International Journal of Community Medicine and Public Health
Bhargavi A. Int J Community Med Public Health. 2026 Oct;13(10):xxx-xxx
https://www.ijcmph.com
pISSN 2394-6032 | eISSN 2394-6040

DOI: https://dx.doi.org/10.18203/2394-6040.ijcmph20263273

Original Research Article

Interpreting India's below-replacement fertility: evidence from Sample Registration System and National Family Health Survey on tempo effects and age-structural change

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Received: 23 August 2026
Revised: 07 September 2026
Accepted: 09 September 2026

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ABSTRACT

Background: Whether India's below-replacement period total fertility rate (TFR) reflects genuine quantum decline or partly reflects tempo distortion from delayed childbearing has not been systematically assessed using nationally representative data. Sample Registration System (SRS) 2023 reports a national TFR of 1.9 and National Family Health Survey-6 (NFHS-6) (2023-24) reports 2.0.

Methods: This study integrates three complementary approaches using SRS 2023, NFHS-5 (2019–21), and NFHS-6 (2023–24) data: age-specific fertility rate (ASFR) redistribution across age groups (2011–13 to 2021–23); retrospective period-specific fertility trends from NFHS-5 birth histories; and an illustrative application of the Bongaarts–Feeney tempo-adjustment framework.

Results: ASFR fell 63.1% among women aged 15–19 and 42.5% among those aged 20–24 between 2011–13 and 2021–23, while it rose 22.7–91.3% across the 30–49 age range; the modal fertility age shifted from 20–24 to 25–29 years. An illustrative Bongaarts–Feeney adjustment (annual r ≈0.0076) yields TFR≈1.91 for 2023, only modestly above the observed period TFR of 1.9. TFR has been stable between NFHS-5 (1.99) and NFHS-6 (2.0).

Conclusions: India's recent fertility decline is accompanied by substantial postponement of childbearing, with fertility shifting from younger to older age groups. Although the illustrative Bongaarts–Feeney adjustment suggests only a modest national tempo correction, period TFR should be interpreted alongside age-specific and cumulative fertility measures before being treated as definitive evidence of declining completed family size.

Keywords: India, Total fertility rate, Age-specific fertility rate, Fertility postponement, Bongaarts–Feeney framework, Fertility transition

INTRODUCTION

India's period total fertility rate (TFR) has declined below replacement level: the Sample Registration System (SRS) 2023 reports a national TFR of 1.9 and the National Family Health Survey-6 (NFHS-6, 2023–24) reports 2.0.[1-3] Successive SRS and NFHS rounds show a changing age pattern of fertility underlying this decline, with steep falls in age-specific fertility rate (ASFR) among younger women alongside rising ASFR at older reproductive ages, a pattern consistent with postponement of childbearing and potential tempo effects rather than a uniform decline across reproductive ages.

Whether this redistribution materially affects how India's period TFR should be interpreted has not been systematically examined using nationally representative data. This study therefore aimed to examine changes in the age distribution of fertility in India, assess retrospective period-specific fertility trends using NFHS birth histories, and illustrate the potential magnitude of tempo adjustment using the Bongaarts–Feeney framework. We sought to determine whether the recent decline in India's period TFR is accompanied by evidence of substantial postponement of childbearing and to discuss the implications for interpreting below-replacement fertility.

The TFR sums age-specific fertility rates across reproductive age groups (15–49), multiplied by five, representing the hypothetical average number of children a woman would bear under current ASFRs with no mortality.[4] As a period measure it does not reflect the completed fertility of any real birth cohort. Cohort TFR, by contrast, tracks the cumulative fertility of women born in the same year across their reproductive lifespan; it is retrospectively derived and delayed, but immune to tempo distortion.[5] Comparing period and cohort TFR is central to distinguishing genuine reductions in family size from artefactual timing effects.

