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Growing Income-Based Inequalities in Old-Age Life Expectancy in Sweden, 2006–2015

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ABSTRACT Sweden is known for high life expectancy and economic egalitarianism, yet in recent decades it has lost ground in both respects. This study tracked income inequality in old-age life expectancy and life span variation in Sweden between 2006 and 2015, and examined whether patterns varied across levels of neighborhood deprivation. Income inequality in remaining life expectancy at ages 65, 75, and 85 increased. The gap in life expectancy at age 65 grew by more than a year between the lowest and the highest income quartiles, for both men (from 3.4 years in 2006 to 4.5 years in 2015) and women (from 2.3 to 3.4 years). This widening income gap in old-age life expectancy was driven by different rates of mortality improvement: individuals with higher incomes increased their life expectancy at a faster rate than did those with lower incomes. Women with the lowest incomes experienced no improvement in old-age life expectancy. Furthermore, life span variation increased in the lowest income quartile, while it decreased slightly among those in the highest quartile. Income was found to be a stronger determinant of old-age life expectancy than neighborhood deprivation.

KEYWORDS Life expectancy • Old age • Income • Inequality • Mortality

Introduction

Inequality in Life Expectancy

Human longevity is on the rise globally. While reductions in infant and adult mortality still play an important role in the developing world, declining mortality during old age has been the main driver of the increase in life expectancy in high-income countries since the 1950s (Wilmoth 2000). In Sweden, the proportion of deaths after age 65 rose from 76% in 1950 to almost 92% in 2017 in life table populations (Human Mortality Database n.d.). However, these overall improvements mask significant inequalities.

The likelihood of a long life presents with an unequal distribution in the population. Individuals with lower socioeconomic positions have a higher risk of death than do individuals with higher socioeconomic positions, regardless of whether this is measured in terms of income, wealth, education, or social class (Mackenbach et al. 2008; O'Donnell et al. 2015; Olshansky et al. 2012). These inequalities are substantial

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and, according to recent data, are increasing at an alarming rate. In a study conducted in the United States, Chetty et al. (2016) found that the difference in life expectancy at age 40 between the richest 1% and the poorest 1% was 14.6 years for men and 10.1 years for women. This gap increased substantially between 2001 and 2014, driven by the rapid improvement in life expectancy observed among those in the highest income brackets. The slower-than-average improvement observed among low-income earners was especially marked among women. Comparable patterns have been reported from several high-income countries, including Nordic countries such as Finland (van Raalte et al. 2018), Denmark (Kreiner et al. 2018), and Sweden (Hederos et al. 2018). As found in the United States, research has shown that in Norway income inequalities in life expectancy at age 40 increased between 2005 and 2015, as low-income earners lagged behind (Kinge et al. 2019). These findings resonate with the "Nordic paradox," namely, the fact that there are remarkably large health inequalities in the Nordic countries despite their egalitarian ambitions (Mackenbach 2017).

In the present study, we address the development of old-age life expectancy and life span variation in Sweden during the period 2006–2015, by examining both household income and degree of neighborhood deprivation.

Old-Age Life Expectancy

While several studies have described the development of the association between income and life expectancy at birth or from adulthood, there is less empirical evidence on income inequalities in life expectancy at older ages. We believe this to be unfortunate for at least two reasons. First, substantial disparities in life expectancy within the older population may function as a bottleneck to further improvement in longevity. Given current patterns in mortality, the most efficient way to further improve life expectancy in high-income countries is to prioritize reductions in mortality within groups with the shortest life spans (i.e., in old age), rather than focus on early life or middle age mortality. Meara et al. (2008) found that at least half the growth in education-related disparity in life expectancy was generated among people aged 65 years or older. Similarly, Kinge et al. (2019) found that the bulk of the income inequality in life expectancy at age 40 in Norway could be attributed to those aged 60 or older. Thus, the identification and monitoring of health among disadvantaged older people ought to have a prominent position in population health research and demography.

The second reason is that a focus on inequality in old-age life expectancy allows for analyzing socioeconomic disparity net of the impact of mortality at younger ages, which often has different causes (e.g., accident, suicide, overdose) and is driven by etiological pathways that are markedly different for mortality in old age (Brooke et al. 2017). For example, Sasson and Hayward (2019) found that much of the increased educational inequality in years of life lost between the ages of 25 and 84 in the United States may have been influenced by drug-related deaths, which typically occur among young or middle-aged individuals. In Norway, deaths due to substance use disorders and external causes represented a disproportionately higher contribution to the inequality in life expectancy in the 40–59 age-group than among people aged 60 or older (Kinge et al. 2019). By focusing on old-age life expectancy, our goal is to estimate how wide the disparity in life expectancy is after removing the influence of early mortality. This represents an opportunity for policymakers and stakeholders, as reducing mortality in old age is likely to require—at least partially—different kinds of public health strategy than those targeting younger individuals.

Income Inequality in Old-Age Life Expectancy

Studies detailing income inequality in old-age life expectancy are few and far between, yet there is evidence that high-income countries experience substantial, and potentially increasing, inequality in late life longevity. Using registry data from the Netherlands for the period 1996–2007, Kalwij et al. (2013) found a clear income gradient in remaining life expectancy at age 65. Likewise, Waldron (2007) analyzed the association between earnings and cohort life expectancy at age 65 for consecutive birth cohorts born between 1912 and 1941 in the United States; the analysis showed tangible and mounting inequality between the top and bottom halves of the earning distribution. Cohorts born later had longer life expectancy but greater socioeconomic disparity in life expectancy than did cohorts born earlier. This was primarily due to a more rapid improvement in life expectancy among high-income earners than among low-income earners. This pattern of substantial and rising inequality in old-age life expectancy in the United States has since been observed repeatedly in registry studies, microsimulations, and studies based on survey data (Congressional Budget Office 2014; Cristia 2009; National Academies of Sciences, Engineering, and Medicine 2015). It is unclear whether these findings apply to countries with narrower social and economic disparities, highly protective welfare programs, and universal health care, which are three characteristics typical of Scandinavia. There is also considerable debate about the respective roles of the socioeconomic circumstances of the individuals and the socioeconomic environment in which these individuals live in generating the observed inequality in longevity.

