Absolute Income, Relative Income, Income Inequality and Mortality

Ulf-G. Gerdtham and Magnus Johannesson

Abstract

We test whether mortality is related to individual income, mean community income, and community income inequality, controlling for initial health status and personal characteristics. The analysis is based on a random sample from the adult Swedish population of over 40,000 individuals who were followed up for 10-17 years. We find that mortality decreases significantly as individual income increases. For mean community income and community income inequality we cannot, however, reject the null hypothesis of no effect on mortality. This result is stable with respect to a number of measurement and specification issues explored in an extensive sensitivity analysis.

Ulf-G Gerdtham, Department of Community Medicine, Lund University, Malmö University Hospital, SE-205 02 Malmö, Sweden. E-mail: ulf.gerdtham@smi.mas.lu.se. Magnus Johannesson, Department of Economics, Stockholm School of Economics, Box 6501, SE-113 83, E-mail: hemj@hhs.se. We thank Björn Lindgren, Katarina Steen Carlsson and an anonymous referee for helpful comments and suggestions. The data used in this article can be obtained beginning XX through XX from Ulf-G Gerdtham at the above address.

I. Introduction

Many studies have shown a positive association between income and survival (see, for instance, the overview of results in Viscusi (1994) and Lutter and Morrall (1994)). This is consistent with the view that an increase in income increases investments in health-enhancing goods, and that health is a normal good (Grossman 1972). However, it has also been argued that it is an individual's relative rather than absolute income that is important for health, with a low relative income being a health hazard (Marmot et al. 1991; Wilkinson 1997, 1998). A low relative income could, for instance, be associated with increased psychosocial stress leading to disease (Cohen, Tyrrell, and Smith 1991; Cohen et al. 1997). In conjunction with the relative-income hypothesis, it has furthermore been suggested that income inequality may be a health hazard in itself (Wilkinson 1996). From a policy perspective it is essential to be able to discriminate between these three hypotheses: the absolute-income hypothesis, the relative-income hypothesis and the income-inequality hypothesis. If it is relative rather than absolute income that affects health, a doubling of everyone's income would, for example, have no effect on health.

The income-inequality hypothesis has been supported by international comparison data showing a strong correlation between income inequality and mortality after controlling for the average income (Rodgers 1979; Flegg 1982; Waldmann 1992; Wilkinson 1996). However, as noted by for instance Smith (1999), it is very difficult to make empirical distinctions between the effects of income and income inequality using aggregate data. This is because a non-linear concave relationship between income and life-expectancy at the individual level will generate a negative relationship between income inequality and life-expectancy at the aggregate level (controlling for the average income). Hence such a relationship cannot per se be interpreted as evidence that income inequality is a health hazard.

To differentiate between the different income hypotheses, individual-level data should ideally be used (Wagstaff and Van Doorslaer 2000; Gravelle, Wildman, and Sutton 2000). Recently a number of studies using individual level data have also been published in the public health field, testing the income-inequality hypothesis on the state or county level in the US.[1] These studies can be divided into studies on self-assessed health status and studies on mortality. The studies on self-assessed health status have tended to find an adverse effect of income inequality on health status (Soobader and LeClere 1999; LeClere and Soobader 2000; Kennedy et al. 1998; Kahn et al. 2000). Two exceptions to this result are the studies by Shibuya, Hashimoto, and Yano (2002) and Sturm and Gresenz (2002) that find no significant effect after controlling for individual characteristics. The results for mortality are mixed. Fiscella and Franks (1997, 2000), Daly et al. (1998) and Osler et al. (2002) find no significant effect of income inequality on mortality, whereas Lochner et al. (2001) find a significantly hazardous effect of income inequality on mortality. The studies by Fiscella and Franks (1997, 2000) and Daly et al. (1998) are based on relatively small samples yielding limited statistical power. The study by Lochner et al. (2001) is based on a large sample size, but do not control for mean community income and potentially important covariates like education. The study by Osler et al. (2002) only investigates small areas of residence (parishes) within a single city (Copenhagen in Denmark).

The studies in the public health field have generated a lot of interest also among economists (Deaton 1999, 2001; Deaton and Paxson 1999; Meara 1999; Miller and Paxson 2000; Mellor and Milyo 2001, 2002). For the present study the contributions by Meara (1999) and Mellor and Milyo (2002) are particularly interesting since they use a similar methodology. Both studies use individual level data to test the effect of state level income inequality on health, infant health (low birth weight) in the Meara (1999) study and self-assessed health status in the Mellor and Milyo (2002) study. Neither of the studies finds a significant effect of income inequality on health status.

The present paper extends previous work on the effects of income and income inequality on health in several respects. In contrast to Meara (1999) and Mellor and Milyo (2002) we use mortality as the health measure. We are also the first study to explicitly discriminate between the absolute-income hypothesis, the relative-income hypothesis, and the income-inequality hypothesis in the same study.[2] Our study is based on high quality register data on both disposable income and mortality, whereas most previous studies are based on self-reported categorical income measures (see the overview by Deaton (2001)). We also use a large data set with over 40,000 individuals followed up for 10-17 years, and we control more comprehensibly for individual characteristics than in most previous studies (age, gender, education, unemployment, immigration, urbanization, marital status, the number of children, and initial health status). To find the optimal functional relationship between income and the mortality rate, we use a Box-Cox analysis. In an extensive sensitivity analysis we also explore a number of measurement and specification issues. Our main finding is that individual income has a protective effect on mortality consistent with the absolute-income hypothesis, whereas for the relative-income hypothesis and the income-inequality hypothesis we cannot reject the null hypothesis of no effect on mortality.

