



University of Dundee

Dundee Discussion Papers in Economics 240

Allanson, Paul

Publication date:
2010

Document Version
Early version, also known as pre-print

[Link to publication in Discovery Research Portal](#)

Citation for published version (APA):
Allanson, P. (2010). *Dundee Discussion Papers in Economics 240: Longitudinal analysis of income-related health inequality: welfare foundations and alternative measures*. (Dundee Discussion Papers in Economics; Vol. 240). University of Dundee.

General rights

Copyright and moral rights for the publications made accessible in Discovery Research Portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.



Dundee Discussion Papers in Economics



Longitudinal analysis of income-related
health inequality: welfare foundations and
alternative measures

Paul Allanson

Department of
Economic Studies,
University of
Dundee,
Dundee.
DD1 4HN

Working Paper
No. 240
August 2010
ISSN:1473-236X

Longitudinal analysis of income-related health inequality: welfare foundations and alternative measures.

Paul Allanson

Economics Studies, University of Dundee, Perth Road, Dundee DD1 4HN, UK.

Email: p.f.allanson@dundee.ac.uk

Abstract

This paper elaborates the approach to the longitudinal analysis of income-related health inequalities first proposed in Allanson, Gerdtham and Petrie (2010). In particular, the paper establishes the normative basis of their mobility indices by embedding their decomposition of the change in the health concentration index within a broader analysis of the change in “health achievement” or wellbeing. The paper further shows that their decomposition procedure can also be used to analyse the change in a range of other commonly-used income-related health inequality measures, including the generalised concentration index and the relative inequality index. We illustrate our work by extending their investigation of mobility in the General Health Questionnaire measure of psychological well-being over the first nine waves of the British Household Panel Survey from 1991 to 1999.

Keywords: income-related health inequality, mobility analysis, longitudinal data

JEL classifications: D39, D63, I18

Acknowledgements

The work for this paper was undertaken with financial support from the Chief Scientist Office (CSO) Grant CZG/2/451. Helpful comments from Dennis Petrie are acknowledged. The author bears sole responsibility for the further analysis and interpretation of the British Household Panel Survey data employed in this study.

1. Introduction

In a recent paper, Allanson, Gerdtham and Petrie (2010; hereafter AGP) consider the characterisation and measurement of income-related health inequality using longitudinal data. In particular, they propose a novel decomposition of the change in the conventional health concentration index (CI) between two periods that yields an index of income-related health mobility, which captures the effect on cross-sectional income-related health inequality of the relationship between relative health changes and individuals' initial level of income, and an index of health-related income mobility, which captures the effect of the reshuffling of individuals within the income distribution on cross-sectional socioeconomic inequalities in health. The aim of this paper is to extend this work in two directions.

First we draw on the literature on the welfare economics foundations of the health concentration index to explore the normative basis of the AGP mobility indices. In particular, we note that the concentration index is the inequality component of the "health achievement index" of Wagstaff (2002). Accordingly, the AGP analysis of the change in income-related health inequality can be embedded within a broader analysis of the change in social welfare or wellbeing, with their decomposition serving to identify how much of the change in the income-related health inequality component is driven by changes in health outcomes (i.e. "health mobility") and how much by changes in individuals' positions in the income distribution (i.e. "income (rank) mobility").

Second we show that the AGP decomposition procedure may also be used to analyse the change in a range of other commonly-used health inequality measures, including the generalised concentration index (GC) and the relative inequality index (RII) (Wagstaff et al., 1991). The choice of inequality index is important as it is known to affect the conclusions

drawn in comparative studies (see, for example, Clark et al., 2002) and this dependence will inevitably carry over to any mobility index that is derived from the decomposition of the change in such indices over time. In particular, mobility indices based on relative and absolute income-related health inequality measures respectively embody ‘rightist’ and ‘leftist’ inequality equivalence criteria,¹ with the former invariant to equiproportionate changes in health across all income groups whereas the latter are invariant to equal absolute changes in health across all income groups. Following the literature on income inequality, relative measures have been more widely used in empirical work on health inequalities, but absolute measures have the advantage that they are invariant to whether inequality is measured with respect to health or morbidity (Clark et al., 2002; Erreygers, 2009).

The paper is structured as follows. The following section explores the ethical basis for the income-related health and health-related income mobility indices proposed by AGP. Parallel analyses are also provided based on the change in the generalised concentration index and with inequality measured with respect to morbidity rather than health. Section 3 investigates the implications of the choice of inequality index by expanding on the empirical application in AGP, which investigates the dynamics of income and mental health over the first nine waves of the British Household Panel Survey (BHPS) using the General Health Questionnaire (GHQ) measure of psychological well-being (Goldberg and Williams, 1988). The final section summarises the contribution of the paper.

¹ In the current context, an inequality equivalence criterion specifies how, given the joint distribution of health and income, an additional amount of health should be distributed in order to leave income-related health inequality unchanged with respect to the starting distribution. See Zoli (2003) for a general discussion of inequality equivalence criteria in relation to the measurement of income inequality.

2. Welfare foundations of the AGP mobility indices

The welfare economics foundations of the concentration index have variously been explored by Bommier and Stecklov (2002), Wagstaff (2002) and Bleichrodt & van Doorslaer (2006) among others. We draw on this literature to elucidate the ethical basis for the measures of income-related health mobility and health-related income mobility proposed by AGP. Thus, our analysis focuses on a single transition between an initial period s and some final period f ($f > s$). Let $\Psi(h_s, y_s, h_f, y_f)$ be the joint cumulative distribution function (cdf) of health, H , and income, Y , in the two periods, where h_t and y_t denote health and income respectively in period t ($t = s, f$), and the health measure lies in the bounded interval $b \geq h_t \geq a$ with $a \geq 0$ by assumption. Moreover, let $\psi_{H_t|Y_t}(h_t, y_t)$ be the joint probability density function (pdf) of health and income in period t , which can in turn be expressed as the product of the conditional pdf of health given income, $\psi_{H_t|Y_t}(h_t | y_t)$, and the marginal pdf of income, $\psi_{Y_t}(y_t)$. Finally, let $\pi_t = \Psi_{Y_t}(y_t)$ be the marginal cdf for incomes in period t , where π_t is the proportion of the population with an income in that period less than y_t . The corresponding quantile function will be $Y_t(\pi_t) = \Psi_{Y_t}^{-1}(\pi_t)$ for $\pi_t \in [0, 1]$, which may loosely be thought of as the income of an individual with a (normalised) rank of π in the period t distribution (Yaari, 1988). Hence, $E(h_t) = \bar{h}_t = \int_0^1 \left(\int_a^b \psi_{H_t|Y_t}(h_t | Y_t(\pi_t)) dh_t \right) d\pi_t = \int_0^1 E(h_t | \pi_t) d\pi_t$ will be mean health in period t , where $E(h_t | \pi_t)$ is mean health conditional upon income rank.

We begin with the social welfare function that underpins the “health achievement” index proposed by Wagstaff (2002).² This function defines overall wellbeing in any period

² But note that Wagstaff considers a health indicator that provides a measure of ill rather than good health. We consider how this affects the analysis at the end of this section.

as a weighted average of the health of all individuals, where the weights are determined by individuals' ranks in the income distribution. Specifically, let wellbeing in period t evaluated on the basis of income ranks π_t in period t be equal to:

$$\begin{aligned}
W_{tt} &= \int_{y_t} \int_a^b h_t \psi_{H_t Y_t}(h_t, y_t) w(\pi_t, \nu) dh_t dy_t && t=s, f \\
&= \int_0^1 \left(\int_a^b h_t \psi_{H_t Y_t}(h_t | Y_t(\pi_t)) dh_t \right) w(\pi_t, \nu) d\pi_t = \int_0^1 E(h_t | \pi_t) w(\pi_t, \nu) d\pi_t && (1) \\
&= \int_0^1 E(h_t | \pi_t) d\pi_t - \int_0^1 E(h_t | \pi_t) (1 - w(\pi_t, \nu)) d\pi_t \\
&= \bar{h}_t - GC_{tt} = \bar{h}_t (1 - CI_{tt})
\end{aligned}$$

where the rank-dependent weights are given by:

$$w(\pi_t, \nu) = \nu(1 - \pi_t)^{(\nu-1)}; \quad \nu \geq 1; \quad (2)$$

GC_{tt} is the extended generalised health concentration coefficient; and $CI_{tt} = GC_{tt} / \bar{h}_t$ is the extended health concentration index.