Geographic Variation in Inequality in Life Expectancy

Two recent studies from Sweden showed that people living in more deprived neighborhoods experienced higher mortality and smaller reductions in cardiovascular mortality over time, compared with those living in less deprived neighborhoods (Oudin Åström et al. 2018a; Oudin Åström et al. 2018b). Some evidence indicates that spatial inequalities in mortality are partly driven by the unequal distribution of hazardous behavioral factors, such as smoking and obesity (Chetty et al. 2016; Warren Andersen et al. 2018). For instance, it is possible that issues such as poor public safety; insufficient infrastructure; and limited access to health care, green areas, and healthy food options constrain the choices made by people living in deprived areas to a greater extent than among people in less deprived areas. It is also well established that there is selective migration in and out of different types of neighborhood, which can lead to the accumulation of individuals with similar socioeconomic traits in certain neighborhoods (Sampson 2012). Differences in health and behavior across neighborhoods are likely to reflect both mechanisms.

The study by Chetty et al. (2016) disaggregated geographic disparity in life expectancy across income groups in the United States, finding that among individuals in the lowest income quartile, life expectancy varied by approximately 4.5 years between the geographic areas with the highest and the lowest life expectancy. Moreover, they found that such disparity was correlated with both area-level health behavior (e.g., proportion of smokers, prevalence of obesity) and sociodemographic characteristics (e.g., proportion of immigrants, proportion of college graduates, local government expenditure). Other studies have disaggregated geographic differences in health and mortality across educational groups in the United States (Montez et al. 2017; Montez et al. 2019), and revealed substantial geographic variation in the steepness of the educational gradient in health. Similarly, studies in the United Kingdom have shown substantial inequality in life expectancy at birth by degree of area-level deprivation, measured using a range of indicators (e.g., income deprivation, employment deprivation, crime) (Mayhew et al. 2020). Taken together, these results suggest that studies of income inequality in longevity that do not account for contextual factors are likely to miss important aspects of the socioeconomic patterning of mortality. We hypothesize that these aspects may be of even greater importance in shaping old-age longevity, as older people are likely to have been living in the same area for a longer time, to spend more time in close vicinity to their homes, and to have fewer opportunities to diversify their daily environment (e.g., by working in a more affluent area than where they live). For the purpose of this study, we had access to a limited number of neighborhood-level characteristics and no possibility of assessing area-level indicators of health behavior or health care accessibility. Thus, our focus here is entirely on neighborhood social deprivation.

Inequality in Life Span Variation in Old Age

Beyond life expectancy, little attention has been paid to inequality in life span variation (Sasson 2016; van Raalte et al. 2018). Historically, life span variation has tended to decrease as life expectancy increased (Vaupel et al. 2011). However, substantial differences have been noted in the development of life span variation across socioeconomic groups. In recent decades, socioeconomically advantaged groups have tended to experience sharp increases in life expectancy, combined with decreases in life span variation ("homogeneous improvement"), while socioeconomically disadvantaged groups have experienced smaller increases in life expectancy, combined with expansion of life span variation ("heterogeneous stagnation") (Brønnum-Hansen 2017; Sasson 2016; van Raalte et al. 2018). The "homogeneous improvement" pattern occurs when death is disproportionally averted at younger ages, leading to a compression of mortality, namely, a reduction in the variance of age at death over time. By contrast, the "heterogeneous stagnation" pattern occurs when more death is averted at older ages than at younger ages, or even when mortality is increasing at younger ages, which leads to an extension of the age at death. Hence, careful monitoring of life span variation trends in old age may serve as a detection system for adverse trends in mortality and indicate when interventions geared toward young-old age-groups (e.g., 65–84 years) are warranted (van Raalte et al. 2018).

Sweden as a Case Study

In the early 1970s, Sweden was leading the developed world in terms of life expectancy for both men and women. Since then, Sweden has had a slower mortality decline than many other countries and, consequently, has fallen in the global ranking (#8 for men and #16 for women). While Sweden still has low mortality by international standards among those in young and middle-aged groups, it has experienced a slower mortality decline in old age during the late twentieth and early twenty-first century than have other low-mortality countries (Drefahl et al. 2014; Nordic Burden of Disease Collaborators 2019; OECD and The King's Fund 2020). In that sense, Sweden is an interesting case of a "bottleneck effect," in which overall improvement in longevity is hindered by suboptimal results late in life rather than by early mortality.

Moreover, socioeconomic patterns in old-age life expectancy in Sweden (according to income, educational attainment, or level of neighborhood deprivation) are of special interest because, compared with other European or North American nations, the country has experienced an exceptional increase in income inequality in old age since the mid-1990s (OECD 2017, 2019). In addition, metropolitan areas in Sweden have been subjected to an increased level of socioeconomic segregation (Andersson and Hedman 2016; Tammaru et al. 2020). Hence, we hypothesized that the slow rate of improvement in old-age life expectancy observed in Sweden hides substantial heterogeneity, and that overall improvement is hampered by a process of stagnation in some socioeconomic groups, but not in others.

Finally, we believe that Sweden provides a good testing ground for assessing trends in old-age life expectancy because of the availability of high-quality register data with detailed information about socioeconomic factors, as well as an exceptionally accurate linking process at the individual level (Ludvigsson et al. 2016; Ludvigsson et al. 2009). In this study, we use routinely collected administrative data that cover the entire population of older adults in Sweden during the period from 2006 to 2015 and link individual information on income (from the Swedish Tax Register), neighborhood social deprivation (from the Swedish Population Statistics Register), and mortality (from the National Cause of Death Register).

Aims

The aims of this study were threefold: (1) to measure the magnitude of income inequality in old-age life expectancy and life span variation; (2) to analyze how these inequalities evolved over time; and (3) to assess whether the extent of income disparity in old-age life expectancy varies depending on the degree of neighborhood deprivation.

Methods

Study Design and Cohort

The study is based on multiple deidentified administrative registries with national coverage in Sweden, linked at the individual level through a unique personal identification number. An open cohort including every person aged 65 years or older living in Sweden was assembled from the Total Population Register (Ludvigsson et al. 2016). This register has existed since 1968 and currently covers virtually all residents (with a ~ 0.1% over-coverage as a result of nonreported emigration). Individuals entered the cohort on either January 1, 2006, the date of their 65th birthday, or their date of immigration. Cohort exit was defined as the date of emigration outside of Sweden, the date of death, or December 31, 2015, whichever came first. We included a total of 2,738,170 distinct individuals, who represented more than 17.4 million person-years between 2006 and 2015.

Outcome

All-cause mortality was ascertained based on data from the Swedish National Cause of Death Register, which includes all deaths that occur in Sweden, as well as the deaths of Swedish residents who die abroad (~800 deaths every year) (Brooke et al. 2017). Between January 1, 2006, and December 31, 2015, a total of 781,064 deaths were recorded. The exact day of death was missing for 2,874 of these (0.37%), in which case the date of death was considered as having occurred on the 15th of the month.

