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Death, Dollars and Degrees: Socio-economic Status and Longevity in Australia*

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We estimate differences in mortality and life expectancy by levels of income, education and area-based socio-economic status using the Household, Income and Labour Dynamics in Australia survey. The study involved 16,905 respondents aged over twenty years interviewed between 2001 and 2007. Mortality estimates were based on proportional hazard regression models. The relative risk of mortality between the poorest and richest income quintile was 1.88 (1.45, 2.44) times higher and this translated into a life expectancy gap (at age twenty) of six years. Having more than twelve years of education was also associated with a significantly lower risk of death. Area-based measures of socio-economic disadvantage were not significant after controlling for individual-level factors.

Keywords: mortality, income, education, health inequalities and life expectancy.

1. Introduction

One of the starkest measures of health inequality is the difference in mortality or life expectancy between individuals in different socio-economic groups. Some of the largest health inequalities in Australia are between the Indigenous and non-Indigenous populations where life expectancy gaps of around ten years have been estimated from mortality data (Australian Bureau of Statistics, 2009). To address these inequalities, there have been recent initiatives such as the *Closing the Gap* strategy which aims to reduce Indigenous disadvantage with respect to life expectancy and child mortality (Rudd, 2010). Inequalities in life expectancy also exist between other groups in the Australian community. Unlike other countries, Australia has not had an official inquiry into the magnitude of health inequalities. However, research by the *Australian Institute of Health and Welfare* found differences in life expectancy between the most and least disadvantaged regions in Australia of four years for males and two years for females (Draper *et al.*, 2004). These findings accord with

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a large of number of studies that have shown area-level differences in mortality or life expectancy within Australia (Burnley, 1998; Turrell and Mathers, 2001; Ho *et al.*, 2008; Brown and Nepal, 2010; Victorian Department of Health, 2010).

To date, almost all Australian studies examine area-level measures such as the Socio-Economic Indexes for Areas (SEIFA) that was developed by the Australian Bureau of Statistics (ABS). These measures are created using principal component analysis on a range of socio-economic characteristics including income, education and measures of household wealth such as the number of motor vehicles (ABS, 2001). The generated measures of advantage/disadvantage are used to rank census Collection Districts in terms of socio-economic status. These are often aggregated into larger geographic areas such as Statistical Local Areas (SLAs).

We are not aware of any prior Australian studies that have looked at the degree to which life expectancy differs by individual measures of socio-economic status such as income or level of education. This may be due to the fact that most researchers have used cross-sectional data, rather than the kinds of longitudinal datasets that permit researchers to link socio-economic characteristics of individuals with those same individuals' subsequent mortality. In our study, we make use of the longitudinal Household, Income and Labour Dynamics in Australia (HILDA) survey, which has a sufficient sample size and survey duration to allow us to observe ''pre-mortality'' socio-economic status for a substantial number of respondents.

There are three reasons for looking at socio-economic status and mortality at an individual level rather than merely by using the ABS SEIFA area-level measures. First, the SEIFA is not used in other countries and there have been changes in its method of construction over time (ABS, 2006) which limits the degree to which these measures can be employed in comparisons of health inequalities. Second, drawing inference regarding individual circumstances and outcomes from area-based measures are subject to an ''ecological fallacy.'' The ecological fallacy arises because individuals are not distributed randomly across neighbourhoods, and therefore area-level correlations may not accurately reflect individual-level correlations. For example, if palliative care facilities tended to be located in high-income neighbourhoods, the use of aggregate data would bias the relationship towards a finding that high-income areas had higher mortality rates. Third, there is considerable international interest regarding the degree to which individual-level measures provide additional information that can be used to predict health outcomes over and above area-level indicators of socio-economic inequality (Bosma *et al.*, 2001; Steenland *et al.*, 2004).

As noted, we use information from the HILDA study, a large nationally representative survey of the general community (Melbourne Institute of Applied Economic and Social Research, 2009a,b). Our approach is to estimate differences in mortality by household income, education, and area-level socio-economic status. We also use multivariate analyses to examine the degree to which mortality is influenced by area-level measures of socio-economic disadvantage after controlling for an individual's socio-economic status. Finally, we use life table methods to convert our mortality risk estimates into life expectancy gaps at different ages.