Period TFR overestimates fertility when childbearing is concentrated at younger ages and underestimates it when childbearing shifts to older ages.[6] A decline in period TFR can therefore occur even when completed family size (quantum fertility) is unchanged, if births are simply postponed.[4,7] Bongaarts and Feeney formalise this relationship as given, where TFR* is the tempo-adjusted TFR and r is the annual rate of change in the mean age of childbearing.[7]

$$TFR* = TFR/(1-r)$$

Figure 1 illustrates the underlying mechanism: a rightward shift in the age pattern of childbearing can lower ASFR at younger ages and raise it at older ages without necessarily changing completed fertility. The method assumes uniform tempo change across ages and is sensitive to the mean-age indicator used; adjustments in low-fertility settings may overstate tempo effects, as discussed further.

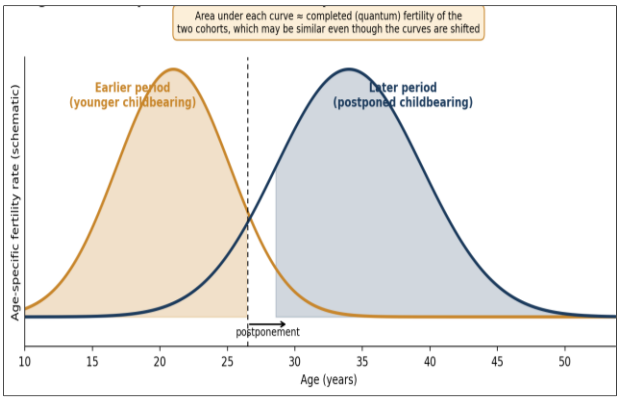

Figure 1: Conceptual illustration of a tempo effect: a rightward shift in the age pattern of childbearing (postponement) can lower period age-specific fertility rate (ASFR) at younger ages and raise it at older ages without necessarily changing completed (quantum) fertility.

METHODS

Study design, setting, and period

This was a secondary analysis of publicly available nationally representative vital-registration and household-survey data from India. No primary data were collected. The geographic scope is national, with disaggregation to the state level for mean age of fertility and TFR (Table 4). The reference periods of the underlying data sources, which together define the study period for this secondary analysis, were as follows: SRS 2023 (calendar year 2023, with trend comparison to the 2011–13 triennium); NFHS-5, with fieldwork conducted in two phases (17th June 2019 to 30th January 2020, and 2nd January 2020 to 30th April 2021); and NFHS-6, with fieldwork conducted in two phases (28th May 2023 to 26th February 2024, continuing through December 2024).[1,3,8] The retrospective fertility analysis (analysis 2, below) additionally draws on NFHS-5 birth histories covering approximately 2002–04 to 2017–19.

Three nationally representative sources were used: the SRS statistical report 2023, providing ASFR by 5-year age group for 2023 and trend comparisons between 2011–13 and 2021–23, plus mean age of fertility for India and states; NFHS-5 (2019–21), providing ASFRs across three survey rounds (NFHS-3, NFHS-4, NFHS-5), ASFR trends for 5-year recall periods, children ever born (CEB), and birth-order distributions; and NFHS-6 (2023–24) fact sheets, providing the most recent national and state TFR estimates.[1,3,8]

Four complementary analyses were conducted.

ASFR redistribution

ASFR was compared across seven age groups (15–19 to 45–49) between the SRS 2011–13 and 2021–23 averages, and across NFHS-3/4/5 cross-sectional estimates, with percentage change used to describe directional shifts.

Retrospective fertility trends

NFHS-5 birth histories were used to estimate ASFRs for four successive 5-year recall periods (0–4, 5–9, 10–14, and 15–19 years before the survey), covering approximately 2002–04 to 2017–19. These were treated as retrospective period-specific estimates rather than true cohort fertility measures.

Illustrative Bongaarts–Feeney adjustment

The annual rate of change in mean age of fertility (r) was estimated from SRS-reported mean age of fertility of 26.3 years in 2013 and 28.3 years in 2023, giving r as calculated below.

$$r = (28.3 - 26.3)/(10 \times 26.3) = 0.0076$$

Applying the Bongaarts–Feeney formulation, TFR ≈ 1.91. Sensitivity to alternative baseline mean ages is reported in Results.

$$TFR = 1.9/(1 - 0.0076) \approx 1.91$$

Cumulative fertility approximation

Mean children ever born (CEB) among women aged 40–49 in NFHS-5 was examined as a descriptive indicator of cumulative lifetime fertility among older reproductive-age women.

