

Fertility recovery in India's below-replacement states: Limits and prospects

Saseendran Pallikadavath

saseendran.p@srmap.edu.in

SRM University, Andhra Pradesh

Mohammad Mahbubur Rahman

University of Salford

Kumar Ch. Satish

SRM University, Andhra Pradesh

Research Article

Keywords: Below replacement level fertility, Female sterilisation, Fertility intentions, Hysterectomy, India, Population ageing

Posted Date: August 15th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10625769/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Additional Declarations: No competing interests reported.

Version of Record: A version of this preprint was published at Journal of Population Research on September 6th, 2026. See the published version at <https://doi.org/10.1007/s12546-026-09433-1>.

Abstract

India has entered the era of below-replacement fertility. In the National Family Health Survey (2019–21), the national total fertility rate (TFR) was 2.0 children per woman and 23 states were below the 2.1 replacement level. As state governments consider policies to raise fertility, the question is how much demographic scope for recovery remains. Existing studies have focused on fertility intentions, but recovery also depends on who remains exposed to childbearing. This paper develops a framework distinguishing three concepts: the limitation stock, women who have permanently exited childbearing through sterilisation, hysterectomy or infecundity; the prospect stock, women still exposed to childbearing; and the recovery prospect, those who also wish to have another child. Across the 23 below-replacement states, the limitation stock reaches 47.4%, of which 43.8 points come from sterilisation. Although 52.6% of currently married women remain exposed, only 41.3% of them wish to have another child, leaving 21.7% as the immediate recovery prospect. One additional birth to each would raise the pooled TFR from 1.79 to 1.95, whereas delaying one-child sterilisation would add only 0.011. If never-married women aged 20–49 experienced the age-specific fertility rates of currently married women, the TFR would rise by a further 0.52, to 2.48. Recovery within marriage is therefore inherently limited, because much of the remaining reproductive capacity has been permanently lost. These findings suggest that policies to support future fertility should place greater emphasis on family formation among younger cohorts, expand access to reversible contraceptive methods, and gradually reduce reliance on female sterilisation as the predominant family planning method.

1. Introduction

Across much of the world, the demographic challenge has shifted from reducing high fertility to responding to persistent below-replacement fertility. Many countries now face population ageing, shrinking labour forces and slower population growth, prompting renewed interest in policies that encourage childbearing. Yet experience from Europe and East Asia suggests that once fertility falls below replacement level, recovery is uncommon despite a wide range of pronatalist policies (Billari & Kohler, 2004; Frejka & Sobotka, 2008; Goldstein et al., 2009; Kohler et al., 2002; Lutz et al., 2006; Myrskylä et al., 2009).

India has now entered this demographic transition. The national total fertility rate (TFR) fell below the replacement level of 2.1 in 2020 and declined further to 1.9 in 2024 (Office of the Registrar General & Census Commissioner, 2026), and is projected to remain below replacement for the rest of the century (Vollset et al., 2020). According to the National Family Health Survey (NFHS-5), 23 states had already reached below-replacement fertility by 2019–21 (IIPS & ICF, 2021). As several state governments have begun introducing policies to encourage larger families (Government of Andhra Pradesh, 2026), an important question is how much demographic scope for fertility recovery actually remains.

Existing research has explained persistent low fertility through delayed childbearing, changing family-size preferences, economic uncertainty and the challenges of combining work and family (Frejka & Sobotka, 2008; Kohler et al., 2002; Lutz et al., 2006). These explanations are also relevant to India and other developing countries that have reached below-replacement fertility (Pallikadavath et al., 2017). However, they largely assume that women remain exposed to childbearing and that fertility recovery depends primarily on changing reproductive preferences. This assumption is less appropriate for India, where fertility decline has been driven predominantly by female sterilisation rather than reversible contraception (IIPS & ICF, 2021; Matthews et al., 2009; New et al., 2017). Because sterilisation permanently removes women from future childbearing, the scope for fertility recovery depends not only on whether couples want another child but also on how many women remain exposed to childbearing.

This paper argues that fertility recovery depends jointly on *demographic capacity* and *fertility intentions*. Existing studies have focused primarily on fertility intentions, with much less attention given to the remaining demographic capacity for

childbearing. Fertility recovery requires both conditions to be satisfied simultaneously: women must remain exposed to childbearing and they must wish to have another child.

This paper aims to develop a demographic framework for assessing the limits and prospects of fertility recovery in India's below-replacement states. The framework distinguishes three complementary concepts: the *limitation stock*, comprising women who have permanently exited childbearing through female sterilisation, hysterectomy or infecundity; the *prospect stock*, comprising women who remain exposed to childbearing; and the *recovery prospect*, comprising women who both remain exposed to childbearing and wish to have another child. By separating demographic capacity from fertility intentions, the framework provides a direct measure of the remaining demographic scope for fertility recovery.

2 Background and literature

2.1 India's transition to below-replacement fertility

India's fertility transition has been long, geographically uneven and distinctive. Fertility first declined in the southern states during the 1970s and 1980s before spreading to the rest of the country, so that by the fifth National Family Health Survey (NFHS-5) most states had reached or fallen below replacement fertility (Dyson, 2018; Guilmoto & Rajan, 2013). This transition has been driven by rising female education, declining child mortality, later marriage, increasing investment in children's education and the diffusion of small-family norms (Bhat, 2002; Drèze & Murthi, 2001). Although these factors operated throughout India, they progressed at different speeds, producing substantial variation across states (James, 2011). Fertility decline has also extended across socioeconomic groups. For example, fertility among Scheduled Castes in Kerala has fallen below the state average, reversing the traditional association between social disadvantage and high fertility (Pallikadavath & Wilson, 2005).

Unlike most low-fertility populations, however, India's transition has relied predominantly on female sterilisation rather than reversible contraception. Female sterilisation has long been the principal method promoted through the national family-planning programme and remains the dominant contraceptive method despite major programme reforms (IIPS & ICF, 2021; Matthews et al., 2009; Santhya, 2003). Sterilisation is commonly adopted after completion of childbearing, typically at relatively low parities, permanently removing women from further childbearing (New et al., 2017; Pallikadavath, Rajan, et al., 2016; Park et al., 2023). This distinctive contraceptive pathway has important implications for fertility recovery.

2.2 Demographic capacity and fertility recovery

The international literature on below-replacement fertility has largely explained persistent low fertility through delayed childbearing, changing family-size preferences, economic uncertainty and work-family conflict (Frejka & Sobotka, 2008; Kohler et al., 2002; Lutz et al., 2006). Implicit in this literature is the assumption that most women remain exposed to childbearing and that fertility recovery depends primarily on changing reproductive preferences or policy interventions. This assumption is broadly appropriate where contraception is dominated by reversible methods but is less appropriate for India, where permanent methods account for most contraceptive use.

Permanent exits from childbearing in India arise through three principal pathways: female sterilisation, hysterectomy and infecundity (Desai et al., 2017; Prusty et al., 2018; Shekhar et al., 2019). Together these progressively reduce the proportion of women who remain exposed to childbearing. Regardless of whether they result from voluntary contraception or biological limitation, women who have permanently exited childbearing cannot contribute to future fertility. Demographic capacity therefore places an upper limit on fertility recovery.

2.3 Fertility intentions and the research gap

Remaining exposed to childbearing does not necessarily imply a desire for another child. Demographic research has long distinguished between fertility intentions and realised fertility and has shown that stated intentions do not always translate into subsequent behaviour (Bongaarts, 1990, 2001; Casterline & el-Zeini, 2007; Morgan & Rackin, 2010). In India, fertility intentions have also been shaped by son preference. Couples have traditionally continued childbearing until achieving their desired number of sons before permanently limiting fertility, often through sterilisation (Bhat & Zavier, 2003; Jayachandran & Kuziemko, 2011). Although son preference has weakened among younger, urban and more educated populations (Chao et al., 2019; Guilmo, 2009; Jayachandran, 2015; Kashyap & Villavicencio, 2016), the desire for additional children remains an important determinant of future fertility.