Level of Income

We characterized the level of income for each older adult on the basis of data from the Swedish Income and Taxation Register, which covers all registered persons in Sweden, and contains information collected by the Swedish Tax Agency, the Swedish Social Insurance Agency, the National Government Employee Pensions Board, the Swedish Pensions Agency, the Swedish Armed Forces, and the National Board of Health and Welfare. Income was operationalized as the annual equivalized household disposable income, which is equivalent to the sum of the total disposable household income divided by the number of consumption units within the household. For individuals who died during a given year, we used income from the year prior to the year of death. Individuals with missing information regarding disposable income during a given year (on average, 0.19% of the total) were excluded from the analysis for that year. Observations with negative income ($n = 34{,}718$) were set to 0. Older adults were ranked based on disposable income relative to all other individuals of the same sex and age for each year and categorized into quartiles. To reduce estimation errors, income quartiles were stratified only by sex (but not age) for individuals aged 95 or older.

The mean age of retirement in Sweden was 64.7 years in 2006, and 64.6 years in 2015 (Pensionsmyndigheten 2019). Thus, most of the individuals in this study rely on a pension for the bulk of their income. This means that while there may be some variation in individual incomes owing to exogenous factors (e.g., late retirement, bereavement, liquidation of assets), the income is less likely to be affected by health decline, especially in the older age-groups.

Level of Neighborhood Deprivation

Neighborhood deprivation was assessed using several sociodemographic indicators calculated for each of the ~9,000 Small Areas for Market Statistics (SAMS) from Statistics Sweden. SAMS are the smallest geographical unit in Sweden, with an average population of ~1,000 inhabitants (from less than 200 in the most rural areas to more than 2,000 in the Stockholm area). Year-specific estimates of neighborhood deprivation were assessed using four indicators: (1) average disposable income (reverse-coded, so that higher values indicate lower incomes); (2) proportion of the population aged between 20 and 64 registered as unemployed; (3) proportion of the population aged 25 or older with less than three years of tertiary education; and (4) the proportion of foreign-born individuals in the total population.

The first three indicators reflect three domains used in the commonly applied English Index of Multiple Deprivation (IMD): "income deprivation," "employment deprivation," and "education, skills and training deprivation" (Departments for Communities and Local Government 2015). The fourth indicator—the proportion of foreign-born in the area—is included to reflect the fact that, in Sweden, foreign-born individuals are much more likely than native-born individuals to experience a range of different social problem configurations, including unemployment, low education, social assistance recipiency, and mental health problems (Fors et al. 2019).

All indicators were standardized to have a mean of 0 and a standard deviation of 1 (z scores) and were then, in turn, included in a principal component analysis to generate a single, composite neighborhood deprivation score. SAMS were then ranked according to deprivation score and divided into quartiles, ranging from the least deprived (Q1) to the most deprived (Q4). We also verified that the association between level of neighborhood deprivation and mortality followed a gradient, where mortality was highest in the most deprived neighborhoods and lowest in the least deprived neighborhoods (data not shown). Because older adults may have changed location during the study period, their area of residence was assessed annually.

Life Table Estimates

Life expectancies at ages 65, 75, and 85 were first calculated for each year separately, depending on sex and income quartile, using period life tables derived from the observed mortality rates in the total study population (Rowland 2003). A second set of year-specific life expectancy estimates was then constructed for every combination of sex, income quartile, and level of neighborhood deprivation. These estimates allowed not only for the assessment of differences in remaining life expectancy across subgroups, but also for the evaluation of trends over time in each of these subgroups. Confidence intervals around life expectancy estimates were constructed using Monte Carlo simulation, based on the work of Andreev and Shkolnikov (2010). Calculations were performed in R version 3.6.1 with the "LifeTableFUN" suite of functions written by Camarda (2015). To limit the influence of outliers in smaller population groups, variance was calculated while truncating age at 100 years.

In addition, we analyzed differences and trends in the mean age at death and life span variation during the study period, by using the expected number of people who die at age x (dx) obtained from the life tables referred to above. The estimation of dx is based on a simulation, in which a hypothetical cohort of 100,000 individuals aged 65 experiences the observed mortality rates at each subsequent age during a given year (cf. Sasson 2016). On the basis of this simulation, we calculated the proportion of deaths expected to occur at each age, the mean age at death conditional on survival to age 65 (μ65), and the variance (standard deviation) around the mean age at death conditional on survival to age 65 (S65). These three parameters were calculated for each income group during each year.

Sensitivity and Post Hoc Analyses

In prespecified sensitivity analyses, we tested the robustness of the association between income and old-age life expectancy with three distinct variants of the main analysis. First, we considered the individual disposable income of each person, instead of the disposable household income per consumption unit, which was expected to produce greater contrast between men and women (Figure A1, online appendix). Second, we excluded those with a negative income or no income during a given year, because these individuals are most likely to be in a specific socioeconomic situation that does not necessarily reflect their daily standard of living (Figure A2, online appendix). Third, we constructed an additional set of life tables stratified by sex, income quartile, level of neighborhood deprivation, and degree of urbanicity of each SAMS (Figures A3-1, A3-2, and A3-3, online appendix). We hypothesized that the gradient observed across income quartile and level of neighborhood deprivation may differ in large cities (800 or more inhabitants per km^2) compared with semi-urban areas (100–799 inhabitants per km^2) or rural areas (fewer than 100 inhabitants per km^2).

We also decided to conduct a series of non-prespecified post hoc analyses to further explore variations in the association between income and old-age life expectancy by examining the highest educational attainment of individuals (primary, secondary, or tertiary education) (Figure A4, online appendix). Education was missing for 62,015 people (2.3% of the total), who were therefore excluded from this analysis. Finally, our main analyses were replicated for 2015, using income percentile to increase the socioeconomic contrast between subgroups (Figure A5, online appendix). The complete Stata code used to produce these results, as well as the life tables generated from the raw data, are available for download (https://github.com/lucasmorin/income_life_expectancy).

Results

Descriptive Statistics

The study population comprised 17,409,578 person-year observations for individuals aged 65 or older who lived in Sweden between 2006 and 2015. The mean age was 75.0 (SD = 7.9) years. Overall, there were 361,776 deaths among men (for a mortality rate of 4,633 per 100,000) and 419,288 deaths among women (for a mortality rate of 4,367 per 100,000).

