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Research Article

Differences in mortality before retirement: The role of living arrangements and marital status in Denmark

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Research Article

Differences in mortality before retirement: The role of living arrangements and marital status in Denmark

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Abstract

BACKGROUND
To make the pension system robust to population ageing, Denmark will increase the statutory retirement age in tandem with national life expectancy. By universally increasing this age, this pension indexation policy might amplify known inequalities in mortality, such as those between people in different living arrangements.

OBJECTIVE
We aim to quantify inequalities in mortality before retirement age by living arrangement over time and to estimate whether an increase in the retirement age could disproportionately affect disadvantaged groups.

METHODS
We estimate the probability of dying between ages 50 and 65/67/70 for several cohorts of Danes living in different household types, stratifying by socioeconomic status. To give a more complete picture, we also calculate equivalent age for each sub-group.

RESULTS
In Denmark considerable mortality inequalities exist depending on living arrangements, and they are becoming larger. Across all the dimensions of mortality we examine, single individuals cumulate a clear disadvantage. An increased retirement age would increase absolute and (for single individuals) relative differences in pre-retirement survival, adding to the widening trends across cohorts.

CONCLUSIONS
Relying on the national average to set the statutory retirement age risks maintaining these subpopulations' disadvantage. While early retirement schemes exist in Denmark, they mostly impact people based on their occupation. We highlight that other characteristics are strongly tied to mortality and should also be considered.

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CONTRIBUTION

This paper falls within a project developed and directed by Jim Vaupel from 2019 until his death. He believed that the Danish pension indexation policy risked unfairly damaging specific groups. The results of this paper show that by neglecting existing and widening inequalities, this might indeed be the case.

1. Introduction

The ageing of European populations has jeopardised the financial sustainability of pension systems across the continent (Doyle et al. 2009; Ediev 2014). In order to address this concern, governments have striven to lengthen the working lives of their citizens, often by increasing the legal retirement age (Social Protection Committee and European Commission 2021; Liu 2021). Specifically, Denmark has been gradually increasing the statutory retirement age (from this point forward 'retirement age') with the objective of indexing (i.e., linking) it to national life expectancy, so that the average individual would live 14.5 years after retirement (Neergaard Larsen 2015).

While this reform makes the pension system more financially sustainable, it also risks making it more unbalanced. By considering a measure of average mortality, pension indexation does not account for the inequalities in mortality that exist within the Danish population. Several studies in Denmark that focus on social inequalities in average length of life and variation in length of life find that those inequalities have been increasing over time (Brønnum-Hansen et al. 2021; Brønnum-Hansen and Baadsgaard 2012). Uniformly raising the retirement age means that all individuals from a cohort are expected to survive longer to reach retirement age. This might disproportionately increase the risk of death before retirement for certain sub-groups of the population. For example, Strozza et al. (2022) have found remarkable inequalities – increasing over time – in survival to retirement age or shortly thereafter among socioeconomic groups in Denmark. Similarly, Alvarez, Kallestrup-Lamb, and Kjærgaard (2021) have found that indexing retirement age to national life expectancy increases uncertainty and socioeconomic inequalities in length of retirement. These studies suggest that such pension reforms risk disadvantaging already underprivileged groups in terms of access to retirement. This is the case even in a country such as Denmark, which has a flexible pension system that allows for 'early exit' from the labour market under certain conditions. However, these studies focus on socioeconomic characteristics and do not consider other features that are associated with mortality.

In this paper we will focus specifically on the impact of mortality differentials linked to living arrangements on the probability of reaching retirement, by examining how the

probability of dying before reaching the retirement age having survived to age 50 differs according to marital status and living arrangements combined in the Danish population. While we focus on pre-retirement mortality, the question of survival differentials after retirement is also relevant in terms of actuarial fairness. Since we consider how mortality changes with age, our results can offer some insight into this issue, even though it does not represent the core question of the paper.

1.1 Relationship status

Living arrangements (together with relationship status) have been shown to be strongly linked to mortality, with married individuals typically enjoying longer lives than other groups (Poulain, Dal, and Herm 2016; Rendall et al. 2011; Zueras, Rutigliano, and Trias-Llimós 2020), an association also reflected in health levels (Grundy and Tomassini 2010; Lawrence et al. 2019; Umberson et al. 2006). Moreover, the distribution of living arrangements has evolved considerably across time (Fokkema and Liefbroer 2008), with an ever-higher share of Europeans living alone, a condition linked to the highest levels of mortality (Esteve et al. 2020; Reher and Requena 2018). While all relationship statuses (e.g., being married, divorced, in a registered partnership, or widowed) and living arrangements (e.g., living alone, living with a small child, living with a partner) have been used in this strand of research, the recent literature has suggested the need to account for both (Zueras, Rutigliano, and Trias-Llimós 2020).

Despite the abundant literature on the subject, there remains a debate about the mechanisms leading to the clear mortality differentials uncovered. The two main competing explanations are protection of marriage/partnership and selection into marriage/partnership. The first argues that marriage offers advantages such as financial stability, economies of scale, emotional support, and institutional recognition (Frisch and Simonsen 2013) and that a live-in partner is more likely to monitor the health habits of an individual and to encourage them to contact health professionals (Lau and Kirby 2009). The second points out that individuals who get married and/or live with someone are probably different from individuals who do not. These differences can be tied to physical health, socioeconomic status (SES), or even personality traits (Requena and Reher 2021). From the moment these traits influence positively both entry into marriage or partnership and survival, they could explain the mortality differentials between various groups. Recent studies find that these two mechanisms coexist, although selection effects may be particularly important at younger ages, while protection effects play a greater role later in life (Franke and Kulu 2018; Requena and Reher 2021).

