Mortality effects of earlier income variation

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ABSTRACT (327 words)

Background: Several studies have shown an inverse relationship between a person's mortality at a certain age and his or her income shortly before. It has also been firmly documented that those who have experienced unemployment or spells of poverty, recently or in the more distant past, have excess mortality. The objective of this study is to analyse the importance of earlier income changes more generally.
Data and methods: The analysis was based on register data that cover the entire Norwegian population and include individual histories of annual labour income. Using a hazard regression approach, it was estimated how the chance of dying within the next year is related to the income two years earlier and various measures of incomes during the previous 13 years. The analysis was restricted to 1990-2002 and to men at age 50-69 who had an income above 200,000 NOK two years earlier, and who therefore presumably had not yet retired. In total, there were 10,317 deaths during 2.1 million person-years of observation.
Results: More than one-third of the men had experienced at least once that the income had fallen to a level more than 15% below the average over the 5 previous years. Just as many had at least once experienced an increase to a level more than 30% above this average. Among the 17% who had experienced a fall of this size at least once and an increase at least twice, or vice versa, mortality was elevated by 17% compared to that among men who had neither experienced a fall nor rise and who had the same average income. Among those who had experienced fewer changes, there were only weak indications of excess mortality. On the whole, variation dominated by falls did not have more adverse effect on mortality than variation dominated by rises.
Conclusion: The analysis supports the idea that the income history matters and suggests that one should consider variation quite generally, and not only large falls resulting from for example unemployment.

(Text with refs and tables is 8500 words)

INTRODUCTION

An inverse relationship between different measures of a person's mortality and his or her income a few years previously has been established in a number of studies (e.g. Martikainen et al. 2009), and much attention has also been devoted to the mortality among persons who have quite recently experienced income decline, and especially unemployment (e.g. Strully 2009). The excess mortality that is typically seen among those with low income, and especially among those who have become unemployed, is thought to reflect both economic disadvantages and psychosocial stress, as well as selection.

In this paper we argue that it is highly plausible that the entire income trajectory is of importance, not only the income level some few years earlier or certain specific recent episodes. We start with a theoretical discussion and subsequently show estimates from statistical models that include various measures of the income history. Special attention is paid to the importance of income variability, including whether the variability is characterized by sharp income falls, sharp rises or both. .

When discussing the potential importance of earlier incomes, it may be helpful to make a distinction between two different dimensions. One is that the income some few years earlier obviously is a poor measure when one seeks to analyze the overall impact of income *levels* on mortality. There is a small, but growing, literature that recognizes these shortcomings, and where various measures of lifetime income are included in the regressions (Duleep, 1986; Menchik, 1993;. Wolfson et al., 1993; McDonough et al., 1997; van Ourti, 2003; von Gaudecker and Scholz, 2007; Duggan et al., 2008; Cristia, 2009). Second, there is *income dynamics*: mortality may be influenced by past (and not only recent) episodes of poverty, unemployment or other rather dramatic income reductions, as well as by other types of income changes. The few studies that have considered such issues have generally had to rely on quite simple operationalizations because of lack of data (see review by Benzeval and Judge 2009). Truly, some advances have been made in recent years, for example by consideringlife-course trajectories of poverty (McDonough and Berglund, 2003; McDonough et al, 2005), but we think even these investigations have important limitations. First, they have focused almost exclusively on the most dramatic income reductions, such as unemployment and poverty, thus neglecting the much more common moderate fluctuations. Second, there has been a rather narrow focus on income reductions, with little consideration of the broader pattern of income changes that they are part of. For example, reductions may be succeeded by slow or sharp increases up to the earlier level, so that the income profile can be described as generally volatile rather than one where reductions are the dominant kind of change. A third and related issue is the lack of attention to the possible role of income increases.

In our statistical analysis we use data on annual labor incomes for the past 15 years for complete Norwegian cohorts (with an eye also to the income during the 5 years before that). The labour income is far from a perfect indicator of a person's purchasing power, but we have restricted the analysis to men younger than 69 who have not yet retired, for whom the measure should be quite relevant (see details below). Our lower age limit is 50, as only about 3% die at younger ages (Statistics Norway 2009). Contrary to earlier research, we consider

both upward and downward changes in income. More precisely, we estimate discrete-time hazard regression models for mortality where we include measures of the frequency and size of these changes in the past years. We do not restrict ourselves to the movements into poverty, which is generally uncommon in Nordic countries, or to the quite large changes that typically result from unemployment.

AN ELABORATION ON POSSIBLY RELEVANT CAUSAL MECHANISMS

In the following we will explain why the entire income trajectory – the income levels as well as the changes - is likely to be of importance for mortality. Even if this main conclusion might seem obvious at the outset, some of the underlying arguments are far from trivial and we think there is little consciousness about them in the literature. We start with a discussion of some general mechanisms and ideas, summarized as three basic "premises". In the next step, we spell out some implications of one or more of these premises for specific situations.

Introductory remarks on income and mortality

We find it useful to distinguish between two main channels through which income affects health. First, economic resources may increase a person's access to high-quality health care and lead to a relatively healthy life-style (with respect to, for example, nutrition, housing standard, physical environment, and leisure activities). Second, in addition to this "material channel", it has been suggested that a person's economic resources may have a completely different type of effect, of a more psychological nature (referred to below as the "psychosocial stress channel"). The idea is that a feeling of inferiority compared to some reference group may be a psychosocial stressor that may have direct physiological consequences or operate more indirectly through unhealthy coping practices such as smoking (Wilkinson 1999, Marmot and Wilkinson 2001). With support from animal experiments (Sapolsky 2005), it has been suggested that the former may involve immune or neuroendocrine mechanisms (Cohen et al. 2007, Sloan et al. 2005). A reference groups is of course not easily defined (Subramanyam et al. 2009; Pham-Kanter 2009). To the extent that the country average can be considered a reasonable yardstick for comparison, those of the country's citizens who earn little will suffer from these kinds of stress responses (in addition to having a disadvantage because they cannot buy as many health goods as those with higher incomes). It is also possible that the relevant reference level is the agent's own income level in other periods, and perhaps especially the most recent period. In that case, a person who experiences an income decline will experience a particular disadvantage compared to one with a stable, and more so if the change is rapid than if it is gradual. To our knowledge, this hypothesis has not been explicitly mentioned in the literature on income and health, though it seems to have been hinted at.

