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Abstract

As with many social transfer schemes, pension systems around the world are often progressive: individuals with lower incomes receive a higher percentage of their income as a subsequent pension. On the other hand, it is well known that those with lower earnings have higher mortality and thus accumulate fewer years of pension income. These opposite factors, therefore, both contribute to the progressiveness of a given pension system. Thus far, empirical research efforts to disentangle the effects of mortality inequality on lifetime pension income have been scarce. To close this gap, we use Swedish taxation data linked with death registers from 1970 to 2018 to study how education and pre-retirement earnings relate to lifetime pension income from age 60 onwards, as well as how inequalities in mortality between groups contribute to overall inequalities in lifetime pension income. The results show that both a progressive replacement structure and mortality differentials contribute to the overall distribution of life-course pension payments. A substantial proportion of the total inequality in lifetime pensions can be attributed to the fact that socially advantaged groups live longer, and this is particularly true for men. Mortality differences can explain up to 28% of the lifetime pension benefits between socioeconomic groups. We conclude that inequalities in mortality play an important part in determining the overall degree of between-group income transfers in a pension system.

Keywords: Pension progressivity, social stratification, retirement, Sweden, mortality inequality, decomposition analysis

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Introduction

A large body of literature has considered the substantial and persistent socioeconomic gradient in mortality risks and longevity. One implication of socioeconomic gradients in mortality is their effect on redistribution through state-regulated programs such as healthcare and pension systems. Demographers are interested in mortality gradients and have examined how population aging differs by SES (Guralnik et al. 1993; Majer et al. 2011), yet how differential mortality affects pension benefits has been examined less. More specifically, do individuals with lower socioeconomic status (SES) benefit less from these programs due to their higher mortality risks?

The combination of three factors determines individual accumulated pension over the life course. First, the *mortality gradient* results in that individuals with higher SES live more years, and accumulate more pension. Second, the overall redistribution also depends on *prior contributions* to a pension system (based on pre-retirement earnings), and third, the explicit *progressive nature* of its programs (i.e., the higher the earnings, the lower the proportional benefits). While the former provides greater benefits to those with higher SES, the latter does the same for those with lower SES. The relative importance of these three factors is far from self-evident.

Pension progressivity—the extent to which the system redistributes toward lower income earners—has conventionally been studied by comparing replacement rates across earnings groups (e.g., Whitehouse 2006; Dudel and Schmied 2019). The replacement rate is defined as the proportion of labor earnings that is translated into retirement pension income. Higher replacement rates mean more benefits with respect to prior contributions, which are often tied to labor earnings. In contrast, a cohort-based life-course analysis may modify the association between SES and annual benefits, as it introduces the additional factor of mortality, which counteracts progressivity on an annual basis. Recent research has highlighted the detrimental effects of SES mortality differences using various methods (e.g., theoretical models, simulations), all leading to the same qualitative conclusions: SES mortality differences increase the inequality in lifetime pension benefit and impede the progressivity that is usually conceptualized on an annual basis without considering SES-specific mortality patterns (e.g., Sánchez-Romero and Prskawetz 2020).

Understanding inequality in lifetime pensions is relevant from a policy-making point of view. For policymakers, progressivity of pension systems is often a policy goal. Yet this does not afford the same level of progressivity for the entire cohort over the life course if the system only considers replacement among *living* retirees compared to their previous incomes. An interesting question is, therefore, which groups benefit (more) from pension systems when longevity varies? The answer depends not only on replacement rates but also on cohort mortality inequalities between members with different social characteristics, and this may differ by gender, cohort, and SES dimensions (e.g., income, education).

In this paper, we use five decades of high-quality Swedish national taxation records on earnings and pension payments from 1970 to 2018 to examine how lifetime pension income is structured across different socioeconomic groups. We aim to disentangle the total inequality in lifetime pension income between various social groups (based on gender, education, and pre-retirement labor earnings) into the parts that are due to differences in annual pension income and differences in mortality, both in the form of age-specific components.

While previous research has documented that mortality affects lifetime pensions, we expand on the literature in several ways. Prior research has not used complete individual-level data that link earnings, pension income, and age at death. This is to a large extent due to the unusually long span of data required for these kinds of lifetime analyses. Additionally, the role of mortality on lifetime pension inequality has mostly been examined by counterfactual analysis, i.e., recalculating lifetime pension based on hypothetical mortality regime (e.g., OECD 2017; Sánchez-Romero et al. 2020), not decomposition techniques that yield additive terms that sum up to the total lifetime pension inequality, and age-specific contributions of mortality differences to the overall lifetime pension are unknown.

Methodologically, our life-table-based decomposition is a novel approach that not only presents age-specific components of total mortality effects but also additive effects of pre-retirement earnings and replacement rates. Data-wise, we measure actual values of lifetime pension payments of real birth cohorts with high-quality register data that—unlike surveys that often suffer from missing values and reporting bias—provide an accurate picture of an entire population. Substantively, our results can inform policymakers who are attempting to balance the goals of social equity and (demographic) actuarial fairness. Furthermore, we shed new light on the literature on income stratification in later life. As the share of older adults in the population increases almost everywhere in the world and given that pension income is the main source of income for most older people, reducing poverty among older adults is becoming ever more important. The share of state budgets allocated to pensions is rising throughout an aging world; at the same time, inequality in pension payments is becoming an increasingly important aspect of income inequality over the life course.

Background

What is the Function of Pension Systems?

Pension systems in contemporary high-income countries serve many different goals, including (a) helping individuals redistribute resources over their life courses from working age to old age; (b) protecting individuals from poverty in old age; and (c) providing insurance and reducing variance in monthly old-age income, no matter if an individual lives unusually short or long. A final goal, (d), is transferring money from individuals with higher incomes to those with lower incomes as an integrated part of larger tax-funded and mandatory government welfare systems, thus helping to meet the requirements of (a), (b), and (c) above. In traditional typologies of pension systems in OECD countries, some systems are described as "Bismarckian", where the system is oriented towards income replacement (goals a and c), while others as "Beveridgean", with a focus on poverty protection (goal a) with less emphasis on relating pensions to previous earnings (Ebbinghaus 2021).

While meeting the first goal of life-course transfers does not necessarily involve any impact on between-individual inequalities, the remaining aspects all involve varying degrees of redistribution between individuals. For instance, goal (c), also known as risk pooling (Ayuso et al. 2017), may counteract the other goals of the pension system if those individuals with unusually long lives are concentrated in high-income groups, as we examine in this article.

In theory, everyone could individually buy private pension insurance during working age, which upon retirement would be translated into annuities from their own savings through an open market, thereby fulfilling goals (a) and (c). Yet, this has never been practiced at the societal level; countries have instead relied mostly on family care (among countries with lower incomes), which has been gradually replaced by public pension systems as countries become richer. For privately funded pension systems, it is hard to create actuarially fairly funded pension insurances due to several factors: mortality differences between genders and socioeconomic groups; difficulties in forecasting future mortality; the great efforts required to maintain a pension scheme over multiple decades; and the risks involved in providing such insurances. As a consequence, all OECD countries (with the partial exception of Chile) have public pension systems through taxes on working-age individuals that are transferred to pensioners (the so-called Pay-As-You-Go or PAYGO system) and/or mandated (and often tax-favored) pension savings for individuals (Whitehouse 2006) to meet the various goals of a pension system.

Reducing inequality at older ages is intrinsic in most pension systems. Indeed, the initial motivation for all pension systems (particular those of the "Beveridgean" tradition) was to eliminate poverty among older adults and to ensure a certain level of living standard for them. Pension systems thus protect against socially unacceptable social deprivation among the very old who can no longer work. As individuals live longer beyond retirement ages, however, it has become less realistic for some to be able to save adequate resources during their working years and fund their retirement accordingly. While high-income earners have other means to ensure financial security in later life, this point is particularly relevant for low-income earners who are more heavily reliant on public pension schemes (GAO 2019). As pension income is a major source of old-age income, and due to the equalizing nature of public pension systems, the proportion of total old-age income out of public pension transfers partly explains income inequality in old ages (Brown and Prus 2004).

Types of Redistributions and Inequalities

To achieve the aforementioned goals of pension systems, different types of redistributions are involved; accordingly, redistribution and inequality can be assessed for different comparison groups. In systems where working-age individuals fund the current retired population, the contributions and total benefits of one generation tend not to be equal, meaning that *intergenerational redistribution* is inevitable, which further stimulates discussions on pension fairness across cohorts. Many studies have focused on this aspect, particularly whether the overall system is sustainable with an aging population following declining fertility and mortality (Howse 2007; Lee and Mason 2011). Other research has focused on pension reforms and differences between funded and non-funded systems (Sinn 2000). We do not elaborate on either of these aspects in this study, but instead focus on the redistribution between individuals of the same cohort, that is, *within-generation, interpersonal redistribution*. Such inequality comes from multiple sources, including differences in labor income, the extent to which labor income can be translated to pension income, and mortality. Mortality is crucial as it determines the length of pension accumulation. Although our focus is on interpersonal redistribution and inequality, understanding *intrapersonal redistribution* (i.e., redistributing income from working age to old age over the life course) is also integral to our lifetime analysis.

We here summarize three important determinants of within-generation inequality. First, pre-retirement labor income is likely to be the most important determinant, as pension income is tied closely with labor income. Higher inequalities in the distribution of labor earnings are likely to result in higher annual as well as lifetime pension incomes. Consequently, if men enjoy higher labor income inequality compared to women, they are likely to have higher pension incomes, on an annual as well as a life-course basis.

The second determinant is the extent to which the system redistributes income from the rich to the poor, often examined by replacement rates. Such redistributive effects of public pension programs, like other government programs, tend to be measured on a yearly basis (Nelissen 1998). Significantly, this ignores the fact that individuals face differential mortality risks and thus differ in the total number of years that they can receive a pension.

The third determinant of lifetime pension is lifespan; the longer individuals live, the more years they can benefit from the pension system. This reflects the risk-pooling nature of pension systems, which protects individuals against uncertainty around how long they will live. With such an instrument, individuals do not risk using up their money long before they die or having unintentional property left upon their death (Ayuso et al. 2017). Consequently, a pension system redistributes money from the shorter-lived to the longer-lived.

Many studies have found that people with higher SES live longer, on average, than those with lower SES (Brønnum-Hansen and Baadsgaard 2012; Mackenbach et al. 2018). The SES gradient in mortality exists even in today's low mortality regimes, although the exact magnitude varies between countries. For example, US men in the top 1% income distribution have been found to live 14.6 years longer than those in the bottom 1% in 2001–2014 (Chetty et al. 2016). Indeed, in many OECD countries, the SES gap has been growing (Kravdal 2017; Meara et al. 2008; Östergren 2015; Permanyer et al. 2018).

Existing Research on how Mortality affects Pension Inequality

Researchers have examined the regressive effects of mortality inequality on the overall redistribution of pension systems, beginning with Aaron (1977), and including studies by organizations like the OECD (2017). Most studies have focused on the US context, with a few others from European countries. While previous studies have used different approaches, they have typically shown that mortality contributes substantially to making pension systems more regressive.

In the US, research has found that due to a mortality gradient, higher SES individuals derive greater benefit from specific welfare programs such as Social Security and Medicare (Goldman and Orszag 2014). The National Academies of Science, Engineering, and Medicine simulated individual life histories for two cohorts (1930 and 1960), finding that the gap in lifetime Social Security benefits between men in the top and bottom income quintiles increased from US$103,000 to US$173,000 across the two cohorts. This was attributed to the growing inequality in life expectancy: projected life expectancy at age 50 increased in the top quintile (from 31.7 to 38.8 years) but decreased in the bottom quintile (from 26.6 to 26.1 years) across the two cohorts (NASEM 2015).

The OECD (2017) examined lifetime pensions across its member countries, assuming a three-year difference in life expectancy between low- and high-income earners and an arbitrary ratio of earnings between them (50% and 200% of average earnings, respectively). The study found that the differences in lifetime pension between low- and high-income earners vary between 10.6 and 16.6% across OECD countries. In reality, the actual magnitude of life expectancy differences between these income groups may be different from that of three years. Nevertheless, fixing the differences at three years is useful to show that the impact of life expectancy gaps is widespread and suggests that the magnitude of lifetime pension inequality is subject to policy differences.

Lifetime pension inequality and mortality has been examined using simulations, often in the context of pension reform, as more and more countries have moved from defined benefits to (notational) defined-contribution pension systems. Lee and Sánchez-Romero (2019) found that a notational defined-contribution (NDC) system using cohort- and income-specific life tables leads to the lowest level of lifetime pension inequality in the US context; a defined-benefit (DB) system with progressive replacement or an NDC system with cohort- but not income-specific life tables shows slightly higher lifetime pension inequality levels; a DB system with a flat replacement rate shows the highest inequality. Thus, the authors conclude that an NDC system should use an income-specific life table to reduce lifetime pension inequality, and a DB system should move toward a more progressive replacement rate arrangement. Theoretical models based on lifecycle hypotheses that incorporate individual behavioral responses (e.g., timing of retirement) have also yielded similar findings (Sánchez-Romero et al. 2020).

In prior research, different approaches have been used. Theoretical analyses have been used to understand the variations of lifetime pension inequality under different pension systems, such as defined-benefit vs. defined-contribution systems (Pestieau and Ponthiere 2016; Sánchez-Romero et al. 2020). Studies have also estimated SES-specific expected lifetime pension income based on SES-specific life tables and pension formulae (OECD 2017; Olivera 2018); notably, inputs are often not from data linked at the individual level, but rather aggregated from different sources or arbitrary SES-specific inputs. This approach is useful for cross-country comparisons where harmonized microdata are unavailable. Another approach uses microsimulation to construct hypothetical cohorts, where mortality and labor force participation transition rates are often obtained from different data sources and future rates are forecasted (Goldman and Orszag 2014; Hurd and Shoven 1985; NASEM 2015; Nelissen 1998). As with theoretical models, the simulation approach can also be used to examine how different pension systems affect lifetime pension inequality (Lee and Sanchez-Romero 2019). An additional advantage of simulation is the possibility of including multiple cohorts to analyze the trend of inequality across cohorts, though whether future trends are consistent with simulations is unclear (Goldman and Orszag 2014).

