





BMJ Open Probability of males to outlive females: an international comparison from 1751 to 2020

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ABSTRACT

Objective To measure sex differences in lifespan based on the probability of males to outlive females.

Design International comparison of national and regional sex-specific life tables from the Human Mortality Database and the World Population Prospects.

Setting 199 populations spanning all continents, between 1751 and 2020.

Primary outcome measure We used the outsurvival statistic (φ) to measure inequality in lifespan between sexes, which is interpreted here as the probability of males to outlive females.

Results In random pairs of one male and one female at age 0, the probability of the male outliving the female varies between 25% and 50% for life tables in almost all years since 1751 and across almost all populations. We show that φ is negatively correlated with sex differences in life expectancy and positively correlated with the level of lifespan variation. The important reduction of lifespan inequality observed in recent years has made it less likely for a male to outlive a female.

Conclusions Although male life expectancy is generally lower than female life expectancy, and male death rates are usually higher at all ages, males have a substantial chance of outliving females. These findings challenge the general impression that ‘men do not live as long as women’ and reveal a more nuanced inequality in lifespans between females and males.

INTRODUCTION

The female survival advantage has been observed over time across many human populations and is rooted in a complex combination of biological, environmental and behavioural factors.^{1–5} For example, males tend to engage in more risky behaviours, such as smoking and heavy drinking, but oestrogen could also be preventive against certain diseases.⁶ A study on cloistered populations reveals a constant female survival advantage of around 0.2 years. The author attributes the remaining sex differences in life expectancy in the general population to differences in lifestyle and socioeconomic burden.⁷ However, even among populations where men and women differ less in terms

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This is the first study using the outsurvival statistic to quantify the probability of males outliving females across multiple populations over time.
- ⇒ The outsurvival statistic shows that lifespan inequalities between sexes have more nuances that cannot be captured by comparisons made with classic summary demographic measures (eg, life expectancy).
- ⇒ The outsurvival statistic does not account for dependence between individuals, such as couples whose health and mortality patterns are positively correlated due to a strong effect of social ties on health and longevity.

of key lifestyle factors, such as Mormons, sex differences in life expectancy still exist.⁸ In 2019, the sex difference in life expectancy was 4.4 years on average worldwide, with large variation across countries.⁹ Females have been found to have longer survival and lower death rates than men at all ages and in most modern populations^{2 4 10–13} and even under extreme mortality conditions.¹⁴

Sex differences in survival are often identified by comparing life expectancy between females and males, which summarises the average length of life. These differences are often interpreted as ‘men do not live as long as women’. Such an interpretation is simplistic as it does not account for the variation around the means (life expectancies) and potential overlaps between female and male lifespan distributions. Despite females having a higher life expectancy than males, not all females outlive all males. On the contrary, a sizeable portion of males might live longer than a sizeable portion of females, even if the life expectancy shows a female advantage. This is because the lifespan distributions of females and males partly overlap, that is, they share a common range of ages at death. The extent of the overlapping indicates how likely it is for



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males to outlive females and, ultimately, how sizeable the portion is of males living longer than females.

Lifespan variation, that is, differences in lifespans within a population, has been receiving increasing attention in the literature.¹⁵ Various indicators reveal heterogeneity in the length of life, beyond what life expectancy indicates. Studies have compared lifespan variation between two populations, focusing on which populations exhibit more inequalities.^{16–18} It has been shown that females systematically experience lower lifespan variation than males.¹⁶ However, it is unclear how this variation around the means leads to potential overlap between the two lifespan distributions.

Only a few studies have used measures of overlap or distance to study inequalities between populations. A previous study has investigated the extent to which two lifespan distributions differ using the Kullback-Leibler (KL) divergence.¹⁹ The indicator is interpreted as the amount of ‘effort’ needed to transform the male’s lifespan distribution into the female’s distribution. A disadvantage of this indicator is that it is not symmetrical, meaning that the effort needed to transform the male’s distribution into the female’s is not the same as the effort needed to transform the female’s distribution into the male’s. Stratification indexes, based on how much two lifespan distributions overlap or do not overlap, have also been used to study mortality differences between socioeconomic groups.²⁰ The larger the overlap, the more likely the individuals in two populations are to survive to the same age. This index is meant to reflect unequal distribution at the societal level, with values varying between 0 (no overlap) and 1 (perfect overlap). A related measure is the outsurvival statistic, which quantifies the probability that an individual from a population with lower life expectancy outlives an individual from another population with higher life expectancy.²¹ The main difference with the stratification index is the interpretation, which focuses on the individuals. If the two populations are males and females, the outsurvival statistic captures the correctness of the assertion that males’ lifespans are lower than females’ lifespans. If both populations have equal lifespan distribution, the outsurvival statistic is equal to 0.5. Unlike the other two measures, the outsurvival statistic also explicitly reveals which of the compared populations has an advantage (values above 0.5) or a disadvantage (values below 0.5).