With respect to the material channel from income to health, the starting point of our argument is the basic predictions of standard economic theories of consumption. Though these theories are primarily concerned with the overall level of consumption, we find it plausible that the consumption of health promoting goods largely follows the same pattern (i.e. that these goods are what economists call a normal good). The standard life-cycle theory for consumption (see e.g. Attanasio, 1999) builds on two fundamental assumptions, in addition to the general one of rationality. One is that agents are forward-looking, i.e. taking expectations about future income into account. The second assumption is that they - in addition to prefering more consumption in each period, with declining marginal utilty - also prefer smooth consumption paths. In an "ideal setting", without any form of credit constraints

or uncertainty, the implications of these two assumptions is that they will exploit the possibility to borrow freely against future income whenever needed to maintain a constant level of consumption, and save in periods when income is higher than needed to maintain this level. This constant level is determined by their perceived lifetime income, and in this simple benchmark case there is no direct influence of current income.

In reality, however, there is both uncertainty and possible credit constraints. Adding these ingredients, the life-cycle model delivers other and richer results. Because of uncertainty the actual average income over the life-course, as realized ex post, can deviate substantially from the perception of lifetime income an agent holds at a given point in time, ex ante. For example, a person may experience a decline in income that was not expected. This will lead to downward revision of the expected lifetime income, and thus reduce consumption. Only unanticipated changes, though, are predicted to have such effects (see e.g. Jappelli and Pistaferri, 2010). Uncertainty about future income will also have an additional effect by inducing precautionary saving. The standard prediction is that the amount of precautionary savings rises with the level of uncertainty, i.e. that for a given level of expected life-time income one will consume less the more uncertain the future income is (see e.g. Cabellero, 1990). Last, but not least, it is crucial to note that absence of credit constraints is a theoretical assumption which only rarely is fully satisfied. When agents are not able to borrow against future income whenever they want to, consumption can be limited by current income, and thus will tend to follow current income much more closely.

Also the psychosocial stress channel probably involves both current income and measures of lifetime income. When comparing their own situation to that of a reference group, it seems plausible that agents put strong weight on their current situation. A feeling of deprivation is likely to arise even if the currently low income is expected to be followed by high income later or income was high in earlier periods. It seems plausible, however, that such considerations of income history can partially modify the effect. As suggested above it is also possible that the relevant comparison is between income now and some measure of what income one is used to or feels one could expect.

Further, it seems highly plausible that economic uncertainty can be a psychosocial stressor with many of the same effects on health as feelings of deprivation and inferiority. There is a large literature showing that job-insecurity is strongly associated with poorer health outcomes (see e.g. Lázló et al, 2010; Burgard et al, 2009; Ferrie et al, 2005). Income variability can in several situations be tightly connected to job insecurity, but there is also reason to expect similar stress effects from the more general economic insecurity embodied in income variation. Thus, income variability can also have direct detrimental health effects induced by mechanisms involving psychosocial stress.

To sum up, we have argued that consumption of health promoting goods in any given period is determined by three factors: current income, expected lifetime income and uncertainty of future income. Our predictions regarding effects through the psychosocial stress channel are somewhat less precise, but can roughly be summarized in an analogue statement: what matters is current income, some measure of overall level of past (and perhaps also future) income, and uncertainty of future income. In our analysis we will not try to operationalize the more subtle differences between these two predictions, for example by separating the predictable and unpredictable components of the income path (as often done in econometric studies of consumption). Rather, we will use average consumption over the observation period as the single measure of the overall level of the income path.

The following statement summarizes our arguments:

A1) The effect of income on health and health-behavior in any given period involves three components: i) current income, ii) life-time income/average income, iii) income variability.

There is a growing research literature on the shape of the relationship between income and health outcomes, with a focus on recent income (Ecob and Smith 1999, Fritzell et al 2004, Mackenbach et al 2005, Rehkopf et al 2008). Though the evidence is not fully consistent, the majority of studies report that the relationship is not uniformly linear. Rather, the contribution to better health from a given increase in income tends to be higher at low levels of income than at higher levels, i.e. the function is concave/curvilinear. Some studies find more extreme versions with a threshold value beyond which there is little or no effect of income. Similar thresholds have been suggested with specific reference to the influence on psychosocial stress (Pham-Kanter, 2009). Such a pattern is also a form of concavity. We thus conclude:

A2) The effects of income on health is concave

So far we have discussed the effects of the economic situation in one period (including perceived lifetime income and income uncertainty) on consumption of health promoting goods in that period, and on psychosocial stress experienced in that period. Presumably, these conditions in turn have effects on health and mortality also later, though probably more so in the short term than in the long term. In other words:

A3) There is a cumulative effect of earlier incomes, in the sense that the health and health behaviour in one period, which is influenced by income (as described in A1 and A2), has implications for later health and mortality.

Implications for effects of income variation

Given the average level of income, how will its distribution in time matter according to the general arguments above? Overall, the most common form of income variation in our data is an upward drift. This is in part due to an economy wide upward trend in real wages, but for most individuals it also reflects wage increases based on seniority. In this study, however, the interest lies in the more volatile patterns, with pronounced falls or increases, which are presumably more unpredictable. Such changes tend to appear in combination with gradual increases (or decreases), but it is possible empirically to separate those two sources of variation (see our operationalization below), and we will focus on the former in the following discussion.