On the other hand, only a few studies are able to directly derive estimates of lifetime pension inequality from individual-level microdata with rich information rather than simulated data. Using samples of German pension data, Haan et al. (2020) found that, by using a lifetime approach, the German public pension system is regressive between groups on the basis of lifetime earnings (i.e., transferring money from low to high lifetime earners). Their analysis also shows that—with a widening gap in life expectancy between lifetime earnings groups—the system is becoming increasingly regressive across cohorts. We also resort to imputing pensions and mortality at very old ages, but these represent only a trivial share of our person-years under study.

Research Gaps and Contributions

Thus far, no study has analyzed lifetime pension inequality based on the *actual* experience of birth cohorts due to data limitations. The long series of individual-level linked administrative data are not subject to the problems that typically affect surveys, such as missing values and reporting bias, especially for income variables. Hence, one major contribution of this study is to provide precise, empirical evidence of the regressive role of the mortality gradient.

Methodologically, our combination of the life table approach with the decomposition technique is a novel addition to lifetime pension inequality research. This analytical framework can answer research questions that have not been well answered to this point. First, how large are the contributions of mortality inequality and pre-retirement earnings to lifetime pension inequality? In most government pension systems, whether they are based on mandatory savings or a DB or NDC system, pension income is highly correlated with pre-retirement labor income, and therefore a large proportion of lifetime pension inequality results from inequality in pre-retirement labor income. Our decomposition method disentangles total lifetime pension inequality into additive components due to mortality differences, pre-retirement earnings differences, and replacement rates. Second, how do mortality differences at a given age affect lifetime pension inequality? Existing evidence suggests that mortality inequality between SES groups becomes smaller with increasing age (Hoffmann 2011; Rehnberg 2020), yet it is unclear whether the importance of mortality inequality as a factor in lifetime pension inequality declines over age. We calculate additive age-specific components of the three sources of lifetime pension inequality (i.e., mortality, earnings, and redistribution).

While the majority of the existing research refers to the US context, less is known about countries with contrasting pension systems, such as Sweden. Our study is also conceptually different from previous research in that we capture all sources of pensions (income-related government pensions, guaranteed pensions, collective-agreement pensions, disability pensions, and widowhood benefits) and provide a holistic view of the entire Swedish social security system. As such, our study provides a comparison point that shows how an entire national pension system works, rather than evaluating individual components of a (government) pension system (e.g., US Social Security). Unlike many prior studies that examine specific pension programs, this is both a drawback and an advantage. The drawback is that this study is not useful for evaluating any individual sub-component of a given pension system; the advantage is that we are able to assess its overall societal redistribution.

The Swedish Context and Pension System

For most of the 20th century, life expectancy in Sweden ranked among the world's highest, although this is no longer the case in recent decades (Drefahl et al. 2014). Male mortality remains low from an international perspective, while female mortality is average according to OECD levels (Drefahl et al. 2014). Sweden is often described as a universalistic welfare state and as an exemplar of the social democratic regime in Esping-Andersen's (1990) typology of welfare states. At the time of our study, Sweden offered a generous public pension system, but occupation pension systems linked to collective agreements covering the majority of the population were also important (Palme 2005), and could broadly be described as "Bismarckian". A detailed overview of the Swedish pension systems for our cohorts is provided in Appendix A.

The statutory retirement age was 65 for our cohorts, although it was possible (and common) for individuals to access many of their retirement benefits from age 60 (Hagen 2013). Our pension variable covers a wide selection of first- and second-tier pensions (Whitehouse 2006), including other pensions targeted at individuals with special needs (such as widow pensions), but it does not cover various sickness and disability pension schemes targeted at ages before the statutory retirement age. For the cohorts analyzed, it was possible to save in private annuities, or "pension insurance", with different tax rates depending on the saver's circumstances. Private pensions (paid out as a normal pension) would be taxed as other pension income and are included in our pension variable. However, private pensions are rare; they reflect less than 2% of all pension payments for cohorts born before 1928 (as measured in 2018; Pensionsmyndigheten 2020) and have only a minor impact on our overall pension variable.

Data and Methods

Data

Our analyses draw on two administrative datasets: tax and death registrations, which are linked with a unique personal ID number. Our sample is restricted to all individuals born in Sweden in the years 1920 and 1925, conditioned on having never migrated after age 50 and surviving to age 60. Our data contain individuals' yearly labor earnings and pension income, both derived from taxation registers. The main outcome variable is lifetime pension income, which includes state pensions, employer-financed pensions, and private pensions (private ones being a very small share, see background), as described in the earlier section. Our measure of pension income is restricted to ages 60 and above; lifetime pension is thus conditional on surviving to 60.

We examine two socioeconomic factors: education and pre-retirement labor earnings. The education variable is constructed from education registers and based on the highest qualification obtained out of three levels: primary, secondary, and tertiary (and above). We group individuals into earnings quintiles based on (pre-tax) labor earnings between age 50 and 59, and the grouping is done by gender. Ideally, we would have included earnings of younger ages for grouping, but this was not possible due to data limitations. Grouping based on lifetime earnings (i.e., earnings over the entire work history) may lead to different results, though at the time of study, the Swedish pension system was based on income during the "best" 15 years (in practice often around age 50-59) and not lifetime earnings. Our average annual earnings over these ten years include years with zero earnings; however, excluding years with zero earnings when calculating the average annual earnings led to very similar results. Both pre-retirement earnings and pension income are shown in the unit of 1,000 Swedish krona (SEK). The exchange rate of SEK to the USD varied over the period, with an average of around 8 SEK to 1 USD.

Our last year of observation for death records is 2019, at which time a certain number of individuals were still alive. In the 1920 cohort, 1,658 (1.6%) out of 103,712 individuals survived to 2020 (age 99), and 8,387 (10.2%) out of 82,074 individuals for the 1925 cohort survived to 2020 (age 94). To compute the complete lifetime pension income, we assume pension income to be constant with the last three years' average over subsequent years.[1]

[1] This assumption is reasonable since inflation-adjusted pension income is relatively invariable over time, as we will show later. We use the gender-specific mortality rates forecasted by Statistics Sweden (2020) for ages that are not observable (100 and above for the 1920 cohort, 95 and above for the 1925 cohort). Within each gender, we calculate mortality rates for socioeconomic groups by assuming relative mortality differences (i.e., mortality ratios) between socioeconomic groups in future years to be the same as those observed in the most recent five years, while matching the total sex-specific mortality rates with those forecasted by Statistics Sweden. The potential bias in our assumption should be minor for our estimates of lifetime pension at age 60, given that only a small proportion of individuals survived to 2020 from the two cohorts.

Lifetime Pension Income

Our analyses are based on the cohort life tables. For each gender, cohort, and education/earnings group, we construct a life table from age 60 to age 105+. Then, we add a column of age-specific pension income (pen_x) to the life table to calculate lifetime pension income. The lifetime pension, conditional upon surviving to 60 (LP_{60}), is calculated as follows:

$$LP_{60} = \sum_{60}^{terminal\ age} L_x \times pen_x$$

where L_x is the life table person years lived in the age interval [x, x+1). L_x can be seen as a function of age-specific mortality rates. Therefore, LP_{60} is a function of a vector V denoted by $LP_{60} = f(V)$, where

$$V = [v_1, v_2, \dots, v_n] = [m_{60}, m_{61}, \dots, m_{105+}, pen_{60}, pen_{61}, \dots, pen_{105+}].$$

For the pension income as well as pre-retirement labor earnings, we adjust for inflation with 2018 as the base year.

Some prior studies have included a discount rate in the calculation of lifetime pensions as they focus on the actuarial sustainability of pension systems (e.g., NASEM 2015; Whitehouse 2006; Whitehouse and Zaidi 2008), which results in adding less weight to pensions paid to individuals at older ages. We do not include a discount rate in our main results, as our primary interest is in the received money flows in the pension system, and accumulating non-discounted values are standard for studies of social stratification in the social sciences. To provide comparability with previous studies focusing on pension sustainability, we present additional analysis with a discount rate of 2% in the Appendix (2% was chosen to approximate wage growth over the period). We chose 2% as it approximates the GDP/capita growth and wage growth over the period, and since overall income growth determines the long-term financial sustainability of a pay-as-you-go system (Samuelson 1958).

The life table approach first aggregates individuals by their lifespan, and then calculates the average lifetime pension. This approach essentially gives the same result as directly taking the average of individual accumulated pension over lifetime (i.e., without aggregating by lifespan first), whereas the variation across individuals of the entire population calculated from a life table approach (e.g., Olivera 2018) can be different from direct individual calculations, since aggregation by lifespan in a discrete life table reduces individual variations within one-year groups.

Decomposition

Our main interest is to understand the extent to which differences in mortality between socioeconomic groups contribute to total differences in lifetime pension. To achieve this goal, we apply the decomposition method developed by Horiuchi, Wilmoth, and Pletcher (2008) to disentangle the total difference in LP_{60} into the components due to differences in mortality and in age-specific pension income. Our LP_{60} can be seen as a differentiable function of the elements in V. The method assumes that the differences between two groups (LP_{60}^1 and LP_{60}^2) are due to continuous changes between them. The total difference can be expressed as follows:

$$LP_{60}^2 - LP_{60}^1 = \sum_{i=1}^{n} \int_{v_i^1}^{v_i^2} \frac{\partial f}{\partial v_i} dv_i = \sum_{i=1}^{n} c_i \,,$$

where c_i is the part of the difference between LP_{60}^1 and LP_{60}^2 that can be solely attributed to the difference in v_i (i.e., the difference between $v_i^1$and v_i^2). The decomposition process is analogous to decomposing healthy life expectancy using the Sullivan (1964) method, as both the pen_x in our case and health prevalence can be seen as weights, and this approach has been suggested by prior research (van Raalte and Nepomuceno, 2020).

We apply a second decomposition by further splitting the pen_x into two components: $earn$ and $diff_x$, and $pen_x = earn - diff_x$, where $earn$ is the average yearly labor earnings between age 50 and 59 and $diff_x$ is the absolute difference between pension income at each age and previous average earnings. The input vector hence becomes:

$$v = [m_{60}, m_{61}, \dots, m_{105+}, diff_{60}, diff_{61}, \dots, diff_{105+}, earn].$$

This reformulation is motivated by the fact that a large proportion of differences in yearly pension income is due to differences in pre-retirement labor earnings. Generally, $diff_x$ takes negative values, as individuals' pension income tends to be lower than their previous labor earnings. A larger $diff_x$ means labor earnings better reflect pension income ($diff_x = 0$ means perfect translation). Comparing $diff_x$ across SES is therefore indicative of a redistribution effect, and if $diff_x$ is smaller (a larger negative value) among low SES groups than high SES groups, the system is more progressive. The total contributions of $earnings$ and $diff_x$ sum to the total contributions of pen_x in the first decomposition. The decomposition method is implemented using the R package DemoDecomp (Riffe 2018).

Results

Table 1 displays the number of individuals in each group, remaining life expectancy at age 60, average pension income at age 70, and the expected lifetime pension at age 60 by education and income groups. Our results show that life expectancy at age 60 increases by education and earnings quintile for both men and women.[2] For the 1920 cohort, men from the top earnings quintile were expected to live 22.0 additional years at age 60, yet those from the bottom quintile could only expect to live 17.5 years, 4.5 years less than men from the top quintile. Similarly, for the 1920 cohort, men with primary education had a lower life expectancy (by 2.6 years) compared to men with tertiary education; this gap became 3.4 years for men of the 1925 cohort. Education and income gradients are also found among women, but to a lesser extent. Interestingly, unlike men, women in the lowest earnings quintile did not have the lowest life expectancy. Overall, mortality differences by income for women are smaller than for men. Table 1 also shows that people who were more educated and who earned higher incomes also had higher pension income at age 70, reflecting an income-based pension system. Overall, pensions increased rapidly up to age 66, and remained stable for all groups thereafter.[3]

[2] See Figures A1 and A2 in the Appendix for graphs of differences in survival curves.
[3] See Figures A3 and A4 in the Appendix for age-specific pension income.

Table 1. Group descriptive statistics on remaining life expectancy at age 60, average pension at age 70, and lifetime pension by cohort, sex, education, and earnings quintile

	Number (%)		LE_{60} (year)		Average pension at age 70 (1000 SEK)[1]		Lifetime pension (1000 SEK)[1]	
Cohort	1920	1925	1920	1925	1920	1925	1920	1925
Male total	51088 (100%)	40368 (100%)	20.0	21.0	192.2	197.6	3173.5	3589.2
Male by education								
Primary	34757 (68%)	25486 (63%)	19.5	20.2	168.5	169.3	2705.7	2992.8
Secondary	13086 (26%)	11328 (28%)	20.8	21.7	222.3	221.0	3795.6	4128.6
Tertiary	3245 (6%)	3554 (9%)	22.1	23.6	311.4	311.9	5650.4	6138.8
Male by earnings								
Lowest	10218 (20%)	8074 (20%)	17.5	18.6	105.8	113.6	1606.6	1913.6
Second	10217 (20%)	8073 (20%)	19.3	20.2	158.4	161.4	2465.2	2802.0
Third	10218 (20%)	8074 (20%)	20.2	21.0	178.0	178.6	2933.0	3273.3
Fourth	10217 (20%)	8073 (20%)	20.9	21.8	204.6	209.8	3507.8	3930.9
Highest	10218 (20%)	8074 (20%)	22.0	23.2	298.3	309.6	5334.9	6014.1
Female total	52624 (100%)	41706 (100%)	24.5	25.1	109.4	118.8	2405.7	2724.6
Female by education								
Primary	41128 (78%)	31049 (74%)	24.2	24.7	99.8	107.3	2178.1	2444.7
Secondary	9363 (18%)	8300 (20%)	25.3	26.0	131.6	136.6	2924.1	3161.5
Tertiary	2133 (4%)	2357 (6%)	27.1	27.3	192.8	203.3	4500.3	4860.7
Female by earnings								
Lowest	10525 (20%)	8341 (20%)	24.6	24.9	65.6	63.5	1481.0	1621.4
Second	10525 (20%)	8341 (20%)	23.2	23.8	72.2	79.6	1618.6	1871.8
Third	10524 (20%)	8341 (20%)	24.7	25.6	93.2	109.0	2117.8	2526.0
Fourth	10525 (20%)	8341 (20%)	24.7	25.2	127.9	141.0	2761.8	3134.1
Highest	10525 (20%)	8342 (20%)	25.4	26.1	185.9	198.0	4044.4	4475.2

Source: Authors' calculation based on linked administrative data from Statistics Sweden.

