Socioeconomic inequalities in survival to retirement age in Denmark: a register-based analysis

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Abstract

Around the world, people are increasingly living to retirement and old age. This poses a threat to the financing of pension systems. In Denmark, statutory retirement age increases gradually to account for changes in life expectancy. However, the chances of reaching retirement age are not equal across the Danish population, and raising the retirement age could disproportionally affect those of lower socioeconomic status. In this paper, we investigate socioeconomic inequalities in mortality before and within five years of retirement age in Denmark. We use Danish registry data over a 30-year period, focusing on individuals aged 50 to 70. We conduct sex-specific survival analyses across socioeconomic groups using three dimensions of socioeconomic status: education, income, and occupation. We find that the gap in survival inequalities has widened over time between the lowest and highest socioeconomic groups for each measure, caused primarily by little or no mortality improvements in the lowest socioeconomic groups. These results are complemented by lifespan inequality measures, which also show increasing inequalities over time between socioeconomic groups. Individual level variability in socioeconomic characteristics therefore play a crucial role in defining the survival chances just before and shortly after retirement and thus should be considered when designing retirement policies.

Introduction

High income countries are experiencing unprecedented population aging, and Denmark is no exception. Two recent shifts in the population dynamics of high income countries account for this; the first half of the twentieth century saw a reduction in the risk of dying at younger ages, while the second half of the twentieth century saw a reduction in the risk of dying at older ages (Lee, 2003; Omran, 1971). As a result, more people are reaching retirement than in previous generations, and they are living longer when they do retire (Burger et al., 2012; Sanderson & Scherbov, 2010, 2015; Vaupel et al., 2021; Zuo et al., 2018). These phenomena, combined with the excess of births from the so-called "baby boomer" cohorts (Van Bavel & Reher, 2013), pose a threat to the sustainability of pension systems. Denmark, as well as several other EU countries, has handled this by implementing a reform that indexes pension age to life expectancy (Whitehouse, 2007). Current Danish legislation mandates a gradual increase in the statutory retirement age as life expectancy increases; in 2018 it was 65.5, and in 2019 it raised to 66. It is scheduled to rise in increments and will potentially increase to 74.5 in 2070, depending on future changes in life expectancy. This reform is designed to make the welfare state more robust to the aging population.

While indexing retirement age to life expectancy makes the pension system more robust, it also comes with economic and demographic challenges. For example, Alvarez et al. found that linking statutory retirement age to life expectancy increased uncertainty when measuring length of life after retirement, and that financial cost became more sensitive to changes in mortality (Alvarez et al., 2021). Additionally, as retirement age rises and people must survive longer to reach retirement age, the risk of death before or shortly thereafter may increase, specifically among sub-groups of the population that experience elevated risks of early death.

One such sub-group that experiences elevated risk of early death is those of lower socioeconomic status (SES) (Mackenbach et al., 2015). Typically, SES is analyzed using one or a combination of three dimensions: education, employment, and economic/financial indicators (Berkman et al., 2014; Mackenbach et al., 2008). Measuring and combining these dimensions comes with challenges, and researchers have used a variety of methods to categorize SES. For example, Mackenbach et al., (2017) used only highest level of educational attainment as a proxy for SES. In other cases, as in van Raalte et al., (2018), all three dimensions were analyzed separately. One notable study that used several economic dimensions was Cairns et al., in which economic and financial indicators from Danish Registry data were combined to develop an affluence index to study socioeconomic inequalities in mortality in Denmark (Cairns et al., 2019). Some dimensions have been found to be better indicators of SES in specific populations, for example Grundy and Holt found the best combination of indicators of SES among older adults in Great Britain to be educational qualification or social class paired with a deprivation indicator. This result was based on criteria ranging from theoretical foundation and ease of collection to association with health gradients. (Grundy & Holt, 2001).

Inequalities in mortality have been increasing over time across European countries. This trend has been observed even in countries with higher national incomes, quality of government, social transfers, healthcare expenditure, and more self-expression (Mackenbach et al., 2017), and cannot be fully explained by changes in social compositions of populations (Brønnum-Hansen & Baadsgaard, 2007, 2012). Socioeconomic inequalities in mortality persist among both older men and older women, and in some countries, these inequalities were found to be of a similar magnitude to those of the middle aged (Huisman et al., 2004). Improvements in life expectancy and lifespan variability have been found to differ across SES groups, with lower SES groups experiencing little improvement in life expectancy and no improvements in lifespan variability (Brønnum-Hansen et al., 2021). Analyzing the individual dimensions of SES shows a similar trend. Those of lower educational attainment have been found to be more at risk of early death, and relative inequalities in premature mortality by education level increased in most European populations through the 1990s and 2000s (Brønnum-

Hansen & Baadsgaard, 2007; Mackenbach et al., 2015). This has also been seen in other high income countries, including the United States (Montez et al., 2019; Sasson, 2016). Income, too, is associated with changing life expectancy, with higher income being associated with longer life expectancy in several high income countries (Chetty et al., 2016; Kalwij et al., 2012).

Increasing mortality disparities across SES groups suggest indexing the pension age to total life expectancy is inherently unfair to those in lower SES groups, as mortality improvements for these groups are negligible or nonexistent compared to higher SES groups (Brønnum-Hansen et al., 2021). Flexible pension schemes, whereby individuals would leave the labor market earlier, have been suggested to account for health inequalities across different SES groups (Brønnum-Hansen et al., 2017, 2020).

Given that social inequalities are persistent in Nordic welfare societies, including Denmark, this study examines how pension reform in Denmark would affect different socioeconomic groups. More specifically, this paper aims to identify who dies in Denmark before pension age or shortly afterward (within five years) by SES group. The analyses are based on all three dimensions of SES and present a complete picture of how early death in Denmark has evolved over time in the context of pension reform. Unlike most existing studies on the topic, we employ a cohort-based perspective in the analyses and use individual-level data to better capture the actual experiences of the cohorts, tracking them in a panel-like setting. Ultimately, this paper aims to determine whether increasing the statutory pension age increases inequalities among those living in Denmark.

Methods

Data

We use Danish registries from 1986 to 2019 to aggregate data on individuals' demographic and socioeconomic characteristics. Danish registry data include a range of health, demographic, and socioeconomic information on all registered residents of Denmark. The study population includes all individuals who were registered as resident in Denmark during the entire study period, aged 45 years or more. Because the study focuses on survival to retirement age (65) and shortly thereafter (70) of those who survived to ages 50 and 65 respectively, we focus on individuals from the year they turn 50 until age 65 or 70. We refer to these groups as "complete cohorts." Data also include individuals who are partially observed, i.e., those who were already older than 50 in 1986 and those who turned 50 after 2000 or 2005.

We analyze three dimensions of SES: education, income, and occupation. For the categorical variables, we compute the modal indicator's value observed between the age of 46 (61 when analyzing survival between 65 and 70), or the earliest age available, and 50 (65). For the continuous variables, we compute the average value observed between the age of 46 (61), or the earliest age available, and 50 (65). Because we are interested in long-term effects of SES, rather than on short-term fluctuations, we fix the computed values for each individual over the whole study period. We use two indicators of education level: the highest level of educational attainment and the length of education in months (Brønnum-Hansen & Baadsgaard, 2012). For highest level of educational attainment, individuals are divided into three categories according to the International Standard Classification of Education (ISCED): low (less than high school), mid (high school), and high (university diploma). We categorize length of education in months by tertiles by age, sex, and cohort. Income is measured in terms of family disposable income. This measure takes into account the different consumption needs of families with different sizes (Brønnum-Hansen & Baadsgaard, 2012).

Income data are divided into quartiles of family income, corrected for inflation, by age, sex, and cohort. Occupation is based on the International Standard Classification of Occupations (ISCO) classification, and is categorized into lower manual workers (Skilled Agricultural, Forestry and Fishery Workers; and Craft and Related Trades Workers), upper manual and lower non-manual workers (Plant and Machine Operators and Assemblers; Elementary Occupations; Technicians and Associate Professionals; Clerical Support Workers; and Services and Sales Workers), and upper manual workers (Managers and Professionals) (Brønnum-Hansen et al., 2020).

Analysis

We conduct two separate analyses to estimate: (a) the risk of dying between ages 50 and 65; and (b) the risk of dying between ages 65 and 70. Because pension policies are implemented by cohort, our main analyses are cohort-based (Ayuso et al., 2021). However, we also perform period-based analyses and present these results in the Appendix. For the cohort analyses, we use complete cohorts to give a better understanding of the different mortality patterns observed over time, and to provide more insights to both researchers and policy makers interested in pensions. We analyze the three SES dimensions separately and stratify the study population accordingly.

