Growing Old Together? The Sex Gap in Population Ageing and the Influence of Survival

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Abstract

Population ageing is one of the most significant population phenomena of this century. Across time and populations, females are, on average, older than males, a trend that is underexplored in the literature. This study presents the sex gap in population ageing, measured with the population mean age, and seeks to understand how it is related to sex differences in mortality. A parallel measure to the population mean age is the "life table mean age", which uses the life table survival function as its main input, as opposed to the observed population counts used in the population mean age. The sex gap in each of the means, population and life table, reveal similar trends over time. Similarly, the age-decomposition of the sex gap of the means resemble each other, with a large sex difference above age 60. Finally, cohort variable-r decomposition of changes in the population mean age further confirms that historical changes in survivorship are the main contributor to the sex gap in the mean for most studied populations. This study contributes to the literature by showing that the sex gap in population ageing can be accounted for by sex differences in mortality at older ages.

Introduction

According to the 2024 World Population Prospects, by 2080 the number of people aged 65 and older will exceed the number of children worldwide (UN 2024). Across time and populations, the number of females per males increases with age (Canudas-Romo et al. 2023). That is, females are, on average, older than males, a fact that has remained true as the overall population ages. We refer to this phenomenon as the "sex gap in population ageing". This sex gap produces many questions, such as: Why has it occurred? How has it changed over time? How is it related to other demographic processes? Understanding the underlying dynamics of population ageing becomes only more relevant to demographers and policy makers as the worldwide population continues to age. For the former, studying the sex gap contributes to elucidating and formalising this demographic process. For the latter, insight into the composition of the older population enables policy makers to address topics affecting older people that have a gendered dimension, such as wellbeing, productivity and engagement, equity, security, and cohesion (Chen et al. 2021).

While many studies look at gender differences in experiences of ageing such as health and disability outcomes (e.g. Gómez-Costilla et al. 2022; Scheel-Hincke et al. 2020; Schmitz and Lazarevič 2020; Srivastava et al. 2022), there is limited research on the structural dynamics of population ageing by sex. Zhang and Li (2020) study the implications of a high sex ratio at birth on a country's ageing. This study finds that cohorts with a high sex ratio at birth are smaller than cohorts with a lower sex ratio at birth, causing disparities in the population structure and population ageing (Zhang and Li 2020, p. 969). However, the sex gap in population ageing remains an area underexplored in the literature.

The proportion of older people in a population is linked to life expectancy, a measure higher for females than males. For example, in 2024 the world's female life expectancy was

82.0 and the male life expectancy was 75.6, a gap of 6.4 years (UN 2024). Numerous studies explore age-specific contributions to the sex gap in life expectancy and how they change over time in high-income countries. Studies find that the sex gap increased between 1950–54 and 1975–79 before narrowing for most countries (Glei and Horiuchi 2007). Zarulli et al. (2020) found that the contribution of the 65–80 age group to the sex gap is strong but peaked around 1980 for most countries while the contribution of the 80+ age group has increased over time. Feraldi and Zarulli (2022) further confirmed that older ages contributed most to the life expectancy sex gap, and that this large contribution was shifting to even older ages over time. The sex gap in life expectancy is well-established in the demographic literature. In contrast, minimal literature on the sex gap in population ageing can be found.

The dynamics of population change, including population ageing, have been carefully studied within formal demography. Variable-r decomposition has been used to express the change in measures of ageing as a function of population growth and further into its three component parts: fertility, migration and mortality. This has been applied to the mean age of a population (Fernandes et al. 2023; Murphy 2017; Preston et al. 1989; Preston and Stokes 2012), the proportion of the population above a particular age (Caselli and Vallin 1990; Horiuchi 1991; Preston and Stokes 2012), and the old-age dependency ratio (Scott and Canudas-Romo 2024). Other analyses use demographic simulations (De Santis and Salinari 2024; Lee and Zhou 2017), counterfactual projections (Murphy 2021), and cointegration analysis (De Santis and Salinari 2023) to understand the structural drivers of population ageing.

As established above, population ageing and life expectancy are closely related, and increasing life expectancies are a key contributor to population ageing. Many papers employing variable-r decomposition found that changes in mortality contributed more than changes in fertility to increases in population ageing (Caselli and Vallin 1990; Horiuchi 1991; Murphy 2017; Preston et al. 1989; Preston and Stokes 2012). Cheng and colleagues (Cheng et al. 2020) analysed instead the impacts of population ageing on mortality, finding that population ageing was associated with positive and negative changes in the number deaths between 1990 and 2017. The well-established strong relationship between life expectancy and population ageing suggests that the sex gap in population ageing is likely due to sex differences in mortality. While this is intuitively very plausible, this link has not been explored in-depth or formalised. Analysing this link to the sex gap in mortality could provide richness to understanding the sex gap in population ageing.

Motivated by the connection between mortality and population ageing, this study seeks to understand how the sex gap in population ageing, measured with the population mean age, is related to sex differences in mortality.

Data

The analysis uses data from the Human Mortality Database (HMD 2025). The HMD is a leading source of high-quality mortality and other demographic data from almost 40 low mortality countries (Wilmoth et al. 2021). The entire series of age- and sex-specific population and life table data from Australia, Spain, Sweden and the US was obtained from the HMD, although the extensive Swedish data was restricted to data from 1900 onwards. This data is available from the HMD (2025) for a number of countries. Australia, Spain, Sweden and the US were chosen for their variety in results.

For the variable-r decomposition, age- and sex-specific population, birth and mortality data was obtained from the HMD (2025) for Italy, France, Finland, Spain, Scotland, Switzerland, the United States, England and Wales, Sweden, Denmark, The Netherlands, Australia and Norway. Net migration data was not available but was inferred using population, birth and mortality data, as explained in the methods section. Variable-r decomposition requires lifecourse data from birth for every cohort present at the time the mean age is calculated. The mean age is taken in 2010 and 2020 so that the variable-r decomposition can be done for the change in mean age between those years. Age-specific data up to the age of "100+" was used in this analysis, meaning that data from 1910 and onwards was required. Countries were included in the variable-r decomposition based on whether this extensive data was available. Australian population and mortality data was only available in the HMD from 1921 onwards and US population, births and mortality data was only available in the HMD from 1933 onwards. The Australian population data was extended using Australian Bureau of Statistics census data from 1911 and 1921 (ABS 1911, 1921) and mortality data was sourced from yearbooks published by the Australian Bureau of Statistics (ABS 2022). For the US, population data was sourced from the US Census Bureau (2016), births data was sourced from the Centers for Disease Control and Prevention (CDC 2020), and mortality data was estimated using data from Bell and Miller (2005). Where necessary, data was adjusted to represent mid-year estimates.

Methods

Population Mean Age

Let $\bar{a}$(t) denote the population mean age at time t. This is defined as

$$\bar{a}(t) = \frac{\int_0^\omega a\,N(a,t)\,da}{N(t)}, \quad (1)$$

where $N(a,t)$ is the number of people aged a at time t, $N(t)$ is the total number of people including all ages at time t, or $N(t) = \int_0^\omega N(a,t)\,da$, and ω represents the maximum age in the population.

Let $\bar{a}_F(t)$ and $\bar{a}_M(t)$ represent the mean age for the females and males in a population, respectively. The sex gap in population mean age will be denoted as $\Delta\bar{a}(t) = \bar{a}_F(t) - \bar{a}_M(t)$. Using the definition of the population mean age given in Eq. (1) and rearranging gives an age-specific expression of the sex gap in population mean age:

$$\Delta\bar{a}(t) = \int_0^\omega a[c_F(a,t) - c_M(a,t)]\,da, \quad (2)$$

where $c_i(a,t)$ is the proportion of the population at age a, defined as $c_i(a,t) = \frac{N_i(a,t)}{N_i(t)}$ at time t, and this is restricted to the female or male subset of the population as indicted with subscript i.

Let a dot above a variable represent the derivative with respect to time (Vaupel and Canudas-Romo 2002). The change in the population mean age with respect to time can be denoted $\dot{\bar{a}}(t)$. Preston, Himes and Eggers (1989) showed that the age-decomposition of the change in population mean age over time can be expressed as:

$$\dot{\bar{a}}(t) = \int_0^\omega r(a,t)c(a,t)[a - \bar{a}(t)]\,da, \quad (3)$$

where $r(a,t)$ is the growth rate of the population at age a, defined as the relative change in the population counts or $r(a,t) = \frac{\dot{N}(a,t)}{N(a,t)}$.