Equation (1) is formally a member of the rank-dependent S-Gini class of functions (see Yitzhaki, 1983) but with ranks based on the distribution of income rather than health. The 'distributional judgement' parameter ν controls the rate at which the weights decrease from poorest to richest. Specifically, $\nu=2$ leads to weights that decrease linearly with π_t from 2 to 0, as with the conventional concentration index, whereas values greater (less) than 2 yield indices that give more (less) social weight to the health of poorer individuals than implied by the conventional health concentration index (see Wagstaff, 2002). In the limit $\nu = 1$ and the social weights are independent of rank.

GC_{tt} and CI_{tt} provide measures of absolute and relative income-related health inequality respectively, which typically will be positive as a result of the positive association between income and health status. Within our framework, GC_{tt} and CI_{tt} may be interpreted

as ‘cost of inequality’ indices in the sense of Atkinson (1970), providing measures of the amount of health per head that could be sacrificed with no loss of overall wellbeing if the remainder were to be distributed equally. Bleichrodt & van Doorslaer (2006) examine the preference foundations of this type of measure, showing that the health concentration index implies that social preferences over health distributions or profiles must be both complete and transitive, and satisfy standard principles of anonymity, additivity, monotonicity and population independence. Additionally, social preferences must satisfy the principle of income-related health transfers whereby a health transfer from a richer individual to a poorer individual does not lead to a reduction in wellbeing provided the transfer does not change the income rankings of the two individuals. If health is an increasing function of income then such transfers will on average be from healthier to unhealthier individuals, but this might not be so in particular cases. Bleichrodt & van Doorslaer (2006, p.955) conclude that the principle will “be more acceptable the stronger the correlation between health and [...] income”.

The formulation of the income-related health inequality measures in (1) makes plain that GC_{it} and CI_{it} are determined solely by expected health levels conditional upon income (rank) and are not therefore affected by the degree of conditional dispersion of health outcomes about these levels. GC_{it} and CI_{it} may therefore be directly interpreted as W_1 type indicators in the sense of Bommier and Stecklov (2002) in that they will take positive (negative) values if expected health is a monotonically increasing (decreasing) function of income, and will equal zero if expected health is independent of income. Nevertheless, even if health endowments did not affect income levels, GC_{it} and CI_{it} would not be fully consistent with a Rawlsian approach to health inequalities in that they do not depend on the

full distribution of health conditional on income, but only its average (Bommier and Stecklov, 2002).

AGP analysis of changes in relative health inequality

AGP propose a decomposition of the change in the health concentration index between two periods into income-related health and health-related income mobility indices. Within our framework, the key to this decomposition is the ex-ante evaluation of wellbeing in period f based on individuals' income rank positions in period s :

$$\begin{aligned}
W_{fs} &= \int_{y_s} \int_a^b h_f \psi_{H_f Y_s}(h_f, y_s) w(\pi_s, v) dh_f dy_s \\
&= \int_0^1 \left(\int_a^b h_f \psi_{H_f | Y_s}(h_f | Y_s(\pi_s)) dh_f \right) w(\pi_s, v) d\pi_s = \int_0^1 E(h_f | \pi_s) w(\pi_s, v) d\pi_s \quad (3) \\
&= \int_0^1 E(h_f | \pi_s) d\pi_s - \int_0^1 E(h_f | \pi_s) (1 - w(\pi_s, v)) d\pi_s = \bar{h}_f - GC_{fs} = \bar{h}_f (1 - CI_{fs})
\end{aligned}$$

where $\psi_{H_f Y_s}(h_f, y_s)$ is the joint density of final period health and initial period income, $E(h_f | \pi_s)$ is mean health in period f conditional upon income rank in period s , and $\psi_{H_f | Y_s}(h_f | Y_s(\pi_s))$, GC_{fs} and CI_{fs} are interpreted analogously to $\psi_{H_t | Y_t}(h_t | Y_t(\pi_t))$, GC_{tt} and CI_{tt} . In particular, if $v=2$ then CI_{fs} is the concentration index of final period health ranked by initial income, providing the reference statistic for the 'ex-ante' decomposition of AGP.

Using (3) the decomposition provided by AGP may be embedded within a broader analysis of the change in wellbeing between the two periods:

$$\begin{aligned}
(W_{ff} - W_{ss}) &= \bar{h}_f (1 - CI_{ff}) - \bar{h}_s (1 - CI_{ss}) = \bar{\Delta h} (1 - CI_{ss}) - (CI_{ff} - CI_{ss}) \bar{h}_f \\
&= \bar{\Delta h} (1 - CI_{ss}) + ((CI_{ss} - CI_{fs}) + (CI_{fs} - CI_{ff})) \bar{h}_f \quad (4) \\
&= \bar{\Delta h} (1 - CI_{ss}) + (M_H^{CI} - M_R^{CI}) \bar{h}_f
\end{aligned}$$

where the first term gives the effect on wellbeing of the mean change in health $\overline{\Delta h} = \overline{h}_f - \overline{h}_s$ and the second that due to the change in relative inequality ($CI_{ff} - CI_{ss}$). Equation (4) makes plain that ceteris paribus increases (decreases) in relative inequality will reduce (raise) wellbeing. The AGP decomposition of ($CI_{ff} - CI_{ss}$) then serves to identify whether such changes in income-related health inequality are driven by changes in health outcomes (i.e. “health mobility”) or by changes in individuals’ positions in the income distribution (i.e. “income (rank) mobility”).

Thus, the income-related health mobility index M_H^{CI} captures the effect of health changes on relative income-related health inequality, being determined by the relationship between relative health changes and individuals’ initial level of income:

$$\begin{aligned}
M_H^{CI} &= CI_{ss} - CI_{fs} = \int_0^1 \left(\frac{E(h_s | \pi_s)}{\overline{h}_s} - \frac{E(h_f | \pi_s)}{\overline{h}_f} \right) (1 - w(\pi_s, v)) d\pi_s \\
&= \int_0^1 \left(\frac{(\overline{h}_f - \overline{h}_s) E(h_s | \pi_s)}{\overline{h}_s \overline{h}_f} - \frac{(E(h_f | \pi_s) - E(h_s | \pi_s))}{\overline{h}_f} \right) (1 - w(\pi_s, v)) d\pi_s \\
&= \left(\int_0^1 \left(\frac{E(h_s | \pi_s)}{\overline{h}_s} - \frac{(E(h_f - h_s | \pi_s))}{\overline{\Delta h}} \right) (1 - w(\pi_s, v)) d\pi_s \right) \left(\frac{\overline{\Delta h}}{\overline{h}_f} \right) \\
&= (CI_{ss} - CI_{f-s,s}) \left(\frac{\overline{\Delta h}}{\overline{h}_f} \right) \\
&\equiv P^{CI} q^{CI}
\end{aligned} \tag{5}$$

where $E(h_f - h_s | \pi_s) = E(\Delta h | \pi_s)$ denotes conditional expected health changes; and $CI_{f-s,s}$ is the concentration coefficient of health changes ranked by initial period income. This provides an ‘ex-ante’ measure in that the evaluation of the costs of inequality in both the initial and final periods is based on the social weights associated with individuals’ ranks in the initial income distribution. This asymmetric treatment may be justified, in the spirit of

Dardanoni (1993), on the grounds that the initially poor are disadvantaged to the extent that they face a worse lottery of future health possibilities than those who are better off, with the ‘distributional judgement’ parameter ν allowing for the calibration of the poverty focus of the evaluation (see Essama-Nssah, 2005). It is also possible in principle to employ individuals’ final period weights to evaluate mobility (see, for example, the alternative income-related health mobility index considered in AGP) but the forward-looking perspective is the more natural one when assessing the impact of mobility over time.

