area of average population 10,000) (Adair & Lopez 2020). Likewise, differences in life expectancy at birth between the most advantaged and most disadvantaged IRSAD deciles, also measured at the SA2 level, showed a difference of almost 7 years for males and 5 years for females in 2021-22 (Timonin et al. 2025). Individual-level analyses found a gap in life expectancy at age 25 between the highest and lowest educational groups of 9.1 years for males and 5.5 years for females (Welsh et al. 2021).

While these studies have provided much insight into socio-economic inequalities in mortality, they are likely to underestimate the full extent of inequalities because, like conventional inequality mortality measures in many high-income countries, they are either only measured at areas of aggregation of significant populations (i.e. average 10,000) or have only considered one aspect of socio-economic status (i.e. education). This study aims to develop a individual-level Socio-Economic Index in Australia using several variables from the Population Census and to use this Index to measure individual-level inequalities in working age death rates (ages 25-64) and life expectancy at age 25.

Methods

Socio-Economic Index

The 2016 Census was used to construct a Socio-Economic Index of individuals. Several variables that have been shown in the literature to signify socio-economic status and to have an association with mortality and life expectancy were used to construct the Index: Household equivalised income, Highest education attainment, Marital status, Language spoken at home, Whether a person migrated to Australia in the last 10 years, State/territory and capital city residence, and IRSAD quantile (20 equal-sized quantiles) at the SA1 area level (average population 500). Other variables deemed too highly correlated with health status (and therefore risk of mortality) were not included, such as employment and disability status. Prior to construction of the Index, the missing values for each variable were redistributed proportionally to non-missing categories based on the age-sex-specific proportions for the population with the same combination of categories for other variables.

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Multiple Correspondence Analysis (MCA) was used to develop the Index from the Census variables (Greenacre, 2006). MCA is a dimensionality reduction method used to create an Index from a set of categorical variables. It is similar to principal components analysis (PCA), which is used on continuous variables and is the basis for IRSAD. In MCA, dimensions are extracted which represent the underlying structure of the data and explain the maximum amount of inertia (variance) present. The first dimension (Dimension 1) explains the greatest amount of the variance of the variables, Dimension 2 explains the next greatest amount of the variance etc. For each dimension, each variable category is assigned a coordinate which explains how well associated that category is with the overall direction of a dimension. From these coordinates, a summary normalised score was calculated for each observation for each dimension.

The Socio-Economic Index was developed for people aged 25 years and above. The Index is age-specific and has been calculated for each of 10-year age groups (25-34, 35-44 … 85+) to account for the socio-economic variables having a different representation of socio-economic status at different ages (e.g. Year 11 education or lower is relatively worse at younger than older ages). Dimension 1 from the MCA was used to calculate the score for each observation. Normalised scores were then used to calculate age-specific Index percentiles for each 10-year age group, with percentiles ranging from 1 (lowest socio-economic status) to 100 (highest socio-economic status). This Index percentile was then used for our analyses.

Death rates and life expectancy at age 25 years

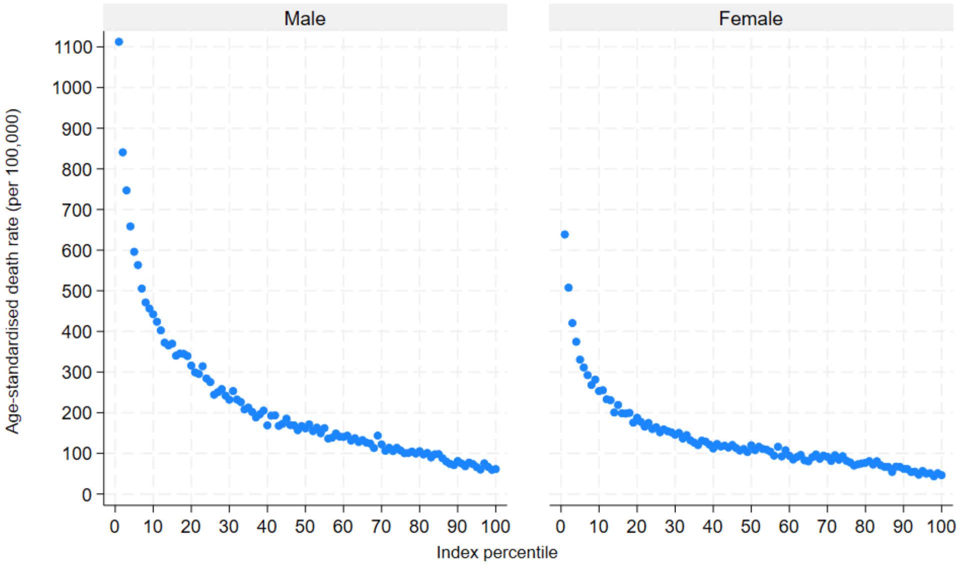
The 2016 Census is linked to death registration data via a Personal Linkage Spine, as part of the Australian Bureau of Statistics (ABS) Person Level Integrated Data Asset (PLIDA)[i] . The linkage rate of the 2016 Census with death registration from Census night on 9 August 2016 to 31 December 2019 was 88.1%. Our analyses were conducted for deaths in the period 9 August 2016 to 31 December 2019, with person-years calculated from the Census population adjusted for over/under-enumeration (using ABS adjustment factors). Age-specific death rates for 5-year age groups (with an open age interval of 95+) were calculated for each percentile using these deaths and person-years. We then calculated age-standardised death rates for 25-64 years for each sex and percentile, standardised to the 2016 Census population. Life expectancy at age 25 years was also calculated by sex and percentile. The average sex-specific population aged 25+ years for each percentile was approximately 60,000.