For each sub-population, we construct sex-specific cohort (and period) life tables. This allows us to compute the probability that, for instance, a 50 year-old male with low SES will die before his 65th birthday.

We compare different sub-populations by analyzing trends of the probability of dying between age 50 and 65 and between 65 and 70 across cohorts. We also compare the change over time of these probabilities of dying by calculating the average yearly rate of improvement for each sub-population. Assuming a constant improvement from one cohort to the next, we can adapt the standard equation for the rate of population growth (Keyfitz & Caswell, 2005) and get:

$$r_i = -\frac{\ln({}_{15}q_{50}^{c_2,i}) - \ln({}_{15}q_{50}^{c_1,i})}{c_2 - c_1},$$

where ${}_{15}q_{50}^{c_1}$ and ${}_{15}q_{50}^{c_2}$ are the probability of dying between age 50 and 65 for cohorts c_1 and c_2, the first and last cohorts, respectively. Thus, r becomes the average rate at which the probability of dying between ages 50 and 65 improved between the 1936 and 1954 cohorts.

We also apply the concept of ages of equivalent mortality (Burger et al., 2012; Vaupel et al., 2021), where attention is not given to chronological age, but rather to mortality levels themselves. We take, as baseline, the probability of dying between age 50 and 65 by sex for the high SES group and calculate the age at which the other SES groups reached the same probability of dying, assuming a proportional increase of the probability from one entire age to the next. Thus, for each cohort we estimate at which ages the low SES groups have already experienced the same mortality level as the high SES group and examine their trends over time to provide an alternative interpretation of fairness in retirement.

Based on the constructed cohort (and period) life tables, we estimate partial lifespan variation between ages 50 and 65 and between ages 65 and 70 – a measure of lifespan inequality – using the relative Gini coefficient:

$${}_{x_2}G_{x_1} = 1 - \frac{1}{{}_{x2}e_{x_1}} \int_{x_1}^{x_2} [l(s)]^2 ds,$$

where ${}_{x_2}e_{x_1}$ is the partial life expectancy between ages x_1 and x_2 and $l(s)$ is the survival distribution following (Shkolnikov et al., 2003). This measure captures the average distance between the ages at death of those individuals in the population who die between ages 50 and 65, and 65 and 70. The analyses were performed in R version 4.0.3, and all the code to replicate the analysis is available on GitHub [will be made available after peer-review].

Results

Looking at the compositional changes in education, income, and occupation in Denmark over time allows us to interpret results of the analyses more accurately. We present descriptive results for education and occupation as prevalence by sex and cohort, fixed at age 50, and income as quartiles of the income distribution by cohort, sex, and year.

Figure 1 shows changes in the educational and occupational compositions (panels a and b, respectively) of the Danish population at age 50 from the first to the last complete cohorts. Although we use education length by tertiles for the survival analyses, here we present educational attainment to highlight the changing composition of the population. The proportion of the population with a low level of educational attainment decreased for both men and women throughout the study period. This means that overall, recent cohorts have been more educated than older ones, though there was a slight increase in the proportion of low-educated individuals for the most recent cohorts. However, we do not see the same composition for men and women. Younger women were more present in the low and high categories, while about half of younger men were included in the middle category. For occupation, the composition for men did not change much between the first and the last cohorts (panel b). Conversely, there is a notable difference among women. The proportion of lower manual female workers decreased while the proportion of upper non-manual female workers increased.

FIGURE 1 HERE

Figure 2 depicts the evolution of family disposable income, adjusted for inflation. We calculate each person's average income for up to five years prior to reaching age 50, as well as the summary measures of the distributions for each cohort, by sex. Median income (indicated by the dots) has been increasing over the past decades for both men and women, with men having higher median incomes than women among older cohorts. However, in more recent cohorts, women and men present similar median incomes. The arrowheads on the left and right of the central dot show the first and third quartiles (25% and 75%) of the distributions, which have been drifting further apart with time, indicating an increase in income variability within each cohort. Most importantly in the context of our exploration of non-survival to pension age, there is evidence of stagnation in average income growth for cohorts after 1945, with divergence among men. Practically, this means that the poorer part of the population remained low-income.

FIGURE 2 HERE

Figure 3 illustrates results of the survival analyses between ages 50 and 65 for the cohorts 1936-1954. Each panel represents one of the three SES indicators: education (measured by length of education), income, or occupation (panels a, b, and c, respectively). In each of the three panels are two plots: the upper plot presents the risk of dying between ages 50 and 65; the lower plot presents the relative Gini coefficient.

The risk of dying between ages 50 and 65 decreased from the earliest to the most recent complete cohort for all SES groups. For instance, the risk of dying between ages 50 and 65 among men in the highest education tertile declined from 13.1% in the 1936 cohort (9.3% among women) – those who turned 65 in 2001, as shown on the x-axis of the plots – to 7.5% in the 1954 cohort (5.1% among women) – those who turned 65 in 2019. While this trend is seen across SES groups, the magnitude of the decrease varies. The plots displaying the probability of dying show that mortality improvements have been mostly experienced by higher SES groups, while there have been little to no improvements among those of lower SES. For example, the risk of dying between ages 50 and 65 for men in the lowest income quartile has remained almost constant across time, just under 25%. Among women a small decline has been observed, from 14.8% in the 1937 cohort to 12.6% in the 1954 cohort. Overall, there is a clear mortality stratification for different SES levels, with men having the biggest difference between groups. For instance, women and men in the lowest income quartile experienced noticeably higher mortality compared to all other groups, with men in the lowest income groups consistently experiencing mortality levels three times as high as those experienced by the highest income quartile. To complement the analyses on mortality trends and assess whether the observed mortality improvements were accompanied by a reduction in the variability of ages at death, we calculate the relative Gini coefficient for each SES group. The lower plots of the three panels comprising Figure 3 illustrate the relative Gini coefficients. Trends over time of the relative Gini coefficients very closely mirror those of the risk of dying. This phenomenon was expected, given the regularities of the relationship between mortality and lifespan inequality measures (Aburto et al., 2020). When analyzing the risk of dying, lifespan inequality reduced more rapidly among those with higher SES, while little to no improvement was observed among those in the lower SES group. To summarize, individuals in the lowest SES group experienced little to no mortality improvements between ages 50 and 65, and little to no reduction in lifespan inequalities over the 18-year study period.

FIGURE 3 HERE

Figure 4 shows results of the survival analyses between ages 65 and 70 for the complete cohorts 1921 to 1949, i.e., those who reached age 70 between 1991 and 2019, inclusive. This figure contains the same panels described for Figure 3.

Similar to what we observed in Figure 3, the risk of dying between ages 65 and 70, presented in the upper plots of the three panels, has been generally decreasing over time. However, here we were able to analyze a greater number of cohorts than previously, allowing us to look further back. Specifically, we see a slight bump in the risk of dying, peaking for the cohorts who reached age 70 in the mid-1990s. This phenomenon is more pronounced among women (mortality stagnation cohorts, see (Lindahl-Jacobsen et al., 2016)), regardless of SES group for both education and income (data were not available for occupation) and among men in the first and second quartile of the income distribution. From 2001, mortality improvements became more pronounced, in line with what we observed in Figure 3, though there are evident differences in the pace of mortality improvements between the SES groups. For instance, women in the second education tertile shifted from having a probability of dying similar to those in the lowest tertile (cohort 1921) to having a probability of dying similar to those in the highest tertile (cohort 1949). Mortality measures are again complemented by lifespan inequality, measured through the relative Gini coefficient. As in Figure 3, the relative Gini coefficients are displayed in the lower plots of each panel. Results are in line with those observed for mortality, with the lowest SES group experiencing little to no improvement in terms of reducing differences in the age at death.

FIGURE 4 HERE

To provide additional insights into mortality inequalities among different SES groups, we compute the equivalent age for the lower SES groups compared to the highest (for details, see the Methods section). In our analyses, we fixed retirement age at 65, which was the statutory retirement age in Denmark from 2004 to 2018, at which point it increased to 65.5, and subsequently to 66 in 2019. Figure 5 includes results of the equivalent age for each sub-population, defined according to the three SES dimensions (panels a, b, c for education, income, and occupation, respectively). The orange line in each plot represents the highest SES group, which was used as benchmark for the calculation of equivalent age by sex, cohort, and for each of the other sub-populations. We also perform these analyses by fixing mortality for high-SES women and comparing all other subgroups (lower SES women, and high to low SES men) to this value (see Figures A2 and A3 in the Appendix). Panel a in Figure 5, for instance, shows that in 2019, men and women in the lowest education tertile at age 56 (58.5 for women) had the same probability of dying as the highest-educated individuals had at age 65, conditional on surviving to age 50. Results for occupation (panel c) are slightly different for women than for men. Mortality differences reduced in the last year of analysis for women, while they continued to increase among men. The most striking difference is in income, shown in panel b. In

2019, the lowest income quartile experienced the same level of mortality at ages just above 53 for men and 55 for women than the highest income quartile experienced at age 65. Figure 5 also clearly illustrates how the study period mortality inequalities have been widening between the highest and lowest SES groups.