Progressivity in this framework is captured by the Kakwani (1977)-type disproportionality index $P^{CI} = (CI_{ss} - CI_{f-s,s})$. P^{CI} will be positive (negative) if the poorest individuals either enjoy a larger (smaller) share of total health gains or suffer a larger (smaller) share of total health losses compared to their initial share of health, and equals zero if relative health changes are independent of income or there are no health changes. For any given P^{CI} , the gross impact on final period income-related health inequalities is proportional to the scale of health changes, $q^{CI} = \overline{\Delta h} / \overline{h}^f$ measured as the ratio of average health changes to average final period health.³ AGP observe that P^{CI} can provide a useful measure of the performance of health improvement programmes in targeting the poor: a given reduction in income-related health inequality can be achieved either by a small-scale but highly targeted intervention to improve the average health of the very poor or by a larger scale but broader health programme. The impact of welfare programmes may also be equalising if the

³ Note that if the average health change is negative, then negative (positive) values of P^{CI} imply that health depreciation is equalising (disequalising) in relative terms in the sense that it will lead to a ceteris paribus reduction (increase) in relative health inequality.

payment of income support to the poor results in contemporaneous improvements in their health on average.

Conversely, the health-related income mobility index M_R^{CI} captures the effect of income rank changes on (relative) income-related health inequality, being determined by the relationship between income rank changes and individuals' final level of health:

$$\begin{aligned}
M_R^{CI} &= CI_{ff} - CI_{fs} = \int_0^1 \left(\frac{E(h_f | \pi_f)}{\bar{h}_f} \right) (1 - w(\pi_f, v)) d\pi_f - \int_0^1 \left(\frac{E(h_f | \pi_s)}{\bar{h}_f} \right) (1 - w(\pi_s, v)) d\pi_s \\
&= \int_0^1 \int_0^1 \left(\frac{E(h_f | \pi_f, \pi_s)}{\bar{h}_f} \right) (w(\pi_s, v) - w(\pi_f, v)) \psi_{Y_f | Y_s}(Y_f(\pi_f) | Y_s(\pi_s)) d\pi_f d\pi_s \\
&= \int_0^1 \int_0^1 \left(\frac{E(h_f | \pi_f, \pi_s) - \bar{h}_f}{\bar{h}_f} \right) (w(\pi_s, v) - w(\pi_f, v)) \psi_{Y_f | Y_s}(Y_f(\pi_f) | Y_s(\pi_s)) d\pi_f d\pi_s,
\end{aligned} \tag{6}$$

where $E(h_f | \pi_s, \pi_f)$ is mean health in period f conditional upon income rank in both periods,

$\psi_{Y_f | Y_s}(Y_f(\pi_f) | Y_s(\pi_s))$ is the density of final period income conditional on initial income, and

the final equality holds because $\int_0^1 \int_0^1 (w(\pi_s, v) - w(\pi_f, v)) \psi_{Y_f | Y_s}(Y_f(\pi_f) | Y_s(\pi_s)) d\pi_f d\pi_s = 0$.

M_R^{CI} is analogous to the re-ranking index proposed by Atkinson (1980) and Plotnick (1981), and considered by Yitzhaki and Wodon (2004) as a measure of mobility in its own right, but may take on negative as well as positive values. Specifically, M_R^{CI} will be positive (negative) if the concentration index of final period health outcomes ranked by final income is greater (less) than that ranked by initial income, which implies that current health is more (less) strongly related to contemporaneous income than to lagged incomes,⁴ and will equal zero if either final period health is uncorrelated with changes in income rank or there are no changes

⁴ It is readily shown from Milanovic (1997) that $CI_{ff} > CI_{ss}$ implies $corr(h_f, \pi_f) > corr(h_f, \pi_s)$ in the special case $v=2$.

in income rank.⁵ Nevertheless, AGP argue that M_R^{CI} may generally be expected to be positive, exacerbating inequalities, since those who move up the income ranking will tend to be healthier (in the final period) than those who moved down. AGP further note that the impact on income-related health inequality of health interventions targeted at the poor will be diminished to the extent that health improvements lead to contemporaneous increases in income (rank), but that welfare programmes may reduce inequality due to re-ranking if recipients move up the income distribution and income (rank) gains are not matched by contemporaneous improvements in health.

Longitudinal analysis of changes in absolute health inequality

AGP focus on changes in relative income-related health inequality, but a parallel analysis is also feasible within our framework based on the change in absolute health inequality between the two periods. Thus, equation (4) may be rewritten as:

$$\begin{aligned}
(W_{ff} - W_{ss}) &= (\bar{h}_f - GC_{ff}) - (\bar{h}_s - GC_{ss}) = \overline{\Delta h} - (GC_{ff} - GC_{ss}) \\
&= \overline{\Delta h} + ((GC_{ss} - GC_{fs}) + (GC_{fs} - GC_{ff})) \\
&= \overline{\Delta h} + (M_H^{GC} - M_R^{GC})
\end{aligned} \tag{7}$$

where the first and second terms again give the effects on wellbeing due to the change in mean health and income-related health inequality respectively, but these terms are now additive. Thus the first term is invariant to the initial distribution of total health among the population while the second term is invariant to the final level of average health. Moreover the second term is now invariant to equal absolute, rather than proportionate, changes in the

⁵ Note that if there are no changes in rank then $w(\pi_s, v) = w(\pi_f, v)$ and $\psi_{\pi_f | \pi_s}(\pi_f = \pi_s | \pi_s) = 1$ for all $\pi_f \in [0, 1]$.

health of all individuals, yielding indices of absolute income-related health and health-related income mobility, M_H^{GC} and M_R^{GC} respectively.

M_H^{GC} captures the effect of health changes on absolute income-related health inequality, being determined by the relationship between absolute health changes and individuals' initial level of income:

$$\begin{aligned}
M_H^{GC} &= GC_{ss} - GC_{fs} = \int_0^1 (E(h_s | \pi_s) - E(h_f | \pi_s)) (1 - w(\pi_s, v)) d\pi_s \\
&= - \int_0^1 (E(h_f - h_s | \pi_s)) (1 - w(\pi_s, v)) d\pi_s \\
&= -GC_{f-s,s} \\
&= -CI_{f-s,s} \overline{\Delta h} \equiv P^{GC} q^{GC}
\end{aligned} \tag{8}$$

where $GC_{f-s,s}$ is the generalised concentration index of health changes ranked by initial period income, which provides an 'ex-ante' measure of the change in the absolute health costs of inequality between the two periods. This measure may in turn be expressed in terms of an absolute disproportionality index $P^{GC} = -CI_{f-s,s}$,⁶ which provides an alternative measure of targeting performance, and the scale factor $q^{GC} = \overline{\Delta h}$. The commonly held belief that the first priority of healthcare policy should be to heal the sick, who are disproportionately poor, implies that healthcare outcomes should be equalising not just in relative but also in absolute terms, i.e. that P^{GC} should be positive for beneficial health interventions. We note that $P^{CI} < 0$ implies $P^{GC} < 0$ if $CI_{ss} > 0$, since health changes must be concentrated among the rich if the poorest individuals experience a smaller share of total health changes than their initial share of health, but not vice versa.

⁶ Note that if the average health change is negative, then P^{GC} will be negative (positive) if health depreciation is equalising (disequalising) in absolute terms such that absolute health losses tend to be larger (smaller) for rich individuals than poor ones.