[1]*:* Inflation was adjusted to the 2018 level when computing average pension at age 70 and lifetime pension (third to sixth columns). Units are in 1000 SEK, ≈ 125 USD

We find substantial gaps in the lifetime pension income between education and earnings groups.[4] Lifetime pension income of men with tertiary education was more than twice that of men with primary education, and the absolute difference was almost 3 million SEK (approximately 375,000 USD); we find similar levels of difference between women with primary vs. tertiary education. Additionally, lifetime pension increased by earnings quintile, and the largest difference was observed between the fourth and top quintiles for both genders and both cohorts. We also find large differences by gender: men have higher average lifetime pensions than women and a shorter life expectancy. Women of a given quintile have lifetime pensions approximately similar to men of the preceding quintile[5].

In addition, we find larger education and earnings differences in life expectancy among men than among women. Gendered differences in the association between SES and mortality have long been documented in the literature (Pappas et al. 1993). On the other hand, the differences in yearly pension income are smaller (in absolute terms) across female groups than male groups due to more homogeneous income distribution among working-age women than working-age men. Mortality and pension levels both result in larger gaps in lifetime pension income across male education and earnings groups.

Figure 1 shows the decomposition results for the comparison between primary and tertiary education groups by gender and cohort. The total differences, indicated in different panels in Figure 1, are the same as calculated by subtracting primary education lifetime pension from that of tertiary education in Table 1. The results show that mortality differences account for a substantial part of the total differences in lifetime pension between the two groups. For men born in 1920, differences in mortality rates of all ages above 60 resulted in a difference of 627,000 SEK in lifetime pension income, and 21% of the total difference (2,944,000 SEK); these figures increased to 822,000 SEK and 26% for the 1925 cohort, while lifetime pension differences due to yearly pension income showed almost no change across the cohorts.

[4] See Figures A5 and A6 in the Appendix for boxplots of observed/truncated accumulated pension income until the end of 2018. While our lifetime pension income is defined as the expected value of accumulated pension from age 60 to death, one could also calculate the expected lifetime pension within a specific age interval starting from 60, analogous to temporary life expectancy (i.e., expected years of life within the specified age interval). These results are presented in Figures A7–A8.

[5] Decomposition results of male-female differences in lifetime pension are presented in Figure A7.

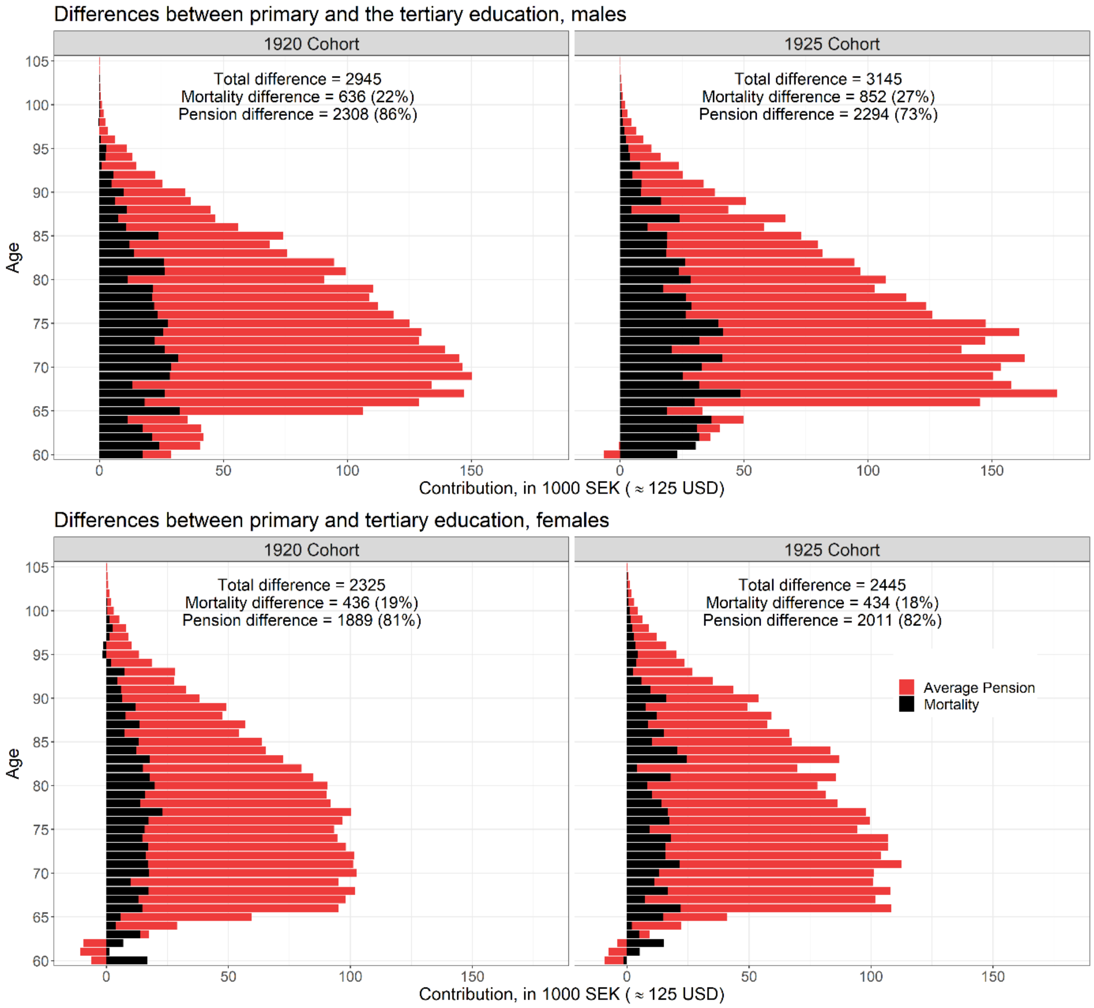

Figure 1 Decomposition of total lifetime pension differences between primary and tertiary education groups into differences explained by mortality and yearly pension, by sex and cohort. *Source:* Authors' calculation based on Swedish register data.

As shown in Table 1, women have lower annual and lifetime pensions than men, and overall, we find a similar SES gradient in annual pension levels for men and women. In absolute terms, but not in relative terms, we find a larger difference in total pension across SES groups of men than of women. Women have a less marked SES gradient for mortality, in particular for earnings.

Among men, we find that a small increase in the importance of mortality differences is in line with the increasing gap in remaining life expectancy between the two cohorts (from 2.6 to 3.4 years). Compared to men, mortality difference contributions are smaller for female educational groups (both in absolute and relative terms), as mortality differences between female education groups are also smaller. The magnitude of contributions of mortality differences decreased only at advanced ages (around 90); before this point, age-specific mortality contributions did not show a clear decreasing trend. The much lower contribution of age-specific pension income and mortality at older ages to differences in lifetime pension reflects that a smaller proportion of the cohort is alive at such ages.

Meanwhile, age-specific differences in pension income only begin to contribute significantly from the ages at which individuals usually retire (i.e., 65). Before 65, contributions to yearly pension income were minor and even reversed for women, as lower educated women retired earlier much more frequently and had higher average pension income for these ages. From age 66, the contribution of yearly pension differences was consistently high and started to decrease rapidly at approximately age 80.

Figure 2 shows the decomposition results when we compare the bottom and top earnings quintiles. For men, we largely find the same patterns as for education. The differences in lifetime pension are larger in the more recent cohorts. The results for women are different, as mortality differences were much smaller for the two cohorts (only accounting for 4% and 6%, respectively). As we have presented above, for women, life expectancy at 60 was not the lowest among the lowest earnings quintile, and mortality was only slightly higher among the bottom quintile women across ages compared to the top quintile.

Figures 1 and 2 both show that the majority of lifetime pension income differences came from differences in yearly pension income, which, to a large extent, was determined by pre-retirement labor earnings. On the other hand, as discussed earlier, most pension systems are progressive and aim to provide higher replacements between earnings and pensions for low SES groups. Thus, the differences in total pension between SES groups from average pensions observed in Figures 1 and 2 are a function of both labor earnings and the pension system's redistribution effect. We further explore this aspect by splitting age-specific pension income into two components: pre-retirement labor earnings and the difference between pension income and labor earnings. We then estimate the extent to which pension systems' redistribution function and labor earnings differences play contributory roles. Before showing these results, we first show how pension income is attached to labor earnings by education and earnings group in Table 2. Specifically, we calculate the difference and ratio between individuals' average yearly pension income between ages 66–75 and average yearly earnings between ages 50–59. Note that this does not reflect any formula for how earnings are translated into pensions in the pension system; this was not possible as our pension variable includes divergent pension programs.

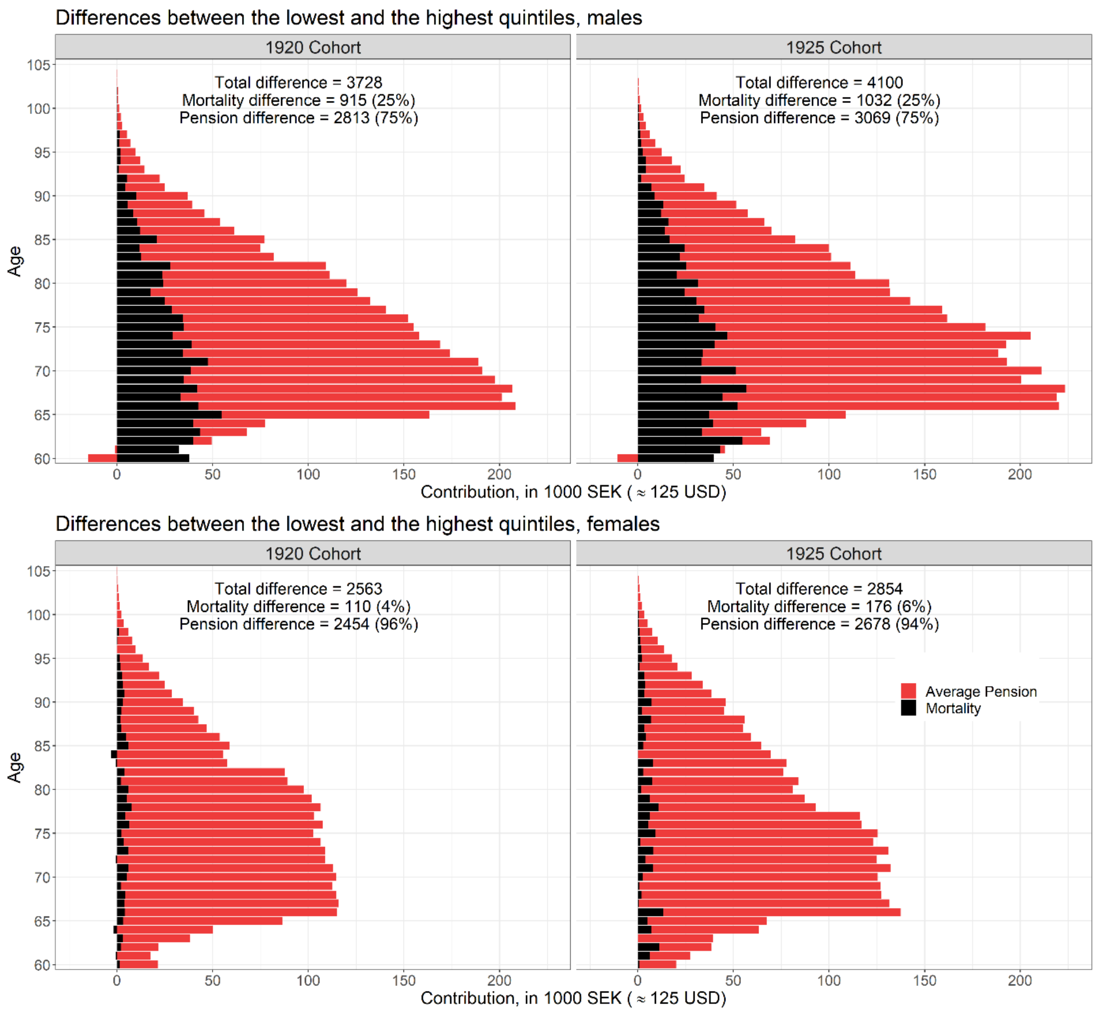

Figure 2 Decomposition of total lifetime pension differences between the bottom and the top earnings quintile groups into differences explained by mortality and yearly pension, by sex and cohort. *Source:* Authors' calculation based on Swedish register data.

Table 2 shows that both the difference and the ratio decline with education and earnings quintile, indicating progressivity in the pension system. In particular, bottom-quintile women born in 1920 received pensions over 15 times their labor earnings (reflecting a guaranteed pension, which benefits individuals with very low earnings such as homemakers), whereas their peers in the top quintile received 0.74 of their labor earnings. However, we can also see that the ratio (as well as the difference) decreased relatively little from the second to the highest income quintile groups (for the 1925 cohort, it decreased from 0.94 to 0.77 for women, and from 0.78 to 0.74 for men), suggesting that the redistribution effects of the pension system were limited for these two cohorts. In particular, for men with median incomes (and women with high incomes, who had income comparable to men of median income), the pension system translated earnings into pensions at a relatively constant rate, with only very modest progressivity. The relatively weak link between earnings of women and men, partly reflects that women received a relatively large share of their income as widow pension (which was independent of their own earnings), as they tend to both marry older husbands (Kolk 2015), and have higher life expectancy.