In this article, we use the outsurvival statistic²¹ to study lifespan inequalities between females and males. We aim to (1) quantify the probability that males outlive females over time and across populations; and (2) assess the sensitivity of the outsurvival statistic to changes in life expectancy and lifespan variation. We computed the outsurvival probability to study sex differences in mortality in 199 populations over 200 years. Despite sometimes large differences in life expectancy, we show that there are substantial overlaps between males’ and females’ lifespan distributions.

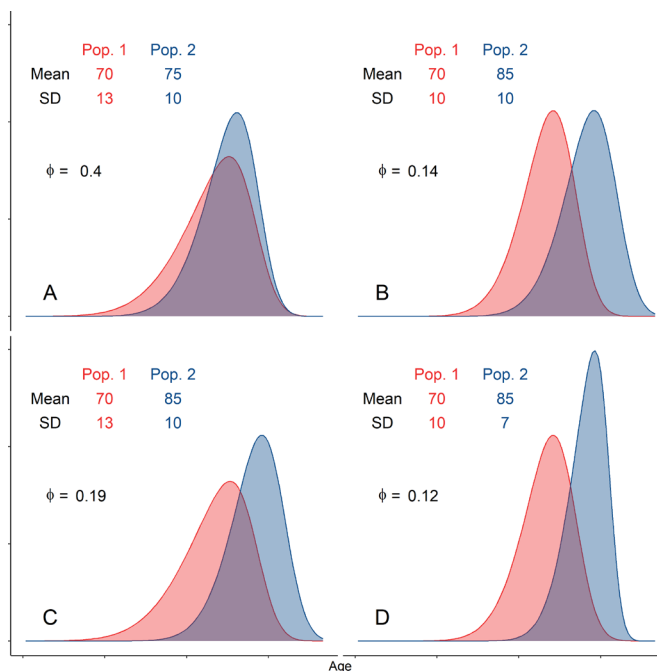


Figure 1 Four scenarios of interactions between lifespan distributions and corresponding statistics.

METHOD

Outsurvival statistic

Consider two populations with mean and standard deviation (SD) of the age of death (see Ouellette and Bourbeau, and Wilmoth and Horiuchi^{22–23} for more details on the SD calculation) specified in panel A of figure 1. The first population (in red) has a smaller mean lifespan and larger SD than the second population (in blue). An inference from these means would be that individuals in the first population are worse off than individuals in the second. However, there is an important overlap between the two distributions, with some individuals in the first population outliving some individuals in the second population. The outsurvival probability, φ , captures this dimension by measuring the probability that an individual from a population with high mortality will outlive an individual from a population with low mortality.²¹ Let $d_i(x)$, $i = 1, 2$ denote the lifespan distribution at age x in two populations. The cumulative distributions are represented by $D_i(x)$, such that $D_i(x) = \int_0^x d_i(t) dt$ and the survivorship is denoted by $l_i(x)$, with $l_i(x) = 1 - D_i(x)$. The probability that an individual from the first population (males) will outlive an individual from the second population (females) is²¹:

$$\varphi = \int_0^{\infty} d_2(x) l_1(x) dx. \quad (1)$$

In scenario A of figure 1, φ is 40%.

In the online supplemental materials, we show that the outsurvival statistic relates to the joint probability density function of two lifespan distributions, which gives the probability of realisations of two lifespans and is thus related to the overlap of the two distributions.

Relation to life expectancy and lifespan variation

Consider the two populations in scenarios B and C of figure 1. The difference in mean lifespan is the same in both cases, that is, 15 years. However, in scenario C, the first population has a larger SD, which implies more individuals surviving to older ages, despite greater inequalities, and thus a greater potential to outlive individuals from the second population. Indeed, φ is higher in scenario C (19%) than in scenario B (14%). Now compare scenario B with scenario D. This time, the second population in D has a smaller SD, with fewer individuals dying at younger ages, making it less likely for individuals in the first population to outlive them. This reduces φ to 12%. Thus, for the same difference in life expectancy, larger lifespan variation in both populations generally results in larger φ . The comparison of scenarios A and C also shows that small differences in life expectancy lead to larger value of φ .

