

Masculinization of populations reverses sex difference in fertility

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Population structures show a growing male surplus around the globe as a consequence of declining mortality, narrowing sex differences in mortality, and sex-selective abortions in some countries. Population structures are important determinants of marriage markets and childbearing. In this study, we estimate the past, current, and future difference between the male and the female total fertility rates around the world using an established indirect demographic approach drawing on data from the UN World Population Prospects. Our results indicate a crossover from historically higher male fertility to increasingly higher female fertility, which occurs globally in 2024. This shift is not toward parity, but rather reflects a growing disparity driven by the increasing male surplus in populations, which exerts downward pressure on male fertility rates relative to those of females. The difference is expected to grow to up to 20% in countries like China and India, where sex-selective abortion has caused sex imbalances in population structures. Overall, we highlight the growing sex inequalities in reproduction and call for more research on sex differences in fertility.

demography | sex-selective abortion | male fertility | marriage markets | sex differences

Fertility is a fundamental demographic process that shapes population structures and profoundly influences individual well-being. Fertility is commonly measured for women but not for men. For instance, statistical offices routinely report the average number of children per woman. Focusing only on women can be misleading in populations with imbalanced population structures, because it does not truly reflect the reproductive behavior of the entire population. While previous studies have demonstrated a strong synchrony between male and female fertility trends globally (1, 2), notable deviations emerge in high-fertility contexts (3) or in populations with marked sex imbalances (2, 4, 5). Despite these observations, the historical evolution and future trajectories of sex disparities in fertility remain poorly understood at the global scale.

Sex differences in fertility arise from two interrelated factors: sex-specific population structures and differential fertility timing. Because fertility is defined as the number of births relative to the population exposed to childbearing, imbalances in the sex ratio of the reproductive population can lead to divergent fertility estimates between sexes. Moreover, men typically exhibit a broader reproductive age window and have children later than women, which can result in higher observed fertility rates among men in young and growing populations (3, 6). These patterns are further modulated by demographic shocks, such as abrupt fertility transitions or mortality crises, that alter the age and sex composition of the population, thereby influencing the observed sex gap in fertility (1, 2, 4, 7).

Sex differences in fertility may indicate imbalanced mating markets in which the more abundant sex faces structural constraints on partnership formation, and may affect union composition in terms of the age gap between the partners and the partners' bargaining power (8–12). Another concern is the effect on fertility and childlessness, as cohorts exposed to sex differences in fertility face a structural constraint to childbearing, potentially leading to increased childlessness among men and women (2, 13, 14). Furthermore, sex differences in partnering and fertility may have downstream implications for social and health outcomes, including increased violence and the spread of sexually transmitted diseases, particularly among unpartnered and childless individuals, who may suffer from loneliness and have fewer kin to care for them at older ages (15–20). Finally, a surplus of men in a population is postulated to increase economic vulnerability as well as violence and conflict (19, 21–24).

This study presents a global analysis of male and female total fertility rates (TFRs). The TFR indicates the average number of children born to a woman or a man by the end of their reproductive period if they were subject to the age-

Significance Statement

Reproductive behavior is typically analyzed using data for women, yet demographic shifts are altering the gender composition of populations, underscoring the need to better understand male fertility dynamics. Declining mortality, artificially high sex ratios at birth, and narrowing sex differentials in mortality contribute to a masculinization of population structures, which leads to a crossover from a higher TFR for men to a higher TFR for women over time. Our analysis identifies 2024 as the year when global fertility levels between men and women diverged, as male fertility declined from approximately 5.7 in 1950 to 2.2 in 2024, while female fertility remained higher. We do not expect a return to parity within the current projection period. These emerging disparities may have far-reaching implications for demographic balance and social stability.

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specific fertility rates of a given year. We examine historical trends and future projections of sex differences in fertility across countries and areas, building on a regression-based prediction of the TFR of men, as suggested by Keilman et al. (25) and leveraging data from the United Nations World Population Prospects 2024 (26). We also use classic demographic standardization to assess the impact of the population structure on sex differences in fertility, removing the impact of age differences in partnering. Our findings reveal a striking temporal shift: while male TFRs (TFR_m) historically exceeded female TFRs (TFR_w) in most nations, a crossover has occurred in recent decades, with the TFR_w now surpassing the TFR_m in an increasing number of countries and areas. This reversal reflects underlying changes in population structure driven by sex-specific mortality and sex ratios at birth. By disentangling these demographic forces, we demonstrate how shifts in the sex composition of reproductive-age populations – particularly through differential survival and sex-selective birth patterns – have fundamentally reshaped the sex-specific dynamics of fertility over time.

Declining male fertility

For the overall overall transition of populations from a higher TFR_m in the past to a higher TFR_w in the future, see Figure 1, which shows a reversal of the sex inequality in reproduction. In 1950, the TFR_m exceeded the TFR_w around the world with 96.2% of the countries and areas showing a higher TFR for men than for women. However, the decline in the TFR_m has been steeper than that in the TFR_w , resulting in a mixed pattern in 2025, with some countries and areas exhibiting a higher TFR_m and others a higher TFR_w . In 2025, 47.5% of countries and areas have higher TFR_m , but this share is expected to fall sharply to only 9.8% by 2100.