While findings consistently point to the greater mortality of single people and individuals living alone and to the higher survival of married individuals and those living

with a partner (Frisch and Simonsen 2013; Kilpi et al. 2015; Rendall et al. 2011; Robards et al. 2012), the role of other characteristics have also been examined. Gender seems to be an important moderator of this relationship, with men benefiting more from marriage than women – although not all analyses find such differences, which may also depend on the national context (Kandler et al. 2007; Rendall et al. 2011; Scafato et al. 2008; Zueras, Rutigliano, and Trias-Llimós 2020). Differences according to living arrangement seem to wane with age, as also happens with other mortality differences, such as those linked to SES. A number of theories have been proposed to explain these results, from the increased prevalence of extremely bad health among older individuals (Hoffmann 2011) to the effect of selection on intrinsic or extrinsic (e.g., education) factors in a heterogeneous population (Dupre 2007; Vaupel and Yashin 1985). At the same time, the literature focuses on differences in mortality at mature ages, so that less is known about the relationship between relationship status and mortality during younger adulthood (Koskinen et al. 2007; Poulain, Dal, and Herm 2016; Zueras, Rutigliano, and Trias-Llimós 2020). Finally, Murphy, Grundy, and Kalogirou (2007) argue that while relative differences decrease, absolute differences actually grow with age.

Another important aspect to consider are marital disruptions such as divorce or widowhood. Divorced and widowed individuals consistently show a higher probability of dying compared to their married counterparts and marital disruptions are typically followed by periods of increased mortality (Berntsen and Kravdal 2012; Leopold 2018; Lucas 2005). While this increase may slow down and even stop with time (Metsä-Simola and Martikainen 2013), its magnitude depends on the individual's characteristics, with men and non-White populations typically suffering more (Berntsen and Kravdal 2012; Liu, Umberson, and Xu 2020; Sullivan and Fenelon 2014). The higher mortality of divorced and widowed people could be endogenously linked to selection as well as to a range of causal mechanisms (e.g., unhealthy behaviours, stress, loss of resources) (Ennis and Majid 2020; Sbarra, Law, and Portley 2011).

1.2 Limitations of previous literature and our contributions

While the literature on the mortality differentials linked to living arrangements and parity is abundant, it has some limitations. Firstly, papers can lack a concrete policy application with regards to the inequalities they uncover, whereas our analysis is explicitly focused on the impact of these differentials on the probability of dying before retirement. Secondly, analyses are often limited to a period perspective because of the unavailability of longitudinal data. Some studies do include long stretches of time (e.g., Kravdal 2017; Valkonen, Martikainen, and Blomgren 2004), but consider the population at each subsequent year (period perspective), rather than based on year of birth (cohort

perspective). On the contrary, by following individuals based on their year of birth, we can examine the overall progression of inequalities across specific cohorts, which is particularly relevant when considering policies that are cohort-based, like those influencing standard and special pension systems. Previous research has also often been based on regression results, identifying the main effects of specific living arrangements or marital statuses, net of other characteristics. However, individuals cumulate (dis)advantageous characteristics and policies should take into account their interaction. By stratifying the population along our variables of interest rather than by controlling for them, we show the actual mortality patterns of living arrangement sub-groups. Moreover, this straightforward approach allows us to not impose any modelling on our data, which could skew the results. Finally, because we have access to information about the whole Danish population rather than a sample, we are able to obtain meaningful estimates of the differences in mortality even when stratifying along multiple characteristics.

2. Methods and data

We use data from the Danish registries. These provide yearly information on, among other variables, socioeconomic, marital, and coresidence status for all individuals residing in Denmark, updated yearly since 1986, for a total of about 3.4 million individuals and 37 million person-years of observation (for a more detailed summary, see Appendix A). We divide the Danish population into meaningful sub-groups defined according to sex, living arrangement, and SES. For each sub-population we extract the exposure and the number of deaths to construct sex-specific lifetables. In such a setting we do not make any assumption about each subpopulation's mortality pattern. From these, we compute the probability of dying between ages 50 and 65, which was the standard retirement age throughout most of our observation period. In the same way, we calculate the probability of dying between ages 50 and 67/70 to estimate how a longer working life would affect each group (67 is the current retirement age, while 70 is the forecast retirement age for 2040 (Ministry of Finance 2020)).

We use a variable capturing both marital status and cohabitation (as suggested by Zueras, Rutigliano, and Trias-Llimós (2020)) to distinguish individuals living in four household types: single people living alone (from this point forward 'single'), married individuals living with their spouse ('married'), individuals cohabiting with a partner ('cohabiting'), and individuals in complex households (i.e., a residual category constructed by Statistics Denmark in its registries, comprising different families living at the same address). Given the definition used in the registries, complex households can also be constituted of parents and children aged 18 or over (we use the term as defined by Statistics Denmark, which is slightly different from the definition used in censuses

(see definition by Insee[3]). On the other hand, children under the age of 18 are not counted, so a single person could be living with one or more minor children. We compute a modal household type for each individual (i.e., the most observed household type for each individual during the observation period – from now on simply 'household type'). This means that we do not consider transitions between households. A considerable share of individuals in all household types (from 40% among the married to 72% among individuals in complex households) transition from one household type to another at some point between ages 50 and 65. However, for 70% of individuals between ages 50 and 65 (up to 76% and 74% for individuals between ages 50 and 67/70, respectively) the modal household type corresponds to the first and last household types recorded, suggesting that these transitions are often impermanent and do not overly influence our results.

We stratify the population by education (which can also be considered a proxy for SES). We calculate the average length of education (in months) observed during the five years before age 50 and compute tertiles by sex and cohort. Further analyses were run using family disposable income and occupation, but are not shown here as they do not substantially change the results. They are available upon reasonable request to the authors.

We take advantage of the longitudinal nature of the registers to adopt a cohort rather than a period perspective (i.e., construct cohort lifetables). As pension reforms affect individuals based on their birth cohort, this framework seems to be the most appropriate (Ayuso, Bravo, and Holzmann 2021). We also focus on cohorts which were fully observed as of 1st January 2019: for the probability of dying between ages 50 and 65 we analyse cohorts born between 1936 and 1954, and for the probability of dying between ages 50 and 67/70 we analyse cohorts born between 1936 and 1951/1948. We define the population as individuals who were residing in Denmark at the 1st January of every year, stratified by cohort, sex, and the variables of interest. Individuals belonging to the observed cohorts can enter the population by turning 50 or migrating into Denmark, whichever comes first, and they can exit the population by turning 65/67/70, migrating out of Denmark, or dying, whichever comes first.

In this work we aim to understand how a pension reform based on the average national mortality, such as that adopted by Denmark, may differentially affect specific groups.