M_R^{GC} captures the effect of income rank changes on absolute income-related health inequality, being determined by the relationship between income rank changes and individuals' final level of health:

$$\begin{aligned}
M_R^{GC} &= GC_{ff} - GC_{fs} = \int_0^1 E(h_f | \pi_f) (1 - w(\pi_f, v)) d\pi_f - \int_0^1 E(h_f | \pi_s) (1 - w(\pi_s, v)) d\pi_s \\
&= \int_0^1 \int_0^1 E(h_f | \pi_f, \pi_s) (w(\pi_s, v) - w(\pi_f, v)) \psi_{\pi_f | \pi_s}(\pi_f | \pi_s) d\pi_f d\pi_s \\
&= \bar{h}_f M_R^{CI}
\end{aligned} \tag{9}$$

which is simply a scaled version of M_R^{CI} , as is shown by the final equality, and will therefore share the same properties as the relative health-related income mobility index.

Analysis of changes in ill-health inequality

AGP focus on income-related health inequalities, but the preceding analysis may readily be refashioned in terms of changes in income-related inequalities in ill-health or morbidity rather than in health or wellbeing. Suppose that we have some measure of ill-health or morbidity $U = (b - H)^7$ with corresponding bounds $0 \leq U \leq (b - a)$ then (1) may be rewritten as:

$$\begin{aligned}
W_u &= \int_{y_t} \int_0^{b-a} (b - u_t) \psi_{H_t | Y_t}(b - u_t, y_t) w(\pi_t, v) du_t dy_t & t=s, f \\
&= b - \int_0^1 \left(\int_0^{b-a} u_t \psi_{H_t | Y_t}(b - u_t | Y_t(\pi_t)) du_t \right) w(\pi_t, v) d\pi_t \\
&= b - \int_0^1 E(u_t | \pi_t) w(\pi_t, v) d\pi_t \\
&= \left(b - \int_0^1 E(u_t | \pi_t) d\pi_t \right) + \int_0^1 E(u_t | \pi_t) (1 - w(\pi_t, v)) d\pi_t \\
&= (b - \bar{u}_t) + GC_u^U = b - \bar{u}_t (1 - CI_u^U)
\end{aligned} \tag{10}$$

⁷ Note that the definitions of H and U may be reversed if one has a primitive indicator of health outcomes that provides a measure of ill-health with non-zero origin. This sub-section would then refer to the derived measure of well-being.

where $E(u_t | \pi_t) = (b - E(h_t | \pi_t))$ and $\bar{u}_t = (b - \bar{h}_t)$ denote conditional and unconditional mean ill-health respectively; $GC_{tt}^U = -GC_{tt}$ is the extended generalised morbidity concentration coefficient, and $CI_{tt}^U = -(\bar{h}_t / \bar{u}_t) CI_{tt}$ is the extended morbidity concentration index. We note that GC_{tt}^U and CI_{tt}^U , unlike GC_{tt} and CI_{tt} , will both typically be negative, reflecting the concentration of ill-health among the poor, with (10) showing that such inequalities in morbidity will lead to a loss in welfare.

Equation (3) may be similarly rewritten to yield concentration indices of final ill-health ranked by initial income, GC_{fs}^U and CI_{fs}^U , enabling the change in welfare between the two periods to be expressed as:

$$\begin{aligned} (W_{ff} - W_{ss}) &= (b - \bar{u}_f (1 - CI_{ff}^U)) - (b - \bar{u}_s (1 - CI_{ss}^U)) \\ &= (\bar{u}_s - \bar{u}_f) (1 + CI_{ss}^U) + (CI_{ff}^U - CI_{ss}^U) \bar{u}_f \end{aligned} \quad (11)$$

which shows that reductions in both average morbidity and (the scale of) morbidity inequalities will serve to improve overall welfare, with the AGP decomposition of $(CI_{ff}^U - CI_{ss}^U)$ then serving to identify the causes of any changes in ill-health inequality:

$$\begin{aligned} (CI_{ff}^U - CI_{ss}^U) &= (CI_{ff}^U - CI_{fs}^U) - (CI_{ss}^U - CI_{fs}^U) = M_R^{CI^U} - M_H^{CI^U} \\ &= (CI_{ff}^U - CI_{fs}^U) - \left((CI_{ss}^U - CI_{f-s,s}^U) \left(\frac{\bar{\Delta u}}{\bar{u}_f} \right) \right) = M_R^{CI^U} - P^{CI^U} q^{CI^U} \end{aligned} \quad (12)$$

where $M_H^{CI^U}$ captures the effect of the relationship between relative morbidity changes and individuals' initial level of income and $M_R^{CI^U}$ captures the redistributive effect of income rank changes weighted by final morbidity status.

The income-related ill-health mobility index $M_H^{CI^U}$ will be positive (negative) if expected morbidity changes conditional upon income have the effect of increasing (reducing) morbidity inequalities. $M_H^{CI^U}$ may in turn be expressed as the product of the progressivity of morbidity changes based on initial income rankings $P^{CI^U} = -(\bar{h}_s/\bar{u}_s)CI_{ss} - CI_{f-s,s}$ and the scale of ill-health changes relative to final average morbidity $q^{CI^U} = -(\bar{h}_s/\bar{u}_s)q^{CI}$, where $CI_{f-s,s}^U = CI_{f-s,s}$ is the concentration coefficient of morbidity changes ranked by initial period income. P^{CI^U} will be negative (positive) if changes in morbidity are less (more) concentrated among the poor than the initial concentration of ill-health, and will equal zero if relative ill-health changes are independent of income or there are no ill-health changes. We further note that P^{CI^U} will be less than P^{CI} if, as usually will be the case, CI_{ss} is positive. Thus, if there is a uniform change in health status then P^{CI^U} will typically be negative and P^{CI} positive, such that a uniform rise (fall) in morbidity will reduce (increase) relative inequalities in ill-health but increase (reduce) relative inequalities in health. Moreover, if there is a proportionate change in morbidity then P^{CI^U} will be zero and P^{CI} will typically be positive, such that a proportionate rise (fall) in morbidity results in no change in relative inequalities in ill-health but to an increase (reduction) in relative inequalities in health. Whereas, if there is a proportionate change in health then P^{CI^U} will typically be negative with P^{CI} zero, such that any resultant rise (fall) in morbidity leads to a reduction (increase) in relative inequalities in ill-health but no change in relative inequalities in health. Finally, if P^{CI^U} is greater than zero then P^{CI} will also typically be positive, such that a rise (fall) in morbidity will increase (reduce) relative inequalities in both ill-health and health, whereas if P^{CI} is less than zero

then P^{CI^U} will also typically be negative, such that a rise (fall) in morbidity will reduce (increase) relative inequalities in both ill-health and health.

The morbidity-related income mobility index $M_R^{CI^U} = -(\bar{h}_t/\bar{u}_t)M_R^{CI}$ will be negative (positive) if the absolute value of the concentration index of final period morbidity ranked by final income is larger (smaller) than that ranked by initial income, which implies that current morbidity is more (less) strongly related to contemporaneous income than to lagged incomes,⁸ and will equal zero if either final period ill-health is uncorrelated with changes in income rank or there are no changes in income rank. In general, $M_R^{CI^U}$ may be expected to be negative as those who move up the income ranking will tend to be less unhealthy (in the final period) than those who moved down. Thus reranking will generally exacerbate inequalities in morbidity as well as in health.

Finally, replacing health with morbidity in (7) yields the parallel decomposition:

$$\begin{aligned}
(W_{ff} - W_{ss}) &= ((b - \bar{u}_f) + GC_{ff}^U) - ((b - \bar{u}_s) + GC_{ss}^U) \\
&= (\bar{u}_s - \bar{u}_f) + (GC_{ff}^U - GC_{ss}^U) \\
&= -\bar{\Delta u} - ((GC_{ss}^U - GC_{fs}^U) + (GC_{fs}^U - GC_{ff}^U)) \\
&= -\bar{\Delta u} - ((-CI_{f-s,s}^U)\bar{\Delta u} + (GC_{fs}^U - GC_{ff}^U)) \\
&= -\bar{\Delta u} - (P^{GC^U} q^{GC^U} - M_R^{GC^U}) = -\bar{\Delta u} - (M_H^{GC^U} - M_R^{GC^U}) \\
&\equiv \bar{\Delta h} + (P^{GC} q^{GC} - M_R^{GC}) = \bar{\Delta h} + (M_H^{GC} - M_R^{GC})
\end{aligned} \tag{13}$$

where $M_H^{GC^U} = -M_H^{GC}$ and $M_R^{GC^U} = -M_R^{GC}$, given the ‘mirror’ property of the generalised concentration index (Erreygers, 2009), with $P^{GC^U} = P^{GC}$ and $q^{GC^U} = -q^{GC}$.