We have already mentioned two related reasons why income variability, to the extent that it reflects income uncertainty, has detrimental health effects. One is the possibly harmful stress responses induced by economic insecurity; the other is the lower level of consumption of health promoting goods forced by the need to make more precautionary savings. In addition, there is a more indirect mechanism building on the concavity of the relationship between income and health. The concavity implies that what is gained in health during years at high income levels (through healthier consumption and/or less psychosocial stress), does not compensate for the corresponding losses when the income is just as much below the average. In other words, given the average income level, the total cumulative impact is more beneficial if income lies constant at this level than if it varies around this average (formally, this is just Jensen's inequality: the mean of a concave function is smaller than the function evaluated at the mean)

It should be stressed that, according to the argument above, we predict that income falls and income rises should both have detrimental effects on mortality when we condition on average income. This contrasts with the existing literature, which has almost exclusively emphasized income falls. The effects do not, however, necessarily have to be of the same size. Their relative importance depends on the exact functional form of the relationship between income and mortality (degree of concavity, presence of thresholds) and on how different income changes affect perceptions of uncertainty. Another reason why the effects of falls and increases may be different is that a person who has experienced a sharp income fall may have a low feeling of wellbeing because of deprivation relative to the past, while one who experiences an increase on the contrary may feel more comfortable because of the relative improvement. One might speculate whether the advantage for the latter person, compared to one who has had a stable income, might be smaller than the corresponding disadvantage for one who has experienced a fall. The implication of such a kind of concavity would be that income variation characterized by just as many falls as increases in income would raise mortality compared to a situation with stable income.

Yet another reason why we may see different effects of income falls and rises is that some factors that are closely linked with these two phenomena may be fundamentally different. Starting with the falls, a number of underlying factors are plausible.

A particularly important one is unemployment, which typically causes quite large reductions of the income (the unemployment benefit replacement rate is Norway is about 2/3, see OECD Employment Outlook 2006, table 3.2), but also may affect mortality through other mechanisms. In particular, not being at work may induce a feeling of shame and thus increase the psychosocial stress, and there may disadvantages associated with a weaker structuring of the days and less contact with colleagues. Several investigations have documented stress responses to unemployment (Cohen et al. 2007; Hintikka et al. 2009; McKee-Ryan et al. 2005; Theodossiou 1998), even in the longer term (Janicki-Deverts et al. 2008).

When it comes to income rises, the story may be quite different. In particular, a person who earns a higher income than earlier may have worked extraordinarily much, because of good opportunities or for other reasons. Overtime work is associated with excess mortality, at least in the short term, according to some studies (Nylen et al. 2001), while other studies are less clear in their conclusions (Lallukka et al. 2008). (A similar explanation has been given for the relatively high mortality rates for countries or regions that have seen an increase in the average income, though it has also been suggested that the elevated mortality is due to accidents resulting from a more intense road traffic during the boom (Miller et al, 2009)

To sum up, some mechanisms give detrimental health effects of both an income rise and an income fall (though not necessarily equally strong), conditional on average income. Another possible mechanism (intertemporal relative income) is more asymmetric and produces a beneficial effect of an income rises that in principle might outweigh the adverse ones.

Selection

As widely recognized, selection is a major problem in studies of the income-mortality relationship. First, the income in a given period is of course strongly dependent on the number of hours worked, which may also affect mortality through other types of channels (see above). In fact, work activity and income are so closely related that the effects in practice are difficult

to separate. Second, there are a number of determinants of a person's work activity and his or her hourly wage that may also influence health. For example, people with particularly low theoretical qualifications or little practical skills may find it difficult to get or hold a job, and if they do work, they may have low productivity and therefore also earn a low wage. Even more importantly, poor health may affect work activity and wages, in addition to having obvious implications for later mortality. (Some would refer to this as "reverse causality") More specifically, a person may have a chronic health condition that gives recurrent episodes of reduced work ability, and for this reason have higher mortality than those who have the same average income but with little variation over time. It is of course very difficult to control adequately for all the individual and community characteristics that may affect job availability and wages as well as mortality. In this analysis, based on administrative registers, we have only included education, age and period as control variables and lagged the "current income" variable two years.

DESCRIBING INCOME HISTORIES

Having discussed theoretically how various aspects of an individual's income history might affect health, it is now time to address how to operationalize these concepts. In our statistical analysis, we compare mortality across groups with different income patterns during a 15-year observation period. We always control for the average income level over the entire period. Thus, estimates of effects of income changes relate to whether there is a role for such changes themselves, over and beyond their effect through the average.

The first question we ask is: What constitutes an income fall? Obviously, a transition to a lower income in one period than in the preceding period is nominally a fall, but is that really what we want to capture? If we consider such a fall from one year to the next in isolation we can, for example, not distinguish between a case where this fall marks the onset of a trough and a case where the fall marks the end of a peak. Observing such an isolated fall can therefore be a reflection of either of these two diametrically different phenomena. Much of the literature has considered income falls as more or less isolated events, thus overlooking such differences.

Distinguishing whether a fall (and a rise) is primarily a reflection of a trough or a peak is not necessarily easy. Consider the income trajectory in Figure 1. We clearly see the income fall QR, but how do we judge whether this is a fall proper or just the end of a period PQR with high income? In this stylized example we are able to see a relatively clear underlying pattern OPRS, so we will tend to lean towards the second alternative. In real data it is much harder to detect such underlying patterns. To capture the underlying trend, we have used the average over the 5 preceding years. We chose a measure based only on historical income figures (i.e. not a classical moving average) because we primarily wanted it to reflect the situation prior to the change. This is important to better capture the most relevant features referred in our theoretical discussion (unpredicted changes, signals of increased uncertainty, comparisons to a reference level based on recent experience). Other and more sophisticated alternatives such as a Hodrick-Prescott filter were considered, but we made our choice of operationalization based on a desire for simplicity and transparency. Almost the same mortality effects were estimated when we tried a 3- or 7-year reference period instead of a 5-year period.

