Sex Differences in the Shape of Mortality

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1. Introduction

Females enjoy longer life expectancies than males throughout the lifecourse. This is true across countries and throughout history (Organization et al. 2019; Austad 2011; Kannisto 1988). Studies have also shown that this advantage persists in communities with particularly healthy lifestyles and high fertility, such as Mormons, as well as in populations withstanding harsh living conditions (Zarulli et al. 2018; Lindahl-Jacobsen et al. 2013). Such research suggests that the female advantage in life expectancy may have, at least partially, an underlying biological cause (Austad and Fischer 2016; Luy 2003).

While life expectancy measures the average age at death, lifespan variation captures the dispersion around this age, indicating the existence of heterogeneity in the mortality levels of a population (van Raalte et al. 2018). Lifespan variation has been shown to have a strong negative relationship with life expectancy, declining as life expectancy increased throughout the Western world (Van Raalte et al. 2011), as the historical changes in mortality that led to an increase in life expectancy also impacted lifespan variation (Vaupel et al. 2011). When measured from birth, females typically hold an advantage in lifespan variation as well (i.e. experience narrower lifespan variation) (Colchero et al. 2016).

These studies compare mortality between sexes by chronological age. By doing so, they consider differences in both the shape and pace of mortality (Baudisch 2011). Abstracting from the pace of mortality to focus on its shape would help us to better understand how mortality behaves in male and female populations *relative* to its sex-specific distribution, rather than at an absoute level. Recently, some studies have taken this approach, by considering survival levels rather than chronological age to estimate mortality improvements and as a framework for analysing mortality in general (Alvarez and Vaupel 2023; Zuo et al. 2018). We adopt this framework to (re)consider the sex ratios in both life expectancy and lifespan variation, highlighting patterns that do not always agree with what is found when focusing on chronological age. By developing these results, we hope to shed some light into the evolution of the shape of mortality for males and females.

2. Methods and data

We use data from the Human Mortality Database (HMD, Barbieri et al. 2015), a high quality database for mortality data, covering more than 40 countries with time series for each going as far back as 1751. We use single age and single year period sex- specific lifetables for six European countries and for all available years. These six countries are the only ones with cohort data available since 1850, which would be valuable for a potential period-cohort comparison. Before calculating the survival decile, we smooth these lifetables using the R package MortalitySmooth to obtain death rates at the first decimal of the age. Because smoothing is difficult when considering both child and adult mortality, for the moment we focuse on ages from 35 year, i.e. on adult mortality.

We use lifespan disparity ($e^{\dagger}$) as a measure of lifespan variation, as it is widely used in the literature (Aburto et al. 2021; Nigri et al. 2021; Vaupel et al. 2011). We calculate the ratio between male and female $e^{\dagger}$ for each country-year as well as the female to male ratio in life expectancy, so that values greater than 1 always indicate a female advantage.

3. Preliminary results

Figure 1 shows results for life expectancy by age and survival decile. The upper graph shows the well-known pattern of this sex ratio by age, with a constant female advantage that increased and then declined during the late XX century. Results by survival decile (in the lower graph) were unexpected. While the very youngest survival deciles again show a female advantage throughout the observation period, older deciles indicate a constant male advantage in life expectancy, which increased and then declined again during the late XX century, in a specular fashion to what we see for the sex ratio by age.

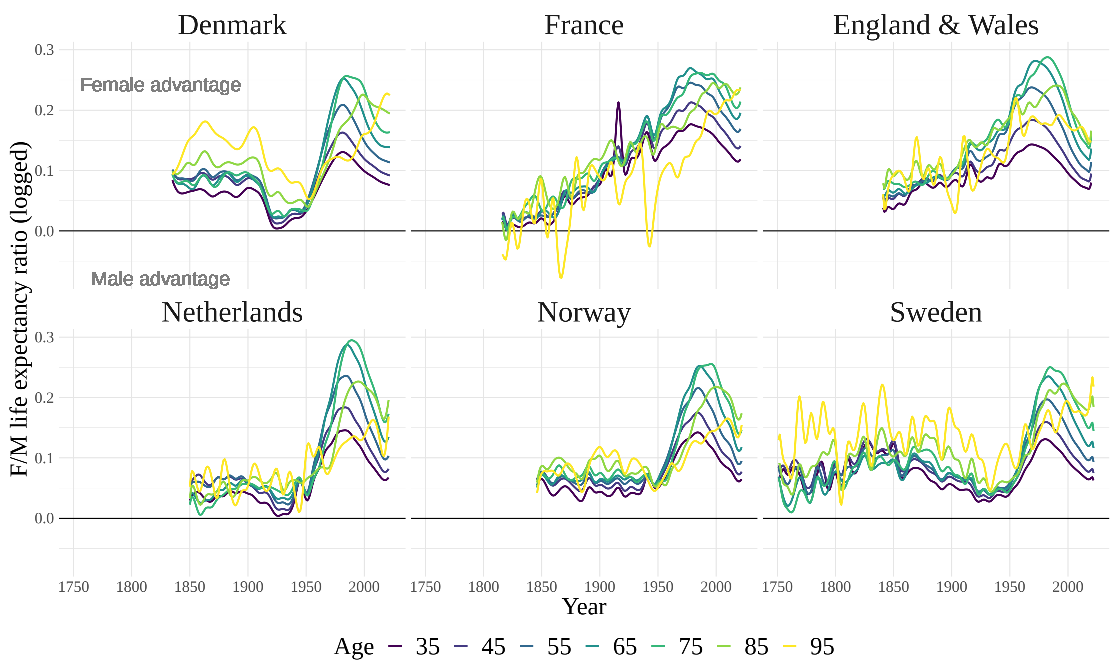
Figure 2 does not reveal such opposite results, but still suggests considerable differences between the two approaches. The sex ratio by age shows a male advantage for the younger ages starting from the early XX century, which started decreasing around the 1970s, and a consistent and stable female advantage for older ages. When considering survival deciles, we see instead a consistent female advantage (with some exceptions), which intensified and then decreased during the late XX century for all deciles. In fact, for both life expectancy and lifespan disparity, the level fo the sex ratio is much more homogemeous across survival deciles than across chronological ages.