FIGURE 5 HERE

Finally, we quantify mortality improvements experienced by each sub-population. Table 1 shows the average yearly rate of improvement by sex, cohort, and for all sub-populations defined by education (tertiles), income, and occupation. From the first birth cohort of 1936 to the last cohort of 1954, the probability of dying between ages 50 and 65 improved, on average, by 1.9% between each pair of successive cohorts, with a faster improvement for women (2.4%) than for men (1.6%). Our results on the different sub-populations again suggest that improvements have been slower, on average, for those of lower SES. For instance, low-educated women experienced an average yearly improvement in mortality of 1.1%, compared to over 3.4% among women in the mid-educated. Those in the mid-educated group experienced a greater improvement than even high-educated women, in line with the results displayed in Figure 3, leading to mortality levels close to those of the high-educated group. The analysis on educational attainment shows that men in the lowest educational group experienced no improvement in mortality across cohorts (see Table A1 in the Appendix). Differences by income are considerable; the mortality rate varies from 0% and 0.9% to 4.4% and 4.1% between the first and fourth quartiles, for men and women respectively. As seen in previous analyses, there has been no improvement in mortality levels among men in the lowest SES group. Results from analyzing occupation resemble the social stratification observed for education and income. However, women in the mid occupational group had even higher mortality improvements than those in the highest one. Overall, these results clearly indicate that mortality improvements were far from equally distributed across SES groups over the course of the study period.

TABLE 1 HERE

Discussion

Socioeconomic inequalities in mortality are consistently observed in Denmark, and the gap is widening. This study addresses whether different socioeconomic groups might be affected differently by the increase in the statutory retirement age. Specifically, we identify who dies in Denmark before pension age (i.e., age 65) or shortly thereafter (i.e., age 70) by SES group, using three dimensions of SES. We advance the understanding of social inequalities in mortality and discuss them in light of pension reform in Denmark.

Overall, the results of this study are consistent with others that find widening social inequalities in life expectancy in Denmark, as well as in other European countries (Brønnum-Hansen et al., 2021; Brønnum-Hansen & Baadsgaard, 2012; Huisman et al., 2004; Mackenbach et al., 2003, 2017). We also find parallels with the body of literature that suggests recent pension reforms will inherently benefit those of higher SES, such that they will receive greater benefits in absolute terms than those of lower SES, even as those of lower SES will receive greater benefits in relative terms (Alvarez et al., 2021; Brønnum-Hansen et al., 2017, 2020; Brønnum-Hansen & Baadsgaard, 2007, 2012). Overall, results for each of the three dimensions of SES reveal that there are increasing inequalities between those in the lowest and highest SES groups. However, the magnitude of these inequalities is different across SES dimensions. Specifically, for the lowest educational attainment and income quartile, mortality was stagnant across the cohorts in analysis (1936-1954).

Our analyses show that Denmark is failing to reduce premature mortality equally across SES groups. We observe little or no progress in reducing lifespan inequality in the lowest SES groups, which has been decreasing at a much higher pace in higher SES groups. A possible explanation for this phenomenon is the higher prevalence of cardiovascular disease- and cancer-cause mortality between ages 40 and 65 among those with lowest SES (Koch et al., 2015; Östergren et al., 2019). Being able to reduce premature mortality by this and other means would lead to a reduction of lifespan inequalities between and within SES groups, and to improvement in life expectancy for low SES groups. The different dimensions analyzed in this study relate to different aspects of SES, each with different features that make them good proxies of SES. Furthermore, results are influenced by how these dimensions are measured. For instance, income does not suffer from compositional change in the sub-populations in the same way that educational attainment and occupation do. This suggests that the explanation for the association between mortality, lifespan variability, and SES change according to dimension.

Inequalities in life expectancy and lifespan variation among different educational groups are well documented, as education data are easily accessible, and, arguably, the most measurable dimension of SES. Belonging to the low-educated group might suggest a lack of material and nonmaterial resources leading to less healthy social environments and behaviors, and subsequently to worse health outcomes and premature mortality (Sasson, 2016). Education usually interacts with other factors, such as sex, race, and place of residence. The latter two have been studied extensively in the United States, where large differences in social inequalities in mortality across races and places of residence have been observed (Montez et al., 2019; Sasson, 2016). Overall, studies focusing on mortality and lifespan inequalities by educational group have reported an increasing gap between the highest- and lowest-educated across European countries and US states (Brønnum-Hansen & Jeune, 2015; Mackenbach et al., 2015; Montez et al., 2019; Sasson, 2016; Torssander et al., 2016). Results might, however, be influenced by the various ways in which education has been defined, as well as by compositional changes in the population over long periods of time. In our study, as suggested by Brønnum-Hansen and Baadsgaard (2012), we use length of education and classify the Danish population according to the distribution of education in three categories (tertiles) to account – at least partially – for changes over time in educational attainment (Brønnum-Hansen & Baadsgaard, 2012). We observe only a small improvement in mortality between ages 50 and 70 for the lowest educational group, with a much lower rate of improvement than for the highest educational group. These relative dynamics lead to greater social inequalities in mortality. We also use educational attainment as measure of SES. Comparisons across cohorts certainly suffer from compositional changes, but on the other hand, these changes make it easier to target specific groups with policy interventions. Among those with the lowest educational attainment (i.e., less than high school) there was no mortality improvement across the cohorts that were analyzed. This suggests that this specific SES group might be disadvantaged by further increasing statutory retirement age.

Income inequalities have increased in recent years in Denmark, as in other Nordic countries. It is possible that this has contributed to the widening mortality inequalities among income groups (Fors et al., 2021). Another possible explanation lies in the nature of the relationship between income and mortality. It is well established that individuals with higher income are more likely to have better living conditions, healthier behaviors, and access to better healthcare, which together lead to better health and longer life. Generally speaking, healthcare is widely accessible in Denmark, leaving behavioral factors as the main explanation for inequalities in mortality across SES groups (Dahl et al., 2021). At the same time, individuals in better health, including mental health, are also more likely to work longer, accumulate more wealth, and consequently have higher incomes at an age when those who are less healthy are more likely to have already retired (Dowd & Hamoudi, 2014; Tetzlaff et al., 2020). We thus used average income over (up to) five years prior to reaching age 50 and 65, rather than year-specific values, to reduce potential bias caused by health-related reduction of income. A third explanation of our results could be the selection into higher socioeconomic groups based on personal characteristics. As societies become more meritocratic, personal characteristics such as intelligence, personality, and non-cognitive traits become important values leading to success –

characteristics that are also associated with mortality (Dowd & Hamoudi, 2014; Fors et al., 2021). If obtaining a high income becomes more and more selective, inequalities in mortality among different socioeconomic groups will also increase. While it is difficult to clearly distinguish the role of each mechanism, our results are in line with other studies on Europe and the US in highlighting the increasing mortality and lifespan variability inequalities among income groups (Brønnum-Hansen et al., 2021; Fors et al., 2021; Kalwij et al., 2012; Tetzlaff et al., 2020; van Raalte et al., 2018).

The body of literature that examines the role of occupation in risk of mortality is not as wide as for education and income. The information on individual's occupation is less easily accessible and is harder to use consistently given the changes in the classification system over time. Furthermore, occupational type, within an individual's lifespan, might vary greatly from one year to another, making mortality calculation for different groups less reliable. We compute the modal occupation over (up to) five years prior to reaching age 50 and fixed if for the duration of the study period. We observed little individual variation across different occupational classes between ages 50, 55, and 60. However, we observed incongruous changes in the occupational class (towards manual workers) close to retirement age. This phenomenon justifies our approach, as it might have led to bias in our estimates, since the risk of dying increases close to retirement age, thus over-estimating the mortality of manual workers. Occupation, as a proxy of SES, is linked to mortality with a similar rationale to education and income. Furthermore, specific types of occupations have a greater impact on physical health than others (i.e., manual vs. non-manual), leading to higher risk of mortality. Overall, studies that focus on occupation as an indicator of SES reveal that manual workers have lower life expectancy than non-manual ones (Brønnum-Hansen et al., 2020; Mackenbach et al., 2008; van Raalte et al., 2018).

Methodologically, the main strength of this study is the use of individual-level data to perform survival analyses in a cohort setting as opposed to the period analyses often reported in the literature.