Reconciling SRS and NFHS data

SRS and NFHS differ in data-collection design and are not directly poolable. SRS is a continuous dual-record vital-registration system in which births are recorded close to occurrence by resident part-time enumerators and cross-checked through an independent half-yearly survey round, so SRS-derived ASFRs carry minimal retrospective recall bias, though they are drawn from a sample of registration units rather than a fresh household sample each round. NFHS is a cross-sectional, multi-stage stratified household survey in which ASFRs are reconstructed from women's retrospective reports of births in the 1–36 months preceding interview; such estimates are subject to recall error, age-heaping, and birth omission, which typically increase with recall length and among older or less-literate respondents. NFHS-3, NFHS-4, and NFHS-5 are independent, repeated cross-sections drawn from different sampled households and primary sampling units, not a longitudinal panel, so NFHS-based trends reflect population-level rather than individual-level change.

To address these design differences, this study treats the SRS 2011–13-to-2021–23 change as the primary evidence of ASFR redistribution (Table 2), because its continuous-registration design minimises recall bias; the NFHS cross-round comparison (Table 2) is used only as corroborating, not primary, evidence. The retrospective fertility analysis was restricted to the four most recent 5-year recall segments (approximately 2002–04 onward) to limit compounding recall bias from more distant recall periods.

Statistical analysis

Descriptive analyses were conducted using published national and state-level estimates. Percentage change in ASFR was calculated as follows.

$$Percentage\ change\ in\ ASFR = [(ASFR(2021-23) - ASFR(2011-13)/ASFR(2011-13)] \times 100$$

The annual rate of change in mean age of fertility was calculated from published SRS estimates, and the Bongaarts–Feeney tempo-adjusted TFR was estimated using the formula given.

$$TFR = TFR/(1 - r)$$

Sensitivity analyses were conducted using alternative baseline mean ages of fertility. No inferential statistical testing or statistical pooling of SRS and NFHS estimates was performed because of differences in study design and estimation procedures.

RESULTS

TFR trends across sources

India's national TFR declined from 2.7 (NFHS-3, 2005–06) to 1.99 (NFHS-5, 2019–21) and 1.9 (SRS 2023), with NFHS-6 (2023–24) reporting 2.0 (Table 1). Urban TFR has fallen to 1.5–1.6 in the most recent rounds, while rural TFR remains above replacement at 2.1.

Table 1: TFR trends across survey rounds and SRS, India.

Source/year	Total TFR	Urban TFR	Rural TFR
NFHS-3 (2005–06)	2.7	2.1	3.0
NFHS-4 (2015–16)	2.18	1.75	2.41
NFHS-5 (2019–21)	1.99	1.63	2.14
SRS 2018	2.2	1.7	2.4
SRS 2021	2.0	1.6	2.2
SRS 2023	1.9	1.5	2.1
NFHS-6 (2023–24)	2.0	1.6	2.1

TFR=Total fertility rate

ASFR redistribution

SRS data document a classic tempo signature (Table 2). ASFR fell 63.1% among women aged 15–19 and 42.5% among those aged 20–24 between 2011–13 and 2021–23, while it rose 22.7%, 40.2%, and 43.2% in the 30–34, 35–39, and 40–44 groups respectively, and 91.3% in the 45–49 group.[1] The modal fertility age shifted from the 20–24 group (ASFR 194.3 in 2011–13) to the 25–29 group (ASFR 141.1 in 2021–23); by 2023 the 25–29 group had overtaken 20–24 as the peak fertility age group.[1] NFHS cross-sectional rounds corroborate this pattern (Table 2), showing a similar, if more modest, shift away from the youngest age groups across NFHS-3, NFHS-4, and NFHS-5; as detailed in Methods, the SRS trend is treated as the primary evidence and the NFHS comparison as corroborating, given the two sources' differing designs.