⁸ It can again be shown from Milanovic (1997) that $CI_{ff}^U > CI_{fs}^U$ implies $corr(u_f, \pi_f) > corr(u_f, \pi_s)$ in the special case $v=2$.

3. Empirical illustration

We investigate the implications of the choice of inequality index by investigating the dynamics of income and mental health using the General Health Questionnaire (GHQ) measure of psychological well-being (Goldberg and Williams, 1988). The GHQ measure is an (additive) Likert scale which can take values between 0 and 36 with higher values corresponding to worse states of mental health. Following Jones and López Nicolás (2004), AGP use $(36 - \text{GHQ})$ to obtain a health measure that is increasing in good health. We report results for both the inverted and original measures to explore the sensitivity of our findings to whether mobility is measured with respect to health or morbidity. Furthermore, we not only analyse changes in the health concentration index but also in the generalised health concentration index, relative inequality index, slope inequality index, and the Wagstaff (2002) and Erreygers (2009) normalisations of the concentration index and generalised concentration index, respectively, which take into account the bounds of the health measure under consideration.

Table I provides definitions of the various income-related health inequality measures considered in the study together with the corresponding sets of mobility indices.⁹ The income-related health and health-related income mobility indices are readily obtained in each case. The appropriate definition of the disproportionality and scale indices, P and q respectively, is less obvious: we choose to define P in each case as the difference between some function of initial income-related health inequality $\theta(CI_{ss})$, which may be zero, and the (extended) concentration index of health changes $CI_{f-s,s}$, with q defined conformably. This

⁹ Expressions for the corresponding inequality measures and mobility indices defined with respect to morbidity, rather than health, are readily obtained by replacing health status h by morbidity u throughout and changing the variable bounds a and b to 0 and $(b-a)$.

approach is consistent with the definitions of P and q provided in the previous section for the extended CI and GC measures, and further implies that the normalisation factor is absorbed into q rather than P for those measures that are defined as simple multiples of these indices. Accordingly, differences in progressivity as measured by alternative disproportionality indices may be interpreted as reflecting differences between the inequality equivalence criteria implied by the underlying income-related health inequality measures.

The derivation of the mobility indices for the (extended) CI and GC measures has already been discussed in the previous section, with the $\theta(CI_{ss})$ values of CI_{ss} and 0 in the two cases corresponding to relative and absolute inequality equivalence criteria respectively. As is well known, “the relative index of inequality (RII) is equal to the concentration index divided by twice the variance of the relative rank variable” (Wagstaff et al., 1991), where $\text{var}(\pi) = (N-1)^2 / (12N^2)$ is a constant determined by the sample size N , and thus the two measures, and the resultant mobility indices, simply differ by a multiplicative factor which will be approximately equal to 1/12 in large samples (Milanovic, 1997). The slope index of inequality (SII) is simply equal to the RII multiplied by mean health so there is a similar relationship between the set of SII and GC indices as between the RII and CI indices. Furthermore, the Erreygers (2009) normalisation (EN) of the health concentration index is simply equal to $(4/(b-a))GC$ so the EN mobility indices are also just a multiple of the corresponding GC measures. However the Wagstaff (2002) normalisation is not a simple multiple of either the CI or GC measures, nor of some linear combination of the two, providing a ‘flexible’ inequality equivalence criterion that is determined by the data rather than embodying some particular criterion, whether that be relative, absolute or intermediate (see Wagstaff, 2009). Specifically, the value of $\theta(CI_{ss}) = \Xi(\bar{h}_s, \bar{h}_f) CI_{ss}$ will depend on the

initial and final levels of mean health in relation to the lower and upper bounds of the health measure a and b . Note first that if $(b - \bar{h}^f) = (\bar{h}^s - a)$, which is only likely to be the case if average health in the two periods is neither very good nor very bad, then the normalisation will exhibit the properties of an absolute measure of income-related health inequality since $\Xi(\bar{h}_s, \bar{h}_f)$ will equal zero. For lower levels of initial average health, the normalisation will provide a more ‘rightist’ measure with $\Xi(\bar{h}_s, \bar{h}_f)$ tending to positive infinity as average health tends to a if $a > 0$ and to $1 - (\bar{h}_f/b)$ if $a = 0$. Conversely, for higher levels of initial average health, the normalisation provides an ‘extreme leftist’ measure with $\Xi(\bar{h}_s, \bar{h}_f)$ tending to negative infinity as average health tends to the upper bound b . Which measure is the most applicable depends upon public perceptions of income-related health inequality.¹⁰

Our empirical analysis serves to replicate and extend the results reported in AGP, which investigates changes in income-related mental health inequality among men over the first nine waves of the BHPS from 1991 to 1999. The annual BHPS is a longitudinal survey of private households in Great Britain, based on an original, nationally representative sample of 5,500 households and 10,300 individuals in 1991. The analysis employs a balanced panel consisting of the sub-set of males in the BHPS for whom full data on GHQ score, income and a range of other socioeconomic variables are available in each of the first nine waves and whose total annual household income lay in the range £2000 to £77000 throughout that period.¹¹ the resulting sample contains nine observations on each of 2018 men. Wave 1 is

¹⁰ Amiel and Cowell (1997) provides evidence in relation to public perceptions of income inequality that “the appropriate inequality equivalence concept depends on the income levels at which inequality comparisons are made”, shifting from a relative or ‘rightist’ attitude to an absolute or ‘leftist’ one as income increases.

¹¹ See Jones and López Nicolás (2004) for a full description of the sample design. AGP note that their results differ slightly from those reported in Jones and López Nicolás (2004), possibly due to the use of an updated release of the BHPS data (University of Essex, Institute for Social and Economic Research, 2007)

Table 1: Definition of income-related health inequality indices and associated mobility measures.

	Definition	Income-related health mobility	Disproportionality index	Scale factor	Health-related income mobility
<i>Relative inequality measures</i>					
Health concentration index	$CI_u = \frac{2}{\bar{h}_t} \text{cov}(h_t, \pi_t)$	$M_H^{CI} = CI_{ss} - CI_{fs}$	$P^{CI} = CI_{ss} - CI_{f-s,s}$	$q^{CI} = \overline{\Delta h} / \bar{h}_f$	$M_R^{CI} = CI_{ff} - CI_{fs}$
Relative inequality index	$RII_u = \frac{1}{\bar{h}_t} \frac{\text{cov}(h_t, \pi_t)}{\text{var}(\pi)}$ $= CI_u / (2 \text{var}(\pi))$	$M_H^{RII} = \frac{M_H^{CI}}{2 \text{var}(\pi)}$	$P^{RII} = P^{CI}$	$q^{RII} = \frac{q^{CI}}{2 \text{var}(\pi)}$	$M_R^{RII} = \frac{M_R^{CI}}{2 \text{var}(\pi)}$
<i>Absolute inequality measures</i>					
Generalised Concentration index	$GC_u = 2 \text{cov}(h_t, \pi_t)$ $= \bar{h}_t CI_u$	$M_H^{GC} = GC_{ss} - GC_{fs}$	$P^{GC} = -CI_{f-s,s}$	$q^{GC} = \overline{\Delta h}$	$M_R^{GC} = GC_{ff} - GC_{fs}$ $= \bar{h}_f M_R^{CI}$
Slope inequality index	$SII_u = \frac{\text{cov}(h_t, \pi_t)}{\text{var}(\pi)}$ $= GC_u / (2 \text{var}(\pi))$	$M_H^{SII} = \frac{M_H^{GC}}{2 \text{var}(\pi)}$	$P^{SII} = P^{GC}$	$q^{SII} = \frac{q^{GC}}{2 \text{var}(\pi)}$	$M_R^{SII} = \frac{M_R^{GC}}{2 \text{var}(\pi)}$
Erreygers (2009) normalisation	$EN_u = \frac{4}{(b-a)} GC_u$	$M_H^{EN} = \frac{4}{(b-a)} M_H^{GC}$	$P^{EN} = P^{GC}$	$q^{EN} = \frac{4}{(b-a)} q^{GC}$	$M_R^{EN} = \frac{4}{(b-a)} M_R^{GC}$
<i>Flexible inequality measures</i>					
Wagstaff (2002) normalisation	$WN_u = \frac{(b-a)}{(b-\bar{h}_t)(\bar{h}_t-a)} GC_u$ $\equiv \Omega(\bar{h}_t) GC_u$	$M_H^{WN} = \Omega(\bar{h}_s) GC_{ss} - \Omega(\bar{h}_f) GC_{fs}$	$P^{WN} = \left(\frac{\Omega(\bar{h}_s)}{\Omega(\bar{h}_f)} - 1 \right) \frac{\bar{h}_s}{\Delta h} CI_{ss} - CI_{f-s,s}$ $= \left(\frac{(b-\bar{h}_f)}{(\bar{h}_s-a)} - 1 \right) \frac{\bar{h}_s}{(b-\bar{h}_s)} CI_{ss} - CI_{f-s,s}$ $\equiv \Xi(\bar{h}_s, \bar{h}_f) CI_{ss} - CI_{f-s,s}$	$q^{WN} = \Omega(\bar{h}_f) q^{GC}$	$M_R^{WN} = \Omega(\bar{h}_f) M_R^{GC}$