In order to do that, we compare the probability of dying between ages 50 and 65 with the probability of dying between ages 50 and 67/70, as examples of an increased retirement age. We show the difference in these probabilities as:

$$diff_{i,c} = \quad {}_{x}q_{50}^{i,c} - \quad {}_{15}q_{50}^{i,c}$$

[3] https://www.insee.fr/en/metadonnees/definition/c1742.

for each household type *i* and cohort *c*, where *x* is 17 (for ages 50 to 67) or 20 (for ages 50 to 70). This measure can effectively be interpreted as the increase in the probability of dying when the threshold age is shifted to 67/70.

We also investigate between-group differences with the concept of equivalent age (Burger, Baudisch, and Vaupel 2012; Vaupel, Villavicencio, and Bergeron-Boucher 2021). We compare mortality between ages 50 and 65 of a target population (the most advantaged) with all the other sub-populations and calculate the age when the same probability of dying of the target population is reached. Let us say we want to compare married and single men at age 50. A 50-year-old married man may have a 10% chance of dying before age 65, while a 50-year-old single man may instead have a 10% chance of dying before age 62. In this case, the equivalent age would be 62. The probability of dying is the same, but the time over which this probability is cumulated is shorter for single than for married men. The relative nature of this metric makes it easier to visualize whether inequalities across cohorts have been increasing or decreasing and to differentiate trends across sub-groups. This calculation is performed by cohort and sex, in addition to the variable(s) of interest. In the Appendix we also show results for ages 50–67/70.

Finally, to consider within-group inequality we also estimate partial lifespan variation. As its patterns largely overlap with those of the probability of dying we do not present the results here, but they are available upon reasonable request.

For each subpopulation and measure, we compute the 95% confidence intervals of every estimate by bootstrapping 10,000 populations of 20,000 individuals each with the subpopulation's underlying lifetable death distribution.

3. Results

Figure 1 shows how the prevalence of household type between ages 50 and 65 has shifted throughout the cohorts in our data, by sex and level of education. In general, we observe a reduction in the prevalence of married couples from the first (1936) to the last (1954) cohort in analysis. This pattern is more pronounced among men, for whom we also observe a clearer educational gradient than for women: Men in the first education tertile are considerably less likely to be married than those in the third tertile.

Figure 1: Prevalence of household type by length of education and sex, birth cohorts 1936–1954

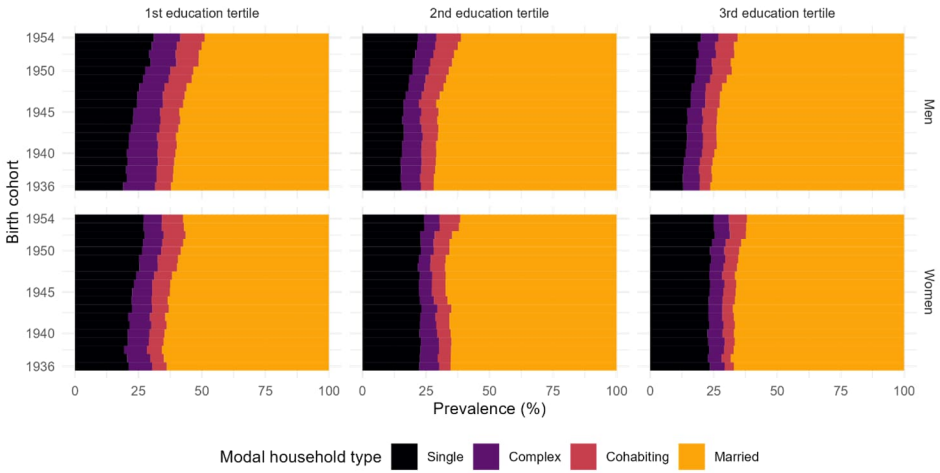


Figure 2 shows the patterns in the probability of dying between ages 50–65. Because we could use longitudinal data it shows the mortality experienced by each group and cohort, rather than a cross-sectional picture of it. Overall, the mortality estimates presented in Figure 2 are characterised by narrow confidence intervals. Results are therefore robust for all the subgroups analysed across cohorts.

Figure 2 highlights a difference in the mortality trends between men and women. The former show very clear and constant differentials, as their trend lines and confidence intervals never cross, with single men having the highest probability of dying, followed by men in complex households and cohabitating men, while married men have the lowest probability of dying. These differentials are wider in the lowest education tertile: for instance, for the 1936 cohort there is a two-fold difference between the mortality of single (26%) and married (13%) men in the first education tertile, which grows to more than a three-fold difference for the 1954 cohort (27% vs. 8%). For highly educated men these differences remain smaller: for the 1936 cohort, single men's probability of dying is double that of their married counterparts (21% vs. 11%) and this difference only reaches the three-fold mark for the 1954 cohort (15% vs. 5%). The probability of dying between ages 50 and 65 for all groups of men decreased, but much less so for single men. Women have overall lower probabilities of dying than men: even the most-educated men tend to have higher or similar probabilities of dying compared to the least-educated women within the same household type. Except for married women, who show markedly higher

survival, there are not significant differences between other household types, whose trends and confidence intervals overlap and cross each other. Even when compared to married women, inequalities in mortality generally stay between 10 and 5 percentage points, although they are larger for the lower education tertiles

Figure 2: Probability of dying between ages 50 and 65 by household type, length of education, and sex. Birth cohorts 1936–1954