Most studies of India's fertility transition have examined fertility decline, contraceptive behaviour or fertility intentions. Similarly, the international literature on below-replacement fertility has focused primarily on postponement, changing fertility preferences and pronatalist policies. Comparatively little attention has been given to the demographic capacity for fertility recovery after accounting for permanent exits from childbearing. This gap motivates the framework developed in the remainder of this paper.

3 Data and methods

To address the research gap identified in the previous section, we develop a demographic framework that distinguishes women who have permanently exited childbearing from those who remain exposed to childbearing and assesses the extent to which the latter wish to have another child. This framework is implemented using nationally representative data from the National Family Health Survey (NFHS-5). We first describe the survey and analytical sample before defining the measures used to estimate the limitation stock, prospect stock and recovery prospect.

3.1 Survey and sample

We use data from the fifth round of the National Family Health Survey (NFHS-5), conducted during 2019–21 by the International Institute for Population Sciences (IIPS) for the Ministry of Health and Family Welfare (IIPS & ICF, 2021). NFHS-5 estimated India's total fertility rate (TFR) at 2.0 children per woman. The Sample Registration System subsequently reported a TFR of 1.9 in 2024 (Office of the Registrar General & Census Commissioner, 2026), indicating that the trend towards below-replacement fertility has continued. Our estimates should therefore be interpreted as a conservative assessment of the current demographic scope for fertility recovery.

NFHS-5 is a nationally representative household survey based on a stratified two-stage sampling design. Primary sampling units were selected within each state, followed by households within sampled clusters, and all women aged 15–49 years in selected households were interviewed about their fertility, contraceptive behaviour and reproductive health. The large sample size permits reliable estimation at both the state and regional levels, which is essential for the state-specific analyses undertaken in this study.

The analysis uses the women's individual recode. All estimates apply the women's sampling weights and account for the complex survey design by clustering standard errors at the primary sampling unit. As a robustness check, standard errors are also clustered at the district level.

Generative artificial intelligence tools assisted with language editing, formatting and parts of the analytical workflow. All statistical analyses and results were independently reproduced and verified in Stata 17. A Stata do-file that reproduces all variables, tables and analyses from the original NFHS-5 recode is available from the corresponding author.

The analysis is restricted to the states, excluding the eight union territories to ensure comparability in administrative units. States are classified as having below-replacement fertility if their weighted TFR, calculated from births during the three years preceding the survey, is below 2.1 children per woman. This criterion identifies 23 states, comprising 493,572 women aged 15–49 years, including 354,650 currently married women. The all-India TFR estimated from the survey reproduces the published NFHS-5 estimate of 2.0, while the state estimates closely match the official NFHS-5 figures (IIPS & ICF, 2021), providing confidence in the fertility measures used in this study. Because childbearing in India occurs overwhelmingly within marriage, the analyses of demographic capacity and fertility recovery are restricted to currently married women aged 15–49 years.

3.2 Measures

Consistent with the conceptual framework, three variables are used to identify women who have permanently exited childbearing. Women are classified as sterilised if their current contraceptive method is female sterilisation, as having undergone hysterectomy if they report that their uterus has been removed, and as infecund if they report that they cannot have children. Infecundity is based solely on self-report; women classified as menopausal through derived survey variables are excluded from the main definition but included in a robustness analysis. The relatively small contribution of this component is consistent with evidence that natural menopause before age 40 affects only about 1.5 per cent of Indian women (Pallikadavath, Ogollah, et al., 2016).

To avoid double counting, women are assigned sequentially to sterilisation, hysterectomy and infecundity. Women not classified into any of these categories are considered to remain exposed to childbearing and constitute the prospect stock. Among these women, fertility intentions are measured using the standard NFHS question on the desire for another child. Women who report wanting a child either immediately or later are classified as wanting another child, while those wanting no more children, who are undecided, or who have already permanently limited childbearing are classified as not wanting another child.

Two additional variables are used in the counterfactual analyses. Parity at sterilisation identifies women sterilised after exactly one child, while years since sterilisation restricts the analysis to recent sterilisations so that the counterfactual aligns with the fertility reference period. The descriptive regression models include age, age squared, years of schooling, age at first marriage, urban residence, household wealth, religion and state fixed effects, all of which are well-established correlates of fertility and contraceptive behaviour in India (Bhat, 2002; Drèze & Murthi, 2001).

3.3 Descriptive statistics

Table 1 reports weighted descriptive statistics for the currently married women in the below-replacement states. Mean parity is about 2.1 children, mean schooling about 7.3 years, and mean age at first marriage about 19 years. About 34 per cent live in urban areas and 12 per cent are Muslim. The reproductive variables already show the main pattern. Nearly half, 47 per cent, are in the limitation stock, 44 per cent are sterilised, and only 22 per cent want another child. These figures point towards the central result: both the capacity for further childbearing and the desire for it are limited in this population.

Table 1
Weighted descriptive statistics, currently married women aged 15–49, below-replacement states

Variable	Mean	SD	Minimum	Maximum
Age (years)	33.824	8.448	15	49
Children ever born	2.109	1.286	0	14
Years of schooling	7.260	5.138	0	20
Age at first marriage	18.809	3.904	10	40
Urban residence	0.340	0.474	0	1
Richest wealth quintile	0.218	0.413	0	1
Muslim	0.121	0.326	0	1
In limitation stock	0.474	0.499	0	1
Female sterilised	0.438	0.496	0	1
Wants another child	0.217	0.412	0	1
Estimates are weighted using the woman's sample weight. Sample: 354,650 currently married women in the 23 below-replacement states of NFHS-5. Binary variables are reported as proportions				

4 Conceptual framework

4.1 Limitation and prospect stocks

We summarise the demographic capacity for fertility recovery with two stocks. Consider currently married women aged 15–49 in a state s . Let S_s , H_s , and N_s be the weighted shares who are sterilised, who have had a hysterectomy, and who are infecund, assigned to these categories in that order so that they do not overlap. The limitation stock is their sum,

$$L_s = S_s + H_s + N_s$$

1

and it measures the share of married women who are, on reasonable assumptions, unavailable for future childbearing. The complement is the prospect stock, $R_s = 1 - L_s$, the share who remain exposed to the possibility of a further birth. Not all of these women want another child. Let w_s be the share of the prospect stock who want a further birth, so that $1 - w_s$ is the share who could have another child but do not want one. The immediate fertility recovery prospect is the product

$$FRP_s = R_s \times w_s$$

2

which is the share of all currently married women who are both still exposed and willing to have another child. FRP_s is expressed per currently married woman, whereas fertility rates are expressed per woman. To place it on the same basis we multiply by m_s , the share of women aged 15–49 in state s who are currently married, so that the implied increment in births per woman is $FRP_s \times m_s$. For the pooled below-replacement population $m = 0.719$, so a recovery prospect of 21.7 per cent of married women corresponds to about 0.16 births per woman. Its two factors correspond to two distinct barriers: unavailability, whether structural or biological, measured by L_s , and unwillingness among the women

who remain available, measured by $1 - w$. The distinction matters because the two barriers call for different policy responses, and because, as the heterogeneity analysis shows, they bind to different degrees in different groups. The limitation stock is a within-cohort statement about currently married women; it constrains the fertility that this cohort could still supply, and it says nothing about women who have not yet married or not yet begun childbearing, whose choices remain open.