Table 1 shows the sample characteristics for three years over the study period (2006, 2011, and 2015). There were more women than men in all three years, but the difference diminished slightly over the period. The mean age of the population decreased from 75.5 (SD = 7.8) in 2006 to 74.7 (SD = 7.8) in 2015. The mean disposable income increased from US$23,000 in 2006 to US$27,800 in 2015. Income inequality increased over time, whether measured using Gini coefficients, Atkinson indices, or percentile ratios (P90/P10). The number of deaths rose from 2006 through 2015, but mortality rates per 100,000 declined substantially among both men and

Table 1 Characteristics of the study population in 2006, 2011, and 2015, Sweden

Characteristic	2006	2011	2015
Number of Older Adults[a]	1,659,937	1,862,950	2,025,723
Number of Men (%)	725,544 (43.7)	842,460 (45.2)	932,780 (46.0)
Number of Women (%)	934,393 (56.3)	1,020,490 (54.8)	1,092,943 (54.0)
Age			
Mean (SD)	75.5 (7.8)	74.8 (8.0)	74.7 (7.8)
65–69, *n* (%)	474,155 (28.6)	629,088 (33.8)	651,759 (32.2)
70–74, *n* (%)	351,538 (21.2)	397,417 (21.3)	498,392 (24.6)
75–79, *n* (%)	317,600 (19.1)	310,095 (16.6)	346,752 (17.1)
80–84, *n* (%)	264,937 (16.0)	253,529 (13.6)	250,350 (12.4)
85–89, *n* (%)	167,148 (10.1)	173,946 (9.3)	170,847 (8.4)
90–94, *n* (%)	66,945 (4.0)	78,452 (4.2)	84,095 (4.2)
≥95, *n* (%)	17,614 (1.1)	20,423 (1.1)	23,528 (1.2)
Disposable Income (US$, thousands)[b,c]			
Mean (SD)	23.0 (30.2)	30.5 (49.7)	27.8 (76.2)
Median (Q1–Q3)	18.6 (15.4–24.6)	23.5 (18.6–33.2)	20.6 (16.0–30.0)
Inequality Indices[d]			
Gini coefficient	0.28	0.32	0.34
Atkinson index, A(2)	0.27	0.41	0.42
Percentile ratios, P90/P10	2.6	3.0	3.2
Number of Deaths			
Men	35,837	36,011	37,375
Women	41,743	41,584	42,034
Mortality Rate (per 100,000 per year)			
Men	5,263	4,554	4,236
Women	4,711	4,309	4,045
Life Expectancy at Age 65 (years)			
Men	17.8	18.6	19.0
Women	20.8	21.3	21.5

[a] Number of individuals alive on January 1 and aged 65 years or older (including people who turned 65 during the year).

[b] Disposable income per individual, adjusted for inflation to price levels in 2006.

[c] Conversion done using the Swedish Central Bank average exchange rate from January 1 to December 31 for each year.

[d] Inequality indices calculated from disposable income.

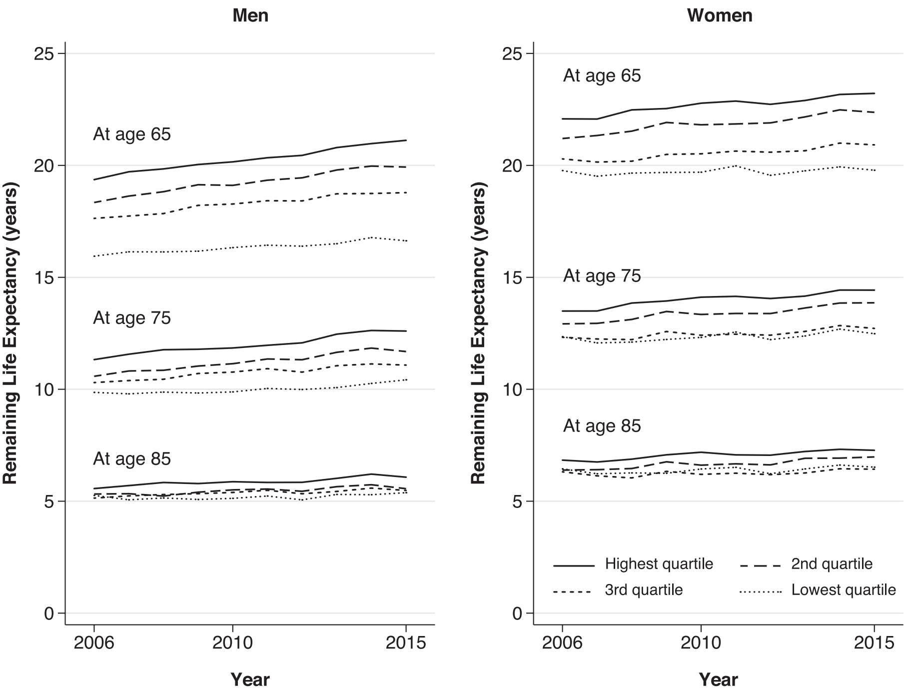

Fig. 1 Remaining life expectancy at ages 65, 75, and 85 by income quartile, for men and women in Sweden, 2006–2015

women. Overall, life expectancy at age 65 increased from 20.8 to 21.5 years among women and from 17.8 to 19.0 years among men.

Table A1 (online appendix) shows the proportion of older adults, in the different income quartiles, who were still receiving an income from work. There was a clear gradient in the likelihood of receiving an income from work after age 65, namely, that those in the higher income quartiles were more likely to receive such income than those in lower quartiles. Moreover, this gradient grew substantially steeper over the study period. Between 2006 and 2015, the proportion of the group that received at least 10% of their income from work increased from 2.9% to 4.1% in the lowest income quartile, whereas the corresponding proportion for the highest quartile rose from 13.1% to 22.8%.

Table A2 (online appendix) shows the mean age across the different levels of neighborhood deprivation. On average, those who lived in the most deprived neighborhoods were somewhat older than those who lived in the least deprived neighborhoods. This pattern was observed across all income quartiles.

