United Nations
Department of Economic and Social Affairs

Population Division

Technical Paper
No. 2013/7

The Association between Two Measures of Inequality in Human Development: Income and Life Expectancy

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Sara Hertog

United Nations • New York, 2013

NOTE

PREFACE

The Population Division of the Department of Economic and Social Affairs (DESA) of the United Nations Secretariat is responsible for providing the international community with up-to-date and scientifically objective information on population and development. The Population Division provides guidance on population and development issues to the United Nations General Assembly, the Economic and Social Council and the Commission on Population and Development and undertakes regular studies on population estimates and projections, fertility, mortality, migration, reproductive health, population policies and population and development interrelationships.

The purpose of the *Technical Paper* series is to publish substantive and methodological research on population issues carried out by experts within and outside the United Nations system. The series promotes scientific understanding of population issues among Governments, national and international organizations, research institutions and individuals engaged in social and economic planning.

This paper describes the concept of lifespan inequality as it relates to the life table and presents a new analysis of the association between the Gini index of income inequality and two measures of lifespan inequality based on data from 28 countries from 1974 to 2010. Results indicate that a positive association exists across countries between the Gini index of income inequality and the Gini and Atkinson indices of lifespan inequality only after controlling for the level of life expectancy at birth. OLS regression indicates that the Gini index of income inequality explains around 1.5 per cent to 3.0 per cent of the total variation in lifespan inequality across all countries and time periods, but that increases to 73 per cent to 89 per cent after life expectancy at birth is added to the model. Fixed-effects analysis further suggests a positive association between income inequality and lifespan inequality within countries after controlling for the level of life expectancy, although the extent of within-country variation in lifespan inequality over the period studied is small and the estimated association is not statistically significant. Results are similar when the analysis is restricted to consider income and lifespan inequalities only among those aged 65 and over. The observed positive associations between income inequality and lifespan inequality are consistent with expectations given the known association between income and health, but imply that in order for comparisons of lifespan inequality across countries—such as in the Inequality-Adjusted Human Development Index—to be meaningful, the tendency for lifespan inequality to decrease with increasing life expectancy must be taken into account.

The *Technical Paper* series as well as other population information may be accessed on the Population Division's website at www.unpopulation.org. For further information concerning this publication, please contact the office of the Director, Population Division, Department of Economic and Social Affairs, United Nations, New York, 10017, USA, telephone (212) 963-3179; fax (212) 963-2147; email: population@un.org.

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THE ASSOCIATION BETWEEN TWO MEASURES OF INEQUALITY IN HUMAN DEVELOPMENT: INCOME AND LIFE EXPECTANCY

Sara Hertog[*]

A. INTRODUCTION

The notion of inequality is widely recognized as an important dimension in the assessment of human well-being. It describes a facet of progress in human development that is conceptually independent of the traditional population average measures, such as per-capita income or life expectancy at birth. Historically, discussions of inequality have centred on imbalances in the distribution of material resources, such as earnings or income, but there is growing recognition of the need to identify and measure inequality in other dimensions of well-being too. Recent work has cast attention on the notion of lifespan inequality, which describes variation in the length of life in a population as a proxy for health inequity. Inequality has been a priority theme in discussions of the post-2015 United Nations development agenda (e.g., UN System Task Team on the Post-2015 UN Development Agenda, 2012) and the United Nations Development Programme (UNDP) now incorporates lifespan inequality, along with income inequality and education inequality, into its Inequality-Adjusted Human Development Index (IHDI) (UNDP, 2011; UNDP, 2013).

Of the three dimensions of inequality in human well-being represented in the IHDI, lifespan inequality is arguably the least intuitive. Income and education inequalities reflect unevenness in the distribution of two goods, namely money and human capital, in a population. In contrast, lifespan inequality summarizes unevenness in the distribution not of a good, but rather of ages at death. If one considers those who die young to be the least healthy members of a population and those who die at advanced ages to be the healthiest, then lifespan inequality can be understood as a proxy measure of the distribution of health. However, some have argued that certain features of the lifespan inequality concept make it an imperfect proxy for the broader concept of health inequality. One concern is that measures of lifespan inequality do not distinguish between healthy and unhealthy years of life (Gakidou, Murray and Frenk, 1999). Furthermore, the upper potential of life expectancy is believed to be restricted by biology, unlike other measures of human well-being, and the strength of association between health and the average length of life may differ across heterogeneous population subgroups more so than for other dimensions of inequality (Ho and Slavov, 2012). Despite those concerns, lifespan inequality has become a widely used proxy for health inequality, particularly in studies that aim to estimate within-group inequality in human well-being (Shkolnikov et al., 2003; Edwards, 2013; Ho and Slavov, 2012).

One clue as to the validity of lifespan inequality as a proxy for health inequality may lie in the association between lifespan inequality and income inequality. A strong and positive association between income and health has been well documented in various settings around the globe (Beckfield and Olafsdottir, 2010). A logical corollary to that association is that a strong and positive association between income inequality and health inequality should be detectable as well. However, previous ecological studies failed to identify any such correlation between measures of inequality in longevity and inequality in income (Hicks, 1997; UNDP, 2011), and thus have not leant support to the use of lifespan inequality as an adequate stand-in for health inequality.

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This paper aims to further explore the relationship between income inequality and lifespan inequality, overcoming some of the key limitations of earlier studies. It begins with a description of the concepts of income and lifespan inequalities and follows with a brief review of the evidence linking income to health and mortality and income inequality to health inequality to understand why we should expect income inequality and lifespan inequality to be correlated. Estimates of income inequality obtained from the Organization for Economic Cooperation and Development (OECD) that are consistent and comparable across countries and over time are united with estimates of lifespan inequality calculated from life tables obtained from the Human Mortality Database (HMD). The two dimensions of inequality are estimated both across all ages and, separately, for ages 65 and above in order to evaluate whether the association between income inequality and lifespan inequality differs for retirees in the advanced stages of life. By restricting the analysis to 28 countries for which high-quality information on lifespan inequality and income inequality is available over time, the analysis sheds light on both between-country and within-country associations between the two dimensions of human well-being. Results indicate that among this subset of mostly high-income countries, a strong association between lifespan and income inequalities exists between countries, but that association is observed only after controlling for the level life expectancy. The magnitudes of the associations are similar when the inequality measures are restricted to those aged 65 and over. Analysis of the correlates of within-country variation in lifespan inequality is hampered by the small degree of variation observed across the years for which data are available (1974-2010) and failed to detect a statistically significant association between income inequality and lifespan inequality. The discussion offers some implications for cross-country comparisons in lifespan inequality, such as those performed in the construction of the IHDI, as well as some key areas for future work.