4.2 Counterfactual fertility and recovery potential

For the timing question we work with age-specific fertility. Let W_x be the weighted number of women in five-year age group x , and let B_x be the weighted number of live births to those women in the three years before the survey; pregnancy losses are not counted, and population-based evidence for India shows miscarriage risk rising with maternal age and birth order (Pallikadavath & Stones, 2005). The observed age-specific fertility rate, expressed on an annual basis, is $f_x = B_x / (3 W_x)$, and the total fertility rate is five times the sum across the seven age groups, $TFR = 5 \sum f_x$. This is the standard synthetic-cohort construction used in the survey's own reports, which is why our estimates reproduce the published figures. Under the counterfactual, women who were recently sterilised after one child would instead have progressed to a second birth. Let a_x be the weighted number of women in age group x who were sterilised after one child in the same three-year window, so that a_x is an annual flow comparable in timing to B_x . Each such woman is assumed to contribute exactly one additional second birth, and no higher-order births are assumed. The counterfactual age-specific rate and total are

$$f_x^* = f_x + \frac{a_x}{3W_x}, \quad TFR_s^* = 5 \sum_x f_x^*, \quad \Delta TFR_s = TFR_s^* - TFR_s$$

3

In words, the counterfactual gives one additional second birth to every woman recently sterilised after her first child, and nothing more. Restricting a_x to recent sterilisations keeps the counterfactual internally consistent, because it adds an annual flow of second births to an annual flow of observed births, rather than adding a stock of past sterilisations to a current rate. The gain ΔTFR_s is therefore, to a close approximation, proportional to the flow of women who stop at one child. In the robustness section we replace the one-child rule with a two-child rule, under which recently sterilised women at parity one or two each have one further birth. This shows how the leverage changes once the far larger group of women who stop at two children is included.

A third margin lies outside the married population. Marriage in India is still almost universal but it now happens later, so at any moment a sizeable share of younger women have not yet married and are therefore counted outside the exposed pool. We ask an upper-bound question about this group. Let W_x^u be the weighted number of never-married women in five-year age group x , let W_x be all women in that group, and let f_x^m be the age-specific fertility rate of currently married women in the same group and state. Suppose every never-married woman at once became exposed and bore children at the marital rate for her age group. The additional age-specific rate and the additional total fertility rate would be

$$g_x = \left(\frac{W_x^u}{W_x} \right) \times f_x^m, \quad \Delta TFR_s^U = 5 \sum_x g_x$$

4

We define this exercise over ages 20–49, so the sum in Eq. (4) runs over the six five-year groups from 20–24 to 45–49. Never-married women aged 15–19 are excluded, since exposure at those ages is neither a plausible nor a desirable margin for policy. The legal minimum age of marriage for women in India is 18. National policy is moving in the direction of still later marriage. A Bill introduced in Parliament in 2021 sought to raise the minimum age to 21; it lapsed

with the dissolution of the Lok Sabha, but it signals where policy is headed (Government of India, 2021). A ceiling that began at 18 would rest partly on ages the state is actively seeking to empty of marriage; beginning at 20 confines the exercise to the ages at which policy could legitimately seek to influence marriage timing.

The three margins combine into a single upper bound on how far fertility could recover in the near term. For each state we add to the observed total fertility rate the prospect-pool margin m_sFRP_s , the gain ΔTFR_s from delaying one-child sterilisation, and the never-married bound ΔTFR_s^U . The potential total fertility rate and its distance from replacement are

$$TFR_s^+ = TFR_s + m_sFRP_s + \Delta TFR_s + \Delta TFR_s^U, \quad Gap_s = TFR_s^+ - 2.1$$

5

TFR_s^+ is deliberately generous and is a ceiling rather than a forecast. It treats every exposed and willing woman as having one further birth, and adds the one-child gain on top. It also assumes that never-married women immediately bear children at the age-specific marital fertility rates of their state. In practice newly exposed women would not reach those rates at once, and most never-married women marry later rather than never. The value of the construction is to show where the remaining demographic potential lies.

4.3 Correlates of limitation and fertility intentions

To describe who is constrained, we estimate linear probability models of two outcomes among currently married women, namely being sterilised, the choice that places a woman in the limitation stock, and, within the prospect stock, the desire for another child. For an outcome y_i we write

$$y_i = X_i' \beta + \epsilon_i$$

6

where X_i collects the woman's age and its square, her years of schooling, her age at first marriage, an urban indicator, and wealth, religion, and state fixed effects. These models are descriptive rather than causal; they summarise the associations that shape the limitation and prospect stocks, and they help identify the groups in which any remaining capacity for recovery is concentrated. We estimate them by survey-weighted least squares, with standard errors clustered at the primary sampling unit.

5 Results

5.1 Limits and prospects for fertility recovery

Table 2 reports the limitation and prospect stocks for each below-replacement state, together with the state total fertility rate. Across these states taken together the limitation stock reaches 47.4 per cent of currently married women, so nearly half are already outside the pool of potential future mothers. Female sterilisation accounts for almost all of it, at 43.8 per cent, while hysterectomy adds about 1.5 per cent and self-reported infecundity about 2.2 per cent. The dominance of sterilisation in the limitation stock is the numerical expression of the sterilisation-focused programme described in Sect. 2, and it is what makes the Indian case different from the reversible-contraception settings of the classic low-fertility literature.

The state pattern is wide. The southern states stand out, with a limitation stock between about 49 and 74 per cent, driven by very high and early female sterilisation, so that in Andhra Pradesh, Telangana, Tamil Nadu, and Karnataka a large majority of married women are already beyond childbearing. Several northern and north-eastern states lie much

lower, often between about 12 and 45 per cent, because sterilisation is less dominant there and childbearing is more recent. This geography matters for the interpretation of any national statement about fertility recovery, since the states with the most entrenched low fertility are generally those with the least remaining demographic capacity to reverse it. Figure 1 maps the states that lie at or below replacement level across the country.

The regional aggregates in Table 2 make the same point more compactly, and they show that a similar recovery prospect can rest on very different foundations. The limitation stock ranges from about 14 per cent in the northeast to 63 per cent in the south, a nearly fivefold difference. Yet the recovery prospect varies hardly at all, from 20.6 per cent in the west to 22.9 per cent in the northeast. The reason is that the two components move in opposite directions. Where limitation is high, as in the south, the few women who remain exposed are strongly selected towards wanting another child, and 59.4 per cent of them do. Where limitation is low, as in the northeast, far more women remain exposed but only 26.5 per cent want a further birth. Capacity and desire therefore substitute for one another across regions, which is why no region has much more room for recovery than any other. The regional aggregates do conceal some variation between states, though far less than the variation in their components. Across states the limitation stock ranges from 12.5 per cent in Assam to 73.6 per cent in Andhra Pradesh, a spread of 61 points, while the recovery prospect ranges only from 14.8 per cent in Sikkim to 33.4 per cent in Mizoram, a spread of 19 points. The median state is at 21.1 per cent, half the states lie between 18.9 and 24.4 per cent, and only three exceed 25 per cent. The spread is therefore real but bounded, and no state has a recovery prospect approaching the level that a return to replacement would require.

The prospect stock is the complement, at 52.6 per cent for the pooled below-replacement population. Exposure, however, is not the same as willingness. Among women in the prospect stock only 41.3 per cent say they want another child. Multiplying the two gives a fertility recovery prospect of 21.7 per cent of currently married women, so about one married woman in five is both still exposed to childbearing and willing to have another child. The remaining four in five are constrained either by permanent limitation or by the wish to stop. This is the central result of the paper. It shows that the room for fertility to rise in the near term is small, and that it is bounded on two sides at once, by capacity and by desire.