Preliminary results

The results of working age mortality rates show a very strong relationship by Index percentile. In fact, for males each percentile from 2 to 14 has a lower age-standardised death rate than the next lowest percentile (Figure 1). The death rate for percentile 1 (p1) is 18 times higher than percentile 100 (p100) for males and almost 14 times higher for females. The ratio of p10 to p90 is 5.5 for males and 4.1 for females.

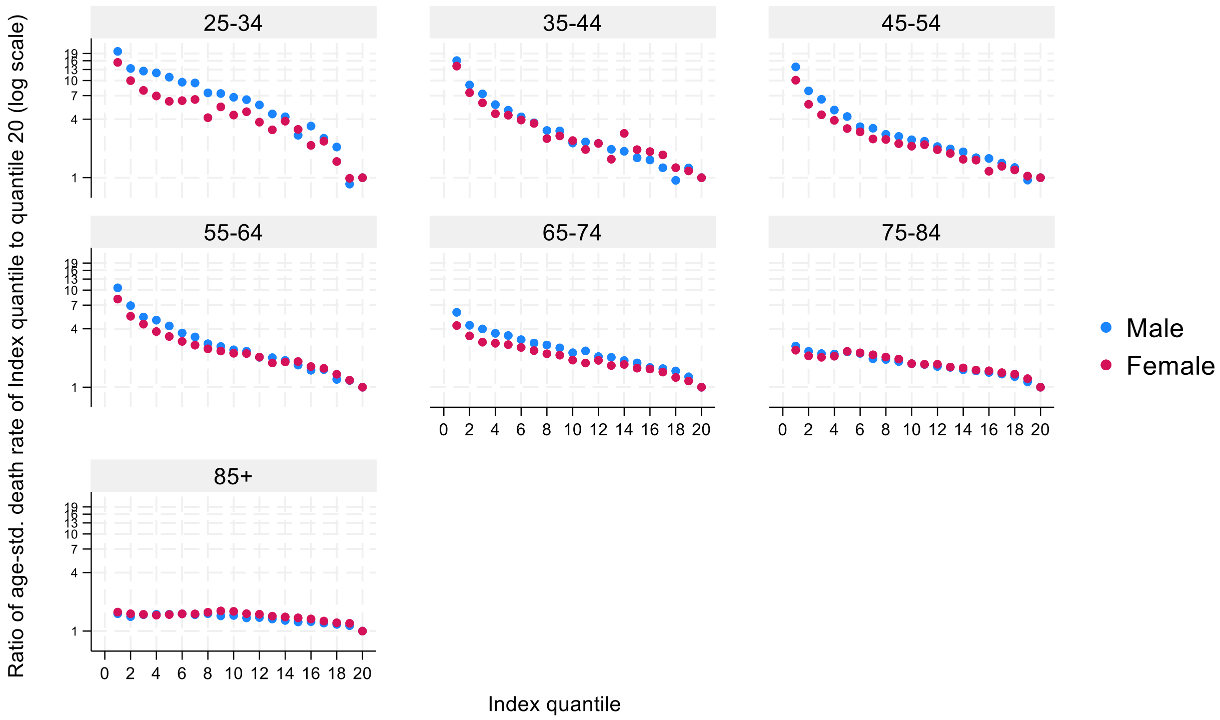
Figure 1: Age-standardised death rate (per 100,000) by Index percentile and sex, ages 25-64, Australia, 2016-19

[i] We acknowledge the ABS and data custodians for making the data available in PLIDA.