Our primary measure of income variation is meant to capture the relatively large changes around this trend. We count as an income fall only situations where we in a single year observe a decline to a value 15% below the average over the preceding years (i.e. trend), and classify individuals according to whether they over the 15-year period have experienced

no, one, or two or more such falls. As already discussed, there is generally an upward drift in income due to economy wide real wage growth and seniority. For this reason we set the limit higher for income rises, counting only increases of at least 30% relative to the average over the preceding 5 years. Again we classify individuals in groups having no, one, or two or more such rises. The exact limits defining a fall and a rise are clearly somewhat arbitrary, but represent interesting cases. The asymmetric limits led to fairly symmetric frequencies of falls and rises, as can be seen from Table 1.

It is worth emphasizing two aspects of how our operationalization treats various types of falls and rises. First, falls from one year o the next of more than 15% will not be counted if the level before the fall was just temporarily quite high, and the fall is to a level within 15% of the average over the 5 preceding years. Second, a trough will usually only be counted as a single fall. If recovery is gradual or happens shortly after the fall, this will not count as an income rise. Only if income stays at the new low level long enough for also the 5-year average to fall to this level will a recovery in a later year count as a rise.

Our second, additional measure is the square root of the average of the squared differences from the average over the 5 preceding years). With this measure we seek to capture income variation more generally, and not only the major income changes. We also adjust for the underlying trend, as with the other measure. A traditional estimate of standard deviation (as employed by Sullivan and Wachter, 2009) seems ill-suited because it will also give high scores in situations with a steady decline or increase, i.e. situation with presumably little income uncertainty (and which we do not consider in our study).

Specification of aims and hypotheses

In light of the preceding theory and our operationalization we present the following hypotheses about effects on mortality:

1) A negative of effect of current income and lifetime income

2) A positive effect of being classified as having experienced an income fall, rising further when income has fallen more than once

3) An uncertain effect of being classified as having experienced an income rise, rising further when income has risen more than once. The effect is most likely positive, though not necessarily as large as that associated with income falls, and it may even be negative if the inter-temporal relative income mechanism dominates.

4) A positive effect of income variability measured as standard deviation from trend

Effect 1 is well established in the literature, and effect 2 is a general version of what is seen with a focus on rather dramatic downward changes, while 3 and 4 are original to this study. In our regressions we use the log of current and lifetime income to reflect the concave relationship that is expected.

DATA AND METHODS

Data

The data, which covered the period up to and including 2002, were extracted from three different sources. One was the Norwegian population register, which includes everyone who has ever lived in Norway after 1960. In these data, there is information about time of death and histories of migration into and out of the country (as well as internal migration, which is not relevant for this analysis) since 1965. The data from the population register were matched with histories of annual labor incomes from 1968 to 2002 (provided by the Taxation Directorate through Statistics Norway), and data on educational levels (from Statistics Norway's education register, based on censuses and schools' reporting). The analysis was restricted to the period 1990-2002.

It is not clear cut what constitutes the most relevant income concept to use in an analysis of the relationship between income and mortality. In this study we used individual pre-tax labor income given in 1000 Norwegian Kroner (NOK) in 1998 prices, adjusted by the consumer price index. The income definition includes unemployment benefits and temporary sickness benefits, but not pensions and benefits for those retired permanently through sickness or disability. The income definition has been quite stable for all years since 1967.

Many studies have been based on measures of household income which adjust for number of consumer equivalents. Such measures are often claimed to be more appropriate indicators of purchasing power. The main reason why we used individual income is that households cannot be identified with certainty in our data. However, individual income should not only be considered an inferior proxy of household income. It is an alternative measure that captures slightly different aspects of an individual's economic position. For example, effects from psychosocial stress can probably be just as much shaped by individual income as by household income.

Admittedly, by using a measure of pre-tax labor income we do not take into account financial income from savings and other assets. It should also be noted that since taxation of labor income is heavy and quite progressive in Norway, the differences in after-tax incomes are much smaller than those in pre-tax incomes (i.e. our 15% decreases translate into smaller decreases in post-tax income). Further, our income measure does not capture retirement pensions and permanent disability benefits. The age at retirement varies, but the common age is 67 and almost all are retired at age 70. One may have a labor income after retirement, but it has been found to usually be very low (not least because of a retirement earnings test that reduces benefits if earnings exceed a base exemption; see e.g. Hernæs and Jia (2007)). Thus, if the analysis is restricted to persons who do not have very low earnings, it is reasonable to assume that they have not yet retired. We have set this lower limit for the income (with a two-year lag as described below) at 200000 NOK, which is above the lowest full-time income in the public sector. Very similar estimates were obtained when the lower income instead was set to 175000 or 225000 (not shown in tables). In additional models, we also excluded the quite few men with incomes above 999000. This also had not impact on the estimates.

Because the analysis starts in 1990 and the income data cover the period back to 1968, we can in principle consider incomes up to 22 years earlier. In most models, we only make

use of a 20-year history, since the measures are based on income levels and changes over the last previous 15 years and comparison with the level 5 years earlier, but one of the sensitivity tests was based on 7-year period of comparison, requiring a 22-year history. Further, although it is possible to have 0 income, for examples because of unpaid vacations, studies or (even among men) homemaking, we estimated some models where all observations with at least one year with 0 income were excluded. This reduced the sample by only about 2% and none of the effect estimates were appreciably changed.

Statistical model

We estimated discrete-time hazard models. For each man, a series of one-year observations was created, starting in January 1990 (if born 1920-1939) or in January the year the man turned 50 (if born 1940-1952). Those born before 1920 or after 1952 did not contribute to the analysis. End of follow-up was at the end of 2002, the end of the year when the man turned 69 (similar results were found with a cut-off at age 64), or at the time of death or last emigration, whatever came first. One-year observations starting when the man was abroad were omitted.