While we think our analysis and data offers many advantages compared to previous studies, there are also some important limitations. One limitation is that Sweden, given its reputation as an egalitarian country, may not be the best laboratory for studying the influence of income inequality on health. To be able to detect an effect of income inequality on mortality across geographical regions it is necessary to have sufficient variation in income inequality across regions. Both the level of income inequality and the variations may be important. The level of income inequality is clearly lower in Sweden than in the US (Bishop, Formby, and Smith 1991). The variation in income inequality across municipalities in our data (the Gini coefficient varies between 0.12 and 0.51), however, seem to be similar to that in the US studies, at least compared to the variation between states in the US (Fiscella and Franks 1997; Daly et al. 1998; Meara 1999; Soobader and LeClere 1999; LeClere and Soobader 2000; Kahn et al. 2000; Lochner et al. 2001; Mellor and Milyo 2002). A further potential problem with Sweden is that the measured income inequality in Sweden may overstate true income inequality given the public services available in Sweden (that are not included in measured income). It is, however, not obvious that the omission of public consumption introduces more bias in income inequality in Sweden than in the US. On the one hand the share of public consumption is higher in Sweden than in the US (OECD 1998). On the other hand public consumption may be more targeted towards low-income groups in the US. Nearly all health care in Sweden is for instance provided within the public health care system (even for high income groups), whereas in the US the public financing is targeted towards the poor (medicaid) and the elderly (medicare). Another limitation is that we have assumed that relative income and income inequality are important on the community level, and we may not have defined the appropriate "community". It may also be the relative income and income inequality for the country rather than the community that is important for health, and this cannot be tested with our data. Furthermore, the relevant reference group to define relative income may not be individuals who live in the same area; the relevant reference group could well be defined with respect to some other dimension like occupation or education (Deaton and Paxson 1999).

The paper is organized as follows. In the next section the data and methods used are outlined. A results section and an extensive sensitivity analysis follow this. The paper ends with some concluding remarks.

II. Data and methods

To test the absolute-income hypothesis, the relative-income hypothesis, and the income-inequality hypothesis we estimate the mortality risk as a function of individual income, mean community income and community income inequality. In these estimations we also control for initial health status (the health status at the start of follow-up) and a number of exogenous personal characteristics that may be related to the mortality risk.[3] Relative income can be defined as the income of an individual relative to the mean income of a reference group (Deaton 1999; Deaton and Paxson 1999). It is not obvious what constitutes the relevant reference group of individuals. The present paper is based on the presumption that the relevant reference group consists of individuals who live in the same area (Miller and Paxson 2000; Fiscella and Franks 1997; Daly et al. 1998). Even with this definition, the geographical area that encompasses a reference group remains to be specified. In US studies it has been common to use the state as the reference group (Daly et al. 1998; Meara 1999; Miller and Paxson 2000; Mellor and Milyo 2002). In the baseline analysis we use municipalities as the reference group. Sweden consisted of 284 municipalities during the time of this study (with populations from about 3,000 to about 700,000).

We use the same data set as employed by Gerdtham and Johannesson (2002) in their recent estimation of the income loss that will induce a fatality. The data set is based on Statistic Sweden's Survey of Living Conditions (the ULF survey) (Statistics Sweden 1997), which has been linked to all-cause mortality data from the National Causes of Death Statistics (which registers all deaths of individuals registered as living in Sweden) and to income data from the National Income Tax Statistics. Since 1975, Statistics Sweden conducts annual surveys of living conditions in the form of one-hour personal interviews with randomly selected adults aged 16-84 years. In this paper we use pooled data from the interviews conducted in 1980-1986 for all the subjects aged 20-84 years at the time of the interview. The total sample consists of 43,898 individuals. After correcting for missing values, the sample is reduced to 41,006 individuals. In Table 1 the variables in the regression analysis are supplied and summary statistics are given.

A. Dependent variable

The dependent variable in the regression analysis is the survival time in years and the survival status at the end of the follow-up period. The date of death was recorded for all subjects who had died by December 31, 1996. The survival time is estimated as the number of years from the interview date to the date of death. The censored survival time of persons alive at the end of 1996 is estimated as the number of years from the interview date to December 31, 1996.

B. Independent variables

1. Individual income

Our income measure consists of two components that are added together: annual disposable income and the annuity of net wealth. In our data set we have information about the disposable income of the household in the interview year. Disposable income consists of income from capital (interest rates, dividends, and capital gains), income from employment and business and all income transfers (for example pension payments, unemployment benefits, paid sick-leave, housing assistance) net of taxes. Disposable income is converted to 1996 prices using the consumer price index.[4] The disposable income of the household is divided by two for persons who are married or cohabiting, in order to obtain the disposable income per adult person in the household. From the National Income Tax Statistics we also have information about the taxable net wealth (total taxable assets minus total liabilities) of the household during the interview year, which is converted to the net wealth at market value (see

Gerdtham and Johannesson (2002) for the details of this estimation). The net wealth of the household is converted to 1996 prices using the consumer price index and is divided by two for persons who are married or cohabiting, in order to obtain the net wealth per adult person in the household. The annuity of net wealth is based on the life-expectancy for men and women of different ages in Sweden and a 3 percent interest rate (Statistics Sweden 1998).

2. Community income and income inequality

We estimate the mean income in each municipality from our data, and this variable is included to test the relative-income hypothesis. The mean annual income varies between about 93,000 and SEK 231,000 in the different municipalities. The relative-income hypothesis implies that mortality should increase with mean community income, holding individual income constant. The coefficient of community income should also be of the same size (but with the opposite sign) as individual income if mortality is solely determined by relative income (this implies that a doubling of everyone's income leaves mortality unchanged). In our baseline analysis we use the Gini coefficient as the measure of income inequality, but in a sensitivity analysis we also use a number of other measures of income inequality. The Gini coefficient is estimated for each municipality based on our data and varies between about 0.12 and about 0.51 in the different municipalities. The income-inequality hypothesis implies that mortality should increase with the Gini coefficient.