Pension policies affect cohorts directly, and drawing them according to results obtained with period analyses might lead to the wrong decisions. Ayuso et al. (2021) explain the importance of using cohort analyses, particularly for pension policy, in more detail.

Our findings have implications for pension systems. The three main objectives of pensions systems are to ensure adequate living standards for the elderly, to provide pensions that are in line with individuals' previous incomes to avoid changes in living standards, and to insure for various probabilistic events, including long life (Andersen, 2015). Widening social inequalities in survival to pension age, or shortly thereafter in Denmark suggest people of lower SES will likely receive their pensions for a shorter time, if at all, relative to those of higher SES. How the Danish pension system deals with this depends on its aim. If the primary goal of the pension system is to stay in line with changes in life expectancy, increasing statutory age as the average life expectancy increases without regard for whose life expectancy is increasing, then that goal has been achieved. However, the goal of the pension system is also to give equal benefits to everyone living in Denmark. While recent reforms have focused on low income groups in order to achieve such a goal, it is unclear how it reflects the increasing mortality inequality between people of lower SES – who will not receive the same benefits through the pension system as – people of higher SES. Alvarez et al. show that indexing the pension age to life expectancy magnifies the inequalities experienced by those of lower SES (Alvarez et al., 2021). In our analyses, we show that a man or woman from the highest income quartile who was born in 1954 would experience the same risk of dying between ages 50 and 65 as a man from the lowest income quartile who was born in the same year would experience between ages 50 and 53, and a woman would experience between ages 50 and 55. Thus, individuals from the lowest income quartile cumulate the same risk of dying in three years (men) or five years (women) as individuals from the highest quartile cumulate in 15 years. This difference is remarkable, and the gap is growing in recent years. It should be accounted for when planning pension reforms.

As of 2022, retirement age is linked to life expectancy to ensure the financial sustainability of the Danish retirement system in the face of increasing longevity. The Danish pension reforms are based on national-level data, both for men and women. In our analysis we focused on survival to pension age (i.e. age 65) and found that the yearly rate of improvement is different between sexes, and the differences are starker when accounting for SES. For instance, our results suggest that while at the population level we have observed a 1.9% reduction of mortality risk between ages 50 and 65 between every pair of successive cohorts, among low-skilled men, this risk increased by 1.2% from 2001 to 2019. Although the proportion of men performing low-skilled jobs in Denmark remained constant over the course of the study period, it is possible that low-skilled workers are more selected (in terms of human capital and health) compared to those who performed the same jobs in the past. Our analyses did not account for the possibility of such differences. This might explain the increased variability in the age of death of such group.

Understanding the mechanisms underlying our results is crucial to address the socioeconomic inequalities in mortality. However, any policy that works towards bridging the gap between SES groups will require time. In the meantime, the change in the pension system might be weighing risks unfairly on the shoulders of those who are already the more disadvantaged today. While we strive towards a fairer society, where mortality is less dependent on occupation or education, we should take into account the inequalities that exist and manifest themselves already. The Danish pension system is already flexible, allowing for an "earlier exit" from the labor force. As such, it should address the inequalities highlighted. Such a system should not only account for different mortality levels, but also for faster and slower rates of improvement across time across different socioeconomic groups.

Pension policies are based on aggregations of national data. They partially account for the persistent inequalities that exist in our societies and might weighs heavily against those who are already less advantaged if the widening social inequalities in mortality are not accounted for. Building systems that accurately represent these inequalities using individual-level data that reflect the real lived experiences of cohorts is a way forward to ensure fairer life in retirement.

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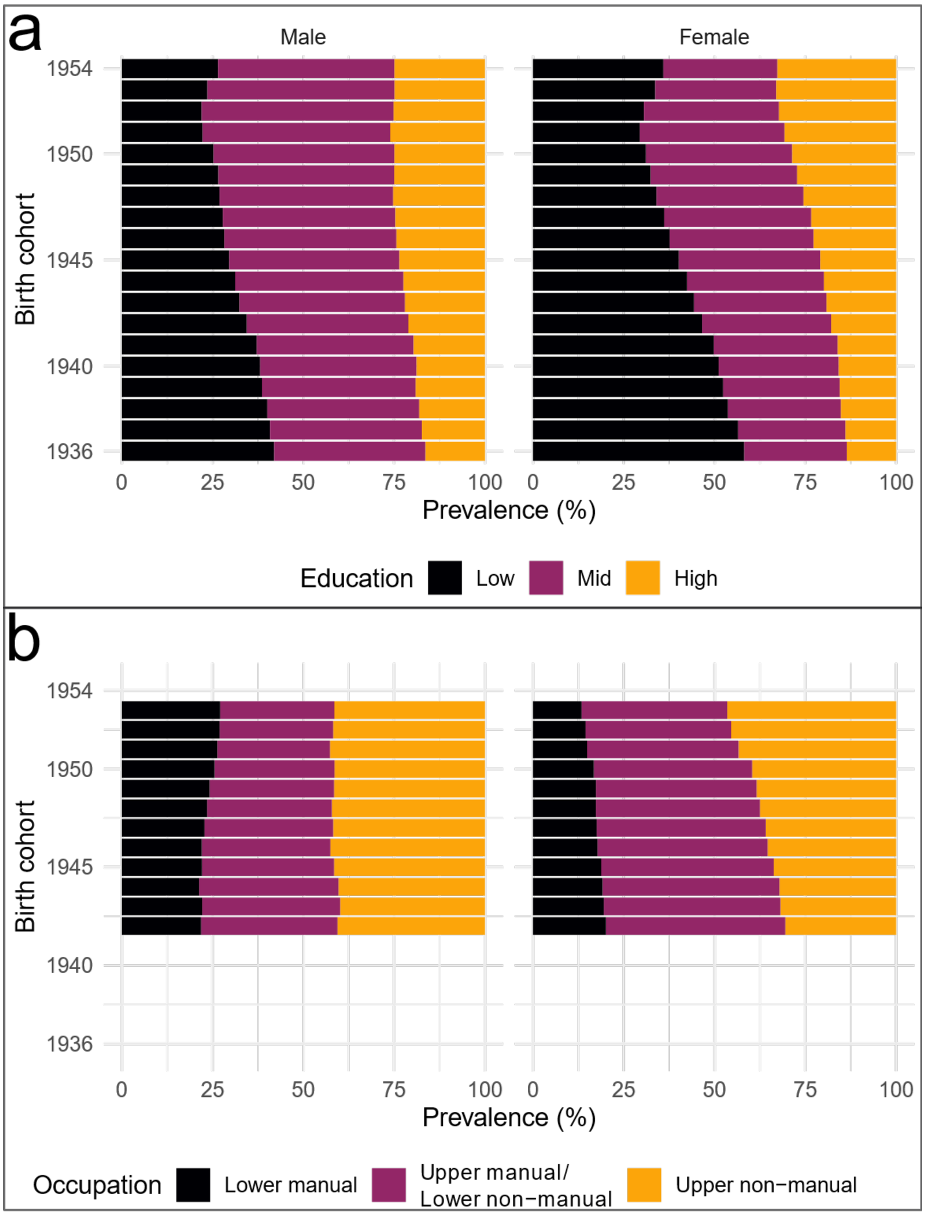
Table 1. Average yearly rate of mortality improvement for different Danish sub-populations and by sex (cohorts 1936-1954). Based on cohort mortality between age 50 and 65. Value for the total population, both sexes combined, sums to 1.9%

Male				Female			
Education tertile	Income quartile	Occupation level	Rate	Education tertile	Income quartile	Occupation level	Rate
.	.	.	1.6%	.	.	.	2.4%
1	.	.	0.5%	1	.	.	1.1%
2	.	.	1.8%	2	.	.	3.3%
3	.	.	3.1%	3	.	.	3.4%
.	1	.	0.0%	.	1	.	0.9%
.	2	.	2.1%	.	2	.	2.4%
.	3	.	3.3%	.	3	.	3.5%
.	4	.	4.4%	.	4	.	4.1%
.	.	low	1.2%	.	.	low	1.5%
.	.	mid	2.4%	.	.	mid	3.1%
.	.	high	4.4%	.	.	high	2.8%

Note: Occupational level low, mid, and high respectively correspond to: lower manual workers, higher manual and lower non-manual workers, and higher non-manual workers.