Table 2
Limits and prospects for fertility recovery, currently married women aged 15–49

State	TFR	Components of limitation			Total limitation	Prospect stock	Want more (of prospect)	Recovery prospect
		Sterilised	Hysterectomy	Infecund				
North	1.92	35.7	1.6	1.8	39.1	60.9	35.7	21.8
Haryana	1.91	32.3	1.5	1.5	35.4	64.7	29.6	19.1
Himachal Pradesh	1.67	37.7	1.1	1.4	40.3	59.7	25.4	15.2
Punjab	1.65	22.8	2.8	2.4	27.9	72.1	25.5	18.4
Rajasthan	2.03	42.4	1.3	1.9	45.5	54.5	45.0	24.5
Uttarakhand	1.83	26.0	1.7	1.5	29.1	70.9	29.0	20.6
Central	1.96	50.7	1.1	1.9	53.7	46.3	47.5	22.0
Chhattisgarh	1.83	47.5	0.9	2.1	50.6	49.4	49.8	24.6
Madhya Pradesh	2.01	51.9	1.1	1.8	54.8	45.2	46.5	21.0
East	1.71	29.0	1.5	1.8	32.3	67.7	32.8	22.2
Odisha	1.82	28.0	1.1	2.0	31.1	69.0	33.5	23.1
West Bengal	1.65	29.4	1.6	1.8	32.8	67.2	32.5	21.9
Northeast	1.86	9.6	1.1	2.9	13.6	86.4	26.5	22.9
Arunachal Pradesh	1.80	18.2	1.9	4.1	24.3	75.7	32.1	24.3
Assam	1.90	9.0	1.0	2.6	12.5	87.5	26.9	23.5
Mizoram	1.85	13.0	2.1	12.2	27.4	72.6	46.0	33.4
Nagaland	1.71	14.4	1.9	7.8	24.1	75.9	27.9	21.1
Sikkim	1.00	14.5	0.6	2.4	17.5	82.5	18.0	14.8
Tripura	1.74	10.5	1.5	2.1	14.1	85.9	19.9	17.1
West	1.75	44.6	1.8	2.3	48.8	51.2	40.3	20.6
Goa	1.32	29.9	1.4	4.3	35.7	64.3	41.1	26.5
Gujarat	1.87	35.9	2.6	2.2	40.7	59.3	36.5	21.7
Maharashtra	1.70	49.1	1.5	2.4	52.9	47.1	42.5	20.0
South	1.73	59.2	1.5	2.4	63.1	36.9	59.4	21.9
Andhra Pradesh	1.69	69.6	2.1	1.9	73.6	26.4	69.1	18.2
Karnataka	1.69	57.4	1.3	3.1	61.8	38.2	64.3	24.6
Kerala	1.80	46.6	1.2	1.4	49.3	50.7	54.6	27.7
Tamil Nadu	1.76	57.8	0.9	2.7	61.4	38.6	54.6	21.1

State	TFR	Components of limitation			Total limitation	Prospect stock	Want more (of prospect)	Recovery prospect
		Sterilised	Hysterectomy	Infecund				
North	1.92	35.7	1.6	1.8	39.1	60.9	35.7	21.8
Telangana	1.75	61.9	2.4	2.2	66.5	33.5	55.9	18.7
Pooled (below-replacement)	1.79	43.8	1.5	2.2	47.4	52.6	41.3	21.7

All figures are weighted percentages of currently married women, except the total fertility rate (TFR), which is in children per woman. States are grouped into the six standard survey regions. The limitation components are assigned in the order sterilised, hysterectomy, infecund, and so sum to the total limitation stock, subject to rounding. The prospect stock is 100 minus the total limitation stock. “Want more (of prospect)” is the weighted share who state that they want another child, calculated among women who are not in the limitation stock. The recovery prospect is the product of the prospect stock and that share. Rows in bold are regional aggregates, weighted across the states in the region

The stocks so far concern currently married women. A third pool completes the accounting: the limitation stock measures capacity already forgone, the recovery prospect measures willing exposure within marriage, and the never-married pool measures exposure not yet begun. Section 4.2 set out the upper bound for the separate group of women who have not yet married. If every never-married woman at once became exposed to childbearing and bore children at the same age-specific rates as currently married women of the same age group and state, how much would fertility rise? Throughout this exercise unmarried means never married; women who are widowed, divorced, or separated are excluded, since their return to childbearing follows a different process. The exercise covers ages 20–49; never-married women aged 15–19 are excluded by construction, as set out in Sect. 4.2. The construction follows Eq. (4).

The potential contribution is large but heavily concentrated at young ages. For India as a whole the additional total fertility rate is about 0.55 of a child, which lifts the counterfactual rate from about 2.00 to about 2.56. For the pooled below-replacement states the additional rate is about 0.52, which moves the counterfactual rate from about 1.79 to about 2.31 and, under this upper bound, above replacement. The state pattern is carried into the combined accounting of Sect. 5.2, and Table 3 shows where in the age range the potential lies. Almost all of it sits in the age groups 20–24 and 25–29, because marital fertility is highest there and, in most states, few older women remain never married. At ages 35 and above the contribution is close to zero.

The state differences are instructive. In the states where late marriage or non-marriage is common, notably Mizoram, Nagaland, Goa, and Sikkim, the potential contribution is far larger, because a substantial share of women remain unmarried well past age 25. In the northern and central states, where marriage is earlier and near-universal, the potential is smaller and comes almost entirely from the youngest group. The exercise makes a broader point. The timing of marriage, and not only the behaviour of couples who are already married, bounds how far fertility could recover. Policies that ease early family formation for those who want it could therefore matter as much as those aimed at married couples, though the estimates are an upper bound and should be read as such.

Table 3
Age decomposition of the potential contribution of unmarried (never-married) women, India

Age group	Unmarried women (%)	Married ASFR	Additional ASFR	Contribution to additional TFR
20–24	39.2	0.2313	0.0906	0.453
25–29	10.6	0.1661	0.0177	0.088
30–34	2.8	0.0741	0.0020	0.010
35–39	1.4	0.0247	0.0003	0.001
40–44	1.2	0.0056	0.0001	0.001
45–49	0.9	0.0012	0.0000	0.000
Total (ages 20–49)				0.554

For each age group, “unmarried women” is the weighted share who have never married (women who are widowed, divorced, or separated are excluded), “married ASFR” is the age-specific fertility rate (ASFR) of currently married women, and “additional ASFR” is the marital rate multiplied by the never-married share, following Eq. (4). The contribution to the additional total fertility rate is five times the additional ASFR; the column sums to the additional TFR in the final row. The exercise covers ages 20–49; never-married women aged 15–19 are excluded, as set out in Sect. 4.2. Figures are for all states of India and are an upper bound

5.2 Combined recovery potential

How much could delaying one-child sterilisation add to fertility? The answer turns on how many women stop at one child. In the below-replacement states one-child sterilisation reaches only about 1.8 per cent of currently married women. Among all sterilised women, only about 4 per cent were sterilised after one child, against about 52 per cent after two children and 28 per cent after three. Table 4 gives the full distribution. Sterilisation in India is concentrated at two children, consistent with the two-child norm documented in the literature, so the one-child margin is small from the outset (Matthews et al., 2009).

Table 4
Distribution of parity at sterilisation among sterilised women, below-replacement states

Parity at sterilisation	Share of sterilised women (%)
1 child	4.0
2 children	51.5
3 children	28.1
4 children	10.6
5 or more children	5.7

Weighted percentages among currently married women whose current contraceptive method is female sterilisation. Sterilisations before any birth, 0.1 per cent of the total, are omitted, so the column sums to 99.9

Table 5 brings the three margins together, each expressed over all women aged 15–49 so that they are additive with the observed rate, following Eq. (5); the age pattern behind the unmarried margin was set out in Sect. 5.1. For the pooled below-replacement population the prospect pool contributes 0.159. This is smaller than the recovery prospect of 21.7 per cent reported in Sect. 5.1. The difference is one of denominator rather than of substance. The 21.7 per cent is a

share of currently married women, whereas the total fertility rate is defined over all women, and currently married women are about 72 per cent of women aged 15–49 in these states. Giving one further birth to every exposed and willing married woman therefore adds 0.159 births per woman, not 0.217. Delaying one-child sterilisation adds a further 0.011, so the two married margins together take the rate only from 1.79 to about 1.96, still short of replacement. This holds in 21 of the 23 states. The exceptions are Rajasthan and Madhya Pradesh, which begin at 2.03 and 2.01 and are carried just past 2.1 by the married margins alone, an unsurprising result for states already at the threshold. The unmarried margin adds 0.515, bringing the ceiling to about 2.48. Even under assumptions that give every margin its maximum, only the exposure of women who have not yet married carries the below-replacement states above 2.1, and two states, Sikkim and West Bengal, remain below it.

The reason is worth stating precisely. The gain in the total fertility rate is proportional to the flow of women who would be induced to have an additional birth, and that flow is small at the one-child margin simply because few women stop there. The same one-birth assumption applied to the far larger flow of women who stop at two children delivers a much larger gain, as we show in the robustness section. Nothing in the construction favours one result over the other; the difference is entirely a feature of where sterilisation occurs in the reproductive career.