Trends in Remaining Life Expectancy

Figure 1 shows remaining life expectancy at ages 65, 75, and 85, by sex and income quartile, from 2006 through 2015. Exact estimates and 95% confidence intervals are reported in Tables A3 and A4 (online appendix). The results show clear income inequality in remaining life expectancy at ages 65 and 75, for both men and women. Older individuals in the highest income quartiles (solid lines) had substantially longer life expectancy than

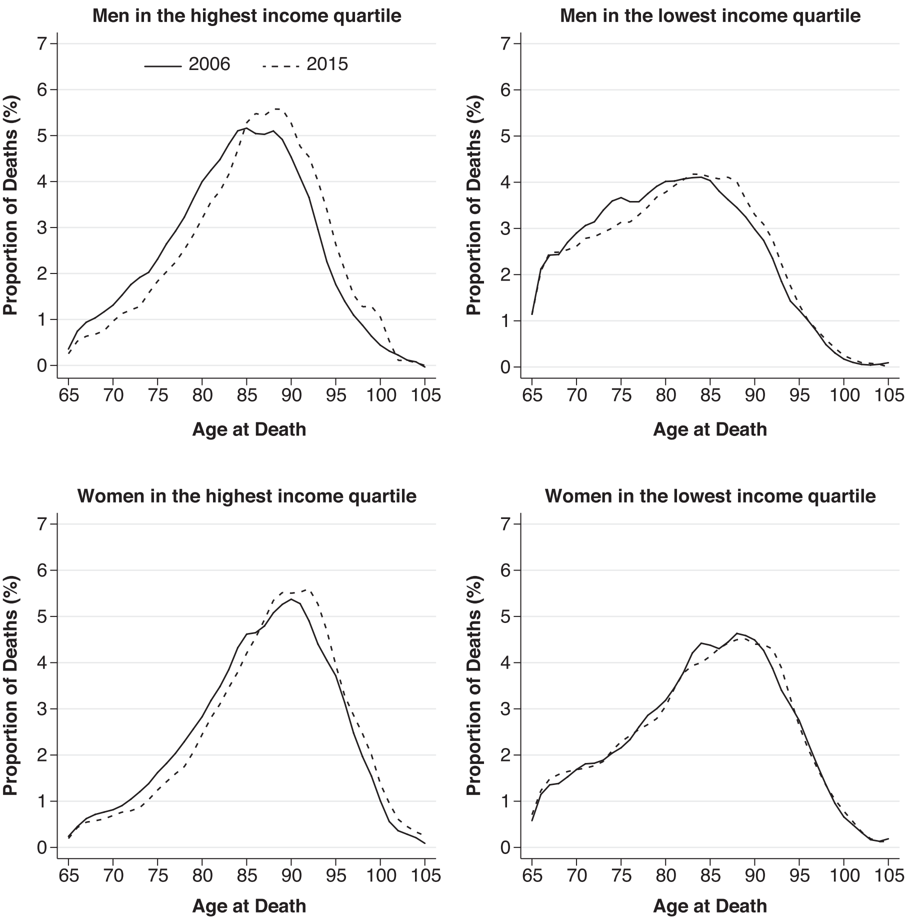

Fig. 2 Distribution of age at death for men and women in Sweden, 2006 and 2015, by highest and lowest income quartiles

those in the lowest quartiles (dotted lines). At age 85, absolute differences in remaining life expectancy were smaller but still noticeable, especially among women.

Moreover, income inequalities in old-age life expectancy increased during the period. The gap between the lowest and the highest income quartiles in life expectancy at age 65 increased by more than a year over the study period, among both men (from 3.42 years in 2006 to 4.49 years in 2015) and women (from 2.31 to 3.44 years, respectively). For life expectancy at age 75, the corresponding increase was 0.72 year for men (from 1.46 to 2.18 years) and 0.81 year for women (from 1.14 to 1.95 years). Finally, the gap between the highest and the lowest income quartiles in life expectancy at age 85 increased by 0.38 year among men (from 0.31 to 0.69) and by 0.36 year among women (from 0.39 to 0.75).

Trends in Life Span Variation

The next part of the analysis focuses on the distribution of death across the age span, the mean age at death conditional on survival to age 65 (μ65), and the standard devi-

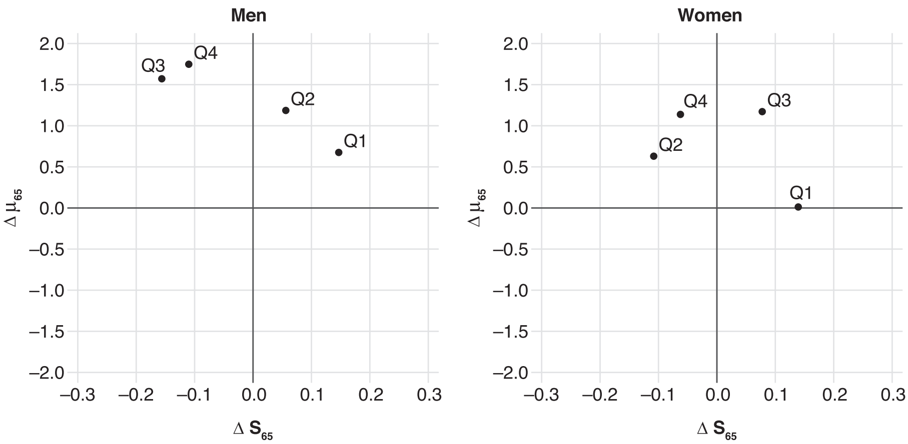

Fig. 3 Change in mean age at death (μ_{65}) and standard deviation around mean age at death (S_{65}) after age 65 by income quartile, for men and women in Sweden, 2006–2015

ation around the mean age at death conditional on survival to age 65 (S65). Figure 2 shows the distribution of death after age 65 for men and women, under the mortality conditions of the lowest and highest income quartiles in 2006 and 2015. The results show that in both years, the shape of the distribution differed for individuals in these quartiles. In the highest income quartile, a very low proportion of deaths occurred at age 65, but after that, the proportion increased continuously up to a peak, after which it declined continuously until the cohort was extinct. This pattern was similar for men and women. In the lowest income quartile, however, the proportion of deaths was already higher at age 65, and distribution was shallower and less peaked than among those in the highest quartile. This pattern was also observed for both men and women, but the difference in the shape of the distribution between the lowest and the highest income groups was starker among men.

Notably, there were income gradients in both mean age at death and life span variation throughout the period. Those with higher incomes had higher μ65, and lower S65, in all periods. Most groups also experienced an increase in μ65 during the period. Figure 3 shows the change in μ65 and S65 between 2006 and 2015 for men and women from all income quartiles (exact estimates are reported in Tables A5 and A6 in the online appendix). With the exception of women in the lowest quartile, all groups experienced a lengthening in μ65 over time. For both men and women, improvement followed a social gradient, namely, people in the highest income quartile experienced the greatest improvement, while those in the lowest quartile experienced the least improvement. There was no meaningful change in S65 for all income groups during the period.

For men in the highest income quartile, μ65 increased by 1.75 years (from 83.87 to 85.62), while S65 declined only marginally (from 7.63 to 7.53). For men in the lowest income quartile, the increase in μ65 was lower—0.68 year (from 80.45 to 81.13)—while S65 increased slightly (from 8.30 to 8.45). Among women in the highest quartile, μ65 increased by 1.14 years (from 86.58 to 87.72), while S65 hardly changed (from 7.78 to 7.72). Women in the lowest quartile saw virtually no improvement at all in μ65 (from 84.27 to 84.28), while S65 increased slightly (from 8.53 to 8.67).

