Dynamics of socioeconomic-related health inequalities in Australia

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Master Thesis

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ABSTRACT

Socioeconomic-related inequalities in health despite gains in extended life spans remain a key equity issue that calls into question society's burden of illness and the role of a universal healthcare system. The extent to which socioeconomic conditions systematically vary with population health has been a matter of empirical analysis aimed at measuring social equity. This paper attempts to measure the dynamics of socioeconomic-related inequalities in health by decomposing contributions of changes in income and health over time.

A long-run measure of socioeconomic-related inequalities in health based on the health concentration index will be constructed following the approach of Allanson, Gerdtham & Petrie (2010) using waves 1 to 5 of the Household, Income and Labour Dynamics in Australia (HILDA) survey. The dynamics of changing inequality will be captured by two indices: the income-related health mobility index and the health-related income mobility index. To further the analysis, the measure will be decomposed to account for both patterns of morbidity and mortality changes as proposed by Petrie, Allanson & Gerdtham (2011).

The study indicates that there has been a positive increase in the concentration index for both males and females in Australia between 2001 and 2005. Upon decomposition, pattern of health changes are shown to favour those with initially higher incomes. Similarly, those in poor health decline from their initial income rankings which further contribute to health inequalities. Accounting for mortality has had a noticeable impact on mobility indices with deaths being biased towards those with lower incomes.

The study concludes that estimates from Australia are akin to estimates from Scotland and England & Wales, while characteristically, greater regressivity in health outcomes is seen for Australian males than for Australian females.

Keywords: HILDA, socioeconomic-related health inequality, longitudinal data, health concentration index

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This paper uses unit record data from the Household, Income and Labour Dynamics in Australia (HILDA) Survey. The HILDA Project was initiated and is funded by the Australian Government Department of Families, Housing, Community Services and Indigenous Affairs (FaHCSIA) and is managed by the Melbourne Institute of Applied Economic and Social Research (Melbourne Institute). The findings and views reported in this paper, however, are those of the author and should not be attributed to either FaHCSIA or the Melbourne Institute.

ABBREVIATIONS

ABS	Australian Bureau of Statistics
BHPS	British Household Panel Survey
CAPI	Computer-assisted personal interviewing instrument
CCD	Census Collection Districts
CI	Concentration Index
CSM	Continuing Sample Members
FaHCSIA	Australian Government Department of Families, Housing, Community Services and Indigenous Affairs
GDP	Gross Domestic Product
GNI	Gross National Income
GSOEP	German Socio-Economic Panel Survey
HF	Household Form (HILDA survey)
HILDA	Household, Income and Labour Dynamics in Australia Survey
HQ	Household Questionnaire
HRQoL	Health-related quality of life
IHA	Index of Health Achievement
IPW	Inverse Probability Weights
MDG	Millennium Development Goals
NHS	National Health Survey
OECD	Organisation of Economic Co-operation and Development
OLS	Ordinary Least Squares
PQ	Personal Questionnaire
QALY	Quality-Adjusted Life Years
SAH	Self-assessed health
SCQ	Self-completion Questionnaire
SG	Standard Gamble
WHO	World Health Organisation

I. INTRODUCTION

In his Second Discourse, first published in 1754, the philosopher Jean-Jacques Rousseau conducted a thought experiment to conceive how inequality could have been born and instituted among men (Rousseau, 2004). In his hypothesis, he differentiated natural or physical inequalities arising as a product of nature from another kind of inequality that his compelling account sought to explain.

Rousseau claimed there to be a second kind of inequality that "depends on some kind of convention, and is established, or at least authorised by the consent of men" (Rousseau, 2010, p.1). *Moral* or *political* inequality, as he calls it, occurred when humans entered civil society, lost the ability to be self-sufficient and in turn became dependent on the esteem of others. These were the course of events that Rousseau hypothesised led humans to accept differences in power and wealth.

Inequalities in health could have emerged in the same way in civil society; accepting socioeconomic differences in illness, however, presents a different and unsettling equity concern. Linking socioeconomic circumstance to one's health prospects suggests that the quality of the lives that we live are somehow limited by our place in society. Bearing little or no choice in circumstance, our sense of fairness or equity is confronted. Inevitably, as Sen (2002, p. 659) asserts, "health equity cannot but be a central feature of the justice of social arrangements" because it is bound to our capability to live life to the fullest.

This thesis offers a bridge from the way things must have been to the way things are. In taking an empirical approach, I will conduct a study on the extent of socioeconomic-related inequalities in health through a measurement framework based on the strength of relationship between one's health and his or her rank in the distribution of a given socioeconomic variable. I take the recent contributions of Allanson, Gerdtham & Petrie (2010) and Petrie, Allanson & Gerdtham (2011) in this domain as my point of departure. In applying their methods using Australian longitudinal data, this study focuses on the dynamics of socioeconomic-related inequalities in health, how it evolves through patterns of health and income changes. By taking a long-run perspective, inequality can be seen in a new light as a social process over a period of time rather than a single snapshot.

Measuring socioeconomic-related inequalities in health empirically is unavoidably troubled by the confluence of factors that determine health, some of which society cannot admit responsibility. Delineating individual choice from the traps of socioeconomic circumstance requires value judgements. Even more so, the influence of genetic factors is hard to remove out of the question. As such, there is disagreement on the actual extent and causes of health inequality which crucially needs a robust and unbiased measurement framework: how could an issue be addressed if it is misdiagnosed?

This study will therefore dedicate part of its analysis on this diagnosis by critically evaluating the limits of inequality measures whilst at the same time motivating the measures adopted for this study.

1.1 BACKGROUND: SOCIOECONOMIC-RELATED INEQUALITIES IN HEALTH AROUND THE WORLD

1.1.1 THE GLOBAL PERSPECTIVE

In any definable human population, a population's health depends on the interaction between the people that constitute it with the different social and physical environments that they are exposed to (Tarlov, 1996, p. 75). Socioeconomic-related inequalities in health finds expression both within and between nation-level populations around the world.

Despite gains in extended life spans, there has been a worldwide trend towards greater disparity in health outcomes between countries of different economic means. Globally, life expectancy at birth (years) has improved for males from 62 to 68 years and for females from 67 to 72 years between the years 1990 to 2011 (WHO, 2013); however, if it is disaggregated among countries by income group according to 2011 gross national income (GNI) per capita, low income countries still remain approximately 20 and 23 years for males and females respectively behind their high income counterparts until now (WHO, 2013). From Figure 1, this global health gradient can be illustrated. The positive association between national income and higher life expectancy at birth is distinct although the relationship becomes less pronounced at the highest levels of national income (OECD, 2011).

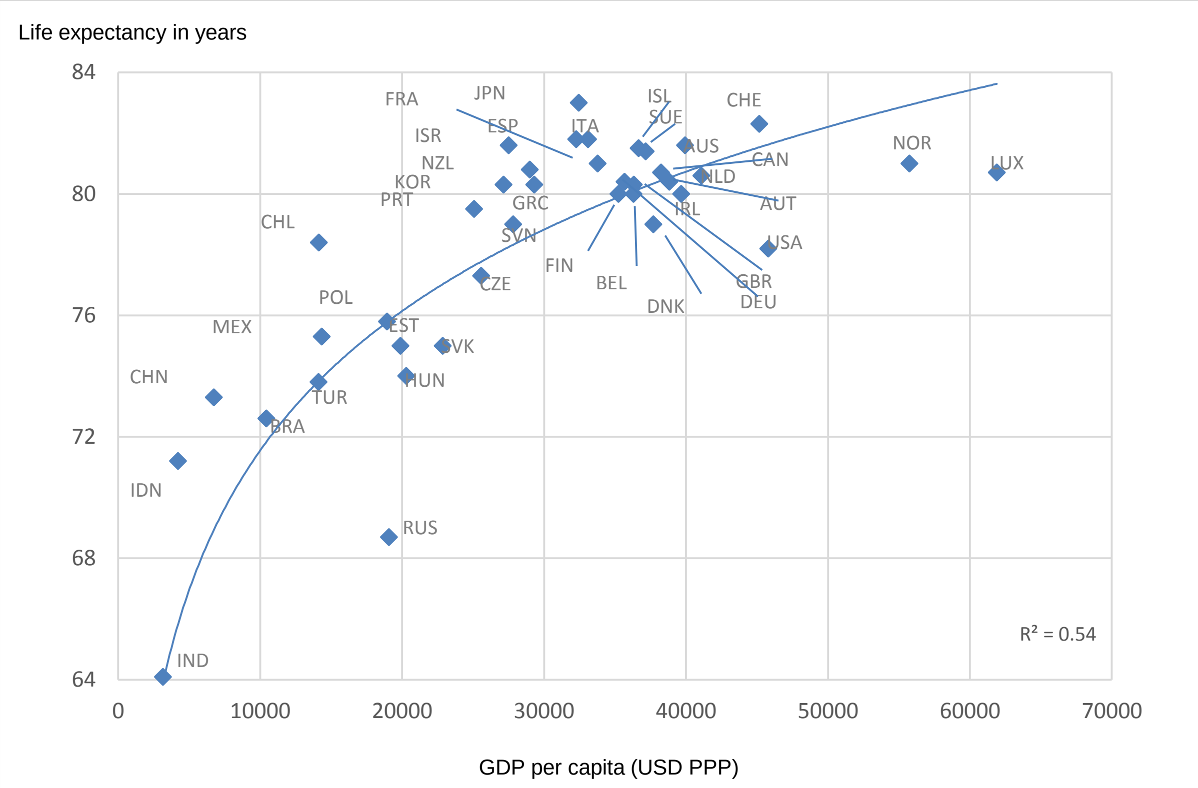


Figure 1: Life expectancy at birth and GDP per capita, 2009 (or nearest year)

[Source: Health at a Glance 2011: OECD Indicators, OECD, 2011.]

In achieving Millennium Development Goals (MDG) pertaining to health, countries with lower incomes fair much worse. The absolute gap in important illness indicators such as the under-five mortality rate between the top and bottom quartile of countries in the global income rank have narrowed. By considering relative reductions, however, the bottom quartile have achieved less or marginally better than their richer counterparts; for instance, the average maternal mortality ratio between 1990 and

2010 in the bottom quartile of countries declined by 44%, which is only marginally higher to the 34% decline observed to the top quartile (WHO, 2013).

The global gap in health outcomes exposes the gradients in socioeconomic factors that underlie them. The socioeconomic determinants of health has received attention in the international arena since the 1970s when the WHO Report, titled *Health by the People*, argued that "the 'causes' of common health problems derive from parts of society itself and that a strict health sectoral approach is ineffective, other actions outside the field of health perhaps having greater health effects than strictly health interventions" (Newell, 1975, seen in Irwin & Scali, 2007, p. 7). It was these health inequalities among socioeconomic lines themselves that led health to be considered as a fundamental human right and a socioeconomic issue as signed in the Declaration of Alma-Ata (WHO, 1978). Achieving health goals became more than just the delivery of medical interventions but rather as requiring changes in economic and social policy.

Activism in health policy as a multi-sectorial approach found its form in the formulation of the Millennium Development Goals (MDGs) where its progress was not to be measured solely through the achievement of the goals themselves but also with consideration of principles of equity. Realising the latter was recognised to require "refocused attention on the need for coordinated multisectoral action" (Irwin & Scali, 2007, p. 25). It was not until 2004 however that the Commission on Social Determinants of Health of the World Health Organisation (WHO) was formed to explore knowledge on the interactions between health and society and to incorporate this knowledge in health policy-making (Marmot, 2005). It is in this context that the enthusiasm for improving and saving human lives meets the fervour for social justice.

1.1.2 THE AUSTRALIAN CONTEXT

Australians, on average, enjoy one of the highest life expectancies in the world and it continues to improve both in length and in quality. In the decade 2001-2011, life expectancy at birth for males rose from 77 to 79.7 years and for females from 82.4 to 84.2 years (AIHW, 2012), further extending the large gains made in the last century.

Older Australians at age 65 can also expect more years without severe or profound core activity limitation while there is now greater chance of survival from ill health (AIHW, 2012). Furthermore, mortality rates from diseases such as cancer have been decreasing over the past two decades while the chances of survival from a heart attack has increased from 3 in 5 (63%) in 2009 t0 fewer than half in 1997 (AIHW, 2012). Yet, despite better health on average, there are marked differences in health along socioeconomic and racial lines.

Health inequalities in Australia are inextricably linked to the history of Indigenous health. The colonial impact on the health and well-being of Indigenous communities in Australia come in different forms: from the immediate biological impact of infectious diseases introduced by European settlers to the lasting impacts of dispossession, marginalisation and poverty (Anderson, 2007). Its true impact has largely been unknown until 1967 when Indigenous persons began to be counted in government censuses and the movement towards Indigenous self-determination began.

Today, the gap between the health of Indigenous and non-Indigenous persons is evident: indigenous mortality rates remain significantly higher than non-indigenous persons and despite falls of 28 and 40 per cent for males and females respectively over 1991 and 2005, the life expectancy at birth for Indigenous males and females are 11.5 and 9.7 years less than their non-Indigenous counterparts (AIHW, 2011). This stark difference is made clear by Figure 1.2 where Indigenous Australians are clearly not in line with the rest of the general population. In some states such as the Northern Territory, the life expectancy gap at birth among males is even more pronounced at 14.2 years of difference (AIHW, 2011).