3. Initial health status

We include three different variables for initial health status from the ULF survey: self-assessed health status (poor health, fair health, good health), functional ability (no limitations in functional ability, some limitations in functional ability (unable to run a short distance but able to climb stairs without difficulty), severe limitations in functional ability (unable to run a short distance and unable to climb stairs without difficulty)), and high blood pressure (persons diagnosed with hypertension).

4. Additional independent variables

We include the following personal characteristics: age, gender, immigration, unemployment, education, marital status, and the number of children. To control for any differences in health risks and costs of living between more and less populated areas we include a variable for urbanization (the number of inhabitants per square kilometer in the municipality of the individual). Finally, we include six dummy variables for the year of inclusion into the study, to control for any differences between the populations included in different years.

C. Estimation methods

To estimate the effect of income and the other covariates on the mortality risk, we estimate a Cox proportional hazard model (Cox 1972).[5] Standard errors are estimated taking a possible intracluster correlation within Swedish municipalities into account.[6] All variables except age, urbanization, individual income, mean community income, and community income inequality are entered as dummy variables. Age is included without any transformation, which implies an exponential relationship between age and mortality risk.[7] As individual income can be expected to be most important at low income levels, a highly non-linear relationship between individual income and mortality is expected. We use the same functional form for individual income and community income, to be able to compare the size of the coefficients directly. To find the optimal functional relationship between income and the mortality rate, a Box-Cox analysis is carried out (Box and Cox 1964); that is we estimate the optimal Box-Cox transformation parameter θ as defined by the operator: $X(\theta)=(X^{\theta}-1)/\theta$ for $\theta\neq 0$ or $\ln X$ for $\theta=0$, where X is income. A one-dimensional grid search is carried out over the interval –1 to 1 for

θ at increments of 0.01 to determine the maximum likelihood point estimate for θ. The Gini coefficient and the urbanization variable are entered untransformed. All tests of statistical significance are carried out on the 5 percent level.

III. Results

A. Baseline results

The results of the estimated Cox model are shown in Table 2. Individual income is highly significant with a negative sign, implying that the mortality risk decreases with higher income. The log-likelihood function is maximized with a Box-Cox transformation parameter for income of 0.31 (θ=0.31). This functional form of income is significantly different from both untransformed income (critical χ^2=3.84; computed χ^2=14.94) and the logarithm of income (critical χ^2=3.84; computed χ^2=15.12).[8] The relationship between annual income and the one-year mortality risk is shown in Figure 1. As can be seen in the figure, the relationship is highly non-linear with a decreasing effect of income at higher income levels. The community income variable has a negative sign, contrary to the relative-income hypothesis. The variable is, however, far from significant. The community Gini coefficient also has a negative sign, and it is non-significant. We cannot therefore reject the null hypothesis that mortality is unaffected by relative income and income inequality at the municipality level.

B. Sensitivity analysis

The results of a number of sensitivity analyses are shown in Table 3. The income measure is varied in the sensitivity analysis. We first reestimate our results without including the annuity of net wealth in our income measure. This leads to similar results as for the baseline analysis. We also reestimate our results with household income and household income per adult equivalent instead of household income per adult person in the household.[9] In these estimations income is significant with the expected negative sign, whereas the mean community income and the Gini coefficient are not significant. We also reestimate our results excluding individuals below 25 years of age and 30 years of age respectively, because many younger individuals may be college students with a current income that is a poor prediction of life-time income. This has little effect on the results. In another analysis, we exclude all individuals below 65 years of age (the retirement age in Sweden). For the remaining persons the annual income may be expected to be very stable over time, since their main source of income consists of pension payments that are stable over time. This reduces the estimated income coefficient slightly from -0.0053 to -0.0042, but the coefficient is still highly significant. We also reestimate our results with two alternative functional forms of income and mean community income (the logarithm of income and untransformed income). This lead to qualitatively similar results as in the baseline analysis, although the significance of income decreases somewhat.

It has been argued that an increased income only decreases the mortality for individuals living in absolute or relative poverty (see Wagstaff and Van Doorslaer (2000) for an overview of this argument). To test this hypothesis, we reestimate our results excluding individuals at low-income levels (the 5 percent, 10 percent, 15 percent, and 20 percent poorest individuals are excluded in four analyses). The protective effect of individual income, however, remains after the poorest individuals have been excluded. We also test the sensitivity towards using other measures of income inequality than the Gini coefficient. We reestimate our results using the Robin Hood index (Kennedy, Kawachi, and Prothrow-Stith 1996), the income share of the 50 percent poorest individuals (Fiscella and Franks 1997), the variance of income, the variance of the logarithm of income (Deaton and Paxson 1999), and the coefficient of variation in income. Our results are, however, not sensitive towards the inequality measure used, and all inequality measures are far from being significant.