Notes: The variance of the relative rank variable, $\text{var}(\pi)$, depends only on sample size and is therefore invariant over time.

treated as the initial period throughout the analysis so as to consider the implications of lengthening the time span over which the change in socioeconomic inequality is measured.

Table 2A shows that both average health and all measures of income-related health inequality were highest in Wave 1, though there was no clear trend in any of the measures over subsequent waves. The decline in average health is to be expected given the balanced nature of the panel. The decline in income-related health inequality implies that the change in inequality between Wave 1 and each subsequent wave was negative for all the measures examined in the study.

AGP note that the decomposition of the change in the health concentration index reveals three main points of interest. First, the index of income-related health mobility M_H^{CI} is positive over all time spans, implying that the depreciation in the health of the sample had the effect of reducing health inequalities since the concentration of health losses among the better-off in Wave 1 was greater than the concentration of initial health as indicated by the negative values of the disproportionality index P^{CI} . Second, the health-related income mobility index M_R^{CI} is positive for comparisons across all but one wave, implying that income-related health inequalities were typically exacerbated by income re-ranking. Finally, the equalising effect of health changes dominated the disequalising effect of income re-ranking over all time spans, with inequality higher in the first wave than in any subsequent wave.

The results in the remainder of Table 2A serve to illustrate the implications of the use of alternative inequality indices as the basis for the mobility analysis. First, the use of the other relative inequality measure, the relative inequality index, clearly leads to the same conclusions, with the same values for the disproportionality index and all other measures

Table 2A. Decomposition of changes in income-related health inequality from Wave 1 (Males only).

BHPS Wave		1	2	3	4	5	6	7	8	9
Average health	\bar{h}_t	25.9995	25.6824	25.7671	25.7349	25.7354	25.5887	25.6016	25.5466	25.6888
Average health change	$\overline{\Delta h}$	-	-0.3171	-0.2324	-0.2646	-0.2641	-0.4108	-0.3979	-0.4529	-0.3107
Health Concentration Index	CI_{it}	0.0102	0.0060	0.0055	0.0040	0.0050	0.0077	0.0074	0.0041	0.0087
Change in inequality	$CI_{it} - CI_{ss}$	-	-0.0042	-0.0047	-0.0061	-0.0051	-0.0025	-0.0027	-0.0061	-0.0015
Income-related health mobility	M_H	-	0.0065	0.0073	0.0075	0.0062	0.0074	0.0049	0.0053	0.0046
Disproportionality Index	P	-	-0.5238	-0.8142	-0.7260	-0.6036	-0.4595	-0.3131	-0.2983	-0.3807
Scale factor	q	-	-0.0123	-0.0090	-0.0103	-0.0103	-0.0161	-0.0155	-0.0177	-0.0121
Health-related income mobility	M_R	-	0.0023	0.0027	0.0013	0.0011	0.0049	0.0021	-0.0008	0.0031
Relative Inequality Index	RII_{it}	0.0610	0.0360	0.0330	0.0241	0.0302	0.0462	0.0447	0.0244	0.0521
Change in inequality	$RII_{it} - RII_{ss}$	-	-0.0250	-0.0280	-0.0369	-0.0308	-0.0148	-0.0163	-0.0366	-0.0089
Income-related health mobility	M_H	-	0.0388	0.0441	0.0448	0.0372	0.0443	0.0292	0.0317	0.0276
Disproportionality Index	P	-	-0.5238	-0.8142	-0.7260	-0.6036	-0.4595	-0.3131	-0.2983	-0.3807
Scale factor	q	-	-0.0741	-0.0541	-0.0617	-0.0616	-0.0963	-0.0933	-0.1064	-0.0726
Health-related income mobility	M_R	-	0.0138	0.0160	0.0079	0.0064	0.0294	0.0129	-0.0049	0.0187
Generalised Concentration Index.	GC_{it}	0.2643	0.1541	0.1416	0.1034	0.1298	0.1969	0.1907	0.1039	0.2231
Change in inequality	$GC_{it} - GC_{ss}$	-	-0.1102	-0.1228	-0.1609	-0.1346	-0.0675	-0.0736	-0.1605	-0.0413
Income-related health mobility	M_H	-	0.1694	0.1916	0.1948	0.1621	0.1929	0.1286	0.1397	0.1214
Disproportionality Index	P	-	-0.5340	-0.8244	-0.7362	-0.6138	-0.4697	-0.3233	-0.3084	-0.3908
Scale factor	q	-	-0.3171	-0.2324	-0.2646	-0.2641	-0.4108	-0.3979	-0.4529	-0.3107
Health-related income mobility	M_R	-	0.0591	0.0688	0.0339	0.0275	0.1255	0.0550	-0.0208	0.0802

.....Table continues on next page

Table 2A continued.....

BHPS Wave		1	2	3	4	5	6	7	8	9
Slope Inequality Index	SI_{it}	1.5860	0.9245	0.8495	0.6206	0.7785	1.1811	1.1443	0.6233	1.3385
Change in inequality	$SI_{jt}-SI_{ss}$	-	-0.6614	-0.7365	-0.9654	-0.8075	-0.4049	-0.4417	-0.9627	-0.2475
Income-related health mobility	M_{it}	-	1.0161	1.1495	1.1688	0.9727	1.1576	0.7718	0.8381	0.7286
<i>Disproportionality Index</i>	P	-	-0.5340	-0.8244	-0.7362	-0.6138	-0.4697	-0.3233	-0.3084	-0.3908
<i>Scale factor</i>	q	-	-1.9028	-1.3944	-1.5876	-1.5847	-2.4647	-2.3874	-2.7174	-1.8641
Health-related income mobility	M_{it}	-	0.3547	0.4130	0.2034	0.1652	0.7527	0.3302	-0.1246	0.4811
Erreygers (2009) normalisation	EN_{it}	0.0294	0.0171	0.0157	0.0115	0.0144	0.0219	0.0212	0.0115	0.0248
Change in inequality	$EN_{jt}-EN_{ss}$	-	-0.0122	-0.0136	-0.0179	-0.0150	-0.0075	-0.0082	-0.0178	-0.0046
Income-related health mobility	M_{it}	-	0.0188	0.0213	0.0216	0.0180	0.0214	0.0143	0.0155	0.0135
<i>Disproportionality Index</i>	P	-	-0.5340	-0.8244	-0.7362	-0.6138	-0.4697	-0.3233	-0.3084	-0.3908
<i>Scale factor</i>	q	-	-0.0352	-0.0258	-0.0294	-0.0293	-0.0456	-0.0442	-0.0503	-0.0345
Health-related income mobility	M_{it}	-	0.0066	0.0076	0.0038	0.0031	0.0139	0.0061	-0.0023	0.0089
Wagstaff (2002) normalisation	WN_{it}	0.0366	0.0209	0.0193	0.0141	0.0177	0.0266	0.0258	0.0140	0.0303
Change in inequality	$WN_{jt}-WN_{ss}$	-	-0.0157	-0.0173	-0.0225	-0.0189	-0.0100	-0.0108	-0.0226	-0.0063
Income-related health mobility	M_{it}	-	0.0237	0.0267	0.0271	0.0227	0.0270	0.0183	0.0198	0.0172
<i>Disproportionality Index</i>	P	-	-0.5500	-0.8404	-0.7522	-0.6298	-0.4855	-0.3392	-0.3242	-0.4068
<i>Scale factor</i>	q	-	-0.0431	-0.0317	-0.0361	-0.0360	-0.0555	-0.0538	-0.0611	-0.0422
Health-related income mobility	M_{it}	-	0.0080	0.0094	0.0046	0.0038	0.0170	0.0074	-0.0028	0.0109