The difference between the TFR_m and the TFR_w can be substantial, and ranges from -61.6% (Qatar, 2009) to +131.01% (Turks and Caicos Islands, 1975). Extreme cases are often found in smaller countries and areas, where a modest change in mortality or migration affecting only one sex can greatly alter the relative size of the male and the female population. However, even in countries and areas with large populations, such as China, India, and the Republic of Korea, marked differences between male and female TFRs have also been observed. Figure 2 shows the relative difference between the male and the female TFR, revealing that a crossover occurred in China in 1996, in India in 2020, and in the Republic of Korea in 1994. Moreover, these countries will reach the minimum of the relative difference in the 2020s and 2030s, respectively, indicating that sex disparities in fertility are likely to become more pronounced in the near future.

The time point when the TFR_w first exceeded the TFR_m globally occurred in the year 2024, but the timing of the fertility crossover varies across geographic regions, see Figure 1. In the majority of European and North American countries, this crossover happened decades ago, mainly in the 1960s and 1970s. In most Latin American countries, the crossover happened in the recent past. The majority of countries in North Africa, East Asia, Oceania, and Central Asia are expected to experience the crossover in the near future. In countries in Sub-Saharan Africa, the crossover is expected to occur much farther into the future, with many of these countries not experiencing the crossover before 2100.

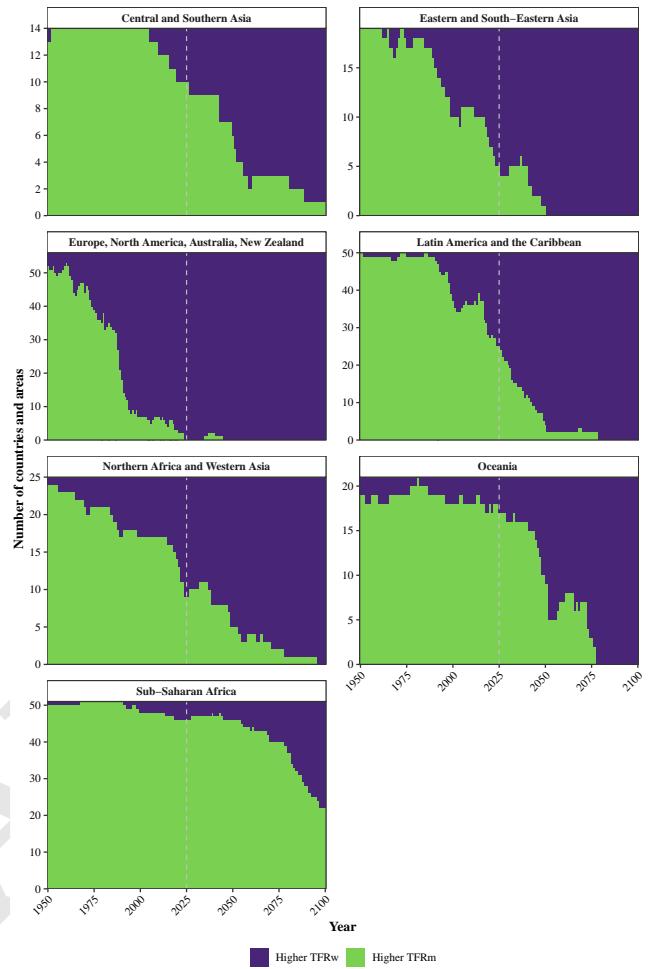


Fig. 1. The number of countries and areas with a higher TFR_m in green and the number of countries with a higher TFR_w in blue in a specific year by SDG region

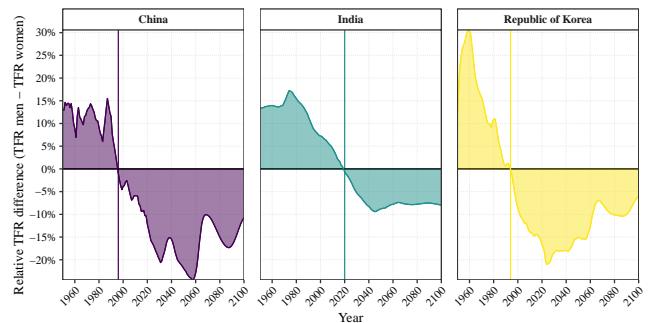


Fig. 2. Percentage difference in male to female TFR (y-axis) in the period between 1950 to 2100 (x-axis) using the regression-based approach. Positive values indicate a higher TFR among men and negative values indicate a lower TFR among men. The vertical lines indicate the crossover from a higher male TFR to a higher female TFR

We use demographic standardization to show the impact of gender differences in the population on sex differences in fertility in the absence of age gaps between parents (see *Materials and methods* Section 1). The standardization results corroborate the regression-based results, showing that the male TFR declines relative to the female TFR over time, which indicates that population sex ratios are the main driver of differences between the TFR_m and the TFR_w . However, two noticeable differences emerge between the regression-based and the standardization approaches. First, fewer crossovers occur in the standardization results than in the regression-based results. Second, the sex differences in fertility in the past are weaker and more muted. Both observations may be related to the fact that it is not just sex differences in population structures that drive the sex differences in fertility, but also larger age differences between fathers and mothers and high population growth rates, which offset the impact of male-skewed populations at reproductive ages (3).