B. DIMENSIONS OF INEQUALITY IN HUMAN WELL-BEING

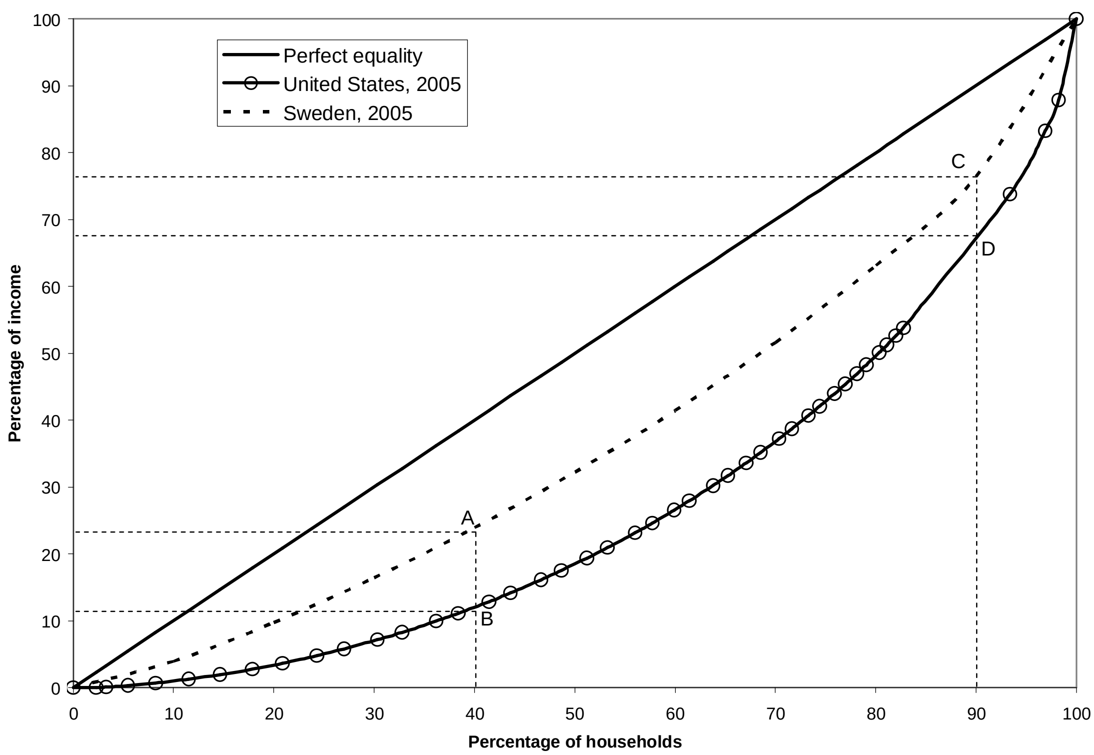
While the concept of income inequality has a long history in the human development literature, the notion of lifespan inequality is both relatively novel and considerably more difficult to conceptualize. Income inequality refers to unevenness in the distribution of all the income earned in a country, in a given year, across persons or households within that country. Inequality in lifespan is more complex. It summarises the variation in the ages at death among a hypothetical cohort of individuals according to the age-specific mortality rates observed in a country during a given period, such as a year. According to this concept, a cohort in which every member dies at the same age — whether age 25 or age 85 — would be perfectly equal, while one in which nearly everyone dies at birth except for one person who lives to be 60 would be perfectly unequal, for example.

Demographers refer to the degree of variation in the ages at death in the life table as “dispersion” and have explored a variety of approaches to measure it (e.g., Wilmoth and Horiuchi, 1999; Shkolnikov et al. 2003; Edwards, 2011). This work has established the concept of life table dispersion as providing information about the pattern and trend of mortality that is distinct from the average expectation of life. While demographers have noted the tendency for the degree of dispersion to decline with increasing life expectancy (Wilmoth and Horiuchi, 1999), the pattern is not universal. Certain epidemiological and social patterns have been observed to produce stagnation or increases in life table dispersion even when life expectancy continues to increase. Such aberrations to the typical pattern were observed, for example, in male mortality in the United States and Spain during the peak years of the HIV/AIDS epidemic (Shkolnikov et al. 2003).

The complexity of lifespan inequality as a concept arises in part from its application to a hypothetical cohort rather than a true cohort of individuals that are born in the same year and are exposed to the same period-specific mortality risk environments throughout their lives. The cohort described in the life table is hypothetical in that it is constructed based on the observed mortality risks among the current population, which is composed of persons of multiple birth cohorts who live their lives under changing mortality conditions. The distribution of ages at death in the life table thus does not reflect variation in the actual lengths of life to be lived by people in the current population, but rather it shows the variation in the *expected* lengths of life that would occur if a cohort were to live their entire lives subjected to the age-specific mortality risks of the given period.

Lifespan inequality can be understood through the construction of a Lorenz curve and associated Gini index, similar to those commonly utilized to describe income inequality. The Lorenz curve for income inequality is constructed by plotting the cumulative percentage of income against the cumulative percentage of households, as shown in figure 1 for Sweden and the United States in 2005. Point A on Sweden's Lorenz curve indicates that the poorest 40 per cent of Sweden's households in 2005 accounted for around 24 per cent of the total income. In the United States, where income is less equally distributed compared to Sweden, the poorest 40 per cent of households accounted for around 11 per cent of total income (point B of figure 1). The upper end of the Lorenz curve reveals the degree of concentration of income among the richest households. Point C indicates that Sweden's wealthiest 10 per cent of households accounted for nearly 25 per cent of total income, while in the United States 32 per cent of income was concentrated among the richest 10 per cent of households (point D of figure 1).

Figure 1. Lorenz curve of income inequality, United States and Sweden, 2005

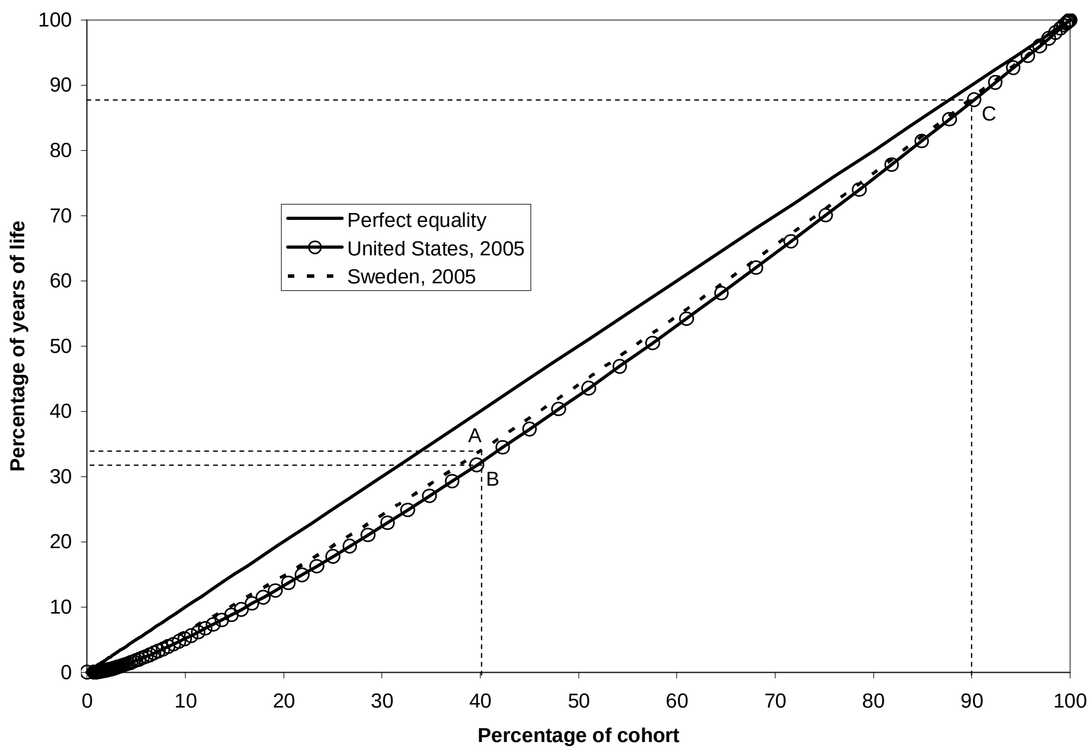


Data sources: Income distribution in the United States is from U.S. Census Bureau, Current Population Survey, 2006 Annual Social and Economic Supplement. Income distribution in Sweden is from Statistics Sweden, http://www.scb.se/Pages/TableAndChart_308959.aspx

The Gini index (also called the Gini coefficient) describes the amount of space between the Lorenz curve and the "perfect equality" line multiplied by two. For Sweden, the Gini index of income inequality in 2005 was estimated at 0.30, while in the United States incomes were distributed less equally and the Gini index was greater at 0.47.

In describing lifespan inequality via the Lorenz curve the axes are modified such that the x-axis reflects the cumulative percentage of individuals in the hypothetical cohort, while the y-axis reflects the cumulative percentage of total life years lived by that hypothetical cohort (figure 2). The total life years for the cohort are equal to the sum of the expected lifespan of each member of the cohort. The share of total life years lived by the shortest-lived members of the cohort (those who died the youngest) is shown at the bottom of the curve, while the share lived by the longest-lived members is shown at the top of the curve. According to period life tables corresponding to the year 2005, in Sweden, the shortest-lived 40 per cent of the hypothetical cohort claimed around 35 per cent of all years of life (point A, figure 2). The lifespan distribution in the United States was somewhat less equal, with the shortest-lived 40 per cent accounting for 32 per cent of all life years (point B, figure 2). At the upper end of the distribution, the two countries were nearly identical. In both Sweden and the United States, based on age-specific mortality risks observed in 2005, the longest-lived 10 per cent of the hypothetical cohorts claimed 12 per cent of the total number of life years (point C, Figure 2).