The growth rate of a population can be further expressed as the sum of the growth rate at birth (r_b), changes in survivorship (Δs) and changes in net migration (Δm) (Horiuchi and Preston 1988):

$$r(a,t) = r_b(t-a) + \Delta s(a,t) + \Delta m(a,t). \qquad (4)$$

A visual representation of the data used in Eq. (4) is presented in the online appendix 1. When Eq. (4) is substituted into Eq. (3) and the result is rearranged, the change in population mean age can be decomposed into the contributions of changes in births, survivorship and net migration (variable-*r* decomposition), or expressed as

$$\dot{\bar{a}}(t) = \widetilde{r_b} + \widetilde{\Delta s} + \widetilde{\Delta m}, \qquad (5)$$

where the tilde above the terms of Eq. (5), correspond to the right side of Eq. (3), but substituting $r(a,t)$ for each of the terms in Eq. (4). For example, $\widetilde{r_b}$ uses $r_b(t-a)$, multiplying it by the population composition and the difference of age a to the mean age, or $c(a,t)[a-\bar{a}(t)]$, as seen in Eq. (3).

The Change Over Time in the Sex Gap of the Population Mean Age

Let $\dot{\bar{a}}_F(t)$ and $\dot{\bar{a}}_M(t)$ represent the change over time of mean age for females and males in a population, respectively. Denote their difference, which is the change over time in the sex gap of the population mean age, as $\Delta\dot{\bar{a}}(t) = \dot{\bar{a}}_F(t) - \dot{\bar{a}}_M(t)$. A further variable-r decomposition substituting Eq. (5) into the female and male components can be used to disentangle the contribution of historical changes in births, survivorship and net migration to the change over time in the sex gap of the population mean age.

Life Table Mean Age

The concept of the life table mean age was previously used to study changes in life expectancy (Keyfitz and Caswell 2005, p. 106; Keyfitz and Golini 1975, p. 15). In the present study, the life table mean age, denoted $\bar{a}_l(t)$, is the average age of survivors in a life table. It is defined as

$$\bar{a}_l(t) = \frac{\int_0^\omega a\, l(a,t)\, da}{e(t)}, \qquad (6)$$

where $l(a,t)$ is the life table survivors at age a, with radix equal to one, or $l(0,t) = 1$, and the life expectancy at birth in that life table is $e(t) = \int_0^\omega l(a,t)\, da$, all calculated at time t. The maximum age in the life table is represented by ω.

Careful inspection of Eq. (1) and Eq. (6) reveal that the life table mean age is identical to the population mean age, with the only difference being that $N(a,t)$, or the number of people in a population aged a at time t in Eq. (1) is replaced with $l(a,t)$, or the life table number of survivors aged a at time t in Eq. (6). Therefore, by replacing $N(a,t)$ with $l(a,t)$ where necessary, the change in the life table mean age with respect to time, the sex gap in the life table mean age and the change over time in the sex gap of the life table mean age can be expressed in ways analogous to those for the population mean age.

The sex gap in the life table mean age can be expressed as

$$\Delta\bar{a}_l(t) = \int_0^\omega a\left[c_{l,F}(a,t) - c_{l,M}(a,t)\right] da\,, \qquad (7)$$

where $c_{l,i}(a,t)$ is the proportion of the life table survivors at age a, or the contribution of age a to life expectancy, defined as $c_{l,i}(a,t) = \frac{l_i(a,t)}{e_i(t)}$, and this is restricted to the female or male subset of the population as indicted by subscript i. Online appendix 2 includes further details of the calculation of the change in life table mean age.

The analysis was undertaken using the statistical software *R* under version 4.4.1 (2024-06-14) (R Core Team 2025). A reproducible copy of the program can be found on GitHub at: https://github.com/TS-Demographer/Growing_Old_Together_R_Program

Results

Figure 1 shows the population mean age over time and by sex for Australia, Spain, Sweden and the United States. The population mean ages for females and males have increased over time, with a slight decline, or rejuvenating period, from around 1945 to 1960 for both sexes in Australia and males in the United States. The figure shows that aside from a few years early in the Australian and United States series, the female population mean age is consistently above male population mean age over time for all populations.

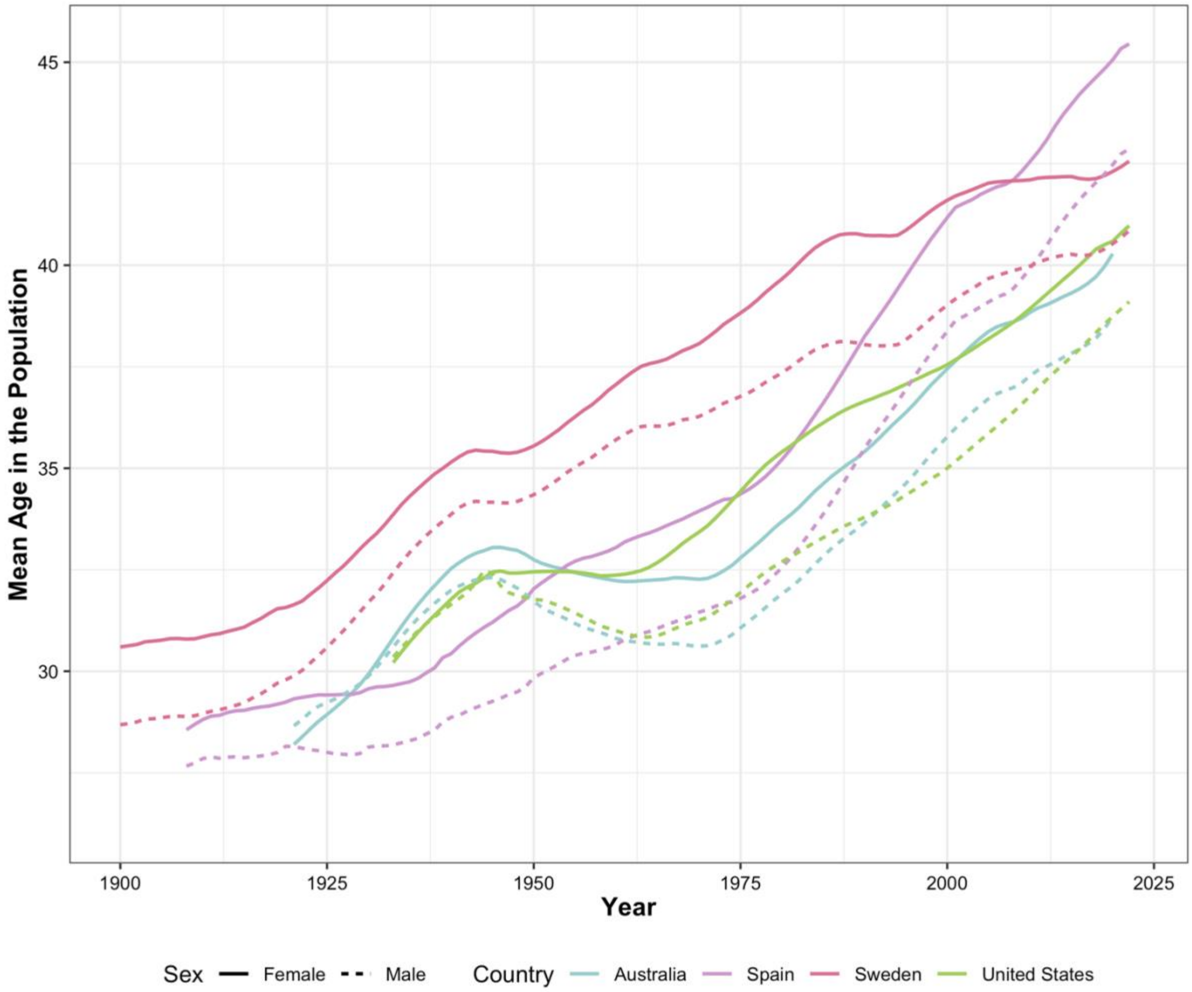

Figure 1. Population mean age by sex for Australia, Spain, Sweden and the United States, 1900–2022

Source: Authors' calculations based on Eq. (1) and data from the Human Mortality Database (2025).