Retrospective fertility trends

Across four successive 5-year recall periods spanning approximately 2002–04 to 2017–19 (Table 3), retrospective period-specific ASFRs declined substantially at ages 15–24, while the decline among women aged 25–29 (from 160 to 122) was comparatively modest. This pattern is consistent with a shift in the age distribution of fertility, although these retrospective estimates cannot by themselves distinguish delayed births from permanently foregone births. Mean CEB among women aged 40–44 (born approximately 1975–80) was 2.87, and among women aged 45–49 (born approximately 1970–75) was 3.09, both well above current period TFR. Among women aged 25–29, mean CEB was 1.67, but these women have 15–25 reproductive years remaining, so period TFR does not represent their eventual completed fertility.

Table 2: ASFR trends by age group, SRS and NFHS, India.

Age group (years)	SRS 2011–13	SRS 2021–23	SRS % change	NFHS-3 (2005–06)	NFHS-4 (2015–16)	NFHS-5 (2019–21)
15–19	30.1	11.1	−63.1	90	51	43
20–24	194.3	111.7	−42.5	209	184	165
25–29	152.6	141.1	−7.5	139	128	122
30–34	66.1	81.1	+22.7	62	51	50
35–39	24.1	33.8	+40.2	25	17	14
40–44	8.1	11.6	+43.2	7	4	3
45–49	2.3	4.4	+91.3	3	1	1

ASFR expressed per 1,000 women. SRS % change is computed from 2011–13 to 2021–23. NFHS rates refer to births in the 1–36 months preceding each survey and are cross-sectional, retrospective estimates; SRS rates derive from continuous vital registration. The two sources differ in design and are not statistically pooled

Table 3: Retrospective period-specific ASFR trends across 5-year recall periods, NFHS-5, India.

Age group (years)	~2002–04	~2007–09	~2012–14	~2017–19	% change
15–19	106	86	72	48	−54.7
20–24	223	204	195	169	−24.2
25–29	160	143	132	122	−23.8
30–34	95	68	56	50	−47.4

ASFR expressed per 1,000 women. Periods are approximate 5-year recall periods reconstructed from NFHS-5 birth histories. These are retrospective period-specific estimates and should not be interpreted as longitudinal cohort fertility

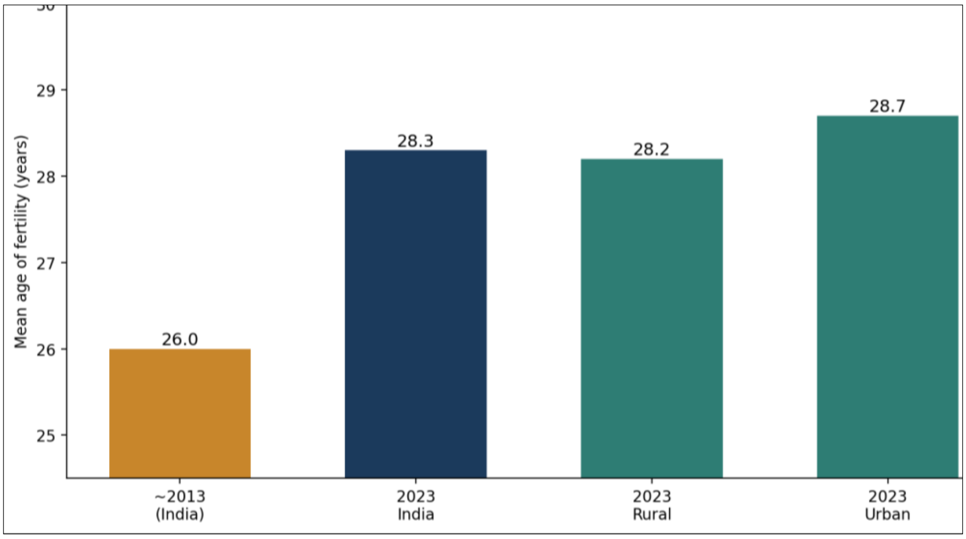

Figure 2: Rise in mean age of fertility, India, ~2013–2023 (SRS).