Figure 1: Prevalence of educational attainment levels and occupational groups at age 50 in the Danish population, by sex and cohort

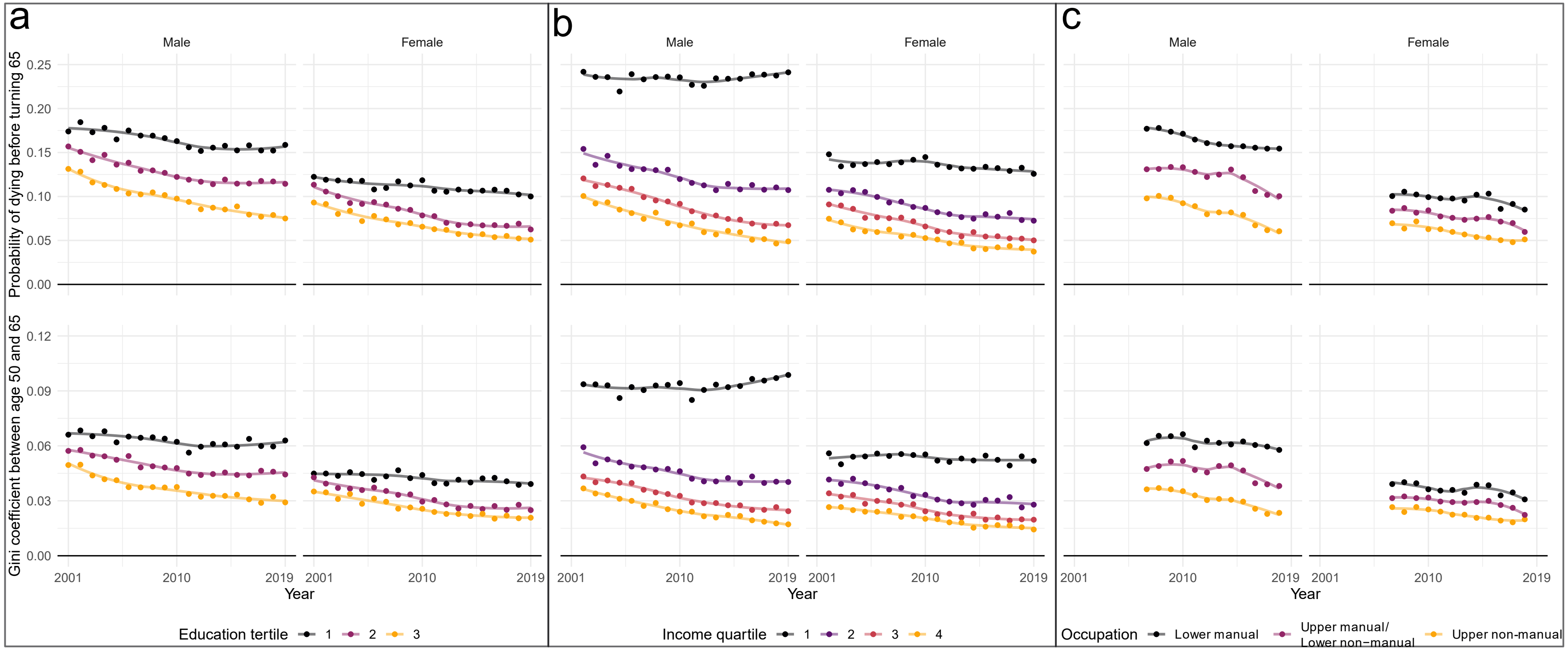


Note: Prevalence of occupational groups at age 50 in the Danish population is only displayed for the cohorts for which there were available data.

Figure 2: Distribution of average family income in the Danish population, by sex and cohort

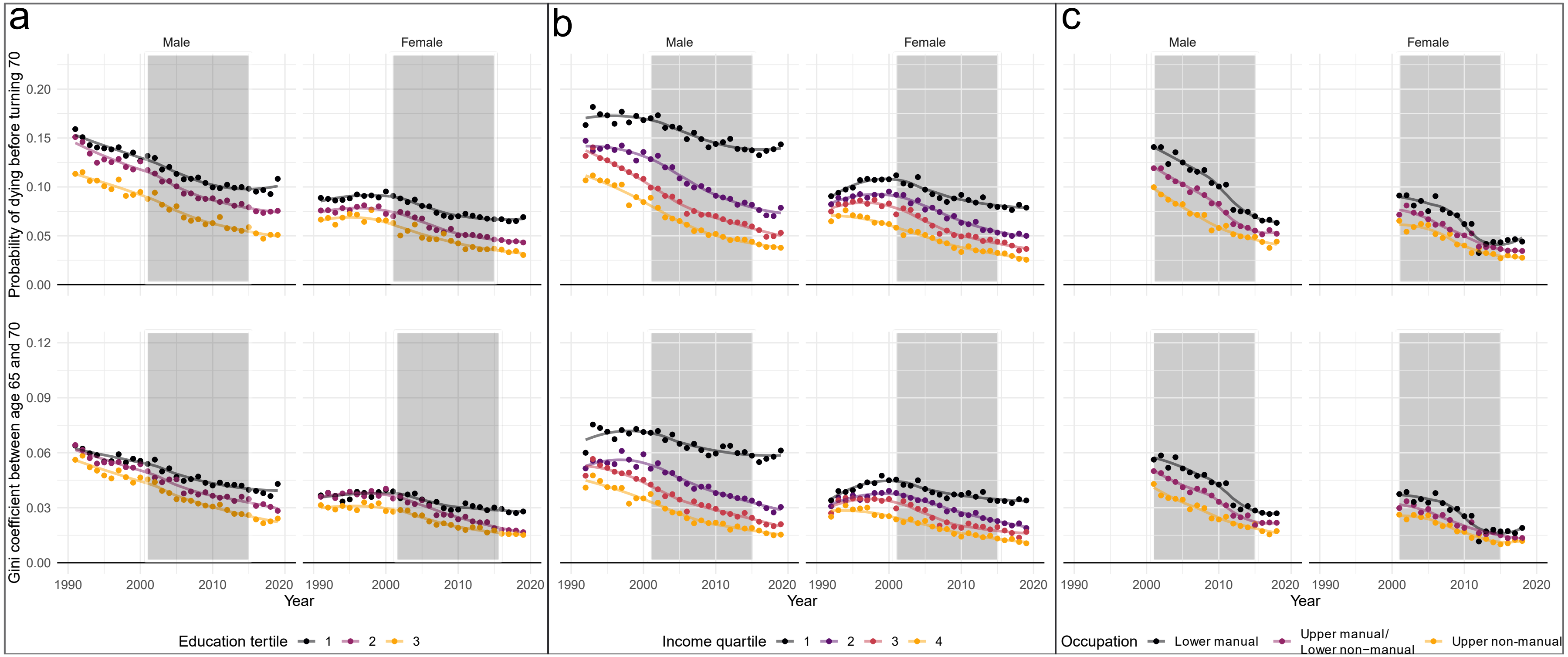
Note: Average family income between the age of 46, or the earliest age available, and 50.

Figure 3. Probability of dying and relative Gini coefficients for educational, income, and occupational groups, between age 50 and 65 in the Danish population, by sex and cohort



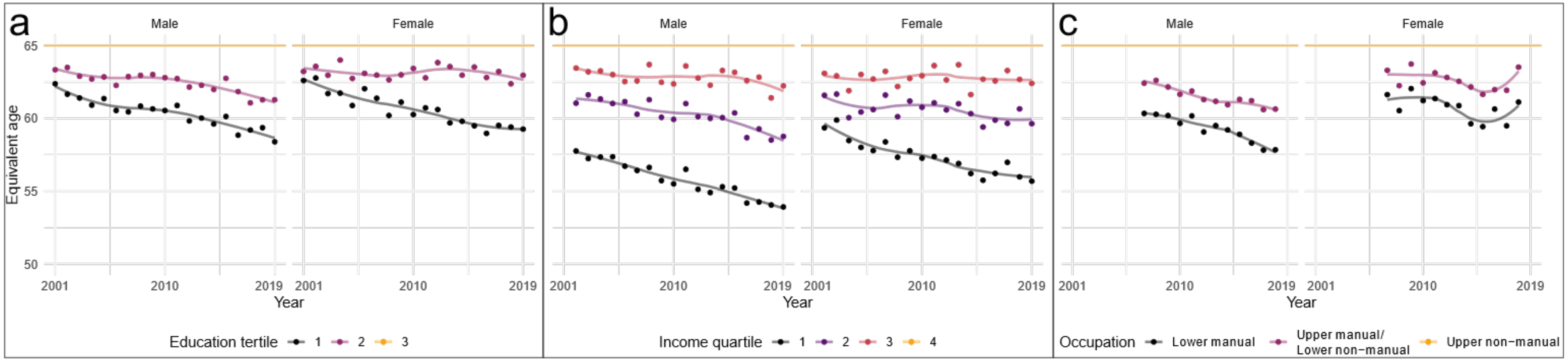
Notes: Income data are missing for the 1936 cohort, i.e., those who turned 65 in 2001. Occupation data are only available for the 1942-1953 cohorts, i.e., those who turned 65 between 2007 and 2018, inclusive.