Table 2 Absolute and relative differences between average yearly pension income (66–75) and average yearly labor earnings (50–59) across different educational groups in earnings quintiles.

	Male				Female			
	1920 cohort		1925 cohort		1920 cohort		1925 cohort	
	Difference (1000 SEK[1])	Ratio	Difference (1000 SEK[1])	Ratio	Difference (1000 SEK[1])	Ratio	Difference (1000 SEK[1])	Ratio
Total	-74.08	0.72	-66.89	0.75	-0.40	1.00	-17.21	0.88
By education								
Primary	-55.54	0.75	-51.56	0.77	5.30	1.06	-12.78	0.90
Secondary	-95.57	0.70	-80.92	0.74	-13.66	0.91	-25.38	0.85
Tertiary	-200.63	0.60	-148.09	0.68	-58.44	0.77	-52.00	0.80
By earnings								
Lowest	-12.10	0.90	-12.17	0.90	60.05	15.14	45.62	3.32
Second	-46.28	0.77	-46.45	0.78	28.29	1.65	-4.76	0.94
Third	-63.31	0.74	-62.06	0.75	-3.24	0.97	-21.89	0.84
Fourth	-82.04	0.71	-76.46	0.74	-25.98	0.83	-42.11	0.77
Highest	-183.41	0.62	-154.00	0.67	-63.75	0.74	-65.98	0.75

Source: Authors' calculation based on Swedish register data. [1] Units are in 1000 SEK, ≈ 125 USD

Table 3 shows our results from an extended three-way decomposition. For simplicity, we refer to these three components due to mortality differences, differences in the absolute difference between pension income and labor earnings, and labor earnings differences as *mortality effect*, *redistribution effect*, and *earnings effect*, respectively. The results show that the majority of the total lifetime pension difference was due earnings effect, but also that differences in lifetime pensions would have been considerably larger without a progressive pension system. If there had been no redistribution between groups, SES differences would have been approximately twice as large. However, note that the decompositions are based on comparisons between the lowest and highest SES groups, and that differences in redistribution are much smaller in the middle of the SES distribution (Table 2). The patterns are similar across the other pairs of comparisons, except for the comparison between bottom vs. top earnings quintiles for women. With respect to the bottom quintile women, top quintile women only had a slight mortality advantage (even disadvantages for certain ages), whereas their earnings are much higher; meanwhile, as shown in Table 2, top quintile women only received around 72% of their labor earnings as their pension (at age 70), whereas bottom quintile women received over 1,500%. Such substantial differences result in huge redistribution and earnings effects, but in opposite directions. The differences explained by mortality are identical as in Figures 1 and 2 and are clearly of lower magnitude than SES differences in earnings and the progressive redistribution of the pension system.

Table 3 Three-way decompositions of the difference in total lifetime pension between different education and earning quintile groups, by sex and cohort

	Male		Female	
	1920 cohort	1925 cohort	1920 cohort	1925 cohort
Primary vs. tertiary education				
Mortality effect	636.2	852.1	436.1	433.5
Redistribution effect	-3597.8	-2963.6	-2086.4	-1569.4
Earnings effect	5906.2	5257.5	3975.2	3580.9
Total difference in lifetime pension	2944.7	3146.0	2325.0	2444.9
Bottom vs. top earnings quintile				
Mortality effect	915.0	1032.0	109.6	175.8
Redistribution effect	-4269.7	-4026.9	-3632.8	-3655.3
Earnings effect	7083.0	7095.5	6086.5	6333.4
Total difference in lifetime pension	3728.3	4100.6	2563.3	2853.8

Source: Authors' calculation based on Swedish register data.
Notes: Mortality effect, redistribution effect, and earnings effect refer to the parts of total lifetime pension difference that are attributable to differences in mortality, differences in the differences between pension income and labor earnings, and differences in labor earnings, respectively. Units are in 1000 SEK, ≈ 125 USD

When comparing SES groups that are less divergent (e.g., primary vs. secondary education, first vs. third earnings quintiles), the absolute differences in lifetime pension are unsurprisingly smaller, yet the share explained by mortality differences is more or less constant across comparisons. This is shown by supplementary analyses in which we compare a larger set of different earnings and educational groups.[6] All our main findings are also robust in these comparisons. The largest differences in lifetime pension are found to be between secondary vs. tertiary education groups and third vs. fifth income quintiles, suggesting that the differences we see between SES groups are particularly large between the most advantageous groups and other groups. To make our results comparable to other calculations on comparisons of the progressivity of pension systems that focus on actuarial aspects and financing of pension systems, we also replicate our calculations where we introduce a discount rate of 2%, giving more weight to present rather than future income.[7] A consequence of this is that money received at younger ages is valued more, and thus we see in calculations with a discount rate that mortality differences are less explanatory of differences between SES groups, as our low SES groups obtain a relatively higher share of their money earlier. In other words, the mortality advantage of higher SES groups at older ages is less important when a higher discount rate is used.

Finally, we compare how yearly earnings, yearly pension, lifetime pension income, and life expectancy differ between SES groups. We calculate the ratios of these four outcomes between tertiary and primary education as well as between top and bottom earnings quintiles in Table 4. We find that pension income on a yearly basis is the most equal among the first three monetary outcomes, while yearly earnings are the most unequal. The inequality level of lifetime pension income falls between the two. One exception is that for female top vs. bottom earnings quintiles, yearly pension is more unequal than lifetime pension income. This is likely due to the ages used to compare yearly pension income (66–75), as we find yearly pension income between the top and bottom female earnings quintiles are more equal at older ages.[8] We also see that differences in life expectancy between SES groups (and between men and women) are much smaller than differences

[6] See Tables A1–A2 and Figures A10–A14 in the Appendix for other comparisons.
[7] See Table A3 and Figures A15–A16 in the Appendix.
[8] See Figure A4 in the appendix.

in lifetime pension, partly explaining why mortality only contributes 25% or less in explaining differences in lifetime pension.

Table 4. Ratios of yearly earnings, yearly pension, lifetime pension, and life expectancy at 60 between education and earnings groups, by sex and cohort

Ratio	Male		Female	
	1920 cohort	1925 cohort	1920 cohort	1925 cohort
Primary vs. tertiary education				
Yearly earnings (average over 50–59)	2.28	2.08	2.66	2.13
Yearly pension (average over 66–75)	1.84	1.84	1.93	1.90
Lifetime pension income (60+)	2.09	2.05	2.07	2.00
Life expectancy at 60	1.13	1.17	1.12	1.11
Bottom vs. top earnings quintile				
Yearly earnings (average over 50–59)	4.10	3.69	58.33	13.63
Yearly pension (average over 66–75)	2.82	2.74	2.86	3.10
Lifetime pension income (60+)	3.32	3.14	2.73	2.76
Life expectancy at 60	1.25	1.25	1.03	1.05

Source: Authors' calculation based on Swedish register data.

Discussion

This study quantifies different factors that explain differences in lifetime pension by SES groups for the 1920 and 1925 Swedish birth cohorts. We find large differences in lifetime pensions across groups defined by both educational attainment and pre-retirement labor earnings. Total lifetime pension inequality is reflected in three factors, two of which contribute to higher inequality in lifetime pensions. First, higher annual earnings before retirement translate into higher annual pension income. Second, higher life expectancy in high SES groups results in higher lifetime pensions. Third, a higher replacement rate among low SES groups decreases differences in lifetime pension through a redistributive pension system. We quantify these effects and find that a mortality advantage explains up to 28% of the higher lifetime pension among high SES groups, with larger shares for men. The remainder of the differences in lifetime pensions are explained mostly by higher earnings in pre-retirement ages of high SES groups. Our main conclusion is that on a lifetime basis, mortality differentials between SES groups dampen the progressivity of pension systems, consistent with several previous studies.

Research suggests an increasing trend of the SES gap in longevity globally (Brønnum-Hansen and Baadsgaard 2012; Kravdal 2017; Meara et al. 2008; Östergren, 2015; Permanyer et al. 2018). Accordingly, we may in the future see that mortality inequality will contribute more to lifetime pension inequality. In the two cohorts considered here, we find only small differences, but the direction of change is consistent with other evidence of a trend toward larger differences.

Lifetime pensions are more unequally distributed across male SES groups than female SES groups. There are three explanations for our pattern. First, the SES mortality gradient is usually stronger for men than for women (Mackenbach et al. 2018), which we also find in our study. Among women, the association between low income and high mortality is even reversed in the lowest two quintiles, which may be explained by the fact that, for our cohorts, women in the lowest quintile may often be outside the labor market and so rely on a husband with higher income, whereas women in the second quintile may be in the labor market and live alone or in households with low income.[9] Second, the redistributive effect is stronger for women. The lowest-income women are protected by the minimum pension, and to some extent widow-pensions (shown by the much higher ratio between pension income and earnings for the lowest income women than for other groups). Third, women have smaller inequality in pre-retirement earnings than men. As the majority of lifetime pension inequality is explained by pre-retirement earnings, gender differences in the magnitude of lifetime pension inequality by SES could also be explained by the more homogeneous earnings distribution across female SES groups, as well as that they more often received widow-pensions.

The difference between yearly pension income and pre-retirement labor earnings is similar from the second to the fourth earnings quintiles, suggesting that the redistributive role of the Swedish pension system is limited for the majority of the population who sit in the middle range of earnings distribution. In contrast, the pension system played a relatively more significant role in redistributing money from the very rich to the very poor, as illustrated by the comparisons between the highest earnings group (which had a large share of earnings that was not translated into lifetime pension) and the lowest earnings group (which received a guaranteed pension, even in the absence of contributions during the time studied), particularly for women.

[9] Prior research has shown that the type of income measure (individual vs. household) has large impacts on the results of mortality inequalities between income groups. A gradient is observed where longevity is monotonically positively correlated with household income, which is not always found for female individual income (Shi et al. 2021).

Health and mortality inequalities in Sweden have been among the lowest in Europe since the 1980s (Mackenbach et al. 2018). Higher SES mortality gradients in other countries or in future cohorts mean that mortality plays an even more important role in lifetime pension than it does in the two Swedish cohorts analyzed here. While Sweden may have comparatively small SES differences in mortality, it has one of the least progressive pension systems among OECD countries (OECD 2011). Allowing lower SES individuals to receive a higher proportion of pre-retirement earnings as pension income would reduce lifetime pension inequalities and narrow old-age income gaps, as would implementing SES-specific life tables adjusting for lower survival among lower SES groups.

Recent policy discussions include raising the statutory retirement age or lowering (yearly) pension benefits. Such policies rarely consider SES differences in longevity but have important impacts on redistribution due to mortality differences. This will be particularly relevant for Bismarckian pension systems, which explicitly aim to redistribute earnings into pensions in an actuarially fair way.

For instance, increasing the statutory retirement age universally will result in an increase in the high SES advantage: the years that high SES individuals are expected to outlive low SES individuals relative to the latter group's remaining life expectancy will become larger. In turn, the mechanism observed here would be reinforced, and the pension system would be more regressive. As advocated by prior research (Sánchez-Romero et al. 2020), we also note that SES-specific life tables would increase pension fairness in both DC and NDC pension systems.

Our definition of "lifetime" is from the age of 60, and we thus exclude premature mortality before age 60, although these individuals will also have paid pension premiums. For instance, SES differences in lifetime pension measured at age 50 would have been larger than our estimates, as the SES-mortality gradient is even higher in ages 40 to 60 (Rehnberg et al. 2019). Future research may wish to examine lifetime *net* pension benefits from an even younger age to capture such effects empirically.

The first contribution of our study is the use of an exceptionally long series of high-quality data on observed earnings, mortality, and all sources of pensions. Economic theoretical models have illustrated the importance of differential mortality to lifetime pension progressivity (Auerbach et al. 2017; Sánchez-Romero et al. 2020), and previous empirical studies have often modeled mortality rates for cohorts whose complete mortality schedules were still unknown (Haan et al. 2020; Olivera 2018). By comparison, our approach is more data-driven in the sense that we do not involve assumptions (as in theoretical models), and we use observed income, mortality, and pension data for birth cohorts where the life course is almost entirely empirically observed.

Second, our demographic decomposition approach is novel. This method has been mostly used in population health research and we illustrate how it can be incorporated to respond to research questions that are of interest to pension researchers. For instance, we show the age patterns of mortality contributions, as well as the exact amount of money that lower SES individuals lose due to their mortality disadvantages at each age. An additional methodological contribution is that we disentangle three effects: mortality, earnings, and replacement rates.

A limitation of this study is that our earnings grouping is based on earnings over ages 50–59 and ignores earlier earnings trajectories. Our comparison of average yearly earnings over these ten years and average yearly pension payments (over ages 66–75) are only illustrative; this differs from strict actuarial calculations on the actual rate of return on actual pension payments. This point is illustrated by our entirely empirical approach, which is both an advantage and disadvantage compared to previous research. Thus, our study is conceptually different from previous research, as our pension variable is the sum of guaranteed pensions, the first tier of income replacement in the public system, sector-wide collective agreement pensions, as well as other pension programs such as widow pensions. The type of pension differs substantially across SES. Therefore, we provide a broad picture of how a national pension system works in practice and their consequences for social stratification, rather than providing calculations for the extent of redistribution of specific pension programs. We argue that this is a contribution lacking in the current literature, but it also makes our results in some ways hard to compare with some previous approaches. A further implication of our empirical approach is that our cohorts for whom we observe nearly their entire lives are born early in the 20th century; thus, we study the pension system in the 1990s and 2000s.