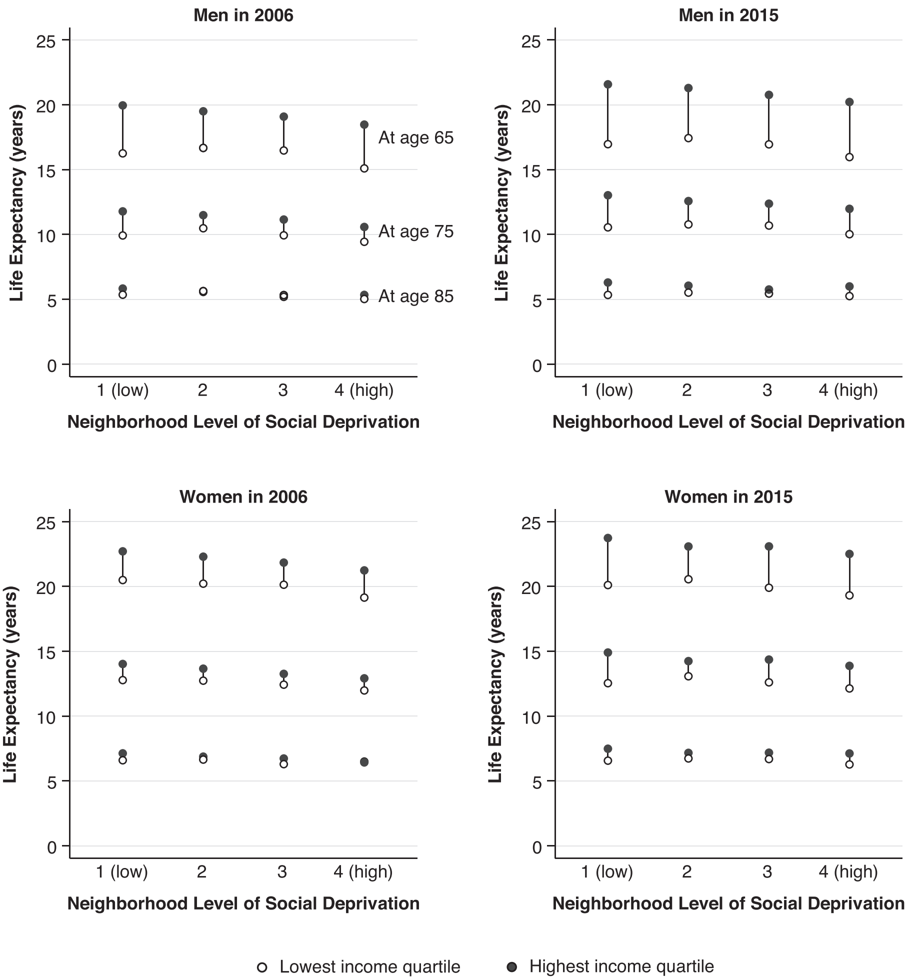

Fig. 4 Range plots of remaining life expectancy at age 65, 75, and 85 in 2006 and 2015, for men and women by income quartile and degree of neighborhood deprivation. Precise estimates and 95% confidence intervals are provided in Tables A7 and A8 in the online appendix.

Neighborhood Deprivation and Remaining Life Expectancy

In the final step of our analyses, we explored whether there were any differences in the gaps in remaining life expectancy at ages 65, 75, and 85 between the highest and the lowest income quartiles for men and women, when stratified by level of neighborhood deprivation. Results are depicted in Figure 4, and are available (with 95% confidence intervals) in Tables A7 and A8 (online appendix).

The results show that, at ages 65 and 75, there was income inequality in remaining life expectancy for both sexes, at all levels of neighborhood deprivation. At age 65, small, nonsystematic variations were seen in the magnitude of the social gradient across the different levels of deprivation. However, the overall gradient was at a lower level in areas characterized by higher levels of neighborhood deprivation,

Table 2 Heat map of changes in the remaining life expectancy at ages 65, 75, and 85 for men and women in Sweden, 2006–2015, by level of neighborhood deprivation and income quartile

	65 Years		75 Years		85 Years	
	Men	Women	Men	Women	Men	Women
Least Deprived Areas						
4 (highest income)	1.6	1.0	1.2	0.9	0.5	0.4
3	1.8	0.9	1.1	0.9	0.0	0.6
2	0.9	0.9	0.7	0.5	–0.3	–0.1
1 (lowest income)	0.7	–0.4	0.6	–0.2	0.0	0.0
Most Deprived Areas						
4 (highest income)	1.7	1.3	1.4	1.0	0.7	0.6
3	1.8	1.2	1.2	0.9	0.4	0.5
2	1.0	0.7	0.5	0.4	0.1	0.2
1 (lowest income)	0.9	0.2	0.6	0.2	0.2	–0.2
Total						
4 (highest income)	1.8	1.1	1.3	0.9	0.5	0.4
3	1.6	1.2	1.1	0.9	0.2	0.6
2	1.2	0.6	0.8	0.4	0.3	0.1
1 (lowest income)	0.7	0.0	0.6	0.1	0.1	0.1

Note: Colors reflect the relative magnitude of the change, ranging from dark green (most positive change) to dark red (least positive change).

showing that life expectancy tended to be shorter across all income quartiles in the more deprived areas. At age 75, income inequality in old-age life expectancy tended to be smaller in the most deprived areas compared with the least deprived areas. At age 85, the difference in remaining life expectancy was small overall, and not distinguishable across levels of neighborhood deprivation.

Table 2 shows the changes in remaining life expectancy for men and women at ages 65, 75, and 85 during the study period, by income quartile and level of neighborhood deprivation. The results show that, overall, all income groups experienced increases in life expectancy, which tended to be greater in the higher income groups. The stratified analyses revealed that some subgroups actually experienced a decline in old-age life expectancy over the period. For example, women in the lowest income quartile, living in the most affluent areas, experienced a decline in remaining life expectancy at all ages. Similarly, men in the two lowest income quartiles, living in the most affluent neighborhoods, experienced decreases in remaining life expectancy at 85. Among women living in the most deprived areas, those in the lowest income quartile also experienced a decrease in remaining life expectancy at age 85.