Figure 4. Probability of dying and relative Gini coefficients for educational, income, and occupational groups, between age 65 and 70 in the Danish population, by sex and cohort



Notes: The grey area corresponds to the cohorts presented in Figure 3. Income data are missing for the 1921 cohort, i.e., those who turned 70 in 1991. Occupation data are only available for the 1930-1948 cohorts, i.e., those who turned 70 between 2000 and 2018, inclusive.

Figure 5: Equivalent age (men and women with highest SES = 65) for educational, income and occupational groups in the Danish population, by sex and cohort



Notes: Income data are missing for the 1936 cohort, i.e., those who turned 65 in 2001. Occupation data are only available for the 1942-1953 cohorts, i.e., those who turned 65 between 2007 and 2018, inclusive.

Appendix

Table A1. Average yearly rate of mortality improvement for different Danish sub-populations and by sex (cohorts 1936-1954). Based on cohort mortality between age 50 and 65. Value for the total population, both sexes combined, sums to 1.9%

Educational attainment	Male	Female
.	1.6%	2.4%
low	0.0%	1.2%
mid	1.7%	2.2%
high	3.2%	3.2%

Table A2. Average yearly rate of mortality improvement for different Danish sub-populations and by sex. Based on period mortality between age 50 and 65. Value for the total population, both sexes combined, sums to 1.8%

Male				Female			
Education tertile	Income quartile	Occupation level	Rate	Education tertile	Income quartile	Occupation (collar)	Rate
.	.	.	1.7%	.	.	.	2.0%
1	.	.	1.0%	1	.	.	1.3%
2	.	.	3.7%	2	.	.	3.9%
3	.	.	2.1%	3	.	.	2.1%
.	1	.	0.8%	.	1	.	1.3%
.	2	.	3.1%	.	2	.	3.0%
.	3	.	4.0%	.	3	.	3.0%
.	4	.	3.6%	.	4	.	3.0%
.	.	low	9.6%	.	.	low	9.5%
.	.	mid	5.9%	.	.	mid	6.1%
.	.	high	6.2%	.	.	high	5.8%

Notes: Results are unstable for occupation due to a high proportion of missingness. Occupational level high, mid and low respectively correspond to: high-white, low-white/high-blue and low-blue collar

Table A3. Average yearly rate of mortality improvement for different Danish sub-populations and by sex. Based on period mortality between age 50 and 65. Value for the total population, both sexes combined, sums to 1.8%

Educational attainment	Male	Female
.	1.7%	2.0%
low	0.8%	-0.2%
mid	1.3%	1.7%
high	3.1%	0.8%

Figure A1. Probability of dying and relative Gini coefficients for educational attainment groups, between age 50 and 65 in the Danish population, by sex and cohort

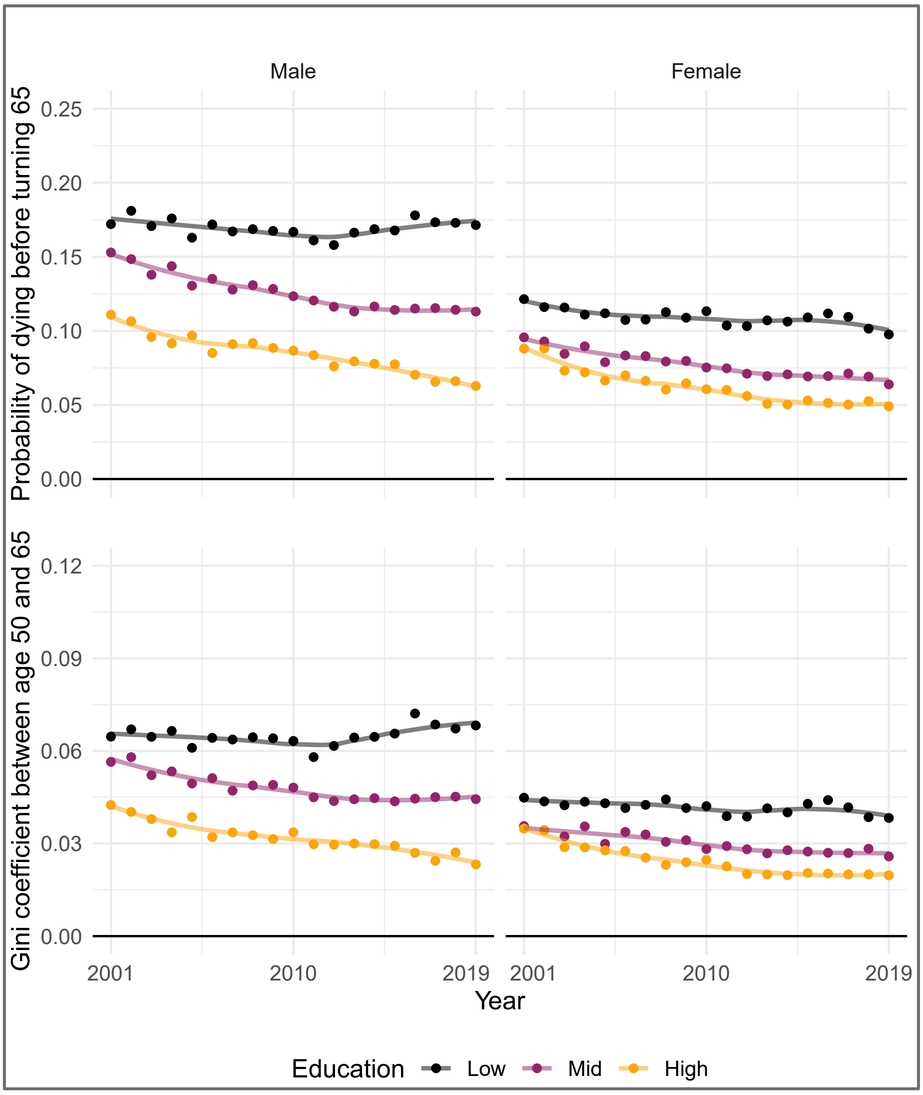
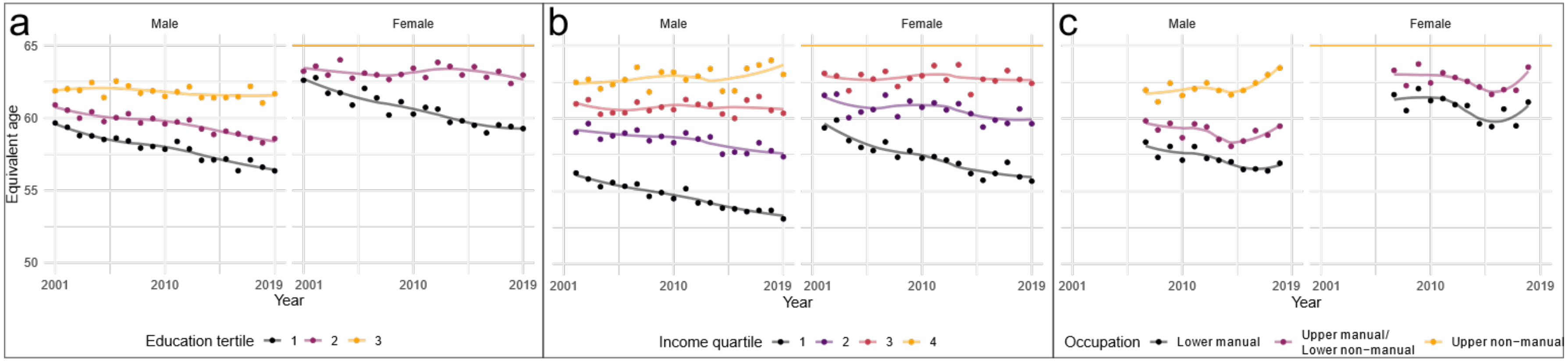


Figure A2: Equivalent age (women with highest SES = 65) for educational, income and occupational groups in the Danish population, by cohort



Notes: Income data are missing for the 1936 cohort, i.e., those who turned 65 in 2001. Occupation data are only available for the 1942-1953 cohorts, i.e., those who turned 65 between 2007 and 2018, inclusive.