differing by a multiplicative factor of 0.1666. Second, the use of the generalised concentration index shows that health depreciation is equalising in absolute as well as in relative terms, with the negative value of the GC disproportionality index implying that health losses were concentrated among the better-off in Wave 1. Moreover the equalising effects of health changes continues to dominate the effects of income re-ranking, which are generally disequalising as before. Third, the use of either of the other absolute inequality indices, the slope inequality index and Erreygers (2009) normalisation, leads inevitably to the same conclusions as for the generalised concentration index, with the same values for the disproportionality index and all the other measures differing only by a simple multiplicative factor. Fourth, the use of the Wagstaff (2002) normalisation leads to essentially the same conclusions as for all the other indices, with the equalising effects of health depreciation again dominating the disequalising effects of reranking, which is to be expected given that the values of the disproportionality index in this case imply a somewhat more ‘leftist’ inequality equivalence criterion than even that implied by the absolute inequality indices.

Finally, Table 2B illustrates the implications of basing the mobility analysis on a measure of morbidity rather than of good health. Average health was highest in Wave 1 so average morbidity is lowest in this wave. Additionally, all the inequality measures indicate that the scale of income-related ill-health inequality was greatest in Wave 1, with the negative values implying that ill-health was concentrated among the poor.

Comparison of the first set of results, for the decomposition of the change in the morbidity concentration index, with those presented in AGP shows that measuring health outcomes in terms of morbidity rather than good health makes little difference to the

Table 2B. Decomposition of changes in income-related morbidity inequality from Wave 1 (Males only).

BHPS Wave		1	2	3	4	5	6	7	8	9
Average morbidity	\bar{u}_t	10.0005	10.3176	10.2329	10.2651	10.2646	10.4113	10.3984	10.4534	10.3112
Average morbidity change	$\overline{\Delta u}$	-	0.3171	0.2324	0.2646	0.2641	0.4108	0.3979	0.4529	0.3107
Morbidity Concentration Index	CI_t^U	-0.0264	-0.0149	-0.0138	-0.0101	-0.0126	-0.0189	-0.0183	-0.0099	-0.0216
Change in inequality	$CI_{ff}^U - CI_{ss}^U$	-	0.0115	0.0126	0.0164	0.0138	0.0075	0.0081	0.0165	0.0048
Income-related ill-health mobility	M_H	-	-0.0172	-0.0193	-0.0197	-0.0165	-0.0196	-0.0134	-0.0145	-0.0126
<i>Disproportionality Index</i>	P	-	-0.5604	-0.8508	-0.7626	-0.6402	-0.4961	-0.3497	-0.3349	-0.4173
<i>Scale factor</i>	q	-	0.0307	0.0227	0.0258	0.0257	0.0395	0.0383	0.0433	0.0301
Morbidity-related income mobility	M_R	-	-0.0057	-0.0067	-0.0033	-0.0027	-0.0121	-0.0053	0.0020	-0.0078
Relative Inequality Index	RII_t^U	-0.1586	-0.0896	-0.0830	-0.0605	-0.0758	-0.1134	-0.1100	-0.0596	-0.1298
Change in inequality	$RII_{ff}^U - RII_{ss}^U$	-	0.0690	0.0756	0.0981	0.0827	0.0451	0.0485	0.0990	0.0288
Income-related ill-health mobility	M_H	-	-0.1034	-0.1159	-0.1179	-0.0988	-0.1174	-0.0803	-0.0870	-0.0754
<i>Disproportionality Index</i>	P	-	-0.5604	-0.8508	-0.7626	-0.6402	-0.4961	-0.3497	-0.3349	-0.4173
<i>Scale factor</i>	q	-	0.1844	0.1363	0.1547	0.1544	0.2367	0.2296	0.2600	0.1808
Morbidity-related income mobility	M_R	-	-0.0344	-0.0404	-0.0198	-0.0161	-0.0723	-0.0318	0.0119	-0.0467
Generalised Concentration Index.	GC_t^U	-0.2643	-0.1541	-0.1416	-0.1034	-0.1298	-0.1969	-0.1907	-0.1039	-0.2231
Change in inequality	$GC_{ff}^U - GC_{ss}^U$	-	0.1102	0.1228	0.1609	0.1346	0.0675	0.0736	0.1605	0.0413
Income-related ill-health mobility	M_H	-	-0.1694	-0.1916	-0.1948	-0.1621	-0.1929	-0.1286	-0.1397	-0.1214
<i>Disproportionality Index</i>	P	-	-0.5340	-0.8244	-0.7362	-0.6138	-0.4697	-0.3233	-0.3084	-0.3908
<i>Scale factor</i>	q	-	0.3171	0.2324	0.2646	0.2641	0.4108	0.3979	0.4529	0.3107
Morbidity-related income mobility	M_R	-	-0.0591	-0.0688	-0.0339	-0.0275	-0.1255	-0.0550	0.0208	-0.0802

.....Table continues on next page

Table 2B continued.....

BHPS Wave		1	2	3	4	5	6	7	8	9
Slope Inequality Index	SII_{it}^U	-1.5860	-0.9245	-0.8495	-0.6206	-0.7785	-1.1811	-1.1443	-0.6233	-1.3385
Change in inequality	$SII_{jt}^U - SII_{st}^U$	-	0.6614	0.7365	0.9654	0.8075	0.4049	0.4417	0.9627	0.2475
Income-related ill-health mobility	M_H	-	-1.0161	-1.1495	-1.1688	-0.9727	-1.1576	-0.7718	-0.8381	-0.7286
<i>Disproportionality Index</i>	P	-	-0.5340	-0.8244	-0.7362	-0.6138	-0.4697	-0.3233	-0.3084	-0.3908
<i>Scale factor</i>	q	-	1.9028	1.3944	1.5876	1.5847	2.4647	2.3874	2.7174	1.8641
Morbidity-related income mobility	M_R	-	-0.3547	-0.4130	-0.2034	-0.1652	-0.7527	-0.3302	0.1246	-0.4811
Erreygers (2009) normalisation	EN_{it}^U	-0.0294	-0.0171	-0.0157	-0.0115	-0.0144	-0.0219	-0.0212	-0.0115	-0.0248
Change in inequality	$EN_{jt}^U - EN_{st}^U$	-	0.0122	0.0136	0.0179	0.0150	0.0075	0.0082	0.0178	0.0046
Income-related ill-health mobility	M_H	-	-0.0188	-0.0213	-0.0216	-0.0180	-0.0214	-0.0143	-0.0155	-0.0135
<i>Disproportionality Index</i>	P	-	-0.5340	-0.8244	-0.7362	-0.6138	-0.4697	-0.3233	-0.3084	-0.3908
<i>Scale factor</i>	q	-	0.0352	0.0258	0.0294	0.0293	0.0456	0.0442	0.0503	0.0345
Morbidity-related income mobility	M_R	-	-0.0066	-0.0076	-0.0038	-0.0031	-0.0139	-0.0061	0.0023	-0.0089
Wagstaff (2002) normalisation	WN_{it}^U	-0.0366	-0.0209	-0.0193	-0.0141	-0.0177	-0.0266	-0.0258	-0.0140	-0.0303
Change in inequality	$WN_{jt}^U - WN_{st}^U$	-	0.0157	0.0173	0.0225	0.0189	0.0100	0.0108	0.0226	0.0063
Income-related ill-health mobility	M_H	-	-0.0237	-0.0267	-0.0271	-0.0227	-0.0270	-0.0183	-0.0198	-0.0172
<i>Disproportionality Index</i>	P	-	-0.5500	-0.8404	-0.7522	-0.6298	-0.4855	-0.3392	-0.3242	-0.4068
<i>Scale factor</i>	q	-	0.0431	0.0317	0.0361	0.0360	0.0555	0.0538	0.0611	0.0422
Morbidity-related income mobility	M_R	-	-0.0080	-0.0094	-0.0046	-0.0038	-0.0170	-0.0074	0.0028	-0.0109