Discussion

Between 2006 and 2015, there has been substantial and increasing income inequality in the remaining life expectancy after age 65 in Sweden. The association between income and old-age life expectancy followed a clear gradient, in which those in the highest income quartile had the highest life expectancy, and those in the lowest income quartile had the lowest life expectancy. Similar differences, albeit smaller in magnitude, were also observed for remaining life expectancy at ages 75 and 85. Over the study period, the income gap in remaining life expectancy increased among both men and women.

These findings resonate with the conclusions from several studies that showed large and increasing income inequality in life expectancy in the general population (Chetty et al. 2016; Hederos et al. 2018; Kinge et al. 2019; van Raalte et al. 2018), and similar patterns have been observed in the older population (Congressional Budget Office 2014; Cristia 2009; Waldron 2007). The decreasing magnitude of the observed inequalities in higher age-groups is also in line with what has been reported previously (Rehnberg et al. 2019). This development has sometimes been attributed to the "age-as-leveler" hypothesis, which posits that, in old age, age itself becomes the primary determinant of health, while exogenous factors play a diminishing role (Dupre 2007; Rehnberg 2019).

The observed increases in income inequality in old-age life expectancy throughout the study period were primarily the result of a more rapid improvement in old-age life expectancy among those with higher incomes, compared with those with lower incomes. Women with low income living in the least deprived areas experienced a systematic decrease in remaining life expectancy at all ages during the period.

Three potential mechanisms have been suggested as potentially contributing to the increasing disparity in old-age life expectancy: social causation, behavior, and selection. First, it is well established that income inequality in the general population (and among older adults) in Sweden has increased considerably during the past decade (OECD 2017, 2019; Pareliussen et al. 2018). If income has a causal influence on the risk of mortality in old age in a dose–response pattern, we would expect that the increasing income inequality would lead to increasing income inequality in life expectancy during old age. However, the potentially causal nature of the link between income and mortality has still not been convincingly established (O'Donnell et al. 2015). Second, it is possible that the increasing inequality is driven—entirely or partially—by healthier lifestyles, living conditions, and more efficient adoption of health-enhancing technologies among those with higher incomes. This is in line with what would be expected under fundamental cause theory (Phelan and Link 2005), which has been summarized as "power and money seek out health improvements" (Deaton 2013a). The third mechanism suggested as a potential explanation is increasing selection into socioeconomic positions based on personal characteristics (Dowd and Hamoudi 2014; Mackenbach 2012). That is, as modern societies have developed in an increasingly meritocratic direction, the role of social background has become less influential on socioeconomic success, while personal characteristics such as intelligence, personality, and noncognitive traits have become increasingly important. To the extent that these characteristics are also associated with health and mortality, this increasing selection would be expected to lead to increasing socioeconomic disparity in health. It has even been suggested that the possibility of such selection makes the results from studies in which groups based on nonstable characteristics (e.g., income) are compared nearly impossible to interpret in causal terms (Dowd and Hamoudi 2014).

Both the "social causation" and "selection" hypotheses find some support in our results that older persons in the higher income quartiles were more likely than those in the lower income quartiles to receive an income from work in old age (and that this difference increased over the study period). On one hand, this may suggest increasing health selection over time among older adults in Sweden, in which frail older adults who were no longer able to participate in paid labor were increasingly likely to end up in the lower income groups. On the other hand, these findings are congruent with a scenario in which individuals in the higher income groups have better labor market opportunities to keep working into old age, and to thereby enhance their income advantage. While both scenarios offer different explanations for the increasing income gap in life expectancy, it is not possible to clearly distinguish between these mechanisms from the findings of the present study. However, the fact that similar patterns of increasing inequality in life expectancy are observed when socioeconomic groups are defined based on education rather than income suggests that these patterns cannot be explained solely by health selection in old age.

Our results also show that life expectancy after age 65 tended to be somewhat lower in socially deprived neighborhoods than in less deprived neighborhoods. However, the income gradient in life expectancy was largely stable across the different types of neighborhood. These findings can be interpreted in at least two different ways. First, there is the possibility that the associations between individual income and old-age life expectancy, and between neighborhood deprivation and old-age life expectancy, are shaped by different causal processes. That is, the hazardous consequences of living in a neighborhood characterized by high levels of deprivation strike uniformly across the different income groups. For example, issues of safety and lack of well-stocked grocery stores (i.e., "food deserts") are likely to affect everyone living in the area, regardless of their individual financial situation. It is also possible that this is a matter of residual confounding; both the measures of individual income and the approximation of the level of neighborhood deprivation are crude and thus unlikely to account for a significant proportion of heterogeneity. Moreover, because these aggregates are correlated, it is possible that some of the association found between level of neighborhood deprivation and old-age life expectancy actually reflects residual confounding by individual income, and vice versa. Yet the differences overall in life expectancy between income quartiles within the different types of neighborhood were greater than the differences within income quartiles across neighborhood types. Thus, we conclude that, in our cohort of older persons, individual income was a stronger predictor of old-age life expectancy than was neighborhood deprivation.

To summarize, we found substantial and increasing income disparity in life expectancy at ages 65, 75, and 85 in Sweden between 2006 and 2015. At the end of the study period, the remaining life expectancy at 65 was 21.1 years for men in the highest income quartile, compared with 16.6 years for men in the lowest quartile. The corresponding estimates for women where 23.2 and 19.8 years, respectively. These findings bring nuance to the often-repeated message of ever-increasing longevity. While most groups of older adults in Sweden experienced increased life expectancy between 2006 and 2015, there were considerable differences in the rate of improvement. Most importantly, women in the lowest income quartile did not experience any improvement at all in their life expectancy at age 65 during the decade-long study period. Notably, women with the lowest incomes, living in the least deprived areas, actually experienced a decrease in life expectancy over the period. These findings resonate poignantly with the recently observed decline in life expectancy among less educated women in the United States (Montez and Zajacova 2014). Future studies should address the causal mechanisms behind this development and why women with low incomes living in privileged neighborhoods seem especially vulnerable. One hypothesis is that compositional changes may hold part of the explanation. Progressively postponed and heterogeneous age of retirement is likely to make health selection an increasingly important driver of health inequality, even in old age. Older adults with health problems are more likely to retire early and live on pensions, while healthy older adults can boost their incomes by working longer. Because older women have more health problems than men, this development is likely to be crucial for women.

As this pattern of increasing income inequality in old-age life expectancy was continuously observed throughout the study period, it is likely that the present work gives us only a snapshot of a longer historical process. That is, this pattern likely started before 2006 and has continued after 2015. An important task for future studies will be to develop and test hypotheses about the causal mechanisms generating these empirical regularities, with a special focus on the slow progress among those with the lowest incomes. Similarly, the observed income inequality in old-age life expectancy is unlikely to reflect solely the development during old age but more likely to reflect inequalities accumulated throughout the life course.