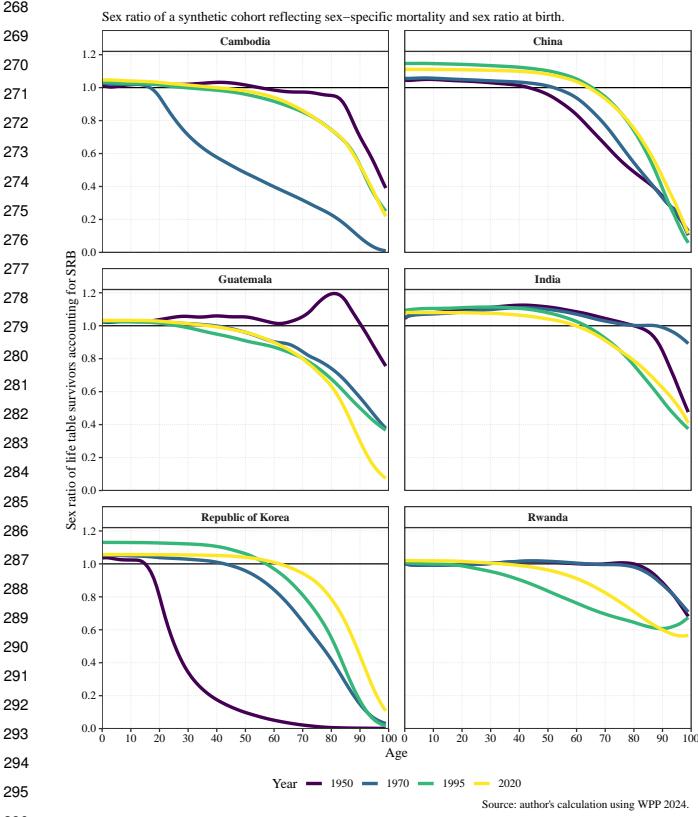


Fig. 3. The sex ratio in a population (y-axis) reflecting period mortality rates and the sex ratio at birth at different ages (x-axis), e.g., excluding migration. Values above one indicate a male population and values below one indicate a female population.

Untangling the demographic drivers. Figure 3 illustrates how sex ratios at birth and sex differences in mortality shape the population sex ratios in Cambodia, China, India, Guatemala, the Republic of Korea, and Rwanda. It shows that both rising sex ratios at birth and changing mortality patterns contributed to the observed crossover in fertility and represent a secular trend toward more masculine populations. In 1950, women began to outnumber men around age 50 in all countries and areas, except in Guatemala and the Republic of Korea, where male survival was lower due to the excess

male mortality caused by war. The upward shift in the age at which women outnumber men is driven by higher sex ratios at birth (reflected in the increased intercept on the y-axis), overall declines in mortality, and narrowing sex differences in mortality (both indicated by the flattening of the curves). By 2020, this crossover occurred at around age 65 in China, India, and the Republic of Korea. India is a special case showing sustained excess men related to the continuously high sex ratio at birth and the narrow gender gap in mortality (due to comparatively high female mortality).

Notably, the cases of Cambodia (1950s to 1960s and 1960s to 1990s), Guatemala (late 1960s and 1970s), the Republic of Korea (early 1950s), and Rwanda (early 1990s) highlight the acute and lasting impact of conflict-related mortality. In these country-years, the sex ratio curves exhibit sharp, transient dips reflecting elevated male mortality during periods of war and violence. For example, in 1950 in the Republic of Korea, a cohort exposed to wartime mortality would have exhibited a sex ratio of 30 men per 100 women at age 30, had mortality rates remained constant. These temporary shocks leave enduring imprints on population structure, skewing the age-sex composition for decades and affecting subsequent fertility, marriage, and labor market dynamics.

Discussion

This article has examined the difference in average reproduction between women and men in the past, the present, and the future around the world. While men used to have higher fertility than women in Europe and North America, male-skewed population structures are expected to deflate reproduction numbers for men in the future, particularly in East Asia. A universal force leading to these sex imbalances in reproduction is declining mortality, which sustains the male-skewed sex ratio at birth longer throughout life (27). A narrowing sex difference in mortality may also contribute to a masculinization of populations at reproductive ages. In some East Asian countries, this effect is reinforced by sex-selective abortion (28).

We observe that male fertility historically exceeded female fertility, in line with previous findings (2, 3). With the onset of the fertility decline and as fertility reaches lower levels, the male and the female TFR cross, and female fertility starts exceeding male fertility. The timing of the crossover depends on the progress of the fertility transition. Crossovers occur first in Europe (1960s) and later in other contexts. In sub-Saharan Africa, some countries are not expected to experience a fertility crossover before 2100, highlighting the implications of recent fertility stalls (29, 30).