A problem with our data on municipality income and income inequality is the low number of observations for some municipalities in our data set. The sample size varies between nine and 3,193 individuals in the different municipalities (mean=585.63; St.Dev.=881.75). This leads to a measurement error problem, which will tend to bias the coefficients for mean municipality income and income inequality towards zero. The sensitivity analysis addresses this problem in several ways. In one sensitivity analysis we reestimate the results excluding municipalities with fewer than 25, 50, 75, and 100 observations.[10] The result for individual income is almost identical to that of the baseline analysis in these sensitivity analyses and the mean community income and the Gini coefficient are not significant in any of these analyses. We also use instrumental variables to try and correct for the potential measurement error problem. We use a split-sample instrumental variables technique, that is we split the sample randomly into two parts of equal size and use estimates of the mean municipality income and the Gini coefficient from half the sample to instrument for the same variables computed from the other half of the sample (Miller and Paxson 2000). These sensitivity analyses lead to similar results as the baseline analysis. Also our measure of individual income could be subject to attenuation bias. It is based on disposable income in a single year and may be an imperfect measure of permanent income. Consequently, we carry out an instrumental variable estimation using the occupational group of the individual and the number of rooms in the house/apartment of the individual as instruments. The instrumentation of income leads to a modest increase in the absolute size of the income coefficient, from about -0.0053 to about -0.0060. It also decreases the precision in the estimated coefficient, but it is still significant.

We also reestimate our results for two alternative geographical definitions of the community used to define relative income and income inequality. In one analysis we use the county as the community. Sweden was divided into 24 counties at the time of this study and this represent a much greater degree of aggregation than municipalities. In another analysis we use local labor markets as the community. Sweden has been divided into 100 local labor markets by Statistics Sweden, and this level of aggregation represents an intermediate level between municipalities and counties. The alternative levels of aggregation lead to nearly identical results for the individual income variable. For local labor markets the community income variable is still negative, but not significant. The coefficient for income inequality changes from a negative to a positive sign, but is still far from being significant. The mean community income at the county level is negative and significant. The negative sign is inconsistent with the relative-income hypothesis and suggests that the mean income of the county has a protective effect. The Gini coefficient at the county level has a positive sign, but it is not significant. In another sensitivity analysis we test including additional controls for geographical areas. In one analysis we include fixed effects for local labor markets and in one analysis we include fixed county effects. This leads to nearly identical results for individual income. As before the mean community income and the Gini coefficient are not significant, although the community income variable switches to a positive sign consistent with the relative-income hypothesis.

The sensitivity towards excluding different variables is also tested. Blood pressure may be related to lifestyle and is excluded. This has little effect on the results. In another analysis all variables for initial health status are excluded. This leads to a sizeable increase in the income coefficient to -0.0085 (t-value=-9.60), but has little effect on the mean community income or income inequality variables. Excluding education increases the income coefficient somewhat, but has little effect on the other variables. We also test if the income inequality variable is affected by excluding income and excluding both income and initial health status, but this has little effect on the income inequality variable.[11] We also test the stability of the results by excluding each subsample from the estimations. The results are relatively stable towards the exclusion of any of the subsamples from the analysis. Mellor and Milyo (2002) also test what they refer to as the weak income-inequality hypothesis, that income inequality may affect only the least well off in society. We test this in a similar way to Mellor and Milyo (2002), by interacting the Gini coefficient with five dummy variables for the five income quintiles. None of these interaction coefficients are significant. Finally we test for interaction effects between the three income measures and age and gender. The only significant interaction is between age and income, suggesting that the income coefficient decreases with age.[12] The coefficients and t-values for the mean community income and the community Gini coefficient are almost identical to the baseline model when the age and income interaction is included.

IV. Concluding remarks

We have tried to discriminate between the absolute-income hypothesis, the relative-income hypothesis, and the income-inequality hypothesis. According to our results mortality decreased significantly with individual income, controlling for mean community income and income inequality. The relationship between income and mortality was also as expected highly non-linear with a decreasing effect of income at higher income levels. The protective effect of individual income was stable towards a large range of sensitivity analyses.

We found no significant effect of community income inequality in our baseline analysis or in any of the sensitivity analyses. Generally speaking, we found no significant effect of mean community income on mortality either. The exception to this result arose when the community was defined on the county level rather than on the municipality level as in the baseline analysis. The mean county income was significant with a negative sign, implying that a higher county mean income has a protective effect controlling for individual income. This is, however, contrary to the relative-income hypothesis. The coefficient for mean municipality income in the baseline analysis had a negative sign, too, but was far from being significant. It is not implausible that a high average community income could have a protective effect on health. Community income could, for instance, be associated with a number of factors with potential health effects, such as the provision of public goods, environmental quality, and access to health care (Miller and Paxson 2000).

Even when individual income was omitted from the regression community income inequality was not significantly related to mortality. This is contrary to most individual level studies for the US, although also in the studies by Daly et al. (1998), Meara (1999) and Sturm and Gresenz (2002) community income inequality was not significant when individual income was omitted (as long as other personal characteristics and community income was controlled for). This indicate that the consumption inequality may be much lower and less variable in Sweden than in the US, and it is possible that this is the reason that we failed to find a significant association between income inequality and mortality in our analysis.

Overall our results are consistent with the absolute-income hypothesis, whereas we fail to confirm the relative-income hypothesis and the income-inequality hypothesis. Our results for mortality are consistent with the recent results of Meara (1999) and Mellor and Milyo (2002) for health status. However, further work is needed before the relative-income hypothesis and the income-inequality hypothesis can be firmly rejected.

References

Bishop, John, John Formby, and James Smith. 1991. “International Comparisons of Income Inequality: Tests for Lorenz Dominance across Nine Countries.” Economica 58(232):461-77.

Box, G. E. P., and D. R. Cox. 1964. “An Analysis of Transformations.” Journal of the Royal Statistical Society, Series B 26(2):211-43.

Chapman, Kenneth, and Govind Hariharan. 1994. “Controlling for Causality in the Link from Income to Mortality.” Journal of Risk and Uncertainty 8(1):85-93.