2. Methods

2.1 Data Source

The HILDA survey commenced in 2001, and we use data from the first seven waves of the survey (2001–2007) on individuals who were over twenty years of age in the first wave. The HILDA data are not currently linked to the National Death Index, so we instead identify deceased respondents using the person response status variable, which codes whether individuals answered the survey in person, over the telephone, or refused to answer the survey. Among the possible reasons for non-response are that the individual is overseas, in prison, refused to answer the survey, or is deceased. To account for the possibility that our mortality estimates may be biased, we compared the mortality rates derived from HILDA with those reported by the ABS in the 2003–2005 Australian life tables. In the HILDA dataset, there are 16,905 individuals over the age of twenty at the time of their first survey during the period 2001–2007. We excluded 2341 individuals who completed just one survey as there was no information on whether they had subsequently died.[3] An additional seven individuals were excluded because they lacked information on the relevant variables, so our analysis was based upon a sample of 14,557 respondents.

2.2 Assessment of Socio-economic Status

We use three measure of socio-economic status in the analysis. First, we classify respondents into three categories based on their level of education in the initial wave: less than twelve years of education (i.e. junior high school); twelve years of education (senior high school or TAFE certificate); or more than twelve years of education (University degree or TAFE diploma). Second, we use a measure of household income (from all sources after taxes and transfers). This is converted into equivalent income by dividing household income by the square root of the number of household members (Luxembourg Income Study, 2010). Individuals were then classified into quintiles based on their income (compared with others of the same five-year age group and sex). Third, we used an area-based measure of socio-economic status: the SEIFA by SLAs developed by the ABS (Australian Bureau of Statistics, 2006). We combined adjoining deciles to create quintiles of socio-economic disadvantage. To take account of the fact that death may directly affect household income (and therefore confound the analysis), all socio-economic measures exclude the year of death.

2.3 Statistical Analysis

Data were analysed using STATA, version 11 (StataCorp, 2009). Unless otherwise noted, all inferences of statistical significance are drawn at the 5 per cent level. Multivariate Cox proportional hazard models are used to assess the relative effect of education, household income, and the SEIFA on mortality after controlling for age (grouped into five-year categories) and sex. The measures of socio-economic status are entered individually and collectively into the regression models. The proportional hazards assumption underlying all models is examined using a test based on Schoenfeld residuals (Cleves *et al.*, 2008).

To translate differences in relative risks in mortality to overall life expectancy, we estimated a survival function from the proportional hazards model (see Appendix for further details). For this purpose, we used the Gompertz parametric form, which has been shown to perform well in modelling human survival (except for the very oldest individuals; see Gavrilov and Gavrilova, 1991). The time at risk is set as the individual's current age based on a person continuing to remain in the same socio-economic group over their remaining lifetime. Separate models for education, income and area-based socio-economic status are fitted using this approach. Life expectancy is then estimated as the area under the survival function for each model.

3. Results

The average age at entry to the study is 47.1 years (SD 16.2), and 52 per cent of respondents in the sample are female. Average household equivalent income is $32,185 per year. In terms of education, 31 per cent had completed high school or a TAFE certificate, and a further 27 per cent had completed a TAFE diploma or University degree. In regard to the follow-up period, just over 75 per cent of individuals completed all seven surveys and over 97 per cent completed two or more surveys. There were a total of 577 reported deaths, during the seven waves of HILDA, included in this analysis, and the average age of those reported to have died was 73.1 years (SD 14.3).

Figure 1 reports the hazard ratios for each of the socio-economic measures adjusting for age and sex. The left panel reports the ratios when each factor is considered in isolation after controlling for age and sex. The relative risk of mortality among individuals in the poorest income quintile is 1.88 (95% CI 1.45, 2.44) times higher than those in the richest income quintile. By education, the relative mortality risk is 1.63 (1.25, 2.12) times higher for those with a ten-year education or less

[3]These excluded individuals had the following summary characteristics: 49 per cent were female and they were on average aged 38.06 (SD 15.80) years. Hence, those excluded tended to be younger and had a slightly lower proportion of females than the sample used in the analysis.