Male and female fertility can differ substantially, with the gap ranging from -60% to +130%. Extreme cases of a very high male TFR relative to female TFR (+100% or above) are mainly observed in the 1950s and 1960s in small populations like those in Lesotho, Tokelau, and Turks and Caicos Islands. Extreme cases of a very low male TFR relative to the female TFR are mostly observed in the 2020s and 2030s in countries like Qatar, the United Arab Emirates, the Maldives, and Oman.

The secular trend behind the crossover of the male and the female TFR is the masculinization of populations related to declining mortality levels, narrowing sex difference in mortality, and, in some countries, artificially imbalanced

373 sex ratios at birth. The impact of mortality on the
374 masculinization of populations has been observed for Western
375 countries before by Schubert and Dudel (2), Spoorenberg
376 (27), and the issue of the missing women has been raised by
377 Sen (28).

378 Beyond the secular trends driving the masculinization
379 of populations, conflicts can have a strong and lasting
380 impact on the sex ratios in populations, leading to a
381 female surplus. Dependent on the intensity and duration of
382 conflicts, population structures can be altered with potential
383 implications for childbearing. Based on the period mortality
384 rates for the Republic of Korea and Cambodia, there would
385 be 30 or 70 men per 100 women at age 30, respectively, if
386 conflict mortality lasted in the these countries for a cohort.
387 The feminization of population structures may have positive
388 effects on gender equality and the participation of women,
389 but it also renders reproduction and partnering more difficult
390 and selective for women.

391 The crossover marks the beginning of a new demographic
392 reality, which will come with new opportunities and challenges.
393 There is evidence suggesting that increasing levels of male
394 childlessness and excess numbers of men will have social
395 and economic consequences. U.S.-based research indicates
396 implications for marriage rates and fertility (9, 31). Research
397 on Finland shows that an excess number of men will lead to
398 higher levels of male childlessness and a steeper socioeconomic
399 gradient of childlessness (2). Moreover, in East Asian
400 countries, an excess of men in the population has been linked
401 to increased rates of crime and sexually transmitted diseases
402 (16, 32, 33). A cultural backlash against progress in gender
403 equality has also been identified as potential risk.

404 Another finding of this study is that male fertility can be
405 readily approximated with a regression-based approach using
406 adult sex ratios and the female TFR. While Keilman et al.
407 (25) suggested this approach and found only a lower model
408 fit ($R^2 = 0.83$), we obtained excellent model performance
409 statistics ($R^2 = 0.97$) and out-of-sample prediction error
410 ($RMSE = 0.041$), especially with a model accounting for
411 age gaps between partners. We encourage future research
412 to fine-tune this model further. Moreover, we contend that
413 systematically measuring male fertility across all countries
414 and areas is crucial for gaining a comprehensive understanding
415 of reproductive behavior.

416
417 **Limitations.** The study has two major limitations. First, male
418 fertility is not directly observed, but is instead approximated
419 through various indirect methods using population structures
420 and female fertility rates. While these approximations yield
421 a high out-of-sample fit (see [SI Appendix Demographic
Scenarios](#) Section 1) and the observed data on male fertility
422 have problems (34, 35), the models assume a certain
423 relationship between the female TFR and the population
424 structure compared to that of the male TFR, which may
425 not hold. For instance, in special cases such as the United
426 Arabic Emirates or Qatar, our results deviate from those
427 reported in (3), because male-dominated labor migration
428 leads to changing population structures, but not changing
429 fertility, rendering our approximation imperfect. Second, we
430 only estimate average fertility, e.g., total fertility rates, and
431 do not study age- and/or parity-specific fertility. Previous
432 research indicates that subnational population imbalances in

433 Finland mainly affect childlessness among the more abundant
434 sex (2), but this may play out differently in other contexts.
435

436
437 **Outlook.** Our results suggest that sex differences in fertility are
438 growing as a result of the masculinization of populations, and
439 that these shifts will come with challenges and opportunities.
440 The challenges are mainly for men who remain childless, a
441 status that is often associated with worse health and growing
442 dependence on professional care in old age. We propose the
443 following specific policy measures to address sex differences
444 in fertility and their consequences (e.g., male childlessness,
445 marriage market imbalances): strengthening the position of
446 women in society to prevent artificially high sex ratios at
447 birth; improving education and job creation to give childless
448 and single men opportunities to pursue a career and to
449 reduce their susceptibility to organized crime; and providing
450 technical solutions for singles and childless individuals, such
451 as friendship groups and legalizing of artificial reproductive
452 technologies. Failing to address the needs of these men could
453 result in a cultural backlash against gender equality and lead
454 to societal conflicts.