Equation (1) is not new and relates to the Mann-Whitney U test, the probability of superiority and to the expected failure probability in a stress–strength interference model. The latter assesses the probability that the stress (population 1) exceeds the strength (population 2) of a material.²⁴ If the distributions of both populations follow a normal distribution with mean μ_i and SD s_i , the probability of failure is $P(Z)$ with $Z = \frac{\mu_2 - \mu_1}{\sqrt{s_1^2 + s_2^2}}$.²⁵ This relation formalises what is illustrated in section in figure 1: φ is sensitive to the difference in the means and to the level of variation in both distributions, with smaller mean differences (numerator) and larger variance (denominator) leading to larger $P(Z)$. However, lifespan distributions are not normally distributed, and additional moments could also affect the value of φ . To better understand this relation, we analysed the correlation between φ and life expectancy as well as between φ and lifespan variation.

Discrete approximation

Similar equivalences to equation (1) can be developed in a discrete time setting. Let ${}_n d_x^i$ be the life table deaths between age x and $x+n$ in population i and ${}_n r_x^i$ the survival probability to age x . For a given age group width of n , the probability of individuals in the first population outliving those in the second population can be found by:

$$\varphi \approx \sum_{x=0}^{\omega} {}_n d_{x-n}^2 {}_n r_x^1 + \bar{d}, \quad (2)$$

with $\bar{d} = \frac{\sum_{x=0}^{\omega} {}_n d_x^1 {}_n d_x^2}{2}$ and $\sum_{x=0}^{\omega} {}_n d_x^1 {}_n d_x^2$ being the probability that individuals in both populations died in the same age group. The latter statistic is sensitive to the width of the age groups such that smaller age groups result in smaller values, with $\lim_{n \rightarrow 0} \sum_{x=0}^{\omega} {}_n d_x^1 {}_n d_x^2 = 0$. In the online supplemental materials, we compared the discrete and continuous approaches and found that both approaches yield comparable results.

Equations (1) and (2) are equivalent to matching random individuals from each population and calculating the proportions of individuals from the first population who outlive the paired individual from the second. We performed such analyses via simulations of individuals from a specific lifespan distribution and estimated the corresponding statistics (see online supplemental materials). Equivalent results were found.

Patient and public involvement

No patients were involved.

DATA

The method was applied to three demographic datasets. First, we used life tables by sex for all available countries and years from the Human Mortality Database (HMD).²⁶ The HMD is freely available and provides comparable long time-series for 41 countries with high-quality data. Data are provided by single-year age groups. We used subnational data for Germany, with separate analysis for East and West Germany, and for the UK, with separate analysis for England–Wales, Scotland and Northern Ireland, amounting to 44 studied populations. The earliest year with available data was 1751 (for Sweden) and the latest was 2020. Information about the available populations and years is provided in the online supplemental materials. We compared females' and males' life tables in each country/region.

Second, we used abridged life tables from the World Population Prospects 2019 Revision (WPP).²⁷ This dataset is also freely available and provides sex-specific life tables for 199 countries by 5-year age groups and 5-year periods from 1950–1954 to 2015–2019. This database covers the whole world, but the data quality varies greatly between countries.²⁸ The HMD and WPP data are used to compare the outsurvival statistic over time and across multiple populations.

Finally, we computed the outsurvival statistic for subpopulations of females and males using US data in 2015–2019. We compared the probability of males to outlive females by education level and marital status to assess if the sex differences emerge from specific subpopulations. We calculated sex-specific life tables by education level and marital status using death counts from the Multiple Cause of Death Dataset (MCDD) from the National Vital Statistics System of the National Center for Health Statistics²⁹ and population counts from the American Community Service (ACS) from the US Census Bureau.³⁰ The MCDD provides death counts by single-year age groups, sex, marital status and education level. The ACS provides data by similar variables and single-year age groups until age 96. However, it is worth noting that the ACS data exhibit an important age heaping at age 95. We therefore ungrouped the population counts from age 90+ using the Penalized Composite Link Model³¹ to obtain the population counts from age 90 to 110 by single year of age.