Figure 2. Lorenz curve of lifespan inequality, United States and Sweden, 2005



Data sources: Author's calculations based on life tables from the Human Mortality Database

A comparison of figures 1 and 2 indicates that the degree of lifespan inequality in both Sweden and the United States is considerably less than the degree of income inequality. This observation is supported by the Gini indices of lifespan inequality for the two countries, again representing the area between the Lorenz curve of each country and the perfect equality line. In 2005, the lifespan Gini for Sweden was 0.09 and that for the United States was 0.11.

Given the complexity of the lifespan inequality concept, the relationship between lifespan inequality and health inequity is not immediately intuitive. Health inequity refers to disparities in access to good health across members of a population. Attempts to measure health inequity have relied largely on efforts to disaggregate common health and mortality indicators by population subgroups, defined by geographic region, race or socioeconomic status, for example (Cristia, 2009; Ho and Slavov, 2012; Kovacevic 2010; Singh and Siahpush, 2006). However, the data requirements for such estimation are onerous and most countries do not have the necessary data available to provide such disaggregation of life expectancy that reflect mortality risks across the full range of ages[1] (i.e., including for both children and adults). Less stringent data requirements have contributed to lifespan inequality's common use as a proxy indicator of health inequity, despite its conceptual complexity.

C. WHY SHOULD WE EXPECT INCOME INEQUALITY AND LIFESPAN INEQUALITY TO BE CORRELATED?

Evidence of a strong and virtually universal income gradient in health and mortality suggests that income inequality and lifespan inequality should be positively correlated. In essentially every population where they have been studied, measures of health and survival are observed to increase monotonically with increasing household income. In the United States, for example, men in 1980 with family incomes in the top 5 per cent of the distribution would live about 25 percent longer than those in the poorest 5 per cent, and proportional gains in income were associated with equivalent proportional gains in survival throughout the distribution (Deaton, 2002). An analysis of 38 countries participating in the World Values Survey (WVS) detected an income gradient in self-reported health in every country, although the degree of the gradient was observed to vary across countries (Beckfield and Olafsdottir, 2010). Furthermore, there is evidence of a strong and positive association between income inequality and inequality in the distribution of heights within a population, which is an alternative proxy for health inequality (Moradi and Baten, 2005). These powerful associations would seem to support the hypothesis that income inequality and lifespan inequality would be associated.

In an early proposal to incorporate lifespan inequality into a composite index of human development, Hicks (1997) constructed Gini indices of income, lifespan and educational attainment for 20 developing countries corresponding to a single point in time and examined their associations through simple correlation. He detected no association between the income Gini and the lifespan Gini. Nor was the income Gini associated with the education Gini. Hicks was unconcerned by the lack of association between income and lifespan inequalities. He explained that "levels of inequality in some spaces are not necessarily related to inequalities in other spaces" (p.1291). The analysis of the 38 WVS counties found inconsistent evidence of an association across countries between income inequality and inequality in self-assessed health. The magnitude of the health advantage to high-income respondents was somewhat greater in countries with higher levels of income inequality, but there was no association observed between income inequality and the degree of health disadvantage to low-income respondents (Beckfield and Olafsdottir, 2010).

In contrast to these earlier studies that took a cross-sectional approach to assessing the association between income inequality and inequality in health and survival, UNDP recently analysed the trends over time in the three dimensions of inequality that contribute to the IHDI in

[1] A notable exception is a paper by Gakidou and King (2002), which presented a new approach to measuring total health inequality with an application to children under age 2 years.

its 2011 *Human Development Report*. They reported a tendency for income inequality to increase at the same time that lifespan inequality and education inequality were decreasing — that is, a negative correlation. A possible explanation as to why income and education inequalities may not be correlated is offered: "The returns to basic education fall as more people gain access. Completion of primary school brought smaller income gains than before, while the relative value of education to those at the top of the distribution increased" (UNDP, 2011, p. 30). However, no explanation is offered as to why income inequality and lifespan inequality might be moving in opposite directions.

Incomplete data make it difficult to investigate the association between income inequality and lifespan inequality. The life tables from which measures of lifespan inequality are derived often reflect mortality models and assumptions about the age pattern of mortality risks, rather than direct observation of the age-specific mortality rates in a population. In the case of Hicks' analysis of 20 developing countries, the life tables came from the United Nations *Demographic Yearbook 1992*, reflecting unadjusted country reports of mortality risks based on registration systems or surveys with varying degrees of completeness and quality. Most previous analyses of the association between income inequality and inequalities in health in survival have relied on cross-sectional study data that reference a single point in time and thus could assess only between-country associations. An exception is the background analysis for the UNDP *2011 Human Development Report*, which included measures of income inequality and lifespan inequality referenced to multiple points in time, thereby enabling assessment of the within-country association between the two dimensions of inequality. However, this assessment also relied on imperfect information on lifespan inequality. The life tables came from *World Population Prospects: The 2008 Revision*, published by the United Nations Population Division. While many of the life tables contained in this set are based on reliable vital registration data and accurately reflect age patterns of mortality, for many countries, particularly less developed countries, such systems are not yet in place and the life tables reflect a model age pattern of mortality combined with an empirical estimate of child mortality or other combination of estimates. As a result, there is a great deal of uncertainty associated with the measures of lifespan inequality utilized in the IHDI.

D. DATA

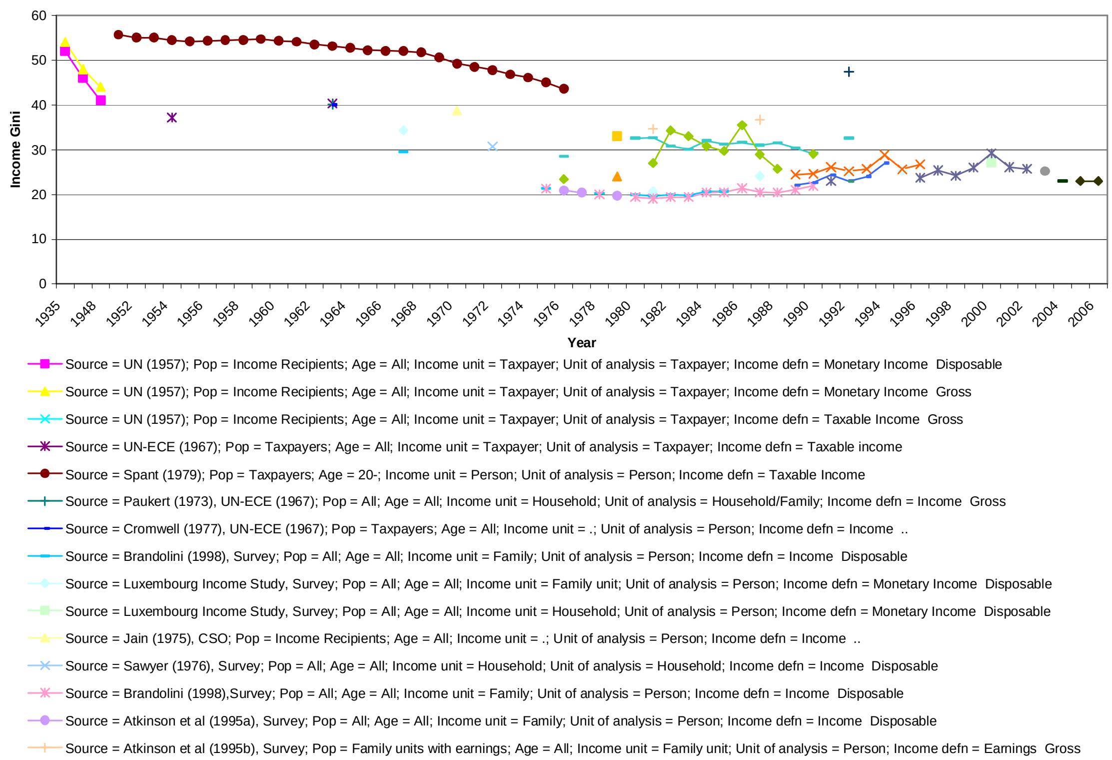
In order to assess the association between income inequality and lifespan inequality both between and within countries over time, it is necessary to obtain a panel of the two indicators that is as complete and consistent as possible. There are multiple sources of information on income inequality and multiple approaches to estimate the Gini coefficient. Some sources utilize tax data, which excludes persons or households that have not filed tax returns. Others utilize surveys or censuses, which can be more representative of the total population, but rely on self-reports of income and expenditure. Alternative definitions of income (e.g., gross, disposable, market) can produce differing Gini estimates as can alternative specifications of the unit of analysis (e.g., person, household, family unit).