Figure 2 shows the sex gap in the population mean age, presented in Eq. (2), and the sex gap in the life table mean age, presented in Eq. (7), for Australia, Spain, Sweden and the United States. The highlighted sections indicate particular time periods used later in the analysis. Consistent with Figure 1, aside from the early Australian and United States series, the sex gap in the population mean age is entirely positive, meaning that the female population mean age is higher than the male population mean age. For the life table mean age, the sex gap is exclusively in favour of females. It can be seen that the sex gap in both means follow a similar pattern over time, though in Australia and the United States the sex gap for the population mean age is typically lower than the sex gap for the life table mean age. The four populations follow a similar general pattern of an increasing sex gap in both means from the 1950s or earlier which culminates in a peak of around 3 years of female ageing advantage in the 1980s before declining. Spain contributes some exceptions to this pattern, namely the sex gap in the life table mean age spikes around the late 1930s to early 1940s and the sex gap in the population mean age remains fairly constant over time, sitting at just under 3 years since the 1970s.

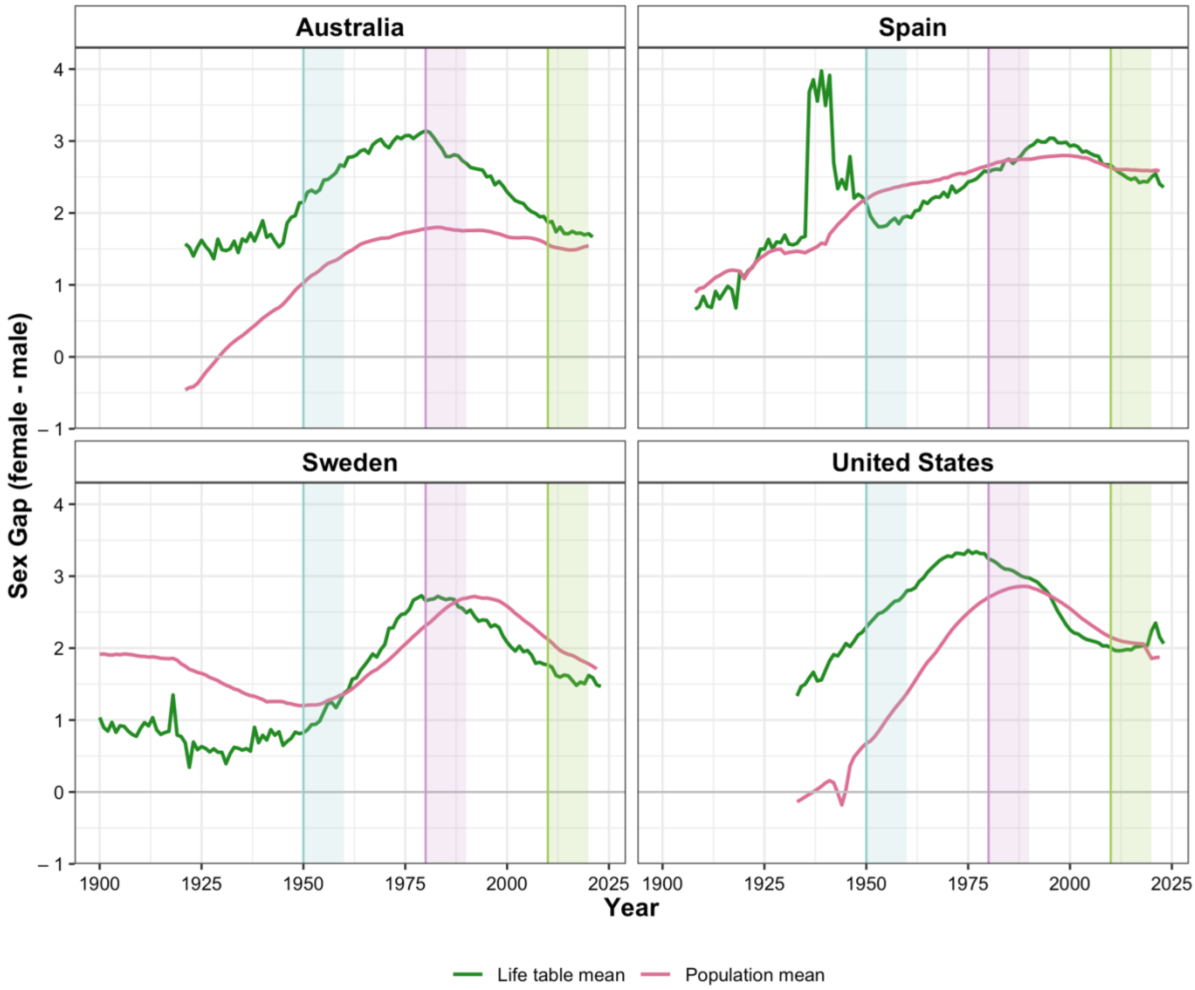

Figure 2. Sex gap in population and life table mean ages for Australia, Spain, Sweden and the United States, 1900–2022

Source: Authors' calculations based on Eq. (2) and Eq. (7) and data from the Human Mortality Database (2025).

Figure 3 shows age-specific contributions to the sex gap in both means, as represented by Eq. (2) and Eq. (7), for Australia, Spain, Sweden and the United States at three time points highlighted in Figure 2: 1950 (blue), 1980 (purple) and 2010 (green). With the exception of Spain, there is typically a greater contribution to the sex gap in both means in 1980 than in the other two time points. This result is consistent with the peak in the sex gap in both means in the 1980s seen in Figure 2 in all countries except Spain. Although there is more fluctuation in the sex gap for the population mean age than the life table mean age, both sex gaps follow a similar age pattern. Over time, the peak age of contribution to the sex gap has shifted towards older ages. The majority of the age-specific contribution occurs above the age of 60, though this result is stronger for the sex gap in the life table mean age than for the population mean age. For all populations and time points for the life table mean age and some for the population mean age, the sex gap below the age of 60 is small but negative, meaning that these ages contribute to a lower overall sex gap. For the gap in population mean age, this corresponds to a greater proportion of the total male population at younger ages when compared to the female population. For the gap in life table mean age, this corresponds to a higher ratio of young male survivors to their life expectancy than young female survivors to their life expectancy, as seen in Eq. (7). Figure 2 shows that the sex gap in the life table mean age widens pre-1980 and narrows post-1980. Figure 3 expands on this by showing that both the widening and narrowing of this gap are almost entirely explained by changes above the age of 60. This result is present but weaker for the population mean age. Furthermore, from 1980 to 2010 a shifting towards older ages of the female ageing advantage is observed in the age-contribution. For example, for the US in 1950 the peak of the life table mean age contribution is found at age 77 with a contribution of 0.13 years, in 1980 the peak corresponds to age 82 and 0.2 years, while in the 2010 the peak corresponds to age 87 and 0.13 years. Furthermore, the progression from a widening to a narrowing sex gap does not occur uniformly over all ages (see Figure A2 in online appendix 2 showing time changes in the age-specific contributions to the change in sex gap).