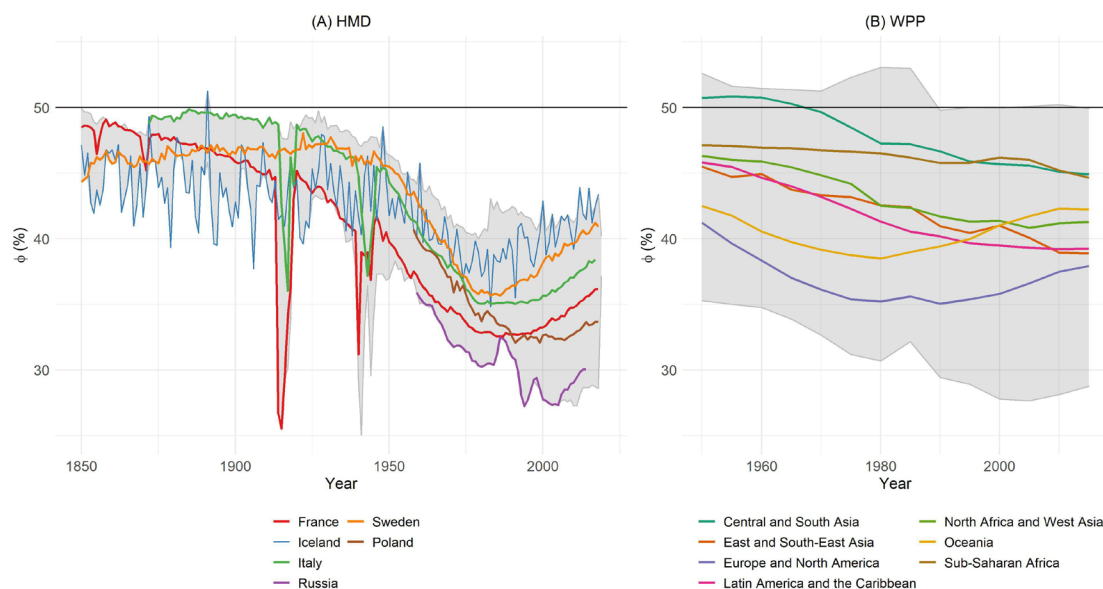


Figure 2 Probability of males outliving females (A) since 1850 for five countries and the range for all countries in the HMD in grey and (B) since 1950–1955 by world regions and the range for all countries in the WPP in grey. Source: HMD,²⁶ WPP²⁷ and authors' own calculations using equation (2). HMD, Human Mortality Database; WPP, World Population Prospects 2019 Revision.

RESULTS

Historical values and trends in ϕ

Figure 2A shows the outsurvival probability of males over females (ϕ) since 1850 for all HMD countries and figure 2B for all WPP countries since 1950–1955. The probability of males outliving females has, at all points in time and across all populations, varied between 25% and 50%, with only few exceptions with values above 50%: Iceland in 1891; Jordan in 1950–1954; Iran in 1950–1964, Iraq in 1960–1969; before 1985 in Bangladesh, India and the Maldives; and between 1995 and 2010 in Bhutan.

For the HMD countries, ϕ was slowly decreasing before the First World War, on average from 47.3% in 1850 to 46.0% in 1913. After the war, ϕ declined faster. In 1930, the mean ϕ across populations was 45.4%, ranging from

42.8% (France) to 48.4% (the Netherlands). By 1985, the mean ϕ was 35.3%, ranging from 31.2% (Russia) to 42.8% (Israel). The value of ϕ started increasing around the 1980s for some countries, but continued to decrease in others until the 2000s, especially in Eastern European countries. The mean for all countries was 37.1% in 2017, with values varying between 28.7% (Belarus) and 42.5% (Iceland).

For the WPP countries, we observed a decrease in ϕ in all regions since 1950, except in Europe, Northern America and Oceania, which increased from the 1980s, as is also shown in the analysis of the HMD data. In 1950–1955, ϕ was 46.1% on average worldwide, with values ranging between 35.3% (in Kazakhstan) and 52.6% (in Iran). By 2015–2019, ϕ declined to 41.2% with values