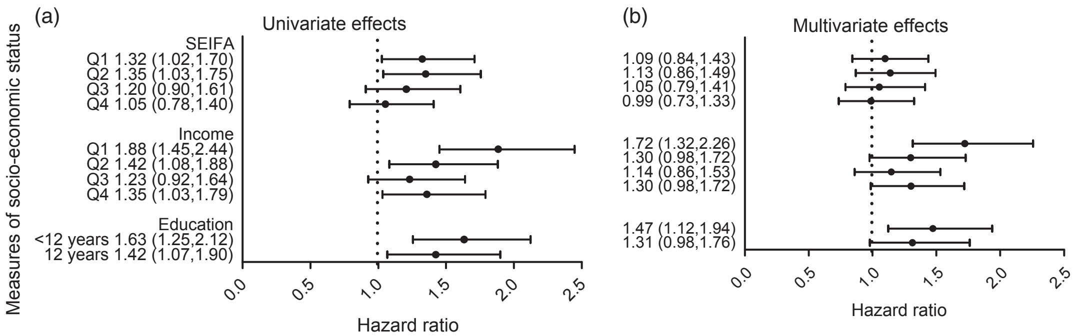

Figure 1. *Hazard Ratios of the Relative Risk of Mortality Among Household, Income and Labour Dynamics in Australia (HILDA) Respondents by Socio-economic Indicators*
Notes: (a) Socio-Economic Indexes for Areas (SEIFA) and income hazard ratios relative to top quintile; education hazard ratios relative to more than twelve years of education. (b) All results control for age (five-year categories) and sex.

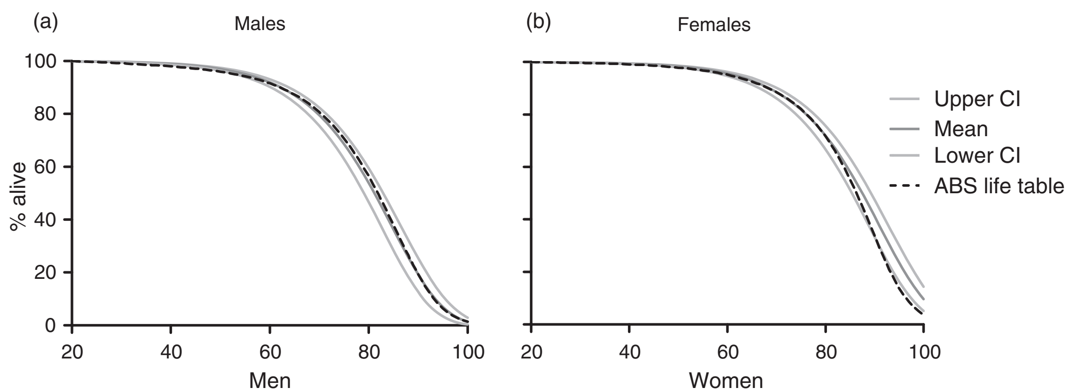

Figure 2. *A Comparison of the Predicted Proportion Surviving by Age Using a Model Based on Household, Income and Labour Dynamics in Australia (HILDA) Respondents Compared with Estimates from 2003 to 2005 ABS Life Tables*
Note: Life table estimates calculated using the 2003–2005 life tables from the Australian Bureau of Statistics.

for respondents with a diploma or degree. In terms of area-based measures of socio-economic status the two most disadvantaged SEIFA areas have a mortality risk that is 1.32 (1.02, 1.70) times higher than the most advantaged area. The right panel of Figure 1 reports comparable ratios when all socio-economic measures are included simultaneously. In this model, the area-based SEIFA is statistically insignificant and the coefficients are close to zero. This indicates that differences in observed mortality are better explained by individual-level measures of socio-economic status than by regional-based measures.