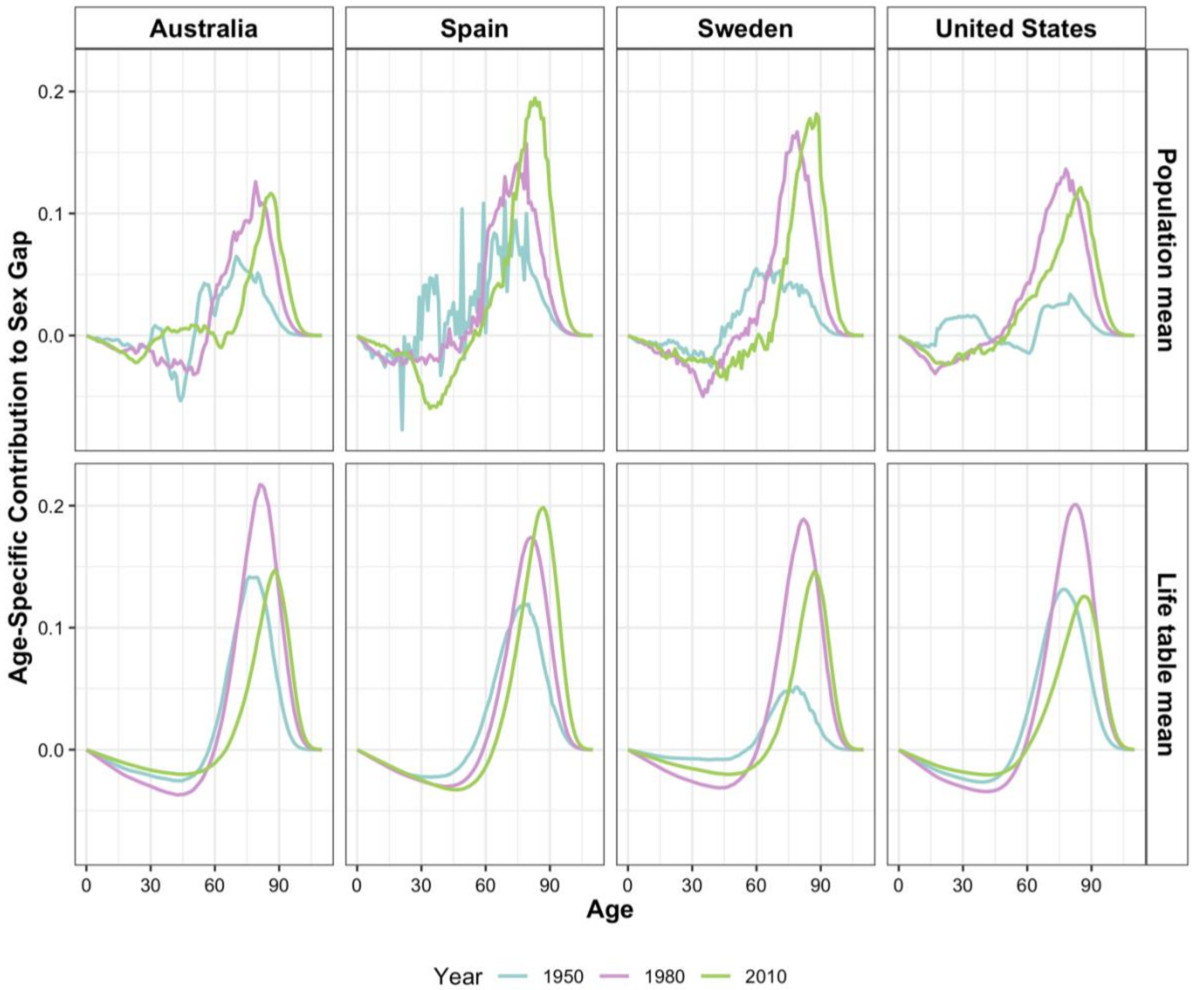

Figure 3. Age-specific contributions to the sex gap in population and life table mean ages for Australia, Spain, Sweden and the United States in 1950, 1980 and 2010

Source: Authors' calculations based on Eq. (2) and Eq. (7) and data from the Human Mortality Database (2025).

Figure 4 shows variable-r decomposition of the change in the female and male population mean age from 2010 to 2020 in 13 countries, as shown in Eq. (5). While the preceding analysis employs a period perspective, Figure 4 takes a cohort perspective. The variable-r decomposition shows how changes in births, survivorship and net migration between cohorts throughout the life course contributes to the changing population mean age.

Variable-r decomposition looks at historical births, survivorship and net migration over the lifecourse of each cohort aged 0 to 100 in 2010 and compares it to the births, survivorship and net migration over the lifecourse of the cohort of the same age in 2020. This produces a growth rate for births, survivorship and net migration for the 101 cohort comparisons of people of the same age in 2010 and 2020 (visual representation included in online appendix 1). These historical changes in births (or survivorship or net migration) for each age are incorporated into the change in population mean age formula, Eq. (5), and summed to represent the overall contribution of changes in births (or survivorship or net migration) on the change in population mean age. This is done separately for females and males, and the coloured bars represent the contribution of changes in births, survivorship and net migration to the change in mean age. The black bubble in each column represents the total change in mean age for females or males in a particular country (Table A1 in the online appendix 3 includes the detailed values). Figure 4 shows an increase in the mean age of females and males in all countries between 2010 and 2020. Historical changes in survivorship are always positive, and contribute more than historical changes in births and net migration to ageing for most countries. The exception to this is found for females in the Netherlands and Australia and both sexes in the US, with births contributing more than survivorship. Survivorship makes a positive contribution to the change in population mean age in all countries for both sexes, though this result is stronger for males than females in all countries except Spain, in which the contribution is equivalent. Changes in births contribute positively to the change in mean age for both sexes in all countries except Sweden, in which changes in births make a negative contribution to the change in mean age for both sexes, and England and Wales, in which there is a negligible negative contribution for females. The contribution of net migration varies between countries. Net migration contributes positively to the change in mean age for both sexes particularly in Spain, Italy, the US and Norway, and to a lesser extent for Denmark and the Netherlands. In Spain, this result is stronger for males while in the other countries the result is similar for both sexes. Net migration contributes positively to the change in mean age for females and negatively for males in France, though these contributions are minimal. In England and Wales, net migration contributes positively to the change in mean age for females and makes no contribution for males. Net migration contributes negatively to the increase in mean age for both sexes in Australia, Sweden, Switzerland and Finland. In Australia, this contribution is noticeably stronger for males than females. In Finland, Switzerland and Sweden, the sex disparity is not as strong but in favour of males in Sweden and in favour of females in Finland and Switzerland.

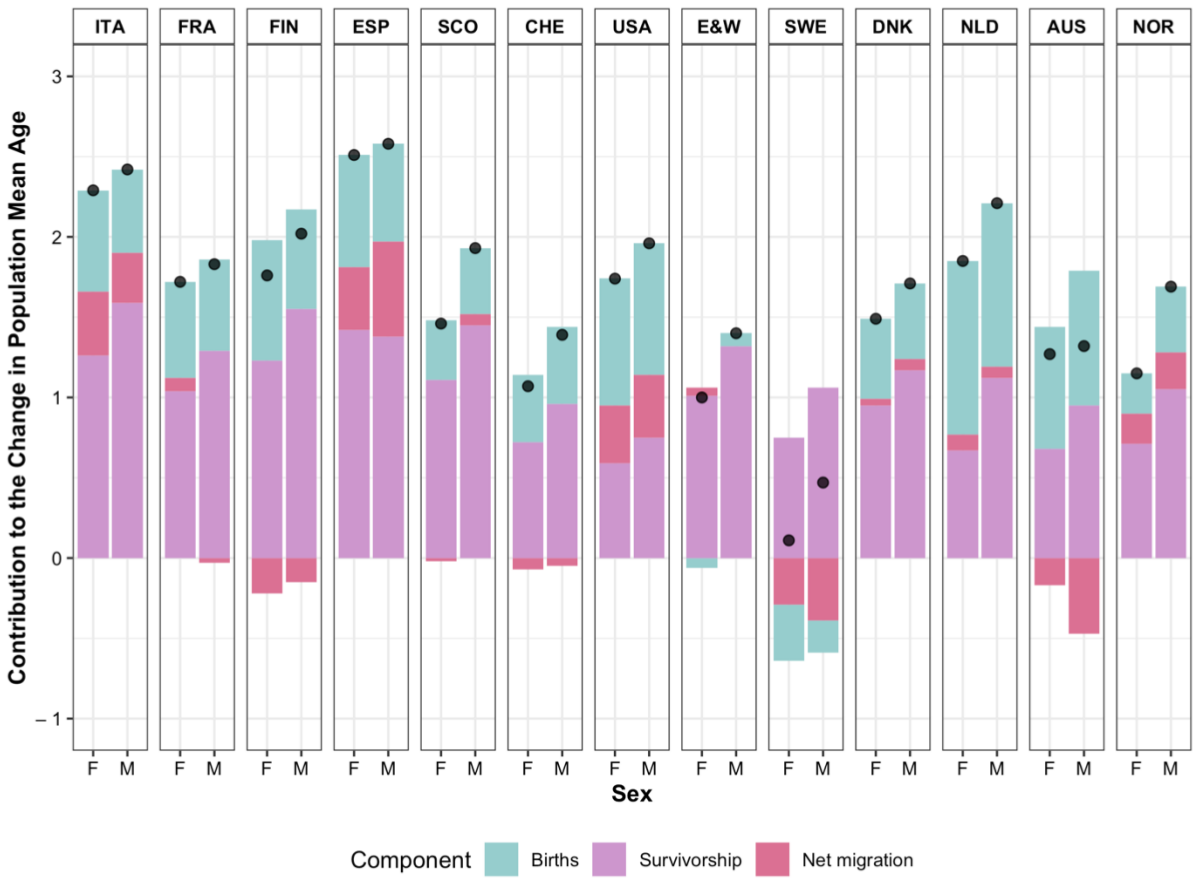

Figure 4. Variable-r decomposition of change in population mean age by sex for selected countries with long mortality series, 2010–2020

Note: countries ordered as in Table 1 from highest to lowest sex gap in 2020. Table 1 also includes the full country names corresponding to the 3-letter codes. Table A1 in the online appendix includes the values of Figure 4.

Source: Authors' calculations based on Eq. (5). Estimates are based on data from the Human Mortality Database (2025), ABS (1911, 1921, 2022), CDC (2020), Bell and Miller (2005) and US Census Bureau (2016).