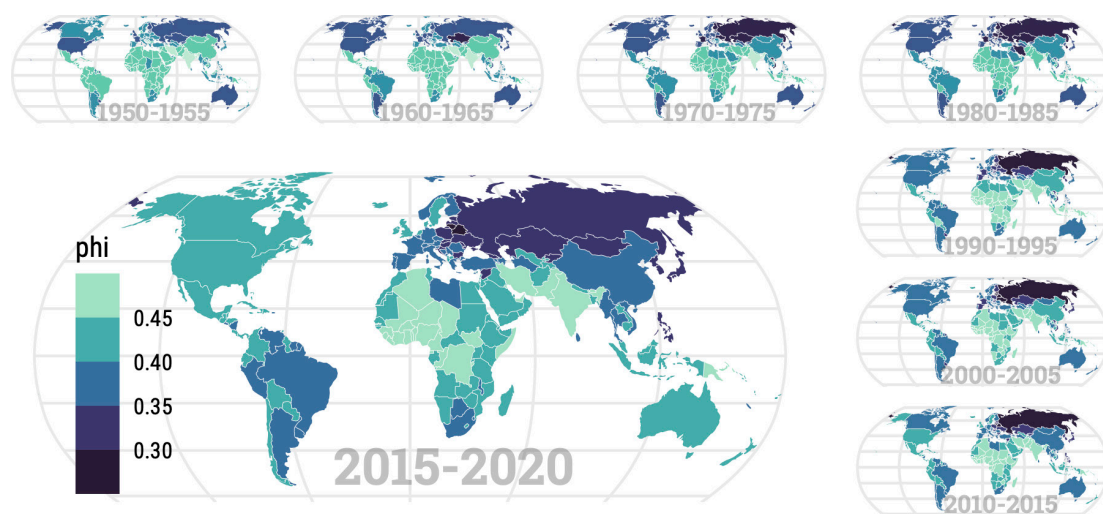


Figure 3 Probability of males outliving females across the world, 1950–1954 to 2015–2019. Source: WPP²⁷ and authors' own calculations using equation (2). WPP, World Population Prospects 2019 Revision.

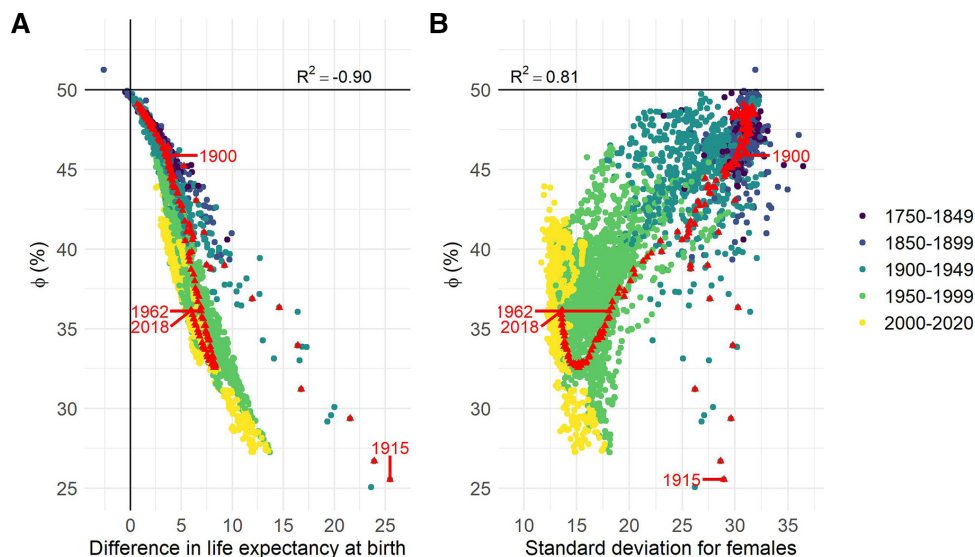


Figure 4 Relation between φ and (A) the sex differences in life expectancy and (B) the SD of lifespans for females for HMD period data since 1751, with France highlighted (red triangles). Source: HMD²⁶ and authors' own calculations. HMD, Human Mortality Database.

ranging between 28.8% (in Belarus) and 49.9% (in Bhutan). **Figure 3** shows φ across the world in different time periods. In recent years, the outsurvival of females was particularly low in Eastern Europe and Northeast Asia and was particularly high in Southern Asia and in Western and Middle Africa. Males from many Southern Asian countries had an especially high chance of outliving females, with φ above 50% before 1970.