Illustrative Bongaarts–Feeney adjustment

Mean age of fertility (MAF) reported by SRS 2023 was 28.3 years nationally (rural 28.2; urban 28.7), compared with 26.3 years in 2013. This gives r=0.0076 and TFR*≈1.91 for 2023, modestly above the observed period TFR of 1.9. Sensitivity analysis using baseline MAF values of 25.5 and 26.0 years yielded TFR* values of approximately 1.92, while a baseline of 26.3 years yielded approximately 1.91. This adjustment relies on 5-year ASFR groupings and assumes uniform tempo shifts across ages. It may overstate tempo effects where postponement is heterogeneous across birth parities or in already low-fertility settings; the method has also been subject to broader methodological critique. The directional finding, that rising MAF can cause period TFR to understate underlying fertility, is nevertheless consistent with the observed redistribution of ASFRs.

DISCUSSION

Interpreting the TFR decline

India's period TFR fell from 2.7 (NFHS-3, 2005–06) to 1.9 (SRS 2023) over roughly two decades (Table 1), a trajectory consistent with James's characterisation of India's fertility transition as advanced overall but highly uneven across states.[8-19] Dharmalingam et al, applying a desired-family-size framework to three NFHS rounds spanning 1992–2006, attributed most of India's fertility decline at that time to falling desired family size and reduced unwanted fertility, with fertility postponement identified as a secondary contributor.[20] The present findings, based on more recent SRS and NFHS data, are consistent with a continuing and possibly growing contribution of postponement to the national trend, without displacing quantum decline as the dominant driver. Singh et al, applying Bongaarts' proximate-determinants model to NFHS-4 data, likewise found that contraceptive use and marriage patterns explained most of India's fertility level nationally, with timing-related mechanisms more prominent in southern states — a pattern the present state-level analysis (Table 4) also suggests.[21]

Age-structural redistribution of fertility

The ASFR redistribution documented here (Table 2) — a decline exceeding 40% among women aged 15–24 and increases of 20–91% at ages 30–49 — parallels patterns reported elsewhere in South Asia during rapid fertility decline. Rabbi and Kabir analysing three rounds of the Bangladesh Demographic and Health Survey (2004–2011), documented a comparable shift of fertility away from younger ages alongside a statistically significant Bongaarts–Feeney tempo effect, and concluded that continued postponement could bring Bangladesh to below-replacement fertility.[24] Bongaarts, using World Fertility Survey and DHS data from multiple developing countries, similarly showed that period fertility measures in transitioning populations become suppressed once postponement of childbearing begins, a mechanism consistent with the redistribution observed in the present SRS and NFHS data.[22] At the district level, recent geospatial analyses of NFHS-5 birth histories have documented spatial clustering of delayed motherhood across India, reinforcing that the age-structural shift identified nationally here is concentrated in specific regions and sub-populations rather than occurring uniformly.[25]

Retrospective fertility trends

The retrospective, period-specific ASFR estimates reconstructed from NFHS-5 birth histories (Table 3) showed a comparatively modest decline at ages 25–29 relative to younger ages, consistent with births being redistributed toward, rather than uniformly away from, this age group. This pattern is broadly consistent with national analyses of age at last birth in India, which report a declining mean age at last birth alongside evidence of delayed first childbearing in the same period, suggesting a compression as well as a shift of the reproductive window rather than a uniform contraction of fertility across all ages.[26] As in comparable retrospective-history analyses, these period-specific estimates cannot, by themselves, distinguish delayed from permanently foregone births, and are best interpreted alongside the tempo-adjustment evidence below.

Tempo adjustment and mean age of fertility

The illustrative Bongaarts–Feeney adjustment applied here yielded TFR of approximately 1.91 using the 2013 national MAF of 26.3 years, only marginally above the observed period TFR of 1.9 (Figure 2). Sensitivity analyses using lower baseline MAF values produced estimates of approximately 1.92 (Figure 2). This is a considerably smaller tempo correction than that documented by Bongaarts for several developed countries in the 1990s, where tempo distortion depressed period TFR by as much as 0.4 births per woman in Italy and Spain, and it is also smaller than the tempo effect identified by Rabbi and Kabir for Bangladesh over a comparable period.[23,24] A large shift in the age pattern of fertility can nonetheless coexist with a small aggregate national tempo correction, because the annual rate of change in mean age of fertility (r) that enters the Bongaarts–Feeney formula depends on the pace, not the total extent, of postponement, and national r can be diluted by offsetting state-level patterns (Table 4). This distinction — between a large redistribution of births across ages and a small aggregate tempo correction to TFR — has previously been noted as a general feature of the Bongaarts–Feeney method and cautions against inferring the magnitude of tempo distortion directly from the size of age-structural change alone.[12,13]