Figure 3 displays available Gini estimates from the 1930s through 2006, for Sweden, obtained from various sources and utilizing alternative units of analyses and definitions of income. The estimates are extracted from the World Income Inequality Database v2.0[2] managed by the World Institute for Development Economics Research (WIDER) of the United Nations University. Based on this figure, it is evident that Gini estimates for a given point in time can vary widely according to different sources and specifications. For example, for the year 1976, Gini

[2] http://www.wider.unu.edu/research/Database/en_GB/database/, accessed 30 November 2012

estimates of income inequality range from a low of 0.20 when family disposable income is self-reported on a survey including all ages to a high of 0.44 based on records of individual taxpayers aged 20 and older.

Figure 3. Estimates of income Gini for Sweden, 1935-2006



Data source: UNU-WIDER World Income Inequality Database (WIID) v.2.0

In order to obtain a panel of income Gini estimates that are comparable both across countries and within each country over time, data accumulated and synthesized by the OECD have been accessed for this analysis[3]. The selected series contains estimates of the income Gini calculated across persons based on household income after taxes and transfers (disposable income). Data are available for 34 mostly high-income countries and refer to years between 1974 and 2010. Not all countries have Gini estimates available for all years. In addition to the income Gini that reflects income inequality across persons of all ages, the OECD database contains separate Gini estimates calculated for the working age population (ages 18 to 64 years) and for the population of older adults (ages 65 years and over). For the analysis presented below, the income Gini for those aged 65 and over is retained to assess the association between income inequality in this group and lifespan inequality at older ages. In addition, the annual per capita gross national income (GNI) for each country was extracted from the OECD database to represent the overall level of development with respect to income.

For 30 of the 34 countries included in the OECD database of income inequality, complete life tables are available through the Human Mortality Database (HMD)[4] maintained at the

[3] http://stats.oecd.org/Index.aspx?DatasetCode=INEQUALITY, accessed 3 December 2013
[4] http://www.mortality.org/, accessed 3 December 2013

University of California at Berkeley. For each of these 30 countries, complete life tables for both sexes combined and corresponding to the mid-points of the seven periods defined in the OECD income inequality data are utilized. The HMD life tables are constructed based on data from the highest-quality vital registration systems in the world and thus are able to reflect the life expectancy and lifespan inequality without relying on models or assumptions, except for adjustments at very old ages in some cases. Analyses are restricted to the 28 countries for which the OECD income Gini and HMD life tables are available for at least two corresponding years between 1974 and 2010. These countries include: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Iceland, Ireland, Israel, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom, and United States of America.

E. METHODS

Two measures of lifespan inequality are calculated for each country-year for which HMD life tables are available. The first, the Gini index of lifespan inequality, is calculated as outlined in the approach by Shkolnikov et al. (2003) for discrete life tables.

A second measure of lifespan inequality comes from the Atkinson (1970) family of inequality metrics. This approach differs from the Gini method in that it is sensitive to the distribution of income and therefore transfers that occur at the lower end of the distribution are given more weight in shifting the inequality index than transfers at the middle of the distribution. The Gini index, in contrast, gives the same weight to transfers at the middle as those given at the ends of the distribution. In constructing the IHDI, UNDP incorporates Atkinson indices of income, education and lifespan inequalities to adjust the composite HDI index of human development according to the method proposed by Foster, Lopez-Calva, and Szekely (2005). For the IHDI, the Atkinson index of life table inequality A(1) is calculated[5] as:

$$A(1) = 1 - \frac{geometric\ mean\ length\ of life}{arithmetic\ mean\ length\ of\ life}$$

The HMD provides all of the life table information needed to calculated the lifespan Gini and lifespan Atkinson indices for each of the 28 countries. However, because the microdata from which the OECD Gini indices of income inequality are calculated are not readily available in many instances, corresponding Atkinson indices of income inequality are not included in this study.

Ordinary least squares (OLS) and fixed-effects analyses are employed to assess the between-country and within-country associations between income inequality and lifespan inequality. The dependent variables are: 1) the lifespan Gini reflecting dispersion across all ages; 2) the lifespan Atkinson reflecting dispersion across all ages; 3) the lifespan Gini reflecting dispersion across ages 65 and over; and 4) the lifespan Atkinson reflecting dispersion across ages 65 and over. Covariates include the income Gini for all ages and ages 65 and over, the life expectancy at birth (e0), the life expectancy at age 65 (e65), and the per capita Gross National Income.

All analyses are performed using R statistical software. The plm package (Linear Models for Panel Data) is used to estimate the fixed-effects models.

[5] For a full description of the Atkinson measures incorporated in the IHDI see UNDP (2011), technical note 2.

F. Results

1. *Summary measures of lifespan inequality and income inequality for 28 countries*

Table 1 lists the 28 countries included in the analysis along with the values of lifespan inequality, income inequality, life expectancy and GNI corresponding to the year 2008. Across the 28 countries, per capita income (US$ purchasing power parity) ranges from a low of $11,870 in Poland to a high of $85,580 in Norway. Income inequality, reflected in the income Gini, ranges from a low of 0.24 in Slovenia to a high of 0.39 in the United States, with a mean of 0.30 across the 28 countries in 2008. While substantial variation is observed across the countries in the level of life expectancy at birth (from a low of 74.1 years in Hungary to a high of 82.7 years in Japan), very little variation is observed in the extent of inequality in lifespan. The lifespan Gini for all ages ranges indicates that Iceland is the most equal (0.08), while Estonia is the least equal (0.12), while the lifespan Atkinson for all ages indicates that Luxembourg is the most equal (0.03) and the United States the least equal (0.07).

Table 1. Measures of income, life expectancy, income inequality and lifespan inequality, 2008, by country

		All ages				Ages 65 and over			
Location	GNIpc (US$ ppp)	Income Gini	Life exp.	Lifespan Gini	Lifespan Atkinson	Income Gini	Life exp.	Lifespan Gini	Lifespan Atkinson
Australia	41,980	0.336	81.5	0.089	0.045	0.328	20.1	0.238	0.139
Austria	46,790	0.261	80.4	0.090	0.042	0.259	19.4	0.242	0.146
Belgium	45,180	0.259	79.6	0.095	0.044	0.231	19.0	0.250	0.153
Canada	43,460	0.321	80.9	0.095	0.052	0.278	20.0	0.253	0.155
Czech Republic	17,840	0.256	77.2	0.097	0.039	0.186	17.1	0.273	0.178
Denmark	59,040	0.242	78.7	0.095	0.045	0.214	18.1	0.270	0.172
Estonia	15,010	0.315	74.2	0.120	0.061	0.258	16.7	0.293	0.199
Finland	47,960	0.259	79.7	0.097	0.039	0.239	19.4	0.247	0.151
France	41,940	0.293	81.1	0.096	0.044	0.291	20.6	0.239	0.144
Germany	42,470	0.287	80.0	0.091	0.041	0.283	19.0	0.250	0.152
Hungary*	12,890	0.272	74.1	0.115	0.060	0.199	16.2	0.300	0.206
Iceland	46,860	0.301	81.5	0.082	0.033	0.322	19.4	0.246	0.147
Ireland	50,260	0.293	79.8	0.092	0.045	0.285	18.7	0.259	0.158
Israel	24,610	0.371	81.0	0.089	0.044	0.398	19.6	0.249	0.146
Italy	35,760	0.315	81.6	0.086	0.040	0.308	20.0	0.238	0.139
Japan*	37,870	0.336	82.7	0.090	0.036	0.341	21.3	0.239	0.139
Luxembourg	83,770	0.288	80.5	0.087	0.031	0.228	19.2	0.245	0.149
Netherlands	48,820	0.286	80.4	0.087	0.041	0.244	19.0	0.248	0.149
New Zealand	27,920	0.330	80.4	0.094	0.051	0.305	19.5	0.248	0.150
Norway	85,580	0.250	80.7	0.087	0.036	0.222	19.3	0.246	0.148
Poland	11,870	0.305	75.5	0.113	0.061	0.257	17.1	0.285	0.192
Portugal	21,550	0.353	79.3	0.093	0.041	0.343	18.7	0.245	0.145
Slovakia	15,900	0.257	74.9	0.108	0.060	0.205	16.0	0.293	0.194
Slovenia	24,210	0.236	78.9	0.096	0.037	0.262	18.5	0.258	0.159
Spain	31,850	0.317	81.1	0.089	0.041	0.284	20.0	0.238	0.138