Materials and Methods

455
456 **Data.** We use data on age-sex specific population counts, annual
457 birth counts by sex, and female TFRs from the United Nations
458 World Population Prospects 2024 (WPP2024), but male TFRs are
459 not included in these data and are therefore estimated indirectly (3–
460 5). WPP2024 provides comprehensive, internally consistent time
461 series of population counts by single age and sex, births, deaths,
462 and international migration for all countries and areas from 1950 to
463 2100. The dataset is freely accessible at <https://population.un.org/wpp/>.
464 It integrates diverse data sources, including civil registration
465 systems, sample registration, censuses, surveys, and national
466 estimates, while explicitly accounting for biases such as under-
467 coverage, under-enumeration, and differential registration quality
468 across age groups and regions (36). The population estimates are
469 derived using the cohort component method, which reconstructs
470 population dynamics through the population balancing equation.
471 This approach ensures temporal consistency and enables reliable
472 projections to 2100. Fertility and mortality indicators, including
473 the TFR_w and adult mortality, are generated via Bayesian
474 hierarchical modeling that synthesizes heterogeneous data sources,
475 adjusts for known measurement errors, and propagates uncertainty
476 appropriately (37–39). This methodological framework enhances
477 the reliability of estimates, particularly in data-sparse regions.

478 For male fertility, we use country- and time-specific TFR
479 estimates derived from multiple sources: Schoen, Schubert and
480 Dudel (1, 4, 5) applied classical demographic methods to vital
481 statistics, whereas Schoumaker (3) employed the own-child method
482 using data from the Demographic and Health Surveys (DHS) (40).
483 These estimates are harmonized to ensure comparability across
484 countries and time periods.

485 In the main analysis, we use the medium scenario for the
486 population, fertility, and mortality projections. In a robustness
487 check, we exploited the different demographic scenarios estimated
488 by the WPP2024 in order to understand the impact of assumptions
489 regarding fertility, mortality, and migration on sex differences in
490 fertility (see [SI Appendix Demographic scenarios](#)). If fertility below
491 age 18 would dropped to zero across the world, the TFR ratios
492 would be lower mainly in high fertility contexts like sub-Saharan
493 Africa, Oceania, and Latin America, where teenage fertility is still
494 substantial. If fertility was instantly set at replacement level, the
495 TFR ratios in lower fertility countries would increase and the TFR
496 ratios in higher fertility countries would drop, highlighting the
497 impact of the female TFR on TFR ratios.

498
499 **Estimating male fertility.** We measure fertility using the total fertility
500 rate for men (TFR_m) and for women (TFR_w). The total fertility
501 rate is a period measure of fertility intensity, indicating the average
502

number of children a woman or a man would have by the end of the reproductive period if she or he was subject to the age-specific fertility of a given year. The TFR_w is obtained from the WPP2024, but the TFR_m is not readily available or is subject to data deficiencies (34, 35), and therefore needs to be estimated.

The estimation of the TFR_m follows Keilman et al. (25) and exploits a theoretical relationship of the TFR_m to adult sex ratios and the TFR_w . The TFR_m usually closely follows the TFR_w (1), but unbalanced population structures can affect the reproduction of the more abundant sex (3, 5). Therefore, the TFR_m is logarithmically related to the overall fertility level (TFR_w) and the sex difference in the size of the population at reproductive age (SR). The estimation is as follows:

$$\log(TFR_m) = \alpha + \beta_1 \log(TFR_w) + \beta_2 \log(SR) + \epsilon \quad [1]$$

where $\log(TFR_m)$ is the logarithm of the TFR for men, $\log(TFR_w)$ is the logarithm of the TFR for women, and $\log(SR)$ is the logarithm of the sex ratio at reproductive age.

We estimate three distinct models that differ in how they account for population sex ratios. The *baseline model* (Model 1) uses the sex ratio in the 20–39 age group, consistent with the approach previously employed by Keilman et al. (25). The *postponement model* (Model 2) adjusts for fertility postponement by estimating the sex ratio within the 25–44 age group (41, 42). The *age gap model* (Model 3) further refines this approach by accounting for the observed pattern of later childbearing among men: it calculates the sex ratio using men aged 25–44 and women aged 20–39, thereby capturing the age gap between partners at the time of childbirth (3, 43). While Models 1 and 2 compare the sex ratios within the same age groups, Model 3 introduces a temporal shift in the male age group to better reflect the demographic realities of partner age differences in contemporary fertility.

Model results. All three models reach a better fit relative to the model in Keilman et al. (25) and the *age gap model* performs best. The *baseline* and *postponement models* yield a robust fit, as the R^2 are at 0.969 and 0.97, respectively, whereas the R^2 in Keilman et al. (25) was only 0.83. The *age gap model* performs best with an R^2 of 0.984. Furthermore, we perform out-of-sample validation using high-quality data from the Human Fertility Collection (1) to evaluate the performance of the regression models and assess the problem of overfitting. Overall, the fit is good, reaching a root mean squared error ($RMSE$) of around 0.05. The best model fit is again found for Model 3 that accounts for the age gap, which has an $RMSE=0.041$. The 90% prediction intervals are conservatively calibrated, as they include 98% of the TFR_m observations.