Life expectancy and lifespan inequality correlation

Figure 4 shows that φ is negatively correlated with the differences in life expectancy and positively correlated with females' SD (as shown in the online supplemental materials, similar results were found when males' SD was used, due to the strong correlation between females' and males' SDs). **Figure 4** is based on the HMD data, but the same relation is found when using the WPP data (see online supplemental materials). This relation empirically demonstrates the formal relation in the Relation to life expectancy and lifespan variation section. The correlation between φ and the SD has been weaker in recent years, due to a reduction in sex differences in life expectancy, which is also driving changes in φ . Even though both life expectancy and lifespan variation affect φ , the statistic appears more sensitive to the differences in life expectancy than to the level of lifespan variation. We also found similar results for cohort data (see online supplemental materials).

The same value for φ can be found for different combinations of sex differences in life expectancy and levels of lifespan variation. For example, the same φ of 36.1% was found in France in 1962 and in 2018 (**figure 4**). However, the sex difference in life expectancy was 6.9 in 1962 and 5.9 in 2018, and the SD for females was 18.1 in 1962 and 13.6 in 2018.

Figure 5 shows the same relations as shown in **figure 4** but for survivors to age 50. Lifespan variation at age 50 has stayed roughly constant over time,³² and comparing φ from this age can help to assess the sensitivity of the measure to changes in lifespan variation (similar results were found when using males' SD, see online supplemental materials). The relation between φ and differences in life expectancy is stronger and more linear from age 50 (correlation coefficient of -0.99) than when using the full age range, increasing predictive ability. For example, for a difference in life expectancy at age 50 of 3 years, males have around 42% probability of outliving females. Note that φ in France was 35.9% in 1962 and 36.3% in 2018.

Similar to the distribution from birth, the probability of males outliving females from age 50 has, in almost all periods and populations, varied between 28% and 50%, with only few exceptions. In recent years, the φ statistics from birth and from age 50 are similar.

Sex differences by education and marital status

Tables 1 and 2 show the φ statistic for some subpopulations of males and females in the USA. For the period 2015–2019, the probability of males to outlive females was 40% in the total US population. However, this statistic varies depending on marital status and education level, being higher among the subpopulations with beneficial characteristics: the probability of males to outlive females was 39% for married individuals and 37% for unmarried individuals (**table 1**); 43% for individuals with a university degree and 39% for those without a high school diploma (**table 2**).

Furthermore, these results highlight that males with beneficial characteristics (being married and having a university degree) have an advantage over women with detrimental characteristics (being unmarried and having only a high school diploma or less).

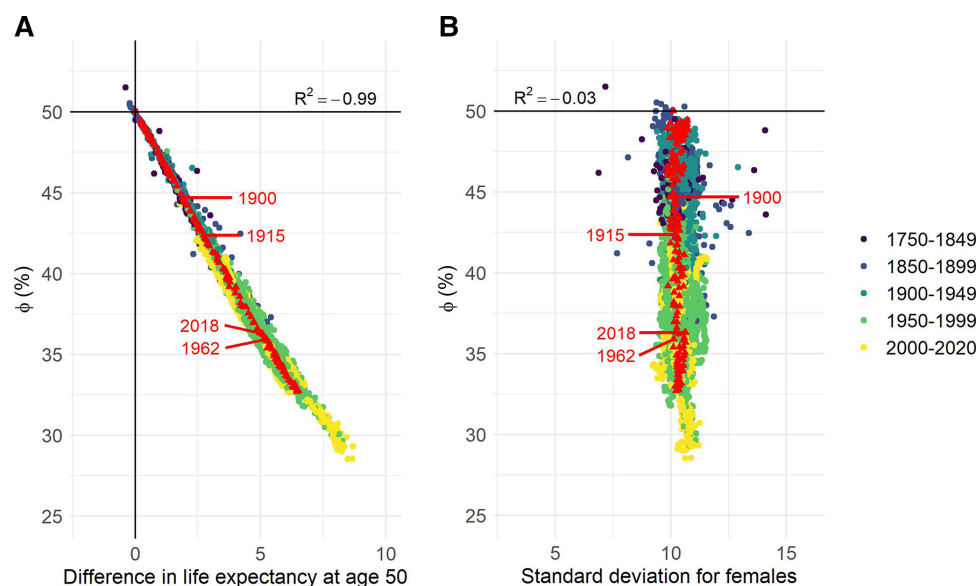


Figure 5 Relation between φ and (A) the sex differences in life expectancy and (B) the SD for females for HMD period data since 1751, conditional to survival to age 50 years, with France highlighted (red triangles). Source: HMD²⁶ and authors' own calculations. HMD, Human Mortality Database.