Cohen, Sheldon, David Tyrrell, and Andrew Smith, 1991. “Psychological Stress and Susceptibility to the Common Cold.” New England Journal of Medicine 325(9):606-12.

Cohen, Sheldon, Scott Line, Stephen Manuck, Bruce Rabin, Eugene Heise, and Jay Kaplan. 1997. “Chronic Social Stress, Social Status, and Susceptibility to Upper Respiratory Infections in Nonhuman Primates.” Psychosomatic Medicine 59(3):213-21.

Cox, D. R. 1972. “Regression Models and Life Tables.” Journal of the Royal Statistical Society, Series B 34(2):187-220.

Daly, Mary, Greg Duncan, George Kaplan, and John Lynch. 1998. “Macro-to-Micro Links in the Relation Between Income Inequality and Mortality.” Milbank Quarterly 76(3):315-39.

Deaton, Angus. 1999. “Inequalities in Income and Inequalities in Health.” NBER Working Paper No. 7141. Cambridge, Massachusetts: National Bureau of Economic Research.

__________. 2001. “Health, Inequality, and Economic Development.” Manuscript. Princeton, New Jersey: Princeton University.

Deaton, Angus, and Christina Paxson. 1999. “Mortality, Education, Income, and Inequality Among American Cohorts.” NBER Working Paper No. 7140. Cambridge, Massachusetts: National Bureau of Economic Research.

Fiscella, Kevin, and Peter Franks. 1997. “Poverty or Income Inequality as Predictor of Mortality: Longitudinal Cohort Study.” British Medical Journal 314(7096):1724-27.

__________. 2000. “Individual Income, Income Inequality, Health, and Mortality: What are the Relationships?” Health Services Research 35(1):307-318.

Flegg, A. T. 1982. “Inequality of Income, Illiteracy, and Medical Care as Determinants of Infant Mortality in Developing Countries.” Population Studies 36(3):441-58.

Gerdtham, Ulf-G, and Magnus Johannesson. 2002. “Do Life-Saving Regulations Save Lives?” Journal of Risk and Uncertainty 24(3):231-49.

Gravelle, Hugh, John Wildman, and Matthew Sutton. 2000. “Income, Income Inequality and Health: What Can We Learn from Aggregate Data?” Discussion Paper Series No. 2000/26, Department of Economics and Related Studies. York: University of York, Greene, William. 1997. Econometric Analysis, Third Edition. Upper Saddle River, New Jersey: Prentice-Hall.

Grossman, Michael. 1972. "On the Concept of Health Capital and the Demand for Health." Journal of Political Economy 80(2):223-55.

Kahn, Robert, Paul Wise, Bruce Kennedy, and Ichiro Kawachi. 2000. "State Income Inequality, Household Income, and Maternal Mental and Physical Health: Cross Sectional National Survey." British Medical Journal 321(7272):1311-15.

Kennedy, Bruce, Ichiro Kawachi, and Deborah Prothrow-Stith. 1996. "Income Distribution and Mortality: Cross Sectional Ecological Study of the Robin Hood Index in the United States." British Medical Journal 312(7037):1004-07.

Kennedy, Bruce, Ichiro Kawachi, Roberta Glass, and Deborah Prothrow-Stith. 1998. "Income Distribution, Socioeconomic Status, and Self Rated Health in the United States: Multilevel Analysis." British Medical Journal 317(7163):917-21.

LeClere, Felicia, and Mah-Jabeen Soobader. 2000. "The Effect of Income Inequality on the Health of Selected US Demographic groups." American Journal of Public Health 90(12):1892-97.

Lochner, Kim, Elsie Pamuk, Diane Makuc, Bruce Kennedy, and Ichiro Kawachi. 2001. “State-Level Income Inequality and Individual Mortality Risk: A Prospective, Multilevel Study.” American Journal of Public Health 91(3):385-91.

Lutter, Randall, and John Morrall. 1994. “Health-Health Analysis: A New Way to Evaluate Health and Safety Regulation.” Journal of Risk and Uncertainty 8(1):43-66.

Marmot, Michael, George Smith, Stephen Stansfield, Chandra Patel, Fiona North, Jenny Head, Ian White, Eric Brunner, and Amanda Feeny. 1991. “Health Inequalities Among British Civil Servants: The Whitehall II Study.” Lancet 337(8754):1387-93.

Meara, Ellen. 1999. “Inequality and Infant Health.” Manuscript. Boston, Massachusetts: Harvard Medical School.

Mellor, Jennifer, and Jeffrey Milyo. 2001. “Reexamining the Evidence of an Ecological Association between Income Inequality and Health.” Journal of Health Politics, Policy and Law 26(3):487-522.

__________. 2002. “Income Inequality and Health Status in the United States: Evidence from the Current Population Survey.” Journal of Human Resources. Forthcoming.

Miller, Douglas, and Christina Paxson. 2000. “Relative Income, Race, and Mortality.” Working Paper. Princeton, New Jersey: Princeton University.

OECD. 1998. OECD Health Data 1998. Paris: Credes.

Osler, Merete, Eva Prescott, Morten Gronbaek, Ulla Christensen, Pernilla Due, and Gerda Engholm. 2002. "Income Inequality, Individual Income, and Mortality in Danish Adults: Analysis of Pooled Data from Two Cohort Studies." British Medical Journal 324(7238):13-16.

Rodgers, G. B. 1979. "Income and Inequality as Determinants of Mortality: An International Cross-Section Analysis." Population Studies 33(2):343-51.