Mathematically, the model is

$$\log (p_{i,t}/(1-p_{i,t})) = \beta_1 X_{i,t-} + \beta_2 t + \beta_2 \log(I_{i,t-2}) + \beta_3 \log(A_{i,t-15,t-3}) + \beta_4 V_{i,t-15,t-3}$$

where $p_{i,t}$ is the probability that man i alive at the beginning of year t dies within that year. $X_{i,\,t-}$ is a vector of control variables referring to characteristics (age and education) of the man at the start of t. $I_{i,t-2}$ is the income in the year t-2. (The mean of log $I_{i,t-2}$ is 5.65 and the standard deviation is 0.31). As mentioned earlier, this two-year lag is introduced to reduce the health-selection problem. $A_{i,t-15,t-3}$ is the average income over the years between t-15 and t-3. (The mean of log $A_{i,t-15,t-3}$ is 5.56 and the standard deviation is 0.30.) $V_{i,t-15,t-3}$ is either of our two measures of income variation described earlier. A linear time effect was included. The same results were obtained when one-year dummies were included instead.

We excluded observations for which there was at least one missing value for annual labor income during the foregoing 15 years, or if the person had lived abroad during some of that period (and the income for at least one year therefore may not be known). As just mentioned, we also left out those earning less than 200000 in the year t-2. Within the remaining 2,125,394 person-years of observation, there were 10,317 deaths.

RESULTS

One can see by summarizing from the figures in Table 1 that 42% of the men had experienced at least once that the income had fallen to a level more than 15% below the average over the 5 previous years. 15% had experienced this two or more times. Further, 40% had at least once experienced an increase to a level more than 30% above the average over the 5 previous years, and 14% had experienced it at least twice.

Among those who had experienced an income decline at least once, a little more than 1/3 had *not* also experienced an income increase, i.e. the decline was the dominant change. Conversely, among those who had experienced an increase, a little more than 1/3 had *not* also

experienced a decrease. The remaining, which were 27% of the entire study population, had experienced at least one decrease and at least one increase. A subset of this group had experienced a decline at least once and an increase at least twice, or vice versa (the three groups in the lower right corner, adding up to 17% of the study population).

(Table 1 about here)

Estimates are shown in Table 2. As expected, a higher age increases mortality, while a a higher education has the opposite effect. There is also a decline in mortality over time. More interestingly from our perspective, the income two years earlier is inversely related to mortality, while there is no significant effect of the average income over the 13 previous years, though the point estimate suggests an effect in the same direction. A 16-19% excess mortality is estimated for the three groups with most variation in income compared to the large group with (according to our definition) no variation. The point estimates suggest a smaller excess mortality for the other groups, but significance at the 5% level is not attained. By comparing opposite cell in the matrix of effect estimates, we see that there is a remarkable symmetry: mortality is the same regardless of whether the income variation is dominated by falls (i.e. clear falls and no or less clear increases) or declines. If the variation indicator was excluded, the effect of the average income was significant (0.884 CI 0.796-0.980; not shown in tables) and was almost the same as that of current income. In other words, the low mortality seen among those with a high average income according to simpler model is explained by the lower amount of variation in this group.

(Table 2 about here).

We also tried an alternative definition of income falls and rises: reduction of 30% compared to the earlier 5 years and increases of 50%. The pattern was quite similar: the excess mortality among those (12%) who had experienced at least one fall and at least one decline was 16%, and there was again symmetry with respect to falls and increases (not shown in tables). The most striking difference was the clearer excess mortality among the very few who had experienced two declines and no rise, or vice versa.

In the next step, we included an alternative measure of income variability, the standard deviation from the trend, as measured by the average over the 5 preceding years (mean 46.8, standard deviation 134.43). With this specification, both the effect of current income and that of average income were significant, and again had even the same size (Table 3). High variability was found to raise mortality significantly, though it is not an effect that matters much. For example, a one-standard-deviation increase in variability is associated with a 0.8% increase in mortality.

When this alternative measure of income variation instead was included *in addition* to the other ("main") measure of income variation, the effects were essentially the same as those shown in Table 2, and the effect of the alternative measure was far from significant (p=0.41).

In other words, there seems not to be an additional effect of small variation (which would be picked up by the alternative measure) around the larger falls and rises considered in the main measure, and the alternative measure is not able to capture much of the effect of these larger changes.

(Table 3 about here)

As mentioned earlier, one reason why one would expect a positive association between income variation and mortality is that there may be a concave relationship between the income in a certain year and the health and health behavior that year (probably with long-term implications). To try to capture that effect, we estimated an additional model where the average of the logarithm of the annual incomes was included instead of the logarithm of the average income. The former turned out to have a clearer negative effect on mortality (see Table 4), actually of the same size as that of current income, but there were only small changes in the effects of income variation. This suggests that the concavity-mechanism either matters little or that the concavity effect is inadequately captured by the logarithmic form.

(Table 4 about here)

SUMMARY AND CONCLUSION

In addition to confirming (for men) the inverse relationship between the chance that a person of a certain age dies within the following year and the income shortly before, we have shown that also the income history matters. Most importantly, even rather moderate income variation is associated with excess mortality. For example, the 17% of the men who had experienced two or more falls of at least 15% in income and one increase of at least 30% , or vice versa, had approximately 17% higher mortality than those with a rather stable income. An excess mortality was also indicated, though not significant at usual levels, for men who had experienced fewer up- or downward changes of this magnitude. If these effects income variation had not been taken into account, one would have concluded that a high average income over the 13 preceding years would be associated with low income. With control for variation, however, the effect of the average was not significant at usual levels. Such an adverse effect of income variation, given the average income, is consistent with ideas about i) a concave relationship between the income level (absolute or relative to for example the country average) in any given year and what one may refer to for simplicity as health or health behavior that year, ii) a reduced feeling of well-being due to income decline compared to what one expects or is used to and a corresponding, but not necessarily equally strong advantage due to relative improvement, and iii) reduced consumption (due to precautionary savings) and psychosocial stress resulting from uncertainty. Admittedly, inclusion of the average of the logarithm of the incomes rather than the logarithm of the average income did

not explain the effects of variation, but that is a crude test of the first-mentioned idea, which we hesitate to reject without stronger evidence.