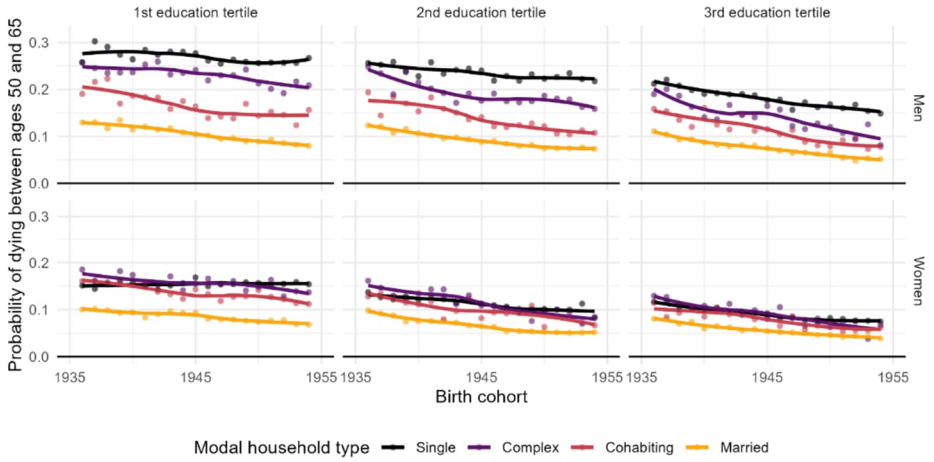
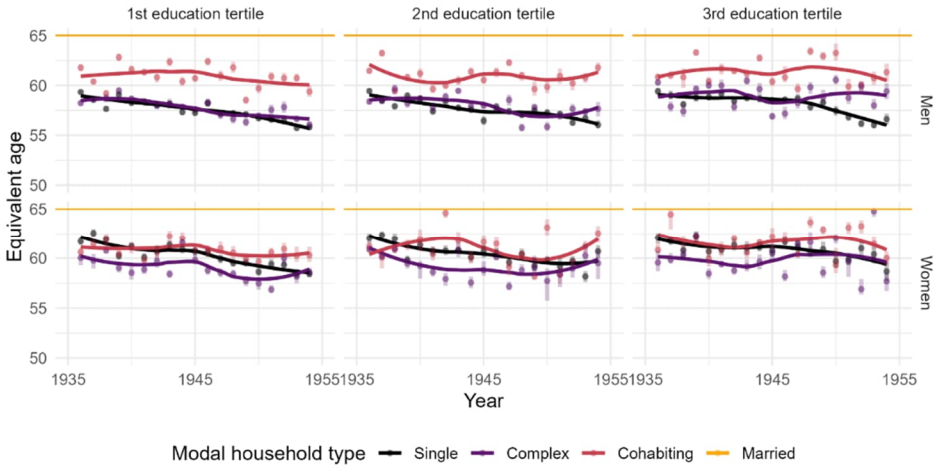


Figure 3 shows the results of the equivalent age analyses by sex, household type, and tertile of the length of education. The confidence intervals around the estimates are narrow, as for Figure 2.

Focusing on changes across cohorts rather than the inequality levels (while still large, they have already been described when commenting on Figure 2), we see that mortality inequalities between married and single people have been increasing. This is true for both sexes and different education tertiles. For instance, the probability of dying between ages 50 and 65 for a highly educated married man born in 1936 equals the probability of dying between ages 50 and 59.4 for a single man with the same level of education. On the other hand, for two men born in 1954, a single man in any education tertile had the same probability of dying by about age 56 as a married man by age 65, both conditional on surviving to age 50. By contrast, the gap between married individuals and individuals in one of the other two household groups either remained stable or decreased between the first and last cohort, except for the least-educated individuals in complex households.

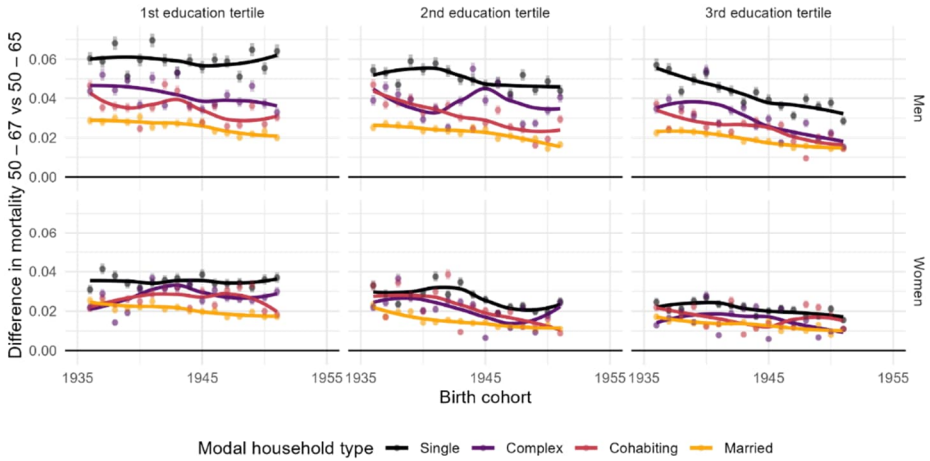
Figure 3: Equivalent age by household type, length of education, and sex. Birth cohorts 1936–1954. Reference category (married) in yellow



Note. The equivalent age shows at which age an individual alive at age 50 in a (sub-)population (e.g., single men) has the same probability of dying as an individual from a reference group between ages 50 and 65. The yellow line shows the reference group, which consists of married individuals.

Figure 4 shows patterns of the increase in mortality when considering ages 50–67 and addresses the question of whether delaying the retirement age would affect some subgroups more than others. In this figure we only show results for age 67. Results for age 70 are in the Appendix and largely support the results shown here. In this case the gradient is less clear and the confidence intervals are larger, making the results more uncertain. Overall, married men and women tend to see the lowest absolute rise in mortality when increasing the age range we consider, while single individuals, especially men, experience the largest rise. It is important to point out that these patterns only hold when considering absolute differences. When calculating relative increases in mortality (e.g., with ratios) the opposite result emerges, with married individuals often experiencing more considerable relative increases in mortality than other groups (see Appendix).

Figure 4: Difference in mortality between ages 50–67 and ages 50–65, by household type, length of education, and sex. Birth cohorts 1936–1951



4. Discussion

In this paper we ask whether an increase in the retirement age would have affected the difference in pre-retirement mortality across household types. Because household types are strongly tied to SES, which is itself a powerful predictor of mortality, we further stratified the population by education tertiles, to consider whether the mortality gradient remained constant across educational levels. In this discussion we will first consider the state of mortality inequalities by household type in Denmark, describing their patterns across gender and education tertile. We will then focus on the main question of this paper, assessing how mortality changes when considering a later retirement age. Finally, we will highlight the trend of widening inequalities across cohorts and offer some comments on the consequences of these patterns for the retirement system in Denmark.

4.1 Consistent mortality gradients

It is well known that living arrangements and marital status are correlated with mortality levels, especially for men (Drefahl 2012; Franke and Kulu 2018; Kandler et al. 2007).