Table 5

Combined recovery potential: Observed TFR, the three margins – the prospect pool, delayed one-child sterilisation, and never-married women (upper bound) – and the resulting potential TFR and gap from replacement, by state

State	Current TFR	Additional TFR by margin			Combined additional TFR	Potential TFR	Gap from 2.1
		Prospect pool ^a	One-child sterilisation ^b	Unmarried women ^c			
North	1.92	0.155	0.009	0.589	0.753	2.673	+ 0.573
Haryana	1.91	0.137	0.005	0.666	0.808	2.718	+ 0.618
Himachal Pradesh	1.67	0.111	0.014	0.794	0.919	2.589	+ 0.489
Punjab	1.65	0.130	0.005	0.786	0.921	2.571	+ 0.471
Rajasthan	2.03	0.175	0.011	0.473	0.659	2.689	+ 0.589
Uttarakhand	1.83	0.142	0.001	0.683	0.826	2.656	+ 0.556
Central	1.96	0.155	0.013	0.593	0.761	2.721	+ 0.621
Chhattisgarh	1.83	0.163	0.010	0.716	0.889	2.719	+ 0.619
Madhya Pradesh	2.01	0.152	0.015	0.538	0.705	2.715	+ 0.615
East	1.71	0.169	0.007	0.334	0.510	2.220	+ 0.120
Odisha	1.82	0.167	0.008	0.555	0.730	2.550	+ 0.450
West Bengal	1.65	0.170	0.007	0.259	0.436	2.086	-0.014
Northeast	1.86	0.166	0.003	0.445	0.614	2.474	+ 0.374
Arunachal Pradesh	1.80	0.167	0.005	0.662	0.834	2.634	+ 0.534
Assam	1.90	0.173	0.003	0.407	0.583	2.483	+ 0.383
Mizoram	1.85	0.184	0.001	1.409	1.594	3.444	+ 1.344
Nagaland	1.71	0.120	0.002	1.579	1.701	3.411	+ 1.311
Sikkim	1.00	0.093	0.004	0.756	0.853	1.853	-0.247
Tripura	1.74	0.136	0.003	0.229	0.368	2.108	+ 0.008
West	1.75	0.151	0.015	0.551	0.717	2.467	+ 0.367
Goa	1.32	0.168	0.014	1.148	1.330	2.650	+ 0.550
Gujarat	1.87	0.158	0.007	0.567	0.732	2.602	+ 0.502
Maharashtra	1.70	0.147	0.018	0.533	0.698	2.398	+ 0.298
South	1.73	0.160	0.013	0.554	0.727	2.457	+ 0.357
Andhra Pradesh	1.69	0.138	0.014	0.426	0.578	2.268	+ 0.168
Karnataka	1.69	0.177	0.020	0.534	0.731	2.421	+ 0.321
Kerala	1.80	0.206	0.009	0.590	0.805	2.605	+ 0.505

State	Current TFR	Additional TFR by margin			Combined additional TFR	Potential TFR	Gap from 2.1
		Prospect pool ^a	One-child sterilisation ^b	Unmarried women ^c			
North	1.92	0.155	0.009	0.589	0.753	2.673	+ 0.573
Tamil Nadu	1.76	0.152	0.005	0.670	0.827	2.587	+ 0.487
Telangana	1.75	0.138	0.019	0.490	0.647	2.397	+ 0.297
Pooled (below-replacement)	1.79	0.159	0.011	0.515	0.685	2.475	+ 0.375

All quantities are in children per woman and all three margins are expressed over all women aged 15–49, so they are additive with the observed rate. The combined additional TFR is their sum, the potential TFR adds it to the observed rate, following Eq. (5), and the gap is the potential TFR minus 2.1, so a positive gap means the ceiling exceeds replacement. The figures are an upper bound. Rows in bold are regional aggregates, weighted across the states in the region

^a The prospect-pool margin is the additional total fertility rate if every currently married woman who is outside the limitation stock and wants another child had exactly one further birth, expressed per woman aged 15–49 so that it is comparable with the observed rate

^b The one-child sterilisation counterfactual is the gain in the total fertility rate when recent one-child sterilisations are treated as second births, following Eq. (3)

^c The unmarried-women bound is the additional total fertility rate if never-married women aged 20–49 bore children at the age-specific rates of currently married women of the same age group and state, following Eq. (4). Its age pattern is shown in Table 3

5.3 Who holds the remaining capacity

Who still has room for, and who still wants, another child? Table 6 disaggregates the four quantities of the framework – the limitation stock, the prospect stock, the desire for another child, and the recovery prospect – by education, wealth, residence, religion, region, and age. Education matters most. The limitation stock falls from about 65 per cent among women with no schooling to about 26 per cent among women with higher education, and the recovery prospect rises from about 9 to 40 per cent. Whatever capacity remains for fertility recovery is therefore concentrated among educated women.

Education is not the only divide in Table 6, although it is the sharpest. Wealth and residence make surprisingly little difference: the recovery prospect varies by barely two percentage points across wealth groups and between urban and rural women. Religion, region, and age matter more. Muslim women have a lower limitation stock than Hindu women, 32 against 50 per cent, and a higher recovery prospect, reflecting their lower reliance on sterilisation. The southern states combine a very high limitation stock, about 63 per cent, with an unusually strong desire for another child among the few women who remain available, about 59 per cent. Their recovery prospect therefore ends up close to the northern figure, but for a different reason. The age contrast is the widest. Among women aged 15–29 the limitation stock is only about 22 per cent and the recovery prospect about 49 per cent. Among women aged 30–49 the stock reaches about 61 per cent, because sterilisation is largely complete by the early thirties. This age gradient is a reminder that the limitation stock binds within a cohort and that its ultimate size for younger women is not yet fixed.

Table 6
Limits and prospects by subgroup, currently married women, below-replacement states

Group	Limitation stock	Prospect stock	Want more (of prospect)	Recovery prospect	N
By education					
No education	65.2	34.8	25.7	8.9	90,111
Primary	57.1	42.9	29.2	12.5	52,245
Secondary	42.3	57.7	43.9	25.3	172,789
Higher	25.7	74.3	53.7	39.9	39,505
By wealth					
Poorer	46.4	53.6	38.9	20.8	138,102
Middle	52.2	47.8	43.9	21.0	78,582
Richer	45.9	54.1	42.0	22.7	137,966
By residence					
Urban	44.9	55.1	40.0	22.0	86,932
Rural	48.7	51.3	42.1	21.6	267,718
By religion					
Hindu	50.0	50.0	42.4	21.2	279,832
Muslim	31.6	68.4	38.0	26.0	32,733
Other	44.1	55.9	36.9	20.6	42,085
By region					
South	63.1	36.9	59.4	21.9	77,271
North and rest	40.9	59.1	36.6	21.7	277,379
By age group					
15–29	21.6	78.4	62.1	48.7	122,472
30–49	61.2	38.8	18.8	7.3	232,178

Weighted percentages of currently married women within each subgroup, except N. “Want more (of prospect)” is the share wanting another child among women not in the limitation stock; the recovery prospect is the product of the prospect stock and that share

These unadjusted comparisons can mislead, because the groups differ in age and parity: educated women, for example, are younger and have fewer children, and both traits raise the wish for another child. Table 7 therefore reports regressions that hold age and parity constant, for being sterilised and, within the prospect stock, for wanting another child; wealth, religion, and state fixed effects are included but not shown. Two results stand out. First, the capacity pattern survives: schooling lowers the probability of sterilisation, so educated women remain in the prospect stock. Second, the desire pattern reverses: educated women appear more eager for another child in Table 6, but at the same age and parity, desire falls with schooling. Educated women therefore hold the most remaining capacity while wanting the fewest additional children, and no group in the population combines capacity with desire.