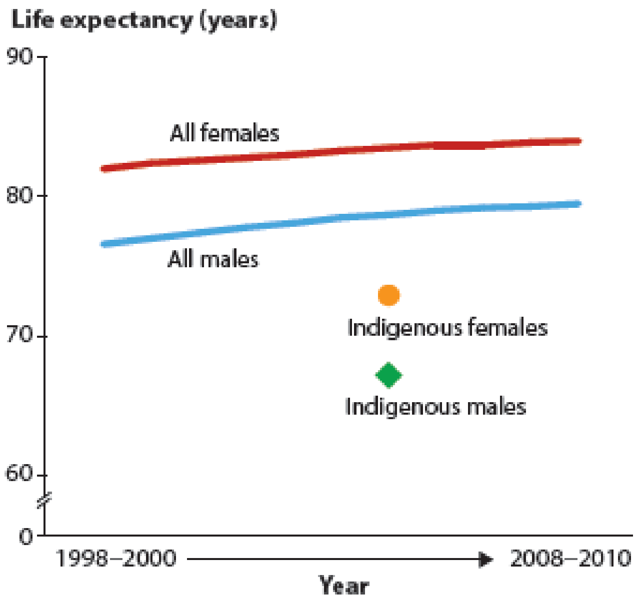


Figure 2: Life expectancy at birth in Australia

[Source: AIHW 2012]

Indigenous persons in Australia only constitute approximately 2.5% of the population, but most are considered to have disadvantaged socioeconomic backgrounds as nearly half (49%) of Indigenous households are in the lowest income quintile and as only 6.5% have a bachelor's degree or higher (AIHW, 2011). To a certain extent, their disadvantage can be linked to the wider disconnect in health along socioeconomic lines.

Taking a socioeconomic perspective, a similar picture could be drawn. Mortality and morbidity rates increase as one moves from relatively socioeconomically advantaged to disadvantaged areas for the general population. According to Australian Census measures, for instance, life expectancy at birth for males in the most disadvantaged areas in 1998-2000 was 3.9 years lower than the least disadvantaged areas while for females it is 2.0 years lower (Draper, Turell & Oldenburg, 2004). Similarly, statistics from the 2001 National Health Survey (NHS) show that there are statistically significant inequalities in morbidity factors such as obesity in persons aged 25-64 years or asthmas in children aged 0-14 years between the most and the least affluent households as measured by equivalised income adjusted for the size and composition of household units (Turrell, Stanley, de Looper & Oldenburg, 2006). It is largely unknown, however, if this socioeconomic gradient is getting steeper.

The Australian experience of better but unequal health reflect similar experiences in other Western nations such as the United Kingdom (Marmot, 2010), Canada (Humphries and van Doorslaer, 2000) and Sweden (Burström, Johannesson & Diderichsen, 2005). Importantly, it raises a pressing question of where gains in health have come from and whether some have greater access or opportunity to gain from them than others.

1.2 AIMS AND SCOPE OF PAPER

The phenomenon of better but more unequal health provides that context behind this study. At its core, this paper seeks to measure the extent of socioeconomic-related health inequalities in Australia and crucially to investigate if the health improvements that is seen today could be biased in favour of the privileged in society. To do so, I will focus on the dynamic process behind socioeconomic-related inequalities in health, how it evolves over time and whether patterns of changes in health perpetuate inequality.

Using Waves 1 to 5 of the Household, Income and Labour Dynamics in Australia (HILDA) survey panel dataset, I will decompose the change in two cross-sectional concentration indices which measure socioeconomic-related health inequality at given time periods. The indices are constructed from a cardinal measure of health based on SF-36 health variables included in the survey and rankings based on annual household equivalised income. As formulated by Allanson et al. (2010), the change will be decomposed into measures of income-related health mobility and the health-related income mobility which indicate how patterns of changes in health or income re-ranking affect inequality. The decomposition will be extended to account for both morbidity- and mortality-related health changes through the approach taken by Petrie et al. (2011).

The paper is structured as follows. In the next section, I will firstly review the academic literature on measures of socioeconomic-related inequalities in health and its applications to reflect upon previous research in the area. I will cover different methodologies and recent developments in ranked-based measures using longitudinal data.

In section 3, I will outline the analytical framework behind measures of socioeconomic-related inequalities in health. I will discuss the concepts of equity and inequality in health before critically appraising what is and what is not captured by measures. In doing so, I intend to locate and define the interpretation of the study's findings.

Section 4 presents the empirical methods of the paper for mobility analysis in which data issues and tests for robustness will be discussed. Section 5 presents the results of the decomposition while Section 6 leads a discussion on the current state of socioeconomic health inequalities in Australia and its contributing factors. Section 7 summarises and concludes the paper.

1.3 LIMITATIONS

The study focuses on socioeconomic-related inequalities in health not on absolute inequalities. In saying so, it does not however seek to directly answer the direction of causality between health and socioeconomic status, but rather it aims to give a descriptive account of the strength of the relationship and lead a discussion on the influence of dynamic patterns of health and income changes over time on inequalities in health.

A priori, socioeconomic status will be defined in terms of economic resources where it is assumed that a measure of income serves as a suitable marker of divisions, real or imagined, in Australian society. The paper focuses on its distribution and how it affects health. There are other important social determinants of health such as the status of women, family composition and health policy-making which will not be explored in this paper.

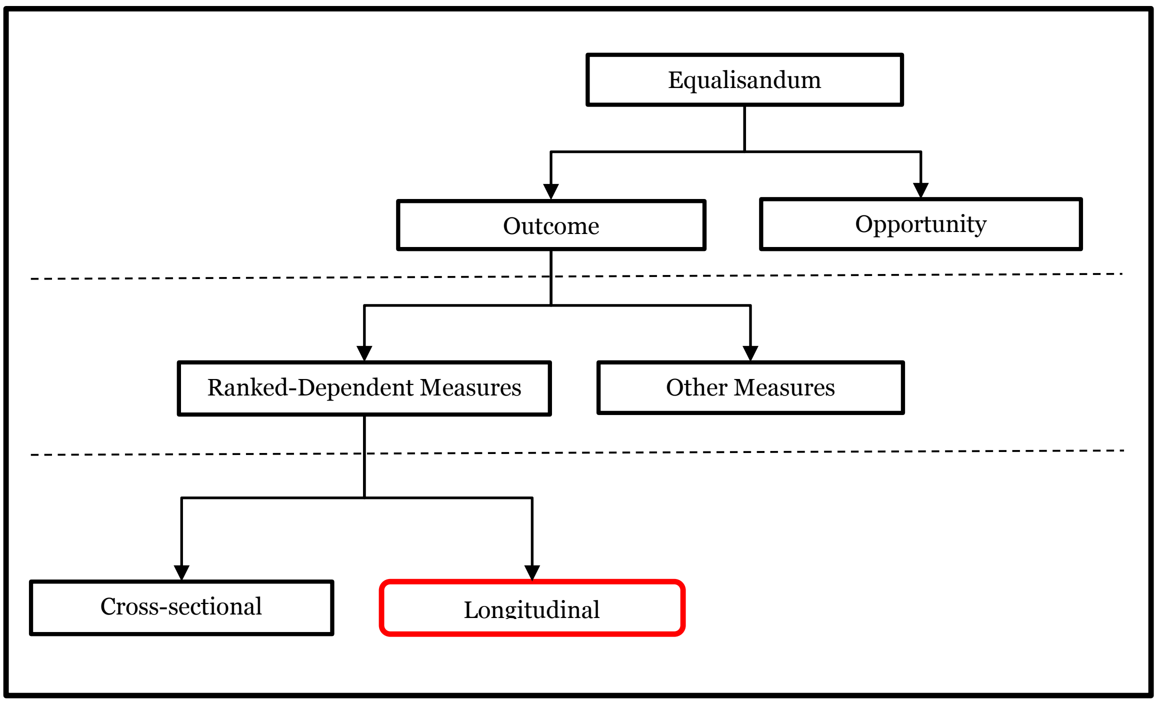
Some statistical limitations and their possible fixes will be discussed; for instance, as data collection uses survey methods, the dataset used in this paper is prone to missing data. Several imputation and sample weighting techniques have been used to ensure that the dataset is as complete and representative as possible and its effects on statistical inference will be discussed in section 4 of the paper. Similarly, there are unavoidable measurement errors and survey-period limitations which will also be discussed.

II. EMPIRICAL REVIEW

Empirical literature on the measurement of equity in health care and health is relatively young with research in the field following earlier works on the measurement of income inequality (Van Doorslaer & Van Ourti, 2011) [hereafter VD&VO, 2011]. In this section, a systematic literature review is performed to document recent movements in the field with the aim of providing the academic context of the main papers of this study: the works of Allanson et al. (2010) and Petrie et al. (2011).

The section follows from the empirical review of Calara (2013) and constructs a typology of approaches as presented in Figure 3. Firstly, the key methodological split between outcome- and opportunity-based measures will be re-visited before developments in ranked-dependent measures are surveyed. A systematic literature review of empirical applications of these measures on longitudinal data will then be presented as has been done by the main papers of this study. The review reaches only to measures of the relationship between socioeconomic and health variables and does not hold studies that specifically determine the causality between them.

Figure 3: Typology of Socioeconomic-related Health Inequality Measurements



2.1 CHOICE OF EQUALISANDUM

There appears to be two key methodological approaches in measuring health inequalities which are divided on the question of what is ought to be equalised. The choice of *equalisandum* predisposes different measurement tools; in the case of socioeconomic-related inequalities in health, empirical studies have the perspective of either equalising outcomes related to health or the opportunity to have better health.

Opportunity-based measures are relatively new with Rosa Dias (2009) pioneering the first methodological application of Roemer's (2002) theoretical work on equality of health opportunity on UK data. Other studies that follow include Trannoy, Tubeuf, Jusot & Devaux (2010), and Tubeuf, Jusot & Bricard (2012). A defining feature of this approach is its portrayal of circumstance firstly as the only legitimate source of inequalities and of it affecting health directly and indirectly through one's lifestyle choices. Very long panel datasets are required for dynamic modelling so that *circumstances* and *choices* can be defined by variables on early-life conditions, e.g., parent's socioeconomic status, and on one's later health-related choices, e.g., smoking and educational attainment, respectively. The degree of inequality in opportunity to have good health is measured by comparing the probability of having good or very good adult health in the distribution of health conditioned on a person's actual circumstance and the probability in a corresponding hypothetical distribution if one were allocated the best circumstances. The measurement toolset in this approach tests the dominance of one distribution over another and those which determine mediating effects.

Outcome-based measures, on the other hand, focus on the actual distribution of health *per se*. The measurement of inequalities in health stems from differences in health among socioeconomic groups. It is supposed in this case that irrespective of socioeconomic group to which one belongs, health outcomes should be more or less the same. A key divide in these measures is on how socioeconomic groups are defined, whether individuals can be ranked or not. Non-rank dependent studies on inequalities in health between geographical locations, occupations and ethnicity use comparisons of means and ranges of health outcomes between defined groups: as an example, Turrell et al. (2006) find that 15.4% of Australian blue-collar workers on average report their self-assessed health as fair or poor while for white-collar workers, the percentage is 12%. Odds ratios, relative risk ratios and the index of dissimilarity are also frequently applied (Wagstaff and van Doorslaer, 2000). Rank-dependent measures are, however, by far the more favoured approach in economics as they allow relative instead of absolute inequalities to be measured. An important shortfall of absolute measures is that they are confounded by differences in levels especially in time-series analysis. Furthermore, rank-dependent measures are able to reflect the experiences of an entire population instead of two groups where not all may strictly be classified (Wagstaff and van Doorslaer, 2000).

The choice of equalisandum in health inequalities measurement is important as it affects the interpretation of findings: whereas opportunity-based measures reveal *cumulative health risk* over a population on the one hand, outcome-based measures reveal *cumulative deprivation* (Calara, 2013).

2.2 RANK-DEPENDENT MEASURES

Ranked-dependent measures of health inequalities have a long history of development with the concentration index and its variants being the most prevalent measurement of choice since it was first proposed by Wagstaff, Paci & Van Doorslaer (1991). Other ranked-dependent measures that have been used in the past were the slope index of inequality (SII) and the relative index of inequality (RII) (Wagstaff et al. 1991; Kakwani, Wagstaff & Van Doorslaer, 1997).

The concentration index is derived from and graphically illustrated by the concentration curve for health which plots "shares of the health variable against quantiles of the living standards variable" (O'Donnell, Van Doorslaer, Wagstaff & Lindelow, 2008, p. 84). After ranking all individuals in a given population by income from lowest to highest, the curve plots the cumulative proportion of the ranked population against the cumulative proportion of health, taken as quantifiable good in this case. Equality in health is shown by a diagonal 45° line where health is then shared equally across persons of different income levels.

Figure 4 illustrates a health concentration curve, *L(p)*, which is unfavourable against persons that ranked low in the income scale. As shown, the curve is formed by plotting points on the axes, cumulative proportion of total ill health in the population and cumulative proportion of persons, ranked by socioeconomic status. If the curve lies above the 45° line, it indicates that a greater proportion of ill health resides with those with lowest incomes; alternatively, if the curve lies below the 45° line, it indicates that it is those with highest incomes that have the greater proportion of ill health.