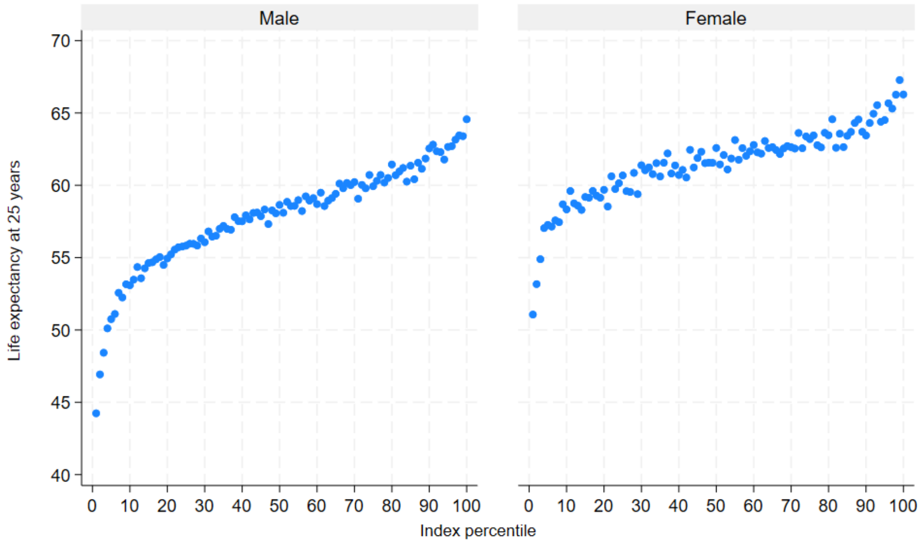
Death rates have a particularly strong relationship with the Index at younger ages, with the ratio of the lowest (p1-5) to highest Index quantile (p96-100) for males exceeding 19 at 25-34 years, with the clearest flattening of the relationship occurring after age 65 (Figure 2). Female ratios were very similar to males except for being smaller in lower Index quantiles in younger ages.

Figure 2: Ratio (log scale) of age-standardised death rate for Index quantile (percentile 1-5, 6-10 etc) to Index quantile 20 (percentile 96-100) by age group and sex , Australia, 2016-19



For life expectancy at age 25 years there is also a strong relationship with the Index (Figure 3). Life expectancy at 25 years us almost 65 years in p100 for males, 20 years higher than p1, and is over 67 years for females, 15 years higher than p1. Between p10 and p90, the life expectancy gap is 9.4 years for males and 5.1 years for females.

Figure 3: Life expectancy at age 25 by Index percentile and sex, Australia, 2016-19



Conclusions

The Socio-Economic Index constructed for this study demonstrated substantial inequalities in working age mortality and life expectancy in Australia that are much wider than found in previous research which were either measured at the area level or for a single individual-level variable. There are several important conclusions from this study. Firstly, the large extent of socio-economic inequalities is alarming, with particularly high death rates for the lowest few percentiles of the Index, even compared with those only a few percentiles higher. At the other end of the socio-economic spectrum, the findings provide insights into the frontier of longevity in a high-income population, with life expectancy at age 25 years exceeding that of any subnational population measured in the Global Burden of Disease (GBD 2023). The very strong relationship of mortality and life expectancy with the Index also demonstrates that several varied characteristics of a person are related to their mortality risk, rather than just income, education or where they live. Such inequalities are therefore best captured using such an Index which was developed independent of the mortality data.

References

Adair, T., Lopez, A.D., Widening inequalities in premature mortality in Australia, 2006-16, *Australian Population Studies*, 2020, 4(1): 37-56

Global Burden of Disease Collaborative Network. Global Burden of Disease Study 2023 (GBD 2023) Results.Seattle, United States: Institute for Health Metrics and Evaluation (IHME), 2024. Available from https://vizhub.healthdata.org/gbd-results/.

Greenacre, M., & Blasius, J. (Eds.). (2006). Multiple Correspondence Analysis and Related Methods (1st ed.). Chapman and Hall/CRC.

Timonin, S., Adair, T., Welsh, J., Canudas-Romo, V., Socioeconomic inequalities in life expectancy in Australia, 2013–22: an ecological study of trends and contributions of causes of death, *The Lancet Public Health*, 2025, 10(7): e599 - e608

Welsh J, Bishop K, Booth H, Butler D, Gourley M, Law HD, Banks E, Canudas-Romo V, Korda RJ. Inequalities in life expectancy in Australia according to education level: a whole-of-population record linkage study. Int J Equity Health. 2021 Aug 3;20(1):178.