DISCUSSION

Our study reveals a nuanced inequality in lifespan between females and males, with between one and two men out of four outliving a randomly paired woman in almost all points in time across 199 populations. These results complement the picture given by the comparisons based on life expectancy, which is a summary measure with no information on variation. A blind interpretation of life expectancy differences can sometimes lead to a distorted perception of the actual inequalities. Not all females outlive males, even if a majority do. But the minority that do not is not small. For example, a sex difference in life expectancy at birth of 10 years can be associated with a probability of males outliving females as high as 40%, indicating that 40% of males have a longer lifespan than that of a randomly paired female. Not all males have a disadvantage of 10 years, which is overlooked by solely making comparisons of life expectancy. However, a small number of males will live very short lives to result in that difference. For example, more baby boys die than baby girls in most countries.

The length of the lifespan of an individual results from a complex combination of biological, environmental and

behavioural factors. Being male or female does impact lifespan, but it is not the only determinant contributing to inequalities. Lifespan has been shown to be influenced by marital status, income, education, race/ethnicity, urban/rural residence, etc.³³ As we only disaggregated the population by sex and because of this complex interaction, lifespan distributions of females and males overlap. This nuance is captured by the φ metric. Males with a lower education level or who are unmarried have a particularly low chance of outliving a female. But males with a university degree or who are married have a higher chance of outliving females, in particular females with a lower education level and who are single.

As previously discussed, the φ metric expresses the probability of males to outlive females among randomly paired individuals, assuming independence between populations. However, males and females in a population are generally not random pairs but often couples, whose health and mortality have been found to be positively correlated due to a strong effect of social ties on health and longevity.³⁴ Coupled individuals also influence each other's health,³⁵ and this is particularly true for males, who benefit more than females from being in a stable relationship.³⁶ The datasets used for the analysis do not permit the estimation of the probability of males outliving females for non-randomly paired individuals. However, the outsurvival statistic relates to the probability of the husbands to outlive their wives, and even though such a measure accounts for the difference in age between husband and wife, it has been shown generally to be between 30% and 40%,³⁷⁻³⁹ values that are quite close to φ .

Other measures of overlap and distance between distributions could have been used. In the online supplemental materials, we compare the outsurvival statistic with a stratification index used by Shi and colleagues²⁰ and the KL divergence. We found that all three indicators are

Table 1 Outsurvival statistics by sex and marital status in the USA, 2015–2019

		Female	
		Married	Unmarried
Male	Married	0.39	0.52
	Unmarried	0.26	0.37

Source: MCDD,²⁹ ACS³⁰ and authors' own calculations using equation 2. ACS, American Community Service; MCDD, Multiple Cause of Death Dataset.

Table 2 Outsurvival statistics by sex and education level in the USA, 2015–2019

		Female		
		University degree	High school diploma	No high school diploma
Male	University degree	0.43	0.51	0.53
	High school diploma	0.32	0.39	0.42
	No high school diploma	0.30	0.37	0.39

Source: MCDD,²⁹ ACS³⁰ and authors' own calculations using equation 2. ACS, American Community Service; MCDD, Multiple Cause of Death Dataset.

strongly correlated and using any one of these would not have changed the general conclusions from this article. However, unlike the other indicators, φ directly indicates when males live longer than females, which we found in a few instances.

Trends over time in φ are consistent with the reversed trends in sex differences in life expectancy⁴⁰: in developed countries, the probability of males outliving females decreased until the 1970s, after which it gradually increased in all populations. Studies showed that the increase in sex differences in mortality emerged in cohorts born after 1880,^{10 41} which is consistent with our analysis of φ (see online supplemental materials). The increase and decrease in sex differences in life expectancy were mainly attributed to the smoking epidemic and other behavioural differences between sexes.^{7 13 42}

The φ values are generally higher in low/middle-income countries. However, this should not be interpreted as a sign of greater gender equality in survival. Southern Asian countries had very high φ values, above 50% in the 1950s and 1960s. Studies for India showed that mortality below age 5 was higher for females than males and remained higher for females in recent years.^{43 44} However, females had a growing mortality advantage above age 15 years since the 1980s, 'balancing out' the disadvantage at younger ages. The reasons for the higher φ and decreasing trends in developing regions vary across countries. It is outside the scope of this study to provide a detailed explanation for the trends in each country.