Subnational variation

India's national TFR masks profound subnational heterogeneity (Table 4): several southern and western states have sustained sub-replacement TFR for over a decade, generally alongside a higher mean age of fertility, while high-fertility states such as Bihar and Uttar Pradesh remain well above replacement.[1] This heterogeneity is well documented: Guilmoto and Rajan, using district-level Census and SRS data, showed that India's fertility transition proceeded at markedly different speeds across regions, with southern and several western districts reaching below-replacement fertility more than a decade before northern and eastern districts; James similarly argued that India's demographic transition is better understood as a composite of distinct, state-specific transitions than as a single national trajectory.[19,27] The relationship between TFR and mean age of fertility across states was not uniform in the present data (Table 4) — West Bengal combined a low TFR (1.3) with a comparatively low mean age of fertility (26.5 years), whereas Uttar Pradesh combined a higher TFR (2.6) with a higher mean age of fertility (29.6 years) — indicating that state-level fertility differences reflect a mixture of quantum and tempo dynamics rather than tempo alone.

Table 4: State-level TFR and mean age of fertility, SRS 2023.[1]

State	TFR	MAF (y)	TFR trend 2011–23
Delhi	1.2	28.9	1.8 → 1.2
Tamil Nadu	1.3	27.4	1.7 → 1.3
West Bengal	1.3	26.5	1.7 → 1.3
Maharashtra	1.4	27.9	1.8 → 1.4
Andhra Pradesh	1.5	26.9	1.8 → 1.5
Kerala	1.5	28.5	1.8 → 1.5
Telangana	1.5	28.2	1.6 → 1.5
India	1.9	28.3	2.4 → 1.9
Uttar Pradesh	2.6	29.6	3.2 → 2.6
Bihar	2.8	28.7	3.3 → 2.8

TFR=Total fertility rate; MAF=mean age of fertility (years)

International comparison

India's TFR (1.9–2.0) remains far above the ultra-low fertility levels recorded elsewhere (Figure 3). South Korea's TFR fell to approximately 0.7–0.8 in the early-to-mid 2020s, the lowest recorded globally, despite large pro-natalist spending with limited demonstrated effect.[14] Japan and Italy have both stabilised near 1.2, and China's TFR is estimated at approximately 1.0–1.2 following the end of its one-child policy and subsequent pro-natalist reforms. Sweden sustained a comparatively higher TFR of roughly 1.5–1.7 for several decades through parental-leave and childcare policy, though it too has declined recently. Bongaarts's analysis of tempo effects across the developed world found that postponement-related distortion of period TFR was largest precisely in the lowest-fertility settings, such as Italy and Spain; India's comparatively small illustrative tempo correction (Figure 2) alongside a still-moderate TFR is broadly consistent with this pattern, in which the magnitude of tempo distortion tends to grow as a population's fertility transition advances.[15,23] India's trajectory nonetheless differs from these comparators in three respects: its national TFR remains substantially higher than East Asian and Southern European lows, even though states such as Delhi, Tamil Nadu, and West Bengal have already reached comparably low levels (Table 4); India shows persistent interstate heterogeneity unlike more demographically homogenous comparator countries; and India's ASFR redistribution shows fertility shifting toward, not away from, the 25–34 age range, suggesting an active, delayed childbearing pattern rather than large-scale foregone fertility, broadly consistent with earlier patterns in the European fertility transition.[16] Several countries introduced pro-natalist incentives only after fertility had fallen well below India's current levels, with limited demonstrated effect, suggesting Indian states have a comparatively wider window to distinguish tempo-related decline from committed quantum decline.[14]