In addition, the effects may reflect selection. First, income is of course very closely related to work activity. In particular, falling incomes may be a result of unemployment and increasing incomes may be a result of an increase in the working hours. Both may have adverse effects on mortality regardless of any effect of income. Second, there may be individual and community factors behind work activity and income that also affect mortality. One obvious example is that a person may have a chronic health condition that gives recurrent episodes of reduced work ability, and for this reason have higher mortality than those who earn the same average over the years. We have only controlled for age, period and education. (Marital status was included as an additional variable in some models, but this had no implications for the main results.)

Interestingly, mortality seems to be the same regardless of whether the income variation is dominated by falls (i.e. clear falls and no or less clear increases) or declines. This may suggest that the concavity argument, which does not to the same extent as the other arguments involve the sharpness of the ups and downs, is relatively important. Another possible interpretation is that any feeling of uncertainty that may lead to reduced consumption or psychosocial stress is also quite unrelated to the sharpness of the changes. One may also consider the findings as lending little support to the argument about income relative to the past few years, which predicts higher morality among those experiencing more sharp falls than sharp rises, than among those experiencing the opposite. Some recent studies have shown pro-cyclical mortality, though there is not agreement about whether it reflects that working-age adults themselves have another lifestyle when incomes are higher and they perhaps work more, or whether everyone is adversely influenced by the generally higher income levels and economic activity. It is not obvious what our study adds to this discussion, since we control for the average income. On the one hand, a period with income increase, given the average level, is found to increase mortality, possibly because of for example the mentioned uncertainty effects or the longer working hours. On the other hand, an increase will contribute positively to the average and current income level, and at least the latter may be an advantage from a health perspective.

While the quality of the income histories should be good, since they are based on tax registers rather than persons' recollections, and we can include those with periods abroad (when they may have earned much that of course is not registered by Norwegian authorities), the study admittedly has some weaknesses. One is that we may not (by setting a lower limit for income) have managed to fully exclude the retired, who have a much higher purchasing power than indicated by their labor income. Another is that we have not included taxes and public transfers, both of which are important for people's purchasing power. Also assets might be worth including, as well as the economic contribution from a spouse or partner.

We hope our findings and arguments can stimulate others to analyze the association between income variation and mortality, preferably with even better data that also allow the focus to be extended to the retired, among whom most deaths occur. If similar patterns also show up in other studies, the message from a public health perspective is that one should try to avoid much variation in incomes, or at least keep a special eye on those who are in this situation.

Table 1. Distribution of observations according to the number of income falls and rises 3-18 years earlier, among Norwegian men aged 50-89 in 1990-2002 (per ecnt).

Number of decreases of at least 15% compared to the average over the previous 5 years	Number of increases of at least 30% compared to the average over the previous 5 years		
	0	1	2 or more
0	45.1	10.8	2.4
1	11.1	9.9	5.0
2 or more	3	5.6	6.4

Table 2. Effects (with 95% CI) on odds of mortality among Norwian men aged 50-69 observed in 1990-2002

Age (years)	1.098*** (1.093-1.102)
Calendar year	0.969*** (0.964-0.974)
Educational level	
10 years	1
11-12 year	0.897*** (0.847-0.949)
13 years	0.855*** (0.803-0.910)
14-17 years	0.772*** (0.725-0.822)
18+ years	0.718*** (0.662-0.777)
Log (Income t-2, in 1000 NOK)	0.815*** (0.732-0.906)
Log (Average income t-15 to t-3, in 1000 NOK)	0.925 (0.833-1.026)

	Number of increases of at least 30% compared to the average over the previous 5 years		
Number of decreases of at least 15% compared to the average over the previous 5 years	0	1	2 or more
0	1	1.070* (0.997-1.148)	1.085 (0.934-1.260)
1	1.047 (0.984-1.114)	1.034 (0.963-1.110)	1.163*** (1.057-1.279)
2 or more	1.077 (0.968-1.197)	1.188*** (1.095-1.289)	1.188***(1.096-1.288)

* p< 0.10; ** p < 0.05; *** p < 0.01;

Table 3. Effects (with 95% CI) on odds of mortality among Norwian men aged 50-69 observed in 1990-2002

Log (Income t-2, in 1000 NOK)	0.873*** (0.789-0.966)
Log (Average income t-15 to t-3, in 1000 NOK)	0.876** (0.790-0.972)
Average of the absolute value of change in change in income	exp(0.000063***) SE=0.000027
	1.000063 (1.000010-1.000116)

Age, calendar year and education were also included in the model

* p< 0.10; ** p < 0.05; *** p < 0.01;

Table 4. Effects (with 95% CI) on odds of mortality among Norwian men aged 50-69 observed in 1990-2002

Log (Income t-2, in 1000 NOK)	0.856*** (0.779-0.942)
Average over t-15 to t-3 in log income, in 1000 NOK	0.859*** (0.792-0.933)

Number of decreases of at least 15% compared to the average over the previous 5 years	Number of increases of at least 30% compared to the average over the previous 5 years					
	0		1		2 or more	
0	1		1.069*	(0.9967-1.1478)	1.080	(0.930-1.254)
1	1.048	(0.984-1.114)	1.025	(0.954-1.101)	1.143***	(1.039-1.258)
2 or more	1.077	(0.969-1.198)	1.172***	(1.080-1.273)	1.149***	(1.057-1.249)

Age, calendar year and education were also included in the model

* p< 0.10; ** p < 0.05; *** p < 0.01;