Shibuya, Kenji, Hideki Hashimoto, and Eiji Yano. 2002. "Individual Income, Income Distribution, and Self Rated Health in Japan: Cross Sectional Analysis of Nationally Representative Sample." British Medical Journal 324(7238):16-19.

Smith, James. 1999. "Healthy Bodies and Thick Wallets: The Dual Relation Between Health and Economic Status." Journal of Economic Perspectives 13(2):145-66.

Soobader, Maj-Jabeen, and Felicia LeClere. 1999. "Aggregation and the Measurement of Income Inequality: Effects on Morbidity." Social Science and Medicine 48(6):733-44.

Statistics Sweden. 1997. "Living Conditions and Inequality in Sweden: A 20 Year Perspective 1975-1995." Living Conditions, Report 91. Stockholm: Statistics Sweden.

Statistics Sweden. 1998. Statistical Yearbook of Sweden 1999. Stockholm: Statistics Sweden.

Sturm, Roland, and Carole Gresenz. 2002. “Relations of Income Inequality and Family Income to Chronic Medical Conditions and Mental Health Disorders: National Survey.” British Medical Journal 324(7328):20-23.

Viscusi, Kip. 1994. ”Risk-Risk Analysis.” Journal of Risk and Uncertainty 8(1):5-17.

Wagstaff, Adam, and Eddy Van Doorslaer. 2000. “Income Inequality and Health: What Does the Literature Tell Us?” Annual Review of Public Health 21:543-67.

Waldmann, Robert. 1992. “Income Distribution and Infant Mortality.” Quarterly Journal of Economics 107(4):1283-1302.

Wilkinson, Richard. 1996. Unhealthy Societies: The Afflictions of Inequality. London: Routledge.

__________. 1997. 'Health Inequalities: Relative or Absolute Material Standards?' British Medical Journal 314(7080):591-5.

__________. 1998. 'Low Relative Income Affects Mortality.' British Medical Journal 316(7144):1611.

Endnotes

1. Two exceptions to the use of US data are the studies by Shibuya, Hashimoto, and Yano (2002) and Osler et al. (2002).

2. Some previous studies include both individual income, mean community income and income inequality enabling a test of all three hypotheses (Fiscella and Franks 1997; Daly et al. 1998; Meara 1999; Mellor and Milyo 2002). They, however, focus on the income-inequality hypothesis and sometimes not even report the result for mean community income.

3. That we control for initial health status essentially imply that we study the effect of income on mortality by following up individuals that are initially in the same health status, but have different incomes (Chapman and Hariharan (1994)).

4. All figures are presented in 1996 Swedish Crowns (SEK). The exchange rate in 1996 was $1=SEK 6.71 and the purchasing power parity for 1996 was $1=SEK 9.83 (OECD 1998).

5. We also use a probit model as well as some common parametric duration models (the Weibull, exponential, log-normal, gamma and Gompertz models) (Greene 1997). These models lead to similar results as the Cox model and do not change the reported conclusions below.

6. Estimation was undertaken using the cluster option in STATA, with the municipalities serving as the clustering variable.

7. We also test including a dummy variable for each age in the data, but this does not significantly improve the model according to a likelihood ratio test (critical χ^2=82.49; computed χ^2=69.88).

8. We also test if the annual disposable income and the annuity of net wealth can be added together as one income measure, by testing if they differ significantly if entered as separate variables. The estimated coefficients for annual disposable income and the annuity of net wealth are: -0.0033 (t-value=-2.81) and -0.0029 (t-value=-5.98). According to a Wald test we cannot reject the null hypothesis of the same effect of annual disposable income and the annuity of net wealth (critical χ^2=3.84; computed χ^2=0.08).

9. Adult equivalents are defined as the number of adults in the household plus half the number of children below 18 years of age (Deaton and Paxson 1999).

10. The number of municipalities (observations) with fewer than 25, 50, 75 and 100 observations is 7 (225), 27 (2,322), 50 (6,790) and 68 (9,296).

11. We furthermore test if the income inequality variable is significantly related to any of the variables for initial health status (self-assessed health status, functional ability, and high blood pressure). Ordered probit and probit models are used in these tests with the same covariates as for the mortality equation (except the initial health status variables). Income is highly significant in the models for self-assessed health status and functional ability, but not in the model for high blood pressure. The mean community income and the income inequality variables are not significant in any of the models for initial health status.

12. In this model the income coefficient is -0.0188 (t-value=-4.344) and the coefficient for the age and income interaction is 0.00020 (t-value=3.180).

Table 1
Descriptive statistics of the variables used in the regression analysis. Number of observations = 41,006.

Variable	**Mean**	**Standard deviation**	**Min**	**Max**
Dependent variable:				
Survival time[a]	12.549	3.330	0.0027397	16.86895
Survival status (=1 if dead at the end of follow-up)	0.164	0.370	0	1
Independent variables, individual level:				
Annual disposable income[b]	106820	44497	1	2778470
Annuity of net wealth[b]	12856	38409	1	5327592
Annual income[b,c]	119676	64375	2	8106061
No limitations in functional ability[d]				
Some limitations in functional ability	0.086	0.281	0	1
Severe limitations in functional ability	0.092	0.290	0	1
Self assessed health status: poor health[d]				
Self assessed health status: fair health	0.190	0.392	0	1
Self assessed health status: good health	0.750	0.433	0	1
High blood pressure	0.081	0.272	0	1
Male	0.496	0.500	0	1
Age	46.657	17.116	20	84
No children in the household[d]				
1 child in the household	0.150	0.357	0	1
2 children in the household	0.159	0.366	0	1
≥3 children in the household	0.056	0.230	0	1
Non-immigrant[d]				
First generation immigrant[e]	0.080	0.271	0	1
Second generation immigrant[f]	0.007	0.086	0	1
Single (not married or cohabiting)	0.310	0.463	0	1
Pre-secondary education[d]				
Short secondary education (≤2 years)	0.309	0.462	0	1
Secondary education (>2 years)	0.096	0.295	0	1
University education	0.180	0.384	0	1
Unemployed	0.024	0.152	0	1
Included in the study 1980[d]				
Included in the study 1981	0.145	0.353	0	1
Included in the study 1982	0.162	0.368	0	1
Included in the study 1983	0.147	0.355	0	1
Included in the study 1984	0.160	0.366	0	1
Included in the study 1985	0.146	0.353	0	1
Included in the study 1986	0.105	0.307	0	1
Independent variables, aggregate level:[g]				
Mean income of the municipality	116655	12833.98	93084.1	230963.9
Gini coefficient of the municipality	0.183	0.032	0.117	0.511
Urbanization (inhabitants/km^2 in the municipality)	118.9225	378.4317	0	3537