As a check on the way in which we derive mortality from the HILDA dataset, Figure 2 compares the estimated proportion of males (a) and females (b) surviving at each age with upper and lower 95% confidence intervals. Except for some younger ages in males and older ages in females, the ABS estimates fall entirely within the confidence intervals. This suggests that the overall mortality risk of HILDA respondents accords with people in the wider community, and provides reassurance

Table 1. *Life Expectancy Gaps Between the Highest and Lowest Socio-economic Groups*

Age	Education			Income			SEIFA		
	12 years	>12 years	Gap	Lowest quintile	Highest quintile	Gap	Lowest quintile	Highest quintile	Gap
Men									
20	55.52	60.13	4.61	54.90	61.05	6.15	57.26	59.90	2.64
40	36.13	40.55	4.42	35.53	41.44	5.91	37.79	40.33	2.54
60	18.69	22.43	3.74	18.17	23.18	5.00	20.07	22.24	2.16
Women									
20	61.83	66.45	4.63	61.20	67.37	6.18	63.19	65.84	2.65
40	42.20	46.71	4.51	41.58	47.60	6.03	43.52	46.11	2.59
60	23.86	27.90	4.04	23.30	28.71	5.41	25.04	27.36	2.32

Notes: SEIFA, Socio-Economic Indexes for Areas. ABS Australian life table estimates of life expectancy at age twenty, forty and sixty are, respectively, 59.2, 40.2 and 22.2 years for men and 63.9, 44.4 and 25.7 years for women.

that our results are not merely an artefact of the way that we determine mortality in the HILDA dataset. The estimated remaining life expectancy, which can be calculated as the area under estimated survival function for a twenty year old male is 58.2 (56.1, 60.0) years in the HILDA data compared with 59.2 years from the ABS's 2003–2005 life table. Life expectancy estimates for women at age twenty were 64.5 (62.4, 66.3) years in the HILDA data and 63.9 years from the ABS life table.

Table 1 reports life expectancies in years at selected ages for individuals in the highest and lowest socio-economic groups. The greatest variation in life expectancy is by household income. For example, twenty year old men in the highest income group could expect to live to 80.0 years, whereas those in the lowest group could expect to live to only 74.9 years: a gap of 6.1 years. By comparison, the gap for education (at the age of twenty years) was 4.6 years of life between respondents with a junior high school education and those with a degree or diploma. By area, the gap is 2.6 years of life between those living in the most advantaged SEIFA quintile and the most disadvantaged SEIFA quintile. However, as noted above, the area-based measures are no longer statistically significant once individual-level covariates are included in the model.

Although women tend to live longer than men, the effect of socio-economic status on longevity does not appear to vary by gender. For income, education, and SEIFA quintiles, our point estimates for women are similar to those of men.

4. Conclusions

Using a large and representative longitudinal dataset, this study quantifies differences in mortality by household income and individual education, in addition to the more traditional area-based socio-economic measures. For both income and education, we found nearly a twofold increase in mortality between the lowest and highest socio-economic groups. In contrast, the differences across groups based on the SEIFA area-level measures were smaller, and became statistically insignificant after controlling for individual-level factors. Translated into life expectancy, we estimate that the gap between the highest and lowest quintiles is six years for income and five years for education. Estimating these gaps using individual-level socio-economic measures is an important prelude to understanding the nature of health inequalities and in developing appropriate policy responses.

Our findings have potential implications for future health inequality research as we have demonstrated a much stronger association between individual measures of socio-economic status and mortality than the widely used SEIFA index. This suggests a need for individual measures such as income when quantifying socio-economic related health inequalities in Australia. Such research would be facilitated by linkage of records from large datasets with mortality records such as probabilistic matching which is routinely undertaken in other countries such as New Zealand (Blakely *et al.*, 2000). In cases where health researchers have access to both individual-level and area-level measures of socio-economic status, our results suggest that the individual-level measures should be preferred.

Closing these socio-economic life expectancy gaps represents a major public policy challenge in Australia. A useful first step would be to better understand of the causes of these gaps. Unlike other countries, Australia has not had a major independent inquiry into socio-economic health inequalities, or a detailed examination of potential policies to address health differences. By contrast, the United Kingdom's Acheson Report (Department of Health, 1998) proved important in advancing debate around socio-economic gaps and advancing a policy agenda (Oliver and Nutbeam, 2003) such as *in utero* and early life interventions aimed at reducing health inequalities.