Previous studies also highlight mortality inequalities among socioeconomic groups in Denmark and elsewhere (Mackenbach et al. 2015; Strozza et al. 2022). What our results show is the magnitude of differentials when combining these two sources of inequality. Over a quarter of the men in the first education tertile born in 1954, who were mostly single between ages 50 and 65, died before reaching retirement, as opposed to fewer than 1 in 10 men with the same level of education who were mostly married. Between these groups there is a threefold difference, which only increases if we add differences by education tertile and sex (married men and women in the highest education tertile had a 5.2% and 3.8% probability of dying before retirement, respectively). These inequalities remain in all our results, but they are modulated along some characteristics.

This study joins previous literature in finding a much stronger mortality gradient for men than women, concerning both living arrangements and education tertiles. That female mortality is not as strongly linked to living arrangements and marital status is a recurrent finding in the literature (Kandler et al. 2007; Staehelin et al. 2012; Williams and Umberson 2004; Zueras, Rutigliano, and Trias-Llimós 2020). Women might benefit less from the protective effect of marriage and partnership. Scafato et al. (2008) argue that the traditional gender roles within marriage may burden women with taking care of their husbands. While such expectations naturally vary across societies, they may also have been stronger for older cohorts in Denmark, such as those we consider here. Indeed, women are more likely to attempt to regulate their (male) partner's health habits and be successful in changing them (Berg and Upchurch 2007; Rook et al. 2011; Umberson 1992; Westmaas, Wild, and Ferrence 2002), as well as providing emotional support within the marriage (Kiecolt-Glaser and Newton 2001). Unmarried men are more likely than their married counterparts to have unhealthy behaviours such as smoking, or to die of cardiovascular and external causes, while this difference is smaller for women (Hilz and Wagner 2018; Martikainen et al. 2005; Peltonen et al. 2017; Wang et al. 2020). Men's health also tends to worsen more after divorce than women's, although women suffer more from the loss of income that follows (Leopold 2018). In Denmark, however, the welfare system may temper such economic consequences. At the same time, selection acts differently on men and women. As we see in Figure 1, higher-educated men are less likely to be single than their less-educated counterparts, while the relationship is not as strong for women. In fact, highly educated women are more likely to be single than their male counterparts (Martikainen et al. 2005; Staehelin et al. 2012). The emergence of single individuals as the highest mortality group among women points to developments in these selection mechanisms. Increased gender equality within couples in Nordic countries (Harsløf, Scarpa, and Andersen 2013) could have encouraged highly educated women to enter a partnership, as has been argued in the case of childbearing (Jalovaara et al. 2019).

While the mortality gradient by living arrangement is clear, it is not constant across strata. Rather, it narrows noticeably as education increases. We have highlighted above how the gap between single and married individuals decreases at higher education tertiles. Another perspective is to consider how mortality changes for the same household type across educational levels. For the 1954 cohort the mortality of married men and women decreases by about 0.3 points between the lowest and the highest education tertiles, whereas the mortality of single women decreases by 0.8 points and that of single men by a full point. Advantageous household types (e.g., being married or cohabiting) seem to protect against the negative association between education and mortality. By contrast, single individuals and those living in complex households are much more vulnerable to the consequences of other characteristics, such as low education.

4.2 Consequences of a later retirement age

So far, we have showed that specific groups within the Danish population are particularly disadvantaged in terms of survival to retirement. However, the central question of this paper is whether an increase in the retirement age would disadvantage them even further. Figure 4 suggests that this would indeed be the case. When increasing the threshold from age 65 to 67, the increase in mortality was larger for non-married and especially single individuals across most cohorts and education tertiles. Moreover, the same patterns emerge as when considering ages 50–65: differences are larger for men than for women and for the least-educated than for the most-educated. When comparing mortality levels for each household type across education tertiles and gender we also notice larger differences for non-married than for married individuals. This suggests that the same mechanisms that drove inequalities between household types at younger ages continue to act later on, exacerbating the gap.

It should be noted, however, that these results only concern the absolute difference in mortality. In fact, when considering relative differences (i.e., the ratio of mortality between ages 50–67/70 and ages 50–65), married individuals tend to experience larger increases in mortality than other groups, across cohorts and education tertiles. Because of married individuals' lower baseline mortality level, even a small absolute increase in mortality can become a considerable rise in relative terms. Such contradictions between absolute and relative differences often come up in the mortality and health literature and which one to emphasise should be informed by ethical and practical concerns regarding which kind of equality to prioritise (Mackenbach 2015; Mackenbach et al. 2016). Murphy, Grundy, and Kalogirou (2007) show that while relative differences in mortality between household types decrease with age, absolute differences increase, with a

divergence that starts appearing after age 70. Our findings support this result but show some divergence already at (slightly) younger ages.

Still, for a few subgroups, especially single women, mortality rises faster than for married populations in both relative and absolute terms. This confirms the persistent disadvantage of single individuals but suggests changing gender patterns, as until now single men were more consistently disadvantage than single women.

Another question concerns differences in mortality after reaching retirement age. While it is not the main focus of this paper, this is also a relevant concern, as it further impacts the actuarial fairness of the retirement system, determining a possibly unequal use of the wealth contributed during the working life. Moreover, because we examine mortality differences in different age ranges, our results can give some insight into differences after retirement. Specifically, they suggest that the inequalities before retirement continue to exist after retirement as well. While we cannot measure these inequalities exactly, especially not in terms of an increase in the retirement age, Alvarez, Kallestrup-Lamb, and Kjærgaard (2021) find that men in disadvantaged socioeconomic positions spend less time in retirement than their more advantaged counterparts and that this gap is magnified when retirement age is linked to national life expectancy. The fact that socioeconomic inequalities persist after retirement and could be intensified by an indexation policy suggests that the same could be true for inequalities linked to living arrangements.