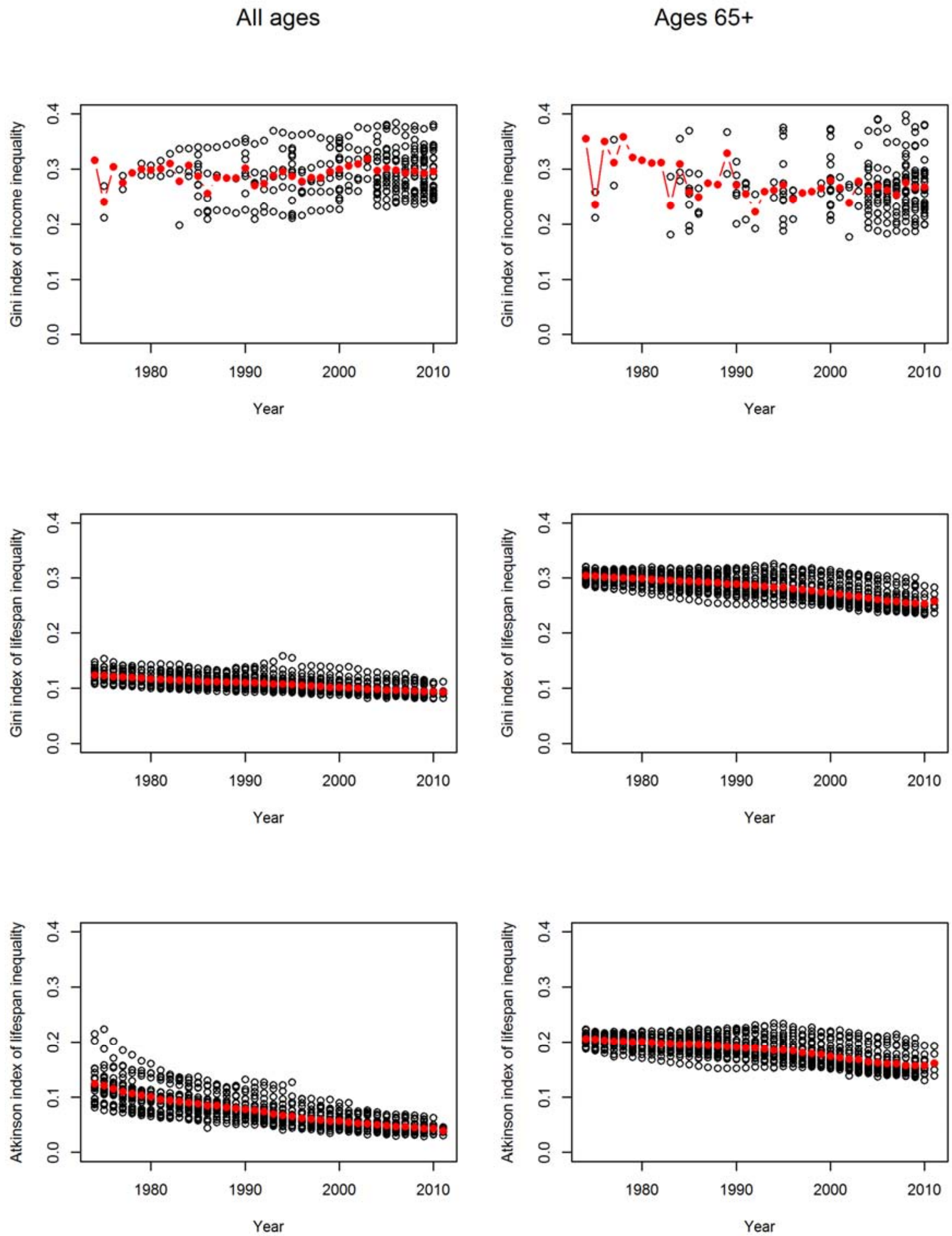
Sweden	52,390	0.259	81.1	0.084	0.033	0.259	19.4	0.240	0.143
United Kingdom	45,700	0.342	79.7	0.094	0.050	0.279	18.9	0.257	0.157
United States	47,890	0.378	78.3	0.109	0.067	0.386	18.9	0.267	0.171

* Income Ginis were not available for Hungary and Japan for 2008, thus the 2009 values are shown.
Data sources: Per capita Gross National Income (GNI) and income Ginis are from the OECD; Life expectancy at birth and at age 65 are from World Population Prospects: the 2012 revision; Lifespan Ginis and Lifespan Atkinsons are the author's own calculations using life tables from the Human Mortality Database.

When the indicators are calculated only among the population aged 65 and over the income Gini tends to be somewhat lower than that for all ages, while the lifespan Gini and lifespan Atkinson tend to be higher than those for all ages. The income Gini for ages 65 and over ranges from a low of 0.19 in the Czech Republic to a high of 0.40 in Israel. According to the lifespan Gini for age 65 and over Italy is the most equal country (0.24) while Hungary is the least equal (0.30). When the lifespan Atkinson for ages 65 and over is compared across the 28 countries, Spain is the most equal (0.14), while Hungary again is the least equal (0.21).

Figure 4 illustrates the time trend in the mean and distribution of income inequality and lifespan inequalities across the 28 countries from 1974 to 2010. Data on income inequality are sparse early in the panel, with just two countries with income Ginis available in the late 1970s. The panel becomes better populated over time such that by 1985 nine countries have income Ginis available and by 2000 income Ginis are available for 16 countries. The mean income Gini for all ages across the 28 countries tended to stay fairly constant over time at close to 0.30. In contrast, the mean income Gini for ages 65 and over was observed to decline from around 0.31 in the mid-1970s to around 0.26 in the mid-1990s and remain fairly constant thereafter.

Figure 4. Mean and distribution of measures of income and lifespan inequalities for 28 countries, by year



Black circles represent country observations while red dots show the mean across all countries for the year.

Data sources: Income Ginis are from the Organization for Economic Co-operation and Development (OECD) and based on household income after taxes and transfers. Lifespan Gini and Atkinson indices are author's own calculations from annual complete life tables obtained from the Human Mortality Database.

Measures of lifespan inequality calculated from the annual life tables contained in the HMD are much better populated relative to income inequality measures, reflecting the continuous data collection of well-functioning vital statistics systems. The mean lifespan Gini across the 28 countries tended to decrease slowly with time and maintain a fairly constant variance. The average lifespan Gini across all ages fell from 0.12 in 1975 to 0.09 in 2010. The mean lifespan Atkinson also declined with time from 0.12 in 1975 to 0.09 in 2010. Lifespan inequality at ages 65 and over followed a similar pattern, with the mean across the 28 countries declining gradually between 1974 and 2010.