Future studies may wish to disentangle how different pension programs (e.g., guaranteed pensions, the state pension, widow pensions, and collective agreement pensions) explain overall differences between SES groups. Future research may also examine whether pension reforms in Sweden in the 1990s—which introduced an NDC system with balances for intergenerational redistribution and actuarially fair flexible retirement ages, and which later became a model for many other OECD countries (Palme 2005)—have changed the broad patterns observed in t
his study. The first cohorts that experienced this new system were born in the mid-1950s.

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Appendix

Appendix A. Overview of pension systems of the cohorts studied

For the cohorts under study (those born 1920 and 1925), the Swedish pension system consisted of a universal guarantee pension (folkpension) and an earnings-related part (Allmän Tilläggspension or ATP), the ATP part was more important and was targeted to contribute 60% of the average of the best 15 years out of a 30-year working period (30 years is the requirement for full pension). In practice, the pension payments were therefore based entirely on 15 years of income. Later a supplemental part, to the ATP pension, was added for those with very low ATP pensions. For formulas and a more detailed description, see Hagen (2013). The ATP-system was introduced in 1960 (Hagen 2013), and the cohorts in the study were entirely covered retroactively (and thus needed less than 30 years to qualify, making the system more generous). Both systems were defined-benefit (DB) systems, funded as PAYGO systems. In the 1980s, political actors saw this pension system as unsustainable, and Sweden instead introduced a Notional-Defined Contribution system which was an early example of pension reform (Hagen 2013; Palme 2005). It differs in substantial ways from the pension system we describe above but is not of relevance for the cohorts in our study.

Importantly, together with the public pension, over 90% of all workers in Sweden are also covered by sector-wide collective agreement pensions negotiated between labor unions and employers (Lindquist and Wadensjö 2009). The characteristics of these vary a lot (for our cohorts they were mostly DB plans), and could contribute substantially to the pensions of, in particular, high-income earners and government workers (rising up to 50% of all pension earnings for the decile with highest earnings), as the ATP system had an income ceiling (Hagen 2013). A typical target was often that workers would receive 80% of their pre-retirement salary (if they had worked for 30 years) through the combination of all pensions described above, though it could be both higher and lower (Hagen 2013). These pensions are also included in our variables.

Private savings for old age in Sweden is instead commonly done outside any formal pension-like saving or annuity (and thus not related to monthly payments as from an annuity or a pension, where payment is linked to length of life), such as capital investments, savings in bank accounts, or housing. We do not consider such aspects of saving for retirement in this study (or as a form of "pension"), as it is not possible to distinguish from overall wealth, and unlike pension, wealth will often be bequeathed to children.

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Appendix B. Tables

Table A1. Three-way decompositions of the difference in total lifetime pensions between primary and secondary education and between secondary and tertiary education, by sex and cohort

	Male		Female	
	1920 cohort	1925 cohort	1920 cohort	1925 cohort
Primary vs. secondary education				
Mortality	261.1	305.5	136.8	159.7
Difference: pension income - earnings	-1047.0	-895.4	-636.6	-513.5
Pre-retirement earnings	1875.9	1725.7	1247.1	1079.4
Total difference in lifetime pension	1090.0	1135.8	747.2	725.6
Secondary vs. tertiary education				
Mortality	341.6	519.6	284.0	243.4
Difference: pension income - earnings	-2598.8	-2099.3	-1457.9	-1062.3
Pre-retirement earnings	4112.0	3589.9	2751.6	2538.3
Total difference in lifetime pension	1854.7	2010.3	1577.8	1719.4

Source: Authors' calculation based on linked administrative data from Statistics Sweden.

Table A2. Three-way decompositions of the difference in total lifetime pensions between other income quintiles (1st vs 3rd, 2nd vs. 4th, and 3rd vs. 5th), by sex and cohort

	Male		Female	
	1920 cohort	1925 cohort	1920 cohort	1925 cohort
First vs. third quintiles				
Mortality	368.8	374.9	8.7	66.9
Difference: pension income - earnings	-1346.5	-1311.0	-1629.4	-2033.6
Pre-retirement earnings	2304.1	2295.8	2257.4	2871.2
Total difference in lifetime pension	1326.4	1359.7	636.8	904.5
Second vs. fourth quintiles				
Mortality	288.1	317.7	162.4	160.9
Difference: pension income - earnings	-881.5	-851.0	-1644.1	-1337.0
Pre-retirement earnings	1636.0	1662.2	2625.0	2438.5
Total difference in lifetime pension	1042.6	1128.9	1143.3	1262.3
Third vs. fifth quintiles				
Mortality	425.9	543.4	105.7	88.6
Difference: pension income - earnings	-3053.5	-2798.9	-1982.5	-1618.1
Pre-retirement earnings	5029.6	4996.4	3803.4	3478.8
Total difference in lifetime pension	2402.0	2740.9	1926.5	1949.3

Source: Authors' calculation based on linked administrative data from Statistics Sweden.

Table A3. Three-way decompositions of the difference in total lifetime pensions between primary and tertiary education and between the bottom and top earnings quintile groups, with 2% discount rate, by sex and cohort

	Male		Female	
	1920 cohort	1925 cohort	1920 cohort	1925 cohort
Primary vs. tertiary education				
Mortality	417.1	556.8	271.7	265.1
Difference: pension income - earnings	-2980.8	-2471.1	-1704.0	-1312.5
Pre-retirement earnings	4711.3	4159.0	3062.9	2748.7
Total difference in lifetime pension	2147.6	2244.7	1630.6	1701.3
Bottom vs. top earnings quintile				
Mortality	618.5	688.8	67.2	108.7
Difference: pension income - earnings	-3573.7	-3357.9	-2886.9	-2894.3
Pre-retirement earnings	5691.8	5653.6	4712.3	4883.0
Total difference in lifetime pension	2736.6	2984.5	1892.5	2097.4

Source: Authors' calculation based on linked administrative data from Statistics Sweden.

Appendix C. Figures

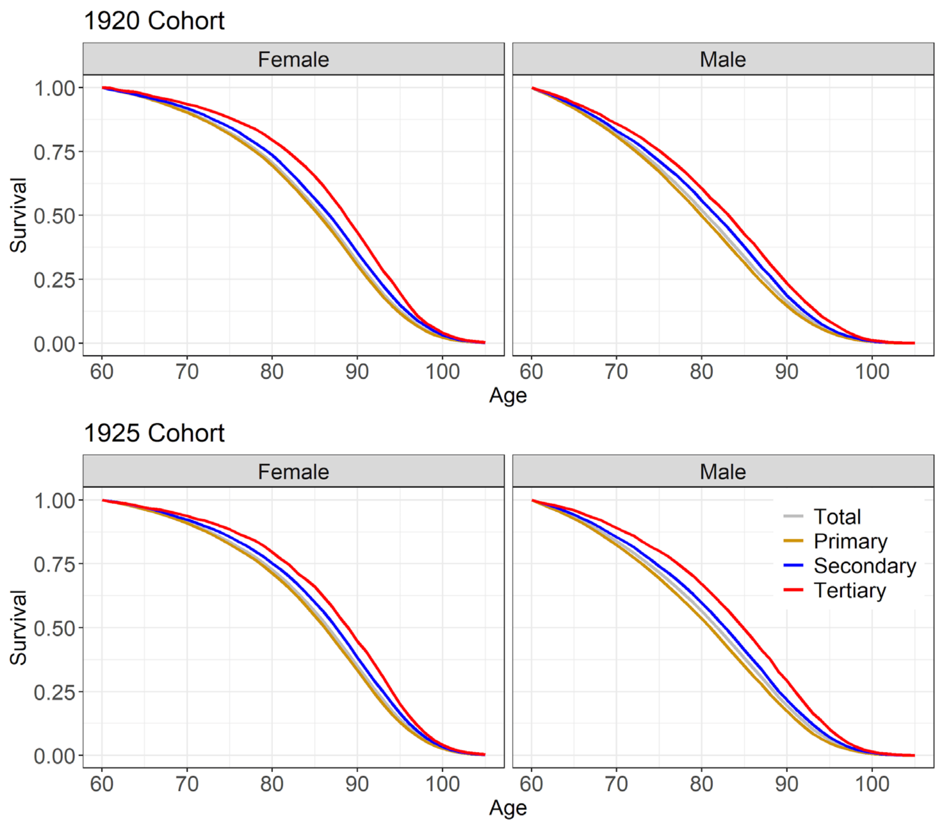

Figure A1. Survival curves by cohort, sex, and education. *Source:* Authors' calculation based on linked administrative data from Statistics Sweden.

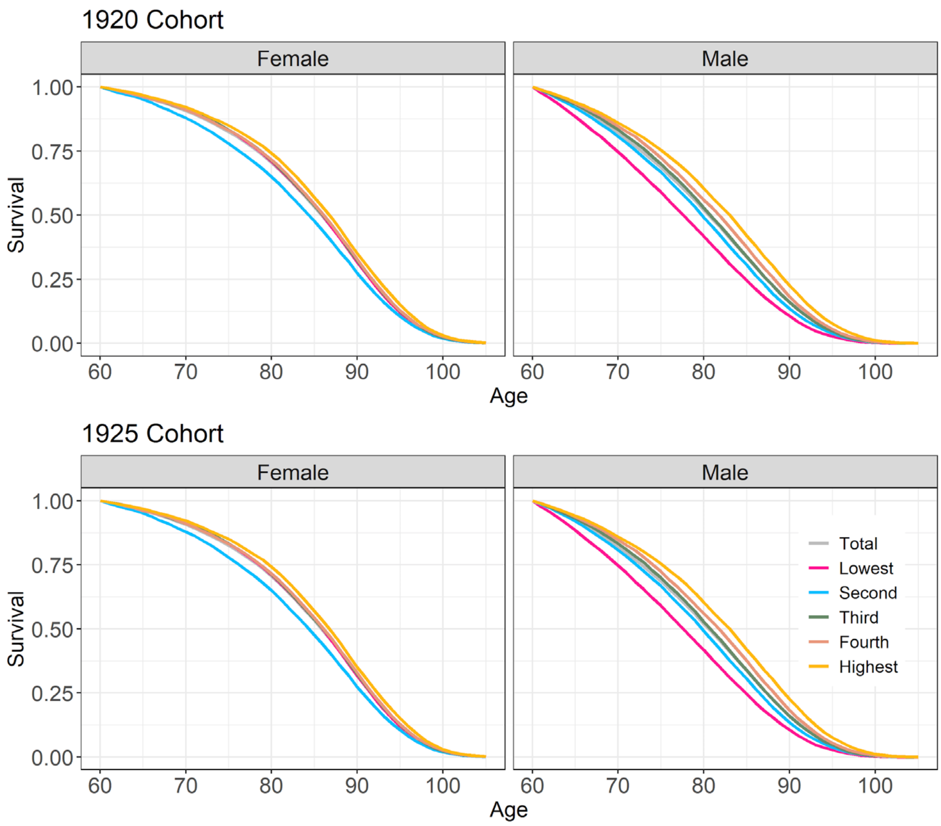

Figure A2. Survival curves by cohort, sex, and income quintile. *Source:* Authors' calculation based on linked administrative data from Statistics Sweden.

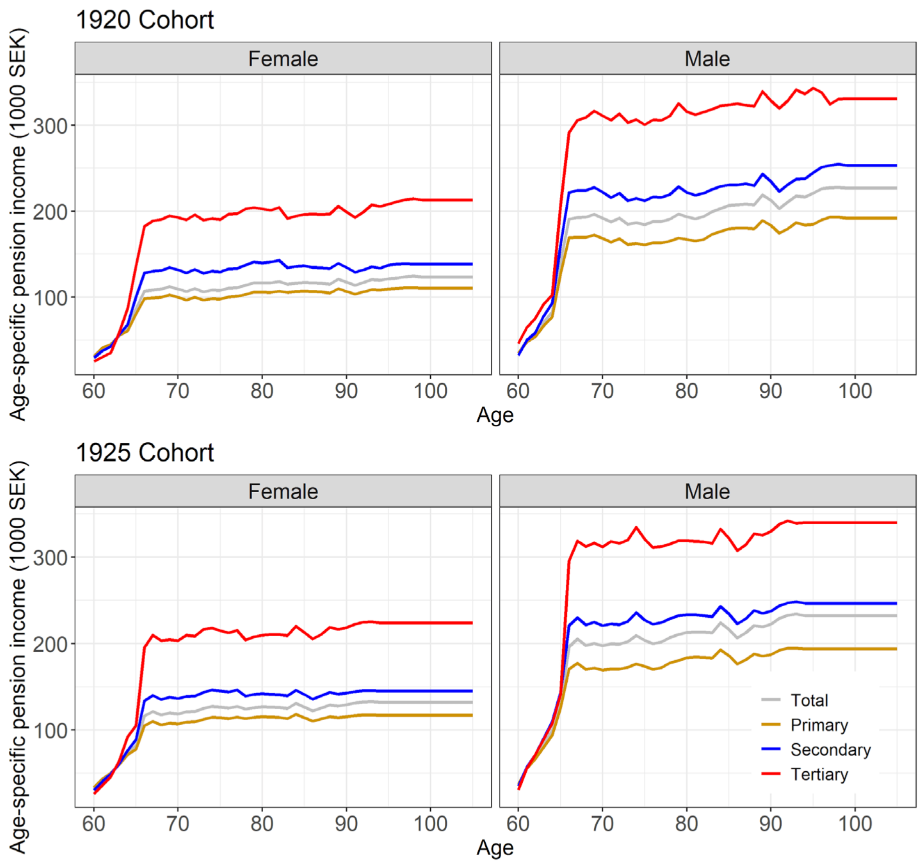

Figure A3. Age-specific average pension income by cohort, sex, and education. *Source:* Authors' calculation based on linked administrative data from Statistics Sweden.