Figure A3: Equivalent age (in panel a men and women with highest SES = 65, in panel b women with highest SES = 65) for educational attainment groups in the Danish population, by sex and cohort

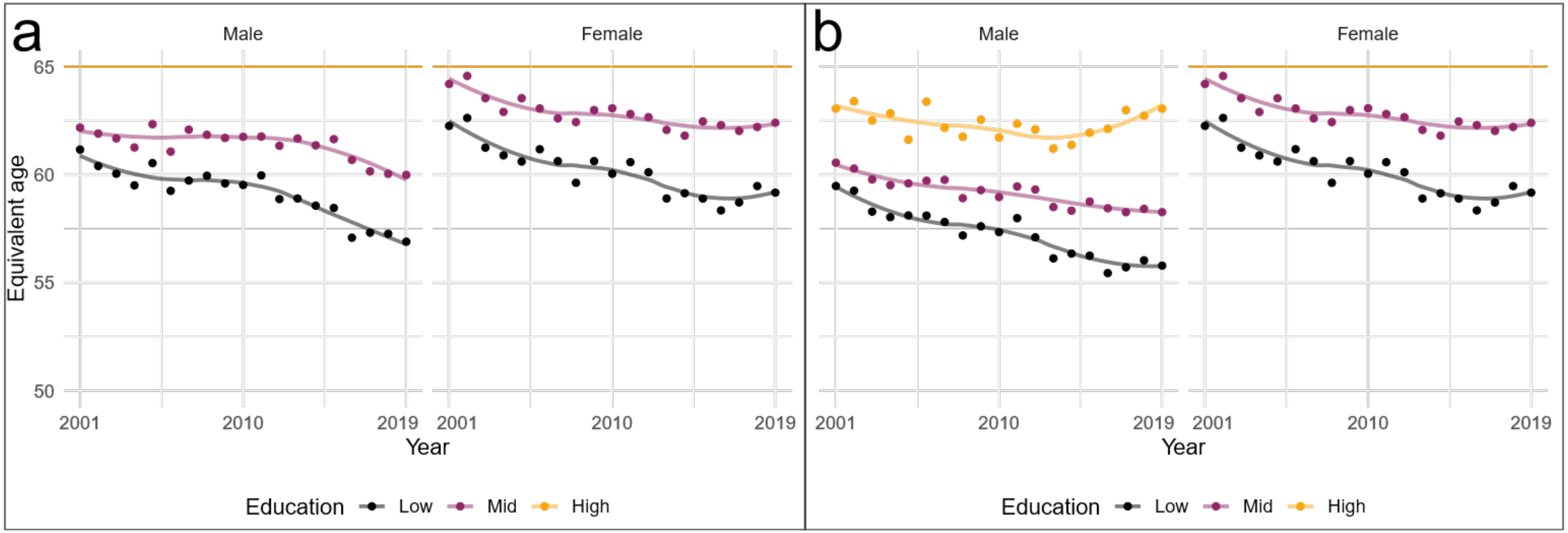
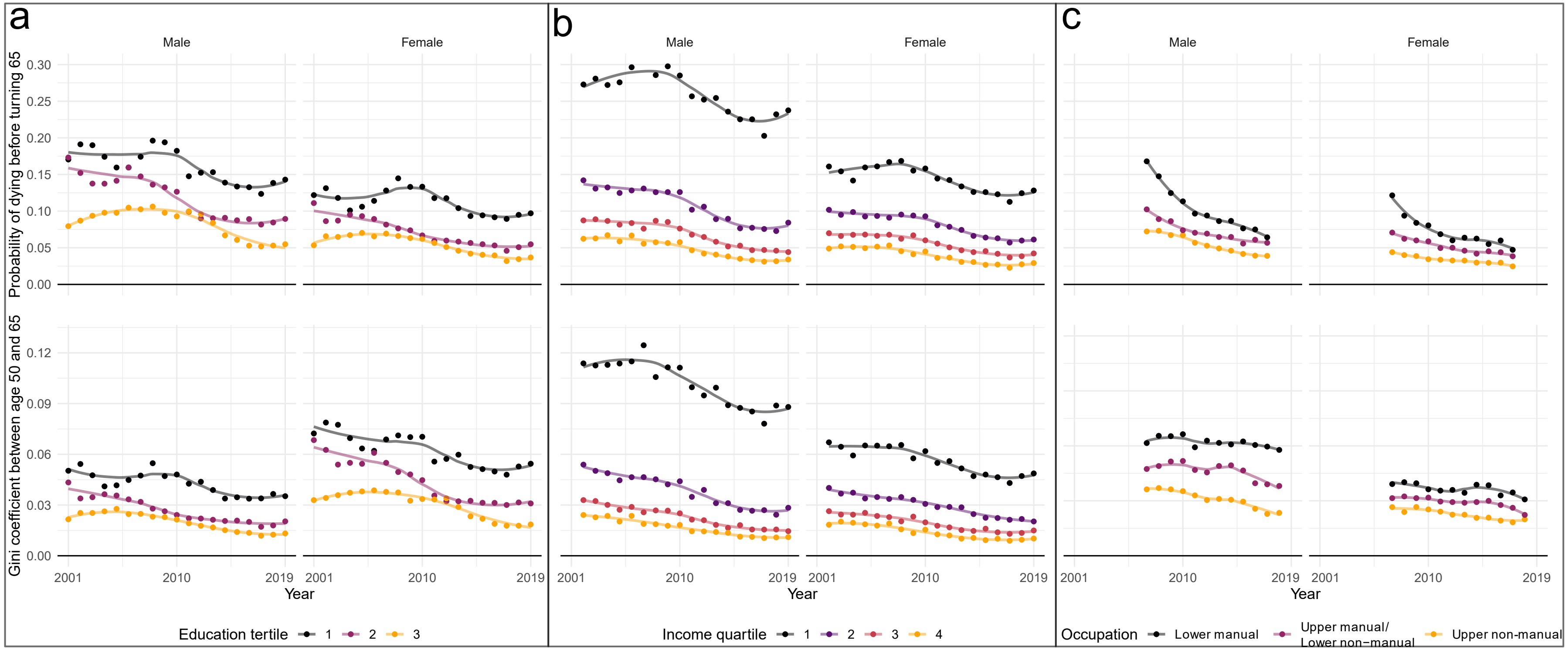
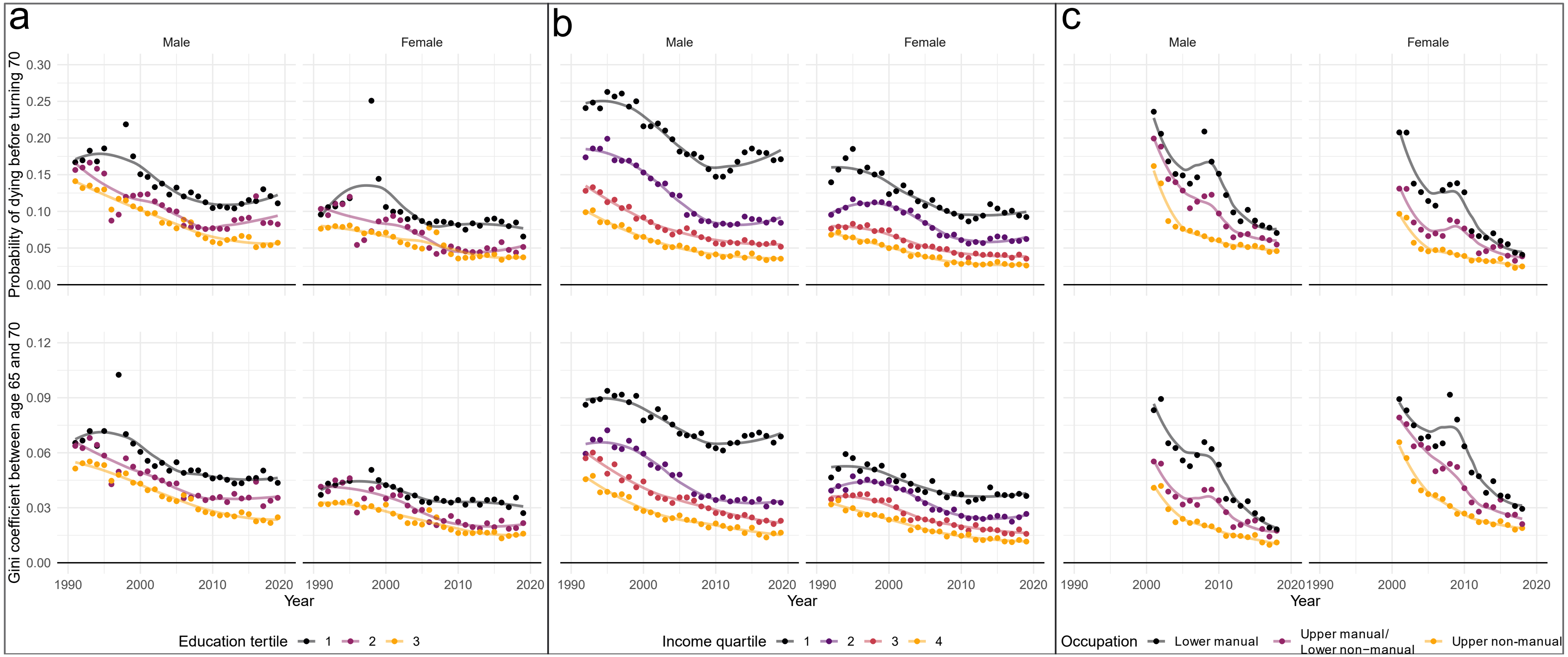