This study is interested not just in the between-country variation in lifespan and income inequalities, but also in the trends and associations within countries over time. Table 2 shows the means and standard deviations of the lifespan Ginis and Atkinsons and income Ginis within each of the 28 countries. The statistics indicate little movement in both lifespan inequality and income inequality within countries. Across the 28 countries, the average within-country standard deviation in the lifespan Gini for all ages is only 0.005 while that for ages 65 and over is 0.012. Those countries that had relatively few years with both lifespan inequality and income inequality measures available also tended to have little within-country variation in lifespan inequality. For example, Belgium, Ireland and Slovakia had only six available data points and standard deviations in the lifespan Gini of just 0.001. Canada, Italy and Sweden showed the most variation in the lifespan Gini, with a standard deviation of 0.009 across 34, 7 and 9 observations, respectively. Greater within-country variation was observed in income inequality across the 28 countries, with the standard deviation in the income Gini (all ages) ranging from 0.003 in Austria to 0.028 in Sweden.

TABLE 2. SUMMARY MEASURES OF PANEL DATA FOR INCOME GINI AND LIFE TABLE GINI, ALL AGES AND AGES 65+, BY COUNTRY

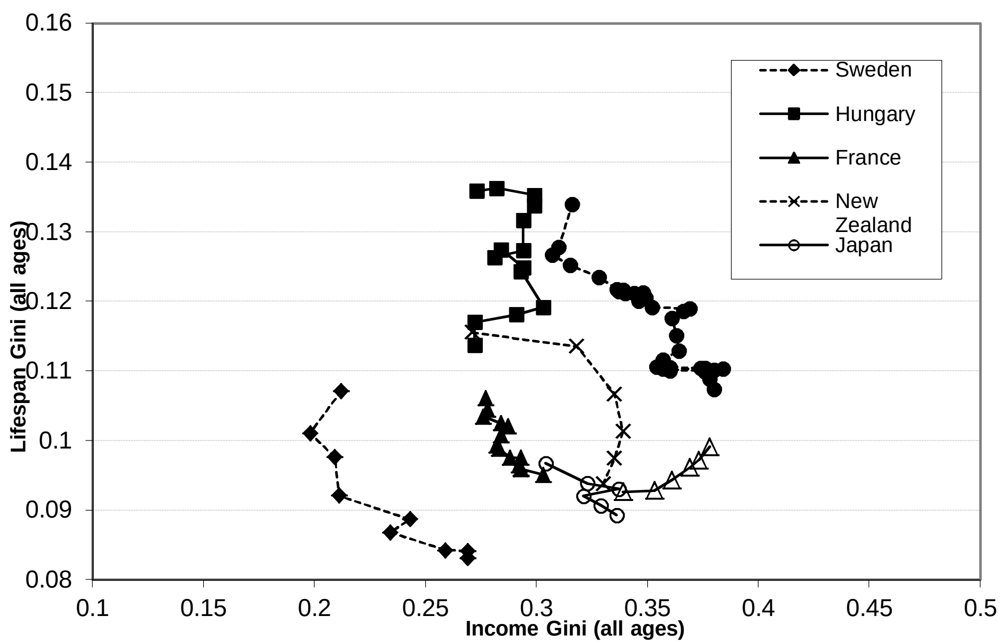
	Number of data points		Measures of lifespan inequality								Measures of income inequality			
			Gini (all ages)		Atkinson (all ages)		Gini (ages 65+)		Atkinson (ages 65+)		Gini (all ages)		Gini (ages 65+)	
	All ages	Ages 65+	mean	std	mean	std	mean	std	mean	std	mean	std	mean	std
Australia	4	4	0.094	0.005	0.052	0.006	0.253	0.014	0.153	0.015	0.319	0.012	0.300	0.029
Austria	7	7	0.092	0.002	0.044	0.002	0.246	0.003	0.150	0.002	0.265	0.003	0.271	0.010
Belgium	6	6	0.095	0.001	0.045	0.001	0.252	0.002	0.154	0.001	0.266	0.005	0.238	0.007
Canada	34	34	0.105	0.009	0.067	0.016	0.279	0.016	0.181	0.017	0.301	0.013	0.283	0.029
Czech Republic	10	10	0.101	0.006	0.048	0.014	0.283	0.013	0.188	0.013	0.256	0.009	0.191	0.009
Denmark	22	10	0.104	0.007	0.058	0.013	0.281	0.015	0.183	0.017	0.228	0.010	0.208	0.011
Estonia	7	7	0.122	0.006	0.061	0.008	0.296	0.007	0.204	0.007	0.325	0.014	0.252	0.013
Finland	6	6	0.100	0.005	0.046	0.008	0.264	0.018	0.167	0.017	0.240	0.021	0.228	0.013
France	15	6	0.100	0.003	0.049	0.004	0.246	0.011	0.151	0.010	0.287	0.007	0.285	0.012
Germany	17	7	0.098	0.005	0.051	0.008	0.262	0.014	0.165	0.014	0.270	0.012	0.269	0.013
Hungary	14	6	0.127	0.007	0.085	0.018	0.310	0.008	0.216	0.009	0.288	0.011	0.228	0.028
Iceland	7	7	0.084	0.002	0.032	0.002	0.242	0.005	0.141	0.007	0.272	0.019	0.265	0.034
Ireland	6	6	0.093	0.001	0.045	0.003	0.261	0.003	0.158	0.002	0.311	0.013	0.274	0.006
Israel	7	7	0.097	0.008	0.061	0.019	0.270	0.020	0.169	0.022	0.352	0.022	0.345	0.074
Italy	7	7	0.095	0.009	0.055	0.019	0.259	0.018	0.159	0.018	0.309	0.021	0.297	0.017
Japan	6	6	0.093	0.003	0.043	0.009	0.248	0.009	0.149	0.008	0.325	0.012	0.355	0.013
Luxembourg	9	9	0.095	0.007	0.045	0.014	0.258	0.015	0.162	0.016	0.268	0.013	0.234	0.016
Netherlands	10	10	0.094	0.007	0.054	0.014	0.267	0.018	0.168	0.018	0.284	0.011	0.259	0.017
New Zealand	6	6	0.105	0.009	0.068	0.016	0.276	0.020	0.177	0.021	0.321	0.026	0.260	0.029
Norway	6	6	0.094	0.007	0.047	0.014	0.260	0.017	0.161	0.017	0.250	0.018	0.227	0.015
Poland	6	6	0.113	0.001	0.063	0.002	0.288	0.003	0.194	0.002	0.319	0.017	0.255	0.006
Portugal	6	6	0.095	0.003	0.044	0.002	0.250	0.006	0.150	0.005	0.362	0.014	0.358	0.014
Slovakia	6	6	0.108	0.001	0.063	0.003	0.294	0.004	0.197	0.004	0.259	0.011	0.203	0.010
Slovenia	6	6	0.098	0.003	0.042	0.005	0.266	0.006	0.168	0.006	0.243	0.004	0.262	0.003
Spain	6	6	0.091	0.002	0.042	0.003	0.242	0.004	0.142	0.003	0.321	0.009	0.296	0.009
Sweden	9	9	0.092	0.009	0.046	0.016	0.258	0.018	0.159	0.017	0.234	0.028	0.223	0.029
United Kingdom	16	16	0.098	0.006	0.059	0.017	0.275	0.019	0.175	0.020	0.334	0.020	0.274	0.013
United States	32	8	0.117	0.007	0.082	0.015	0.285	0.018	0.189	0.018	0.352	0.021	0.370	0.013

Data sources: Income Ginis are from the Organization for Economic Co-operation and Development (OECD) and based on household income after taxes and transfers.
Lifespan Gini and Atkinson indices are author's own calculations from annual complete life tables obtained from the Human Mortality Database, University of California at Berkeley.
Std=standard deviation.

2. Association between income inequality and lifespan inequality

To yield a preliminary indication of the extent to which lifespan inequality moves in the same direction as income inequality, figure 5 plots the lifespan Gini (all ages) against the income Gini (all ages) for a selected group of countries. No common pattern is evident. For Sweden, France and the United States, there appears to be some tendency for the lifespan Gini to decline with increasing income Gini, but the data points for Portugal indicate the opposite association, with a higher lifespan Gini accompanying a higher income Gini. For Hungary, Japan and New Zealand, multiple values of the lifespan Gini are associated with similar levels of income Gini.