Table 7
Correlates of sterilisation and of the desire for another child (survey-weighted linear probability models)

Covariate	Sterilised	Wants another child
Years of schooling	-0.0055*** (0.0003)	-0.0038*** (0.0004)
Urban residence	-0.0298*** (0.0040)	-0.0113*** (0.0039)
Muslim	-0.0742*** (0.0027)	0.0364*** (0.0025)
Age at first marriage	-0.0178*** (0.0003)	0.0179*** (0.0004)
Parity	0.0842*** (0.0016)	-0.1347*** (0.0019)
Age (centred at 30)	0.0213*** (0.0002)	-0.0246*** (0.0003)
R-squared	0.327	0.403
Observations	354,650	199,784

Each column is one survey-weighted linear regression among currently married women in the below-replacement states. The model for wanting another child is estimated among women in the prospect stock. Parity is the woman's number of living children. Standard errors, clustered at the primary sampling unit, are in parentheses. Age squared, wealth quintile, religion, and state fixed effects are included but not shown

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$

5.4 Robustness

Table 8 collects a set of checks on the demographic results, and they leave the conclusions intact. The limitation stock and the recovery prospect are not sensitive to reasonable changes in method. Our main measure of infecundity is the woman's own declaration that she cannot have children; adding the broader group of women recorded as infecund or menopausal raises the limitation stock from 47.4 to 55.3 per cent and lowers the recovery prospect only from 21.7 to 19.5 per cent, so the conclusion is unchanged. Adding male sterilisation to the limitation stock changes it only trivially, because male sterilisation is rare in India. Using a stricter threshold of 2.0 rather than 2.1 to define below-replacement states leaves 21 states and almost identical figures. The counterfactual gain from delayed one-child sterilisation stays near 0.011 of a child under the stricter threshold, and near 0.010 when we exclude the southern states, so it is not the product of any one group of states. Measuring fertility over a five-year rather than a three-year window raises the level of the total fertility rate slightly, consistent with a modest amount of birth postponement, but does not change the counterfactual.

The most instructive row is the two-child comparison. When we replace the one-child rule with a two-child rule, in which recently sterilised women at parity one or two each have one further birth, the counterfactual total fertility rate rises from 1.794 to 2.13, a gain of about 0.34 of a child. This is roughly thirty times the one-child gain, and it shows that the demographic leverage lies at the two-child margin, where sterilisation actually occurs, not at the one-child margin. Even so, the two-child counterfactual takes the pooled rate only just above replacement level, and even acting on the far larger margin would not, on its own, restore replacement fertility in the states that are furthest below it.

Table 8
Robustness of the demographic results and the counterfactual

Specification	Limitation stock	Recovery prospect	TFR	TFR*	Δ TFR
Main specification	47.4	21.7	1.794	1.805	0.011
Infecundity: include menopausal (derived)	55.3	19.5	—	—	—
Include male sterilisation	47.8	21.7	—	—	—
Threshold TFR < 2.0	46.9	21.5	1.745	1.756	0.011
Exclude southern states	40.9	21.7	1.821	1.831	0.010
Two-child counterfactual	—	—	1.794	2.131	0.338
Fertility window: 5 years	—	—	1.836	—	—

Pooled below-replacement figures for states only. The limitation stock and the recovery prospect are weighted percentages of currently married women. The two-child counterfactual assumes that recently sterilised women at parity one or two each have one further birth. A dash means the check does not alter that column

6 Discussion

This paper contributes to the growing literature on below-replacement fertility by showing that fertility recovery depends not only on fertility preferences but also on demographic capacity. The classic literature on very low fertility, developed largely from the experience of Europe and East Asia, has emphasised delayed childbearing, changing family-size preferences, economic uncertainty and the challenges of combining work and family (Frejka & Sobotka, 2008; Kohler et al., 2002; Lutz et al., 2006). These mechanisms are clearly relevant to India's below-replacement states. However, the Indian case adds a further demographic constraint that has received little attention in the international literature: the widespread and early adoption of permanent female sterilisation. In settings where contraception is predominantly reversible, fertility decline remains, at least in principle, reversible within a cohort because couples can subsequently revise their reproductive intentions. In India, by contrast, early sterilisation permanently removes a large proportion of women from future childbearing, so demographic capacity itself becomes an important determinant of fertility recovery.

This distinction between demographic capacity and fertility intentions is the principal contribution of the paper. Existing studies have examined fertility preferences, contraceptive behaviour and pronatalist policies largely in isolation. By distinguishing the limitation stock, the prospect stock and the recovery prospect, we show that fertility recovery is jointly constrained by demographic capacity and reproductive intentions. The framework therefore provides a direct measure of the demographic room for fertility recovery and can be readily implemented using standard fertility surveys. Although developed for India, it is applicable to other settings where permanent methods account for a substantial share of contraceptive use.

The analysis also highlights an important distinction between current and future cohorts. The limitation stock describes the reproductive capacity of women who are currently married and of reproductive age. It does not determine the behaviour of younger women who have not yet entered marriage or completed childbearing. Consequently, the long-term trajectory of fertility will depend less on women who have already undergone sterilisation than on whether future cohorts continue to adopt permanent contraception as early and as widely as previous generations. A gradual shift towards a broader contraceptive method mix would increase demographic flexibility even if completed family size remained unchanged.

The policy implications follow naturally from this framework. First, the results suggest that policies aimed at raising fertility within marriage are likely to have limited demographic leverage because the remaining recovery prospect is small. Second, greater emphasis on reversible contraception would preserve reproductive choice by allowing couples to postpone, rather than permanently end, childbearing, a choice that a small share of sterilised women later regret (Singh et al., 2012). Such an approach is consistent with the broader goals of reproductive autonomy and informed choice that underpin contemporary family-planning programmes (New et al., 2017). Third, policies supporting family formation, including affordable childcare, parental leave, flexible employment and measures that reduce barriers to marriage and childbearing, may help individuals achieve their desired family size. International evidence suggests that such measures generally have modest effects on completed fertility but may reduce the gap between intended and realised fertility (Luci-Greulich & Thévenon, 2013; Sobotka et al., 2019). Indian conditional cash transfers have likewise shifted the use of health services rather than family size (Rahman & Pallikadavath, 2018). Finally, irrespective of future fertility trends, continued population ageing will require sustained policy responses in pensions, health care and labour markets (Bloom et al., 2010; Gietel-Basten et al., 2022).

Several limitations should be acknowledged. The counterfactual analyses are demographic accounting exercises rather than behavioural forecasts and should therefore be interpreted as upper bounds rather than predictions. Fertility is measured over a three-year reference period, although sensitivity analyses using a five-year window produce similar conclusions. Fertility intentions are based on stated preferences, which do not always translate into subsequent behaviour (Morgan & Rackin, 2010). Finally, the analysis describes the demographic situation at the time of the survey and does not project future fertility. Nevertheless, the conclusions remain robust across alternative definitions of permanent limitation, different fertility thresholds and alternative analytical specifications.

7 Conclusion

The demographic scope for fertility recovery in India's below-replacement states is narrow, and it is bounded on two sides at once. Nearly half of currently married women have already permanently exited childbearing, almost entirely through early sterilisation, and only a minority of those still exposed want another child. This constraint holds across India's diverse demographic regimes: although the limitation stock ranges from 12.5 per cent of married women in Assam to 73.6 per cent in Andhra Pradesh, the recovery prospect varies only from 14.8 to 33.4 per cent, because where capacity is scarce the few remaining women tend to want another child, and where capacity is ample most do not. Even substantial changes in reproductive behaviour within marriage would therefore leave fertility below replacement level in almost all states.

Three conclusions follow. First, pronatalist measures aimed at currently married women confront a demographic ceiling, not merely reluctant preferences, and cannot restore replacement fertility on their own. Second, the largest remaining margin lies with cohorts who have not yet married: policies that ease family formation, together with a broader contraceptive method mix that replaces permanent exits with reversible choices, would do more for future fertility than any attempt to change the intentions of women who are already married. Third, in settings where permanent contraception predominates, analyses of fertility recovery must count demographic capacity before preferences. The limitation-prospect-recovery accounting developed here makes that constraint directly measurable from any standard fertility survey, in India and beyond.