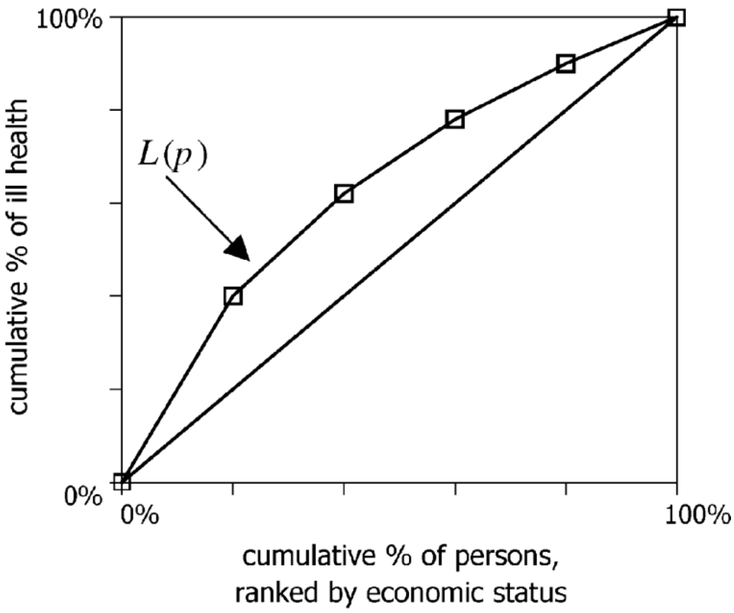


Figure 4: Concentration Index of Ill Health

[Source: Wagstaff 2012, p. 209]

The concentration index gives a measure of the magnitude of inequality and is equal to twice the area between *L(p)* and the 45° line. The mathematical formulation of the index integrated from the concentration curve can be computed (VD&VO, 2011), as shown:

Equation 1: Concentration Index

$$CI(h) = \frac{1}{n}\sum_{i=1}^{n}\left[\left(\frac{h_i}{\bar{h}}\right)\left(2R_i^y - 1\right)\right]$$

where h_i denotes health of individual i, $\bar{h}$ is the average of h_i, and $R_i^y = n^{-1}(i - 0.5)$ is the fractional rank of socioeconomic status y_i where individuals are ranked from low to high socioeconomic status. The index is bounded between $n^{-1}(1 - n)$ and $n^{-1}(n - 1)$, where 0 indicates perfect equality while a positive value indicates that health is less experienced with those ranked low in terms of income.

This formula can transformed in a more convenient form in terms of the covariance between the health variable and the income rank (O'Donnell et al., 1998) as shown:

Equation 2: Concentration Index in covariance form

$$C = \frac{2}{\mu} cov(h_i, y_i)$$

where h refers to the health variable, μ refers the mean of the health variable while r denotes fractional rank in a living standards variable. Socioeconomic variables which define 'rank' relates to where 'health' is most and where it is least in the distribution. The concentration index, therefore, holds a bivariate relationship between the health variable and the rank of the living standards variable.

As the concentration index is derived from the Gini coefficient of income inequalities, the health variable should have the same properties as income to fit the index measurement (Kjellsson & Gerdtham, 2013). Since the health variable lack ratio scale measurement properties and is bounded, extensions and corrections have been proposed from the health concentration index by Wagstaff et al. (1991).

The generalised concentration index (GC), for instance, was proposed by Clarke et al. (2002) to try gain mirror properties where the concentration index for health and ill health are exact inverse of one another. The Wagstaff (2005) index, on the other hand, was constructed for binary health variables to overcome the dependence of the bounds of the concentration indices on its mean. Erreygers (2009) provide a correction on the cross-sectional CI that achieves four desirable properties for analysis: transfer, mirror, level independence and cardinal invariance. Each of the variants of the original concentration index serve to overcome limitations of the underlying variables but they can also have normative implications.

From the debates and discussions on the value judgments implicit in concentration indices, Kjellsson & Gerdtham (2013) find that the family of rank-dependent indicators each have a different perspective on socioeconomic-related inequalities in health depending on how they weight absolute inequalities. Similarly, Allanson & Petrie (2013) demonstrate how the choice of health inequality index can affect estimation of income-related health inequalities as a particular measure implies a particular vertical equity judgement. In sum, both papers suggest that the difference is normative rather than technical.

2.3 APPLICATIONS OF THE CONCENTRATION INDEX

Van Doorslaer and colleagues (1997) feature one of the first works to utilize the concentration index in cross-country comparisons of health inequality. Using cross-sectional health survey data, respondents are ranked within decile groups according to disposable household income per adult while the health indicator used is self-assessed health (SAH). *Avoidable* inequalities, as it is termed in their paper, are reflected through the unequal shares of ill-health among income groups standardised accordingly to the demographic factors of age and sex, which have also been considered as confounding factors. Direct standardisation occurs by determining the average rate of ill health for each income group. In a similar study, Kunst, Geurts & Van den Berg (1995) use levels of education as ranked socioeconomic groupings and dichotomizes the SAH variable to *good* and *bad* health.

Wagstaff, Van Doorslaer & Watanabe (2003) extend the concentration index by providing the first instance of decomposing income-related inequalities in health. Unlike direct standardisation, decomposition allow total inequality to be partitioned into *potentially avoidable* and *unavoidable* health inequality (Kakwani et al., 1997). The decomposition methods of the paper assume the substitution of the variable of interest, y_i, into its linear regression model of its k determinants (Wagstaff et al., 2003a), as such:

Equation 3: Linear Regression Model of k determinants

$$y_i = \alpha + \sum_k \beta_k x_{k,i} + \varepsilon_i$$

Given this specification, the concentration index can therefore be decomposed into three terms:

Equation 4: Linear Decomposition of Concentration Index

$$C = \sum_{g} (\frac{\beta_g \overline{x_g}}{\mu}) + \sum_{h} (\frac{\beta_h \overline{x_h}}{\mu}) + \frac{GC_\varepsilon}{\mu}$$

where the first term refers to the effect of a set of g avoidable determinants, the second term being that of the effect of a set of h unavoidable determinants and the last term being that denoted to the residual term. This decomposition is only possible with linear specifications.

Wagstaff and Watanabe (2003) apply linear decomposition to micro-level data on malnutrition inequalities in Vietnam. In their linear regression on the height-to-age variable (an indicator for stunting), there was no specification of two sets of equitable and inequitable determinants as above. However, it can be inferred that *relevant* dimensions to socioeconomic determinants were those that where included while the error term can refer to the *irrelevant* determinants. In results of Wagstaff and Watanabe (2003), these *residual* effects accounted for 25 per cent of total variation.

Van Doorslaer & Koolman (2004) [hereafter VD&K, 2004] apply the same decomposition method on panel European data but uses instead a cardinalised health (utility) variable. The degree of *potentially avoidable* inequality (VD&K, 2004, p. 621) is calculated by subtracting the contributions of age and gender from total inequality, that is, through eliminating their effects in the decomposed index. Unlike Van Doorslaer et al. (1997), in this study, an indirect method of standardisation is utilised whereby *partial* effects of age and gender are accounted for.

2.4 LONGITUDINAL APPROACHES

Concentration indices have developed through different methods of construction and decomposition but also through the availability of longitudinal data. Unlike cross-sectional or repeated cross-sectional data, longitudinal data is collected from the same individuals or households at several points in time which allows differences between and within individuals to be tracked over time. As longitudinal datasets tend to contain many waves or repeated observations for long periods of time, they provide extra information beyond describing the extent of a problem at a given point. Crucially in the analysis of inequalities in health, it can help understand persistence in divergent health outcomes between rich and poor.

A systematic literature search was performed in this category of measurement to identify previous research and to allow comparability between this study which uses longitudinal data and others that have been made using similar methods. The search was carried out on July 23d 2013 using the EconLit database for peer-reviewed journal articles and working papers dating from the year 2000 onwards. The search strategy consisted of the text word combination 'health inequality' and 'longitudinal' and it was limited to papers in English.

An overview of the selection process and results of the systematic review is depicted in Figure 5. The initial search result of 39 papers were minimised to 8 after excluding replicate results and papers with unrelated research questions.

Figure 5: Literature search process

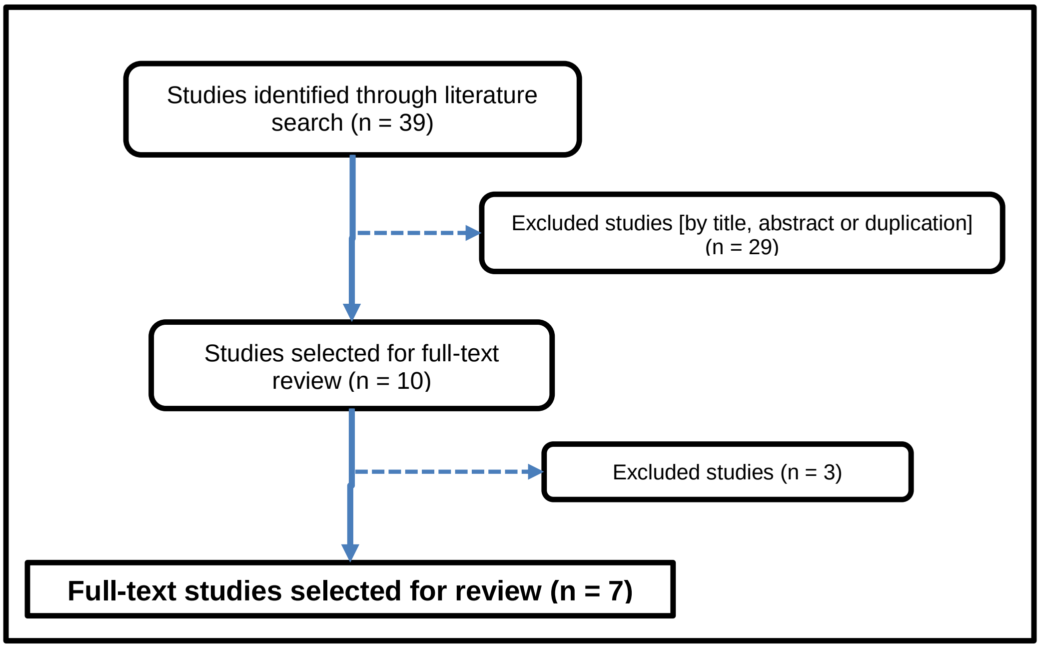


Figure 6 features a summary of all full-text studies for the review. The majority of published studies use the British Household Panel Study (BHPS) for analysis while there has not been a study conducted using Australian data. An unpublished report from the Australian Government Department of Families, Housing, Community Services and Indigenous Affairs (FaHCSIA) using a longitudinal measure of socioeconomic-related inequalities in health however will be included. In general, longitudinal analysis is relatively new. Common to the studies is the use of concentration indices while a key source of difference is the interpretation of *mobility* when analysing changes in inequality.

Hauck and Rice (2004) analyse long-term health inequalities between socioeconomic groups in terms of mobility in mental health; in this case, inequality is judged in terms of differences in suffering permanent decrements in mental health. The first measure used was derived by partitioning unobserved variability in health states into transitory and permanent components using random effects model specifications of the mental health status variable. The measure of health mobility is obtained from calculating the contribution of the permanent component to total variability; the greater the contribution, the lesser is mobility. A second measure was further derived by estimating the coefficient of the lagged health status variable in a dynamic OLS model specification. The smaller the coefficient the greater the extent of health mobility as it signifies that there is less inter-state transmission of health status. A key finding of Hauck and Rice (2004) was that persons in the two lowest income quintiles show greater mental illness as well as greater persistence in having this condition in comparison to their counterparts in the two highest income quintiles.

Jones and López-Nicolás (2004) [hereafter JLN] were the first to attempt measuring health inequality using longitudinal data. They apply the methods of Shorrock (1978) which analyses income mobility to see if socioeconomic-related inequalities measured using short-run, i.e., cross-sectional, concentration indices differ from long-run indicators. They construct the long-run concentration index as "the weighted sum of short-term concentration indices and a second term summarizing whether there are systematic health differences between individuals that are upwardly and downwardly mobile in terms of socioeconomic status" (VD&VO, 2011, p. 847). Mobility in this framework refers to the direction in which individuals move in income rank over a longer period of time compared to a shorter period: a person is upward (downward) mobile if his/her income rank is higher (lower) in the long run than in the short run. Mobility is measured by an index of *health-related income mobility* that is constructed to observe if income over time has an equalising or disequalising effect on the health distribution. The index further decomposed into contributing factors using a linear regression model (OLS). Their analysis found using the British Household Panel Survey (BHPS) that the absolute value of the concentration index increased by 15% for men and 5% for women when a long-run perspective is taken. As the health-related income mobility index was found to be negative, changes in income in the long-run had a disequalising effect and thus added to measured inequalities in health.

Lecluyse (2007) follows from the methodology of Jones and López-Nicolás (2004) and applying it to Belgian panel data but adds a comparison of the decomposition of the mobility index with the decomposition of the CI to see whether the same factors contribute. Likewise with the UK study, the health-related income mobility index was negative and it was found that the same factors of income, education, job status and age contribute to higher long-run CIs. The absolute value of the CI increased by 9.45% when taking a long-run perspective.

Brandrup and Kortt (2007) compiled a report for the Australian Government Department of Families, Community Services and Indigenous Affairs (FaHCSIA) estimating the extent of socioeconomic-related inequalities in Australia by applying the methods of JLN (2004) on the HILDA dataset. They extended decomposition using a fixed-effect model to potential determinants of the relationship between income and health. Likewise with the results of the UK study by JLN (2004) and Lecluyse (2007), short-run concentration indices were smaller than long-run concentration indices for Australia and the health-related income mobility index was negative. The OLS decomposition of the mobility index suggests an unaccounted for dynamic in measures that healthy individuals which are more concentrated among the rich are also more likely to be upward mobile. From the fixed effects decomposition, however, this is inconclusive.

