SSM - Population Health 2 (2016) 750–756

Contents lists available at ScienceDirect

SSM - Population Health

journal homepage: www.elsevier.com/locate/ssmph

Article

The shape of the association between income and mortality in old age: A longitudinal Swedish national register study

Johan Rehnberg*, Johan Fritzell

Aging Research Center, Karolinska Institutet and Stockholm University, Gävlegatan 16, SE-113 30 Stockholm, Sweden

ARTICLE INFO

Keywords:
Income
Health inequality
Mortality
Old age
Late-life
Non-linear
Diminishing returns
Sweden

ABSTRACT

This study used data on the total population to examine the longitudinal association between midlife income and mortality and late-life income and mortality in an aging Swedish cohort. We specifically examined the shape of the associations between income and mortality with focus on where in the income distribution that higher incomes began to provide diminishing returns. The study is based on a total Swedish population cohort between the ages of 50 and 60 years in 1990 (n=801,017) followed in registers for up to 19 years. We measured equivalent disposable household income in 1990 and 2005 and mortality between 2006 and 2009. Cox proportional hazard models with penalized splines (P-spline) enabled us to examine for non-linearity in the relationship between income and mortality. The results showed a clear non-linear association. The shape of the association between midlife (ages 50–60) income and mortality was curvilinear; returns diminished as income increased. The shape of the association between late-life (ages 65–75) income and mortality was also curvilinear; returns diminished as income increased. The association between late-life income and mortality remained after controlling for midlife income. In summary, the results indicated that a non-linear association between income and mortality is maintained into old age, in which higher incomes give diminishing returns.

1. Introduction

Income is one of the most stratifying dimensions of living conditions in Western societies. Despite welfare states' efforts to redistribute income and reduce inequality, relative differences in income and wealth persist and are even growing in most countries (Nolan et al., 2014; OECD, 2011). Both low income and income inequality are associated with a wide variety of negative outcomes for individuals and for society (Fritzell, Rehnberg, Hertzman, & Blomgren, 2014; Marmot, 2002; Pham-Kanter, 2009; Subramanian & Kawachi, 2004; Wilkinson & Pickett, 2011).

Some of the most detrimental consequences of low income are those linked to health. Income and wealth affect the health of individuals by enabling those who are well-off to lead healthy lifestyles and consume better and more health care, while at the other end of the spectrum, those at the bottom of the income distribution have fewer of these enabling resources (Marmot, 2002). Income inequality in itself has also been linked to people's health, often referred to as the relative deprivation hypotheses (Pham-Kanter, 2009; Pickett & Wilkinson, 2015). The mechanisms of this hypotheses is mainly the stress that people are exposed to from being in comparably lower social positions. More unequal societies should by this logic have higher inequality. Like income inequality, the association between income and health persists even in countries with extensive welfare state programs designed to mitigate the influence of income on health (Åberg Yngwe, Fritzell, Burström, & Lundberg, 2005; Kondo, Rostila, & Yngwe, 2014; Lundberg, Åberg Yngwe, Kölegård Stjärne, Björk, & Fritzell, 2008).

There is ample evidence of a positive relationship between income and health in the working-age population (Deaton, 2002; Subramanian & Kawachi, 2004). Less is known about the relationship between income and health in those beyond normal working age, although some findings indicate that the pattern may be similar (Fors, Modin, Koupil, & Vågerö, 2011; Huisman, Kunst, & Mackenbach, 2003). In the working-age population, the association between income and health follows a curvilinear gradient; effects on health tend to decrease as income increases (Deaton, 2002; Dowd et al., 2011; Mackenbach et al., 2005; Rodgers, 1979). Sweden, with its high long history of universalistic, relatively generous policies, and its strong focus on egalitarianism, is not an exception: researchers have also found a curvilinear association between income and health there (Fritzell, Nermo, & Lundberg, 2004; Lundberg et al., 2008). Empirical findings on the shape of the association between income and health can provide insight into the efficiency of redistributive policies; in particular, the point in the income distribution at which

* Corresponding author.
E-mail addresses: johan.rehnberg@ki.se (J. Rehnberg), johan.fritzell@ki.se (J. Fritzell).

http://dx.doi.org/10.1016/j.ssmph.2016.10.005
Received 27 May 2016; Received in revised form 22 September 2016; Accepted 12 October 2016

increased income begins to have diminishing returns.

A better understanding of the income-mortality association in old age after retirement is needed. This area is of particular relevance given that a larger share of the population is surviving into old age. Most deaths today also occur in old age; 90 percent of all deaths during the mortality follow-up period in this study (2005 through 2009) occurred in people aged 65 or older (Human Mortality Database, 2015). Following an older cohort thus allowed us to capture a segment of the population in which a large share of deaths occur and one that is the focus of relatively few studies.