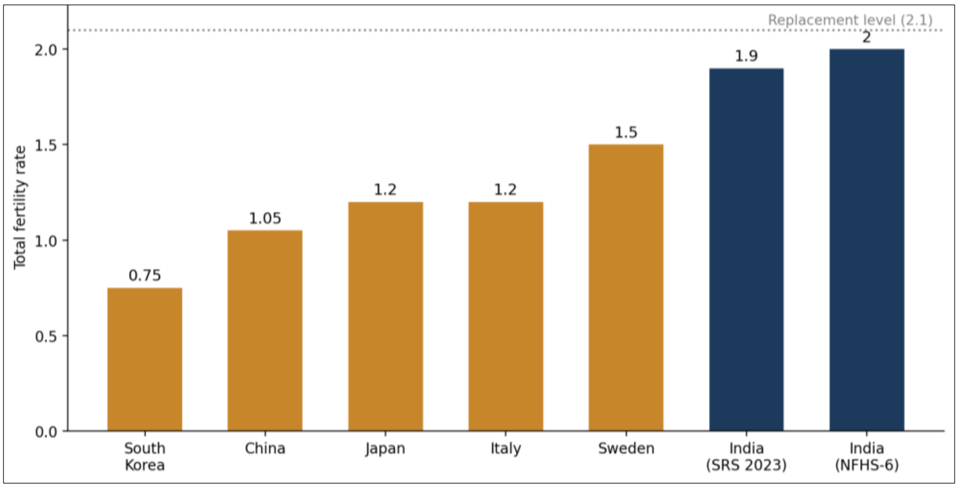

Figure 3: India's total fertility rate (TFR) in international context, circa 2023–2024. Values for South Korea, China, Japan, Italy, and Sweden are approximate.[14,15,23]

Policy relevance

Andhra Pradesh, with an SRS 2023 TFR of 1.5, has announced a third-child incentive scheme.[17] The results presented here show period TFR is sensitive to shifts in childbearing timing, so decisions based on period TFR alone risk overestimating the extent and permanence of quantum fertility decline. This paper does not evaluate the design or desirability of such policies; its scope is limited to fertility measurement and interpretation.

Strengths and limitations

This study's principal strength is its integration of three complementary approaches — age-structural redistribution, retrospective period-specific trends, and an illustrative tempo adjustment — alongside explicit reconciliation of SRS and NFHS data, rather than relying on a single indicator or data source. Several limitations should nonetheless be considered. Period TFR is not simply downward-biased: when childbearing was concentrated at younger ages, as in India historically, period TFR overestimated quantum fertility, while the ongoing shift toward older ages now has the opposite effect; this bidirectional sensitivity should be recognised explicitly in demographic reporting. India's public data systems provide only 5-year ASFR age groups, lack annual birth-order-specific rates, and are updated through NFHS rounds spaced 5–6 years apart, limiting the precision of tempo adjustment and precluding parity-specific analysis of the kind used in more detailed national studies.[20,21] State-level TFR ranges from 1.2 (Delhi) to 2.8 (Bihar); a single national estimate conflates populations at markedly different stages of the fertility transition, and the national tempo adjustment applied here masks state-level variation in timing shifts. Retrospective NFHS birth histories are subject to age misreporting and birth omission, particularly among older women, affecting both ASFR and the retrospective period-specific estimates; the Bongaarts–Feeney adjustment additionally relies on an estimated rather than directly measured baseline MAF and assumes tempo shifts are the sole source of period–cohort divergence, and more advanced parity-specific tempo methods were not feasible with the available public data.[18]

CONCLUSION

India's recent fertility decline is accompanied by a marked shift in the timing of childbearing, with substantial reductions in fertility at ages 15–24 and increases at older reproductive ages. This age redistribution, together with the rise in mean age of fertility, is consistent with an important tempo component in India's fertility transition. However, the illustrative Bongaarts–Feeney adjustment produces only a modest increase in the national TFR, from 1.90 to approximately 1.91, indicating that postponement alone does not explain the observed decline. Period TFR should therefore be interpreted alongside age-specific fertility, cumulative fertility among older women, and cohort-based measures where available. Further analyses using birth-order- and parity-specific data are needed to distinguish more precisely between delayed and permanently foregone births, particularly at the state level.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Bhargavi A. Interpreting India's below-replacement fertility: evidence from Sample Registration System and National Family Health Survey on tempo effects and age-structural change. Int J Community Med Public Health 2026;13:xxx-xx.