Allanson et al. (2010) provide a critique of the health-related income mobility index of JLN (2004) and propose an alternative measure that reflects both income and health mobility. It is argued that the estimated value of the index is commonly negative as it is dependent on the typically unimodal shape of the income distribution and the strength of the positive relationship between income and health. Having this influence, it implies that the index has less bearing on measuring the effect of mobility on the long-run concentration index as supposed by the authors. Crucially, the JLN measure does not account for income-related health mobility which Allanson et al. (2010) saw as just as important. The index would equal zero if incomes are unchanged but health outcomes changed over a given time period. In their new approach, it is supposed that "any change in income-related health inequality over time must arise from some combination of changes in health outcomes (i.e. "health mobility") and changes in individuals' position in the income distribution (i.e. "income (rank) mobility")" (Allanson et al., 2010, p. 82). They thus decompose the change in the short-run CI between an initial period and a final period into these two parts as the income-related health mobility and the health-related mobility indices. Unlike the JLN index, the mobility indices are not anchored on averages but rather on the dependence of patterns of change on initial values. The income-related health mobility index measures, for instance, whether the pattern of health changes that have occurred favour those with initially low or high incomes. Similarly, the health-related mobility index measures whether the patterns of income ranking changes favour those with initial low or high health. The impact of the income-related health mobility index on final period income-related health inequalities depends on the progressivity and scale of health changes or income re-rankings captured by a Kakwani-type (1977) progressivity index and scale factor measured as the ratio of average health changes to average final period health. The distribution of health losses for example may be disproportionate against the poor but it will not impact the inequality measure if the losses are relatively small. As this study replicates their methods, more details on the construction of the indices will be given in the following chapter on this study's methodology.

Petrie et al. (2011) offer an extension of Allanson et al. (2010) by accounting for mortality within populations, which is a key source of missing data in previous analyses of health inequality. In previous research, respondents who have died during the survey collection process have either been dropped or have had their responses imputed through inverse probability weights (IPWs). In their approach, Petrie et al. (2011) explicitly accounts for mortality by firstly including deceased persons in the panel dataset and by secondly denoting their health utility values as zero, which is the lowest value in the cardinal scale. By accounting for mortality, mobility indices can be further decomposed into mortality-related and morbidity-related causes as will be further elaborated in this study's methodology. Results from this paper will also be used as the basis of international comparisons for concentration and mobility indices in Section5.3.

Allanson and Petrie (2011) further decompose changes in concentration indices from Petrie et al. (2011) by employing an error correction model (ECM) of conditional health changes in order to clearly distinguish between the short-run and long-run effects of changes in health determinants on income-related health inequality. The empirical estimates using the British Household Panel Survey (BHPS) imply that health determinants are more disequalising over the long-run which is leading to greater income-related health inequality in the long term.

Allanson and Petrie (2013) again extend the measurement by considering different health inequality measures from the commonly used concentration index. As the authors illustrate, the choice of measure matters in the long-run analysis of income-related health inequalities as each measure implied a particular vertical equity judgement (see Section 2.2).

Figure 6: Summary of studies on health inequality using longitudinal rank-based measures

Name of Study	Year	Dataset	Methodological Contribution	Interpretation of Mobility
Hauck and Rice	2004	British Household Panel Study (BHPS)	(1) Estimation of variance components from random effects models (2) OLS dynamic regression model	The extent to which the effect of mental health problems are persistent / permanent as opposed to transitory.
Jones and Lopéz-Nicolás	2004	British Household Panel Study (BHPS)	(1) Long-run concentration index: CI using average health and rank after *T* periods. (2) Health-related income mobility index: ratio by which the long-run CI differs from the weighted average of the cross-sectional CIs.	Income mobility defined as the extent to which one's income rank is higher or lower in the long run (defined over multiple periods) compared to the short run (defined only in the current period).
Lecluyse	2007	Belgian Household Panel Study (BHPS)	Same as Jones and Lopéz-Nicolás (2004)	Same as Jones and Lopéz-Nicolás (2004).
Allanson, Gerdtham & Petrie	2010	British Household Panel Study (BHPS)	Long-run concentration index: CI between two periods, initial and final, where it is decomposed into within-period changes in health outcomes and in income rank.	(1) Income-Related Health Mobility: the relationship between relative health changes and individual's initial level of income (or final level of income). (2) Health-Related Income Mobility: the relationship between income rank changes and individual's final level of health. (or initial level of health)
Allanson and Petrie	2011	British Household Panel Study (BHPS)	Decomposition methods of long-run concentration index from Allanson, Gerdtham & Petrie (2010) through the application of an error correction model (ECM) of conditional health changes	Same as Allanson, Gerdtham & Petrie (2010).
Petrie, Allanson & Gerdtham	2011	British Household Panel Study (BHPS)	Accounting for mortality-related attrition by decomposing mobility indices from Allanson, Gerdtham & Petrie (2010) into morbidity and mortality factors.	Same as Allanson, Gerdtham & Petrie (2010).
Allanson and Petrie	2013	British Household Panel Study (BHPS)	Construction of the long-run concentration index in the manner of Allanson, Gerdtham & Petrie (2010) using variants of CIs.	Same as Allanson, Gerdtham & Petrie (2010) expressed in different constructions of mobility indices.

III. ANALYTICAL FRAMEWORK

3.1 EQUITY AND EQUALITY IN HEALTH

In a general sense, health appeals to personal experience or a state of individual being, as the constitution of the WHO (1946) aptly describes it: “health is a state of complete physical and social well-being and not merely the absence of disease or infirmity”. Economics makes the same appeal. Microeconomic models regarding health often represent individuals as its agents, guided by the rational motive to optimise their health among the attainment of other goods and commodities (Grossman, 1972).

As examining inequality *per se* involves comparisons between persons, conceiving inequalities in health, on the other hand, requires us to depart from examining health at the individual level. Inequalities in health could be conceived instead in terms of a hypothetical distribution where people in a given population enjoy unequal shares of health as a quantifiable good. Viewing this *distribution* does not necessary imply a *distributor* or *distributors* but facts to the contrary could indicate otherwise that there is a systematic force for some to have more capacity for health than others. Redistribution, in a similar sense, is not feasible as health is a distribuendum (the entity to be distributed) that cannot be redistributed. Within this framework, how inequalities in health is subject of contention can be analysed.

In the first instance, however, equality must be distinguished from equity. Whereas equality signifies equal shares, equity attaches a notion of ‘fairness’ to equal shares and as such, equality is not always the desired outcome. It is from the chosen set of principles of equity upheld by society that carries the moral and ethical overtones of inequalities, whether in health or in another good. In general, it is the subscription to a theory of distributive justice that determines what would be *equitable inequalities* as opposed to *inequitable inequalities* (Olsen, 2011). In the context of public health, individual responsibility and societal avoidability are two compelling and contrasting principles that guide *fairness* towards an unequal but justifiable distribution (Olsen, 2011).

These two principles make an important distinction in the determinants of health that an individual should be held responsible for on the basis of his or her ability to make a choice. The principle of individual responsibility says that determinants of health that are within one's control such as health-related lifestyle choices are illegitimate sources of inequality. On the other hand, the principle of societal avoidability removes responsibility from the individual. It does so on the basis that one should not suffer from *circumstances* in which he or she is born with. Whether population health is distributed systematically or not, circumstances should not play a role. It therefore rejects health outcomes being transmitted between generations, whether unavoidably or avoidably through genetic endowments or the socioeconomic status of one's parents. For moral theorists such as Dworkins (1981), this constitutes the only ground for compensation from an unequal distribution.

An alternative voice in the debate is to aim for health equality as the desired outcome. Sen (1992) makes the case against inequalities by arguing that equality in health is an end to itself as health is important to many other aspects of life in many ways. Our health is ultimately tied to our "freedoms and capabilities that we are able to exercise" (Sen, 2002, p. 663) and therefore inequality in health ultimately equates to an unequal capability to flourish (Sen, 1992). His notion of fairness is attached to the capabilities enjoyed with health.

The difficulty, however, lies in determining what defines conscientious individual choice. Health-related choices cannot always be assumed to be voluntary nor could health-related preferences across social classes be necessarily the same (Balia and Jones, 2008). There is therefore no consensus to what extent of *self-control* inequality becomes inequitable. Moreover, it cannot be assumed that social mobility does not occur throughout a lifetime and that circumstances do not change. These underlying relationships make it difficult to separate where the individual and society takes responsibility for inequalities in health. Despite this debate, there is consensus from leading governing bodies such as the WHO and national or state bodies to reduce overall inequalities in health (CSDH, 2008; WHO, 2009).

In this section, I will elaborate upon the standpoint of equity in which I will be conducting my analysis namely where "the health distribution in a just society (is) as one where access to health has not been determined by socioeconomic status or income" (Bommier and Stecklov, 2002, p. 502) and crucially to situate its application in economic theory. A review of different approaches to equity reflected in economic theory will firstly be presented and from this the theoretical basis of my analysis will be presented.

3.2 MEASURING HEALTH INEQUALITIES: EQUITY-EFFICIENCY TRADE-OFF

Efficiency goals have been primary in economic analysis but it is by no means the only important measure to account for. Economist have also developed analytical tools for the measurement and explanation of inequality. Indeed, equity concerns can be brought to the fore when social divides have been shown to have nefarious effects not just on social mobility but also to fundamental welfare matters such as health.

Philosophical arguments on justice translate into economic parlance primarily through quantification. Economists contribute to debates on equity by focusing on outcomes and the trade-offs involved in achieving multiple ends rather than qualitatively determining the veracity of arguments. Economic reasoning has also been applied on equity of opportunities to have better health rather than outcomes.

In his outcome-based framework, Williams (1997) applies the fundamental economic problem of scarcity to achieving health equity where efficiency is supposed as the opportunity cost of health equity. The efficiency-equity trade-off in the analysis of Williams can be phrased into a question: how far are we willing to have the overall level of health of the community reduced in order to reduce inequalities in the distribution of health? Principles are not the only the determinant of what is fair as "giving priority to one group inevitably disadvantages others" (Williams, 1997, p. 128).

The trade-off is borne from divergent efficiency and equity goals in social welfare theory. Whereas efficiency refers to the goal of maximising uniformly valued health gains, equity attaches different values to potential health gains. From an economic point of view, if society is to increase health gains it should do so indiscriminately unless some countervailing equity argument changes the value of the 'quantum benefit' of certain groups (e.g., the old, the poor, etc.).

From his analysis, Williams (1997) proposes to attach *equity weights* to health outcomes such as QALYs to measure the relative strength of different people's equity-based claims on health care resources over a lifetime. One source of weights, for instance, could be for different social classes. His analysis is unique in taking us from a point of view of no value judgment to where the relativity of ethical values are judged accordingly to their efficiency trade-off "in the presence of such unanimity about the relativity of ethical values" (Williams 1997, p. 120). Inequalities in health could then be measured as differences in health that still exist before and after weights have been applied. In the same way, Wagstaff and Van Doorslaer (2000) discuss the contrast between measuring pure inequalities in health and alternatively socioeconomic inequalities in health.

To determine the right set of weights empirically, a method that has been used by economists is to determine it under a *veil of ignorance* where individuals respond to the trade-off without knowing which position in society he/she is in. Rawls' (1971) suggestion that individuals arrive at just social decisions under a veil of ignorance is operationalize as taking the trade-off under genuine uncertainty or a choice under risk (Andersson and Lyttkens, 1999).

In a pilot study, Johansson and Gerdtham (1996) estimated the equity-efficiency trade-off for QALYs by having Swedish participants respond to a hypothetical choice between two societies (society A and society B) that differed only with respect to life-years in full health between two groups within them (group 1 and group 2). By telling participants that they had an equal probability of belonging in a group, Johansson and Gerdtham (1996) supposed to imitate the condition of deciding under a veil of ignorance. It was estimated that the mean marginal trade-off was 0.45 which signify that individuals are willing to reduce 1 QALY from a group that has more QALYs to increase the QALY in the group that has less by 0.45. Additionally, Johansson and Gerdtham (1996) found that whilst subjects were willing to trade more QALYs from a group that has more QALYs to a group that has less, they were not increasingly more willing to do so when there are larger difference in QALY between groups. In a larger study, however, Andersson and Lyttkens (1999) found the trade-off was lower in favour of more efficiency and less equity but found that higher relative difference between groups did impact the trade-off in favour of equity. This therefore supposes that measuring inequality that matters depends on the aversion of individuals against inequality.

3.3 MEASURING HEALTH INEQUALITIES: RELEVANT DIMENSIONS

Relevant dimensions of equity to be accounted for are expressed by economists in different ways. Dichotomies are often made about determinants of inequality including those that are avoidable as opposed to unavoidable or policy relevant as opposed to policy irrelevant or yet in stronger words, illegitimate as opposed to legitimate sources. Measuring health inequalities ultimately reflects normative choices.

Williams (1997) himself applies the normative concept of the *fair innings* as a compelling argument where he supposes that people have an entitlement to a certain expected life expectancy of a population. What is considered fair and unfair is clear and quantifiable. To broadly account for multiple dimensions of socioeconomic-related inequalities in health, however, greater rigour is needed.