Figure 5. Lifespan Gini and Income Gini (all ages), selected countries



Data sources: Income Ginis are from the Organization for Economic Co-operation and Development (OECD) and based on household income after taxes and transfers. Lifespan Gini and Atkinson indices are author's own calculations from annual complete life tables obtained from the Human Mortality Database, University of California at Berkeley.

Table 3 displays the Pearson's correlation coefficients across all countries and periods of the levels of life expectancy, lifespan Ginis and Atkinsons, level of per capita GNI and income Ginis. As expected, the lifespan Gini and lifespan Atkinson measures are highly correlated (0.90 for all ages and 0.99 for ages 65 and over). Both measures of lifespan inequality are negatively correlated with the level of life expectancy, with a correlation coefficient of -0.93 between the all-ages lifespan Gini and the life expectancy at birth and a coefficient of -0.86 between the all-ages lifespan Atkinson and the life expectancy at birth. Similarly strong negative correlations are detected between the measures of lifespan inequality at ages 65 and over and the life expectancy at age 65. Life expectancy at birth and at age 65 are positively correlated with per capita GNI (0.76 and 0.74, respectively), but no association is evident between life expectancy at birth and the income Gini for all ages and only a weak association is detected between the life expectancy at age 65 and the income Gini for ages 65+ (0.33). Moreover, the correlations between lifespan inequality and the income Gini are weak when measured across all ages (0.14 for the lifespan Gini and 0.18 for the lifespan Atkinson) and negative when measured for ages 65 and over (-0.18 for the lifespan Gini and -0.20 for the lifespan Atkinson).

TABLE 3. CORRELATION MATRIX

	Lifespan Gini (all ages)	Life expectancy at birth	Lifespan Gini (ages 65+)	Life expectancy at age 65	Lifespan Atkinson (all ages)	Lifespan Atkinson (ages 65+)	Income Gini (all ages)	Income Gini (ages 65+)	Gross national income (per capita)
Lifespan Gini (all ages)	1								
Life expectancy at birth	-0.93***	1							
Lifespan Gini (ages 65+)	0.85***	-0.94***	1						
Life expectancy at age 65	-0.81***	0.96***	-0.94***	1					
Lifespan Atkinson (all ages)	0.90***	-0.86***	0.76***	-0.80***	1				
Lifespan Atkinson (ages 65+)	0.85***	-0.94***	0.99***	-0.92***	0.74***	1			
Income Gini (all ages)	0.14*	0.10	-0.07	0.24***	0.18**	-0.08	1		
Income Gini (ages 65+)	0.02	0.22**	-0.18**	0.33***	0.16*	-0.20**	0.74***	1	
Gross national income (per capita)	-0.71***	0.76***	-0.73***	0.74***	-0.68***	-0.71***	-0.08	-0.09	1

* p<.05 ** p< .01 *** p< .001

Regression analysis permits an assessment of the between-country and within-country association between variables while also allowing controls for variables that might mediate those associations. Table 4 presents the results of ordinary least squares (OLS) and fixed-effects regression of the lifespan Gini on the income Gini in the top half and the lifespan Atkinson on the income Gini in the bottom half. This first set of models selects the lifespan inequalities measured across all ages as the dependent variable. Consistent with the weak correlation between the income Gini and lifespan Gini shown in table 3, OLS model 1 shows a weak effect of the income Gini on the lifespan Gini, explaining only 1.5 per cent of the total variation in the lifespan Gini across all observations. Controlling for the level of life expectancy at birth (OLS model 2) yields a stronger and statistically significant positive association between the income Gini and the lifespan Gini and vastly improves the model fit, explaining 89 per cent of the variation overall. Consistent with observations in the demographic literature, the lifespan Gini tends to decrease as life expectancy at birth increases. Further adding the natural log of GNI to the model (OLS model 3) fails to explain the residual variation in the lifespan Gini.

Fixed-effects regression models account for the lack of independence across observations for the same country, thereby assessing the within-country association between the covariates and the dependent variable. Fixed-effects model 1, which includes no controls for the level of life expectancy or GNI, indicates a negative and statistically significant association between the income Gini and the lifespan Gini. Controlling for life expectancy at birth in fixed-effects model 2 yields no statistically significant association between the income Gini and the lifespan Gini. Again, the within-country association between life expectancy at birth and lifespan Gini is negative. Fixed-effects model 2 explains nearly 84 per cent of the total within-country variation in the lifespan Gini across all ages. As with the OLS models, further adding GNI as a covariate (fixed-effects model 3) yields no improvement to model fit.

Results are similar when the lifespan Atkinson across all ages is the dependent variable. OLS model 5 shows a positive association between the income Gini and lifespan Atkinson after controlling for the negative association between the life expectancy at birth and the lifespan Atkinson. Together the two variables explain 73 per cent of the overall variation in the lifespan Atkinson for all ages. Fixed-effects model 5, which includes both the income Gini and life expectancy at birth covariates explains close to 79 per cent of the within-country variation in the lifespan Atkinson, but no statistically significant association is detected between the income Gini and lifespan Atkinson.

A second set of models selects the lifespan Gini and lifespan Atkinson at ages 65 and over as the dependent variables (table 5). OLS models 7 and 10, which do not control for the level of life expectancy, indicate a negative association between the income Gini and both measures of lifespan inequality, but when the level of life expectancy at age 65 is added in OLS models 8 and 11, the association between the income Gini and lifespan inequality becomes positive. The income Gini for ages 65 and over and the life expectancy at age 65 together explain 89 per cent of the variation in the lifespan Gini at ages 65 and over across all observations, and 87 per cent of the variation in the lifespan Atkinson at ages 65 and over.

Like the models of lifespan inequality at all ages, the fixed effects models of lifespan inequality at older ages do not indicate income inequality as a determinant of within-country variation. Fixed-effects models 7 and 10, which include only the income Gini at ages 65 and over as a covariate, fit the data poorly, while in fixed-effects models 8 and 11 the coefficients on the income Ginis fail tests of statistical significance. Only the life expectancy at age 65 has a statistically significant association with lifespan inequality and the models explain 82 per cent of the within-country variation in the lifespan Gini for ages 65 and over and 81 per cent of the variation in the lifespan Atkinson for ages 65 and over.

TABLE 4. RESULTS OF OLS AND FIXED-EFFECTS ANALYSIS OF ASSOCIATION BETWEEN LIFESPAN INEQUALITY AND INCOME INEQUALITY (ALL AGES)

Dependent variable: Lifespan Gini (all ages)

	OLS Model 1	OLS Model 2	OLS Model 3	Fixed-effects Model 1	Fixed-effects Model 2	Fixed-effects Model 3
	Coeff. (std error)	Coeff. (std error)	Coeff. (std error)	Coeff. (std error)	Coeff. (std error)	Coeff. (std error)
Intercept	0.092 ***	0.396 ***	0.406 ***			
	(0.005)	(0.006)	(0.007)			
Income Gini (all ages)	0.038 *	0.064 ***	0.065 ***	-0.255 ***	0.008	0.008
	(0.016)	(0.005)	(0.005)	(0.020)	(0.009)	(0.009)
e0		-0.004 ***	-0.004 ***		-0.004 ***	-0.004 ***
		(0.000)	(0.000)		(0.000)	(0.000)
lnGNI (per capita)			0.002 **			-0.0002
			(0.001)			(0.001)
n	293	293	291	293	293	291
Adj-R2	0.015	0.894	0.899	0.342	0.838	0.833
F	5.4 *	1229.0 ***	856.6 ***	161.3 ***	1861.7 ***	1199.2 ***
F test for individual fixed effects				47.3 ***	47.8 ***	44.5 ***

Dependent variable: Lifespan Atkinson (all ages)