4.3 Widening inequalities

Another trend we should consider is the change in mortality across cohorts. Mortality levels declined with time across household types; however, this did not lead to a reduction in inequalities. In relative terms (see Figure 3), cohabiting men and women have maintained a rather constant difference from their married counterparts, but the difference from single individuals or those living in complex households increased between the 1936 and the 1954 cohorts, especially for men. This is true across education tertiles. While in the highest education tertiles mortality levels tend to be lower for all groups and the absolute inequalities between them narrower, relative differences do not decrease more. Mackenbach (2015) and Mackenbach et al. (2016) argue that in contexts of falling mortality, it is more likely to see narrowing absolute than relative inequalities. This is indeed what we see for most household types, with one glaring exception. Single individuals experience either a stagnation or, for the least-educated, an absolute increase of the mortality gap with their married counterparts. The increased disadvantage of single individuals is counterintuitive because being single between ages 50 and 65 became more common in Denmark during the same period, meaning that single individuals are less

(negatively) selected now than before (while single women may have been positively selected in the past, the same is not true for men). The strengthening of the mortality gradient by living arrangement in Denmark mirrors a wider trend that has been documented since the 1970s (Kravdal 2017; Murphy, Grundy, and Kalogirou 2007; Valkonen, Martikainen, and Blomgren 2004) in low-mortality countries. While living arrangements and education are strongly associated, we show here that this trend is not completely due to the inequalities by SES that have been documented for Denmark in the same period (Strozza et al. 2022). Kravdal, Grundy, and Keenan (2018) find that in Norway changes in education (in terms of both composition and death rate) contributed little to the growing mortality advantage of married individuals, and the same could be true in Denmark. Even if education changes did influence this gap in Denmark, our results show that they were more than offset by other disadvantaging mechanisms.

As outlined above, there is a broad literature on the potential explanations of mortality differences by living arrangement. The development of prevention and social policies, including the way they target a population and their uptake, could contribute to explaining why some groups benefitted more than others from the improvement in survival experienced overall by the Danish population. Moreover, female Danish life expectancy stagnated between the late 1970s and the early 1990s. This stagnation has been mainly attributed to smoking (Kallestrup-Lamb, Kjærgaard, and Rosenskjold 2020; Lindahl-Jacobsen et al. 2016), which is more prevalent among single and childless individuals (Görlitz and Tamm 2020; Nielsen et al. 2006).

4.4 Consequences for retirement age

So far, we have seen that the mortality gap between household types exists, that it is substantial, and that it interacts with other characteristics. We have also seen that the relative, but not the absolute, disadvantage could to some extent be mitigated by an increase in the retirement age because of a catch-up in the mortality of married individuals shortly after age 65. At the same time, the gap between married and single individuals is increasing across cohorts, in both relative and absolute terms. How do these sometimes contradictory trends combine? Appendices B and C show the probability of dying and the equivalent age for individuals between ages 50 and 67/70. These do not show substantial differences compared to results for individuals between ages 50 and 65, meaning that, while an increase in the statutory retirement age would not necessarily unfairly impact non-married individuals in relative terms, it should not be considered a way to reduce the already staggering inequalities that exist between household types, especially since some single individuals would be overly impacted even in relative terms.

The Danish retirement system is flexible, allowing early retirement, a practice that remains very popular among Danish workers (Meng, Sundstrup, and Andersen 2020). These policies, however, are mainly tied to length or type of occupation, time spent in the labour market, and health capacity to work, and only marginally include considerations of other characteristics, such as living arrangements (Employment, Social Affairs and Inclusion n.d.; Hummelgaard 2019). Increasing awareness of the mortality differentials that exist in terms of living arrangements is crucial in order to develop policies aimed at more broadly reducing inequalities in access to retirement. Between the 1950s and 1980s, Denmark allowed single women to retire five years earlier than the rest of working Danes (at 62 years instead of 67), showing that mortality inequalities associated with marital status have been taken into account in the past (Sørensen, Olesen, and Olesen 2018). Today, most of the research and data on differences in labour force participation and age at retirement also focus on SES indicators, such as education. These have shown, for example, that in Denmark the least-educated are less likely to be employed (own analyses of Eurostat data[4]) and that they retire earlier than more-educated groups, although the difference has been decreasing (Amilon and Larsen 2023). By reducing the importance of the standard retirement age, these patterns could to some extent mitigate the increasing gap in survival between household types as less-educated individuals are also more likely to be single, but to the disadvantage of other dimensions such as earnings. However, in order to more efficiently address inequalities by household type in terms of retirement, more research is needed on employment, labour force participation, and retirement behaviour by household type.

Tailoring retirement systems to living arrangements certainly has its drawbacks, as living arrangements are easier to change strategically than other characteristics. Moreover, because they are less likely to have children, single individuals contribute less, demographically, to the pension system (in analyses not shown here, we also find that childless individuals suffer from higher pre-retirement mortality across household types and education tertiles). As a consequence, it has been argued that some parents should receive compensation in their old age for the resources they invested in raising future contributors (van Groezen, Leers, and Meijdam 2003; Regős 2015; Sinn 2005), although these studies tend to neglect that childbearing can be affected by external constraints such as economic resources, even in Nordic countries today (Jalovaara et al. 2019; Savelieva, Jokela, and Rotkirch 2023). At the same time, other research has asserted that reducing inequalities may not be the main objective of retirement systems (Vanhuysse, Medgyesi, and Gal 2021). Still, the existence of such large inequalities by household type, and especially their widening with time, questions the effectiveness of policies – even besides retirement – that should ensure similar opportunities and economic returns to everyone. Such policies (e.g., health prevention campaigns) should explicitly take into account the

[4] https://ec.europa.eu/eurostat/databrowser/view/LFSI_EDUC_A/default/table?lang=en

differences in the population, including in living arrangements and the differences in resources they entail. But while other policies may be the designated mean to mitigate the inequalities we have highlighted, pension policies should take care not to magnify these further by overlooking them.

5. Limitations

By considering a single household type per person, we neglect the dynamic nature of living arrangements. Analyses not shown here reveal that the likelihood of transitioning between household types during the observation period was lowest for individuals who were married for most of this period. Given that household transitions can have a strong effect on mortality, especially when concerning couple dissolutions (Liu 2012; Williams and Umberson 2004), part of the mortality disadvantage that we capture for individuals living alone and in complex households could be related to a higher number of transitions, rather than to the fact of living alone or in a complex household itself, especially for men. Moreover, individuals who survive for longer have more time to transition between household types, but transitions themselves tend to be positively associated with mortality (as highlighted before for divorce and widowhood). It is difficult to estimate how these contrasting forces influence our results. A sequence analysis or multistate modelling approach could better account for transitions in household type throughout the observation period, while increasing the complexity of the analysis and influencing the interpretation of the results. However, it is unlikely that more complex models such as these would be considered in the design of pension (or other) policies. In approaches using one summary measure of household type we found consistent results when using household type at age 50 or household type at exit. Of these we preferred the modal household type, as it captures the prevalent state in which a person lives during the observation period, which we assume has a stronger influence on the mortality profile than a simple snapshot at the beginning or end of observation. However, the modal value may be influenced by mortality, as partnered individuals who reach older ages are more likely to become single (e.g., through widowhood). This phenomenon risks underestimating the disadvantage of single individuals (as longer-living individuals are more likely to be recorded as single), so that in this sense our results can be considered a lower bound of the mortality gap. At the same time, this is unlikely to overly affect our results because mortality at these ages in Denmark is still relatively low.