Measuring unfair inequalities requires normative choices on identifying and separating variables between *legitimate* and *illegitimate* sources (Fleurbaey and Schokkaert, 2009). Thus, if the principle of individual responsibility is called upon, for instance, it should be clear that the effects of lifestyle choices are excluded from calculation. In a simplified version, a function determining health given by $h_i =$

$h(y_i, l_i)$ splits variations in health according to a social determinant, income (y_i), from a choice determinant, lifestyle (l_i).

Fleurbaey and Schokkaert (2009) set two strict conditions in which measurements of socioeconomic inequalities in health can validly dichotomize sources: firstly, the measure should not reflect variations in outcomes which are caused by differences in legitimate variables (no influence of legitimate differences); secondly, when measures of unfair inequality is zero there should be no illegitimate differences left (compensation). Even through standardisation, it is difficult to circumvent problems with isolating out variables. Fleurbaey and Schokkaert (2009) themselves have had to build a complex structural model composed of reduced form equations.

Another set of economists do not try to disentangle variables but rather to apply equity principles on opportunities rather than outcomes. In contrast to outcomes, opportunities are not affected by certain factors. When removing lifestyle choices that give rise to inequalities in health, opportunities provide a better alternative as choices do not endogenously affect opportunities to better one's health.

In his opportunity-based framework, Roemer (2002) refers to inequality of opportunity in health as individuals, having expended the same effort, achieving different outcomes due to different circumstance. He is able to make clear and be confident that variables related to effort are taken out of the equation by indexing the distribution of each individual's effort according to his/her social circumstance. Individual responsibility is thereby removed in this way from socially-produced inequalities. An appropriate metric for opportunity needs to be further defined however which is not influenced by individual choices.

The analytical framework of this thesis discussed in the next section features another opportunity-based approach.

3.4 ANALYTICAL APPROACH OF STUDY

If a form of socioeconomic-related inequalities in health are to be considered inequitable inequalities, as mentioned beforehand, an underlying theory of justice is required. Additionally, measures of inequality must reflect the same theoretical base and at the same time allow us to make judgements on what distribution is more or less unequal.

In this study, I will take a bi-dimensional notion of inequality based on the Rawlsian approach proposed by Bommier and Stecklov (2002) in which:

> "...the health distribution in a just society (is) as one where access to health has not been determined by socioeconomic status or income" (2002, p. 502).

Their approach adopts Rawls' (1971) First Principle of Justice where access to health resources is defined as a basic freedom, which, like all other basic freedoms, should be distributed equally in the ideal society (equalisandum). Thus, health inequality measurements are to assess the level of inequality based on the degree to which health access is equally distributed.

As access to health is unobserved, measurement rests upon individual health status, denoted as h. Bommier and Stecklov (2002), however, use the following relationships to derive an inequality measure of an unobserved variable:

- Health endowments (e) is a key determinant of health status (h) which is a proxy for health access (a).
- Therefore, if e is distributed independently of a socioeconomic variable (y), then y should then also be independent of h (independence assumption).

The strength of the relationship between y and h gives a measure of the strength of the inequality in health access, a. It must be acknowledged that the association between y and h may not account for the entire variation in a. This depends on the relationship between access to health and health outcomes. The socioeconomic variable y should be independent of health endowments and likely to reflect a major cause of discrimination in access to health. There are not many socioeconomic variables that cannot escape the endogeneity of health. Household income however used in this study is a good candidate as one's household income is likely to be jointly determined by multiple persons.

In this framework, I focus on one source of avoidable inequalities, socioeconomic status, rather than overall inequalities in health using income as a proxy. I assume that the effect of socioeconomic factors such as income on health is not independent of life-style choices. The causality of the relationship between life-style choices and income is unclear. In this case, I assume that inevitably all effort is correlated in some way to circumstance. Analysing the strength relationship between income and health, however, captures the minimum bound of illegitimate sources of inequalities in health.

3.5 A LONGITUDINAL PERSPECTIVE

The analysis offered in this study will be conducted from a longitudinal perspective to reflect the dynamics of socioeconomic-related inequalities in health over time. The study contributes to understanding the persistence of income-related health inequalities and what the underlying process is in its evolution instead of examining its current state. In other words, it offers us a way to understand inequality given that relative positions of individuals vary over time (Shorrocks, 1978). The longitudinal perspective is therefore more inclusive of factors such as income history and changes in educational attainment.

IV. METHODOLOGY

This study replicates the methodology of two key papers by Allanson et al. (2010) and Petrie et al. (2011) for determining socioeconomic-related inequalities in health using Australian household survey data from which health and income observations were extracted. The sample of this study and its respective sample weighting mechanism are intended to be comparable to their methods. Analysis was undertaken using STATA 12.0 software (StataCorp).

4.1 MEASURING INEQUALITY

The concentration index of health over the long-run will be constructed as the change in short-run concentration indices between the initial period, *s*, and a final period, *f*. This approach taken by Allanson et al. (2010) will then be taken further by applying a decomposition of the long-run concentration index that accounts for mortality-related attrition as proposed by Petrie et al. (2011).

Concentration indices that will be constructed are modelled on the convenience equation shown in Equation 2: Concentration Index in covariance form. Though decomposition is an important exercise to derive probable causes of inequality, this study concerns itself in pin-pointing how socioeconomic-related inequalities in health change. Mobility indices nonetheless will be differentiated between morbidity and mortality factors.

The approach of Allanson et al. (2010) takes the analysis of health inequality to longitudinal datasets by estimating the change in short run CIs between two periods as such:

Equation 5: Change in two cross-sectional concentration indices

$$CI_f - CI_s = \frac{2}{\bar{h}_f} cov\left(h_{if}, R_{if}\right) - \frac{2}{\bar{h}_s} cov(h_{is}, R_{is})$$

The change in short run CIs will be decomposed into mobility indices which provide indices of income-related health mobility and health-related income mobility. They will be constructed to account for both morbidity and mortality changes in health as formulated by Petrie et al. (2011). This means that in the final period, *f*, the concentration index will be constructed *without excluding those who may have died between this period and the initial period, s*. As such, the cross-sectional CIs will be decomposed as:

Equation 6: Allanson et al. (2010) decomposition

$$\begin{aligned} CI_f - CI_s &= \frac{2}{\bar{h}_f} cov\left(h_{if}, R_{if}\right) - \frac{2}{\bar{h}_s} cov(h_{is}, R_{is}) \\ &= \left(\frac{2}{\bar{h}_f} cov\left(h_{if}, R_{if}\right) - \frac{2}{\bar{h}_f} cov\left(h_{if}, R_{is}\right)\right) + \left(\frac{2}{\bar{h}_f} cov\left(h_{if}, R_{is}\right) - \frac{2}{\bar{h}_s} cov(h_{is}, R_{is})\right) \\ &= \left(CI_{ff} - CI_{fs}\right) + \left(CI_{fs} - CI_{ss}\right) \\ &= M_R - M_H \end{aligned}$$

Income-related health mobility is expanded splitting changes in health between those due to morbidity (health utility score remains positive) and to mortality (health utility score becomes zero). The impact of morbidity- and mortality-related causes on health inequality is composed of its progressivity captured by the progressivity index (p^{MB} and p^{MT}) and its relative scale captured by the scale factor (q^{MB} and q^{MT}). The decomposition is illustrated in Equation 7.

Equation 7: Decomposition of Income-Related Health Mobility

$$
\begin{aligned}
M_H &= (CI_{ss} - CI_{\Delta s})\left(\frac{\overline{\Delta h}}{\overline{h_f}}\right) = Pq \\
&= \left(\frac{2}{\overline{h_s}} cov(h_{is}, R_{is}) - \frac{2}{\overline{\Delta h}} cov(\Delta h_i, R_{is})\right)\left(\frac{\overline{\Delta h}}{\overline{h_f}}\right) \\
&= \left(\frac{2}{\overline{h_s}} cov(h_{is}, R_{is}) - \frac{2}{\overline{\Delta h}} cov(\Delta h_i^{MB} + \Delta h_i^{MT}, R_{is})\right)\left(\frac{\overline{\Delta h^{MB}} + \overline{\Delta h^{MT}}}{\overline{h_f}}\right) \\
&= \left(\frac{2}{\overline{h_s}} cov(h_{is}, R_{is}) - \frac{2}{\overline{\Delta h^{MB}}} cov(\Delta h_i^{MB}, R_{is})\right)\frac{\overline{\Delta h^{MB}}}{\overline{h_f}} \\
&\quad + \left(\frac{2}{\overline{h_s}} cov(h_{is}, R_{is}) - \frac{2}{\overline{\Delta h^{MT}}} cov(\Delta h_i^{MT}, R_{is})\right)\frac{\overline{\Delta h^{MT}}}{\bar{h}_f} \\
&= (CI_{ss} - CI_{\Delta s}^{MB})\left(\frac{\overline{\Delta h^{MB}}}{\overline{h_f}}\right) + (CI_{ss} - CI_{\Delta s}^{MT})\left(\frac{\overline{\Delta h^{MT}}}{\bar{h}_f}\right) \\
&= p^{MB}q^{MB} + p^{MT}q^{MT} = M_H^{MB} + M_H^{MT}
\end{aligned}
$$

Health-related income mobility is expanded by splitting re-ranking due to shuffling between those still alive (M_R^{MB})and to the dead dropping out of the sample (M_R^{MT}). The decomposition is shown as:

Equation 8: Decomposition of Health-Related Income Mobility

$$
\begin{aligned}
M_R &= \left(\frac{2}{\overline{h_f^A}} cov\left(h_{if}^A, R_{if}^A\right) - \frac{2}{\overline{h_f}} cov\left(h_{if}, R_{is}\right)\right) \\
&= \frac{2}{N\bar{h}_f}\sum_i^A \left(h_{if}^A\right)\left(R_{if}^A - R_{is}^A\right) + \frac{2}{N\bar{h}_f}\sum_i^A \left(h_{if}^A\right)\left(R_{is}^A - R_{is}\right) \\
&= M_R^{MB} + M_R^{MT}
\end{aligned}
$$

Using the HILDA dataset, I will construct both indices treating wave 1 (2001) as the initial period and wave 5 (2005) as the final period. The time period between waves is chosen to allow comparisons with results from the United Kingdom (Petrie et al., 2011).

4.2 DATA

4.2.1 THE HILDA SURVEY

This study draws its population of interest from the Household, Income and Labour Dynamics in Australia (HILDA) survey. The survey is a nation-wide household-based study with a longitudinal design that covers a broad range of social and economic questions. The first yearly wave of the survey commenced in 2001 with an initial sample of 7,682 households and 19,914 individuals selected for participation; thus far, eleven out of sixteen planned waves of the survey have been undertaken. Out of the starting sample in the first wave of the survey, 7,229 respondents have been interviewed throughout all waves including the current wave (Summerfield, Freidin, Hahn, Ittak, Li, Macalalad, Watson, Wilkins & Wooden, 2012). In this study, waves 1 to 5 of the HILDA survey available under General Release 11 will be used. *General Release* refers to a release of data from which personal information has been made unidentifiable to users of the dataset.

The initial sample that constitutes the survey is intended to be representative of all Australian households and various data sampling methods have been used to ensure that all households have the same probability of selection. Household sample units of the survey were selected to participate through a multi-staged approach across Census Collection Districts (CDs) as defined by the Australian Bureau of Statistics (ABS, 1996). Household is defined, following the ABS, as "a group of people who usually reside and eat together" (ABS, 2000). A household in the survey, however, can either be a one-person or multi-person household. In wave 11 of the survey, 2,153 additional households were added to the sample in order to reflect recent changes to Australian demographics, particularly due to immigration. It is worth noting that as the survey targets persons living in private dwelling, it does not account for person living in institutions, i.e., students in boarding schools, retirees in aged-care facilities or other non-private dwelling. Those living in very remote areas of Australia were also excluded where remoteness derived from the Australian Statistical Geography Classification (ASGC). To be more precise, persons that constitute this study are therefore representative of the Australian population living in private households not located in very remote areas of the country. In line with the aims of this paper, health inequalities will be assessed along differences between Australian households as sampled by the HILDA survey.

As the survey is completed largely on a voluntary basis with minimal respondent incentives[1], the desired sample, nonetheless, may diverge from the sample it was intended for. Crucially, households who were initially chosen to be in the survey may not respond at all. Watson and Wooden (2002) finds under-representation in the responding sample in the first wave of the survey from those living in the Sydney urban area, immigrants from non-English speaking backgrounds, unmarried persons and males. They concluded nonetheless that the size of the discrepancies are not large enough to discredit the data. Thus, it appears that the responding sample of the survey has maintained its representativeness.

4.2.2 DATA COLLECTION METHODS

Data collection comprised of four different instruments:

- the Household Form (HF);
- the Household Questionnaire (HQ);
- the Person Questionnaire (PQ); and
- the Self-Completion Questionnaire (SCQ).

The Household Form (HF) records basic information about the composition of a household and its participation in the survey. Whereas it is completed only once upon first contact, the Household Questionnaire (HQ) collects information every wave on the changing nature of the household. Similarly, Person Questionnaires (PQ) are administered to every member of all households aged 15 years and over annually. Both HQ and PQ are conducted through face-to-face or telephone interviews occurring in mid-August each year. From wave 9 onwards, however, the computer-assisted personal interviewing (CAPI) instrument was introduced to replace face-to-face interviews. With this instrument, interviewees answered questionnaires in a specially-

[1] Cash incentives to participate range from 25 to 50 AUD throughout the waves of the dataset (Summerfield et al. 2012).

designed computer program rather than responding to a human interviewer. A nominated person from a given household completes the HQ on behalf of other members. All persons who have completed a PQ through interviews are then asked to complete a Self-Completion Questionnaires (SCQ) to be completed and collected at a later date.