In studies of income in different age groups, it is important to take income variability and the source of income into account (Böhlmark & Lindquist 2006; Palme & Svensson, 1999). Palme and Svensson (1999) have shown that the share of income from work in Sweden drops steadily after age 58; simultaneously, income from pensions starts to increase rapidly, and the share of income from capital grow slightly. Income levels stabilize during the middle to late stages of working life and then fluctuate again at the very end of working life (Baker & Solon, 2003; Björklund, 1993; Böhlmark & Lindquist, 2006). After retirement, income variability tends to be smaller. This is especially true at the very bottom of the income scale because of minimum pension schemes (European Commision, 2015; Smeeding, 2001). In Sweden, the pension system was reformed during the 1990s and now includes both private and state-organized pension savings (Barr, 2013; Palmer, 2000). The level of income from pensions in old age is dependent on income during earlier working life, and there is a means-tested guaranteed pension for those with low or no previous income. The varying dynamics of the income distribution – both the source of incomes and income variability over the life course – can affect the form of the observed association between income and health at different ages. Late-life income may be a better measure of income and wealth accumulated during life than midlife income. We would then expect a stronger association between income in late-life and mortality. On the other hand, if income after retirement is heavily redistributed due to minimum pension schemes that leads to lower overall income inequality we would expect a weaker association between late-life incomes and mortality compared to midlife incomes.

To increase knowledge about the association between income and mortality in midlife and old age we followed an aging cohort in this study and look at the mortality in people age 65 and above. The aim of this study was to examine the longitudinal association between midlife income and late-life mortality and late-life income and late-life mortality in an aging cohort in Sweden. The shape of the association was examined for non-linearity, and differences in the shape of the association between midlife income and mortality and late-life income and mortality were explored. We seek to answer the following research questions:

1. Do we find an association between late-life income and late-life mortality?
2. Is the association between late-life income and late-life mortality curvilinear with diminishing returns of income and similar to that of midlife income?
3. Does the association between late-life income and late-life mortality remain when we control for midlife income?

This study built on previous findings of curvilinearity in the association between working-life income and mortality and focused on the shape of the association between income and health in older ages, the time when health starts to deteriorate more rapidly at a population level and the vast majority of all deaths occur.

2. Data and method

2.1. Design and population

The data used in the study came from The Swedish Work and Mortality Database (HSIA). HSIA consists of multiple national registers that are linkable at the individual level. The data in HSIA cover all individuals living in Sweden. Information is available for each year from 1990 to through 2009. The sample in this study consisted of a cohort of people who were between the ages of 50 and 60 years in 1990. Income was measured in 1990 and again in 2005 when most of the people in the cohort had retired, and mortality was followed up during the four-year period between 2006 and 2009. Only data from those who lived in Sweden at baseline in 1990 and at the start of mortality follow-up in 2006 were used in the analyses. Data on those who emigrated or died before 2006 or immigrated after 1990 were not included. Sample characteristics of the excluded people are shown in Supplementary Table 1. The study included 801,017 people.

2.2. Variables

2.2.1. Income

Yearly equivalent disposable income was measured as an aggregate variable that consisted of all after-tax income, including income from work, transfer payments, and capital. To compare the income of different types of households, the measure was equivalized by dividing disposable household income by the square root of number of household members. Income in 1990 was adjusted to 2005 price levels using the consumer price index. In the regression analyses, everyone with an income above the 99th percentile was given the 99th percentile income value (top coded).

2.2.2. Mortality

All-cause mortality was measured during the four-year period between 2006 and 2009. In our study population a total of 49,110 deaths occurred during this period.

2.2.3. Control variables

Age at baseline and sex were included as control variables.

2.3. Methods

Cox proportional hazard models with penalized splines (P-spline) were used to analyze the data (Eilers & Marx, 1996). The smoothHR package in R was used to fit the models (Cadarso-Suárez, Meira-Machado, Kneib, & Gude, 2010). P-spline is a smoothing function that can be used in regression models to better fit and describe non-linear data. Splines are fitted by polynomial sections joined together at knots that creates continuous and flexible estimation of the predicted variable. We choose P-splines over other smoothing methods because of its compatibility with many standard regression methods, because it is penalized as to not overfit the data and because it has limited boundary effects (Cadarso-Suárez et al., 2010; Eilers & Marx, 1996).

The first step in fitting the models was to establish whether the associations were non-linear. This was done by specifying income as linear or non-linear; non-linear terms were estimated by using a P-spline function. The Bayesian information criterion (BIC) was used to estimate the optimal amount of degrees of freedom (df) for the spline function. BIC was chosen over the Akaike information criterion (AIC) as the Bayesian criterion has less tendency to overfit the data when n is large (Dziak, Coffman, Lanza, & Li, 2012; Schwarz, 1978). Standard regression tables are presented. They show the results of regression analyses of income both as a linear and a non-linear variable. The tables are complemented by figures that show P-spline smoothed log hazard curves with 95 percent confidence intervals (CIs) to illustrate the shape of non-linear associations. All figures are presented with the