Estimates of life expectancy are also relevant in understanding a wide range of economic phenomena including savings behaviour (Bloom *et al.*, 2003) as well as retirement and consumption behaviour over the life cycle (Hamermesh, 1984). In this regard, an obvious practical use for our estimates is in financial planning. It would also be useful to examine whether subjective assessments of life expectancy across income and education groups accord with our more objective estimates. Although there has been some examination of this in the United States (Hamermesh, 1985; Smith *et al.*, 2001), we are unaware of any comparable research involving Australians. Exploring this issue would require adding questions regarding the subjective assessment of life expectancy into HILDA or another population survey which also has objective follow-up information on mortality.

Although ours is the first Australian study to estimate the gap in life expectancy based on an individual's socio-economic status, the analysis has limitations. First, we identify mortality by relying on neighbours and other members of the household telling the interviewer that the respondent is deceased. This method necessitated the removal of around 15 per cent of the sample who completed just one survey. Although we were initially concerned that the exclusion of these individuals might underreport mortality (particularly in single-person households), comparisons with the rates of mortality in the general population suggest that bias arising from the method of death reporting is minimal. The broader question of whether this attrition impacts on the association between measures of socio-economic status and mortality is an issue that should be re-examined if HILDA data is linked with the National Death Index.

The second limitation is that we use self-reported income. Although HILDA has a detailed battery of questions to elicit household income, it is likely that there is some measurement error in our estimates. To the extent that this measurement error is classical, it is likely to attenuate the estimated life expectancy gaps towards zero, meaning that the true gaps may be larger than those reported here. A third limitation is that although we omit income data from the year of death, it is possible that income may fall during an individual's final years due to chronic disease (either because the respondent ceases work, or because others in the household cut back on work in order to perform caring duties). Hence, the relationship between income and mortality should be seen as an association rather than a direct causal relationship between the level of income and mortality. As the HILDA panel becomes longer, other researchers may be able to address this by using long lags of income (e.g. from a decade prior to death). This longitudinal feature of the dataset also provides the opportunity to examine other measures of income such as the permanent and transitory components and its relationship with mortality.

Although the HILDA dataset provides a unique opportunity to examine the relationship between individual and household level socio-economic measures and mortality, our study should be seen only as a starting point for further research. Researchers who have conducted cross-sectional surveys that include precise measures of income and education can potentially link these records to the National Death Index. Such linkages would help researchers to learn more about the individual-level factors that are predictive of future mortality and thereby increase our understanding of health inequalities in Australia.

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Appendix: The Estimation of Life Expectancy

The life expectancy at various ages is the area under the estimated survival function at ages twenty, forty and sixty years (Gray *et al.*, 2010). This was based on a Gompertz proportional hazards model in which current age was the time at risk and gender and socio-economic quintile were covariates.

For example, the estimated model based on income quintiles was:

Variable	Coefficient	SE
1st (lowest) quintile	0.622	0.131
2nd	0.328	0.138
3rd	0.183	0.142
4th	0.297	0.137
Male	0.637	0.083
Const.	−11.624	0.280
γ	0.100	0.003

The proportion of survivors at each age can be estimated using the formula $S_t = \exp\{-\exp(x_j\beta)\gamma^{-1} \times (\exp^{\gamma t} - 1)\}$, where x_j are covariates, γ is the Gompertz shape parameter and t is the person's age. Using this formula, the expected proportion surviving can be calculated for any age. For example for males at fifty years, 95% (98 per cent) can be expected to survive from birth for the lowest (highest) income quintile. The life expectancy can then be calculated as the area under the survival curve using the trapezoidal rule. Our estimates of life expectancy gaps were made under the assumption that individuals remained in the top and bottom quintiles over their remaining lifetimes. All estimated equations will be made available at http://sydney.edu.au/medicine/public-health/heconomics/.