Interviewers monitor forms for consistency and completeness to ensure the best possible accuracy and quality in the data provided. The high level of internal and external consistency dataset was further tested by Watson and Wooden (2002) whom found that HILDA survey data are general consistent with estimates in ABS surveys.

4.2.3 MEASURING HEALTH

Health is a multi-faceted concept that is linked to many sources of well-being. In the medical profession, the use of biomarkers such as systolic blood pressure (SBP) or glycated haemoglobin (HbA1c) provide an objective measure of health to be used for the diagnosis and tracking of diseases. In light of other experiences of health, however, that could be linked to socioeconomic factors, the use of biomarkers are limited. Capturing the many attributes of health and obtaining a single measure among them is thus a methodological challenge.

In this study, the SF-36 Health Survey, incorporated in the Self-Completion Questionnaire (SPQ) in each wave, will be used to assess health, in terms of self-reported health-related quality of life (HRQoL) among respondents across eight dimensions: physical functioning, role-physical, bodily pain, general health, vitality, social functioning, role-emotional and mental health. In each dimension, scores are derived from survey questions before they are transformed onto a 0-100 scale. As these scales are not comparable across dimensions (and therefore not simply additive), they will be transformed into a single measure of health by incorporating preferences which accounts for the trade-offs between dimensions.

A preference-based measure of health will thus be derived using utility weights developed by the work of Brazier, Roberts and Deverill (2002), where preference determines how much utility is associated with a particular health state. In their methodology, the dimensions of the SF-36 Health Survey are firstly minimised from eight to six where a total of 18.000 unique health states can be defined. This refers to the SF-6D health state classification system.

A valuation survey using a variant of the standard gamble (SG) technique (Furlong et al., 1990, seen in Brazier et al., 2002) is then used to rank a sample of 249 health states. The valuation survey is completed by a representative sample (n = 836) of the UK general population. As there is no equivalent study using Australian participants, it will be assumed that valuations will not be significantly divergent. Using this data, an estimated model is developed to predict health state valuations for all definable health states of SF-6D.

In this way, a bounded, continuous and cardinal measure of health status along an interval state of 0.0 (death) to 1.0 (full health) is derived. Having such a scale to measure self-assessed health (SAH) instead of a categorical variable is particularly important for quantitative differences to be meaningful. Short of a ratio-scale measure, this cardinal measure allows the creation of long-run concentration indices with desirable properties.

4.2.4 ACCOUNTING FOR DEATHS

Mortality is often not captured in survey datasets as can be unidentified, but if it is so, it poses two crucial issues to calculating health inequalities: firstly, whether its occurrence is non-random and secondly, whether mortality can be classified as a health state. In previous studies using a longitudinal approach to socioeconomic-related inequalities in health, mortality has been treated as a type of sample attrition. If mortality is considered as non-random, the sample is re-weighted (Allanson et al., 2010), but otherwise, respondents missing observations are dropped out and a balanced panel subsample is kept (Jones and López-Nicolás, 2004; Lecluyse, 2007).

As in Petrie et al. (2011), mortality will be directly accounted for by ensuring that the health states of those that have died are counted as the opposite of full health in the cardinal health utilities scale and will thus denote a value of 0. The lowest health state defined by the SF-6D in the valuation study of Brazier and colleagues (2002) is not death itself, however, it was found that for most respondents gave it a utility value above 0 which suggests that death is the lowest point of the scale.

4.2.5 MEASURING INCOME

Income as the monetary indicator of a person or household's economic resources will be used as a proxy for socioeconomic status. As income defined at the household level is used instead of person-level, income in this case is interpreted more in terms of availability of economic resources rather than income as an exchange for labour. At the household level, individual health can also assumed to be less of a determinant of income as income, in this case, is likely to be traded for labour by more than one individual who is part of the household.

For each survey respondent, income levels will be measured as the disposable income of the household in which they belong for a given financial year. Disposable income is calculated as total household income after receipt of government benefits and deduction of income tax. In this measure of disposable income, realised capital gains are not accounted for as the HILDA Survey does not collect information on it.

To allow comparability between households of different compositions and over time, the variable is transformed into household equivalised disposable income which is calculated using the Organisation of Economic Co-operation and Development modified equivalence scale first proposed by Haagenars, de Vos & Zaidi (1994) and currently used by EUROSTAT and ABS.

It is formulated as:

$$household\ equivalised\ disposable\ income = \frac{\_hifdip\ (FY\ disposable\ income)}{1 + 0{,}5\ \times (number\ of\ adults - 1) + 0{,}3\ \times number\ of\ children}$$

where:

- ‘Number of children’ corresponds to the count of resident and non-resident persons belonging to a household that are aged less than 15 years old
- ‘Number of adults’ corresponds to the number persons in a household minus the ‘number of children’

This income variable does not need to be adjusted into real terms as the analysis only involved relative income ranks at points of time (Petrie et al., 2011). Ranking is fractional $\left(\frac{1}{10}, \frac{2}{10}, \frac{3}{10}, \dots\right)$ and varies between 0 to 1 where 0 is the poorest household and 1 is the richest household. The fractional ranking system also takes into account of sample weights and is thus defined as follows (O’Donnell et al., 2008):

Equation 9: Fractional Income Rank

$$r_i = \sum_{j=0}^{i-1} w_j + \frac{w_i}{2}$$

where w_i is the sample weight scaled to sum to 1 with observations sorted in ascending order of equivalised household income, and $w_0 = 0$.

4.2.6 ATTRITION

The HILDA survey experienced sample attrition that is slightly higher than other household surveys such as the British Household Panel Study (BHPS) with 58.1 per cent of wave 1 respondents (7,229 persons) having responded to all waves of the survey to date, which reflects the general trend towards lower response rates to surveys in recent times (Summerfield et al., 2012). Response, in this case, refers to persons having conducted an interview in person or by phone with survey personnel.

Attrition is not a problem by itself though it may reduce the efficiency of estimates as the sample size decreases, but it can lead to bias if persons and households that select themselves (or otherwise drop out) of the study have characteristics that are systematically different from those who remain. Apart from people who have died or moved overseas which are excluded in these figures, Watson and Wooden (2004) found continued correspondence to be harder to maintain among people who were of Aboriginal or Torres Strait Islander descent, was without post-school education, had low levels of personal income or was unemployed. Overall, however, they found that this difference was unlikely to have significant consequences on analyses of most outcome variables as factors that have shown to affect attrition do not have strong correlation with outcome variables of interest (Watson and Wooden, 2004).

An important source of attrition that is recognised in this study, however, is mortality as it affects the distribution of the chosen health variable. Deaths were recorded in the dataset as being *out of scope* which is the same category as that of persons who have moved overseas and therefore are missing. Deceased persons will be explicitly accounted for by re-including them in the sample for this study instead of omitting them as mentioned beforehand. Sample weights will be re-adjusted for all sources of attrition except for those related to mortality. Section 4.2 further outlines the method in this regard.

4.2.7 MISSING DATA

Even when selected persons participate in the survey, there persists the problem of incomplete questionnaires where parts have not been answered, whether purposely or not. In a longitudinal study, the likelihood is even higher as there are multiple waves. Missing data is a well-known and well-researched issue that affects the data quality of household survey data and the HILDA survey is no exception.

According to Rubin (1976), there are three types of missing data:

- Missing completely at random (MCAR)
- Missing at random (MAR)
- Missing not at random (MNAR)

Unlike the first two types of missing data, data missing not at random (MNAR) must be accounted for in longitudinal data analysis as it is a type of mechanism that leads to possible bias (Newsom et al., 2012). Missing data ceases to be random when the probability distribution of being missing or not missing is related to observed demographic variables. Mathematically, this means that the probability distribution of a dependent variable, y_i, when conditioned on a missing data indicator, r_i, where one indicates missing data, no longer becomes independent of independent variables, x_i^k, that is, the following equality no longer holds (Verbeek, 2012):

Equation 10: Conditional probability distribution under missing data

$$E\{\{y_i|x_i, r_i = 1\}\} = E\{y_i|x_i\}$$

If observations from respondents are discarded due to incomplete information, the remaining respondents may therefore fail to be representative of the total sample. There is also a loss of statistical efficiency if missing data is omitted instead of being accounted for (Verbeek, 2012). In the construction of concentration indices, Zhong (2010) highlights this particular issue and asserts that significant bias would be seen in cases where missing income data is concentrated at a given segment of the income distribution and/or missing values are concentrated among individuals with very good health or there is a high item non-response to income or health-related questions.

Two main sources of missing data in the dataset that is relevant to this study are those arising from health and income variables. Health data could be coded as missing if health utility scores from the SF-36 Health Survey included in the self-completion questionnaire (SCQ) could not be determined. This could be due to one or more item non-responses to SF-36 survey questions. For the SCQ instrument of the HILDA dataset, non-response rates averaged at around 2.5 per cent per question in wave 1 (Watson and Wooden, 2002).

A more significant data quality issue is missing income data as about one in five households had some component of financial year income missing (Summerfield et al., 2012). As with respondents' health utility scores, some key income variables are derived by using information from multiple questions which thus heightens the chance of missing observations. Watson and Wooden (2002) surmises additionally that the problem is due to the fact that there is generally an aversion against specifying monetary value. They find that the item non-response rates are not random as some variables such as gender and labour force status are correlated to the presence of financial year income data. These variables however do not have high predictive power in determining non-response to income questions.

The missing data problem will be treated in two different ways: imputation methods will be used to replace missing income data while new sample weights using Inverse Probability Weights (IPWs) will be used to account for missing health data.

Imputation involves systematically replacing missing data by a predicted value given to the household with incomplete data instead of arbitrary doing so, i.e., zero or the sample average). For all responding households, missing income data is imputed already by the HILDA survey team through various methods as covered by Hayes and Watson (2009). The income variable of interest, financial year household disposable income, is available for all responding households as all missing observations have been imputed. Imputation occurred in 15.6 per cent of households in wave 1 (Hayes and Watson, 2009). Imputed values update with each additional wave of income data as more information is used.

Accounting for missing health data is accounted for by re-weighting the sample and this is explained in greater detail in section 4.3.

4.2.8 OTHER DATA QUALITY ISSUES

Bias could arise in the data collection process of the survey. The survey instruments used are not immune to measurement errors and errors arising from data entry especially as the survey is completed by a large sample.

Various data management controls, however, were set in place to ensure the data collection process has minimal interference with the reliability of the results. All interviewers were required to attend training sessions prior to data collection at each wave; as well as that they were consistently monitored for fieldwork quality. Watson and Wooden (2002) provides further details on monitoring methods. The use of the CAPI instrument also reduces the potential bias resulting from having a human interviewer. Direct contact carries the risk that respondents react to personal characteristics and behaviour of the interviewer; monitoring against it however is difficult to control (Boardman et al., 2011).

4.3 SAMPLE CONSTRUCTION AND WEIGHTING

The sample that will be used in this analysis is designed to be as representative as possible of the Australian population. From the data collection methods conducted by the HILDA team, a feasible sample that could be collected is for representation according to Census Collection Districts (CCDs) in 2001 based on a random selection households of within private dwellings. Households in very remote Australia and living in non-private dwellings were excluded from the sample.

To compare estimates from Petrie et al. (2011), the long-run concentration index and its decomposition will also be constructed using relative health and income changes within five waves. In the HILDA dataset, changes from waves 1 to 5 or from the years 2001 to 2005 will be considered.

As deaths are to be accounted for in the analysis, a balanced longitudinal sample from waves 1 to 5 of the dataset is not of interest as persons who have dead between the waves will not be counted. Rather, a balanced subpanel of respondents alive in both wave points and additionally those who have become deceased in-between is of interest. The base sample of this study is therefore those classified as continuing sample members, also known as CSMs, which includes all members of wave 1 households.

Two restrictions will be further placed on the CSMs sample: firstly, only those that are identified as having conducted an interview for wave 1 will be included which ensures household questionnaires that contain relevant income data are included. To keep a representative sample, the cross-sectional weight ***ahhwrtp*** included in the HILDA dataset under Release 11 is used. It was constructed using inverse probability weight (IPW) methods. More details on its construction are given in HILDA technical papers (Watson, 2012).

The second restriction placed is the exclusion of persons who have conducted an interview but have incomplete health data. Health data is gathered from the self-completion questionnaire (SCQ) given to those who have completed an interview. SCQs are not necessarily completed at the same time as scheduled interviews: they can be completed at home and sent back to survey personnel. Furthermore, information provided in them can be incomplete and thus health utility scores are not necessarily derived from them. To keep a representative sample in this case, the cross-sectional weight ***ahhwrtp*** is re-weighted using inverse probability weights (IPWs).

IPWs are calculated by firstly estimating the following probit model:

Equation 11: Probit Model of Complete Health Data

$$Full_i = \begin{cases} 1 \quad if \quad \beta_0 + \beta_1 y_{0i} + \beta_2 Male_i + \beta_3 Age_{0i} + e_{1i} > 0 \\ \qquad\qquad 0 \quad if \quad otherwise \end{cases}$$

where the dependent variable $Full_i$ is equal to 1 if the individual has data on health at initial wave in 2001 and e_{1i} is assumed to be normally distributed.