a The number of life-years from inclusion in the study to the end of follow-up.

b Per adult person in the household in 1996 Swedish Crowns (SEK; exchange rate 1996 $1=SEK 6.71, purchasing power parity 1996 $1=SEK 9.83).

c Annual income=annual disposable income + annuity of net wealth

d Baseline category in the regression analysis.

e Persons born abroad whose parents are current or previous foreign citizens.

f Persons born in Sweden whose parents are current or previous foreign citizens.

g Descriptives calculated at municipality level.

Table 2
Results from the Cox model (t-values adjusted for clustering on municipalities). Number of observations = 41,006.

Covariate	**Coefficient**	**t-value**	**p-value**
Annual income[a]	-0.00526	-5.705	0.000
Mean income of the municipality	-0.0034875	-0.567	0.571
Gini coefficient of the municipality	-0.0483714	-0.085	0.932
Some limitations in functional ability	0.3469776	10.653	0.000
Severe limitations in functional ability	0.5095445	13.501	0.000
Self assessed health status: fair health	-0.4234859	-10.138	0.000
Self assessed health status: good health	-0.7106089	-16.511	0.000
High blood pressure	0.1455391	4.433	0.000
Male	0.7236752	28.858	0.000
Age	0.0863758	63.305	0.000
1 child in the household	-0.0973553	-1.520	0.128
2 children in the household	-0.3663134	-3.557	0.000
≥3 children in the household	-0.259431	-1.857	0.063
First generation immigrant	-0.079856	-1.325	0.185
Second generation immigrant	-0.0409613	-0.134	0.894
Single	0.3056043	12.374	0.000
Short secondary education (≤2 years)	0.0033199	0.092	0.927
Secondary education (>2 years)	-0.1201864	-2.335	0.020
University education	-0.064147	-1.172	0.241
Unemployed	0.1889092	1.670	0.095
Urbanization	0.0000271	2.583	0.010
Included in the study 1981	0.0598677	1.302	0.193
Included in the study 1982	0.0310944	0.714	0.475
Included in the study 1983	0.0166707	0.368	0.713
Included in the study 1984	-0.0189795	-0.414	0.679
Included in the study 1985	0.0128269	0.244	0.807
Included in the study 1986	-0.0248417	-0.469	0.639
-Log-Likelihood	-62208.452		
Iterations Completed	6		
Likelihood ratio $\chi 2$ (df) test of all coefficients=0	11626.64 (27)		

a The functional form of annual income is: (annual income$^{0.31}$-1)/0.31.

Table 3
Sensitivity analysis of the estimated coefficients of income, mean community income and community income inequality (t-values in parentheses adjusted for clustering on municipalities).

	Income	**Mean community income**	**Community income Inequality**
Baseline result	-0.00526	-0.0034875	-0.0483714
	(-5.705)	(-0.567)	(-0.085)
Alternative income measures:			
Annual household income per adult in the household (annuity of net wealth excluded)	-0.0043982	-0.003129	-0.0743207
	(-3.770)	(-0.612)	(-0.117)
Annual household income (annuity of net wealth included)	-0.0044667	-0.002399	-0.0211131
	(-5.374)	(-0.694)	(-0.040)
Annual household income (annuity of net wealth excluded)	-0.0032678	-0.0029827	-0.0518246
	(-3.088)	(-0.812)	(-0.077)
Annual household income per adult equivalent (annuity of net wealth included)	-0.0054154	0.0034549	-0.6283268
	(-5.829)	(0.535)	(-0.971)
Annual houshold income per adult equivalent (annuity of net wealth excluded)	-0.0046664	0.0020426	-0.6532173
	(-3.864)	(0.366)	(-1.000)
Excluding different ages:			
Age <25 years excluded	-0.005317	-0.0037042	0.0093508
	(-5.701)	(-0.688)	(0.015)
Age <30 years excluded	-0.0051683	-0.0033038	0.0045067
	(-5.505)	(-0.612)	(0.007)
Age <65 years excluded	-0.0041956	-0.003627	-0.3754456
	(-3.550)	(-0.541)	(-0.478)
Alternative functional form of income:			
Natural log of income	-0.086886	-0.23178	0.0033822
	(-4.499)	(-0.996)	(0.006)
Untransformed income	-1.11e-06	-1.34e-06	0.0448461
	(-3.424)	(-0.729)	(0.076)
Excluding the poorest individuals:			
5% poorest individuals excluded	-0.0043757	-0.0034076	0.0866697
	(-3.867)	(-0.637)	(0.169)
10% poorest individuals excluded	-0.0038701	-0.0054668	0.1302324
	(-2.878)	(-0.985)	(0.245)
15% poorest individuals excluded	-0.0028343	-0.0071051	0.2864644
	(-2.197)	(-1.186)	(0.498)
20% poorest individuals excluded	-0.003126	-0.0079587	0.7532521
	(-2.211)	(-1.261)	(1.165
Alternative income inequality measures:			
Robin Hood index	-0.0052556	-0.0037275	0.0001582
	(-5.717)	(-0.605)	(0.021)
Income share of the 50% poorest individuals	-0.0052435	-0.0043013	0.2894-068
	(-5.71)	(-0.72)	(-0.29)
Variance of income	-0.0052641	-0.0031045	-1.57e-13
	(-5.725)	(-0.517)	(-0.647)
Variance of the logarithm of income	-0.0052564	-0.0036523	-0.0019681