The regression results are displayed in Table 1, indicating a positive correlation of the TFR_w with the TFR_m and a negative correlation of the adult sex ratio (SR) with the TFR_m across models. The coefficients across the regression models in Table 1 are statistically significant, unlike the results in Keilman et al. (25), because of a larger sample size (n) and/or the better model fit ($R^2=0.983$). Hence, we use the complete regression equation for the approximation of the TFR_m . We now present the results for Model 3, which is the best performing model. If the population is balanced (sex ratio=1) and the TFR_w is at replacement level ($TFR_w=2.1$ births per woman), the TFR_m is predicted to be slightly lower, at 2.09 births per man. However, if there are twice as many women as men in the reproductive age ranges (sex ratio=0.5), the TFR_m is predicted to increase to 3.31 (90% PI: 3.05–3.59). If there are half as many women as men in the reproductive age ranges ($SR=2$), the TFR_m drops to 1.32 (90% PI: 1.22–1.44), holding the TFR_w at replacement level. Holding the population balanced, the impact of the TFR_w is negative, which implies that at a lower TFR_w of 1.0, the TFR_m equals 0.92 (90% PI: 0.85–1.00), and if the TFR_w increases to 3.0, the TFR_m reaches 3.1 (90% PI: 2.86–3.36).

In a robustness check, we accounted for fundamental uncertainty in the regression model and used 90% prediction intervals, which blurred the picture a bit (see SI Appendix Prediction intervals). The TFR differences for the Caribbean, Central America, and the less developed regions became indistinguishable from zero due to prediction uncertainty, but the findings for high-income countries and sub-Saharan African and East Asian countries remained robust.

Standardization. Beyond the regression-based approach, we employ demographic standardization to isolate the impact of sex specific population structures on observed sex differences in total fertility rates (TFRs). Standardization is a widely used technique to disentangle the influence of population composition, such as age and sex structure, on aggregate demographic indicators (44). Here, we apply the distribution of births by maternal age to the male population structure, effectively estimating what the male TFR would be if men experienced the same fertility schedule as that of women, but were exposed to the actual age distribution of the male population. The standardized TFR is computed as:

$$TFR_{std} = \sum_{x=15}^{55} \frac{B_x}{P_x^m}, \quad [2]$$

where B_x denotes the number of births to mothers aged x , and P_x^m is the male population aged x in the reproductive age range (15–55 years). This approach implicitly assumes that the fertility schedule is identical across sexes — a simplification that does not hold in reality. While empirical evidence shows that male fertility schedules are typically shifted to older ages, exhibit a broader reproductive window, and decline more gradually after the peak compared to female schedules (3, 6), the standardization reveals how much of the observed difference in the TFRs of men and women is solely attributable to the skew in sex ratios within age groups at reproductive ages. For selected countries, we also conducted further analyses accounting for the age differences between men and women, based on data from Dudel and Klüsener (1). The findings match the regression results very closely (see SI Appendix Age gap approach).

Untangling the demographic drivers of sex imbalances. To disentangle the contributions of sex ratios at birth and sex-specific mortality to changing population structures, we leverage sex-specific life tables and sex ratios at birth from the WPP2024. We construct age-specific sex ratios by applying a synthetic cohort approach: starting from the sex ratio at birth (e.g., the number of male births per 100 female births), we project the survival of males and females through each age group using the corresponding sex-specific life tables (the probability of surviving to the next age, $p(x)$). Specifically, we set the radix for males to the observed sex ratio at birth (e.g., 105 males per 100 females) while setting the radix for females to 100, and then we apply the cumulative product of age-specific survival probabilities,

$$SR(x) = 100 \cdot \frac{\frac{B_m}{B_w} \cdot \prod_{i=0}^x p_m(i)}{\prod_{i=0}^x p_w(i)} \quad [3]$$

where B_m and B_w are the numbers of male and female births, respectively, and $p(x)$ is the age-specific probability of surviving to the next age. This approach allows us to compute the age-specific sex ratio – i.e., the number of men per 100 women – at each age, reflecting the cumulative impact of imbalanced sex ratios at birth and sex-specific mortality across the life course. By using this approach, we effectively isolate the demographic forces shaping the sex composition of the reproductive age population, neutralizing the influence of international migration, which is not directly modeled in this decomposition.

Data availability

All code and data required to replicate the main and supplementary results of the article can be found here: https://github.com/Henrik-Alexander/global_birth_squeezes.

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Table 1. Regression table presenting the results from regression in equation 1. The predictor variables are the total fertility rate for women (logarithm) and the sex ratio at ages 20 to 39 (logarithm). The outcome variable is the total fertility rate for men (logarithm). The top panel presents the regression coefficients and the bottom panel presents the model metrics.