	OLS Model 4	OLS Model 5	OLS Model 6	Fixed-effects Model 4	Fixed-effects Model 5	Fixed-effects Model 6
	Coeff. (std error)	Coeff. (std error)	Coeff. (std error)	Coeff. (std error)	Coeff. (std error)	Coeff. (std error)
Intercept	0.035 ***	0.460 ***	0.455 ***			
	(0.007)	(0.016)	(0.018)			
Income Gini (all ages)	0.080 **	0.116 ***	0.113 ***	-0.525 ***	-0.038	-0.035
	(0.025)	(0.013)	(0.014)	(0.040)	(0.023)	(0.022)
e0		-0.006 ***	-0.005 ***		-0.007 ***	-0.005 ***
		(0.000)	(0.000)		(0.000)	(0.000)
lnGNI (per capita)			-0.002			-0.0082 ***
			(0.001)			(0.001)
n	293	293	291	293	293	291
Adj-R2	0.030	0.730	0.731	0.362	0.788	0.793
F	10.0 **	396.4 ***	263.7 ***	177.1 ***	941.8 ***	683.8 ***
F test for individual fixed effects				25.7 ***	38.1 ***	43.2 ***

* p<.05 ** p< .01 *** p< .001

Note: e0: life expectancy at birth; e65: life expectancy at age 65; GNI: Gross National Income.

TABLE 5. RESULTS OF OLS AND FIXED-EFFECTS ANALYSIS OF ASSOCIATION BETWEEN LIFESPAN INEQUALITY AND INCOME INEQUALITY (AGES 65 AND OVER)

Dependent variable: Lifespan Gini (ages 65+)

	OLS Model 7	OLS Model 8	OLS Model 9	Fixed-effects Model 7	Fixed-effects Model 8	Fixed-effects Model 9
	Coeff. (std error)	Coeff. (std error)	Coeff. (std error)	Coeff. (std error)	Coeff. (std error)	Coeff. (std error)
Intercept	0.290 ***	0.508 ***	0.523 ***			
	(0.008)	(0.006)	(0.008)			
Income Gini (ages 65+)	-0.077 **	0.062 ***	0.050 ***	-0.008	0.011	0.009
	(0.028)	(0.010)	(0.011)	(0.044)	(0.010)	(0.010)
e65		-0.014 ***	-0.013 ***		-0.013 ***	-0.012 ***
		(0.000)	(0.001)		(0.000)	(0.001)
lnGNI (per capita)			-0.003 **			-0.0023
			(0.001)			(0.001)
n	230	230	228	230	230	228
Adj-R2	0.028	0.890	0.891	0.000	0.823	0.818
F	7.5 **	928.3 ***	617.2 ***	0.0 ***	1783.9 ***	1155.3 ***
F test for individual fixed effects				10.1 ***	29.5 ***	28.5 ***

Dependent variable: Lifespan Atkinson (ages 65+)

	OLS Model 10	OLS Model 11	OLS Model 12	Fixed-effects Model 10	Fixed-effects Model 11	Fixed-effects Model 12
	Coeff. (std error)	Coeff. (std error)	Coeff. (std error)	Coeff. (std error)	Coeff. (std error)	Coeff. (std error)
Intercept	0.195 ***	0.422 ***	0.438 ***			
	(0.008)	(0.006)	(0.009)			
Income Gini (ages 65+)	-0.090 **	0.054 ***	0.041 ***	-0.003	0.016	0.015
	(0.030)	(0.011)	(0.012)	(0.045)	(0.012)	(0.012)
e65		-0.015 ***	-0.013 ***		-0.013 ***	-0.013 ***
		(0.000)	(0.001)		(0.000)	(0.001)
lnGNI (per capita)			-0.004 **			-0.001
			(0.001)			(0.001)
n	230	230	228	230	230	228
Adj-R2	0.035	0.874	0.874	0.000	0.808	0.801
F	9.3 **	792.8 ***	527.8 ***	0.0	1309.7 ***	835.8 ***
F test for individual fixed effects				11.0 ***	26.3 ***	24.8 ***

* p<.05 ** p< .01 *** p< .001

Note: e0: life expectancy at birth; e65: life expectancy at age 65; GNI: gross national income.

G. DISCUSSION

Income and health are inextricably linked. Higher incomes afford better access to health care, while good health, in turn, affords greater opportunities to grow income through productive work. Poorer people also tend to have greater exposure to poor diet, cigarette smoking and unhealthy environments (Deaton, 2002). That average health status tends to increase monotonically with increasing income suggests that some association between income inequality and health inequity may be expected as well. However, previous research that failed to detect an association between an index measure of income inequality and an index measure of lifespan inequality as a proxy for health inequity (Hicks, 1997 and UNDP, 2011) ran counter to this expectation.

This study sought to further investigate the relationship between income inequality and lifespan inequality. First, we acquired estimates of the Gini index of income inequality compiled in the OECD income inequality database for 34 countries for various years between 1974 and 2010. Second, we calculated Gini and Atkinson indices of lifespan inequality from life tables obtained from the Human Mortality Database for countries and time periods for which at least two corresponding estimates of income inequality were available in the OECD database (28 countries). By uniting the two series into a single panel, we were able to assess the association between income inequality and lifespan inequality, both between and within countries.

A simple correlation indicated only weak positive associations between the income Gini and both the lifespan Gini and lifespan Atkinson indices across all ages and weak negative associations when the metrics were restricted to describe inequality only among those aged 65 and over. These results are generally consistent with those reported by Hicks (1997), which suggested no association between income inequality and lifespan inequality between countries. However, regression models that controlled for the levels of life expectancy indicated a positive and statistically significant association between the all-ages lifespan Gini and the all-ages income Gini across countries and time. A similar result came from analysis of the associations between inequalities among those aged 65 and older across countries and time. These results indicate that the tendency for lifespan inequality to decrease with increasing life expectancy — a phenomenon well documented in the demographic literature (e.g., Wilmoth and Horiuchi, 1999) — masks the extant association between income inequality and lifespan inequality. After the influence of increasing life expectancy is removed, the association between income inequality and lifespan inequality is in the expected direction.

Fixed effects analysis, however, failed to further bolster evidence of an association between income inequality and lifespan inequality within countries over time. Yet the very small degree of variation within countries in the income Gini, but especially in the lifespan inequality measures, could preclude the detection of an association even where one exists. The present study has advantages over previous studies in that it relies exclusively on high-quality life tables from which to estimate lifespan in equality and utilizes a panel dataset that facilitates assessment of the association between income inequality and lifespan inequality within countries over time. It is, however, limited by the small number of countries and time periods for which both estimates of the income Gini were available from the OECD and life tables were available from the HMD. Most of the 28 countries that met the data availability criteria were characterized by high life expectancy at birth and high income, as well as relatively low levels of income and lifespan inequalities. As a result, the power of the study to detect an association between income inequality and lifespan inequality is limited and the results may not be generalisable to a wider set of countries and time periods. More data are needed to expand the panel with high-quality, consistent and comparable estimates of income inequality and lifespan inequality to cover a greater number and diversity of countries and time periods.

The evidence of an association between income inequality and lifespan inequality from OLS models provides some reassurance of the validity of the two measures of lifespan inequality as proxies for health inequality, but at the same time implies that comparisons of lifespan inequality across countries should take into account differences in the level of the life expectancy at birth. One such cross-country comparison in lifespan inequality is designed into the UNDP inequality-adjusted human development index (IHDI). Estimates produced for the 2013 *Human Development Report* show that while income inequality contributes proportionally more than lifespan and education inequalities to the discounting of the IHDI, lifespan inequality discounting is consequential nonetheless. The percentage reduction in the life expectancy component of the HDI indicated by the Atkinson measure of lifespan inequality ranges from 3 per cent in Iceland, Hong Kong and Singapore, where life expectancy at birth was exceeded 81 years in 2012, to 52 per cent in Chad, where life expectancy at birth was 50 years in 2012. Further investigation is warranted to ensure that the lifespan inequality discounting truly is reflecting the degree of health inequalities in the population and not double counting disparities between countries in the level of life expectancy, which are already accounted in the unadjusted HDI.

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