We also do not include any information on health. While health characteristics are thought to influence the probability of entering a partnership (Requena and Reher 2021), stratifying by both education and health would have risked excessively fragmenting the population. Already stratifying by education only, some groups (especially complex

households, the smallest sub-population) showed substantial year-to-year variations. Future research should take advantage of the wealth of information on health contained in the Danish registries.

Finally, based on these findings we cannot claim any causal relationship between living arrangements and mortality. However, we believe that this does not substantially limit the scope of this paper, as our aim is to identify disadvantaged sub-groups within the Danish population and quantify the magnitude of their disadvantage in light of a specific retirement policy.

6. Conclusion

Within the framework of the recent policy linking retirement age with national life expectancy, we set out to analyse differentials in mortality and its improvement across cohorts and ages of Danish residents, depending on their living arrangements. The population-wide data available in Danish registries allowed us to construct several mortality measures by household type and education. Because these data are longitudinal rather than cross-sectional we were not limited to a period perspective but could instead adopt a cohort approach, more suited to investigating pension policies. Focusing on mortality between ages 50 and 65, we found that single individuals are consistently disadvantaged on multiple dimensions regardless of length of education, experiencing higher rates of mortality, higher uncertainty of their times of death, together with a widening relative and absolute gap between cohorts born in 1936 and 1954. At the same time we found that mortality increases faster between ages 65 and 67/70 for most single individuals than for their married counterparts, suggesting that increasing the retirement age would have disadvantaged them further and that they may already be disadvantaged in terms of survival during retirement. Given that most of the focus on inequalities in term of retirement tends to be on measures of SES, and especially occupation, we want to highlight how other dimensions of life, in this case living arrangements, should also be considered when setting up public policies, even besides retirement.

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Appendix A – population summary

	Single	*Complex household*	*Cohabiting*	*Married*
Men	352,300 individuals/ 4.4 million person-years	171,669 / 2.0 million	144,840 / 1.8 million	1.1 million / 14.6 million
Women	437,613 individuals / 5.5 million person-years	141,590 / 1.6 million	127,890 / 1.6 million	1.0 million / 14.2 million

Appendix B – results for ages 50 to 67

Figure B-1: Probability of dying between ages 50 and 67 by household type, length of education and sex, birth cohorts 1936–1951

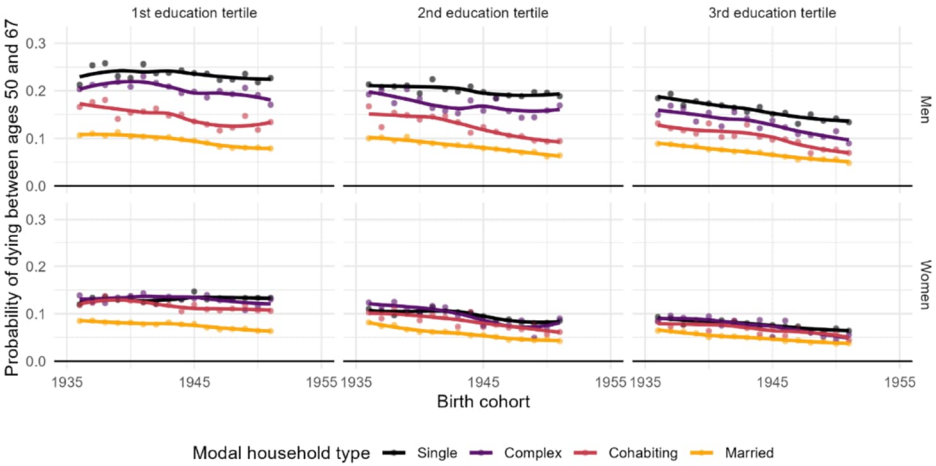


Figure B-2: Equivalent age by household type, length of education, and sex. Birth cohorts 1936–1951. Reference category (married) in yellow

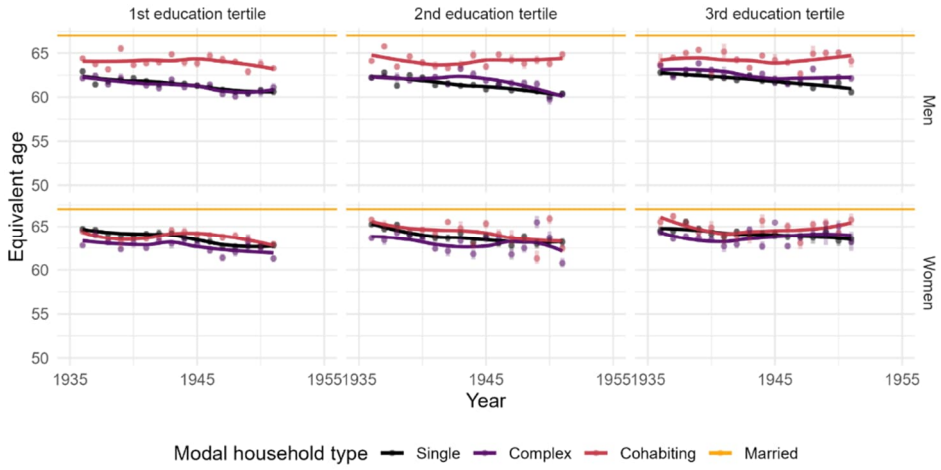
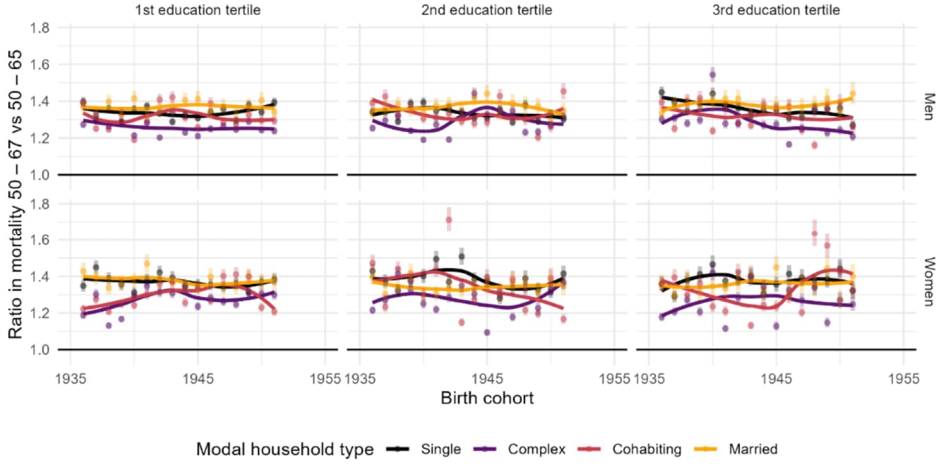