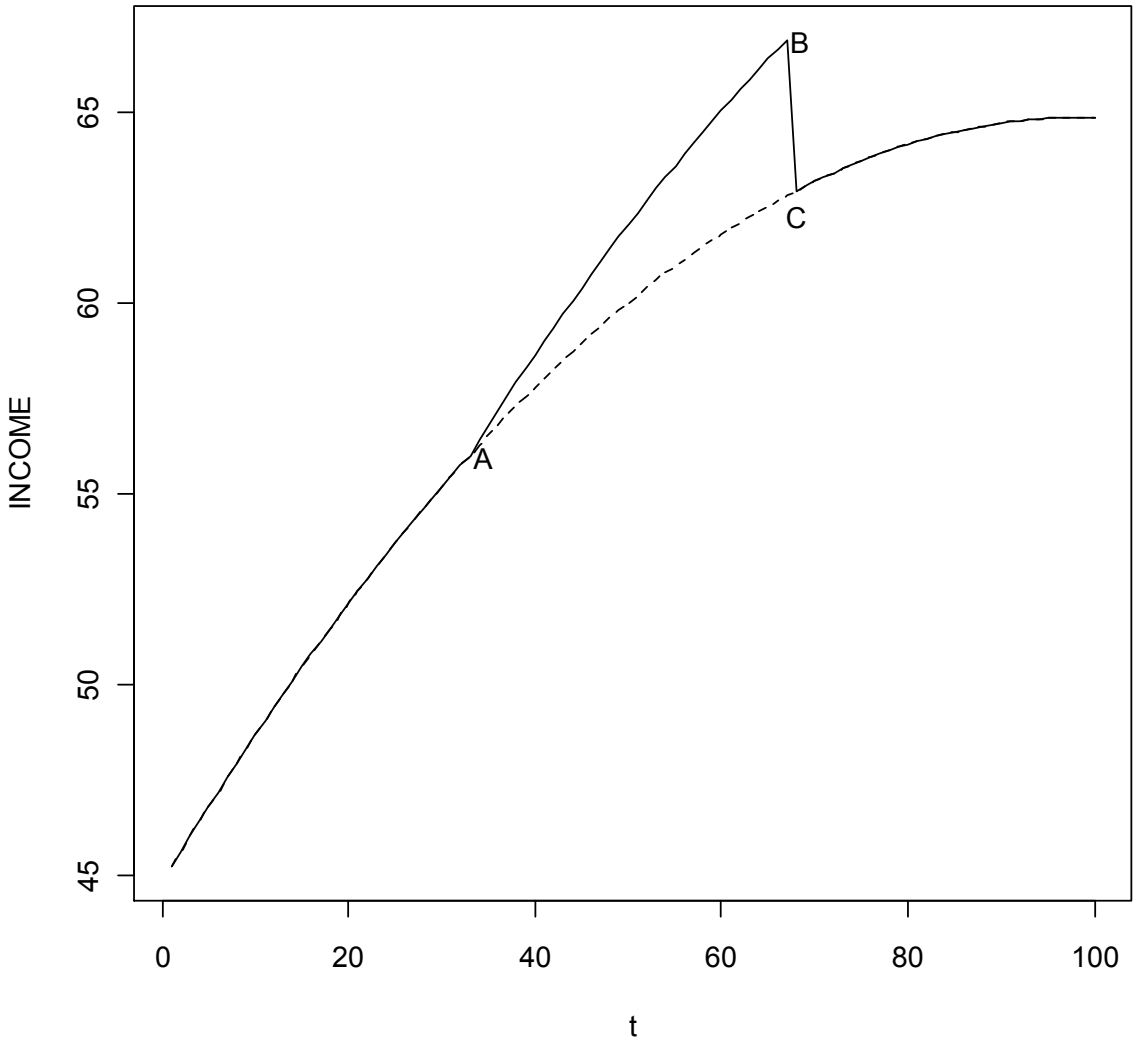

Figure 1: What is a income fall? Should we consider BC an income fall, or rather as the conclusion of an income peak ABC?

REFERENCES

Attanasio, O. (1999): “Consumption”, Chapter 11 in Handbook of Macroeconomics, Volume 1B, John B. Taylor and Michael Woodford, eds. North Holland.

Benzeval M and K. Judge (2001): “Income and health: the time dimension”, Social Science & Medicine, 52: 1371-1390.

Browning, M. and T.F. Crossley (2008): “The log-run cost of job loss as measured by consumption changes”, Journal of Econometrics 145, pages 109-120.

Burgard SA, JE Brand and JS House. 2009. Perceived job insecurity and worker health in the United States. Social Science & Medicine 69: 777-785.

Caballero, RJ (1990): „Consumption puzzles and precautionary savings“, Journal of Monetary Economics, 25:113-136

Cohen S, Janicki-Deverts D and GE Miller 2007. Psychological stress and disease. JAMA 298: 1685-1687.

Cohen F, ME Kemeny, LS Zegans, P Johnson, KA Kearney and DP Stites. 2007. Immune function declines with unemployment and recovers after stressor termination Psychosomatic Medicine 69: 225-34.

Cristia, JP (2009): „Rising mortality and life expectancy differentials by lifetime earnings in the United States“ Journal of Health Economics, 28: 984-995.

Duggan, JE. R. Gillingham, JS. Greenlees (2008): "Mortality and lifetime income: evidence from U.S. social security records“, IMF staff papers, 55(4), 566-594.

Duleep HO. (1986) „Measuring the effect if income on adult mortality using longitudinal administrative record data“, Journal of Human Resources, 21(2): 238-251.

Ecob R and GD Smith (1999) „Income and health: what ist he nature of the relationship?“, Social Science & Medicine, 48(5):693-705

Eliason M and D Storrie. 2009. Job loss is bad for your health – Swedish evidence on cause-specifi hospitalization following involuntary job loss. Social Science & Medicine 68: 1396-1406.

Elstad, J.I., Dahl, E., & Hofoss, D. (2006). Associations between relative income and mortality in Norway: a register-based study. *European Journal of Public Health*, 16, 640-644.

Ferrie JE, MJ Shipley, K Newman, SA Stansfeld, M Marmot (2005) "Self-reported job insecurity and health in Whitehal II study: potential explanations of the relationship", Social Scinece & Medicine, 60:1593-1602.

Fritzell J, M Nermo, and O Lundberg (2004): "The impact of income: assessing the relationship between income and health in Sweden", Scandinavian Journal of Public Health, 32:6-16

von Gaudecker, H.-M. and R.D. Scholz. 2007. Differential mortality by lifetime earniongs in germany. Demographic Research 17: 83-108.