Strengths and Limitations

To our knowledge, this is the first study to track income inequality in old-age life expectancy over time in Sweden. As the study is based on data for the total population, and the indicators used are manifest and measurable, we believe that our study provides a reliable account of the development in income disparity in old-age life expectancy and life span variation during the period. Yet this study has several limitations and the results should be interpreted with caution.

First, these are descriptive analyses. The nature of the study prohibits us from drawing any conclusions in terms of the causal nature of the observed associations. This kind of conclusion would require a different study design that would enable us to account for nonrandom selection into the different income quartiles. Nevertheless, the study offers a reliable account of the income differences in old-age life expectancy, and how these differences developed in Sweden over a decade. As such, we believe the study is important in its own right, because it provides a detailed account of a range of empirical regularities for future studies to address (Goldthorpe 2015).

Second, we only had access to data for persons aged 65 years or older. While this is enough to analyze inequalities in remaining life expectancy in old age, we were not able to assess prior events in these cohorts of older adults. For example, conducting analyses of mortality selection to age 65, or using cumulative life course measures of income or maximum life span income rather than current income, might have been informative in terms of the social and demographic mechanisms underpinning the observed patterns. Although this was not feasible with the data available, our analyses can give some indication of the role played by earlier mortality selection and socioeconomic conditions. It has been suggested that decreasing age truncation (as a greater portion of each subsequent birth cohort survives to old age) will lead to increased heterogeneity in life span variation in the older population (Engelman et al. 2010; Fries 1984). Because mortality rates are higher in low-income groups, it is likely that the age truncation is stronger in those groups. This could not be examined in the present study, but it is worth noting that our results revealed no substantial change in the within-group life span variation for the different income groups during the study period. In addition, previous analyses have shown similar patterns for educational groups (i.e., groups unlikely to be susceptible to transition after age 65) (Statistics Sweden 2020). This suggests that the observed development is unlikely to be entirely attributable to health selection in late adulthood.

A third limitation arises from the categorization of income into quartiles. Dividing the income distribution into only four groups evidently leads to the omission of a vast amount of variation in income. To the extent that this variation is associated with mortality in the same way as the grouped income used in the study, we could be substantially underestimating the total inequality in old-age life expectancy by income. As expected, in post hoc analyses in which disposable income was categorized into percentiles instead of quartiles, inequality in life expectancy was of a greater magnitude (although not to such an exceptional degree as in the United States, as reported by Chetty et al. (2016)). It is also important to keep in mind that we based the classifications on household income per consumption unit, rather than on individual income. The rationale for doing so was that a previous study of social class inequality in mortality in Sweden showed that among women it was underestimated when an individual measure was used, rather than a household-based measure (Erikson 2006). However, the results from our sensitivity analyses suggest that an income measure based on individual income produced similar results.

Fourth, we measured neighborhood deprivation at the SAMS level. However, the SAMS neighborhood division has been criticized for not efficiently delineating real and homogeneous residential neighborhoods (Amcoff 2012). To the extent this is true, it may explain why we observed only minor associations between neighborhood deprivation and remaining life expectancy in the study. However, the SAMS neighborhood division has been used extensively in Swedish research, and has been shown to be associated with a wide range of living conditions (cf. Andersson 2004; Edling and Rydgren 2012), including mortality (Oudin Åström et al. 2018a; Oudin Åström et al. 2018b). Moreover, the results from our sensitivity analyses suggest that the associations are robust across SAMS neighborhoods characterized by different levels of urbanicity. Our analyses also showed that, on average, those who lived in the more deprived neighborhoods were somewhat older than those who lived in the less deprived neighborhoods. This difference is partially addressed through the age standardization inherent in life table analyzes. Yet this might indicate that the older population in more deprived neighborhoods has been shaped by selective mortality to a larger extent than the older population in less deprived areas. This might have contributed to underestimating the association between the level of neighborhood deprivation and old-age life expectancy.

A final study limitation is that we estimated life expectancy based on period life tables. Hence, the remaining life expectancy at a given age, and at a given time, does not reflect the life expectancy of any real-life cohort. Rather they are calculated on the assumption that the age-specific mortality rates for the given period will remain frozen in time, as an artificial cohort is allowed to age to extinction under those conditions. Historically, this has meant that period life expectancy has tended to substantially underestimate the actual life expectancy, experienced by real-life cohorts, as mortality has fallen over time (Deaton 2013b). As shown by the increasing life expectancy observed in this study, this was true also for the period covered by our study.

Similarly, the analyses are also insensitive to transition across income quartiles after the age of 65. To the extent that such transition is selective in terms of health and risk factors for health problems, this is likely to lead to inflated observed inequalities in life expectancy. Nevertheless, this is unlikely to entirely explain our findings as other analyses of inequality in later life (e.g., life expectancy by educational attainment, which is less susceptible to transition in old age than income) have shown similar patterns in terms of the magnitude and development over time (Statistics Sweden 2020). Yet this underscores the fact that life expectancy should be interpreted as a summary population metric of mortality during a specific period, rather than a survival prediction that applies to single individuals.

Conclusions

Overall, the results clearly show that there was substantive, increasing income inequality in old-age life expectancy in Sweden in the decade from 2006 to 2015. While level of neighborhood deprivation was negatively associated with old-age life expectancy, the income gradient in old-age life expectancy was stable across the different types of neighborhood. However, it is worth noting that women with low incomes, living in the least deprived neighborhoods, actually experienced a decline in old-age life expectancy during the period. Taken together with the broader trend of stagnating old-age life expectancy among all women with low incomes during the period, these observations should be a cause for concern.

The trend of increasing income inequality in old-age life expectancy was observed in Sweden during a period in which Swedish society had lost ground in terms of life expectancy and continued to lose ground in terms of economic egalitarianism. This raises the question of whether there really is a "Nordic paradox," in which substantive inequalities in mortality coexist with financial egalitarianism or, rather, whether we are witnessing a general shift away from egalitarianism in the Nordic countries.

In a study of differences in total inequality in mortality across different types of welfare states, Popham et al. (2013) found that the Nordic countries had comparatively low mortality at younger ages, contributing to small total inequality in mortality and high life expectancy. Nevertheless, these nations did not do as well in terms of old-age mortality. Hence, it is also possible that the Nordic paradox simply does not apply to old-age mortality, perhaps because of lower rates of selective mortality at younger ages. This is a question left unanswered in anticipation of future research. ■

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