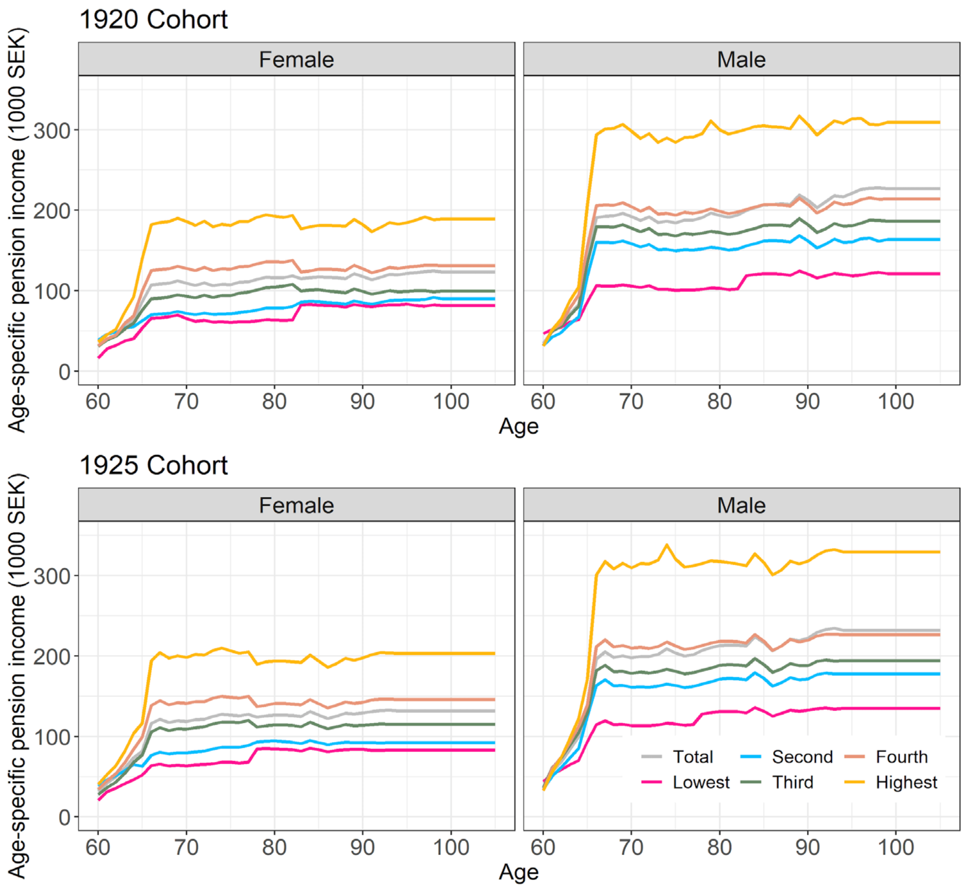

Figure A4. Age-specific average pension income by cohort, sex, and earnings quintile. *Source:* Authors' calculation based on linked administrative data from Statistics Sweden.

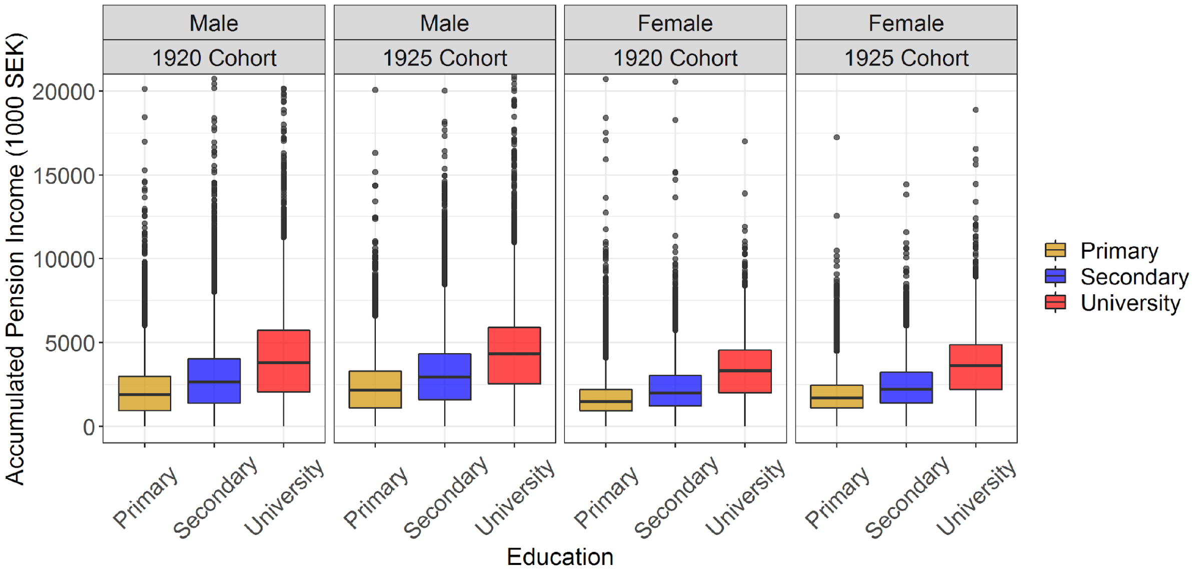

Figure A5. Boxplots of accumulated pension income until 2018 by cohort, sex, and education. *Source:* Authors' calculation based on linked administrative data from Statistics Sweden. *Notes:* Accumulated pension income is the sum of pension income from age 60 to 98 for the 1920 cohort, and from age 60 to 93 for the 1925 cohort. Outliers (dots) that are defined as above the Q3 + 1.5IQR are displayed. The y axis is truncated, and extreme outliers and the maximum are not shown.

Figure A6. Boxplots of accumulated pension income until 2018 by cohort, sex, and earnings. *Source:* Authors' calculation based on linked administrative data from Statistics Sweden. *Notes:* Accumulated pension income is the sum of pension income from age 60 to 98 for the 1920 cohort, and from age 60 to 93 for the 1925 cohort. Outliers (dots) that are defined as above the Q3 + 1.5IQR are displayed. The y axis is truncated, and extreme outliers and the maximum are not shown.

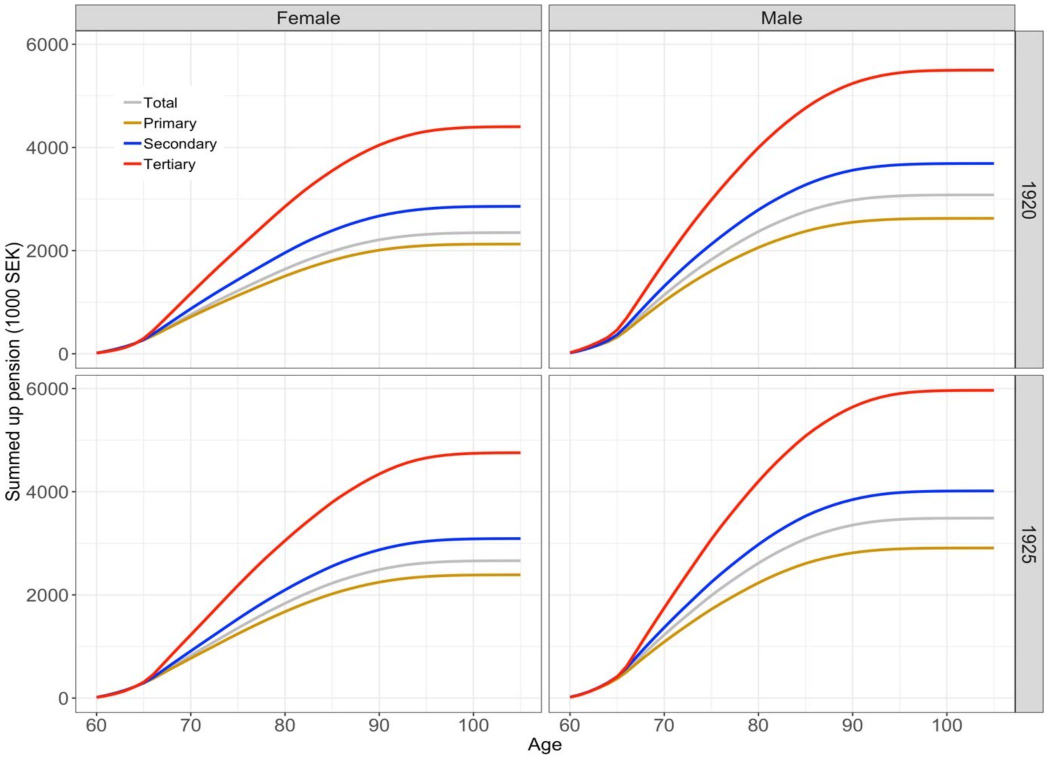

Figure A7. Age-specific cumulative pension income, by cohort, sex, and education. *Source:* Authors' calculation based on linked administrative data from Statistics Sweden. *Notes:* Age-specific average accumulated pension income refers to the expected value of pension between age 60 and *x* along the age axis. The end points of the lines can be interpreted as our lifetime pension income.

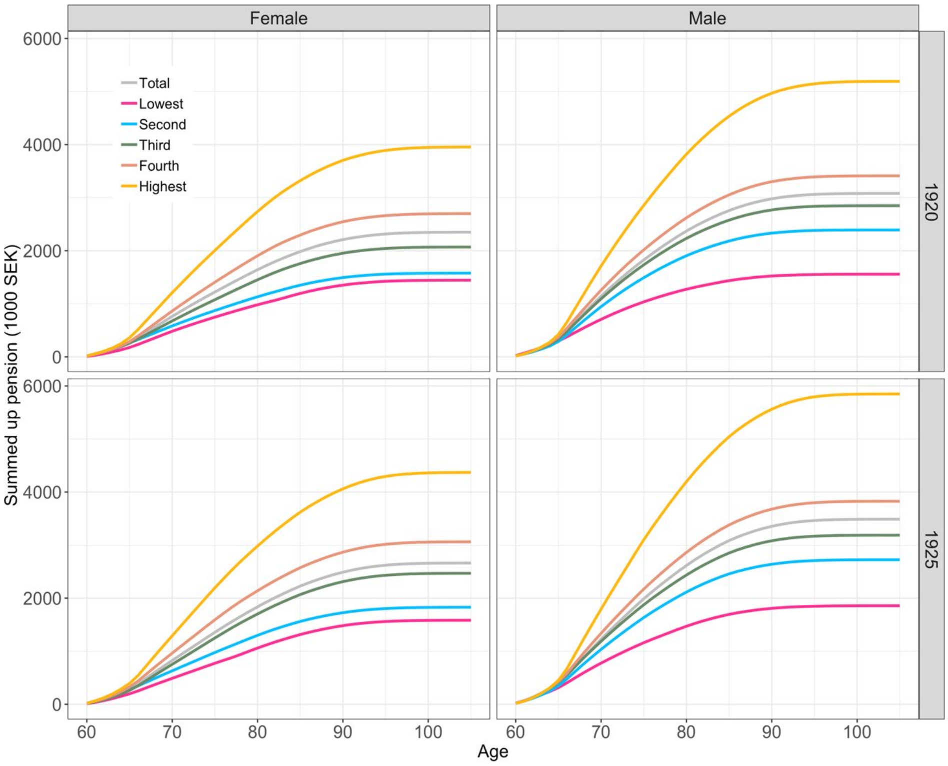

Figure A8. Age-specific cumulative pension income, by cohort, sex, and earnings. *Source:* Authors' calculation based on linked administrative data from Statistics Sweden. *Notes:* Age-specific average accumulated pension income refers to the expected value of pension between age 60 and *x* along the age axis. The end points of the lines can be interpreted as our lifetime pension income.

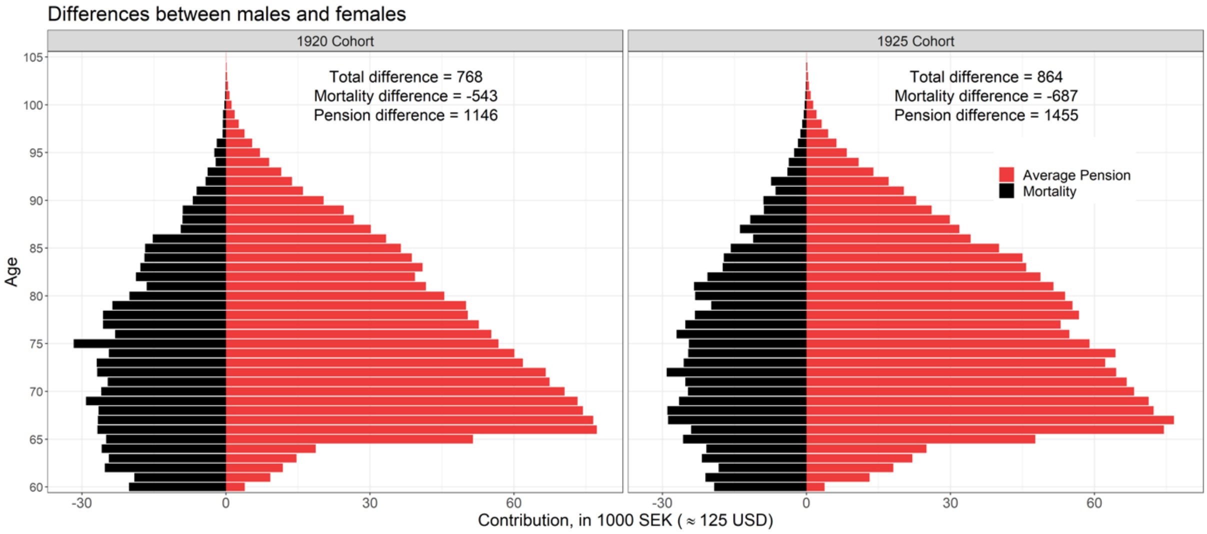

Figure A9. Decomposition of total lifetime pension differences between men and women into differences explained by age and mortality, by cohort. *Source:* Authors' calculation based on linked administrative data from Statistics Sweden.