Table 1 continues on from Figure 4, showing the values for the components of the variable-r decomposition of the sex gap in the population mean age. While the sex gap is positive in 2010 and 2020, the change in sex gap between 2010 and 2020 is negative for all countries analysed, meaning that the sex gap narrowed over this period, consistent with Figure 2. This narrowing of the gap can be explained by changes in the sex gap in survivorship. The contribution of survivorship to the narrowing of the overall sex gap is strong for all countries other than Spain in which it is negligible and still in favour of females, as anticipated from Figure 4. The change in the sex gap in births is small and varies between countries as to whether it contributes to a widening or narrowing of the overall sex gap. Changes in net migration also vary as to whether they contribute to a widening or narrowing of the overall sex gap. The contribution is small in most countries with a few exceptions. In Australia, the change in sex gap in net migration is positive and strong, offsetting the impact of survivorship in narrowing the overall sex gap. A similar result is present in France, though the change in sex gap in net migration offsets just under half of the change in sex gap in survivorship. In Spain, the change in sex gap in net migration is strong and negative, explaining the narrowing of the overall sex gap.

Table 1 shows that changes in survivorship explain the majority of the change in the sex gap in the population mean age for all countries other than Spain, validating the findings of Figures 1–4 showing a close relationship between the population mean age and the life table mean age. Online appendix 4 shows variable-r decomposition for 1950–1960 and 1980–1990.

Table 1. Variable-r decomposition of change in the population mean age sex gap for selected countries with long mortality series, 2010–2020

Country	Sex Gap		Change	Contribution to Change in Sex Gap by		
	2010	2020	2010–2020	Births	Survivorship	Net Migration
Italy (ITA)	2.99	2.88	–0.13	0.11	**–0.33**	0.09
France (FRA)	2.95	2.83	–0.11	0.03	**–0.25**	0.11
Finland (FIN)	2.89	2.62	–0.27	0.13	**–0.32**	–0.07
Spain (ESP)	2.64	2.58	–0.06	0.09	0.04	**–0.20**
Scotland (SCO)	2.32	1.86	–0.47	–0.04	**–0.34**	–0.09
Switzerland (CHE)	2.34	2.02	–0.32	–0.06	**–0.24**	–0.02
United States (USA)	2.17	1.95	–0.22	–0.03	**–0.16**	–0.03
England & Wales (E&W)	2.07	1.67	–0.40	–0.14	**–0.31**	0.05
Sweden (SWE)	2.16	1.79	–0.36	–0.15	**–0.31**	0.10
Denmark (DNK)	1.98	1.75	–0.22	0.03	**–0.22**	–0.03
The Netherlands (NLD)	1.97	1.61	–0.35	0.06	**–0.45**	0.03
Australia (AUS)	1.59	1.52	–0.06	–0.08	–0.27	**0.30**
Norway (NOW)	2.03	1.49	–0.54	–0.16	**–0.34**	–0.04

Note: countries ordered from highest to lowest sex gap in 2020. Bold type indicates the most significant component to the change in sex gap.

Source: Authors' calculations based on Eq. (5). Estimates are based on data from the Human Mortality Database (2025), ABS (1911, 1921, 2022), CDC (2020), Bell and Miller (2005) and US Census Bureau (2016).

Discussion

Our results show an increase in the population mean age for females and males in all populations analysed, with the female mean exceeding the male mean. The sex gap in the population and life table mean ages follow similar time trends: both means widen from the start of the series to a peak around 1980 and then narrow. The variable-r decomposition confirms that mortality is central to understanding the sex gap in population mean age. For almost all of the countries considered, changes in survivorship are the most important factor in the sex gap in the changing population mean age over time.

The sex gap in population ageing can be accounted for by sex differences in mortality. The time trends of the sex gap in the population and life table mean ages peak around 1980 before declining (see Figure 2). This consistency between both means suggests that mortality is responsible for this peak. Studies concerned with the sex gap in life expectancy also find a peak around 1980 (Cui et al. 2019, p. 2312; Glei and Horiuchi 2007, p. 145; Trovato and Heyen 2006, p. 392; Trovato and Lalu 1998, p. 3). The widening of the life expectancy sex gap reflects male life expectancy lags due to elevated mortality in males aged 60 and above (Zarulli et al. 2021, p. 1) and the narrowing reflects declines in male deaths due to circulatory conditions and risky behaviours, again affecting males aged 60 and above (OECD 2017, p. 50). Thus, the widening sex gap preceding 1980 can be explained by stronger overall improvements in female mortality compared to male mortality, while the narrowing of the sex gap in life expectancy has more to do with the catching up of male life expectancy to female life expectancy (Feraldi and Zarulli 2022; OECD 2017, p. 50; Trovato and Lalu 1998).

The age-specific contributions to the sex gap in the population and life table mean ages follow a similar pattern (see Figure 3). However, the age-specific sex gap in the population mean age does show considerably more fluctuation than the sex gap in life table mean age. While the latter reflects only mortality, the population mean age is influenced by mortality, births and net migration, thus there are more confounding variables involved. Both sex gaps in mean ages are due to sex differences above the age of 60, and that this is true at time points when the gap is widening, when it peaks and when it is narrowing. For the population mean age, this means that a greater proportion of the female population are above the age of 60 compared to the male population. For the life table mean age, this means that a greater proportion of the female expected life above the age of 60, respect to its life expectancy, is found compared to the male proportion of expected life. The similar pattern between the sex gaps in both mean ages suggests that sex differences in mortality above the age of 60 explain the sex gap in population mean age**.** This is consistent with the literature on the sex gap in life expectancy. One study found that the 65–80 age group was the strongest contributor to the life expectancy sex gap (Zarulli et al. 2020), while another study found that the 60–79 age group contribute most to the widening of the gap over time, but the age group 40–79 contributed most to its narrowing over time (Glei and Horiuchi 2007).

The strong relationship between the sex gap in population mean age and the sex gap in life table mean age presented earlier is confirmed from a cohort perspective by the variable-r decomposition. Table 1 shows the strong influence of sex differences in changes in survivorship to the narrowing of the sex gap from 2010–2020. In Australia, despite survivorship and births contributing to the narrowing of the overall sex gap, this is largely offset by net migration, resulting in a relatively small decrease in the sex gap. Figure 4 indicates that in Australia, net migration of both females and males contribute negatively to the change in population mean age. This result is stronger for males, leading to an overall positive contribution to the sex gap in population mean age. For England and Wales, changes in female net migration contributes a negligible positive contribution to the change in population mean age, while changes in male net migration make no contribution. In Spain, changes in the sex gap in net migration makes a stronger contribution than other countries. This is a negative contribution, meaning that the sex gap is narrowing. Figure 4 shows that changes in female and male survivorship have made equally strong contributions to the increase in mean age in Spain.

A natural question at this stage is how the sex gap in population ageing might look into the future. The sex gap in population ageing has been declining since the 1980s for most countries analysed. This strong result suggests that the sex gap may continue declining. The sex gap in population mean age shows a close relationship with the sex gap in life table mean age, indicating that mortality forecasts could be used to predict future patterns in the sex gap in ageing. Forecasts of mortality to 2050 expect the sex gap in life expectancy to continue to decrease (Bergeron-Boucher et al. 2018). Age-specific decomposition of the sex gap in both means (see Figure 3) show that the peak age of contribution to the sex gap is moving towards older ages. It can then be expected that the peak age of contribution to the sex gap will continue to shift to older ages.

Our findings are consistent with the results of other studies that changes in survivorship typically contribute more than changes in births and net migration to the change in population mean age (see Figure 4). This result has been found for several countries over various time periods. Using variable-r decomposition, changes in mortality was found to be the most significant factor in changes in the mean age of a population for the US and Sweden between 1980 and 1985 using data from 1895–1985 (Preston et al. 1989), “more and less developed countries” between 2005 and 2010 using data from 1910–2010 and 1950–2010, respectively (Preston and Stokes 2012) and Europe between 1900 and 2012 using data from 1676–2012 (Murphy 2017). A recent study of the US looking at the change in mean age between 2013 and 2018 using data from 1920–2018 found births to be a more important factor than changes in mortality to population ageing (Preston and Vierboom 2021), which was also found for the US for the period 2010–2020 using data from 1910–2020 in the present study. In contrast to the findings of the present study, one analysis of the change in old-age dependency ratio for the same countries and time period analysed in the present study shows that, in general, births contributed more to the change in old-age dependency ratio (Scott and Canudas-Romo 2024).