	Dependent variable:		
	log TFR men		
	(1) Baseline	(2) Postponement	(3) Age gap
log TFR women	1.182*** (1.175, 1.190)	1.197*** (1.190, 1.205)	1.101*** (1.095, 1.107)
log SR (20-39)	-0.887*** (-0.922, -0.852)		
log SR (25-44)		-0.849*** (-0.884, -0.814)	
log $\frac{\text{men}_{25-44}}{\text{men}_{20-39}}$			-0.661*** (-0.675, -0.646)
Intercept	-0.092*** (-0.098, -0.086)	-0.114*** (-0.119, -0.108)	-0.078*** (-0.082, -0.074)
Observations	4,024	4,024	4,024
R ²	0.968	0.968	0.983
Adjusted R ²	0.968	0.968	0.983

Note:

*p<0.1; **p<0.05; ***p<0.01

1. Christian Dudel and Sebastian Klüsener. Male–Female Fertility Differentials Across 17 High-Income Countries: Insights From A New Data Resource. *European Journal of Population*, 37(2):417–441, April 2021. ISSN 0168-6577, 1572-9885. .
2. Henrik-Alexander Schubert and Christian Dudel. Too many men? Subnational population imbalances and men's childlessness in Finland. *Population Studies*, 0:1–21, 2025. ISSN 0032-4728. .
3. Bruno Schoumaker. Male Fertility Around the World and Over Time: How Different is it from Female Fertility? *Population and Development Review*, 45(3):459–487, September 2019. ISSN 0098-7921, 1728-4457. .
4. Robert Schoen. Population growth and the birth squeeze. *Social Science Research*, 14(3): 251–265, September 1985. ISSN 0049089X. .
5. Henrik-Alexander Schubert and Christian Dudel. Subnational Birth Squeezes? Male–Female TFR Differences across Eight High- and Middle Income Countries over Time, 2025.
6. W. John Paget and Ian M. Timæus. A Relational Gompertz Model of Male Fertility: Development and Assessment. *Population Studies*, 48(2):333–340, July 1994. ISSN 0032-4728, 1477-4747. .
7. Nicolas Brouard. Évolution de la fécondité masculine depuis le début du siècle. *Population (French Edition)*, 32(6):1123, November 1977. ISSN 00324663. .
8. H V Muhsam. The Marriage Squeeze. *Demography*, 11(2):291–299, 1974.
9. Donald S. Akers. On Measuring the Marriage Squeeze. *Demography*, 4(2):907–924, 1967. .
10. Ran Abramitzky, Adeline Delavande, and Luis Vasconcelos. Marrying Up: The Role of Sex Ratio in Assortative Matching. *American Economic Journal: Applied Economics*, 3(3): 124–157, 2011. ISSN 1945-7782.
11. Carol Mulford Albrecht. Sex Ratio and Family Structure in the Nonmetropolitan United States. *Sociological Inquiry*, 71(1):67–84, January 2001. ISSN 0038-0245, 1475-682X. .
12. Andreas Filser and Kai P. Willführ. Sex ratios and union formation in the historical population of the St. Lawrence Valley. *PLOS ONE*, 17(6):e0268039, June 2022. ISSN 1932-6203. .
13. Øystein Kravdal. Sex Differences in Childlessness in Norway: Identification of Underlying Demographic Drivers. *European Journal of Population*, 37(4-5):1023–1041, November 2021. ISSN 0168-6577, 1572-9885. .
14. Thomas Klein. Die Geburt von Kindern in paarbezogener Perspektive / Fertility in Male–Female Partnerships. *Zeitschrift für Soziologie*, 32(6):506–527, December 2003. ISSN 2366-0325. .
15. Thérèse Hesketh. Too many males in China: The causes and the consequences. *Significance*, 6(1):9–13, 2009. ISSN 1740-9713. .
16. Lena Edlund. Sex and the City. *The Scandinavian Journal of Economics*, 107(1):25–44, 2005. ISSN 1467-9442. .
17. Therese Hesketh and Zhu Wei Xing. Abnormal sex ratios in human populations: Causes and consequences. *Proceedings of the National Academy of Sciences*, 103(36): 13271–13275, September 2006. ISSN 0027-8424, 1091-6490. .
18. Joseph D Tucker, Gail E Henderson, Tian F Wang, Ying Y Huang, William Parish, Sui M Pan, Xiang S Chen, and Myron S Cohen. Surplus men, sex work, and the spread of HIV in China. *AIDS*, 19(6), 2005.
19. Josh Angrist. How do Sex Ratios Affect Marriage and Labor Markets? Evidence from America's Second Generation. *Quarterly Journal of Economics*, pages 997–1039, 2002.
20. Monica Das Gupta. China's Marriage Market and Upcoming Challenges for Elderly Men, 2010.
21. Henrik Urdal. A Clash of Generations? Youth Bulges and Political Violence. *International Studies Quarterly*, 50(3):607–629, September 2006. ISSN 0020-8833. .
22. Gudrun Østby and Henrik Urdal. Demographic Factors and Civil War. In Edward Newman and Karl DeRouen, editors, *Routledge Handbook of Civil Wars*. Taylor & Francis Group, Oxford, 2014.
23. Nicolás Corona Juárez, Henrik Urdal, and Krishna Chaitanya Vadlamannati. The significance of age structure, education, and youth unemployment for explaining subnational variation in violent youth crime in Mexico. *Conflict Management and Peace Science*, 39(1): 49–73, January 2022. ISSN 0738-8942, 1549-9219. .
24. Bilal Barakat and Henrik Urdal. *Breaking The Waves ? Does Education Mediate The Relationship Between Youth Bulges And Political Violence ?* World Bank, November 2009. .
25. Nico Keilman, Krzysztof Tymicki, and Vegard Skirbekk. Measures for Human Reproduction Should Be Linked to Both Men and Women. *International Journal of Population Research*, 2014(1):908385, 2014. ISSN 2090-4037. .
26. United Nations Department of Economic and Social Affairs. *World Population Prospects 2024: Methodology of the United Nations population estimates and projections*. 2024.
27. Thomas Spoenenberg. On the masculinization of population: The contribution of demographic development – A look at sex ratios in Sweden over 250 years. *Demographic Research*, 34:1053–1062, June 2016. ISSN 1435-9871. .
28. Amartya Sen. More Than 100 Million Women Are Missing. *The New York review of books*, 1990. ISSN 0028-7504.
29. Bruno D. Schoumaker and David A. Sánchez-Páez. Disruptions in Educational Progress and Fertility Dynamics by Educational Level: Unraveling the Link between Education and Fertility Stalls in Sub-Saharan Africa. *Population and Development Review*, 50(1):59–85, March 2024. ISSN 0098-7921, 1728-4457. .
30. John Bongaarts. Fertility Transitions in Developing Countries: Progress or Stagnation? *Studies in Family Planning*, 39(2):105–110, 2008. ISSN 1728-4465. .
31. Tim Dyson. Causes and Consequences of Skewed Sex Ratios. *Annual Review of Sociology*, 38(1):443–461, August 2012. ISSN 0360-0572, 1545-2115. .
32. Lena Edlund, Hongbin Li, Junjian Yi, and Junsen Zhang. Sex Ratios and Crime: Evidence from China. *The Review of Economics and Statistics*, 95(5):1520–1534, December 2013. ISSN 0034-6535, 1530-9142. .
33. Catherine Tucker and Jennifer Van Hook. Surplus Chinese Men: Demographic Determinants of the Sex Ratio at Marriageable Ages in China. *Population and Development Review*, 39(2):209–229, June 2013. ISSN 00987921. .
34. Kara Joyner, H. Elizabeth Peters, Kathryn Hynes, Asia Sikora, Jamie Rubenstein Taber, and Michael S. Rendall. The Quality of Male Fertility Data in Major U.S. Surveys. *Demography*, 49(1):101–124, February 2012. ISSN 0070-3370, 1533-7790. .