Gender, equivalised FY household income and age at initial wave are used as independent variables. The predicted probability of the dependent variable for each individual is then used to adjust ***ahhwrtp*** to derive new weights, as such:

Equation 12: Inverse Probability Weights for Missing Health Data at Initial Wave

$$WN_{1i} = \frac{ahhwrtp_i}{\hat{P}(Full_i)}$$

As the study uses data from wave 5, some sample attrition was experienced. All sources of sample attrition will be accounted for except deaths as deceased persons are specifically (re-)included for this study's sample. A special weight is constructed for this using inverse probability weights (IPWs) as done so beforehand:

Equation 13: Probit Model of No Sample Attrition

$$Noatt_i = \begin{cases} 1 \quad if \quad \alpha_0 + \alpha_1 y_{0i} + \alpha_2 Male_i + \alpha_3 Age_{0i} + \alpha_4 Health_{0i} + e_{2i} > 0 \\ \qquad\qquad 0 \quad if \quad otherwise \end{cases}$$

where the dependent variable $Noatt_i$ is equal to 1 if the individual had data on health in the final period or had been recorded as having died before the final period in 2005 and e_{1i} is assumed again to be normally distributed.

Gender, equivalised FY household income, age and health at initial wave are used as independent variables. The predicted probability of the dependent variable for each individual is then used to adjust $\boldsymbol{WN}_{1i}$ to derive new weights that accounts for non-mortality-related sample attrition, as such:

Equation 14: Inverse Probability Weights for Missing Health Data

$$WN_{2i} = \frac{WN_{1i}}{\hat{P}(Noatt_i)}$$

4.3.1 ROBUSTNESS

In order to test the robustness of estimates, I will conduct a bootstrapping resampling procedure 2000 times which produces bootstrap standard errors and 95% confidence intervals. Both normal and percentile confidence intervals will be considered depending on the normality of the bootstrap distribution of each estimate. The bootstrap method provides a valid procedure for statistical inference as it takes into account special features of multivariate data such as stochastic dependencies (Biewen, 2002).

Another form of robustness check of estimates is to take a conservative approach and denote a health utility value of 0.302 to deaths instead of 0 as was conducted by Petrie et al. (2011). Due to time restrictions, however, this will not be carried out.

V. EMPIRICAL RESULTS

5.1 DESCRIPTIVE STATISTICS

From the initial CSMs sample of 19,914 persons at the start of data collection 13,969 are classified as responding persons that have attended and completed an interview. 1,774 persons were excluded from this due to incomplete health data. Two different samples are drawn for analysis using wave 5. The wave 5 study sample excluded 3,680 persons due to non-mortality-related sample attrition. Table 1 outlines the evolution of the sample.

Table 1: Evolution of Study Sample

Exclusion Criteria	Sample Size	Excluded
Enumerated Persons in Wave 1	19914	
(1) Responding Persons in Wave 1 (No Interview)	13969	5945
(2) No Full Health Data in Wave 1	12195	1774
(3) Non-mortality-related sample attrition from wave 1 to 5	8515	3680

Out of 360 respondents that were classified as dead by wave 5, only 260 had full health data in wave 1 which are therefore included in the study sample. In Table 2, sources of attrition are differentiated between those due to deaths and those due to other sources. As shown, deaths account for approximately 6.60% of total sample attrition.

Table 2: Source of Sample Attrition

Wave	N	as a % of total sample attrition
Non-mortality-related attrition	3680	93.40%
Mortality-related attrition	260	6.60%
Total sample attrition	3940	100.00%

After restricting the full sample, there were a total of 12,195 persons in the wave 5 study sample, 5,765 of which are male while 6,430 of which are female. Descriptive statistics by gender sub-sample are shown below in Table 3:

Table 3: Descriptive Statistics of Restricted Sample (by gender)

	Respondents	Mean	SD
MALES			
Equivalised Household Income in Wave 1	5765	28673	18660
Health in Wave 1	5765	0.77	0.13
Age at Wave 1	5765	43	17
Change in Health from Wave 1 to 5	3957	-0.03	0.17
FEMALES			
Equivalised Household Income in Wave 1	6430	27512	18048
Health in Wave 1	6430	0.75	0.12
Age at Wave 1	6430	43	17
Change in Health from Wave 1 to 5	4558	-0.02	0.15

* responding person with full health data in wave 1

The study sample had initial mean health of 0.77 for males and 0.75 for females with the average age at 43. As equivalised household income accounted for negative values, there is large dispersion in the mean value. Over five years, mean health decreased by less than 4%. When compared to the descriptive statistics of the full study sample, as shown in Table 4, there is a great difference in mean age as persons under 15 years old did not complete self-completion questionnaires nor were those between 15 and 18 years old required to do it. The study also encountered unintentional restriction to the final study sample due to sample attrition. Appendix Table 1 provides estimates from the probit model used to re-weight cross-sectional weights from these restriction.

Table 4: Descriptive Statistics of Full Sample (by gender)

	Respondents	Mean	SD
MALES			
Equivalised Household Income in Wave 1	9799	27102	17778
Health in Wave 1	5765	0.77	0.13
Age at Wave 1	9799	34	22
Change in Health from Wave 1 to 5	3957	-0.03	0.17
FEMALES			
Equivalised Household Income in Wave 1	10115	26102	17171
Health in Wave 1	6430	0.75	0.12
Age at Wave 1	4558	35	22
Change in Health from Wave 1 to 5	10115	-0.02	0.15

* enumerated persons in wave 1

5.2 LONG-RUN CONCENTRATION AND MOBILITY INDICES

Table 5 presents the concentration and mobility indices for both Australian males and females in the study sample. The statistical significance of the estimates are indicated by significance level using bootstrap standard errors.

Table 5: Concentration and Mobility indices for Australia

	FEMALES	MALES
Mean Health at Start Wave	0.747***	0.764***
Mean Health at Final Wave (including dead)	0.731***	0.736***
Mean Health at Final Wave (excluding dead)	0.750***	0.766***
Mean Income at Start Wave	27.3***	28.8***
Mean Income at Final Wave (excluding dead)	33.2***	35.4***
Concentration Index at Start Wave	0.0179***	0.0182***
Concentration Index at Final Wave (including dead)	0.0220***	0.0232***
Change in Concentration Index	0.00409**	0.00498***
Income-related health mobility index	-0.0118***	-0.0204***
Income-related health mobility (morbidity-related only)	-0.0029**	-0.00549***
Income-related health mobility (mortality-related only)	-0.0089***	-0.0149***
Progressivity Index	0.537***	0.531***
Progressivity Index (morbidity-related only)	47.113	1.552
Progressivity Index (mortality-related only)	0.406***	0.428***
Scale Factor	-0.0220***	-0.0384***
Scale Factor (morbidity-related only)	-0.0001	-0.0035
Scale Factor (mortality-related only)	-0.0220***	-0.0349***
Health-related income mobility index	-0.0078**	-0.0154***
Due to income re-ranking of those still alive	0.0025***	0.0016
Due to income re-ranking as the dead drop-out	-0.0102***	-0.0170***

* Significant at 10% level ** Significant at 5% level *** Significant at 1% level

The change in cross-sectional concentration indices for both females and males increased indicating greater socioeconomic-related inequalities in health. The concentration indices for males are higher than for females in both periods. When accounting for mortalities, mean heath decreases during the study period, while conversely, if it is unaccounted for, mean final health would slightly increase. In this analysis, we take mean health including deaths and therefore the mean change in health is negative. Conversely, mean household incomes increased in between wave periods.

When decomposing the initial and final concentration indices, health changes are found to be biased against those in the lower end of the income rankings as the income-related health mobility index is negative for both males and females, i.e., the decrements in health experienced over the study period occurred more for those who were poor. Australian males are shown to have greater bias having nearly twice the absolute value as Australian females. Net health morbidity losses are very concentrated amongst the poor as indicated by high values on the progressivity indices, however, the scale of morbidity-related changes in health, as indicated by its scale factor, is too small to affect the inequality measure. Interestingly, the results show that the bias in favour of households with higher relative income ranks stem from mortality-related causes as the poor suffer greater mortality losses.

The negative values on the health-related income mobility index for males and females suggest that the healthy are more upward mobile, however, this is largely due to the dead dropping out of the income ranks. Once again, the results show greater bias for Australian males than for females.

5.3 INTERNATIONAL COMPARISONS

Overall, results calculated for similar time frames (early 2000s) were comparable between Australia, Scotland and England & Wales. Table 6 and Table 7 presents comparative concentration and mobility indices between nations for males and females, respectively.

Mean household incomes increased between wave periods whilst mean health decreased when accounted for both morbidity and mortality losses. Cross-sectional health concentration indices are largely similar between the three populations with estimates at around 0.0200.

Greater inequalities in health among Australian males compared to Australian females becomes more notable from international comparisons. Australian males had the greatest positive change in the concentration indices compared to its UK counterparts. The greatest change for females was calculated for England & Wales followed by Australia. Moreover, the income-related health mobility indices for males and females in the UK were not as disparate as they are between Australian males and females.

Changes in health for both morbidity and mortality is most regressive in Australia having the highest progressivity index values. However, Australia did not register the highest income-related health mobility index value. Estimates for the health-related income mobility index are highest for England & Wales which indicates that upward income mobility is more favourable against the healthy than the poor in England.

Interestingly, the greater contributor to the mobility indices was the plight of those who dead than that of morbidity losses for all population groups except for males in England & Wales on the income-related health mobility index.

Table 6: Males - Concentration and Mobility Indices (Five Waves) for Australia, Scotland and England & Wales

	Australia	Scotland	England & Wales
Mean Health at Start Wave	0.764	0.817	0.822
Mean Health at Final Wave (including dead)	0.736	0.778	0.767
Mean Health at Final Wave (excluding dead)	0.766	0.829	0.820
Mean Income at Start Wave	28.8	22.6	23.8
Mean Income at Final Wave (excluding dead)	35.4	28.3	28.8
Concentration Index at Start Wave	0.0182	0.0198	0.0175
Concentration Index at Final Wave (including dead)	0.0232	0.0227	0.0216
Change in Concentration Index	0.00498	0.00284	0.00413
Income-related health mobility index	-0.0204	-0.0179	-0.0257
Income-related health mobility (morbidity-related only)	-0.00549	0.00833	-0.00325
Income-related health mobility (mortality-related only)	-0.0149	-0.0187	-0.0225
Progressivity Index	0.531	0.355	0.357
Progressivity Index (morbidity-related only)	1.552	0.173	0.249
Progressivity Index (mortality-related only)	0.428	0.339	0.381
Scale Factor	-0.0384	-0.0504	-0.0721
Scale Factor (morbidity-related only)	-0.0035	0.0046	-0.0121
Scale Factor (mortality-related only)	-0.0349	-0.0525	-0.0551
Health-related income mobility index	-0.0154	-0.0151	-0.0216
Due to income re-ranking of those still alive	0.00161	0.00687	0.00442
Due to income re-ranking as the dead drop-out	-0.0170	-0.0219	-0.0260

* Statistics for Scotland, England & Wales were obtained from Petrie et al. (2011).

Note: Income is measured in pounds for Scotland, England & Wales and of Australian dollars for Australia

Table 7: Females - Concentration and Mobility Indices (five waves) for Australia, Scotland and England & Wales

	Australia	Scotland	England & Wales
Mean Health at Start Wave	0.747	0.785	0.780
Mean Health at Final Wave (including dead)	0.731	0.730	0.732
Mean Health at Final Wave (excluding dead)	0.750	0.782	0.780
Mean Income at Start Wave	27.3	21.3	22.0
Mean Income at Final Wave (excluding dead)	33.2	25.3	26.5
Concentration Index at Start Wave	0.0179	0.0186	0.0205
Concentration Index at Final Wave (including dead)	0.0220	0.0220	0.0261
Change in Concentration Index	0.0041	0.0034	0.0057
Income-related health mobility index	-0.0118	-0.0198	-0.0273
Income-related health mobility (morbidity-related only)	-0.0029	-0.0004	-0.0053
Income-related health mobility (mortality-related only)	-0.0089	-0.0193	-0.0220
Progressivity Index	0.537	0.265	0.419
Progressivity Index (morbidity-related only)	47.1128	0.0271	0.480
Progressivity Index (mortality-related only)	0.406	0.332	0.406
Scale Factor	-0.0220	-0.0747	-0.0653
Scale Factor (morbidity-related only)	-0.0001	-0.0152	-0.0104
Scale Factor (mortality-related only)	-0.0220	-0.0543	-0.0508
Health-related income mobility index	-0.0078	-0.0164	-0.0217
Due to income re-ranking of those still alive	0.0025	0.0052	0.0040
Due to income re-ranking as the dead drop-out	-0.0102	-0.0216	-0.0256

* Statistics for Scotland, England & Wales were obtained from Petrie et al. (2011).

Note: Income is measured in pounds for Scotland, England & Wales and of Australian dollars for Australia

5.4 SENSITIVITY ANALYSIS

Full results of the bootstrap sampling procedure conducted for the base case analysis are shown in Appendix Table 2 for females and Appendix Table 3 for males. From the bootstrap sample statistics, morbidity-related progressivity indices and scale factors lacked statistical significance. This is largely due to the low variation in morbidity losses during the time period. Some variables such as average final health (excluding death), progressivity index (morbidity-related), initial period concentration index, final period concentration index and change in concentration indices did not have normally distributed bootstrap results. Percentile confidences intervals are used for these variables.