4. Next steps

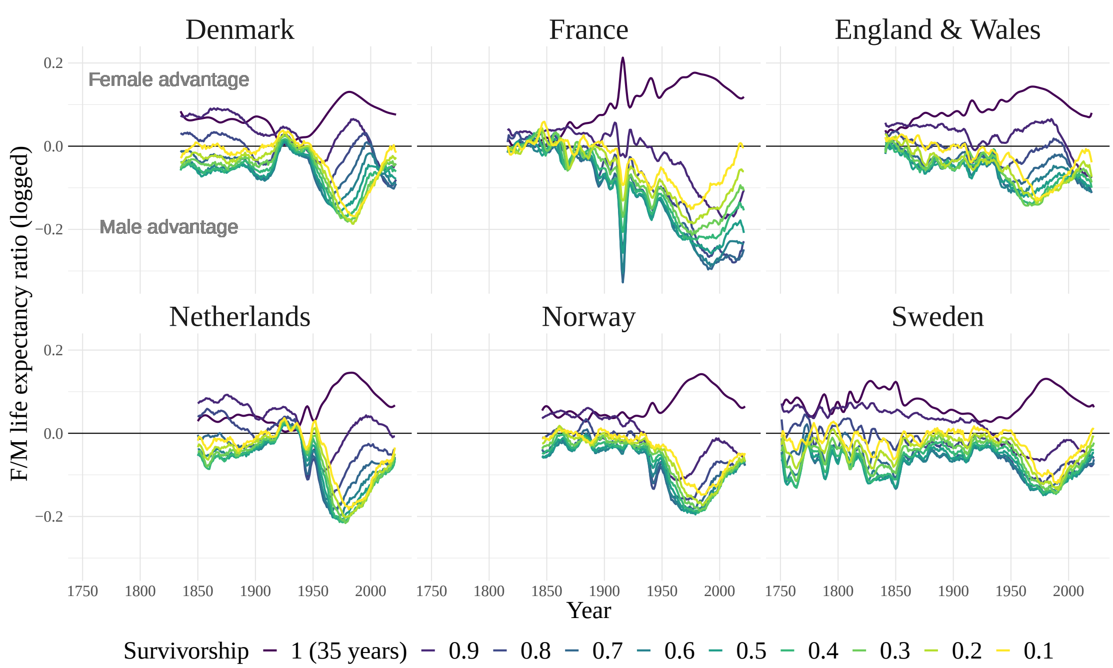
Our preliminary results suggest that the shape of mortality between male and female populations might be rather different, with a longer right tail for males, as suggested by their higher remaining life expectancy and higher lifespan variation at the same survival decile. It is possible that the mortality improvement among males might have been pulled by a small group of very long lived individuals, while the female mortality improvement might have been more equally shared among the population.The fact that these differences only hold relative to the sex-specific distribution, but not in absolute terms (the longest-lived females still outlive the longest-lived males in chronological age) advocates for the use of survival levels together with that of chronological age.

In order to refine these results and examine our hypothesis, we plan to divide the population according to survival percentiles, rather than deciles. This will allow us to focus on smaller and more selected groups of individuals at the very front of survival. We will also focus on the evolution of mortality improvement, by considering the relative movements between percentiles, as was shown by Zuo et al. (2018). Finally, we will either expand our analysis to include a cohort perspective, or consider a larger selection of populations, depending on our future results.