The outsurvival statistic can be informative for public health interventions.²¹ Governments develop public health programmes to reduce lifespan inequalities at different levels (eg, socioeconomic status, race, sex, etc). It would be misleading to say that half of the population is disadvantaged by sex differences in lifespan. The inequalities are more nuanced. If 40% of males live longer than females, it could be argued that if a policy aiming at reducing inequalities between sexes targeted the full male population, some of the efforts and investments would be misallocated. Such a policy could be more efficient if φ approaches 0, indicating that sex would explain a large part of the lifespan inequalities within the population, whereas a φ closer to 0.5 indicates that other characteristics (eg, socioeconomic and marital statuses) are involved in creating inequalities. We showed that some subpopulations of males have a high probability (above

50%) of outliving some subpopulations of females. Males who are married or have a university degree tend to outlive females who are unmarried or do not have a high school diploma. Inequalities in lifespan between sexes are attributable to some individuals within each population and not to the whole population. Indeed, Luy and Gast¹² found that male excess mortality is mainly caused by some specific subpopulations of males with particularly high mortality. Being able to better identify the characteristics of the short-lived men could more efficiently help tackle male–female inequality.

An important result of our analysis is that the smaller the SD in the age at death, the smaller the φ . The reduction of lifespan inequality observed over time has then made it less likely for males to outlive females. This is partly explained by the fact that lifespan variation reduction has been driven by mortality declines at younger ages.⁴⁵ When looking at the lifespan distribution (as in figure 1, scenario D), survival improvements at younger ages narrowed the left tails of the distribution for both sexes. By reducing the left tail of female distribution, without increasing the right tail of the male distribution, the overlapping area is reduced. In other words, the number of females with shorter lifespan, easier to outlive, decreased over time. Indeed, it has been shown that mortality declined at a faster pace for females than males below age 50, especially in the first half of the 20th century.^{46 47} This finding implies that more efforts are required today than in the past to reduce these inequalities, for a same difference in life expectancy. While inequalities were mainly attributable to infant and child mortality, they are today increasingly attributable to older and broader age groups. Men maintained their disadvantage at younger ages, but also faced an increasing disadvantage at older ages. Men are more prone to accidents and homicides in their 20s and 30s than females, and they tend to smoke and drink more leading to higher cancer prevalence and death in their 60s. At the same time, women benefited from reduced maternal mortality and recorded faster mortality decline at older ages. Efforts in reducing lifespan inequalities must thus target diverse factors, causes and ages.^{13 46 48}

A decrease of φ might indicate a discrepancy in the causes of death that affect males and females. External mortality due to accidents and suicide has become more relevant in shaping sex differences in survival in recent years in high-income populations.¹² Another example is

observed in Latin American populations, where homicides and violent deaths have had an increased burden among males in comparison with females since the 1990s.^{49 50} In Mexico, for example, the increase in homicide mortality, especially among men between 20 and 40 years, contributed to increasing the gap in mortality between females and males.⁵¹ This phenomenon is reflected in the decrease over time in the overlapping of lifespan distributions, directly informing healthcare systems of emerging inequalities.

However, one might ask if a wider overlapping is necessarily better for healthcare systems. On the one hand, a larger overlapping means less inequality between sexes, but on its own it does not ensure that there is more 'health justice'. For example, if the overlapping areas are large, this still shows a situation of great uncertainty in lifespan for both groups. One health evaluator actor could even prefer a situation where there is a small gap between groups but less inequality within the groups. In the case of sex differences, there might always be between-group differences due to biological factors,^{2 52} but more health equity could be reached by reducing within-group inequalities. We argue that the outsurvival statistic is a new tool to evaluate health inequalities between groups within a population by uncovering underlying dynamics that are otherwise hidden when looking only at conventional indicators. Therefore, it can inform healthcare systems of the subsequent directions to reach the preferred goal.

CONCLUSION

Comparing life expectancy between females and males provides a simplistic view of lifespan inequalities between sexes. Using measures of overlap between two distributions of lifespans complements these summary measures and offers a more comprehensive understanding of inequalities.

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Contributors M-PB-B designed and conceptualised the study. M-PB-B, J-AA and IK produced the results and did the analysis. M-PB-B, J-AA, IK and VZ contributed to the interpretation of the results; and the drafting, revision and approval of the manuscript. M-PB-B is acting as guarantor.

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Patient consent for publication Not required.

Ethics approval Not applicable.

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