	(-5.72)	(-0.70)	(-0.03)
Coefficient of variation of income	-0.005266	-0.0029746	-4.31e-08
	(-5.725)	(-0.491)	(-0.720)
Excluding small municipalities:			
Municipalities with <25 observations excluded	-0.005241	-0.0028319	-0.1355153
	(-5.692)	(-0.528)	(-0.269)
Municipalities with <50 observations excluded	-0.0054727	-0.0054534	-0.1652021
	(-5.770)	(-0.960)	(-0.302)
Municipalities with <75 observations excluded	-0.0048806	-0.0094775	0.2153093
	(-4.980)	(-1.309)	(0.333)
Municipalities with <100 observations excluded	-0.0052863	-0.0080869	0.345395
	(-5.171)	(-1.006)	(0.352)
Instrumental variable estimation:			
Split sample IV method for community variables and	-0.0052793	-0.0042037	0.3221342
no instrumentation of individual income	(-5.724)	(-0.536)	(0.209)
Split sample IV method for community variables and	-0.0060935	-0.0085242	-0.2694503
instrumented individual income	(-2.108)	(-1.084)	(-0.173)
Instrumented individual income and no	-0.0059758	-0.003973	-1.30256
instrumentation of community variables	(-2.073)	(-0.904)	(-0.874)
Alternative community definitions:			
Counties instead of municipalities	-0.0050677	-0.0523183	3.078016
	(-5.332)	(-2.327)	(1.113)
Local labor markets instead of municipalities	-0.0052411	-0.010286	0.32479
	(-5.917)	(-1.221)	(0.289)
Geographical fixed effects			
Local labor markets	-0.0052413	0.0019028	-0.0837946
	(-5.66)	(0.22)	(-0.12)
Counties	-0.0052042	0.0105819	-0.3681249
	(-5.65)	(1.58)	(-0.65)
Excluding regressor variables			
Blood pressure excluded	-0.0052277	-0.0035334	-0.0498471
	(-5.72)	(-0.57)	(-0.09)
All initial health status variables excluded	-0.0084508	-0.0021933	-0.2401227
	(-9.60)	(-0.39)	(-0.39)
Education excluded	-0.0056178	-0.0039845	-0.0729435
	(-6.30)	(-0.65)	(-0.13)
Annual income excluded	-	-0.0079185	0.1039548
		(-1.30)	(0.18)
Annual income and health status variables excluded	-	-0.0092584	-0.0155515
		(-1.66)	(-0.03)
Excluding subsamples:			
1980 subsample excluded	-0.0056811	0.0009165	-0.5299988
	(-5.939)	(0.162)	(-0.964)
1981 subsample excluded	-0.0051142	-0.0009353	-0.0547607
	(-5.416)	(-0.168)	(-0.097)
1982 subsample excluded	-0.0049527	-0.0017518	-0.1801989
	(-4.801)	(-0.323)	(-0.317)
1983 subsample excluded	-0.0056851	-0.0053195	0.227986

	(-5.899)	(-0.894)	(0.415)
1984 subsample excluded	-0.0052763	-0.000994	-0.6854959
	(-5.078)	(-0.17)	(-1.116)
1985 subsample excluded	-0.0049209	-0.0045009	0.1403991
	(-4.74)	(-0.746)	(0.263)
1986 subsample excluded	-0.0054594	-0.0025556	-0.456
	(-5.587)	(-0.456)	(-0.108)

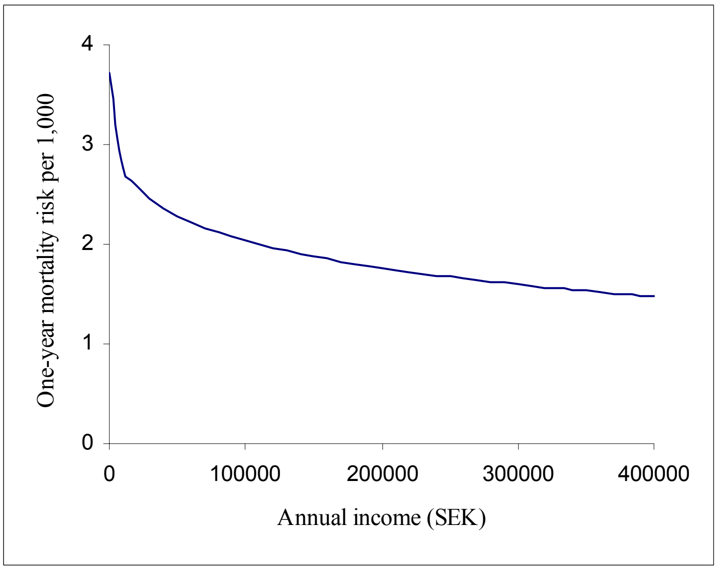

Figure 1
The relationship between annual income and mortality (at the mean of the covariates).