Within the bounds of 95% confidence intervals, mean health at final wave (including dead) remains lower than mean health at the initial wave. The change in concentration indices between the initial and final waves are positive and statistically significant for both genders. Income-related health mobility indices and health-related income mobility indices for males and females do not change signs within the intervals.

VI. DISCUSSION

From a longitudinal perspective, socioeconomic-related inequalities in health in Australia shows persistence and has been shown to perpetuate due to the contributions of regressive health changes and income re-ranking with mortality losses being a significant driver of the increase in the concentration index.

Generally speaking, estimates from the concentration and mobility indices for Australia are comparable to those obtained for the UK which suggests that both countries witness similar experiences of socioeconomic-related inequalities in health. While both countries have a universal health care system, health losses are shown to be greater and thus *accumulate* over time towards those with lower incomes. In turn, upward income mobility is also biased towards the healthy. A notable distinction however to the Australian estimates is the experience of greater regressivity in health outcomes amongst Australian males in comparison to Australian females. The study supports a similar finding by Draper and colleagues (2004) mentioned earlier in which Australian males show a steeper social gradient in life expectancy nearly twice as steep as that of Australian females. Further research on the gendered nature of inequality in health in Australia could explore key drivers to health differences and highlight equalising policies.

Notably, the inclusion of mortality losses was a significant driver of the positive increase in concentration index between wave periods through both mobility indices. Though deaths may not be due exclusively to health reasons *per se*, it has been shown that its incidence occurred more for those with lower incomes. The same result is consistent for Scotland and England & Wales. Even when adopting a conservative approach of specifying deaths with the lowest health utility value of anyone alive, Petrie et al. (2011) found that the income-related health mobility index remained negative. The availability of this measure has been omitted in past research due to the unavailability of longitudinal panel datasets which can register deaths occurring over a period of time. The contribution of mortality losses to socioeconomic-related inequalities in health nonetheless motivates its greater inclusion in future research.

The empirical analysis in the study has some caveats to consider.

Firstly, international comparisons are limited with concentration and mobility indices as socioeconomic differentials within populations could act as key drivers of health inequalities. As shown by Islam, Gerdtham, Clarke & Burström (2010), for instance, the conventional unstandardized concentration index tends to increase over time as a given population ages due to retired people dropping in relative income ranking and the coefficient of health increasing. Health inequalities may therefore rise faster for one population than another. While it has been assumed that socioeconomic differentials are similar between Australia and the United Kingdom for this study, determining these differentials and accounting for them could be a subject of further research.

Secondly, the measure of health is not fully reflective of all health states, especially those pertaining to forms of disability. Within the dataset, there is a conspicuous drop from the health utility of person who has died and a person who has the lowest health utility value in the survey from 0.301 to 0.000. This gap could be reflective of health states of a high degree of sickness that is not captured in the measure. Attrition due to illness is noted in the survey, however, including it in the study faces two problems; firstly, it is difficult to determine the appropriate health utility for a largely unknown state and secondly, a respondent may be feigning illness in order to skip an interview session. Another limitation of the health measure is that the SP-6D health survey is not validated with Australian health preferences but rather a preference algorithm from the United Kingdom has been imposed. Its effect on estimates, however, could be marginal as mean health values in this study are in line with Australian health-related quality of life population norms as studied by Norman, Church, van den Berg & Goodall (2013).

Thirdly, mobility indices could be affected by fluctuations in the business cycle as declines or increases in economic growth may have different impacts on the real incomes of different socioeconomic groups. As such, the waves in which movements in income are observed may play a role as a determinant of health-related income mobility index. With dynamic measures of inequality, Shorrocks (1978, p. 376) notes also that “particular consideration is given to the interval of time between observations, since a relationship is expected between the amount of observed movement and the length of time over which movement takes place”. Even in a very mobile society, with a short space of time, there is little opportunity for movement. This is what may have occurred with regards to morbidity-related causes. The length of time to allow for social mobility however is largely unknown and could arguably require very long panels.

Last but not least, there is a matter of the normative choice of ranked-dependent socioeconomic measure to coincide with the measure of health. The concentration index and its variants that can be applied in this case each satisfy different properties and imply a particular normative judgment on vertical equity. From the study of Allanson and Petrie (2013), the choice of measure can affect results of mobility indices through their different inequality equivalence criteria, i.e., what counts as disequalising or equalising change in health. The conventional concentration index used in this study, for instance, is deemed to have a *rightist* inequality equivalence criterion as an equiproportionate change in health for all individuals does not change the value of the index. Other measures with *leftist* or *variable* equivalence criterion could be used extend sensitivity analysis.

From the analytical framework of this study, however, two details could be gathered from the findings of this study that are worth noting.

On the larger scheme of relevant dimensions, the measurements offered in this study clearly provides a small picture of the state of socioeconomic-related health inequalities as only a bivariate relationship was considered. Other important socioeconomic indicators such as aboriginality, education and geographical remoteness could also qualify as relevant socioeconomic dimensions. The bivariate relationship between income rank and health nonetheless provide one instance of a source of, arguably, avoidable inequality in isolation. Should access to health ought to be equal, the findings in this study for Australia of a stronger relationship between income rank and health over time then suggest the contrary. Crucially, if the measure only captures the minimum bound to the total amount of illegitimate sources of socioeconomic-related inequalities in health, then there is cause for greater concern.

As a final important note, regressivity in health patterns against the background of improvements in health outcomes could be portrayed as an illustration of the equity-efficiency trade-off occurring. Equity itself as a competing policy goal that could be dynamic as society becomes more or less willing to achieve it depending on its aversion to inequalities in health (Costa-Font & Hernández-Quevedo, 2012). The Index of Health Achievement (IHA) proposed by Wagstaff (2002) provide the first steps to capture the trade-off which could be further expanded upon information from the income-related mobility index. It remains unclear however how the trade-off can be quantified or can be modelled or if it a relevant concern.

VII. CONCLUSION

The evolution of socioeconomic-related inequalities in health strongly contrasts to the leaps in life spans and quality of life experienced in Australia as with other Western nations. While population health may be improving overall, it was hypothesised in this study that changes of health biased against persons with relatively lower incomes perpetuate inequality.

A ranked-based measure was applied to Australian longitudinal data to investigate the dynamics of inequality, how it changes through health changes and income re-ranking over time. Using waves 1 to 5 of the HILDA dataset, it was found that socioeconomic-related health inequalities have indeed increase over the given time period and that the increases could be attributed to regressive patterns of health changes, most notably from mortality. Bias in income re-ranking in favour of the healthy also contribute in expanding inequality.

While the analysis only reveals one dimension of socioeconomic-related inequalities in health, it gives an indication of potentially larger avoidable differences. Putting them right is not just a trade-off but also a matter of social justice.

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APPENDIX

Appendix Table 1: Probit models used to adjust sample weights

Dependent Variable	**Health data available at initial wave (2001)**	**Health data available for final wave (2005) and not reported dead**
Constant	1.302 (0.047)	-0.063 (0.085)
Age (2001)	-0.007 (0.001)	0.009 (0.001)
Equivalised Income (2001)	0.000 (0.000)	0.244 (0.097)
Health (2001)	N/A	0.000 (0.000)
Male	-0.057 (0.027)	-0.071 (0.024)
Sample Size	13969	12195
Pseudo R^2	0.0152	0.011

Appendix Table 2: Females - Bootstrap sampling estimates

	Observed Coef.	Bootstrap Std. Err.	95% Conf. Interval		
Mean Health at Start Wave	0.747	0.00180147	0.7438826	0.750944	(N)
			0.7438926	0.75081	(P)
Mean Health at Final Wave (including dead)	0.731	0.00261367	0.7261746	0.73642	(N)
			0.7261211	0.736376	(P)
Mean Health at Final Wave (excluding dead)	0.750	0.00193578	0.7460742	0.753662	(N)
			0.7460541	0.753675	(P)
Mean Income at Start Wave	27258.83	247.69201	26773.36	27744.3	(N)
			26777.52	27744.49	(P)
Mean Income at Final Wave (excluding dead)	33164.51	321.73298	32533.92	33795.09	(N)
			32493.16	33804.08	(P)
Concentration Index at Start Wave	0.0179	0.00150961	0.0149115	0.020829	(N)
			0.0149069	0.020883	(P)
Concentration Index at Final Wave (including dead)	0.0220	0.00148312	0.0190532	0.024867	(N)
			0.0190864	0.024851	(P)
Change in Concentration Index	0.0041	0.00167523	0.0008064	0.007373	(N)
			0.000636	0.007408	(P)
Income-related health mobility index	-0.0118	0.00205673	-0.0158745	-0.00781	(N)
			-0.0157982	-0.00788	(P)
Income-related health mobility (morbidity-related only)	-0.0029	0.00143581	-0.0057362	-0.00011	(N)
			-0.0057254	-0.00018	(P)
Income-related health mobility (mortality-related only)	-0.0089	0.00147679	-0.0118159	-0.00603	(N)
			-0.0118281	-0.00593	(P)
Progressivity Index	0.537	0.10735119	0.3270099	0.747819	(N)
			0.3545589	0.776674	(P)
Progressivity Index (morbidity-related only)	47.1128	67.57966	-85.34091	179.5665	(N)
			-23.22815	15.23666	(P)
Progressivity Index (mortality-related only)	0.406	0.05356587	0.3009787	0.510953	(N)
			0.2927476	0.503303	(P)
Scale Factor	-0.0220	0.00343947	-0.028779	-0.0153	(N)
			-0.028713	-0.01546	(P)
Scale Factor (morbidity-related only)	-0.0001	0.0025376	-0.0050356	0.004912	(N)
			-0.0050453	0.004712	(P)
Scale Factor (mortality-related only)	-0.0220	0.00224637	-0.0263786	-0.01757	(N)
			-0.0265931	-0.01774	(P)
Health-related income mobility index	-0.0078	0.00205364	-0.0117788	-0.00373	(N)
			-0.0116844	-0.0038	(P)
Due to income re-ranking of those still alive	0.0025	0.0012432	0.0000165	0.00489	(N)
			0.0000538	0.004791	(P)
Due to income re-ranking as the dead drop-out	-0.0102	0.00160001	-0.0133491	-0.00708	(N)
			-0.0134116	-0.00703	(P)

(N) - Normal CIs (P) - Percentile CIs

Appendix Table 3: Males - Bootstrap sampling estimates

	Observed Coef.	Bootstrap Std. Err.	95% Conf. Interval		
Mean Health at Start Wave	0.764	0.00202649	0.760063	0.768006	(N)
			0.760051	0.767903	(P)
Mean Health at Final Wave (including dead)	0.736	0.00315939	0.72958	0.741964	(N)
			0.729171	0.741838	(P)
Mean Health at Final Wave (excluding dead)	0.766	0.00210766	0.761729	0.769991	(N)
			0.76172	0.770078	(P)
Mean Income at Start Wave	28805.18	265.6025	28284.61	29325.75	(N)
			28289.98	29317.29	(P)
Mean Income at Final Wave (excluding dead)	35410.25	378.27508	34668.85	36151.66	(N)
			34677.02	36168.13	(P)
Concentration Index at Start Wave	0.0182	0.00161516	0.015021	0.021352	(N)
			0.015001	0.021378	(P)
Concentration Index at Final Wave (including dead)	0.0232	0.00160394	0.020027	0.026315	(N)
			0.020037	0.026378	(P)
Change in Concentration Index	0.00498	0.0018075	0.001442	0.008527	(N)
			0.001441	0.008664	(P)
Income-related health mobility index	-0.0204	0.00233277	-0.02498	-0.01583	(N)
			-0.02496	-0.0159	(P)
Income-related health mobility (morbidity-related only)	-0.00549	0.00145334	-0.00834	-0.00264	(N)
			-0.00826	-0.00261	(P)
Income-related health mobility (mortality-related only)	-0.0149	0.00184931	-0.01854	-0.01129	(N)
			-0.01871	-0.01141	(P)
Progressivity Index	0.531	0.06497091	0.403852	0.658534	(N)
			0.411361	0.667332	(P)
Progressivity Index (morbidity-related only)	1.552	29.896144	-57.0432	60.14758	(N)
			-11.8874	11.35835	(P)
Progressivity Index (mortality-related only)	0.428	0.04020067	0.348806	0.506389	(N)
			0.349923	0.504109	(P)
Scale Factor	-0.0384	0.00405062	-0.04635	-0.03047	(N)
			-0.04666	-0.0312	(P)
Scale Factor (morbidity-related only)	-0.00354	0.00261128	-0.00866	0.00158	(N)
			-0.00901	0.001569	(P)
Scale Factor (mortality-related only)	-0.0349	0.00306324	-0.04088	-0.02887	(N)
			-0.04113	-0.02908	(P)
Health-related income mobility index	-0.0154	0.0025088	-0.02034	-0.0105	(N)
			-0.02035	-0.01053	(P)
Due to income re-ranking of those still alive	0.00161	0.00140976	-0.00115	0.004378	(N)
			-0.0011	0.004381	(P)
Due to income re-ranking as the dead drop-out	-0.0170	0.00211901	-0.0212	-0.01289	(N)
			-0.0214	-0.01309	(P)

(N) - Normal CIs (P) - Percentile CIs