Figure B-3: Ratio of mortality between ages 50–67 and ages 50–65, by household type, length of education, and sex. Birth cohorts 1936–1951



Appendix C – Results for ages 50 to 70

Figure C-1: Probability of dying between ages 50 and 70 by household type, length of education, and sex. Birth cohorts 1936–1948

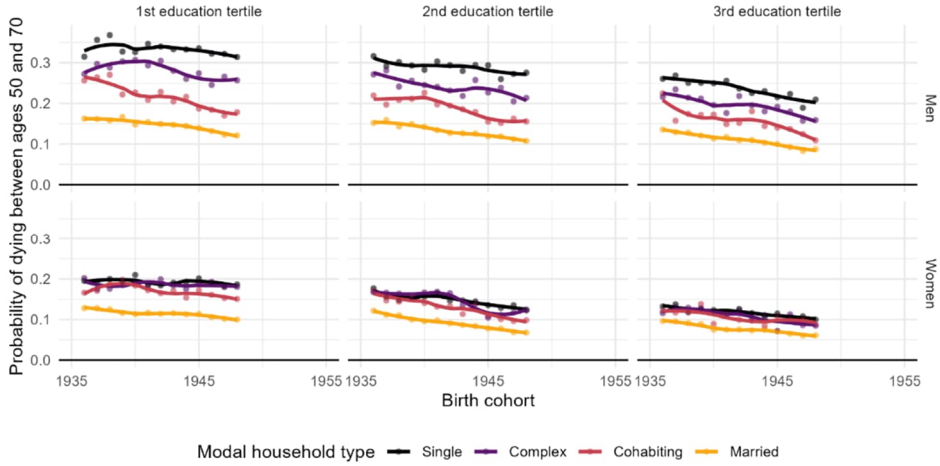


Figure C-2: Equivalent age by household type, length of education, and sex. Birth cohorts 1936–1948. Reference for equivalent age calculation in yellow

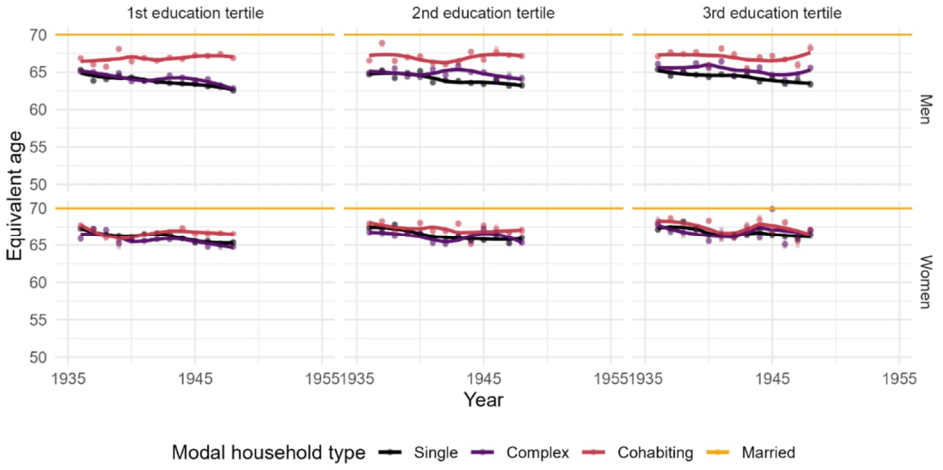


Figure C-3: Difference in mortality between ages 50–70 and ages 50–65, by household type, length of education, and sex. Birth cohorts 1936–1948

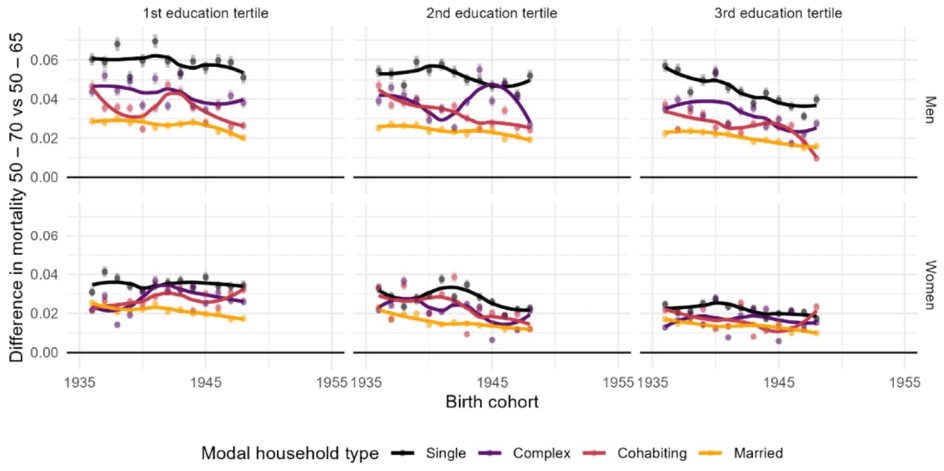


Figure C-4: Ratio of mortality between ages 50–70 and ages 50–65, by household type, length of education, and sex. Birth cohorts 1936–1948