Whether changes in survivorship or births contributes more to population ageing depends on the measure of ageing as well as the country and time period analysed. Both the present study and the Scott and Canudas-Romo (2024) study use identical time periods and countries but differ on the measure of ageing used. The change in mean age formula, used in the present study, gives increasing weight to ages older than the mean age (Eq. (3), term $[a - \bar{a}(t)]$). In contrast, the change in old-age dependency ratio, used in Scott and Canudas-Romo (2024, p. 1013) gives a consistent weight to all ages 65 or over (see online appendix 5). As gains in survivorship occur at older ages, and these older ages are given more importance by the change in mean age formula, the present study gives greater relative importance to the change in survivorship than when using the old-age dependency ratio.

This link between the sex gap in population ageing and the sex gap in mortality is important because it allows researchers to strengthen their understanding of population ageing by leveraging existing and emerging work on mortality. This link is also important because the sex gap in population ageing is persistent but variable. Research into mortality can be used to illuminate why the sex gap in ageing exists, why it varies, and how it might look in the future.

This study contributes to the literature by formalising and strengthening the link between the sex gap in population ageing and the sex gap in mortality. The robustness of this relationship is demonstrated using period- and cohort-level decompositions. This strengthens demography's understanding of the underlying structural dynamics of population ageing.

Ageing has implications for sex and gender. This distinction is important; while most females identify as women and males as men, some do not. Transgender older adults experience unique challenges in ageing, including worse physical and mental health, stigma and higher rates of disability (Johnson et al. 2018). Females and males experience different age-related health conditions. Globally, older females experience a higher burden of disease from lower back pain, depressive disorders and headache disorders, while older males experience a higher burden of disease from COVID-19, road injuries and ischaemic heart disease (Patwardhan et al. 2024). Gendered experiences of ageing also vary notably. One study analyses wholistic experiences of ageing across the five domains of wellbeing, productivity and engagement, equity, security, and cohesion. This study found that men were better off than women over all domains (Chen et al. 2021). Understanding the sex gap in population ageing, the age-specific contributions towards this gap, and how it is changing over time allows policy makers to address the sex- and gender-specific needs of older adults.

Some limitations to the present study are potential avenues for further research. Firstly, although the period analysis of the population mean age and life table mean age can be done for many countries, variable-r decomposition requires extensive cohort data from as early as 1910. This limits the variable-r decomposition to mainly European countries. When longer series of data for Asian countries become available, variable-r decomposition could provide valuable insight into the sex gap in population ageing in Asia. Results for Asia could be influenced by numerous demographic factors impacting the region including the heavily skewed sex ratio at birth for some Asian countries, as anticipated by Zhang and Li (2020). Alternatively, a shorter version of the variable-r decomposition (Canudas-Romo et al. 2024) could also be used instead. However, testing this is beyond the scope of the present study. Secondly, the present study shows a strong empirical link between the sex gap in population mean age and mortality as expressed in the life table mean age but does not provide a mathematical relationship between the two means. Future work developing an analytical link between the two means could give more explanatory power to the results presented here. Finally, this study provides a broad overview of the link between the sex gap in population mean age and the sex gap in life table mean age and as such only involves comparisons at the national level. This could obfuscate important results at the subnational level, including analysis by geographic location, ethnicity or other factors. Future work in this area could consider subnational analysis.

Conclusion

The title of this study poses the question of whether females and males are 'growing old together'. By reviving a measure of the age distribution of mortality, undertaking age-specific decomposition and utilising variable-r decomposition, this study analyses the sex gap in population ageing. This study shows that, for the countries considered, the population mean age has increased steadily for females and males, but that there is a consistent sex gap in favour of females. Over time, the sex gap in the population mean age closely follows the sex gap in the life table mean age, a measure of the age distribution of mortality. Both sex gaps appear to have peaked around 1980 for most countries and have narrowed since. Analysis of age-specific contributions reveal that sex differences above the age of 60 explain the sex gap in both the population mean age and the life table mean age at times when the sex gap was widening, peaked and narrowing. The final stage of the analysis, using variable-r decomposition, confirms that improvements in survivorship for males across cohorts have explained recent decreases in the sex gap in population mean age. Thus, the sex gap in population ageing can be accounted for by sex differences in mortality at older ages.

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Appendices

Appendix 1: Visual Representation of Variable-r Decomposition Through Lexis Diagram

Appendix 2: The Sex Gap in Life Table Mean Age Over Time

Appendix 3: Detailed Values of the Variable-r Decomposition Results for 2010–2020

Appendix 4: Variable-r Decomposition Results for 1950–1960 and 1980–1990

Appendix 5: Variable-r Decomposition of the Change in Old-Age Dependency Ratio

Appendix Tables & Figures

Appendix 1: Visual Representation of Variable-r Decomposition Through Lexis Diagram

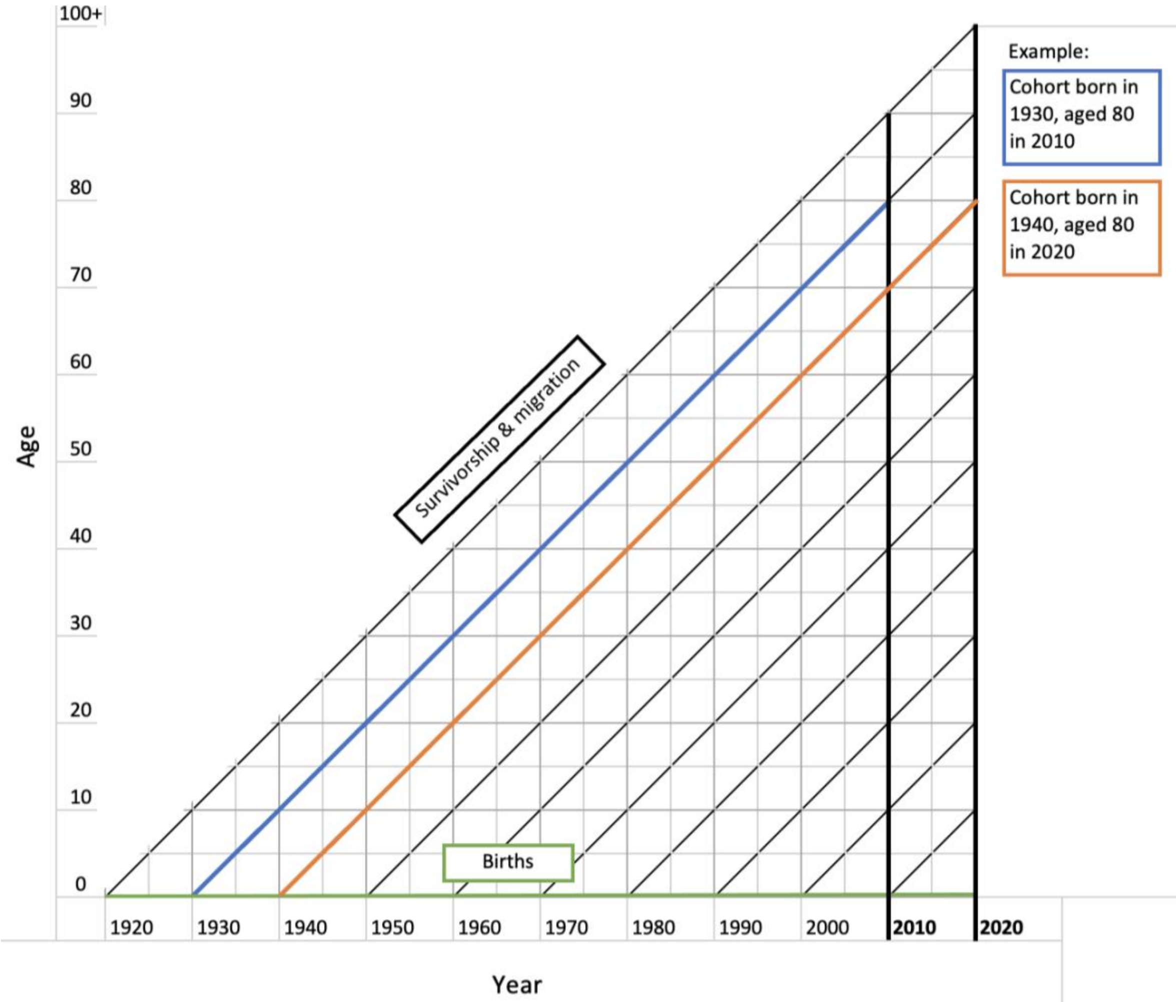

Figure A3. Lexis diagram representation of the data requirements to calculate the variable-r decomposition of the change in the mean age of the population between 2010 and 2020

Source: Created by author.