Figure 1: Sex ratios of life expectancy (e_x) by age and survival decile



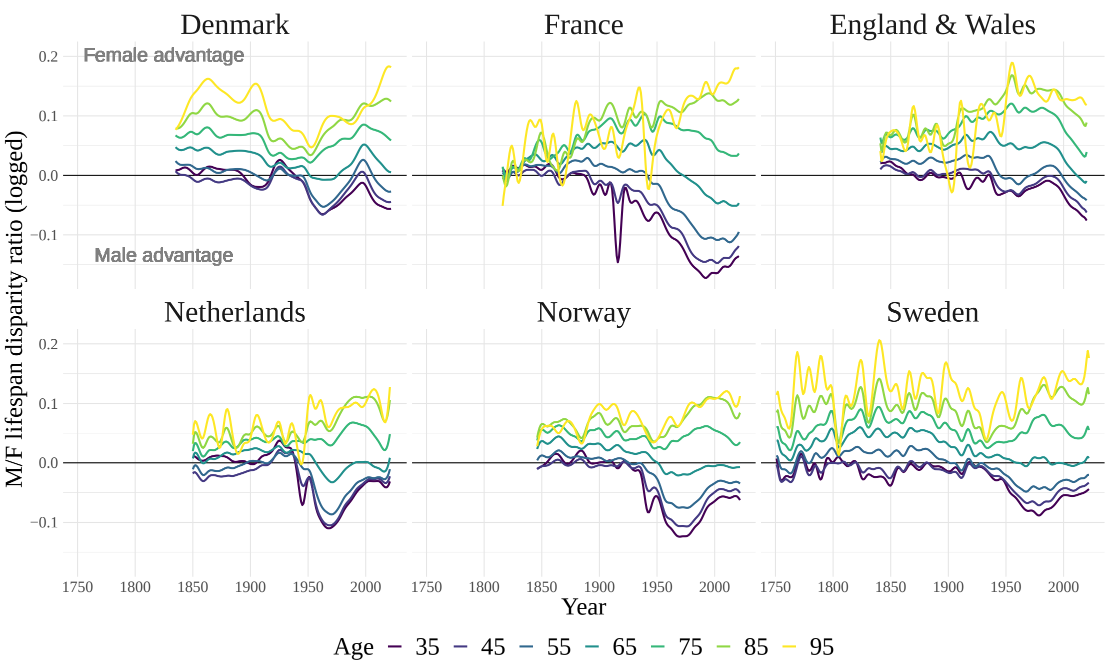
(a) Sex ratio in e_x by age



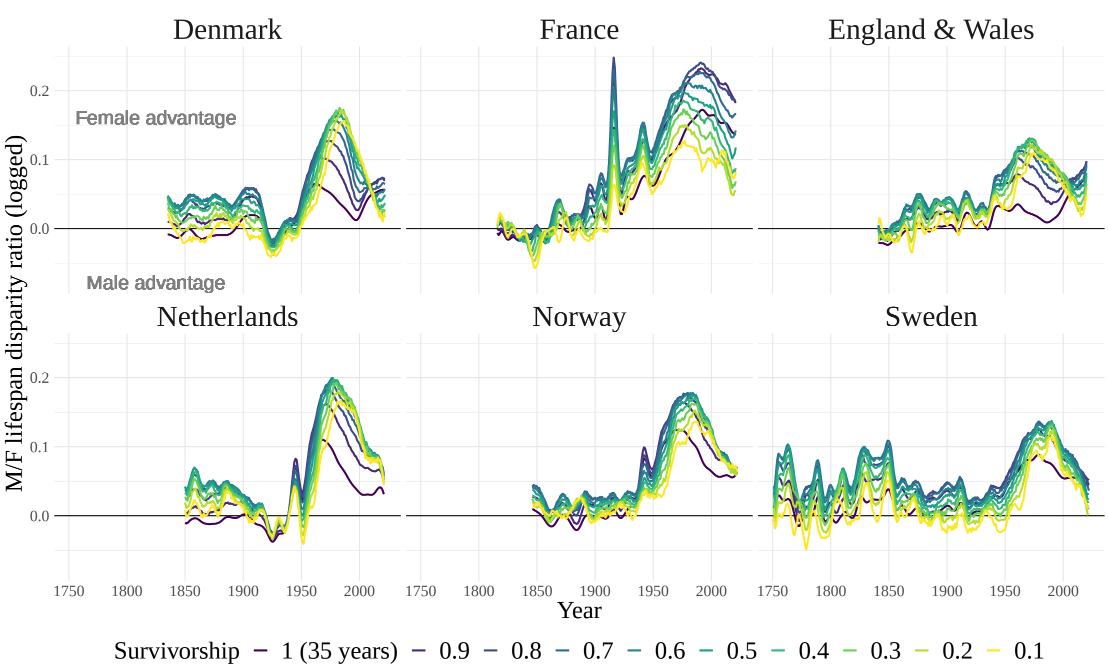
(b) Sex ratio in e_x by survival decile

Source: HMD

Figure 2: Sex ratios of lifespan disparity ($e^\dagger$) by age and survival decile



(a) Sex ratio in $e^\dagger$ by age



(b) Sex ratio in $e^\dagger$ by survival decile

Source: HMD

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