745	35. Christian Dudel and Sebastian Klüsener. Estimating men's fertility from vital registration 746 data with missing values. <i>Population Studies</i> , 73(3):439–449, September 2019. ISSN 747 0032-4728, 1477-4747..	807
748	36. Peter Johnson, Thomas Spoorenberg, Sara Hertog, and Patrick Gerland. Method protocol 749 for the evaluation of census population data by age and sex. Technical report, United 750 Nations Department of Economic and Social Affairs, Population Division, New York, 2022.	808
751	37. Fengqing Chao, Patrick Gerland, Ivan Williams, Sara Hertog, Lubov Zeifman, Helena Cruz, 752 Sehar Ezdi, Giulia Gonnella, Danan Gu, Yumiko Kamiya, Pablo Lattes, Joseph Molitoris, 753 Thomas Spoorenberg, and Mark Wheldon. Estimating levels and trends in adult mortality 754 rates in countries with high HIV prevalence from 1950 to 2023. Technical report, United 755 Nations Department of Economic and Social Affairs, Population Division, New York, 2025.	809
756	38. Fengqing Chao, Vladimirka Kantorova, and Giulia Gonnella. Estimating age-specific fertility 757 rate in the World Population Prospects: A Bayesian modelling approach. Technical report, 758 United Nations Department of Economic and Social Affairs, Population Division, New York, 759 2023.	810
760	39. Population Division United Nations Department of Economic and Social Affairs. World 761 Population Prospects 2024. Technical Report 3, 2024.	811
762	40. Bruno Schoumaker. Measuring male fertility rates in developing countries with 763 Demographic and Health Surveys: An assessment of three methods. <i>Demographic 764 Research</i> , 36:803–850, March 2017. ISSN 1435-9871..	812
765	41. E Beaujouan. Latest-Late Fertility? Decline and Resurgence of Late Parenthood Across the 766 Low-Fertility Countries. <i>POPULATION AND DEVELOPMENT REVIEW</i> , 46(2):219–247, 767 June 2020. ISSN 0098-7921..	813
768	42. Éva Beaujouan and Tomáš Sobotka. Late Motherhood in Low-Fertility Countries: 769 Reproductive Intentions, Trends and Consequences. 2017.	814
770	43. Christian Dudel, Yen-hsin Alice Cheng, and Sebastian Klüsener. Shifting Parental Age 771 Differences in High-Income Countries: Insights and Implications. <i>Population and 772 Development Review</i> , 49(4):879–908, 2023. ISSN 1728-4457..	815
773	44. Samuel H. Preston, Patrick Heuveline, and Michel Guillot. <i>Demography: Measuring and 774 Modeling Population Processes</i> . Blackwell, Oxford, 9. [pr.] edition, 2001. ISBN 775 978-1-55786-214-3.	816
776		817
777		818
778		819
779		820
780		821
781		822
782		823
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