Haider S and G Solon. 2006. Life-cycle variation in the assocuiation between current and lifetime earnings. American Economic Review 96: 1308-1320.

Hernæs, E. and Z. Jia (2007): "An evaluation of the labour market response of eliminating the retirement earnings test rule", Working Paper 1/2007, Ragnar Frisch Center for Economic Research

Hintikka J, SM Lehto, L Niskanen, A Huotari, KH Herzig, H Koivumaa-Honkanen, K Honkalampi, S Sinikallio and H Vikimäki 2009. Unemployemtn and ill health: a connection through inflammation. BMC Public Health 12; 9: 410.

Janicki-Deverts D, S. Cohen, KA Matthews and MR Cullen. 2008. History of unemployment predicts future elevantions in C-reactive protein among male participants in the coronary artery risk development in young adults (CARDIA) study. Annals of Behavioral Medicine 36: 176-185.

Jappelli T and L Pistaferri (2010): "The consumption response to income changes", Annual Review of Economics, 2:479-506

Lallukka T, E Lahelma, O Rahkonen, E Roos, A Laaksonen, P Martikainen, J Head, E Brunner, A Mosdol, M marmot, M Sekine, A Nasermoaddeli and S Kagamimori. 2008. Association of job strain and working overtime with adverse health behaviors and obesity:

evidence from the Whitehall II study, Helsinki Health Study, and the Japanese Civil Servants Study. Social Science & Medicine 66: 1681-1698.

Lázló KD, H Pikhart, MS Kopp, M Bobak, A Pajak, S Mayutina, G Salavecz, M Marmot (2010): "Job insecurity and health: A study of 16 European countries", Social Scinece & Medicine, 70:867-874

Mackenbach JP, P Martikainen, CW Looman, JA Dalstra, AE Kunst, E Lahelma, SEdHA working group (2005) "The shape of the relationship between income and self-assessed health: an international study", International Journal of Epidemiology, 34(2):286-293.

Marmot M. and RG Wilkinson. 2001. Psychosocial and material pathways in the relationship between income and health: a response to Lynch et al. Britsih medical Journal 322: 1233-1236.

Martikainen P, Valkonen T, Moustgaard H. (2009). The effects of individual taxable income, household taxable income, and household disposable income on mortality in Finland, 1998-2004. Population Studies 63: 147-162.

Massakowski KN. 2008. Is the duration of poverty and unemployment a risk factor for heavy drinking. Social Science & Medicine 67: 947-955.

*Massakowski KN. 2009. The influence of past unemployment duration on symptoms of depression among young women and men in the United States. American Journal of Public Health 99: 1826-32.

McKee-Ryan FM, Z Song, CR Wanberg, AJ Kinicki 2005. Psychological and physical well-being during unemployment: A meta-analytic study. Journal of Applied Psychology 90: 53-76.

McDonough, P., G.J. Duncan, D. Williams and J. House (1997): "Income dynamics and adult mortality in the United States, 1972 through 1989", American Journal of Public Health, 87(9): 1476-1483.

McDonough, P., and P. Berglund (2003): "Histories of poverty and self-rated health trajectories", Journal of Health and Social Behavior, 44:198-214.

McDonough, P., A. Sacker, and RD Wiggins (2005):; “Time on my side? Life course trajectories of poverty and health”, Social Science & Medicine, 61: 1795-1808.

Menchik, P.L. (1993). Economic status as a determinant of mortality among black and white older men: Does poverty kill? Population Studies 47: 427-436.

Miller DL, ME Page, AH Stevens, and M Filipski (2009); “Why are recessions good for your health?”, American Economic Review, Papers & Proceedings, 99(2):122-127.

Nylén L, M Voss and B Floderus. 2001. Mortality among women and men relative to unemployment, part time work, overtime work, and extra work: a study based on data from the Swedish twin registry. Occup Environ Med 58: 52-57.

OECD Outook 2006

van Ourti, T. (2003): “Socio-economic inequality in ill-health amongst the elderly. Should one use current or permanent income?”, Journal of Health Economics, 22:219-241.

Pham-Kanter G. 2009. Social comparison and health: Can having richer friends and neighbors make you sick? Social Science & Medicine 69: 335-344.

Rehkopf DH, LF Berkman, B Coull, and N Krieger (2008) “The non-linear risk of mortality by income level in a healthy population: US National Health and Nutrition Examination Survey mortality follow-up cohort, 1988-2001”, BMC Public Health, 10(8):383

*Sapolsky RM. 2005. The influence of social hierarchy on primate health. Science 308: 648-652.

Sloan RP, MH Huang, S Sidney, K Liu, OD Williams and T Seeman. 2005. Socioeconomic status and health: is parasympathetic nervous system activity an intervening mechanism. International Jourmnal of Epidemiology 34: 309-315.

Steptoe A, L Brydon, S Kunz-Ebrecht. 2005. Changes in financial strain over three years, ambulatory blood pressure, and cortsol responses to awakening. Psychosomatic Medicine 67: 281-287.

Strully KW (2009): Job loss and health in the U.S. labor market, Demography 46: 221-246

Subramanyam M., I. Kawachi, L. Berkman, and S.V. Subramanian. 2009. Relative deprivation in income and self-rated health in the United States. Social Science & Medicine 69: 327-334.

Theodossiou I. 1998. The effects of low-pay and unemployment on psychological well-being: a logistic regression approach. Journal of Health Economics 17: 85-104.

Voss M., L Nylén, B Floderus, F Dideriksen and PD Terry. 2004. Unemployment and early cause-specific mortality: A study based on the Swedish twin registry. American Journal of Public Health 94: 2155-2161.

(Wagstaff A and E van Doorslaer. 2000. Income inequality and health: What does the literature tell us? Annual Reviews of Public Health 21: 543-567.)

Wilkinson RG 1999. Health, hierarchy, and social anxiety. Annals of the New York Academy of Sciences NYAS