Declarations

Author Contribution

Conceptualisation: Saseendran Pallikadavath; Methodology: Saseendran Pallikadavath, Mohammad Mahbubur Rahman and Ch. Satish Kumar; Formal analysis and investigation: Mohammad Mahbubur Rahman; Writing – original draft preparation and review and editing: Ch. Satish Kumar. All authors read and approved the final manuscript.

References

1. Bhat, P. N. M. (2002). Returning a favor: Reciprocity between female education and fertility in India. *World Development*, 30(10), 1791–1803. [https://doi.org/10.1016/S0305-750X\(02\)00065-7](https://doi.org/10.1016/S0305-750X(02)00065-7)
2. Bhat, P. N. M., & Zavier, A. J. F. (2003). Fertility decline and gender bias in northern India. *Demography*, 40(4), 637–657. <https://doi.org/10.2307/1515201>
3. Billari, F. C., & Kohler, H. P. (2004). Patterns of low and lowest-low fertility in Europe. *Population Studies*, 58(2), 161–176. <https://doi.org/10.1080/0032472042000213695>
4. Bloom, D. E., Canning, D., & Fink, G. (2010). Implications of population ageing for economic growth. *Oxford Review of Economic Policy*, 26(4), 583–612. <https://doi.org/10.1093/oxrep/grq038>
5. Bongaarts, J. (1990). The measurement of wanted fertility. *Population and Development Review*, 16(3), 487–506. <https://doi.org/10.2307/1972833>
6. Bongaarts, J. (2001). Fertility and reproductive preferences in post-transitional societies. *Population and Development Review*, 27(Suppl. Global Fertility Transition), 260–281.
7. Casterline, J. B., & el-Zeini, L. O. (2007). The estimation of unwanted fertility. *Demography*, 44(4), 729–745. <https://doi.org/10.1353/dem.2007.0043>
8. Chao, F., Gerland, P., Cook, A. R., & Alkema, L. (2019). Systematic assessment of the sex ratio at birth for all countries and estimation of national imbalances and regional reference levels. *Proceedings of the National Academy of Sciences*, 116(19), 9303–9311. <https://doi.org/10.1073/pnas.1812593116>
9. Desai, S., Campbell, O. M. R., Sinha, T., Mahal, A., & Cousens, S. (2017). Incidence and determinants of hysterectomy in a low-income setting in Gujarat, India. *Health Policy and Planning*, 32(1), 68–78. <https://doi.org/10.1093/heapol/czw099>
10. Drèze, J., & Murthi, M. (2001). Fertility, education, and development: Evidence from India. *Population and Development Review*, 27(1), 33–63. <https://doi.org/10.1111/j.1728-4457.2001.00033.x>
11. Dyson, T. (2018). *A population history of India: From the first modern people to the present day*. Oxford University Press. <https://doi.org/10.1093/oso/9780198829058.001.0001>
12. Frejka, T., & Sobotka, T. (2008). Overview Chap. 1: Fertility in Europe: Diverse, delayed and below replacement. *Demographic Research*, 19(3), 15–46. <https://doi.org/10.4054/DemRes.2008.19.3>
13. Gietel-Basten, S., Rotkirch, A., & Sobotka, T. (2022). Changing the perspective on low birth rates: Why simplistic solutions won't work. *Bmj*, 379, e072670. <https://doi.org/10.1136/bmj-2022-072670>
14. Goldstein, J. R., Sobotka, T., & Jasilioniene, A. (2009). The end of lowest-low fertility? *Population and Development Review*, 35(4), 663–699. <https://doi.org/10.1111/j.1728-4457.2009.00304.x>
15. Government of Andhra Pradesh. (2026). *Draft population management policy*. Department of Health, Medical and Family Welfare, Government of Andhra Pradesh.
16. Government of India (2021). *The Prohibition of Child Marriage (Amendment) Bill, 2021* (Bill No. 163 of 2021). Lok Sabha Secretariat. <https://prsindia.org/billtrack/the-prohibition-of-child-marriage-amendment-bill-2021>
17. Guilmoto, C. Z. (2009). The sex ratio transition in Asia. *Population and Development Review*, 35(3), 519–549. <https://doi.org/10.1111/j.1728-4457.2009.00295.x>

18. Guilmoto, C. Z., & Rajan, S. I. (2013). Fertility at the district level in India: Lessons from the 2011 Census. *Economic and Political Weekly*, 48(23), 59–70. <https://www.epw.in/journal/2013/23/special-articles/fertility-district-level-india.html>
19. International Institute for Population Sciences (IIPS), & ICF (2021). *National Family Health Survey (NFHS-5), 2019–21: India*. IIPS. <https://dhsprogram.com/pubs/pdf/FR375/FR375.pdf>
20. James, K. S. (2011). India's demographic change: Opportunities and challenges. *Science*, 333(6042), 576–580. <https://doi.org/10.1126/science.1207969>
21. Jayachandran, S. (2015). The roots of gender inequality in developing countries. *Annual Review of Economics*, 7(1), 63–88. <https://doi.org/10.1146/annurev-economics-080614-115404>
22. Jayachandran, S., & Kuziemko, I. (2011). Why do mothers breastfeed girls less than boys? Evidence and implications for child health in India. *Quarterly Journal of Economics*, 126(3), 1485–1538. <https://doi.org/10.1093/qje/qjr029>
23. Kashyap, R., & Villavicencio, F. (2016). The dynamics of son preference, technology diffusion, and fertility decline underlying distorted sex ratios at birth: A simulation approach. *Demography*, 53(5), 1261–1281. <https://doi.org/10.1007/s13524-016-0500-z>
24. Kohler, H. P., Billari, F. C., & Ortega, J. A. (2002). The emergence of lowest-low fertility in Europe during the 1990s. *Population and Development Review*, 28(4), 641–680. <https://doi.org/10.1111/j.1728-4457.2002.00641.x>
25. Luci-Greulich, A., & Thévenon, O. (2013). The impact of family policies on fertility trends in developed countries. *European Journal of Population*, 29(4), 387–416. <https://doi.org/10.1007/s10680-013-9295-4>
26. Lutz, W., Skirbekk, V., & Testa, M. R. (2006). The low-fertility trap hypothesis: Forces that may lead to further postponement and fewer births in Europe. *Vienna Yearbook of Population Research*, 4, 167–192. <https://doi.org/10.1553/populationyearbook2006s167>
27. Matthews, Z., Padmadas, S. S., Hutter, I., McEachran, J., & Brown, J. J. (2009). Does early childbearing and a sterilization-focused family planning programme in India fuel population growth? *Demographic Research*, 20(28), 693–720. <https://doi.org/10.4054/DemRes.2009.20.28>
28. Morgan, S. P., & Rackin, H. (2010). The correspondence between fertility intentions and behavior in the United States. *Population and Development Review*, 36(1), 91–118. <https://doi.org/10.1111/j.1728-4457.2010.00319.x>
29. Myrskylä, M., Kohler, H. P., & Billari, F. C. (2009). Advances in development reverse fertility declines. *Nature*, 460(7256), 741–743. <https://doi.org/10.1038/nature08230>
30. New, J. R., Cahill, N., Stover, J., Gupta, Y. P., & Alkema, L. (2017). Levels and trends in contraceptive prevalence, unmet need, and demand for family planning for 29 states and union territories in India: A modelling study using the Family Planning Estimation Tool. *The Lancet Global Health*, 5(3), e350–e358. [https://doi.org/10.1016/S2214-109X\(17\)30033-5](https://doi.org/10.1016/S2214-109X(17)30033-5)
31. Office of the Registrar General & Census Commissioner, India. (2026). *Sample Registration System statistical report 2024*. Ministry of Home Affairs. <https://censusindia.gov.in/nada/index.php/catalog/47152> Government of India.
32. Pallikadavath, S., Ogollah, R., Singh, A., Dean, T., Dewey, A., & Stones, W. (2016). Natural menopause among women below 50 years in India: A population-based study. *Indian Journal of Medical Research*, 144(3), 366–377. <https://doi.org/10.4103/0971-5916.198676>
33. Pallikadavath, S., Rajan, S. I., & Wilson, C. (2016). Impact of low fertility and early age at sterilisation on women's formal education and skill development in South India. *Journal of Population Research*, 33(3), 199–220. <https://doi.org/10.1007/s12546-016-9167-y>
34. Pallikadavath, S., Rajan, S. I., & Wilson, C. (2017). Low fertility in developing countries: Causes and implications. *Journal of Biosocial Science*, 49(S1), S1–S3. <https://doi.org/10.1017/S002193201700058X>