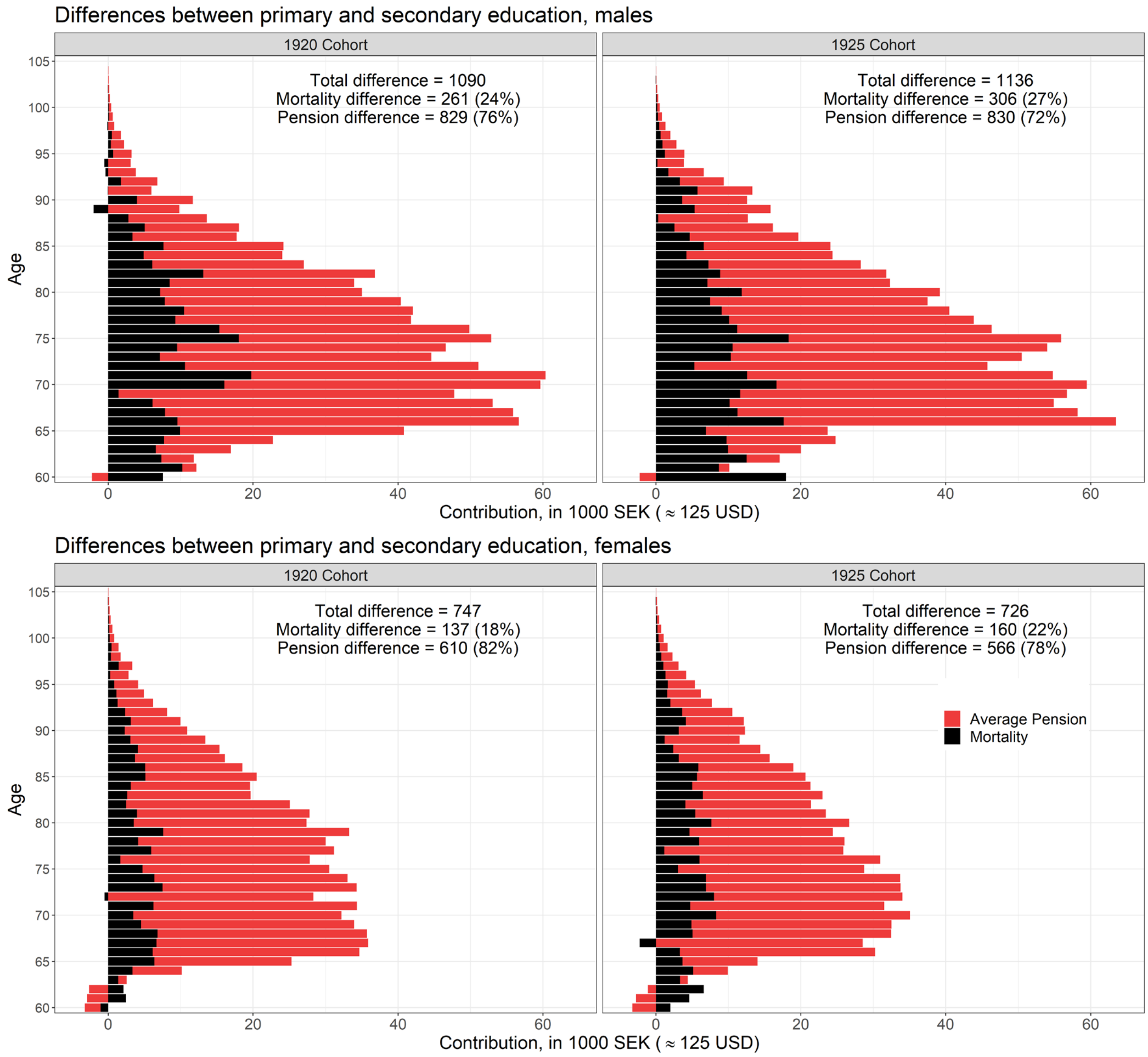

Figure A10. Decomposition of total lifetime pension differences between primary and secondary education groups into differences explained by age and mortality, by sex and cohort. *Source:* Authors' calculation based on linked administrative data from Statistics Sweden.

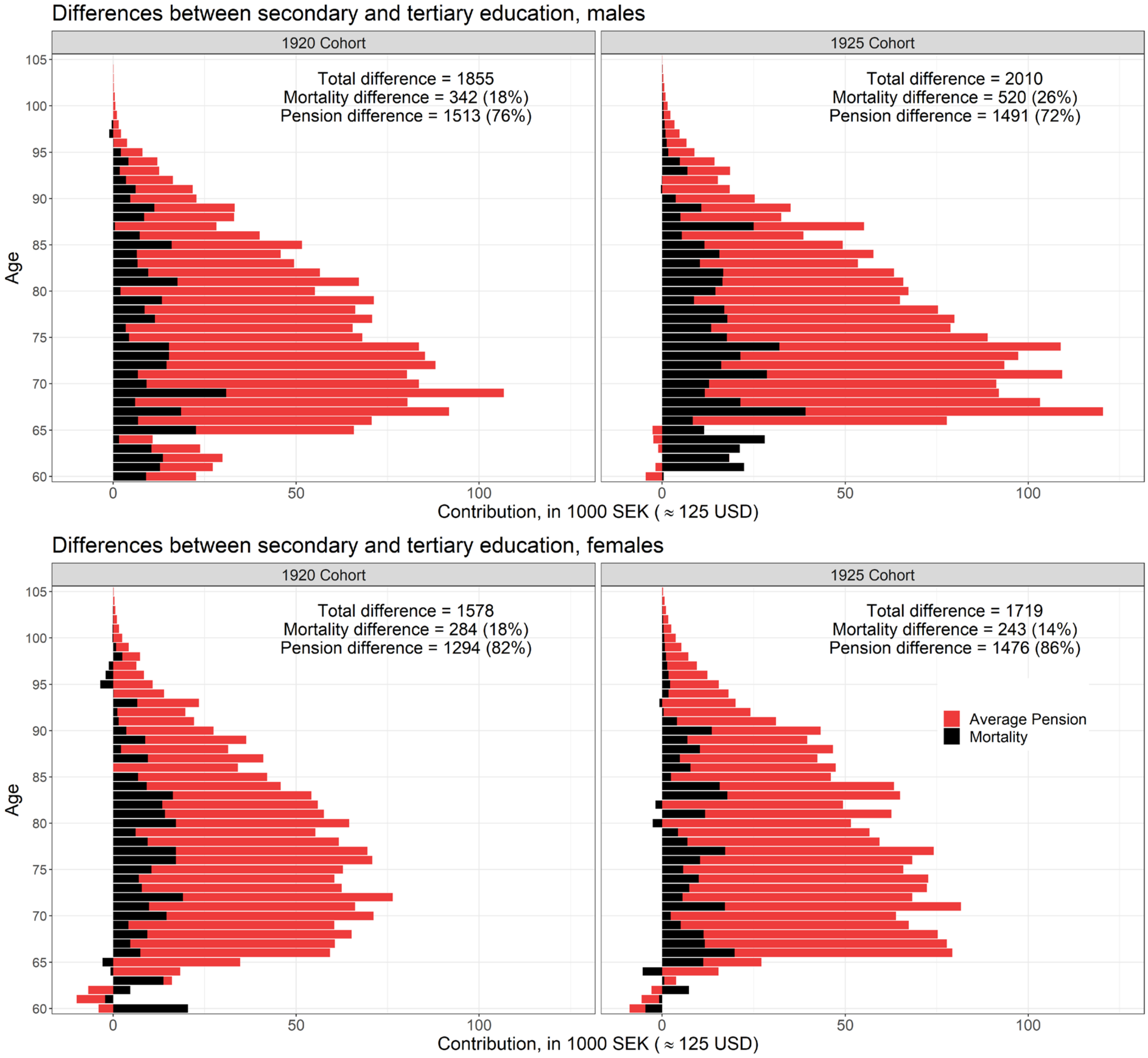

Figure A11. Decomposition of total lifetime pension differences between secondary and tertiary education groups into differences explained by age and mortality, by sex and cohort. *Source:* Authors' calculation based on linked administrative data from Statistics Sweden.

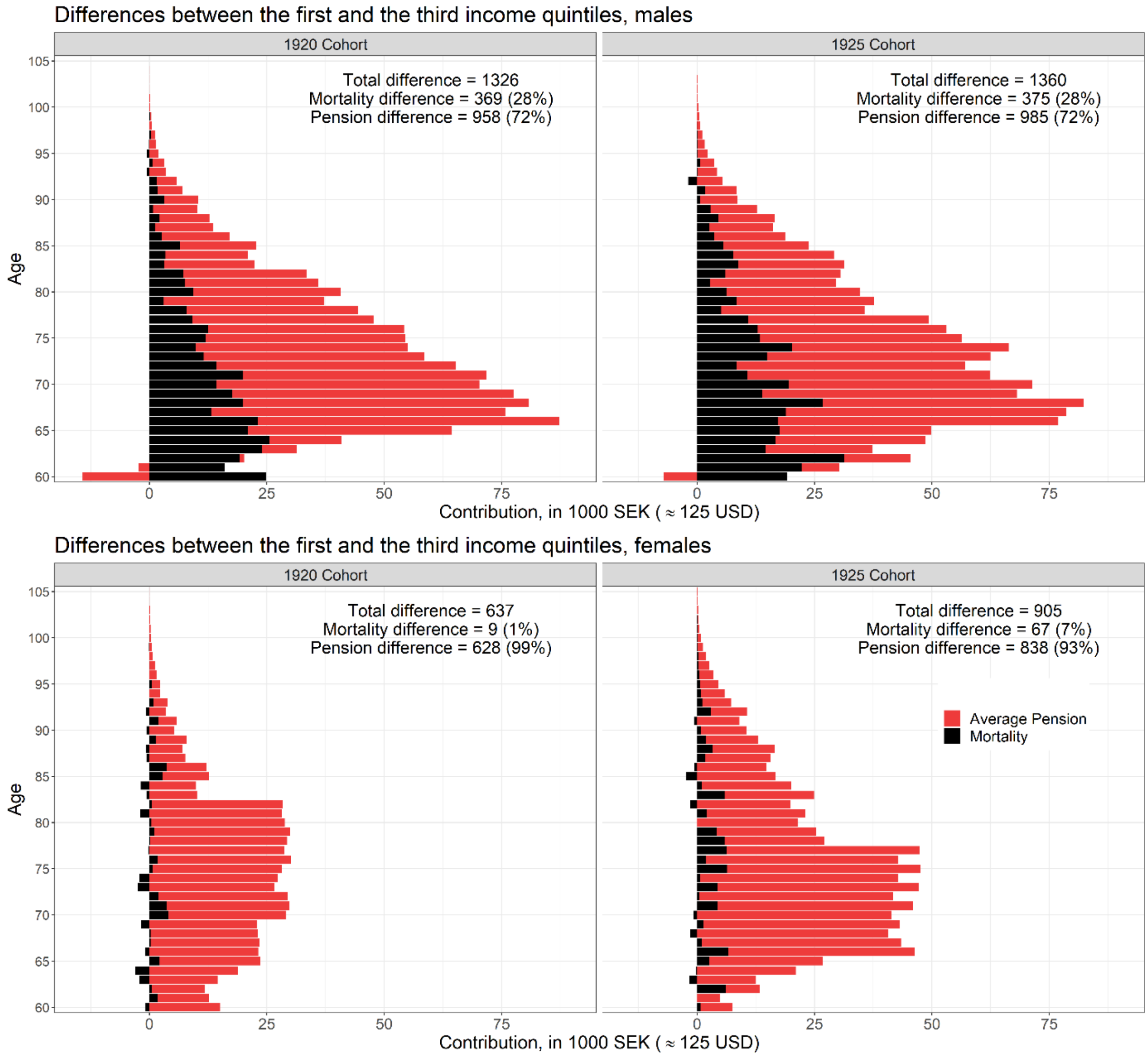

Figure A12. Decomposition of total lifetime pension differences between the bottom and the third earnings quintile groups into differences explained by age and mortality, by sex and cohort. *Source:* Authors' calculation based on linked administrative data from Statistics Sweden.

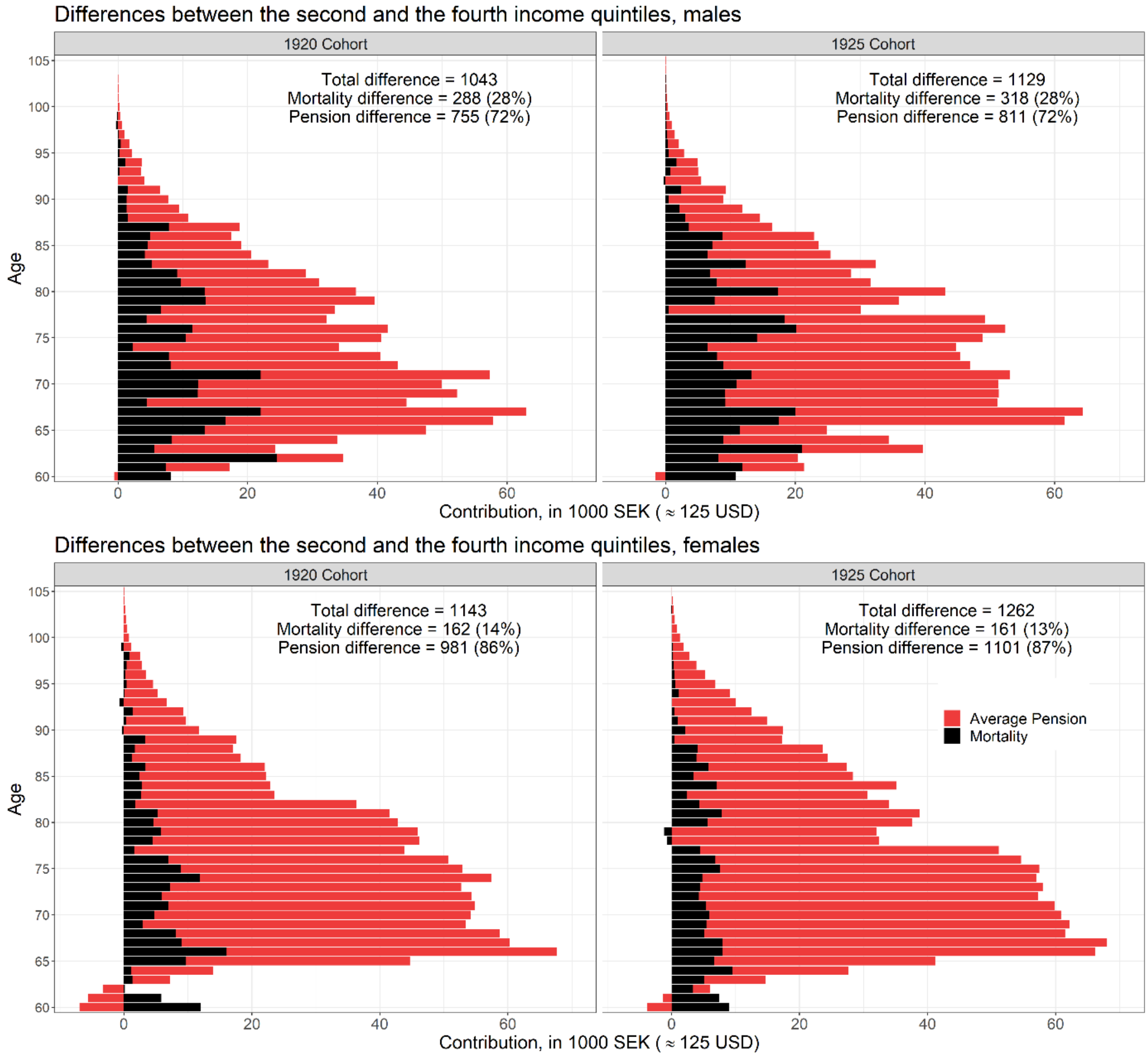

Figure A13. Decomposition of total lifetime pension differences between the second and the fourth earnings quintile groups into differences explained by age and mortality, by sex and cohort. *Source:* Authors' calculation based on linked administrative data from Statistics Sweden.