Appendix 2: The Sex Gap in Life Table Mean Age Over Time

Method

The change in life table mean age with respect to time can be expressed as

$$\dot{\bar{a}}_l(t) = \int_0^{\omega} r_l(a,t)c_l(a,t)[a - \bar{a}_l(t)]\, da, \qquad \text{(A1)}$$

where $r_l(a,t)$ is the growth rate in the life table survivors at age a, or relative change over time, defined as $r_l(a,t) = \frac{\dot{l}(a,t)}{l(a,t)}$.

The sex gap in the change in life table mean age with respect to time can be expressed as $\Delta\dot{\bar{a}}_l(t) = \dot{\bar{a}}_{l,F}(t) - \dot{\bar{a}}_{l,M}(t)$, and Eq. (A1), applied to the female or male subset of the population, can be substituted to represent age-specific contributions.

Result

Figure A2 shows the 10-year time change (derivative with respect to time) of the sex gap in the population mean age and life table mean age, that is, the derivative of Figure 2. Positive values indicate a widening in the sex gap over the preceding 10 years while negative values indicate a narrowing of the gap.

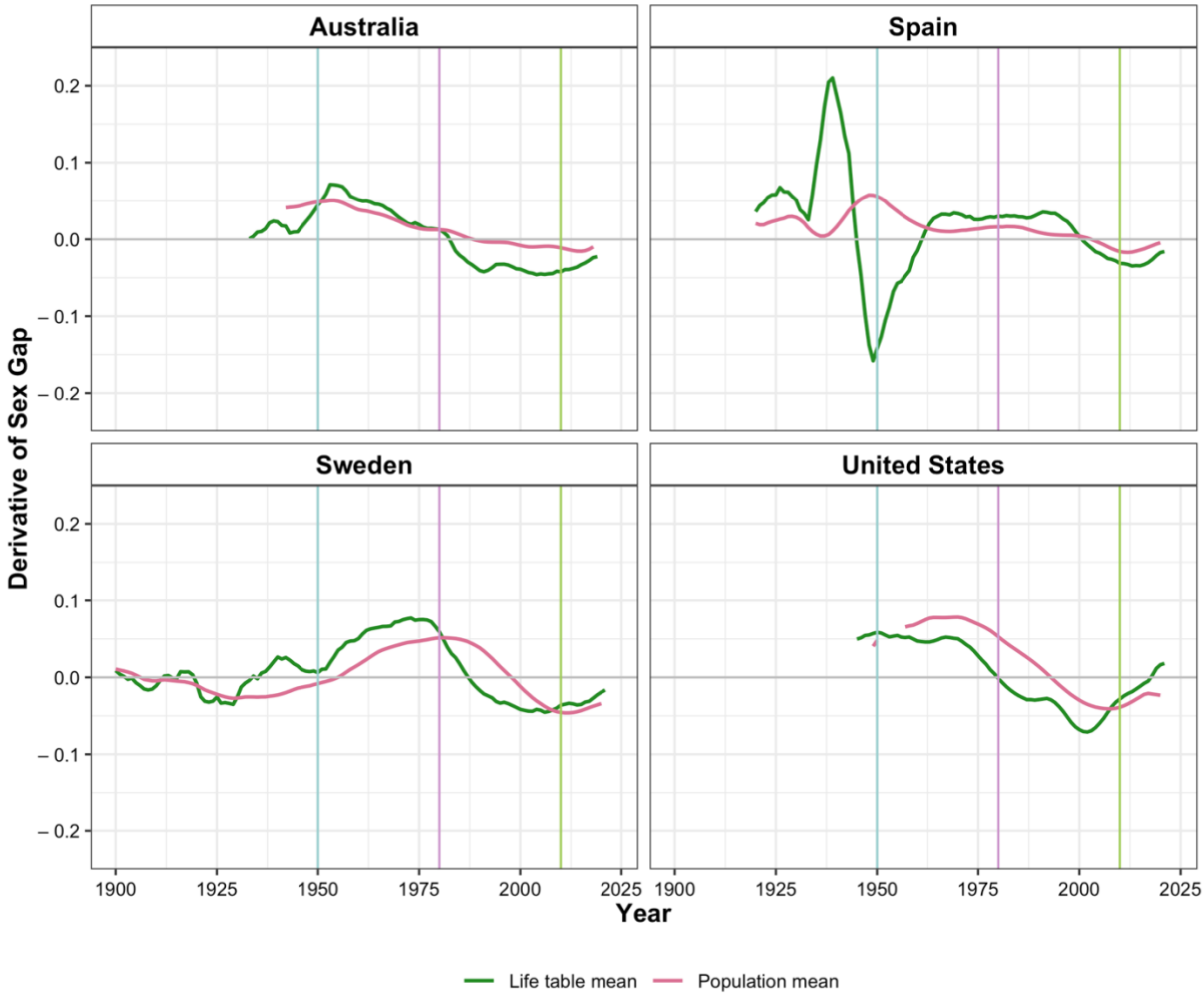

Figure A2. Rolling average of 10-year change in the sex gap in population and life table mean ages for Australia, Spain, Sweden and the United States, 1900–2022

Source: Authors' calculations. Estimates are based on data from the Human Mortality Database (2025).

Figure A3 shows the age-specific contributions to change over time of the sex gap for both means. It is analogous to Figure 3, but instead of showing age contributions to the sex gap at three discrete time points, 1950, 1980 and 2010, it shows age contributions over time to the change in the sex gap for three time periods, 1950–1960, 1980–1990 and 2010–2020. As Figure A2 shows whether the gap is widening or narrowing over 10-year periods, Figure A3 expands on this by showing age contributions to the widening and narrowing of this gap. As with Figure 3, the patterns between the two means are fairly similar, with significantly more noise in the population mean age than the life table mean age. As seen in Figure 2 and Figure A2, the period 1980–1990 captures the peak in the sex gap for both means for Australia, Sweden and the US. Figure A3 shows that the progression over time from a widening to a narrowing sex gap does not occur uniformly over all ages. Growth in the proportion of males exceeding growth in the proportion of females occurs first at middle ages before progressing to older ages over time.

In the US and Spain there is non-uniformity in age-specific contributions over time. In Spain, 1950–1960 saw growth in favour of males in middle ages but growth in females at older ages while 1980–1990 saw growth only in favour of females and 2010–2020 saw growth only in favour of males. In the US, 1950–1960 saw growth only in favour of females, 1980–1990 saw growth in favour of males in middle ages and younger-old ages but growth in females at the oldest ages and 2010–2020 saw growth in favour of females in middle ages and younger-old ages but growth in males at oldest ages. Australia and Sweden, in contrast to Spain and the US, both show a similar pattern over time. Around the time of the peak in 1980–1990, growth favoured males at ages 45 to 85, while growth at ages 85 and above favoured females. By 2010–2020, growth favoured males at ages 60 to 95, and the ages at which growth favoured females shifted to ages 95 and above.