35. Pallikadavath, S., & Stones, R. W. (2005). Miscarriage in India: A population-based study. *Fertility and Sterility*, 84(2), 516–518. <https://doi.org/10.1016/j.fertnstert.2005.02.023>
36. Pallikadavath, S., & Wilson, C. (2005). A paradox within a paradox: Scheduled caste fertility in Kerala. *Economic and Political Weekly*, 40(28), 3085–3093.
37. Park, N., Vyas, S., Broussard, K., & Spears, D. (2023). Near-universal marriage, early childbearing, and low fertility: India's alternative fertility transition. *Demographic Research*, 48(34), 945–956. <https://doi.org/10.4054/DemRes.2023.48.34>
38. Prusty, R. K., Choithani, C., & Gupta, S. D. (2018). Predictors of hysterectomy among married women 15–49 years in India. *Reproductive Health*, 15(1). Article 3. <https://doi.org/10.1186/s12978-017-0445-8>
39. Rahman, M. M., & Pallikadavath, S. (2018). How much do conditional cash transfers increase the utilization of maternal and child health care services? New evidence from Janani Suraksha Yojana in India. *Economics & Human Biology*, 31, 164–183. <https://doi.org/10.1016/j.ehb.2018.08.007>
40. Santhya, K. G. (2003). *Changing family planning scenario in India: An overview of recent evidence* (South & East Asia Regional Working Paper No. 17). Population Council. <https://doi.org/10.31899/rh5.1037>
41. Shekhar, C., Paswan, B., & Singh, A. (2019). Prevalence, sociodemographic determinants and self-reported reasons for hysterectomy in India. *Reproductive Health*, 16(1). Article 118. <https://doi.org/10.1186/s12978-019-0780-z>
42. Singh, A., Ogollah, R., Ram, F., & Pallikadavath, S. (2012). Sterilization regret among married women in India: Implications for the Indian National Family Planning Program. *International Perspectives on Sexual and Reproductive Health*, 38(4), 187–195. <https://doi.org/10.1363/3818712>
43. Sobotka, T., Matysiak, A., & Brzozowska, Z. (2019). *Policy responses to low fertility: How effective are they?* (UNFPA Technical Division Working Paper Series, Population & Development Branch, Working Paper No. 1). United Nations Population Fund. <https://www.unfpa.org/publications/policy-responses-low-fertility-how-effective-are-they>
44. Vollset, S. E., Goren, E., Yuan, C. W., Cao, J., Smith, A. E., Hsiao, T., Bisignano, C., Azhar, G. S., Castro, E., Chalek, J., Dolgert, A. J., Frank, T., Fukutaki, K., Hay, S. I., Lozano, R., Mokdad, A. H., Nandakumar, V., Pierce, M., Pletcher, M., & Murray, C. J. L. (2020). Fertility, mortality, migration, and population scenarios for 195 countries and territories from 2017 to 2100: A forecasting analysis for the Global Burden of Disease Study. *The Lancet*, 396(10258), 1285–1306. [https://doi.org/10.1016/S0140-6736\(20\)30677-2](https://doi.org/10.1016/S0140-6736(20)30677-2)

Figures

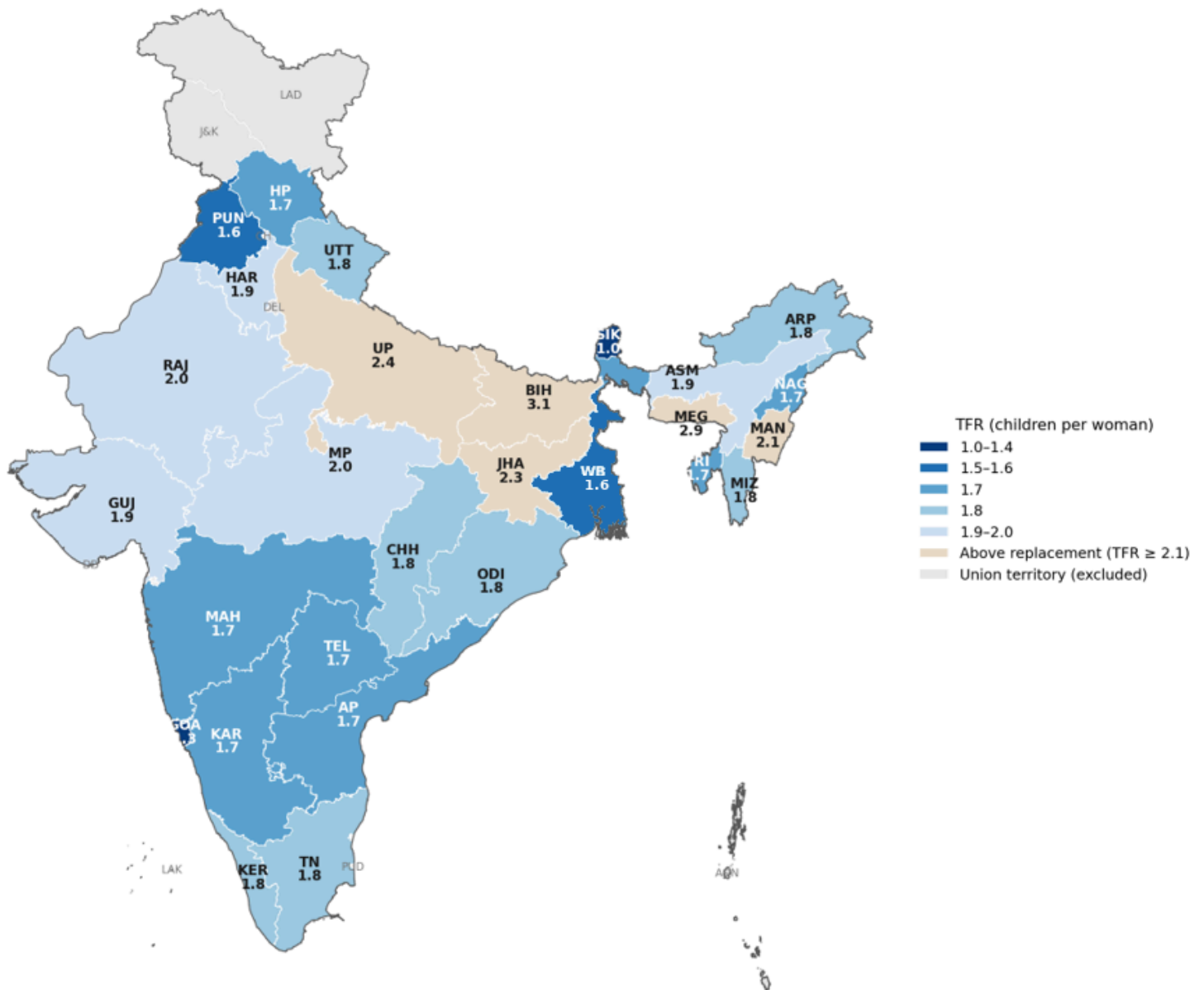


Figure 1

Total fertility rate by state, NFHS-5 (2019–21). States shaded in blue have a total fertility rate below replacement level (TFR < 2.1) and are the 23 states analysed in this paper; the blues follow five classes of the TFR rounded to one decimal (1.0–1.4, 1.5–1.6, 1.7, 1.8, and 1.9–2.0), shown in the legend, with darker blue denoting lower fertility, so that each state’s colour corresponds exactly to its printed value; states in beige are the five states at or above replacement, and union territories, shown in grey, are excluded from the analysis and included only for geographic context

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Appendix.docx](#)