substantive findings in this particular case study. Thus, the negative values of the index of income-related morbidity mobility $M_H^{CI^U}$ imply that the observed change in health outcomes also had the effect of reducing inequalities in ill-health because morbidity changes were more concentrated among the rich than the initial distribution of ill-health: the negative values of the disproportionality index P^{CI^U} in this case follow inevitably from the negative values of P^{CI} reported in Table 2A. Second, income re-ranking typically served to exacerbate inequalities in morbidity as well as in health, with the negative values of $M_R^{CI^U}$ implying that those who moved up the income distribution tended to be less unhealthy in the final period than those who moved down. Finally, the equalising effects of health outcome changes dominate the disequalising effects of income re-ranking as before.

Nevertheless, this correspondence between the health and morbidity findings is not guaranteed with the use of a relative measure of inequality. To ensure strict equivalence an absolute measure of inequality, such as the generalised concentration index, must be employed, with the results presented for these measure in Tables 2A and 2B simply differing in terms of the sign of the matching mobility indices. By way of counter-example, we note finally that the results for the Wagstaff (2002) normalisation in Table 2B imply an ‘intermediate’ rather than ‘extreme leftist’ inequality equivalence criterion when changes in inequality are measured with respect to morbidity rather than health.

4. Conclusions

This paper sets out to further elaborate the approach to the longitudinal analysis of income-related health inequalities proposed in Allanson, Gerdtham and Petrie (2010). The resultant contribution is twofold. First, we establish the normative basis of the AGP mobility indices

by embedding the AGP decomposition of the change in the health concentration index within a broader analysis of the change in “health achievement” or wellbeing. In particular, we show that AGP’s income-related health mobility index provides an ‘ex-ante’ measure of health mobility in which individuals’ health changes are evaluated on the basis of their positions in the initial income distribution, with this asymmetric treatment potentially justifiable on the grounds that the initially poor are disadvantaged to the extent that they face a worse lottery of future health possibilities than those who are better off. We are further able to show within our framework that income re-ranking leads to a loss of welfare to the extent that it exacerbates income-related health inequalities.

Second, we demonstrate that the decomposition procedure set out in AGP may also be used to analyse the change in a range of other commonly-used income-related health inequality measures, including the generalised concentration index and the relative inequality index. The choice of inequality measure is shown to affect the results of the subsequent mobility analysis to the extent that different inequality measures embody alternative inequality equivalence criteria, though such differences in results prove not to be of a substantive nature in the illustrative empirical study reported in the paper. We further note that mobility analyses based on absolute inequality measures, such as the generalised concentration index, have the desirable property that the conclusions will be invariant to whether inequality is measured with respect to health or morbidity. However, the exact choice of inequality measure should not be guided by analytical convenience but by public perceptions of what health changes constitute an improvement in income-related health inequalities, on which little is currently known. Until more is known about these values,

studies should present findings using both relative and absolute measures in order to provide policymakers with a fuller assessment of the nature of health changes taking place.

References

- Allanson, P., Gerdtham, U-G. and Petrie, D., 2010. Longitudinal analysis of income-related health inequality, *Journal of Health Economics*, 29, 78-86.
- Amiel, Y. and Cowell, F., 1997. Income transformation and income inequality. STICERD, LSE discussion paper DARP 24.
- Atkinson, A. B., 1970. On the measurement of inequality. *Journal of Economic Theory*, 2, 244–263.
- Atkinson, A.B., 1980. Horizontal equity and the distribution of the tax burden, in Aaron, H. and Boskin, M.J. (eds.), *The Economics of Taxation*, Washington D.C., USA: Brookings Institute, p. 3-18.
- Bleichrodt, H. and Van Doorslaer, E., 2006. A welfare economics foundation for health inequality measurement. *Journal of Health Economics* 25 (5), 945–957.
- Bommier, A. and Stecklov, G., 2002. Defining health inequality: why Rawls succeeds where social welfare theory fails. *Journal of Health Economics* 21, 497–513.
- Clarke, P.M., Gerdtham, U.-G., Johannesson, M. and Bingefors, K., Smith, L., 2002. On the measurement of relative and absolute income-related health inequality. *Social Science & Medicine* 55 (11), 1923–1928.
- Dardanoni, V., 1993. Measuring social mobility. *Journal of Economic Theory*, **61**, 372-94.
- Erreygers, G., 2009. Correcting the Concentration Index. *Journal of Health Economics*, 28, 504–515.
- Essama-Nssah, B., 2005. A unified framework for pro-poor growth analysis. *Economic Letters*, 89, 216–221.

- Goldberg, D. and Williams, P., 1988. *A User's Guide to the General Health Questionnaire*. NFER-Nelson, Windsor, UK.
- Jones, A.M. and López Nicolás, A., 2004. Measurement and explanation of socioeconomic inequality in health with longitudinal data. *Health Economics*, 13, 1015-1030.
- Kakwani, N.C., 1977. Measurement of tax progressivity: An international comparison. *Economic Journal*, 87, 71-80.
- Milanovic (1997) A simple way to calculate the Gini coefficient, and some implications. *Economics Letters*, 56, 45-49.
- Plotnick, R., 1981. A measure of horizontal equity. *Review of Economics and Statistics*, 63, 283-88.
- University of Essex. Institute for Social and Economic Research. 2007. *British Household Panel Survey: Waves 1-15, 1991-2006* [computer file]. 3rd Edition. Colchester, Essex: UK Data Archive [distributor], June. SN: 5151.
- Wagstaff, A., 2002. Inequality aversion, health inequalities, and health achievement. *Journal of Health Economics* 21 (4), 627–641.
- Wagstaff, A., 2009. Correcting the Concentration Index: A comment. *Journal of Health Economics*, 28, 516–520.
- Wagstaff, A., Paci, P. and Van Doorslaer, E., 1991. On the measurement of inequalities in health. *Social Science & Medicine* 33 (5), 545–557.
- Yaari, M. E., 1988. A Controversial Proposal Concerning Inequality Measurement, *Journal of Economic Theory*, 44(2), 381–97.
- Yitzhaki, S., 1983. On an extension of the Gini inequality index. *International Economic Review*, 24, 617–28.
- Yitzhaki, S. and Wodon, Q., 2004. Inequality, mobility, and horizontal equity. In: Y. Amiel and J. A. Bishop (eds.), *Studies on Economic Well-Being: Essays in Honor of John P. Formby*. Research on Economic Inequality, 12, p. 177–98. Elsevier, Oxford.
- Zoli, C., 2003. *Characterizing Inequality Equivalence Criteria*. Mimeo. University of Nottingham.