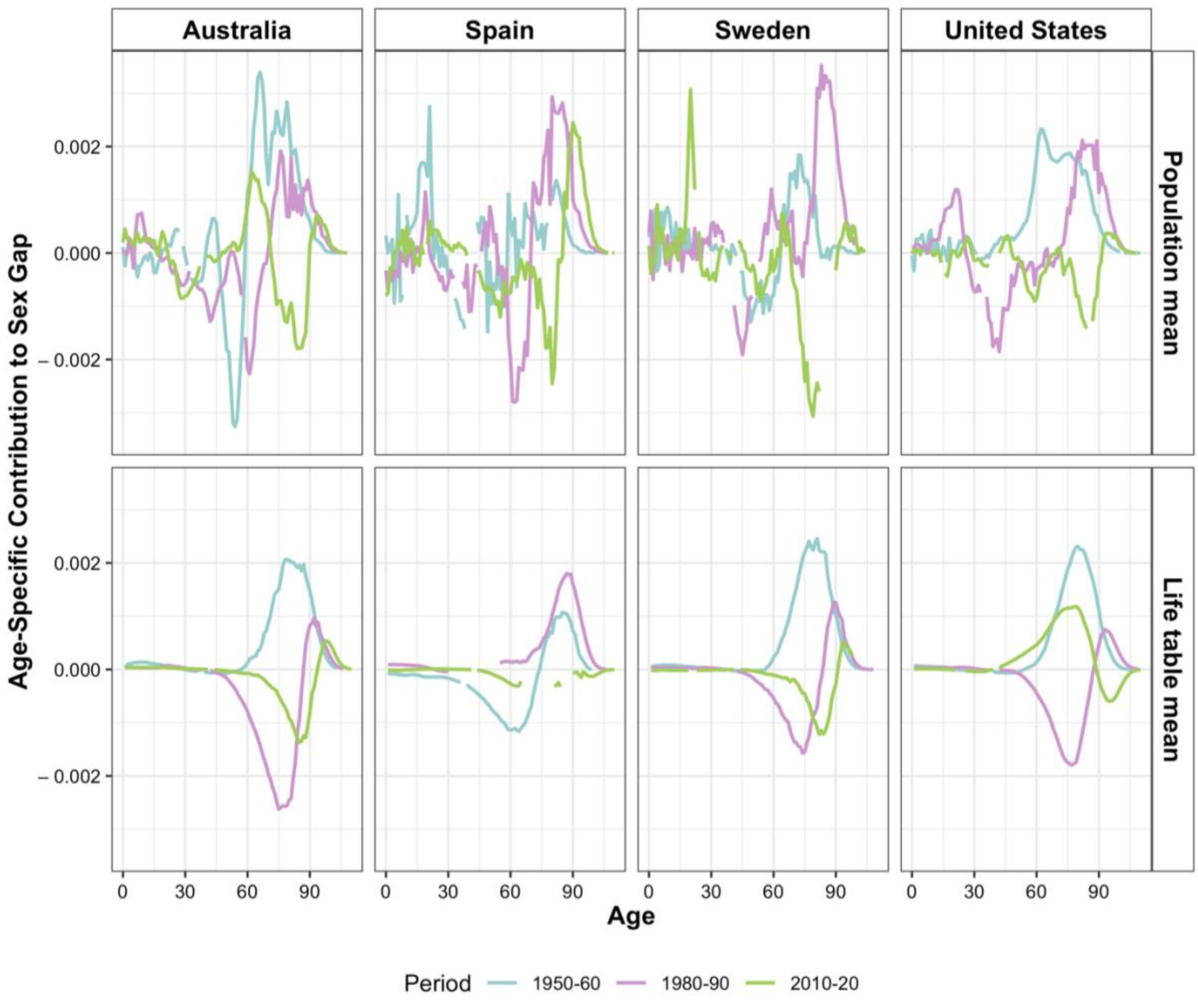

Figure A3. Age-specific contributions to the change in sex gap in population and life table mean ages for Australia, Spain, Sweden and the United States in 1950–1960, 1980–1990 and 2010–2020

Source: Authors' calculations based on Eq. (3) and Eq. (A1). Estimates are based on data from the Human Mortality Database (2025).

Appendix 3: Detailed Values of the Variable-r Decomposition Results for 2010–2020

Table A1. Variable-r decomposition of change in the population mean age by sex for selected countries with long mortality series, 2010–2020

Country	Contribution to Change in Female Population Mean Age			Contribution to Change in Male Population Mean Age		
	Births	Survivorship	Net Migration	Births	Survivorship	Net Migration
Italy (ITA)	0.63	1.26	0.40	0.52	1.59	0.31
France (FRA)	0.60	1.04	0.08	0.57	1.29	–0.03
Finland (FIN)	0.75	1.23	–0.22	0.62	1.55	–0.15
Spain (ESP)	0.70	1.42	0.39	0.61	1.38	0.59
Scotland (SCO)	0.37	1.11	–0.02	0.41	1.45	0.07
Switzerland (CHE)	0.42	0.72	–0.07	0.48	0.96	–0.05
United States (USA)	0.79	0.59	0.36	0.82	0.75	0.39
England & Wales (E&W)	–0.06	1.01	0.05	0.08	1.32	0.00
Sweden (SWE)	–0.35	0.75	–0.29	–0.20	1.06	–0.39
Denmark (DNK)	0.50	0.95	0.04	0.47	1.17	0.07
The Netherlands (NLD)	1.08	0.67	0.10	1.02	1.12	0.07
Australia (AUS)	0.76	0.68	–0.17	0.84	0.95	–0.47
Norway (NOW)	0.25	0.71	0.19	0.41	1.05	0.23

Note: countries ordered as in Table 1. Bold type indicates the most significant component to the change in the population mean age.

Source: Authors' calculations based on Eq. (5). Estimates are based on data from the Human Mortality Database (2025), ABS (1911, 1921, 2022), CDC (2020), Bell and Miller (2005) and US Census Bureau (2016).

Appendix 4: Variable-r Decomposition Results for 1950–1960 and 1980–1990

Table A2 and Table A3 are analogous to Table 1 in the main text. They show variable-r decomposition of the sex gap in the mean age of the population between 1950–1960 and 1980–1990, respectively. These tables include fewer countries than Table 1 as many countries do not have enough data to complete these early time series. Between 1950–1960, the sex gap increased for all countries except Norway, consistent with the pattern seen in the countries in Figure 2. The most significant factor in the ageing of each country is highlighted with bold text. Survivorship is the most significant factor for all countries with an increase in the sex gap. For Norway, survivorship contributed positively to the sex gap, but this effect was overpowered by net migration contributing to a decreasing sex gap.

In 1980–1990, the sex gap increased for some countries and decreased for others. The absolute value of the change in sex gap is low when compared to the results for 1950–1960 and 2010–2020. In Figure 2, the peak of the sex gap for countries considered was around 1980–1990, which explains the low values and varying direction of the results. In the six countries with an increasing sex gap, survivorship contributes most to this change. In the four countries with a decreasing sex gap, the most significant factor varies. Survivorship makes a positive contribution to the change in sex gap in all countries except England and Wales.

Table A2. Variable-r decomposition of change in population mean age sex gap for selected countries with long mortality series, 1950–1960

Country	Sex Gap		Change	Contribution to Change in Sex Gap by		
	1950	1960	1950–1960	Births	Survivorship	Net Migration
France (FRA)	3.08	3.28	0.20	0.04	**0.21**	–0.03
England & Wales (E&W)	2.26	3.04	0.77	0.25	**0.40**	0.13
Sweden (SWE)	1.20	1.35	0.14	0.08	**0.18**	–0.11
Denmark (DNK)	1.09	1.36	0.27	0.05	**0.31**	–0.09
Norway (NOR)	1.67	1.64	–0.03	0.09	0.15	**–0.26**

Note: countries ordered from highest to lowest sex gap in 2020. Bold type indicates the most significant component to the change in sex gap.

Source: Authors' calculations based on Eq. (5). Estimates are based on data from the Human Mortality Database (2025).

Table A3. Variable-r decomposition of change in population mean age sex gap for selected countries with long mortality series, 1980–1990

Country	Sex Gap		Change	Contribution to Change in Sex Gap by		
	1980	1990	1980–1990	Births	Survivorship	Net Migration
Italy (ITA)	2.78	2.91	0.14	0.01	**0.27**	–0.15
France (FRA)	3.25	3.12	–0.13	**–0.36**	0.08	0.15
Finland (FIN)	3.75	3.73	–0.03	–0.04	**0.17**	–0.15
Scotland (SCO)	3.66	3.49	–0.17	–0.03	0.06	**–0.19**
Switzerland (CHE)	2.83	2.95	0.12	–0.17	**0.40**	–0.11
England & Wales (E&W)	3.33	3.08	–0.25	**–0.14**	–0.08	–0.03
Sweden (SWE)	2.27	2.68	0.42	–0.03	**0.51**	–0.06
Denmark (DNK)	2.45	2.77	0.31	0.00	**0.49**	–0.18
The Netherlands (NLD)	2.32	2.60	0.28	–0.07	**0.52**	–0.18
Norway (NOR)	2.43	2.76	0.33	–0.06	**0.55**	–0.14

Note: countries ordered from highest to lowest sex gap in 2020. Bold type indicates the most significant component to the change in sex gap.

Source: Authors' calculations based on Eq. (5). Estimates are based on data from the Human Mortality Database (2025).

Appendix 5: Variable-r Decomposition of the Change in Old-Age Dependency Ratio

Scott and Canudas-Romo (2024, p. 1013–1014) present the following equations for the decomposition of the change in old-age dependency ratio (OADR):

$$OA\dot{D}R(t) = OADR(t)\left[\left(\frac{1}{c(65+,t)}\int_{65}^{\omega} r(x,t)c(x,t)dx\right) - \left(\frac{1}{c(15-64,t)}\int_{15}^{65} r(x,t)c(x,t)dx\right)\right]$$

where the dot above the OADR refers to its derivative over time, $c(x,t)$ refers to the proportion of people aged *x* with respect to the total population and $r(x,t)$ denotes the age-specific population growth rate at age *x*, both between times *t* and *t+h*.