Figure A4. Probability of dying and relative Gini coefficients for educational, income, and occupational groups, between age 50 and 65 in the Danish population, by sex and period



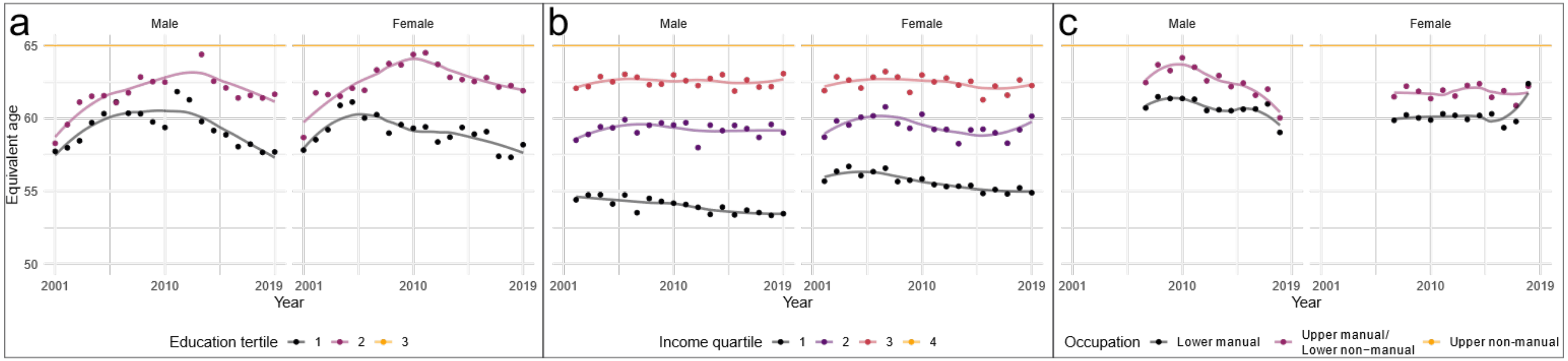
Notes: Income data are missing for 2001. Occupation data are only available between 2007 and 2018, inclusive.

Figure A5. Probability of dying and relative Gini coefficients for educational, income, and occupational groups, between age 65 and 70 in the Danish population, by sex and period



Note: Income data are missing in 1991. Occupation data are only available between 2000 and 2018, inclusive.

Figure A6: Equivalent age (men and women with highest SES = 65) for educational, income and occupational groups in the Danish population, by sex and period



Notes: Income data are missing for 2001. Occupation data are only available between 2007 and 2018, inclusive.

Figure A7. Probability of dying and relative Gini coefficients for educational attainment groups, between age 50 and 65 in the Danish population, by sex and period

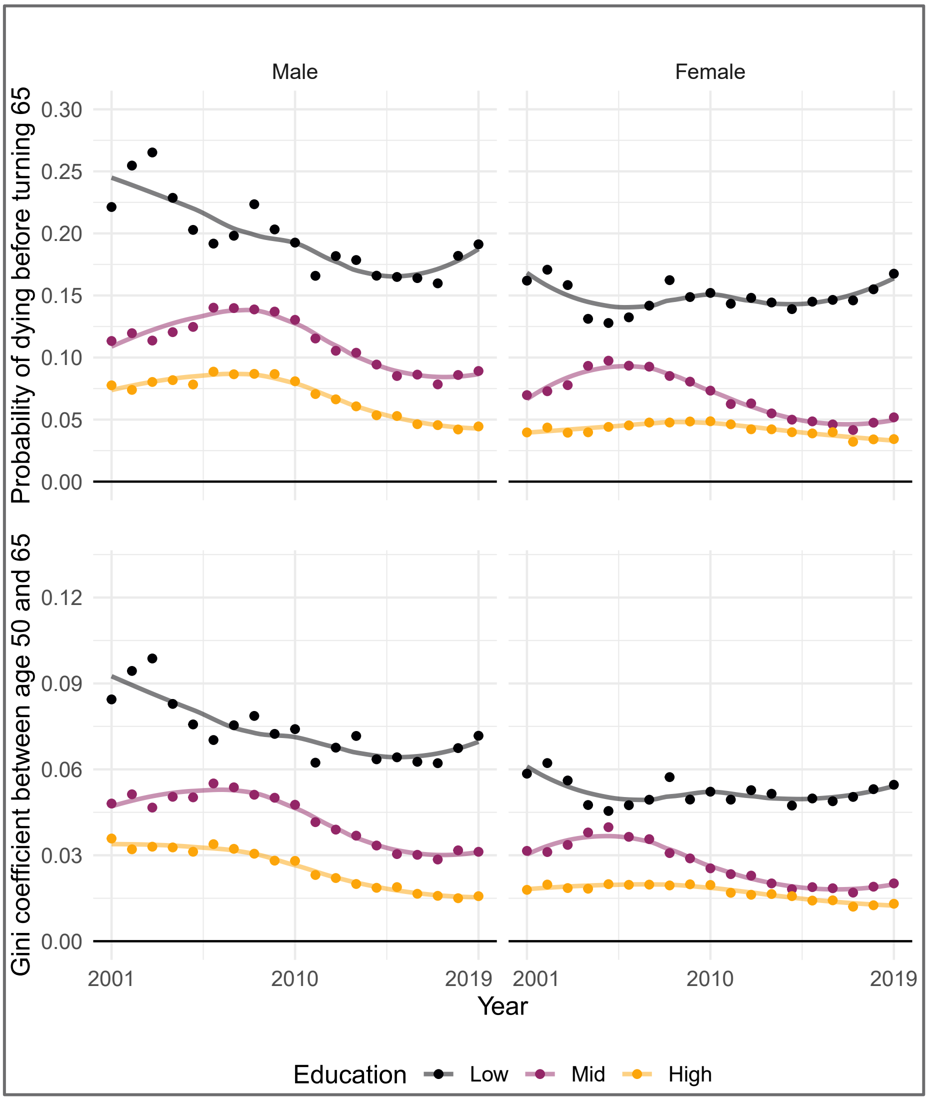
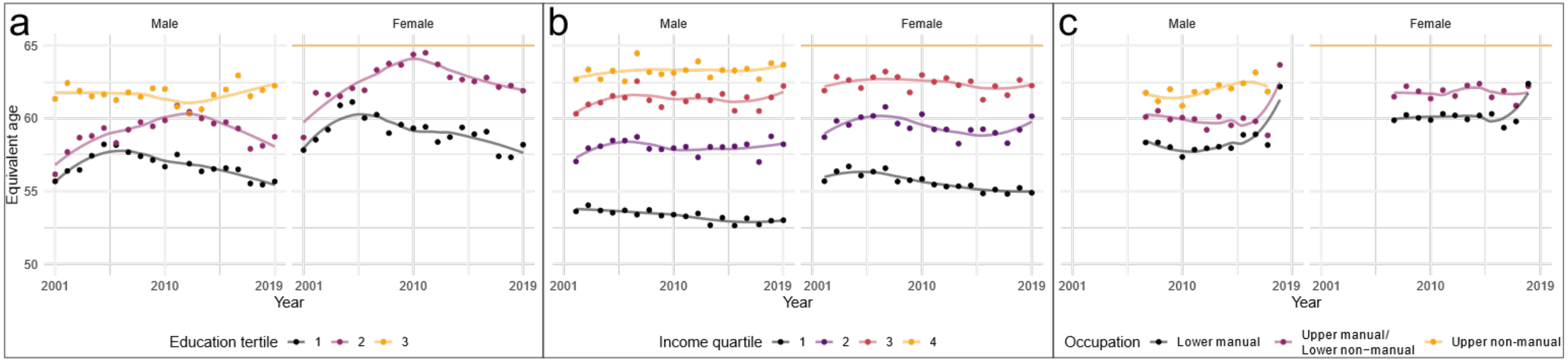


Figure A8: Equivalent age (women with highest SES = 65) for educational, income and occupational groups in the Danish population, by period



Notes: Income data are missing for 2001. Occupation data are only available between 2007 and 2018, inclusive.

Figure A9: Equivalent age (in panel a men and women with highest SES = 65, in panel b women with highest SES = 65) for educational attainment groups in the Danish population, by sex and period