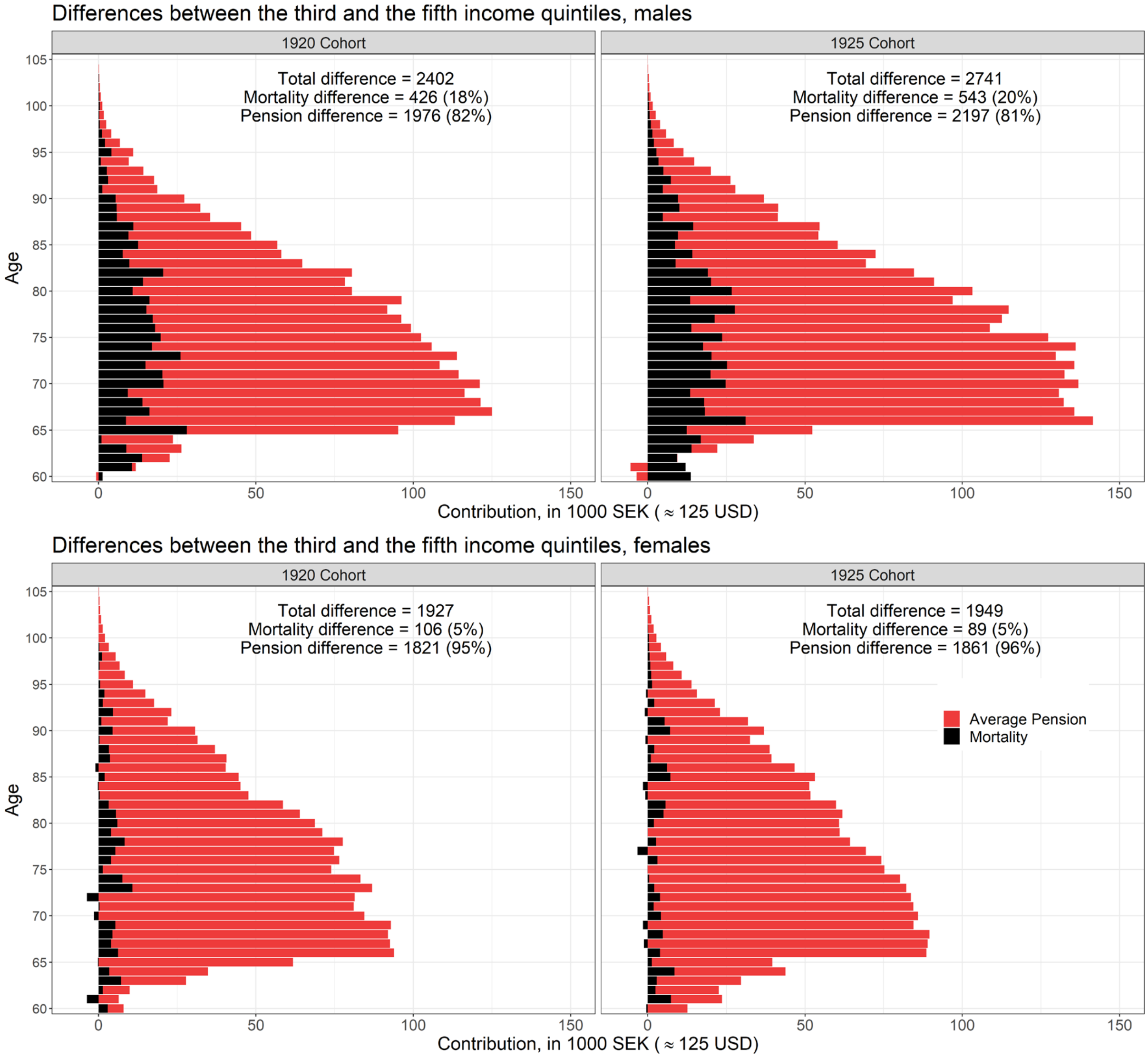

Figure A14. Decomposition of total lifetime pension differences between the fifth and the top earnings quintile groups into differences explained by age and mortality, by sex and cohort. *Source:* Authors’ calculation based on linked administrative data from Statistics Sweden.

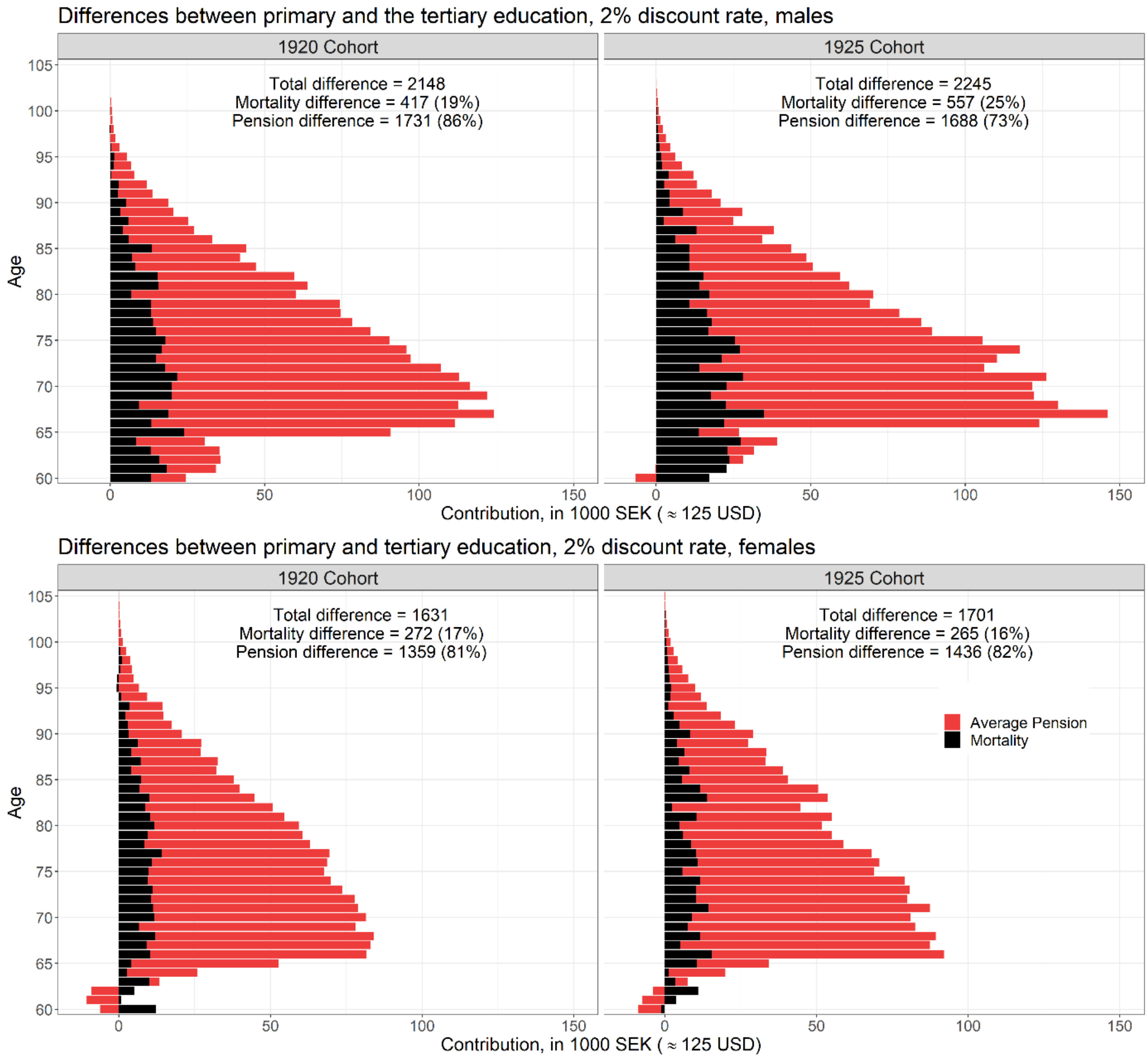

Figure A15. Decomposition of total lifetime pension differences between primary and tertiary education groups into differences explained by age and mortality, with 2% discount rate, by sex and cohort. *Source:* Authors' calculation based on linked administrative data from Statistics Sweden.

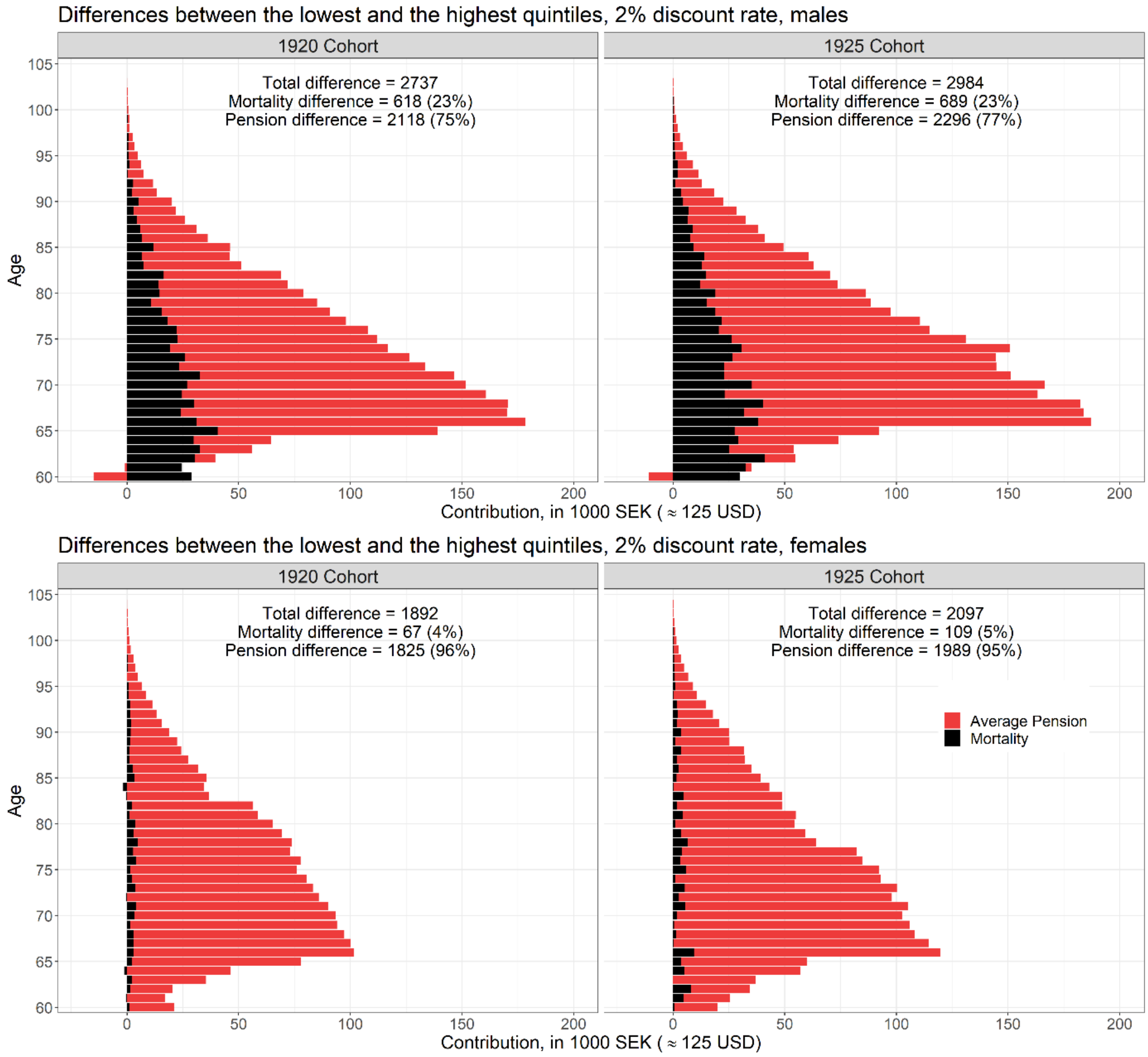

Figure A16. Decomposition of total lifetime pension differences between the bottom and the top earnings quintile groups into differences explained, with 2% discount rate, by age and mortality. *Source:* Authors' calculation based on linked administrative data from Statistics Sweden.

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